THE ENHANCMENT OF FLORAL BIODIVERSITY

IN SMALL SCALE CONSTRUCTED WETLAND

TREATMENT SYSTEMS

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Doctor of Philosophy

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SUMMARY

Within the U.K. small-scale treatment wetlands are primarily constructed using a monoculture of *Phragmites australis.* This thesis investigates the potential for enhancing the biodiversity value of these wetlands by the inclusion of appropriate floral species.

Extensive literature reviews found that although there was a plethora of data for the design of constructed wetlands, there was a dearth of information on enhancing the biodiversity value of these wetlands. Three potential biodiversity enhancing species were identified which could be beneficial; purple loosestrife *Lythrum salicaria*, meadowsweet *Filipendula ulmaria* and water mint *Mentha aquatica*.

A microcosm study was undertaken to investigate the growth of these species, the interactions between them and with *Phragmites australis*. The two pollutants employed in these studies were nitrogen and salinity. A second parallel system was constructed where competition between the plants was restricted by installing root dividers.

The results of the microcosm study identified that selected species survived within all of the nutrient concentrations employed. The roots of the biodiversity enhancing species predominantly stayed within the upper humus layer of the wetland and so would not interfere with the subsurface flow of the wetland or the treatment potential of the *Phragmites australis* roots. The area coverage of the biodiversity enhancing species combined with the coverage and treatment potential of the *Phragmites australis* roots show that these species are suitable for growing within a small-scale constructed wetland at the tested nutrient concentrations. Fatalities were present within the salinity concentrations, therefore they can only be utilised at up to a limiting salinity concentration.

A field study was subsequently undertaken at operational sites to investigate the addition of biodiversity enhancing species into mature and newly restored reedbeds with mixed results.

Following the study, design principle recommendations are made for including biodiversity enhancing species within a small-scale treatment wetland systems within the U.K.

KEYWORDS

Biodiversity, Enhancement, Constructed Wetland, Phytoremediation, Microcosm.

DEDICATION

For my wife, sons, and the canine vandal, with love.

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NOTATIONS

BOD	biochemical oxygen demand. A measure of the amount of dissolved oxygen consumed by the degradation of organic matter by microorganisms.
BOD_5	biochemical oxygen demand. A measure of the amount of dissolved oxygen consumed by the degradation of organic matter by microorganisms, over a five day period at 20^0C.
COD	chemical oxygen demand. A measure of the amount of oxygen consumed by chemical oxidation reactions. Commonly used as a measure for the oxidizable pollutants found in water.
HDPE	High – density polyethylene

UNITS OF MEASUREMENT

cm^2	centimetres squared
g	gram
g/l	grams per litre
g/m^2	grams per metre squared
kg/m^2	kilograms per metre squared
kg/ha	kilograms per hectare
l	litres
m	metres
ml	millilitres
mm	millimetres
mg/l	Milligrams per litre
ppt	parts per thousand
%	Percentage
‰	Within this report the salinity is reported as per mille (‰, ppt) which is approximately related to a Practical Salinity Scale (UNESCO 1981 and 1985) .
^0C	Temperature (Celsius)

NOTATION continued

Chemical symbols

B	Boron
Cl	Chloride
Cu	Copper
Fe	Iron
K	Potassium
Mn	Manganese
Mo	Molybdenum
N	Nitrogen
NO_3-N	Nitrate
NH_3-N	Ammonia
NH_4-N	Ammonium
P	Phosphorus
pH	A measure of the molar concentration of hydrogen ions expressed in a scale using the negative logarithm to the base 10.
TN	Total Nitrogen
TP	Total Phosphorus
Zn	Zinc

1. INTRODUCTION

1.1 Origins of the project

Landfill leachate is the liquid by-product resulting from the breakdown of waste within the landfill environment in the presence of moisture within the waste and any water – percolating into the landfill site. Older non-operational landfills, which were filled with a higher proportion of inert waste, usually have lower levels of contaminants and higher volumes of leachate (caused by water ingress due to less efficient old style clay liners or the lack of any liners) than modern landfills (Sanford, 1999). As there are still many old landfill sites whose leachate is costly to collect and transport to appropriate treatment works, it was decided to explore the potential for phytoremediation. The lower levels of contaminants in this leachate would generally not be phytotoxic to the flora within a constructed wetland treatment system, and as such would not require any additional mechanical pre-treatment.

A project was therefore conceived to:

> *"design a constructed wetland treatment system to ameliorate contaminants found in landfill leachate produced from a stereotypical old style landfill, which has been filled with generally inert materials, to a standard which will not deteriorate the environment upon which it is released into"* (Steggall *et al.,* 2005).

Funding was obtained from the Landfill Tax Grants Scheme for this study in 2001. Subsequently, after undertaking an extensive literature review on this topic, a pilot system was designed to be situated on an old landfill site, and planning permission was obtained. Had the pilot been implemented, the process would have involved pumping landfill leachate out of a borehole, running the leachate through the treatment system, and monitoring the levels of contaminants within the different sections of the treatment system, before returning the effluent back into a different borehole.

Unfortunately, the national statutory body for overseeing waste management within England and Wales, the Environment Agency, took the decision that a Waste Management Licence would be required for the process of running the leachate through the pilot treatment system as technically waste was being treated. The cost of obtaining the Waste Management Licence and paying for the fees, which the Environment Agency wanted in order for them to run parallel tests on the effluent, went beyond the economic means of the available funding. The owners of the landfill would not allow a new application for a Waste Management Licence for the landfill (the last licence had been surrendered several years earlier), as the landfill no longer met modern day requirements. If they obtained a Waste Management Licence for the site, then they would not be able to surrender it until they replaced the old clay liner with a modern high-density polyethylene (HDPE) one in order to meet the new requirements.

After further consideration the transfer of the pilot system to an alternative location was deemed not to be feasible, and consequently the project and its associated funding were cancelled.

Since the original project was terminated, the Environment Agency have developed mechanisms to facilitate such research without the requirement of a waste management licence, by assessing research proposals on a case by case basis. However, the original proposal contributed positively to this thesis by identifying a paucity of information on biodiversity enhancement in wetland treatment systems, as discussed below.

Following a period of reflection and re-grouping, a new project was designed to research the potential for increasing the biodiversity within constructed wetland treatment systems. Constructed wetland treatment systems are generally planted with monocultures and the literature revealed a paucity of information on the interactions of different floral species within the same system. Where more than one species is present, this is in separate treatment cells, or within larger wetlands sub divided into areas planted with robust dominant species such as *Phragmites australis*, *Typha* sp. and *Scirpus* sp. Due to the low biodiversity value within the smaller <1 ha constructed wetland treatment systems common in the U.K., the biodiversity value could potentially be increased by planting additional floral species, which would in-turn increase the resources available to faunal species.

1.2 Aims and Objectives

1.2.1 Aim

The aim of the research is

> *'to produce design principles for the implementation, creation and management of biodiversity sections/corridors within monoculture phytoremediation treatment systems.'*

In producing the design principles for treatment systems the effluent constituents would be salinity (found in waste effluent from industrial processes and road runoff) and nutrients, focusing upon nitrogen (found in both domestic and industrial waste effluents). Both of these constituents can have an impact on the species diversity within a wetland treatment system by having fatal/limiting effects on some species, whilst allowing more tolerant species to takeover.

1.2.2 Objectives

To achieve the aim, the following objectives were identified:

Objective 1: Undertake a literature review focusing upon the design, management and floral species requirements of horizontal flow constructed wetlands. A literature review of effluents and their parameters will also be undertaken.

Objective 2: From the literature review, a range of floral species will be chosen which could prove beneficial in increasing the biodiversity value of constructed wetlands.

Objective 3: Design and implement an experimental microcosm study to identify the suitability of the selected species and their interactions, when subject to different contaminant ranges.

To assess the suitability of the floral species, the results from the microcosm study will be used to test the following hypotheses (1 to 8). These hypotheses were chosen to determine the survivability of the different species and therefore their suitability for use within a constructed wetland treatment system. The hypotheses were also chosen to investigate the design of restricting root competition and the affect of the competition parameters on the vegetation growth and water usage.

Hypothesis 1 – *"Where all four chosen floral species survive in the chemical concentrations studied, no single floral species will take over and oust other floral species."*

Hypothesis 2 – *"Where all four chosen floral species survive in the chemical concentrations studied, no single floral species will take over and oust other floral species, and restricting root competition between the different floral species will have an effect."*

Hypothesis 3 – *"The higher concentrations of the chosen chemical ranges will have an effect on the stem heights or stem widths of the surviving plants."*

Hypothesis 4 – *"The higher concentrations of the chosen chemical ranges will have an effect on the stem heights or stem widths of the surviving plants, and restricting root competition between the different floral species will have an effect."*

Hypothesis 5 – *"The higher concentrations of the chosen chemical ranges will have an effect on the above and below ground total biomass of the plants."*

Hypothesis 6 – *"The higher concentrations of the chosen chemical ranges will have an effect on the above and below ground total biomass of the plants, and restricting root competition between the different floral species will have an effect."*

Hypothesis 7 – *"The higher concentrations of the chosen chemical ranges will have an effect on the water consumption."*

Hypothesis 8 – *"The higher concentrations of the chosen chemical ranges will have an effect on the water consumption, and restricting root competition between the different floral species will also have an effect."*

Objective 4: From results of the microcosm study in Objective 3, implement a field study to investigate the survivability of the floral species when planted within a newly refurbished/created constructed wetland treatment system and also when retrofitting the floral species into an established constructed wetland treatment system.

To assess the suitability of the floral species within an operational setting, the results from the field study will be used to test the following hypothesis (9). This hypothesis was chosen to determine the survivability of the different species and therefore their suitability for use when either retrofitting existing mature reedbeds or planting new/restored reedbeds within a constructed wetland treatment system.

Hypothesis 9 – *"Where the chosen floral species survive, there will be no difference between retro-planting these species within a mature reedbed, compared to planting these species within a newly created/restored reedbed and no single floral species will take over and oust other floral species."*

Objective 5: Use the findings of both the microcosm and the field studies to develop design principles to ensure the chosen floral species will be sustainable within a constructed wetland treatment system.

1.3 Thesis Structure

Section Two provides a review of the current literature. It sets down an overview of phytoremediation and constructed wetland treatments, and the biodiversity potential available. It explores at the types of effluent, from general domestic municipal to industrial wastewater, that constructed wetlands could potentially contend with. The flora utilised in generic constructed wetlands is also discussed.

Section Three presents a design overview of the microcosm study site; it sets down the methodology used and reasoning behind both the methodology employed, and the rational for the selection of growing media, pollutant concentrations and why the four species of flora used were chosen. It explains the duration of the field experiment starting with the acclimatisation period all the way through to the final measurements (and their methodology) during the harvesting phase.

The results of the microcosm study are presented in Section Four along with a discussion of the findings in relation to the hypothesis along with general recommendations identified from the microcosm study

Section Five presents a design methodology of the field study with Section Six field study results and discussion.

Section Seven puts forward design recommendations for potential biodiversity enhancements based on conclusions drawn from this study. Section Eight provides an evaluation of the study and details further research requirements, and Section Nine contains the conclusions to this study.

2. INTRODUCTION TO PHYTOREMEDIATION OF WASTEWATER

2.1 Overview of Phytoremediation and Constructed Wetland Treatment Systems.

It is not the purpose of this thesis to demonstrate the design and effectiveness of the different types of constructed wetlands or their vegetation and as such only a brief overview is provided. For detailed information about the design of and processes within constructed wetlands there is a plethora of information which the reader can refer to, including Austin & Yu (2016), Cooper *et al*., (1996), Ellis *et al*., (2003), Grant *et al*., (2000), Grant & Griggs (2001), Kadlec & Knight (1996), Kadlec & Wallace (2009), Nuttall *et al*., (1997), Scholz (2011), Stefanakis *et al*., (2014), Wallace & Knight (2006) and Vymazal & Kröpfelová (2008).

There are various types of constructed wetland treatment systems throughout the world that employ phytoremediation, and these can be broadly split into two groups: surface flow systems and subsurface flow systems. The types of systems available are constantly being updated and modified as new information and hybrid designs comes to light. The broad system types can be found in Table 2.1, with a brief description provided below.

Surface Flow	Free Water Surface Flow Systems	Floating Macrophyte Systems
		Submerged Macrophyte Systems
		Emergent Macrophyte Systems
		Waste Stabilisation Ponds
		Vegetated Ponds / Marshes
		Rafted Lagoon / Hydroponic Systems
Subsurface Flow	Horizontal Subsurface Flow	Emergent Macrophytes
	Vertical Subsurface Flow	Emergent Macrophytes

Table 2.1: Prime Types of Constructed Wetland Treatment Systems

For the waste treatment to fall into the category of phytoremediation, the system must contain vegetation that participate in/contribute to the treatment process. The vegetation predominantly consists of macrophytes, which are the non-microscopic vegetation that include most of the kingdom of Plantae. The majority of species utilised within constructed wetland treatment systems are Monocots (i.e. grasses, palms and lilies), with Dicots (i.e. broad-leaved plants such as willows and roses) used less frequently.

One of the main considerations when determining the feasibility of employing a constructed wetland treatment system is whether or not the effluent to be treated is harmful to the species of vegetation to be used (Vymazal, 2011). If it is the designer must consider whether an alternative species can be utilised, or whether mechanical pre treatment of the effluent is required. Pre-treatment can also be required when other contaminants are present in the effluent which could interfere with the operation of the constructed wetland, such as gross solids and high levels of suspended solids (Tchobanoglous, 2003). Furthermore, where there is insufficient space for the size of wetland required to treat the higher concentration effluents (Kelman Wieder *et al*., 1998) or a chemical present which cannot be ameliorated, then pre-treatment may resolve the problem.

The presence of vegetation in wetlands benefits the treatment process in a multitude of ways. Brix (1994; 1997; 2003), Nuttall *et al*., (1997) and Stottmeister *et al*., (2003), all list the role vegetation plays (depending upon the species), and these include the following;

- they can stabilise the bed surface and reduce scouring;
- they can reduce turbulence and facilitate the settlement and separation of solids;
- certain species release antimicrobial chemicals from the roots;
- certain species release oxygen from the roots resulting in localised areas of aerobic conditions within an anaerobic bed;
- they can take up nutrients and certain metals;
- the detritus they produce can provide insulation during cold spells and can provide a source of carbon to facilitate further plant growth and microbial processes;
- the roots can provide hydraulic pathways through the growing media by breaking up the media and also through their decomposition;
- the surfaces of the vegetation provide additional surfaces for microbial films to attach to, which enhances the treatment process; and,
- they provide habitat for a range of species and can be aesthetically pleasing.

Again it is not the purpose of this thesis to go into detail about the different treatment benefits which vegetation has within a treatment wetland, as this can be found detailed within the generic texts detailed above and within numerous research papers. However, the following synopsis of the various wetland treatment systems (see Table 2.1), provide a brief summary of the key role played by the vegetation in each.

Floating Macrophyte Systems

Floating macrophyte systems consist of a pond with a shallow depth, containing floating macrophytes. Species usually include *Lemna* sp., duckweeds, *Eichhornia crassipes*, water hyacinth and *Pistia stratiotes,* water lettuce. The main treatment processes are through microbial action (present either as films on the root surfaces or as free floating organisms) or by uptake by the macrophytes and their subsequent harvesting. Due to the rapid growth rates required, these systems are generally utilised more within countries with hotter climates (Bonomo *et al*., 1997; Brix, 2003; Vymazal, 2003 and Vymazal, 2008).

Submerged Macrophyte Systems

Submerged macrophyte systems are similar to floating macrophyte systems in that they are usually in a shallow pond. The vegetation within these ponds is submerged and consists of species such as *Ceratophyllum demersum* Rigid Hornwort, *Elodea sp*. waterweeds and *Myriophyllum* sp. water milfoil. Due to the physiological requirements of these species for photosynthesis, they generally require oxygenated water with low turbidity. As with floating macrophyte systems, the main treatment processes are through microbial action (present either as films on the root surfaces or as free floating organisms) or by uptake of the macrophytes and subsequent harvesting (Kadlec & Wallace, 2009 and Vymazal, 2003).

Emergent Macrophyte Systems

Emergent macrophyte systems consist of a wetland planted with emergent vegetation where the effluent being treated flows at a shallow depth over the surface of the growing media. Species commonly utilised as emergent vegetation are those considered to be hardy species and rapid colonisers, such as *Phragmites australis*, *Typha* sp., *Scirpus* sp. and *Phalaris arundinacea*. The main treatment process is from contact with the microbial films on the surface of the vegetation (Brix, 2003; Kadlec & Wallace, 2009 and Vymazal, 2003).

Waste Stabilisation Ponds

Waste stabilisation ponds are not considered to be true constructed wetland treatment systems, as they are not typically planted with aquatic macrophytes. They can be beneficial in enhancing the biodiversity of a site and they can also be used within hybrid wetland treatment systems (Kadlec, 2003a). They comprise three types of ponds linked together. The first pond is a deep anaerobic pond where the main treatment is through the sedimentation of materials and the anaerobic digestion of the sludge. Once the sediments have been removed, the effluent enters a shallow facultative pond, which is used to further reduce the BOD through bacteria and free floating algae. The outflow from this then flows into the third pond, which is a shallower maturation pond where any remaining pathogens are removed through bacterial action, free floating algae and the sun's natural UV radiation (Mara *et al*., 1992; Mara & Pearson, 1998; Johnson *et al*., 2007 and Shilton & Harrison, 2003).

Vegetated Ponds / Marshes

Vegetated ponds and marshes are usually in the form of large-scale wetlands over 4000 ha and are both constructed and naturally occurring, which receive and treat waste effluent. They usually consist of a hybrid of treatment types, including areas of open water, with a mix of submerged, floating and emergent vegetation occupying the different niches available (Kadlec & Wallace, 2009 and Knight 1997).

Rafted Lagoon / Hydroponic Systems

These are surface flow wetlands where the vegetation is grown on a floating mat on the surface of the water. The mat can either be artificially created or can develop naturally on decaying leaf litter. The main species utilised in these systems are *Glyceria maxima*, *Typha* sp. and *Phragmites australis*. The main treatment process is the removal of nitrogen through the anaerobic conditions found in the sediment and the floating mats facilitating the denitrification process (Vymazal, 2003).

Horizontal Sub-Surface Flow

Horizontal sub-surface flow treatment wetlands are one of the main treatment wetlands utilised within the U.K and as such, enhancing the biodiversity within this type of system is the main focus of this research. These are sub-surface flow wetlands where the effluent is fed in at the inlet and flows horizontally through a porous media to the outflow (Figure 2.1). The system is usually planted with emergent species capable of developing an extensive root system to facilitate the treatment process. The main species used within these systems are *Phragmites australis*, *Typha* sp., *Scirpus* sp. and *Phalaris arundinacea.* A multitude of treatment processes are evident within a sub-surface flow system, including filtration, nitrification and denitrification due to the anaerobic areas and the aerobic films around the plant roots (i.e. *Phragmites australis*) (Brix, 2003; Kadlec & Wallace, 2009; Vymazal, 2003 and Vymazal, 2011).

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Figure 2.1: Horizontal Subsurface Flow Wetland General Layout
(From Wallace and Knight, 2006)

Vertical Sub-Surface Flow

Vertical sub-surface systems are similar to horizontal subsurface flow systems. However, rather than the effluent being fed from one end and collected at the other, the effluent is fed across the surface of the wetland to create a flooded environment. The effluent then seeps through the media to the base of the wetland where the outflow is situated. This process pulls oxygen down behind the effluent into the media, which enhances the nitrification and BOD removal rates. The main species used within these systems are *Phragmites australis*, *Typha* sp., *Scirpus* sp. and *Phalaris arundinacea* (Brix, 2003; Cooper *et al*., 1996; Cooper *et al*., 1997; Kadlec & Wallace, 2009 Stefanakis *et al*., 2014 and Vymazal, 2003).

For both vertical and horizontal subsurface flow treatment wetlands, different media can be used to aid the treatment processes for different chemicals. These can include calcite, light weight aggregates, shale and pumice for enhanced phosphorous and metal removal (Arias *et al*., 2003; Brix *et al*., 2001; Drizo *et al*., 1997; Jenson & Krogstad, 2003; Molle *et al*., 2003; Njau *et al*., 2003; Paris & Maehlum, 2003; Scholz & Xu, 2002; Stefanakis *et al*., 2014; Zhu *et al*., 1997 and Zhu *et al*., 2003),

Hybrid Systems

The different types of constructed wetlands are often combined to produce hybrid systems. This is undertaken as the different types allow for different treatment processes and thus when combined in a hybrid system result in better removal efficiencies of different pollutants (Cooper, 2003a; Hogain, 2003; Kadlec & Wallace, 2009 and Nuttall *et al*., 1997).

2.2 Types of Effluent and Pollutants Treated by Wetland Systems.

Constructed wetlands have been used to treat a variety of effluents ranging from general domestic municipal wastewater to industrial effluents (Cooper *et al*., 1996; Kadlec & Wallace 2009; & Nuttall *et al*., 1997). Types of effluent which have been studied by researchers include:

- single household wastewater (Cooper *et al*., 1996; Cooper 2003b; Grant *et al*., 2000; Grant & Griggs 2001);
- municipal waste water and combined sewerage systems (Cooper *et al*., 1996; Kadlec & Wallace 2009; Nuttall *et al*., 1997);
- road and urban storm water run-off (Davies *et al*., 2001; Kadlec & Wallace 2009; Lee & Scholz, 2007; Scholz, 2011; Lund *et al*., 2001; Nuttall *et al*., 1997; Pontier *et al*., 2001; Pontier *et al*., 2003; Scholes *et al*., 1999; Shutes *et al*., 2001; Shutes *et al*., 2003);
- landfill leachate (Bernard 1999; Bulc *et al*., 1997; Connolly *et al*., 2004; DeBusk, 1999; Eckhardt *et al*., 1999; Kadlec, 1999; Kozub & Liehr 1999; Mæhlum, T. 1995; Mulamoottil *et al*., 1999; Nuttall *et al*., 1997);
- fish farm effluent (Naylor *et al*., 2003);
- oil refinery waste effluent (Simi & Mitchell 1999; Wallace 2002a);
- cheese processing waste (Wallace 2002b);
- dairy farm/swine waste effluent, farm run-off and slurry dewatering (Cordero *et al*., 2003; Edwards *et al*., 2001; Hill *et al*., 2001; Kern 2003; Mantovi *et al*., 2002; Sooknah & Wilkie, 2004);
- potato processing waste water (Kadlec *et al*., 1997);
- explosive removal (Best *et al*., 2001);
- airport de-icing treatment effluent (Thoren *et al*., 2003; Karrh *et al*., 2002; Worrall *et al*., 2002);
- pulp and paper mill (Abira *et al*., 2003);
- slaughter house (Pogy-varaldo *et al*., 2002; Revira *et al*., 1997);
- army vehicle test course run-off (Cavallaro 2002); and,
- mine drainage (Groudev *et al*., 2002; Mays & Edwards 2001; Mitsch & Wise 1998).

This wide range of effluents can contain a multitude of polluting chemicals at different concentrations. Again, it is not the purpose of this thesis to discuss the different pollutants found within each effluent and their different concentrations levels, and as such only a brief overview is provided. For detailed information about the pollutants there is a plethora of information which the reader can refer to, including the key texts of Cooper *et al*., (1996), Ellis *et al*., (2003), Grant *et al*., (2000), Grant & Griggs (2001), Kadlec & Knight (1996), Kadlec & Wallace (2009), Nuttall *et al*., (1997) and Wallace & Knight (2006) and also the specific case study papers detailed under the effluent list above.

Generically the pollutants can be placed into the following basic groups (Kadlec 2009):

- suspended solids;
- biochemical oxygen demand;
- nutrients, nitrogen & phosphorus;
- halogens, sulphur, metals and metalloids;
- pathogens; and,
- organic chemicals

Suspended Solids

Suspended solids are one of the main causes of turbidity and anaerobic conditions in a waste effluent and generally carry pollutants such as metals and organic chemicals into the environment (Kadlec & Wallace 2009; Tchobanoglous & Burton 1991). They can reduce and even stop light penetration through the water column, which within a wetland can have a detrimental effect on the ability of submerged aquatic plants to photosynthesis. The low light and anaerobic conditions can also be detrimental to the ability of aquatic fauna and fishes to survive (Grant *et al*., 2000).

Suspended solids are present in most waste effluents at a variety of concentrations and compositions. The majority are removed through any pre-treatment phase although constructed wetlands can remove the remaining suspended solids by filtration and settlement on passing through the bed media, and the high levels of vegetation creating a filter and slowing the flow rate (Cooper *et al*., 1996; Kadlec & Wallace, 2009). High levels of suspended solids can kill plants within submerged macrophyte treatment systems and can cause hydraulic blockages / degradation within subsurface flow constructed wetlands (Blazejewski & Murat-Blazejewska 1997; Cooper *et al*., 1996; Kadlec, 2003b; Kadlec & Wallace, 2009; Knowles *et al*., 2010; Langergraber *et al.,* 2003; Platzer & Mauch 1997; Sanford *et al*., 1995; Winter, K.J. and Goetz, D. 2003).

Biochemical Oxygen Demand

The Biochemical Oxygen Demand (BOD) is a way of monitoring the organic pollution in water. It involves the measurement of the amount of dissolved oxygen used by microbial organisms to oxidise the organic matter in a sample of water (Kadlec & Wallace 2009; Tchobanoglous & Burton 1991). The test is usually carried out over 5 days under controlled temperature conditions. The results are displayed as BOD_5 and usually expressed in mg/l. Problems arise when effluent with a high BOD is disposed of into watercourses, as the high oxygen demand of the effluent reduces the available oxygen in the watercourse. This in turn can have a detrimental impact on the biota that naturally inhabits the water body receiving the discharged effluent (Kadlec & Wallace 2009; Tchobanoglous & Burton 1991).

The Biochemical Oxygen Demand is reduced within a wetland system by four main processes; removal of solids, ingestion, microbial decomposition, and adsorption and absorption (Nuttall *et al*., 1997).

<u>Nutrients, Nitrogen & Phosphorus</u>

Nutrients are one of the key variables found within waste effluent, the concentrations and form in which the nutrients are found varies considerably between the effluent types (Kadlec & Wallace 2009; Tchobanoglous & Burton 1991). Although essential to maintain plant growth within the constructed wetlands, high levels can become phytotoxic (Kadlec & Wallace 2009). Furthermore, if left untreated, the high levels of nutrients can cause undesirable effects, such as algal blooms, to grow within the receiving water body, which subsequently can have an adverse effect due to reduction in available oxygen and light levels (Tchobanoglous & Burton 1991).

The key removal processes within constructed wetlands for the main nutrients (nitrogen and phosphorus) are, nitrification and denitrification, volatilisation, nutrient uptake by vegetation (when combined with harvesting), precipitation, storage in leaf litter, microbial decomposition, adsorption and absorption (Kadlec & Wallace 2009; Nuttall *et al*., 1997).

<u>Salinity, Halogens, Sulphur, Metals and Metalloids</u>

Additional chemicals can also be required by constructed wetland flora for healthy growth as macro or micro nutrients. However, when the levels of these chemicals are elevated they can become phytotoxic to the treatment plants and also to the biota of the receiving water body (Kadlec & Wallace 2009; Tchobanoglous & Burton 1991). These chemicals include salinity, sodium, potassium and chlorides, the key removal processes for which are adsorption and absorption, uptake by vegetation (when combined with harvesting), oxidation and precipitation, storage in leaf litter, microbial decomposition and settling (Drizo *et al*., 1997; Kadlec & Wallace 2009; Nuttall *et al*., 1997).

Pathogens

Pathogens in waste effluent (including human and animal waste) can have an adverse effect if untreated, when a suitable host comes into contact with the effluent after it has been released back into the environment (Tchobanoglous & Burton 1991). Natural wetlands will remove the majority of harmful pathogens through the mechanism of exposure to UV radiation, predation, natural die off, settling and filtration (Kadlec & Wallace 2009; Tchobanoglous & Burton 1991).

Organic Chemicals

Organic chemicals in effluents vary in type and concentration. They can have a variety of adverse effects on the environment and may be toxic to flora and fauna, such as the run-off of pesticides (Tchobanoglous & Burton 1991). Whether or not wetlands can successfully be used to treat organic chemicals depends upon the toxicity of the chemical in question, not only to the flora of the treatment wetland, but also to the microbiology. Where organic chemicals are inactive, they will not be treated by constructed wetlands and as such pre-treatment would be required for their removal (Kadlec & Wallace 2009; Nuttall *et al*., 1997; Tchobanoglous & Burton 1991).

2.3 Treatment Vegetation

Constructed wetlands vary in size and in the North America can reach over 100 ha (Kadlec & Knight, 1996; Vymazal, 2003), with natural treatment wetlands reaching over 4000 ha (Knight, 1997). However, these function more as a natural wetland (Vymazal, 2003) with different conditions for a variety of species to exploit. Within North America, Knight *et al*., (2001) report that over 1400 species have been recorded within constructed and natural treatment systems. This includes 824 species of aquatic invertebrate, 78 species of fish, 21 species of amphibian, 31 species of reptile, 412 species of birds and 40 species of mammals.

The purpose of this research is to investigate how different species of vegetation may be utilised to enhance biodiversity in conjunction with the main treatment species within small constructed wetlands, such as those typically found in Europe. In the U.K. the treatment species is usually *Phragmites australis* (Cooper *et al*., 1996), and the design conditions are usually homogeneous within each cell (Cooper *et al*., 1996; Kadlec & Wallace, 2009). As a consequence, there are very few areas and niches for other floral species to colonise and thereby avoid competing with the dominant treatment species. Furthermore, the small scale of constructed wetlands in the U.K. limits their usage by many species, for example by large mammals and the larger birds, such as geese and ducks. As these treatment systems are usually segregated from similar habitats this reduces their potential for attracting specialist wetland species such as bitterns and bearded tits.

The biodiversity within a constructed wetland treatment system can be enhanced where different species are planted in different cells and treatment process (Nuttall *et al*., 1997). However, the species utilised are generally the more robust treatment ones such as *Glyceria maxima, Phalaris arundinacea, Phragmites australis* and *Schoenoplectus lacustris,* rather than the more delicate floral species usually associated with attracting a range of invertebrates, such as *Filipendula ulmaria* and *Mentha aquatica*. The addition of extra floral species not only enhances the biodiversity of the reedbed but it also enhances its aesthetics too.

The main flora species utilised within small scale constructed wetlands are those which have been proven to be robust against high nutrient concentrations, or those which have specific tolerance of the pollutant which they are treating. It is not the purpose of this thesis to detail the benefits and tolerances of the species employed as this can be found in the generic texts listed in Section 2.1 and numerous research papers. However, a brief overview of a selection of commoner species utilised in constructed wetlands (Table 2.2) and their water level requirements is provided below.

Acorus calamus	Sweet-flag	I.P
Carex sp.	Sedges	N.P
Ceratophyllum sp.	Hornworts	N.P
Elodea sp.	Waterweed	I.P
Glyceria maxima	Reed Sweet-grass	N.P
Iris pseudacorus	Yellow Flag	N.P
Juncus sp.	Rushes	N.P
Lemna sp.	Duck Weed	N.P
Phalaris arundinacea	Reed Canary Grass	N.P
Phragmites australis	Common Reed	N.P
Schoenoplectus lacustris (aka *Scirpus lacustris*)	Common Club-rush	N.P
Typha latifolia	Common Reedmace	N.P

Note: N = Native, I = Introduced, P = Perennial.
Where the text refers to a species group, several species can be utilised

Table 2.2: General Flora used in Constructed Wetland Treatment Systems

Sweet-flag *Acorus calamus* is an emergent rhizomatous introduced perennial, iris-like plant of 50 cm - 1.25 m height. It can be found in shallow still or flowing water, and fresh to brackish marshes with a salinity tolerance of <10 ppt (Knight, 1997). It would thus be beneficial in treatment systems which treat road runoff, where de-icing salt can be present within the effluent. The preferred water levels for this plant are - 10 cm to + 30 cm (English Nature, 1997) with a regular to permanent inundation of water and it can tolerate partial shade. It has a scattered distribution across the British Isles.

Several species of sedge can be utilised. Two species native to the U.K. are Lesser Pond Sedge *Carex acutiformis* and Bottle Sedge C*arex rostrata. Carex acutiformis* is a rhizomatous native perennial of wet meadows, marshes and near open water. It grows to 1.5 m height and is common throughout the British Isles, though rare in the north. The water levels for this plant are - 40 cm to + 50 cm with a preferred depth of 0 cm (English Nature, 1997). C*arex rostrata* is a native perennial of acid swamps, lake fringes and reedbeds. Common in the north and west of Britain and Ireland but rare or absent elsewhere. Bernard (1999) has found this species to have nearly a double life-span in Sweden, not due to the cold weather but due to the low nutrients found in the oligotrophic lakes. The water levels for this plant are - 15 cm to + 60 cm with a preferred depth of 0 cm to + 30 cm (English Nature, 1997). *Carex* species are generally a hardy plant within treatment wetlands.

Hornworts are submerged aquatic species and can be used to filter effluents and utilise different nutrients from the effluent. One of the native species to the U.K. is Rigid Hornwort *Ceratophyllum demersum* which is a perennial of still or slow flowing water growing up to 1.0 m. It has a salinity tolerance of 0.05 ppt (Knight, 1997) and has been shown to remove both macronutrients and micronutrients from effluent, including increasing the levels of sodium and potassium within its tissues when these constituents are present (Foroughi 2011). Its distribution is scattered over England and Wales being rare in the rest of the British Isles.

Another submerged group of plants used in constructed wetlands are the waterweeds *Elodea* species. Three species plus their hybrids are found in the U.K. all of which have been introduced. The three species are Canadian Waterweed *Elodea canadensis,* Nuttall's Waterweed E*lodea nuttallii* and South American Waterweed *Elodea callitrichoides.* All species of *Elodea* are listed on Schedule 9 of the Wildlife and Countryside Act 1981 (as amended), it is now illegal in England and Wales to encourage the spread of this species, and as such this group is not considered further.

Reed Sweet-grass *Glyceria maxima* is an emergent native perennial some 2.5 m in height. Distribution is common throughout England though scattered in Wales, Scotland and Ireland. Found in and by water, and can be found in deeper water than other species. The water levels for this plant are - 40 cm to + 1.0 m with a preferred depth of + 40 cm (English Nature, 1997). Within a constructed wetland this species has a high biomass and the aerenchymatous nature of its roots allows oxygen to penetrate into the rhizosphere (Vymazal & Kröpfelová, 2008).

Yellow Flag *Iris pseudacorus* is a rhizomatous native perennial of wet places to 1.5 m in height, and is common throughout the British Isles. The water levels for this plant are - 60 cm to + 60 cm with a preferred depth of – 10 cm to + 10 cm (English Nature, 1997).

Several species of rush can be utilised. One species native to the U.K. is Soft Rush *Juncus effusus.* This species is a native tufted perennial to 1.5 m in height. Distribution is very common throughout the British Isles. It has a salinity tolerance of 0.5 ppt (Knight, 1997) in all types of wet or damp soils tolerating partial shade. The preferred water levels for this plant are – 55 cm to + 30 cm (English Nature, 1997).

Duckweed's *Lemna* spp. are small floating macrophytes which grow between 1-3 mm in length. They can form dense mats on the surface of water bodies, their numbers doubling every four days under optimal conditions. They are considered to be one of the most vigorously growing plants in the U.K., which is partly due to their ability to absorb nutrients through all of their body. In other plants, nutrients are mainly absorbed through the root system (Bonomo *et al*., 1997). Five species can be found in the U.K. of which four are native. The duckweeds native in the U.K. are Fat Duckweed *Lemna gibba,* Common Duckweed *Lemna minor,* Ivy-leaved Duckweed *Lemna trisulca* and Rootless Duckweed *Wolffia arrhiza*. Common duckweed has a salinity tolerance of 0.05 ppt (Knight, 1997), and can tolerate partial shade. Duckweed grows in still water or slow flowing water. They can survive in a variety of waters including moderately polluted, eutrophic and saline. The pH range for optimal growth is between 4.5-7.5, but they can survive at levels just outside this range. In the U.K they tend to be most frequently found in the south, being rarer in the north of Scotland and Ireland depending on the species involved. They require water temperatures above 5^{o}C and air temperatures above 2^{o}C. When temperatures drop below the optimal ranges for the plants, they go to the bottom of the waterbody and lay dormant until suitable conditions return, which makes them a poor candidate to be used for treatment purposes in areas with cold climates. The plants consist of approximately 95% water, nutritionally they are mainly comprised of protein, being very low in fibre (Bonomo *et al*., 1997).

Reed Canary Grass *Phalaris arundinacea* is a *n*ative rhizomatous perennial of wet or damp places to 2 m in height forming dense stands. Common throughout the British Isles. Phalaris has been shown (in Bernard, 1999) to grow for two weeks longer in the autumn and start growing two weeks earlier in the spring within wetland systems receiving effluent from landfill sites due to the warm leachate temperatures entering the reedbed of 5-8^{o}C. The water levels for this plant are - 60 cm to + 30 cm with a preferred depth of – 40 cm to 0 cm (English Nature, 1997).

Common Reed *Phragmites australis* (aka *communis*) is a native rhizomatous perennial of wet ground or shallow water, including the edges of salt marshes and estuaries. It grows to 3.5 m in height, forming dense stands and is common throughout the British Isles. *Phragmites* has a salinity tolerance of up to 20 ppt (Knight, 1997). The water levels for this plant are - 1.0 m to + 50 cm with a preferred depth of – 20 cm to 0 cm (English Nature, 1997). This is the most utilised species for constructed wetlands within the U.K. and will be the main treatment species utilised in this study, and is discussed in more detail in Section 3.

Common Club-rush *Schoenoplectus lacustris* (aka *Scirpus lacustris*) is an extremely rhizomatous native perennial growing erect to 3 m in height. Found in shallow, still or slow flowing water it is frequent throughout Britain. The preferred water levels for this plant are – 10 cm to + 1.5 m (English Nature, 1997), it has been shown to release antibiotics from its roots (Brix, 1997) and is good for nutrient and pathogen removal (Soto, 1999).

Reedmace (aka Bulrush & Cattail) *Typha* spp. are frequently used in treatment wetlands as they become established quickly. The most common *Typha* species in the U.K. is Common Reedmace *Typha latifolia,* which is a rhizomatous perennial of mud or still/slow flowing fresh water. It forms dense stands growing up to 2.5 m and is frequent throughout most of the British Isles except for north and west Scotland. *Typha latifolia* has a salinity tolerance of < 0.05 ppt (Knight, 1997). The water levels for this plant are - 20 cm to + 1.0 m with a preferred depth of + 10 cm to + 75 cm (English Nature, 1997).

2.4 Enhancement of Floral Biodiversity in Constructed Wetland Treatment Systems

With regards to the biodiversity of the large-scale American wetlands which act predominantly as natural wetlands Kadlec & Wallace (2009) state;

> *"The wetland treatment system designer should not expect to maintain a system with just a few species. Such attempts frequently fail because of the natural diversity of competitive species and the resulting high management costs associated with eliminating competition, or because of imprecise knowledge of all the physical and chemical requirements of even a few species. Rather, the successful wetland designer creates the gross environmental conditions suitable for group or guilds of species; seeds the wetland with diversity by planting multiple species, using soil seed banks and inoculating from other similar wetlands; and then uses a minimum of external control to guide wetland development. This form of ecological engineering results in lower initial cost, lower operation and maintenance costs, and most consistent system performance."*

A variety of ecological niches can be created within the same large-scale wetland, as opposed to the opportunities for enhancement of biodiversity in small scale constructed wetlands, which this research is focused towards. Kadlec & Wallace (2009) do however acknowledge the difficulties in maintaining a few known species, with one of the reasons being the imprecise knowledge of the physical and chemical requirements. This research aims to contribute to reducing this lack of knowledge, and identifying the parameters which will enable a few biodiversity enhancing species to co-exist together with the main treatment species within a confined small scale constructed wetland.

The general physiological types of flora found within a natural wetland are:

- submerged aquatic species;
- floating aquatic species;
- emergent and marsh species including:
    - grasses, sedges and rushes;
    - upright herbaceous perennials;
    - creeping herbaceous perennials; and,
    - woody perennials.

As this study is restricted to small scale constructed wetlands, and in particular constructed reedbeds, it will focus on the potential of emergent and marsh vegetation to enhance biodiversity. The interaction between species from each of the four groups found within this broad physiological category will be studied to investigate how they interact when planted within the same small-scale wetland.

The growth characteristics of the four groups comprising emergent and marsh species are:

- grasses, sedges and rushes, include species such as *Carex* sp., *Phalaris arundinacea, Phragmites australis*, *Scirpus lacustris* and *Typha latifolia*. Within a wetland these species are usually perennial, being tolerant of high nutrient loadings and will rapidly colonise new areas. Due to their robustness, they are usually the main treatment species group utilised in constructed wetlands with emergent species (Cooper *et al*., 1996; Kadlec & Wallace, 2009), and as such any non-treatment species utilised to enhance the biodiversity will have to be able to survive alongside this group;
- woody species includes the broad group of trees such as *Alnus* sp. and *Salix* sp. and also shrubs and woody perennials such as *Lythrum salicaria*. Woody species once established should be able to hold ground more robustly when other species (such as the prime treatment species) are competing for space. However, to avoid adverse effects upon the treatment of the effluent, they must not adversely affect the main treatment species utilised within the wetland. One example of this is willow species *Salix* sp., which can adversely

affect *Phragmites australis* by producing large amounts of shade (Copper *et al*., 1996) and whose roots can also damage liners (Copper *et al*., 1996; Ellis *et al*., 2003);

- upright perennial herbs include *Alisima plantago-aquatica*, *Caltha palustris*, *Filipendula ulmaria, Myosotis scorpioides* and *Ranunculus flammula*. These species do not generally spread quickly and might be disadvantaged when competing against more vigorous plants such as *Phragmites australis*; and,
- creeping species (rhizomatous/stoloniferous) include *Mentha aquatica,* and are generally quick at growing and colonising. Their rhizomatous/stoloniferous nature allows them to intertwine between the stems of different species, quickly colonising new openings (i.e. in the growing media and where light is present) as they become available.

To aid in the selection of biodiversity enhancing flora for incorporation in constructed wetlands, the community structures of natural reedbeds containing *Phragmites australis* within the U.K was looked at. The main reedbed communities within the U.K. described by Rodwell (2000) in the National Vegetation Classification are:

- S4: *Phragmitetum australis* swamp;
- S24: *Peucedano-Phragmitetum* tall-herb fen;
- S25: *Phragmites-Eupatorium* tall-herb fen; and
- S26: *Phragmites-Urtica* fen.

Due to the large number of species present within these floral communities it was not feasible within this study to investigate each species, and consequently the author used his long experience as a practicing ecologist to choose species which are native to the U.K., hardy, have a wide distribution and which have a beneficial effect on biodiversity. In order that the final design principles could be applied across a large geographic gradient, all of the species chosen were both common (to avoid introducing new species into a specific geographic area) and readily available.

To investigate the floral interaction within a *Phragmites australis* reedbed treatment system, the four species chosen from each of the four groups were:

- *Phragmites australis* - grasses, sedges and rushes;
- *Lythrum salicaria* - woody perennial;
- *Filipendula ulmaria* - upright herbaceous perennial; and,
- *Mentha aquatica* - creeping herbaceous perennial.

All of these are present within the S24, S25 & S26 communities and as such are known to co-exist with *Phragmites australis* in larger natural wetlands. Although Kadlec & Wallace (2009) and Wallace & Knight (2006) detail *Lythrum salicaria* as an invasive weed within Northern America and recommend that it is not planted, within the UK it does not exhibit this characteristic and as such will be studied within the community mix.

The four selected species listed above are discussed in more detail in Section 3.3, in connection with the design of the microcosm systems described in Section 3.

3. MICROCOSM STUDY METHODOLOGY AND EXPERIMENTAL DESIGN

3.1 Design Overview

3.1.1 Introduction

To determine if constructed wetland treatment systems can have their biodiversity increased by incorporating some common floral wetland species (which are not generally associated with the treatment process), a three-year microcosm study was devised. It is recognised that the static flow in a microcosm study does not truly simulate the dynamic flow regime of a full scale reedbed treatment system, and that the methodology detailed within Section 3 is pseudo-replication. However, it provides a relatively controlled environment for the study of the viability of introducing a range of biodiversity enhancing species, and the results were to be utilised in the design of full scale studies in operating reedbed treatment systems (see Section 5).

The study involved the addition to the water of two different chemical parameters in different strengths, to simulate a wastewater liquid effluent, and to determine both the tolerance of the different species to these pollutants and the interactions between the plants. To allow competition between the plants to occur, the study was undertaken over the course of three full growing seasons.

A second parallel microcosm system was also set up to restrict the majority of root interaction. This was to determine if minimising root competition had any effect, since this could influence the design of future constructed wetland treatment systems, by allowing vulnerable biodiversity enhancing species to survive.

For convenience of access and to facilitate regular monitoring, the microcosm study site was located in the village of Marton, Warwickshire, England at National Grid Reference SP 407 687. Figure 3.1 details the location of the site within the UK and Figure 3.2 details the location of the site within Marton.

Aston University

Illustration removed for copyright restrictions

Figure 3.1: Location of Marton within United Kingdom

Aston University

Illustration removed for copyright restrictions

Figure 3.2: Site Location within Marton (Ordnance Survey 2017a)

3.1.2 Containers

Each microcosm consisted of a plant pot style container constructed from high-density polyethylene (HDPE), which had a base diameter of 720 mm, a top diameter of 838 mm and a height of 610 mm (see Figure 3.3). HDPE was used as this material is generally stable, not reacting/breaking down when it comes into contact with the wide variety of chemicals found in high strength industrial effluents, such as landfill leachate. HDPE is used to line modern landfills to stop leachate from escaping and contaminating ground water. In addition, under normal circumstance this resilience to chemical attack/degradation stops the liner from degrading easily and releasing additional chemicals back into the environment.

3.1.3 Growing Medium Selection

The fill within the container was divided into three layers (see Figure 2.1), to simulate the design of a constructed wetland treatment system.

The bottom layer was 10 mm washed pea gravel, which was placed in the container to a depth of 480 mm. Pea gravel was used as this is the primary media employed in sub-surface flow reedbed treatment systems (Grant *et al*., 2001, Copper *et al*., 1996, Ellis *et al*., 2003), and Copper *et al*., (1996) reports three typical gravel sizes, 3 – 6 mm, 5 – 10 mm and 6 – 12 mm. The pea gravel should be washed as this minimises fine material within the treatment system and helps to reduce the speed at which the system becomes blocked (Grant *et al*., 2001, Copper *et al*., 1996). Grant *et al*., (2001) report the general depth of the gravel media for tertiary treatment to be 400 – 600 mm, with Copper *et al*., (1996), Kadlec *et al*., (1996, updated 2009) and Ellis *et al*., (2003) giving a standard depth of 600 mm, as this is generally the maximum depth which the rhizomes of *Phragmites australis* will penetrate to.

The next section situated on top of the gravel subsurface layer was an artificial humus layer 30 mm deep to give an overall planting depth of 510 mm, which is within the 400 mm and 600 mm range referred to above. This layer was incorporated to replicate a mature reedbed where old leaf litter has accumulated on the surface of the treatment system. The humus layer has benefits for reedbeds by providing an insulating layer for the substrate (Wallace & Knight 2006, Wittgren & Maehlum 1997**,** Hiley 2002, Ellis *et al*., 2003, Kadlec & Wallace 2009). General-purpose peat free compost (with no added nutrients) was used, which was high in fibre content as recommended in Wallace and Knight (2006).

The gravel and humus layer were subsequently saturated and the container filled with water to produce the final layer, 100 mm depth of surface water.

A perforated HDPE pipe was placed in the centre of the microcosm to facilitate water level and water usage monitoring.

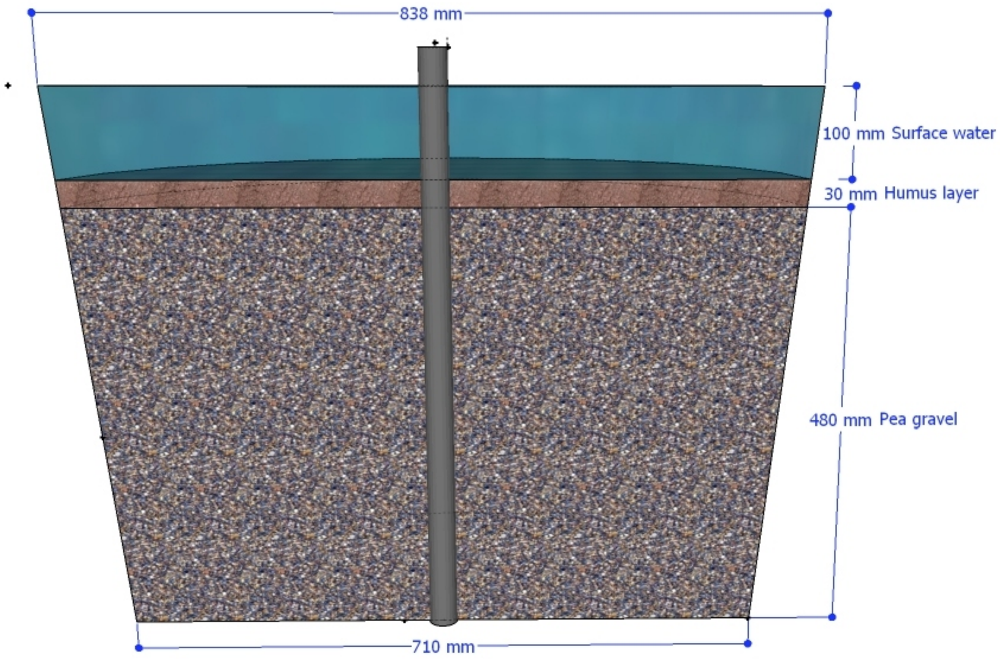


Figure 3.3: Cross Section of the Media Layers within the Microcosms with Full Competition

The green domed layer above the humus layer on Figure 3.3 is caused by the 3D nature of the figure, combined with the transparent nature of the surface water, which has resulted in a proportion of the humus layer bed being visible.

3.2 Concentration Selection

Two main potential pollutants were used to test the floral interactions under different concentrations. These were nitrogen and salinity.

Nitrogen can be found in a variety of domestic and industrial effluents in a multitude of forms and concentrations (Kadlec & Wallace 2009, Tchobanoglous & Burton 1991). Nitrogen is an essential element in the growth of plants, which utilise it in the form of nitrate and ammonia. Too much or too little can have adverse effects on vegetation and alter the plant community dynamics (Baldwin 2013; Dickson & Gross 2013; Silliman & Bertness 2004; Suding *et al*., 2005). A study undertaken on natural marsh (infrequently inundated) and swamp (frequently inundated) habitats identified that the addition of nitrogen caused the perennial species to increase their area coverage whilst the annual species decreased their coverage (Baldwin 2013).

Many industrial effluents contain salinity in a multitude of forms and concentrations (Kadlec & Wallace 2009, Tchobanoglous & Burton 1991). It is also becoming more present in domestic effluent due to the increased use of water softeners (Kadlec & Wallace 2009). Salinity causes stress to plants, can affect their ability to utilise water and can affect their growth (Howard 2010; Mauchamp & Mesleard 2001; Munns 2002; Pagter *et al*., 2005; Pagter *et al*., 2009; Tchobanoglous & Burton 1991). It can affect the species composition of plant communities depending upon the tolerance levels of the individual plant species present and the levels of concentration (Mauchamp & Mesleard 2001; Silliman & Bertness 2004).

The concentrations of these potential pollutants are discussed below.

3.2.1 Nitrogen

The levels of nitrogen within effluent vary between the different types (i.e. domestic and industrial) and also depends upon the processes which produce the effluent (i.e. whether there are water saving devices within the property, which can result in a more concentrated effluent). With regards to industrial effluent, nitrogen levels can vary considerably depending upon the industry involved and the processes which produced the effluent. Similarly, landfill leachate can vary considerably depending upon the waste deposited, the design and management of the landfill. Although in general less leachate is produced at newer landfills, this is usually at higher concentration, as the design allows for greater moisture control and leachate re-circulation (Sanford 1999).

The range of nitrogen concentrations found in waste effluents or being fed into constructed wetland treatment systems can be found within the plethora of papers reporting the treatment capabilities of different treatment systems. However, a selection of the ranges identified by various authors are provided in Table 3.1 for comparison.

Given the variability of nitrogen within different effluents as illustrated by Table 3.1, it was decided to choose values which covered general domestic wastewater and the lower strength industrial effluents, which generally range between 20 mg/l and 125 mg/l. This level would not have fatal consequences for *Phragmites australis*, the main species utilised within U.K. reedbed treatment systems.

Author	Sample	Ammonia NH_3-N (mg/l)	Ammonium NH_4-N (mg/l)	Total Nitrogen (mg/l)	Total Oxidised Nitrogen NO_3-N + NO_2-N (mg/l)
Sewage					
Tchobanoglous & Burton (1991)	Generic Untreated Domestic Wastewater	-	-	20 (weak) 40 (medium) 85 (strong)	-
Cooper (2003b)	Little Stretton Sewage Treatment Works Secondary Sewage Treatment Inlet	-	8.0 – 24.8	-	2.2 – 22.2
	Oaklands Park Secondary Sewage Treatment Inlet	-	50.5	-	1.7
	Dwelling built for 8 people equivalent Secondary Sewage Treatment Inlet. Low water usage and solid separator results in concentrated effluent.	-	93.9	124.5	-
Grant and Griggs (2001)	Wildfowl and Wetlands Trust Visitor Centre at Slimbridge Secondary Sewage Treatment Inlet	31.72	-	-	0.1
Kadlec & Wallace (2009)	Generic Raw Municipal Wastewater	-	12-50	20-85	-
	Residential Septic Tank Effluent	-	40-60	-	0-1
Industrial					
Kadlec & Wallace (2009)*	Generic Effluent for Landfill Leachate	-	0.01 – 1,000	70 – 1,900	-
	Generic Effluent for Petroleum Refinery	-	0.05 -300	-	-
	Generic Effluent for Electroplating	-	-	10-120	-
	Generic Effluent for Breweries	-	-	25-45	-
Croft & Campbell 1992	Review of Landfill Leachate from Various Sites	-	0 – 2582 (mean 421.8)	-	0 – 33.6 (mean 5.8)
Steggall *et al.*, 2005	Poolsfield Landfill. Old landfill Filled with Inert Waste	-	-	0.4 - 107 (mean 24.59)	-

* This is not an exhaustive list of industrial effluents and is only provided to illustrate a variety of industrial effluents.

Table 3.1:Selected Nitrogen Concentrations of Waste Effluents

The nitrogen solution concentrations employed in the experiments are shown in Table 3.2 below.

	Total N (mg/l)
Base Concentration	10
1/3 of Maximum Dose Level	50
2/3 of Maximum Dose Level	100
Maximum Dose Level	150

Table 3.2:Concentration of Nitrogen Solutions Used

Tchobanoglous & Burton (1991), indicate that a weak concentration of total nitrogen within domestic wastewater is 20mg/l. Whereas at the opposite end of the scale, Cooper (2003b) states that a strong concentration of total nitrogen within domestic wastewater is 124.5mg/l total.

Taking these two findings into consideration, it was therefore decided that the base concentration for this research would be set at 10mg/l, and the maximum dose level would be set at 150mg/l giving the two extreme concentrations to be tested. The reasoning's behind these choices were, a base level of 10mg/l would be half the value of Tchobanoglous & Burton’s (1991) findings, but still provide some nutrients for the vegetation to utilise, and a maximum dosage of 150mg/l would allow for 'future proofing' should domestic wastewater become more concentrated due to advancements in water saving and recycling technologies.

Tchobanoglous & Burton (1991), also state that 40mg/l is the medium concentration of nitrogen within domestic wastewater effluent, and therefore 50mg/l total nitrogen was chosen as the medium level since it is exactly a third of the maximum dosage, but is slightly higher than the medium concentration of domestic wastewater effluent described within Tchobanoglous & Burton (1991) although within the ranges of the total combined nitrogen described within Kadlec & Wallace (2009) and Cooper (2003b).

The 100 mg/l total nitrogen was used as this is slightly higher than the strong concentration of domestic wastewater effluent described within Tchobanoglous & Burton (1991) and is also slightly higher than the range identified by Kadlec & Wallace (2009). This concentration is lower than the concentrated domestic wastewater effluent described in Cooper (2003b) created by water saving and recycling mechanisms, and is also at the upper end of the total nitrogen range identified for Poolsfield Landfill which was the landfill site at the focus of the original study (Steggall *et al*., 2005).

3.2.2 Salinity

Within this thesis the salinity is reported as the per mille (‰, ppt) which is approximately related to the Practical Salinity Scale (UNESCO1981 and 1985). The reporting of the salinity as per mille is due to the measured salinity within the microcosms being composed of different salts and not just a single salt such as Chloride. Where the specific salts have been identified within the literature, these have been reported as the scientific unit identified and not converted to a combined salinity value.

Chloride can be present in domestic wastewater effluent with a main source being the use of water softeners. Kadlec & Wallace (2009) identifies that a wastewater treatment plant in Genoa-Oceola, Michigan, receives very high chloride loads (about 400-550 mg/l).

Salinity can find its way into treatment wetlands when de-icing salt used to treat the roads in cold weather is washed off the road. This can vary in concentration depending upon the level of salt used between each rainfall event flushing the salt off the road. Kadlec & Wallace (2009) identify that within Cumberland County, Pennsylvania, the chloride within these flushes of de-icing salt entering treatment wetlands reaches 140 mg/l, with approximately 175 mg/l chloride being present at one created wetland in Connecticut (Moore *et al*., 1999).

In the U.K. de-icing salt has been shown to alter roadside vegetation communities, with maritime species including Reflexed Saltmarsh-grass *Puccinellia distans*, Common Saltmarsh-grass *Puccinellia maritima,* Lesser Sea-spurrey *Spergularia marina* and Sea Plantain *Plantago maritima* spreading inland along the road network (Scott & Davison 1982).

Sandford (1999) identified that the chemical composition of landfill leachate can vary considerably depending upon the waste deposited, the design and management of the landfill. Croft & Campbell (1992) compiled a review of landfill data and presented the general salinity constituents shown in Table 3.3. The constituents found within an older landfill site filled with inert waste identified during the original study (Steggall *et al*., 2005) are also presented in Table 3.3.

Constituent	Croft & Campbell 1992		Steggall *et al*., 2005	
	Range (mg/l)	Mean (mg/l)	Range (mg/l)	Mean (mg/l)
Chloride (Cl^-)	41-16150	2083	<2-524	186
Sodium (Na)	112-3475	1249	17-169	107
Potassium (K)	9-1800	444	2.6-18	8.65
Magnesium (Mg	7-754	190.1	26-192	116
Calcium (Ca)	40-1133	297.5	43-183	139

Table 3.3:Concentration of Main Salinity Consituents Identified within Landfill Leachate

As this study aims to look at enhancing the floral diversity of freshwater wetland treatment systems within the U.K., the impact of low levels of salinity or infrequent doses of salinity (i.e. where wetlands are used as an emergency backup to store sudden surplus effluent before it is fully treated) was explored. *Phragmites australis* is the main species used within the UK for constructed wetlands and thus the salinity concentrations employed were based upon its tolerance levels. The salinity tolerance of *Phragmites australis,* which varies depending upon where the individual specimens originated, has been previously studied by a number of researchers (Lissner & Schierup 1997; Adams & Bate 1999; Clevering & Lissner 1999; Lissner *et al*., 1999a&b; Hartzendorf & Rolletschek 2001; Mauchamp & Mesleard 2001; Hurry *et al*., 2013).

Knight (1997) reports that *Phragmites australis* has a salinity tolerance of up to 20 ppt and Lissner & Schierup (1997) found that a salinity of 35 ‰ proved fatal for all *Phragmites australis.* At 22.5 ‰ salinity the plants taken from established rhizomes had a survival rate of 75 % with only 12 % of juvenile plants surviving this concentration. At greater than 5 ‰ salinity levels the leaf number and shoot height decreased, but were unaffected below this concentration (Lissner & Schierup, 1997).

Antonellini, M & Mollema, P.M. (2010), found that in natural wetlands, when the salinity reaches 10-12 ‰, the species diversity reduces, and the area becomes almost barren, with only a few reed species surviving.

As *Phragmites australis* has been demonstrated to have high survival rates below 20 ‰ salinity and is not significantly affected below 5 ‰, a range of salinities between these concentrations was utilised in the experimental study, as shown in Table 3.4.

	Salinity (‰) (g/l)
Base Concentration	< 0.5 (fresh water)
1/3 of Maximum Dose Level	5
2/3 of Maximum Dose Level	10
Maximum Dose Level	15

Table 3.4: Concentration of Salinity Solutions Used

Due to the variation in industrial effluents and the different chemical composition and concentrations making up the salinity component of these (depending upon the processes involved) it was not possible to identify a generic composition for use in the study. Consequently, a general aquarium sea salt (Instant Ocean 2008) was used, as it was readily available, thereby allowing the microcosms to be quickly adjusted should the design salinity concentrations become diluted. With this synthetic sea salt being used for livestock it has a constant chemical composition, as shown in Table 3.5.

Ion	Mean Composition of Natural Seawater (g/l)	Instant Ocean (g/l)
Sodium (Na+)	10.781	10.780
Potassium (K+)	0.399	0.420
Magnesium (Mg++)	1.284	1.320
Calcium (Ca++)	0.412	0.400
Strontium (Sr++)	0.008	0.0088
Chloride (Cl-)	19.353	19.290
Sulphate (SO4)	2.712	2.660
Bicarbonate (HCO3)	0.126	0.200
Bromide (Br-)	0.067	0.056
Boric Acid (B(OH)3)	0.026	-
Fluoride (F-)	0.001	0.001

Table 3.5: Composition of Natural Seawater and Instant Ocean Synthetic Sea Salt (Instant Ocean 2008)

3.3 Vegetation Species Selected

Firstly, *Phragmites australis* was chosen as the key experimental species, since it is the most widespread of species used within European constructed wetland treatment systems (Copper *et al*., 1996; Price & Probert, 1997; Ellis *et al*., 2003; Kadlec *et al*., 1996 and second edition 2009). *Phragmites australis* is a robust species, tolerant of a wide range of pollutants and nutrient levels (Copper *et al*., 1996; Ellis *et al*., 2003). It has a high biomass root density and can tolerate fluctuating water levels (Copper *et al*., 1996, Ellis *et al*., 2003).

As discussed in Section 2, in addition to *Phragmites australis*, three generally robust perennial species were identified which could be beneficial to enhancing the biodiversity potential of a constructed wetland treatment system. The four individual species chosen from the four general physiological flora types found in natural wetlands were:

- *Phragmites australis* - grasses, sedges and rushes;
- *Lythrum salicaria* - woody perennial;
- *Filipendula ulmaria* - upright herbaceous perennial; and,
- *Mentha aquatica* - creeping herbaceous perennial.

In Sections 3.3.1 to 3.3.4, the morphology, distribution and general habitats for each species is discussed. In addition, research into each of the species relevant to this study was reviewed, and is also included. The quantity and relevance of information available for each of the species varied considerably. For *Phragmites australis* there is a plethora of information, including salinity tolerances and biomass production, whereas at the opposite end of the scale for *Filipendula ulmaria*, there is minimal information of relevance.

For clarity, where more than one of these species is discussed within the same publication, the relevant sections from the publication have been divided and incorporated into the appropriate species sections.

3.3.1 Phragmites australis

As well as being the most frequently used macrophyte within treatment wetlands, *Phragmites australis* represented the grasses, sedges and rushes group (see Section 2.4).

Morphology

Phragmites australis is an erect perennial grass which can grow <1 m to 3.5 m high (Rose, 1989; Stace, 1997) (Figure 3.4). The leaves are lanceolate and a grey/green colour (Hubbard, 1992; Rose, 1989) and the roots are rhizomatous and can be stoloniferous (Hubbard, 1992; Rose, 1989). The inflorescences are present in panicles (up to 150 mm to 400 mm long) with purple to brown colouration (Hubbard, 1992; Rose, 1989). The spikelets are 10 mm – 16 mm long (Hubbard, 1992; Rose, 1989; Stace, 1997). The rhizomes of *Phragmites australis* have been reported as extending 20 m (Holm *et al*., 1977), and Curtis (1959) them growing at an equivalent of 40 cm per year.

Distribution and General Habitat

Phragmites australis is a native species to the U.K with a widespread, common and stable distribution (BSBI, 2002; Hubbard, 1992; Rose, 1989; Stace, 1997). In Europe this species is also both widespread and common (Rose, 1989).

It is generally found in lowland wetland habitats such as lake edges, ditches, swamps, fens, salt marshes and river banks (BSBI, 2002; Hubbard, 1992; Rose, 1989; Stace, 1997). The soils can vary and include alkaline, neutral and acid soils in fresh or brackish water (Rose 1989). The recommended water level requirements for *Phragmites australis* range from 1000 mm below the growing media surface level, to 500 mm above, with a preferred range of 200 mm below the surface to level with the ground surface (English Nature, 1997).

General Structure

Panicle and Upper Leaves

Figure 3.4: ***Phragmites australis***

Key Research Literature

There is a plethora of information on this species and its use within constructed wetlands. Consequently, this section highlights key research relevant to this study and does not go into detail about its efficiency (including nutrient distribution and oxygen root transfer) as a wetland treatment species. This information can be found within the generic texts on constructed wetland treatment systems which have been detailed earlier (See Section 2).

Although *Phragmites australis* is a native plant in North America, an aggressive invasive genotype has been introduced (Blossey *et al*., 2002; Kettenring *et al*., 2011) which is rapidly colonising natural wetlands and causing it to become a nuisance. As such this species is discouraged within constructed wetland treatment systems within North America (Kadlec and Wallace, 2009). The opposite is true for the UK and Europe, where this is the main native species recommended for use (Cooper *et al*., 1996; Vymazal, 2011).

Kadlec and Wallace (2009) note that above and below ground biomass responds to an influx of nutrients. However, they state that high nutrient levels can lead to nutrient toxicity within aquatic plants in treatment wetlands and although they note that the biomass for *Phragmites australis* is not affected by 20-80 mg/l ammonia, no toxicity level is given. Peverly *et al*., (1995), found *Phragmites australis* used for the treatment of landfill leachate grew well in leachate with values of 300 mg/l NH_4^+, 300 mg/l BOD, 30 mg/l Fe, 1.5 mg/l Mn, 500 mg/l K, and pH of 7-7.2.

Meuleman *et al*., (2002) investigated the nutrient storage of an infiltration wetland receiving 82 mg/l Total-N and a natural wetland receiving <5 mg/l Total Nitrogen. They found that the Shoot : Root ratio of the infiltration wetland was 2.1, whereas it was 0.55 within a natural wetland. This shows that in the infiltration wetland the plants produced over twice as much above ground biomass than below ground biomass. Within the lower nutrient natural wetland, the opposite was true. Meuleman *et al*., (2002) attribute this to the availability of nutrients, explaining that where nutrient levels are low, as they were in the natural wetland, plants invest more resources in below ground biomass, where as the increased nutrient availability within the infiltration wetlands facilitated a higher production in above ground biomass. Meuleman *et al*., (2002) did not discuss the effects of potential plant competition on the biomass, but in the natural wetlands *Phragmites australis* was the dominant species with *Typha latifolia* and several *Carex* species present, compared to the infiltration wetland which consisted of a monoculture of *Phragmites australis*. Therefore plant competition could have been a variable in the different Shoot : Root ratios encountered.

Bastelova *et al*. (2004) undertook a garden tub experiment, where they studied two species *Lythrum salicaria* and *Phragmites australis,* both of which have vigorously invaded North America. They took individuals across a wide geographical area across Europe and grew them for one growing season at two water levels and at three nutrient levels for *Lythrum salicaria* and two nutrient levels for *Phragmites australis*. For *Phragmites australis*, six populations from six geographical locations were studied in 5 l plastic pots, with four pots/plants representing each population. The two nutrient loadings were 1 and 6 g/l of a slow diluting granulate fertilizer (Osmocote Plus N-P-K 15-11-13). The water levels were classed as high (300 mm above the surface of the pot) and low (at the surface of the pot). With regards to *Phragmites australis* these were separated into three distinct groups with the Swedish and Romanian populations being far apart and the remaining four locations (Netherlands, Czech Republic, Hungary and Spain) occupying the middle ground. These plants generally showed the trend of increasingly taller and thicker stems the further south along the geographical gradient from which they were sourced. The increase in nutrients was positively significant giving an increase in dry weight of both above and below ground biomass, but it did not significantly increase the heights of the tallest stems. The different water levels did not have a significant effect on *Phragmites australis,* with the exception of the below ground biomass dry weight which decreased with increasing water levels. This study is discussed further in the Section 3.3.2 detailing the choice of *Lythrum salicaria*.

Phragmites australis is not a true halophyte but tolerant of certain salinity concentrations. The salinity tolerance of *Phragmites australis,* has been extensively studied, and been found to vary depending upon where the individual specimens originated (Knight, 1997; Lissner & Schierup, 1997; Adams & Bate, 1999; Clevering & Lissner, 1999; Lissner *et al*., 1999a&b; Hartzendorf & Rolletschek, 2001; Mauchamp & Mesleard, 2001; Hurry *et al*., 2013). Relevant aspect have already been explored in the salinity concentration selection discussion in Section3.2.2.

3.3.2 Lythrum salicaria

Lythrum salicaria was selected as the species to represent the woody species group. The adaptive nature of this species to different growing conditions and its reported vigorous nature should allow it to survive when competing with other vigorous plants.

<u>Morphology</u>

Lythrum salicaria is a woody herbaceous perennial (see Figure 3.5) which can grow to a height of 1.5 m (Stace 1997). The leaves are sessile, slightly pubescent, lanceolate to ovate and generally in opposite pairs with the upper leaves being alternate (Rose, 2006; Shamsi and Whitehead, 1974a; Stace, 1997). The red-purple inflorescences are present in whorls for 100 – 300 mm at the ends of the stems (Figure 3.5) and each inflorescence is up to 15 mm long in a calyx-tube with 6 petals. The inflorescences are usually present in June to September/October. Shamsi and Whitehead (1974a) report that a healthy plant generally produces approximately 900 seed capsules each year with approximately 120 seeds per capsule. It does not disperse much by vegetative spread, but as the seeds are small and light, they are dispersed in the air. The stems die back each winter with the plant perennation being in the root where new shoots are produced from the top of the root stock in the spring. The roots comprise a tap root, which is present throughout the life of the plant, maturing to provide secondary and tertiary root branches.

Distribution and General Habitat

Lythrum salicaria is a native species to the U.K. with a widespread, common and stable distribution, except for northern Scotland (BSBI, 2002; Rose, 2006; Stace, 1997). In Europe this species is widespread and relatively common.

It is generally found in wetland habitats such as marshland, wet woodland, tall herb fens and also on the banks of rivers, canals and standing water bodies, with either permanently wet soil or in areas which are temporarily flooded (BSBI, 2002; Rose, 2006; Stace, 1997). The soils can be either acid or alkaline (Shamsi and Whitehead, 1974a). The recommended water level requirements for *Lythrum salicaria* range from 400 mm below the growing media surface level to 100 mm above, with a preferred range of 100 mm below the surface to 100 mm above (English Nature, 1997).

Lythrum salicaria is generally found in open habitats, but is tolerant of light shade and moderate shade when established (Shamsi and Whitehead, 1974a). Shamsi and Whitehead (1974b) have shown that this species adapts to shade by producing fewer lateral branches and a larger leaf with a thinner depth. The reduction in light also reduced the number of flowers produced. Overall a decrease in dry weight was found with decreasing light levels, but the root proportions did not alter.

General Structure

Inflorescences

Figure 3.5: ***Lythrum salicaria***

Key Research Literature

Non-native strains of this species which were introduced into the United States and Australia have been problematic, often outcompeting other wetland flora species and forming dense stands (Bastlova & Kvet, 2002; Blossey & Kamil, 1996; Edwards *et al*., 1998; Schooler *et al*., 2006; Thompson *et al*., 1987). Thompson *et al*., (1987) identified that one of the native plants which *Lythrum salicaria* displaces is *Typha latifolia*, a species which is used in constructed wetland treatment systems.

This dominance of the non-native American strains was attributed to the different life strategies of non-native American strains and native European strains. It was identified that the non-native strains are taller with larger above ground biomass and less reproductive effort is used compared to the native strains (Bastlova & Kvet, 2002, Bastlova *et al*., 2006). Bastlova & Kvet, (2002) identified that the dry weight partitioning for different parts of the plants was different for native and non-native plants. Non-native plants had a higher proportion of dry weight in their shoots and roots than native plants, but native plants had a higher proportion of dry weight in the leaves and reproductive parts. The native plants also flowered 10 days earlier than non-native individuals. This difference in dry weight partitioning allows for non-native individuals to grow taller earlier in the season than the native individuals, hence they gain an advantage over adjacent vegetation when competing for solar irradiance (Bastlova & Kvet, 2002). This extra partitioning of dry weight to the shoots and the earlier increase in height allows for non-native individuals to compete with taller species such as *Phragmites australis* and *Typha latifolia,* which it does in the U.S.A. By comparison the European native species are generally found in shorter plant communities (Bastelova & Hanzelyova, 2001; Bastlova & Kvet, 2002)

Notzold *et al*., (1998) noted that when *Lythrum salicaria* (seeds collected from the USA) was subject to competition with *Phleum pratense* within a pot, that during year one the above ground heights and biomass of *Lythrum salicaria* was slightly higher than the control but not statistically significant. During year 2 the competition resulted in a significant reduction in the fine roots of *Lythrum salicaria* and also delayed flowering.

The garden tub experiment where Bastelova *et al*., (2004) studied two species *Lythrum salicaria* and *Phragmites australis,* has already been described in Section 3.3.1. For *Lythrum salicaria*, the results showed that it could be divided into three main geographical groups separated by latitude. The first group were the southern European populations which had a strong main shoot and flowered later in the year. The second group was the north European populations which were shorter, had lateral branches almost as thick as the main stem and exhibited earlier flowering. The remainder were from central Europe which had characteristics falling between the northern and southern populations. These plants had the general characteristics found within the identification guides for this species, being a main stem with obvious lateral branches, inflorescences along the terminal spikes of the main stem and lateral stems, and the flowering season was in the middle, being late July to early August. The low and intermediate nutrient levels for *Lythrum salicaria* enhanced the plants growth, however the higher nutrient dose did not further increase the dry weights of the plants, with the plant becoming more vulnerable to herbivory and growth stress (damaged tips and leaf necrosis).

Shamsi and Whitehead (1977c) found that by diluting the standard dose of a soluble fertilizer and applying the various dilutions to *Lythrum salicaria*, the dry weight of the plants decreased with the greater dilutions. They also identified that the root/shoot ratio increased with the decrease in nutrient concentrations. Shamsi and Whitehead (1977c) found that reducing the concentration of nitrogen, phosphorus and potassium reduced the dry weight of the plants with the reduction in nitrogen having the most affect on the individual plants. When Shamsi and Whitehead (1977d) planted *Lythrum salicaria* and *Epilobium hirsutum* at high densities in two different nutrient solutions, *Lythrum salicaria* became the dominant species. *Epilobium hirsutum* was outcompeted either totally dying out or becoming prostrate and forced to the edge of the containers.

Antonellini, M & Mollema, P.M. (2010), looked at the impacts of groundwater salinity on vegetation species richness in the coastal pine forests and wetlands of Ravenna, Italy. They identified that *Lythrum salicaria* was present in areas where the salinity levels were 1.5 g/l. In their literature review Antonellini, M & Mollema, P.M. (2010) identify that *Lythrum salicaria* has a salt tolerance of 1.5 to 2 ds/m (approximately 0.96 to 1.28 g/l, based upon 1 ds/m equating to 640 mg/l salt).

Hutchinson (1998) mentions that *Lythrum salicaria* has been found invading subsaline marshes in the Pacific Northwest. In the Fraser River delta it has been recorded at salinity values of 8 ppt for short periods of time in the early growing season but no further quantitative data on the salinity gradients for the Pacific Northwest exist.

Previous studies have looked at the soil characteristics where *Lythrum salicaria* has invaded habitats to successfully form a dominant monoculture. Fickbohm, S.S. & Zhu W.X. (2006) found that in the Montezuma National Wildlife Refuge (New York State), the soil characteristics differed between old (>20 years) dense stands of *Lythrum salicaria* and the native stands of *Typha latifolia*. They found that the stands of *Lythrum salicaria* had significantly higher standing dead biomass (1.88 kg m^2 compared to 0.59 kg m^2) and a higher organic soil content in the upper 200 mm of soil (35.2 kg m^2 compared to 27.5 kg m^2). The decaying *Typha latifolia* leaves produced a thicker leaf litter layer which was absent in the *Lythrum salicari*a stands. This was attributed to the leaf drop occurring earlier in the year for *Lythrum salicaria*, with *Typha latifolia* slowly collapsing over the winter months when less microbial activity is being undertaken. *Lythrum salicaria* also had higher average monthly nitrogen mineralisation rates (911 mg N m^2 compared to 638 mg N m^2). Fickbohm, S.S. & Zhu W.X. (2006) note that the extensive fine root system of *Lythrum salicaria* could be an adaptation for this species in dealing with limited nutrients (N is usually a limiting factor in freshwater marshes) improving its invasive capabilities.

Weihe & Neely (1997) undertook a short (three month) study of *Lythrum salicaria* and *Typha latifolia*. In the study they placed a mixed ratio of each species (maximum 5 plants per 1 l pot) in both unshaded and shaded areas. In the unshaded areas, they identified that *Lythrum salicaria* increased its above ground biomass when a higher proportion of *Typha latifolia* was present. Where no *Typha latifolia* was present the above ground biomass for each *Lythrum salicaria* plant weighed 5.3 g and increased to 17.7 g where four *Typha latifolia* plants were present for each *Lythrum salicaria* plant. The below ground biomass also increased from 3.02 g per plant where no *Typha latifolia* was present, to > 7 g per plant where four *Typha latifolia* plants were present for each *Lythrum salicaria* plant. In the shade (60% less light), where no *Typha latifolia* was present the above ground biomass for each *Lythrum salicaria* plant weighed 3.69 g and increased to 8.88 g where four *Typha latifolia* plants were present for each *Lythrum salicaria* plant. The below ground biomass also increased from 2.0 g per plant where no *Typha latifolia* was present, to 4.3 g per plant where four *Typha latifolia* plants were present for each *Lythrum salicaria* plant. The study also showed that *Lythrum salicaria* suppressed the dry biomass of *Typha latifolia* both above and below ground compared to the pots where *Lythrum salicaria* was absent.

Twolan-Strutt & Keddy (1996) undertook a short-term study looking at the competition between *Lythrum salicaria* and *Carex crinite*. The aspects of competition which they investigated were: full competition with both roots and shoot interaction; part competition where the shoots were held back with netting so that only the roots interacted; and no competition where the roots and shoots were separated. The species were planted in a high standing crop wetland with high nutrients (fertile bay) and within a low standing crop wetland with low nutrients (infertile sandy shoreline). The seedlings were planted into the relevant plots in June and then harvested in September the same year. The above ground biomass was cut at ground level and the below ground biomass was sampled using 10 cm diameter soil cores to a depth of 20 cm. They analysed the results to calculate a competition intensity which was based upon the relative growth rates from the starting biomass of seedlings, and the final biomass of the plants over the duration of one growing season. They found that for *Lythrum salicaria* there was no significant difference between the two wetlands for the mean total competition intensity. When the results were separated further, they identified that both the above ground and below ground competition intensities between the two wetlands were significantly different. In the high nutrient wetland *Lythrum salicaria* had greater above ground component with the opposite being true for the low nutrient wetland.

Although the study by Twolan-Strutt & Keddy (1996) looks at competition intensity within a wetland, the aims of the study presented in this thesis did not permit the same methods to be utilised, as they were deemed unsuitable for identifying the mid to long term feasibility of using a mixture of aquatic species within a wetland treatment system. The Twolan-Strutt & Keddy (1996) competition intensity looked at the starting biomass of the plants and the end biomass over one season. The study presented in this thesis had additional factors which included reproduction and mortality over multiple growing seasons and as such the Twolan-Strutt & Keddy (1996) competition intensity calculation could not be utilised. Another factor was the limited sampling of the root biomass undertaken by Twolan-Strutt & Keddy (1996) who utilised 10 cm diameter soil cores to a depth of 20 cm. This study investigates the feasibility of using wetland species within an operational sub-surface flow treatment wetlands which extend beyond the 20 cm sample depth. The treatment in sub-surface flow treatment wetlands occur primarily, as the name suggests, in the sub-surface media and vegetation roots. With the main treatment occurring below ground, the root interactions below the 20 cm depth and beyond the 10 cm core needs to be investigated, and given time to develop and interact over multiple growing seasons. The greater depth and multiple growing seasons utilised in this study permit any potential future design issues to be identified such as the growth rates of the roots. The growth patterns for the roots, and any parameters which have an adverse affect on the root growth needs to be identified, as this could adversely affect any future effluent treatment and as such could render certain species or design principles unsuitable for deployment into operational treatment wetlands.

Although this thesis is looking at the ability of *Lythrum salicaria* to survive long-term as a biodiversity enhancer within a constructed wetland treatment system, and not at its treatment potential, *Lythrum salicaria* has the ability to facilitate the removal of pollutants. Zhang *et al.*, (2007) found from a study of *Lythrum salicaria* grown in pots that after a 15 day retention period, TN removal was 88.8 %, TP removal was 97 %, BOD_5 removal was 88.8 % and COD removal was 88.7 %. These were all significantly higher than the unplanted pots used as controls. The study also explored the removal of metals from the tested effluent and found that *Lythrum salicaria* removed significantly higher amounts of Cr (81.3 % removal), Pb (87 % removal) and Fe (99.1 % removal) than the controls.

3.3.3 Filipendula ulmaria

Filipendula ulmaria was identified as the species to represent the perennial herbs originating each year from a perennating bud. In the U.K. this species is often found in damp roadside ditches which would be affected by de-icing salt spreading of the roads, and as such could have some tolerance to low levels of salinity. It is also found in both open environments and shady (wet woodland) environments and therefore might be able to tolerate being shaded out when competing with other vigorous wetland plants.

Morphology

Stace (1997) and Rose (2006) report *Filipendula ulmaria* as an herbaceous perennial which can grow to 1.2 m high (Figure 3.6). The leaves are pinnate and stalked with 2-5 pairs of main leaflets (80 mm long) with smaller leaflets present in-between. The leaflets are toothed terminating in a point with a dark green hairless upper surface and pale green downy surface underneath. The white-cream inflorescences are present in panicles (with the panicles up to 150 mm across) at the end of the main flowering stem. Each inflorescence is up to 4-10 mm across with 5 petals and are usually present in June to September. The stems die back each winter with the plant perennation being in the root with new shoots produced from the top of the root stock in the spring.

Basal Leaves with Flowering Stem

Inflorescence Buds

Basal Leaves

Figure 3.6: ***Filipendula ulmaria***

Distribution and General Habitat

Filipendula ulmaria is a native species to the U.K. with a widespread and common and stable distribution (BSBI, 2002; Rose, 2006; Stace, 1997). In Europe this species is widespread and relatively common.

It is generally found in wetland habitats such as swamps, tall herb fens damp meadows roadside/railway ditches and also on the banks of rivers, canals and standing water bodies (BSBI, 2002; Rose, 2006; Stace, 1997). The soils are generally neutral to calcareous and moderately fertile (BSBI, 2002; Rose, 2006). The recommended water level requirements for *Filipendula ulmaria* range from 600 mm below the growing media surface level to 50 mm above with a preferred range of 200 mm below the surface to level with the surface (English Nature, 1997). Price & Probert (1997) note that *Filipendula ulmaria* is a native species which is a good nectar source for invertebrates with its key attributes being shade tolerant and scour resistance.

Key Research Literature

There is a void in research on *Filipendula ulmaria* being utilised within constructed wetlands. The majority of research which lists *Filipendula ulmaria* as a species present within a natural habitat being studied, gives no detail about this specific species. There is no information upon its salinity tolerance limits.

Pauli *et al*., (2001) studied the effects of nutrient enrichment in calcareous fens, and looked at the impact of increasing nutrients on *Filipendula ulmaria*. After 16 months of growth the plants were measured during August. The results found that in unfertilised plots, this species had an average of two leaves with a length of 144 mm. The above ground biomass was 0.2 g, the below ground biomass was 0.6 g giving an approximate shoot:root ratio of 0.3. The plots which were only subject to additional Nitrogen were not affected. The sites which were subject to a mixed NPK fertiliser had increased leaf lengths of 56% and increased above ground biomass of 78%. The below ground biomass did not alter and consequently, the shoot:root ratio increased. They identified that these increases were parallel with the increase in biomass of the surrounding calcareous fen vegetation and as such *Filipendula ulmaria* was able to compete for the available light resource.

Studer-Ehrensberger *et al*., (1993), found that *Filipendula ulmaria* can be displaced by *Glyceria maxima* within a dune slack environment. *Glyceria maxima* is less anoxia tolerant and starts growing earlier in the season due to its aerenchyma providing it with access to oxygen. This helps to displace *Filipendula ulmaria* which stays dormant for longer until the water subsides within the dune slacks.

Smirnoff & Crawford (1983) found that although *Filipendula ulmaria* is a flood tolerant species, when subject to flooding, this species does not produce extensive aerenchyma which resulted in low root porosity. When compared to wild *Mentha aquatica* the authors note that the porosity is similar to *Filipendula ulmaria*, however *Mentha aquatica* has aerenchyma and therefore they did not know the reason for *Filipendula ulmarias'* low porosity.

3.3.4 Mentha aquatica

Mentha aquatica was selected as the species to represent the creeping plant group. The rhizomatous/stoloniferous nature of these plants should allow them to intertwine between the stems of the different species, quickly colonising new openings (i.e. in the growing media and where light is present) as they become available. This should allow this species to survive when competing with other vigorous plants.

Morphology

Stace (1997) and Rose (2006) report *Mentha aquatica* (Figure 3.7) as a rhizomatous and stoloniferous herbaceous perennial which can grow to 900 mm high. The leaves are subglabrous, ovate with shallow blunt teeth and in opposite pairs with a mint aroma. The mauve inflorescences are present in whorls up to 20 mm across in a rounded ball situated just above the higher leaves on the main stem. Each inflorescence is up to 3-4.5 mm long in a hairy calyx-tube, and are usually present from July to October. The plant generally dies back each year, storing its reserves over winter within its rhizomes (Lenssen *et al*., 2000).

Inflorescence

Upright Stems

Prostrate Stems Under Water During The Winter

Figure 3.7: ***Mentha aquatica***

<u>Distribution and General Habitat</u>

Mentha aquatica is a native species to the U.K with a widespread, common and stable distribution (BSBI, 2002; Rose, 2006; Stace, 1997). In Europe this species is also widespread and common.

It is generally found in wetland habitats such as marshland, wet woodland, tall herb fens, dune slacks, ditches and also on the banks of rivers, canals and standing water bodies (BSBI, 2002; Rose, 2006; Stace, 1997). The recommended water level requirements for *Mentha aquatica* range from 600 mm below the growing media surface level to 200 mm above, with a preferred range of 100 mm below the surface to 100 mm above (English Nature, 1997).

Key Research Literature

There is minimal research on *Mentha aquatica* being utilised within constructed wetlands. The majority of research which lists *Mentha aquatica* as a species present within a natural habitat, gives no detail about this specific species. There is no information available on its salinity tolerance limits.

Price & Probert (1997) have *Mentha aquatica* in a table which details that it is one of the most commonly used plant species in UK constructed wetlands. However, the reference for this table entry, Biddlestone *et al*., (1991), contradicts this as it does not state that it is one of the most commonly used plants. Biddlestone *et al*., (1991) provide a list of plants in their introduction, which have the ability to treat wastewater and reference notes from a workshop in 1989. Price & Probert, (1997) also list *Mentha aquatica* as a native species which attract butterflies and other invertebrates with its key attributes being shade tolerant, scour resistance and that it helps to improve water quality.

A literature search showed that this is not a commonly used plant for treatment purposes, but is used within some constructed wetland treatment systems. Research has been undertaken upon this species' ability to provide a beneficial antibacterial effect when treating wastewater. Stottmeister *et al*., (2003) in their review of the effects of plants and microorganisms refer to previous research undertaken by Seidel (1971) on *Mentha aquatica* within pot experiments. Seidel's work showed that *Mentha aquatica* was very good at removing *E. Coli* (up to 99 %) and *Enterococci*, as well as being good at removing colif. bacteria, salmonella, acidifiers, moulds and yeasts.

Although this thesis is looking at the ability of *Mentha aquatica* to survive long-term as a biodiversity enhancer within a constructed wetland treatment system, and not at the treatment potential of the biodiversity enhancing species, it has the ability to facilitate in the removal of pollutants. Kamel *et al*., (2007) found from a study of *Mentha aquatica* grown in a solution containing heavy metals, that after a 21 day retention period, heavy metals were reduced from 28.06 mg/l to 18.3 mg/l for zinc (34.77 % reduction, comprising of 39.55 % plant uptake and 60.45

% precipitation), 5.56 mg/l to 3.48 mg/l for copper (30.89 % reduction, comprising of 50.86 % plant uptake and 49.13 % precipitation), 103.55 mg/l to 7.30 mg/l for iron (92.92 % reduction, comprising of 96.72 % plant uptake and 3.28 % precipitation) and 501 μg/l to 0.02 μg/l for mercury (99.99 % reduction, comprising of 90.05 % plant uptake and 9.95 % precipitation).

Smirnoff & Crawford (1983) found that *Mentha aquatica* has aerenchyma. The presence of aerenchyma should permit the flow of oxygen to the roots and as such permit this species roots to spread within anoxic wetland soils.

3.4 Planting Configuration for Microcosms

Two planting configurations were utilised to determine if different design principles would permit different species to live within the treatment wetland. The first system focused on full competition between the different species within the same microcosm. The second system focused on restricting the root competition between the different species with the only competition present being above ground. This latter was included to determine if the addition of below ground root baffles in full scale treatment systems would limit competition and permit the different species to co-exist more easily, and as such inform future design principles.

3.4.1 Microcosms with Full Competition

3.4.1.1 Experiment Design

A total of eight microcosms were installed to measure the long-term sustainability and interactions between the different floral species with full species interactions. Four of these microcosms were subject to the four different nutrient concentrations, whilst the remaining four microcosms were subject to the four different salinity concentrations.

Each microcosm was divided into four sections (no physical dividers were used within the tank to allow for competition of roots), with each section covering 25 % of the surface area (Figure 3.8) and planted with a different species. The surface area of the microcosm was 5515.4 cm^2 which gives an allocated planting area for each of the four floral species of 1378.85 cm^2.

3.4.1.2 Planting Configuration

Figure 3.8 and Figure 3.9 detail the layout of each container used in the microcosms with full competition. The central circle contained *Phragmites australis*. The outer circle was divided into three equal sections, in each of which a different floral species was planted. This ensured that all of the species were in contact with and competing against each other. The location of *Phragmites australis* in the centre allowed for it to interact more with the other floral species, having a contact length of 453 mm, compared with 174 mm between the outer species. As the majority of a traditional constructed wetland treatment system consists of *Phragmites* australis, this greater level of competition would occur in any final created treatment system and thus required particular attention.

A total of four 90 mm pot plants for each species were planted (without the pots) within each microcosm. Cooper *et al*., (1996) recommend planting four plugs of *Phragmites australis* per m^2. However, a higher planting density and the 90 mm pot plants were chosen above plug plants, to help achieve a fully vegetated microcosm as quickly as possible, and thus shorten the time before the competition interactions between the species would occur. All pot plants were of native provenance.

The flora within these microcosms were planted on the 28th and 29th July 2007. This accords with the preferred planting time in Western Europe of between May and August, as recommended by Cooper *et al*., (1996) for wetland treatment systems.

Figure 3.8: Layout of Each Microcosm with Full Competition
Note: the internal lines are hypothetical divides on the surface of the microcosm and are not actual dividers.

Figure 3.9: Planted Microcosm with Full Competition Illustrating Gravel Layer and Partially Completed Humus Layer

3.4.2 Microcosms with Restricted Root Competition

3.4.2.1 Experiment Design

The second experimental system was designed to restrict root competition. A total of eight microcosms were installed to measure the long-term sustainability and interactions between the different floral species with restricted root competition. As with the full competition microcosms, four were subject to the four different nutrient concentrations, and four to the different salinity concentrations discussed in Section 3.2.

The materials and growing media were installed using the same configuration as the microcosms with full competition. However, to restrict root competition, solid internal dividers constructed from HDPE were installed. These dividers extended to 300 mm below the surface of the media and for 50 mm above the surface of the media (Figure 3.10).

Stopping the dividers before the base of the container allowed the chemical concentration to disperse across the base of the microcosm. This also applied for extending the dividers 50 mm above the surface of the growing media, thereby allowing a further 50 mm of solution above the divider for added chemicals to disperse and interact above the media surface in the free water layer. These precautions were taken to prevent the dissolved chemicals within the water from becoming locally concentrated in areas of a microcosm.

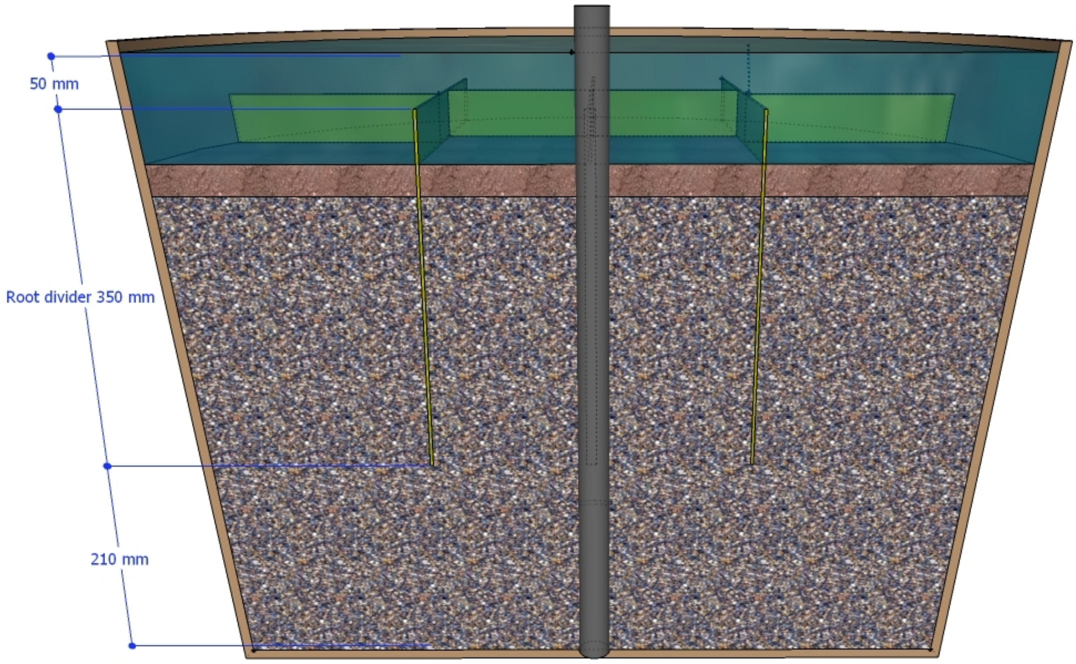


Figure 3.10: Cross Section of the Media Layers and Root Dividers within the Microcosms with Restricted Root Competition

3.4.2.2 Planting Configuration

As with the full competition experiment, four of each of the chosen flora were planted in each microcosm, which was divided into 16 equal compartments. With a microcosm surface area of 5515.4 cm^2 this gave a total growing area for each of the 16 compartments of 344.7 cm^2. Within each compartment a single 90 mm pot plant was planted on the 28th and 29th July 2007, as detailed in Figure 3.11.

Rather than divide each microcosm into quarters with one for each species, each quarter of the microcosm was subdivided into four compartments. This configuration was chosen for ease of construction, but the arrangement of the inserted root dividers resulted in four different plan shapes for the plants to grow in (Figure 3.11). The planting arrangement was designed so that overall all of the four species experienced all of the four differently shaped growing compartments, yet had a quarter of the total available surface area for growth. This created four replicas within the same microcosm which would facilitate statistical analysis of individual stem heights, stem widths and area coverage during the acclimatisation and treatment phases. For reasons discussed in Section 3.8.1.3 these individual measurements had to cease and group measurements for each species had to be reverted to.

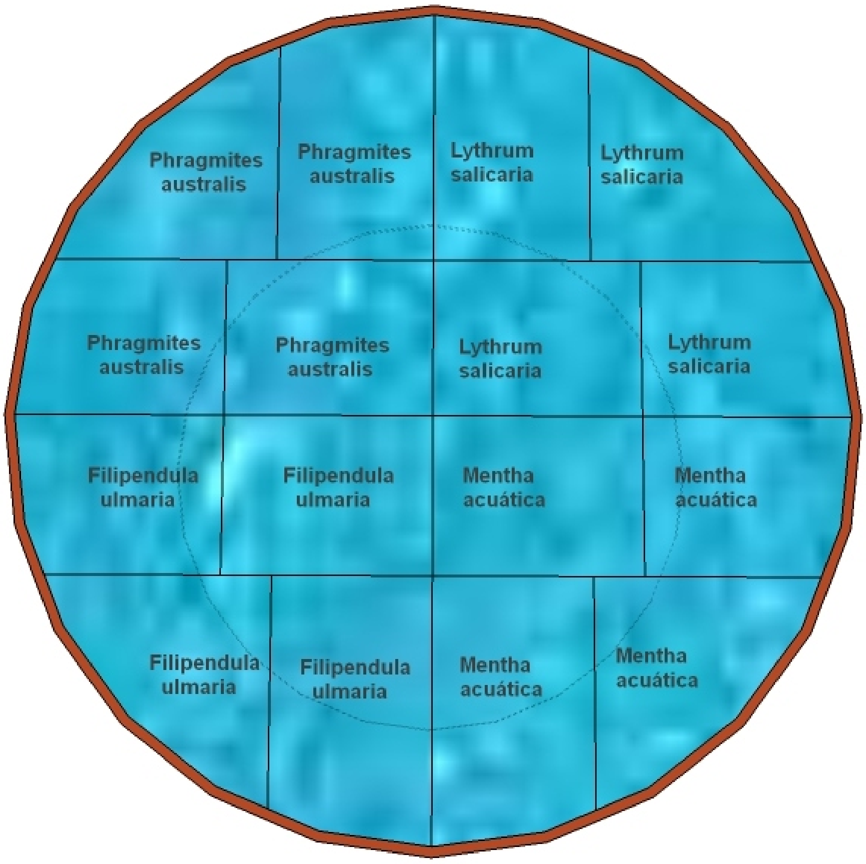


Figure 3.11: Layout of Each Microcosm with Restricted Root Competition
Note: the internal lines are the locations of the actual dividers.

3.5 Layout of Study Area

Figure 3.12 to Figure 3.14 illustrate the general layout of the study area, which was positioned in a location where the microcosms would receive the least amount of shading. Shading only occurred for a short period each day at sunrise and at sunset from the adjacent 1.8 m wooden fence panels. Laying out the microcosms in rows enabled ease of access to facilitate monitoring and maintenance. Microcosms 1 to 8 are being used to investigate the interactions of the species with full competition, with microcosms 1 to 4 investigating nutrients and 5 to 8 investigating salinity. Microcosms 9 to 16 are being used to investigate the interactions of the species with restricted root competition, with microcosms 9 to 12 investigating nutrients and 13 to 16 investigating salinity.

To monitor the natural water input from rainfall, an automatic weather station with a built in data-logger (Oregon Scientific WMR200 Professional Weather Station (Oregon Scientific, 2014)) was installed adjacent to the microcosms. The automated weather station was chosen over a manual weather station to minimise the physical monitoring required, in addition to which, automated weather stations are capable of taking more frequent measurements. The weather station was used to monitor the daily meteorological data, particularly rainfall which when combined with the irrigation input produced a total water input for each microcosm.

Figure 3.12 and Figure 3.15 show the location of the weather station within the study area. Due to canine vandalism, the weather station was moved approximately 2 m during the first year to a more secure location within the fenced area. As the new location was close to the original position, its move was not detrimental to the study.

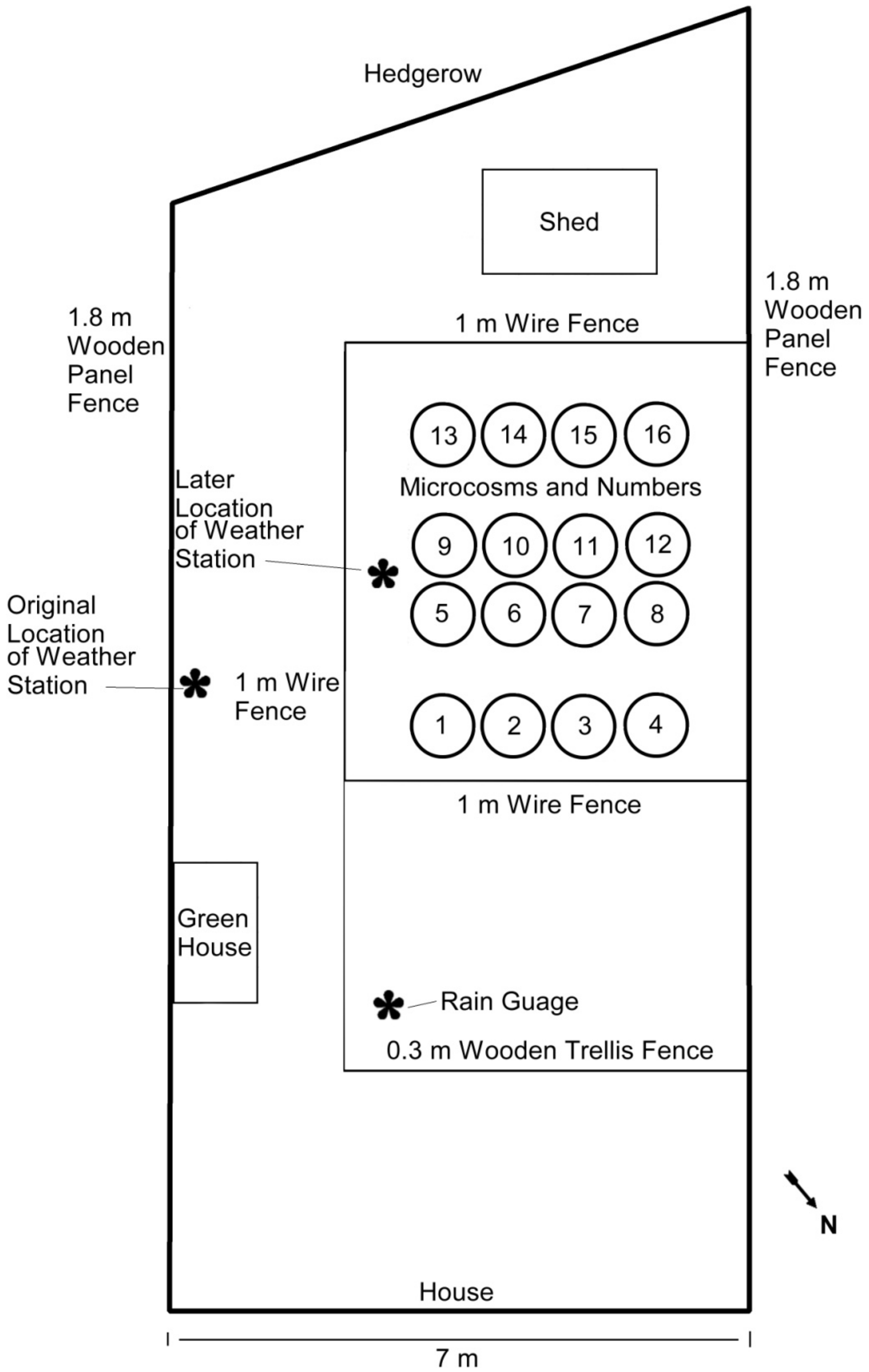


Figure 3.12: Plan Layout of Study Area.

Figure 3.13: Study Area Pre Planting.

Figure 3.14: Study Area Post Planting.

Figure 3.15: Oregon Scientific WMR200 Professional Weather Station.

3.6 Acclimatisation Period

Cooper *et al*. (1996) showed that if a reedbed was managed correctly, *Phragmites australis* usually achieved a suitable cover after a full growing season. Consequently, once all of the microcosms had been planted, they were given 12 months to acclimatise and colonise their allocated space within the microcosm. During this period all of the microcosms were provided with a general purpose plant food (Miracle-Gro, water soluble all purpose plant food) (Miracle-Gro 2014), equivalent to 10 mg/l total nitrogen. The chemical composition of the plant food is an NPK blend of 24-8-16 with trace nutrients and can be found in Table 3.6.

The nutrient dosing levels and volume of water were calculated using the experimentally determined porosity of the media present within an un-vegetated microcosm. The porosity of the humus layer and gravel layer were calculated by measuring the volume of the media using displacement. Measurements were taken for ten samples of each media and the mean value of the calculated porosities was used. The porosity and volume of water in each of the microcosm layers can be found in Table 3.7.

Chemical	%
Nitrogen (N) total	24
Ammoniacal nitrogen (N)	3.5
Ureic nitrogen (N)	20.5
Phosphorus pentoxide (P_2O_5) soluble in neutral ammonium citrate and in water	8 (3.5 % P)
of which soluble in water	8 (3.5 % P)
Potassium (K) soluble in water	13.3
Boron (B) soluble in water	0.02
Copper (Cu) soluble in water	0.03
Iron (Fe) soluble in water 0.19 % chelated by EDTA	0.19
Manganese (Mn) soluble in water 0.05 % chelated by EDTA	0.05
Molybdenum (Mo) soluble in water	0.001
Zinc (Zn) soluble in water	0.03

Table 3.6 Chemical Composition of the Miracle-Gro Plant Food.

	Depth of Media Layer (m)	Radius at Top of Media Layer (m)	Radius at Base of Media Layer (m)	Volume of Media Layer (l)	Porosity of Media (%)	Volume of Water (l)
Free Water Level	0.1	0.419	0.409	53.8535	100	53.8535
Humus Layer	0.03	0.409	0.406	15.6506	44.15	6.9097
Gravel Layer	0.48	0.406	0.36	221.9995	37.3	82.8058

Table 3.7: Porosity of Growing Media and Volumes of Water in Unvegetated Microcosms.

During the acclimatisation period the microcosms were not supplied with nutrients when the plants were going dormant and over the winter months. The cessation of nutrients over the winter months when the plants are dormant was to reduce the risk of nutrients building up to concentrations above the desired levels as the microcosms are a still system and not a through flow reedbed. Plant food was supplied on five monthly occasions during the growing season (Table 3.8) at the following monthly rate; Miracle grow to a nitrogen concentration of 10 mg/l. Given the porosity of the growing media and microcosm volume this equates to a nitrogen addition of 2.603 g/m^2 or 26.031 kg/ha. The corresponding macronutrient additions of phosphorous is 3.333 mg/l (0.868 g/m^2 or 8.677 kg/ha) and potassium is 5.542 mg/l (1.443 g/m^2 or 14.425 kg/ha).

It should be noted that although the nitrogen concentrations are based upon the varying nitrogen concentrations of wastewater identified within the literature review, the actual nutrients provided were in the form of a soluble plant food. As the nitrogen concentrations of the soluble plant food are increased during the treatment phase to the required concentrations (Section 3.7), the other plant nutrients supplied increased at the same ratio within the nutrient mix.

As detailed in Section 3.8, at the beginning of each month (prior to the fresh batch of nutrients being mixed) the remaining liquid within the microcosms were tested for nutrients in the form of nitrate and ammonia. These levels were measured to determine the concentration of nutrients required to return the nutrient concentrations back to the desired levels. It was identified that negligible amounts of nitrate and ammonia were present and as such the full concentrations of plant food were required to return the nutrient concentrations back to the desired levels. This was also the case for all concentrations of nutrients investigated in Section 3.7. The analysis was undertaken on the nitrate and ammonia on the assumption that the ureic nitrogen supplied in the plant food had been transformed into the more available forms of nitrogen's which usually takes 2-4 days (University of Minnesota, 2017).

The phosphorous was investigated at the start of the project for the same reasons as the nitrate and ammonia, which also found that negligible levels remained in the remaining liquid.

Date	Nitrogen			Phosphorous			Potassium		
	Mg/l	Equivalent to		Mg/l	Equivalent to		Mg/l	Equivalent to	
		g/m^2	kg/ha		g/m^2	kg/ha		g/m^2	kg/ha
29th July 2007	10	2.603	26.031	3.333	0.868	8.677	5.542	1.443	14.425
1st September 2007	10	2.603	26.031	3.333	0.868	8.677	5.542	1.443	14.425
30th April 2008	10	2.603	26.031	3.333	0.868	8.677	5.542	1.443	14.425
1st June 2008	10	2.603	26.031	3.333	0.868	8.677	5.542	1.443	14.425
1st July 2008	10	2.603	26.031	3.333	0.868	8.677	5.542	1.443	14.425

Table 3.8: Levels of Nutrients Supplied to Each Microcosm During The Acclimatisation Period.

The levels of nutrients supplied has been also provided as g/m2 and kg/ha within Tables 3.8 and 3.9 for reference. These are the two commoner notations for nutrient studies where vegetation is involved. However, as this study is related to wastewater treatment the mg/l notation will be used throughout this thesis.

Figure 3.16 illustrates the layout of the microcosms and the plant food levels provided during the acclimatisation period.

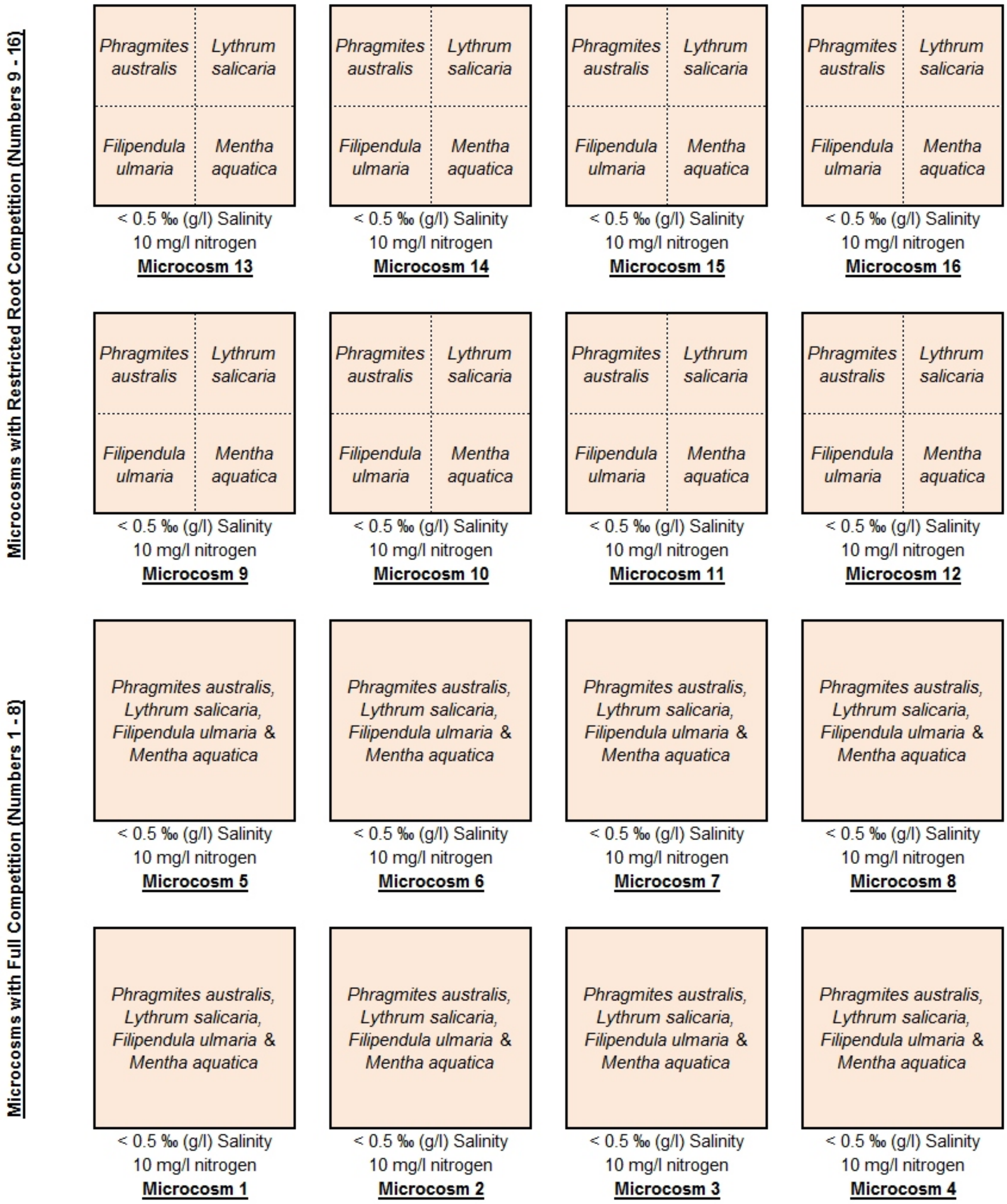


Figure 3.16: Representative Layout of the Microcosms and the Plant Food Levels during the Acclimatisation Period.

3.7 Treatment Period August 2008 and November 2010

Following the acclimatisation period, the concentrations of the nutrients and salinity were adjusted to the selected design levels (see Section 3.2) on the 1st August 2008. Subsequently the levels of nutrients and salinity were monitored and adjusted at the beginning of each calendar month throughout the study period to maintain the desired concentration (Table 3.9). As per the acclimatisation period, the microcosms were not supplied with nutrients when the plants were going dormant and over the winter months between October and April.

Figure 3.17 illustrates the layout of the microcosms and the nutrient and salinity concentrations from August 2008 to November 2010.

Date	Microcosm Number	Nitrogen			Phosphorous			Potassium		
		Mg/l	Equivalent to		Mg/l	Equivalent to		Mg/l	Equivalent to	
			g/m^2	kg/ha		g/m^2	kg/ha		g/m^2	kg/ha
1^{st} August 2008	1, 5, 6, 7, 8, 9, 13, 14, 15, 16	10	2.603	26.031	3.333	0.868	8.677	5.542	1.443	14.425
	2, 10	50	13.015	130.153	16.666	4.338	43.384	27.708	7.213	72.126
	3, 11	100	26.030	260.306	33.333	8.677	86.769	55.417	14.425	144.253
	4, 12	150	39.046	390.459	50	13.015	130.153	83.125	21.638	216.379
31^{st} August 2008	1, 5, 6, 7, 8, 9, 13, 14, 15, 16	10	2.603	26.031	3.333	0.868	8.677	5.542	1.443	14.425
	2, 10	50	13.015	130.153	16.666	4.338	43.384	27.708	7.213	72.126
	3, 11	100	26.030	260.306	33.333	8.677	86.769	55.417	14.425	144.253
	4, 12	150	39.046	390.459	50	13.015	130.153	83.125	21.638	216.379
1^{st} May 2009	1, 5, 6, 7, 8, 9, 13, 14, 15, 16	10	2.603	26.031	3.333	0.868	8.677	5.542	1.443	14.425
	2, 10	50	13.015	130.153	16.666	4.338	43.384	27.708	7.213	72.126
	3, 11	100	26.030	260.306	33.333	8.677	86.769	55.417	14.425	144.253
	4, 12	150	39.046	390.459	50	13.015	130.153	83.125	21.638	216.379
31^{st} May 2009	1, 5, 6, 7, 8, 9, 13, 14, 15, 16	10	2.603	26.031	3.333	0.868	8.677	5.542	1.443	14.425
	2, 10	50	13.015	130.153	16.666	4.338	43.384	27.708	7.213	72.126
	3, 11	100	26.030	260.306	33.333	8.677	86.769	55.417	14.425	144.253
	4, 12	150	39.046	390.459	50	13.015	130.153	83.125	21.638	216.379
30^{th} June 2009	1, 5, 6, 7, 8, 9, 13, 14, 15, 16	10	2.603	26.031	3.333	0.868	8.677	5.542	1.443	14.425
	2, 10	50	13.015	130.153	16.666	4.338	43.384	27.708	7.213	72.126
	3, 11	100	26.030	260.306	33.333	8.677	86.769	55.417	14.425	144.253
	4, 12	150	39.046	390.459	50	13.015	130.153	83.125	21.638	216.379
1^{st} August 2009	1, 5, 6, 7, 8, 9, 13, 14, 15, 16	10	2.603	26.031	3.333	0.868	8.677	5.542	1.443	14.425
	2, 10	50	13.015	130.153	16.666	4.338	43.384	27.708	7.213	72.126
	3, 11	100	26.030	260.306	33.333	8.677	86.769	55.417	14.425	144.253
	4, 12	150	39.046	390.459	50	13.015	130.153	83.125	21.638	216.379
1^{st} September 2009	1, 5, 6, 7, 8, 9, 13, 14, 15, 16	10	2.603	26.031	3.333	0.868	8.677	5.542	1.443	14.425
	2, 10	50	13.015	130.153	16.666	4.338	43.384	27.708	7.213	72.126
	3, 11	100	26.030	260.306	33.333	8.677	86.769	55.417	14.425	144.253
	4, 12	150	39.046	390.459	50	13.015	130.153	83.125	21.638	216.379
1^{st} May 2010	1, 5, 6, 7, 8, 9, 13, 14, 15, 16	10	2.603	26.031	3.333	0.868	8.677	5.542	1.443	14.425
	2, 10	50	13.015	130.153	16.666	4.338	43.384	27.708	7.213	72.126
	3, 11	100	26.030	260.306	33.333	8.677	86.769	55.417	14.425	144.253
	4, 12	150	39.046	390.459	50	13.015	130.153	83.125	21.638	216.379
31^{st} May 2010	1, 5, 6, 7, 8, 9, 13, 14, 15, 16	10	2.603	26.031	3.333	0.868	8.677	5.542	1.443	14.425
	2, 10	50	13.015	130.153	16.666	4.338	43.384	27.708	7.213	72.126
	3, 11	100	26.030	260.306	33.333	8.677	86.769	55.417	14.425	144.253
	4, 12	150	39.046	390.459	50	13.015	130.153	83.125	21.638	216.379
1^{st} July 2010	1, 5, 6, 7, 8, 9, 13, 14, 15, 16	10	2.603	26.031	3.333	0.868	8.677	5.542	1.443	14.425
	2, 10	50	13.015	130.153	16.666	4.338	43.384	27.708	7.213	72.126
	3, 11	100	26.030	260.306	33.333	8.677	86.769	55.417	14.425	144.253
	4, 12	150	39.046	390.459	50	13.015	130.153	83.125	21.638	216.379
1^{st} August 2010	1, 5, 6, 7, 8, 9, 13, 14, 15, 16	10	2.603	26.031	3.333	0.868	8.677	5.542	1.443	14.425
	2, 10	50	13.015	130.153	16.666	4.338	43.384	27.708	7.213	72.126
	3, 11	100	26.030	260.306	33.333	8.677	86.769	55.417	14.425	144.253
	4, 12	150	39.046	390.459	50	13.015	130.153	83.125	21.638	216.379
1^{st} September 2010	1, 5, 6, 7, 8, 9, 13, 14, 15, 16	10	2.603	26.031	3.333	0.868	8.677	5.542	1.443	14.425
	2, 10	50	13.015	130.153	16.666	4.338	43.384	27.708	7.213	72.126
	3, 11	100	26.030	260.306	33.333	8.677	86.769	55.417	14.425	144.253
	4, 12	150	39.046	390.459	50	13.015	130.153	83.125	21.638	216.379

Table 3.9: Levels of Nutrients Supplied to Each Microcosm During the Treatment Period.

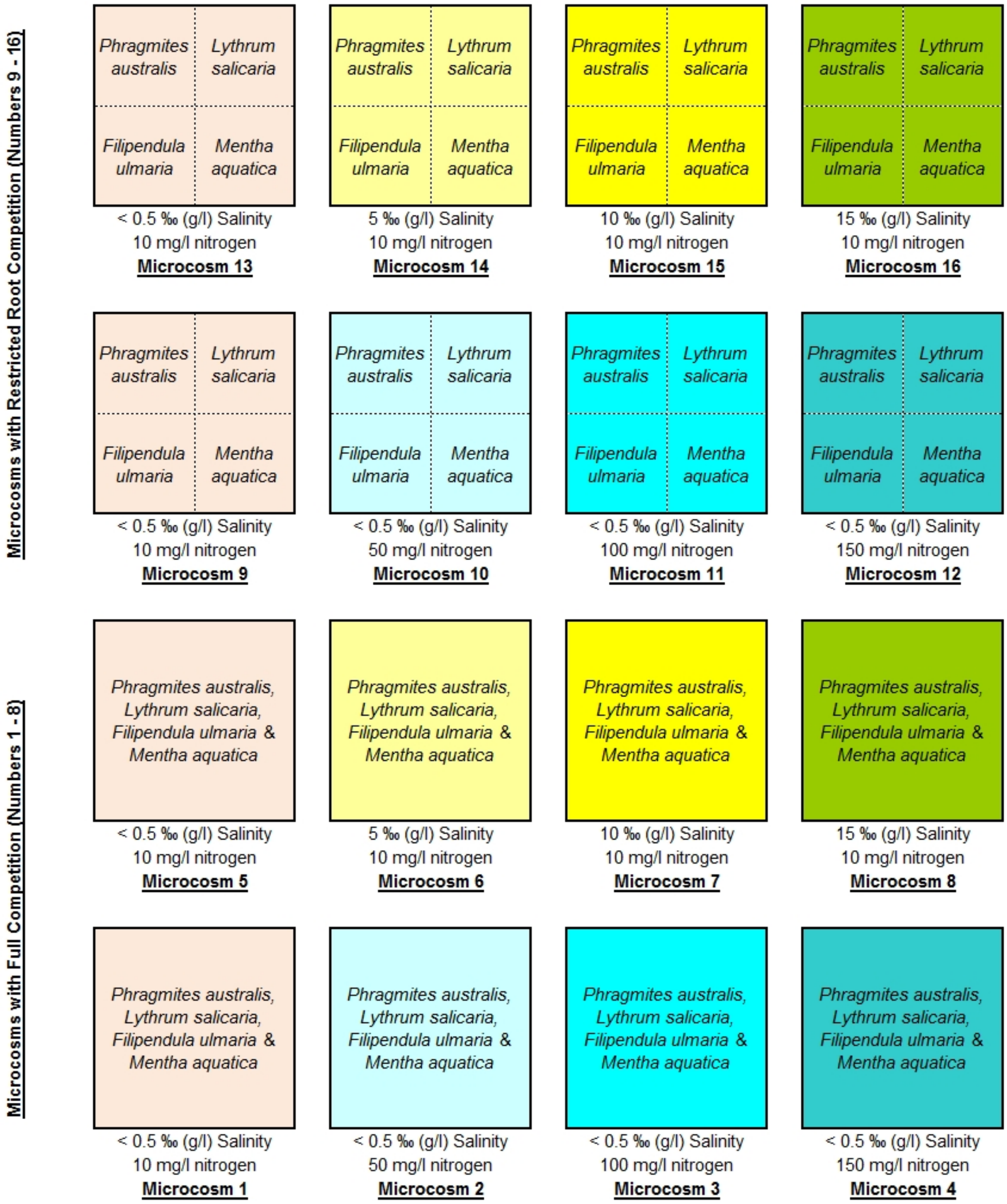


Figure 3.17: Representative Layout of the Microcosms and the Plant Food and Salinity Levels from August 2008 to November 2010.

3.8 Measurements and Harvesting

3.8.1 Measurements during the Operational Phase

3.8.1.1 Water Usage

During the operational phases of the study, the monthly water usage rates were calculated, when the microcosms were artificially watered via a hose pipe, which during the summer months occurred up to four times per month.

Prior to the microcosms being watered, the depth of the water was measured using a rule via the central water level monitoring tube. The volume of water used since the microcosm was last watered was calculated and hence how much water was required to refill the microcosm. The amount of water required to return the level to the starting datum was calculated using the known porosity rates of the un-vegetated media, and the known circumference of the microcosm at the different depths. A table was created which detailed the water volume required at the various depths (Table 3.10), the values from which, when combined with the recorded precipitation input, enabled the total monthly water use rate to be determined.

Water Depth (mm)	Water Required to Return the Depth to 610 mm (L)	Water Depth (mm)	Water Required to Return the Depth to 610 mm (L)	Water Depth (mm)	Water Required to Return the Depth to 610 mm (L)	Water Depth (mm)	Water Required to Return the Depth to 610 mm (L)	Water Depth (mm)	Water Required to Return the Depth to 610 mm (L)	Water Depth (mm)	Water Required to Return the Depth to 610 mm (L)	Water Depth (mm)	Water Required to Return the Depth to 610 mm (L)	Water Depth (mm)	Water Required to Return the Depth to 610 mm (L)
610	0.0000	529	43.6213	448	66.2836	367	80.2571	286	94.2306	205	108.2041	124	122.1776	43	136.1511
609	0.5385	528	44.1599	447	66.4562	366	80.4296	285	94.4031	204	108.3766	123	122.3501	42	136.3236
608	1.0771	527	44.6984	446	66.6287	365	80.6021	284	94.5756	203	108.5491	122	122.5226	41	136.4961
607	1.6156	526	45.2369	445	66.8012	364	80.7747	283	94.7481	202	108.7216	121	122.6951	40	136.6686
606	2.1541	525	45.7755	444	66.9737	363	80.9472	282	94.9207	201	108.8941	120	122.8676	39	136.8411
605	2.6927	524	46.3140	443	67.1462	362	81.1197	281	95.0932	200	109.0666	119	123.0401	38	137.0136
604	3.2312	523	46.8525	442	67.3187	361	81.2922	280	95.2657	199	109.2392	118	123.2126	37	137.1861
603	3.7697	522	47.3911	441	67.4912	360	81.4647	279	95.4382	198	109.4117	117	123.3852	36	137.3586
602	4.3083	521	47.9296	440	67.6637	359	81.6372	278	95.6107	197	109.5842	116	123.5577	35	137.5311
601	4.8468	520	48.4681	439	67.8363	358	81.8097	277	95.7832	196	109.7567	115	123.7302	34	137.7037
600	5.3853	519	49.0067	438	68.0088	357	81.9822	276	95.9557	195	109.9292	114	123.9027	33	137.8762
599	5.9239	518	49.5452	437	68.1813	356	82.1548	275	96.1282	194	110.1017	113	124.0752	32	138.0487
598	6.4624	517	50.0838	436	68.3538	355	82.3273	274	96.3008	193	110.2742	112	124.2477	31	138.2212
597	7.0010	516	50.6223	435	68.5263	354	82.4998	273	96.4733	192	110.4467	111	124.4202	30	138.3937
596	7.5395	515	51.1608	434	68.6988	353	82.6723	272	96.6458	191	110.6193	110	124.5927	29	138.5662
595	8.0780	514	51.6994	433	68.8713	352	82.8448	271	96.8183	190	110.7918	109	124.7653	28	138.7387
594	8.6166	513	52.2379	432	69.0438	351	83.0173	270	96.9908	189	110.9643	108	124.9378	27	138.9112
593	9.1551	512	52.7764	431	69.2163	350	83.1898	269	97.1633	188	111.1368	107	125.1103	26	139.0838
592	9.6936	511	53.3150	430	69.3889	349	83.3623	268	97.3358	187	111.3093	106	125.2828	25	139.2563
591	10.2322	510	53.8535	429	69.5614	348	83.5349	267	97.5083	186	111.4818	105	125.4553	24	139.4288
590	10.7707	509	54.0838	428	69.7339	347	83.7074	266	97.6808	185	111.6543	104	125.6278	23	139.6013
589	11.3092	508	54.3141	427	69.9064	346	83.8799	265	97.8534	184	111.8268	103	125.8003	22	139.7738
588	11.8478	507	54.5445	426	70.0789	345	84.0524	264	98.0259	183	111.9994	102	125.9728	21	139.9463
587	12.3863	506	54.7748	425	70.2514	344	84.2249	263	98.1984	182	112.1719	101	126.1453	20	140.1188
586	12.9248	505	55.0051	424	70.4239	343	84.3974	262	98.3709	181	112.3444	100	126.3179	19	140.2913
585	13.4634	504	55.2354	423	70.5964	342	84.5699	261	98.5434	180	112.5169	99	126.4904	18	140.4639
584	14.0019	503	55.4658	422	70.7690	341	84.7424	260	98.7159	179	112.6894	98	126.6629	17	140.6364
583	14.5404	502	55.6961	421	70.9415	340	84.9150	259	98.8884	178	112.8619	97	126.8354	16	140.8089
582	15.0790	501	55.9264	420	71.1140	339	85.0875	258	99.0609	177	113.0344	96	127.0079	15	140.9814
581	15.6175	500	56.1567	419	71.2865	338	85.2600	257	99.2335	176	113.2069	95	127.1804	14	141.1539
580	16.1560	499	56.3871	418	71.4590	337	85.4325	256	99.4060	175	113.3795	94	127.3529	13	141.3264
579	16.6946	498	56.6174	417	71.6315	336	85.6050	255	99.5785	174	113.5520	93	127.5254	12	141.4989
578	17.2331	497	56.8477	416	71.8040	335	85.7775	254	99.7510	173	113.7245	92	127.6980	11	141.6714
577	17.7717	496	57.0780	415	71.9765	334	85.9500	253	99.9235	172	113.8970	91	127.8705	10	141.8440
576	18.3102	495	57.3084	414	72.1491	333	86.1225	252	100.0960	171	114.0695	90	128.0430	9	142.0165
575	18.8487	494	57.5387	413	72.3216	332	86.2950	251	100.2685	170	114.2420	89	128.2155	8	142.1890
574	19.3873	493	57.7690	412	72.4941	331	86.4676	250	100.4410	169	114.4145	88	128.3880	7	142.3615
573	19.9258	492	57.9994	411	72.6666	330	86.6401	249	100.6136	168	114.5870	87	128.5605	6	142.5340
572	20.4643	491	58.2297	410	72.8391	329	86.8126	248	100.7861	167	114.7595	86	128.7330	5	142.7065
571	21.0029	490	58.4600	409	73.0116	328	86.9851	247	100.9586	166	114.9321	85	128.9055	4	142.8790
570	21.5414	489	58.6903	408	73.1841	327	87.1576	246	101.1311	165	115.1046	84	129.0781	3	143.0515
569	22.0799	488	58.9207	407	73.3566	326	87.3301	245	101.3036	164	115.2771	83	129.2506	2	143.2240
568	22.6185	487	59.1510	406	73.5292	325	87.5026	244	101.4761	163	115.4496	82	129.4231	1	143.3966
567	23.1570	486	59.3813	405	73.7017	324	87.6751	243	101.6486	162	115.6221	81	129.5956	0	143.5691
566	23.6955	485	59.6116	404	73.8742	323	87.8477	242	101.8211	161	115.7946	80	129.7681		
565	24.2341	484	59.8420	403	74.0467	322	88.0202	241	101.9937	160	115.9671	79	129.9406		
564	24.7726	483	60.0723	402	74.2192	321	88.1927	240	102.1662	159	116.1396	78	130.1131		
563	25.3111	482	60.3026	401	74.3917	320	88.3652	239	102.3387	158	116.3122	77	130.2856		
562	25.8497	481	60.5329	400	74.5642	319	88.5377	238	102.5112	157	116.4847	76	130.4582		
561	26.3882	480	60.7633	399	74.7367	318	88.7102	237	102.6837	156	116.6572	75	130.6307		
560	26.9267	479	60.9358	398	74.9092	317	88.8827	236	102.8562	155	116.8297	74	130.8032		
559	27.4653	478	61.1083	397	75.0818	316	89.0552	235	103.0287	154	117.0022	73	130.9757		
558	28.0038	477	61.2808	396	75.2543	315	89.2278	234	103.2012	153	117.1747	72	131.1482		
557	28.5424	476	61.4533	395	75.4268	314	89.4003	233	103.3737	152	117.3472	71	131.3207		
556	29.0809	475	61.6258	394	75.5993	313	89.5728	232	103.5463	151	117.5197	70	131.4932		
555	29.6194	474	61.7983	393	75.7718	312	89.7453	231	103.7188	150	117.6923	69	131.6657		
554	30.1580	473	61.9708	392	75.9443	311	89.9178	230	103.8913	149	117.8648	68	131.8382		
553	30.6965	472	62.1434	391	76.1168	310	90.0903	229	104.0638	148	118.0373	67	132.0108		
552	31.2350	471	62.3159	390	76.2893	309	90.2628	228	104.2363	147	118.2098	66	132.1833		
551	31.7736	470	62.4884	389	76.4619	308	90.4353	227	104.4088	146	118.3823	65	132.3558		
550	32.3121	469	62.6609	388	76.6344	307	90.6079	226	104.5813	145	118.5548	64	132.5283		
549	32.8506	468	62.8334	387	76.8069	306	90.7804	225	104.7538	144	118.7273	63	132.7008		
548	33.3892	467	63.0059	386	76.9794	305	90.9529	224	104.9264	143	118.8998	62	132.8733		
547	33.9277	466	63.1784	385	77.1519	304	91.1254	223	105.0989	142	119.0724	61	133.0458		
546	34.4662	465	63.3509	384	77.3244	303	91.2979	222	105.2714	141	119.2449	60	133.2183		
545	35.0048	464	63.5234	383	77.4969	302	91.4704	221	105.4439	140	119.4174	59	133.3909		
544	35.5433	463	63.6960	382	77.6694	301	91.6429	220	105.6164	139	119.5899	58	133.5634		
543	36.0818	462	63.8685	381	77.8420	300	91.8154	219	105.7889	138	119.7624	57	133.7359		
542	36.6204	461	64.0410	380	78.0145	299	91.9879	218	105.9614	137	119.9349	56	133.9084		
541	37.1589	460	64.2135	379	78.1870	298	92.1605	217	106.1339	136	120.1074	55	134.0809		
540	37.6974	459	64.3860	378	78.3595	297	92.3330	216	106.3065	135	120.2799	54	134.2534		
539	38.2360	458	64.5585	377	78.5320	296	92.5055	215	106.4790	134	120.4524	53	134.4259		
538	38.7745	457	64.7310	376	78.7045	295	92.6780	214	106.6515	133	120.6250	52	134.5984		
537	39.3131	456	64.9035	375	78.8770	294	92.8505	213	106.8240	132	120.7975	51	134.7710		
536	39.8516	455	65.0761	374	79.0495	293	93.0230	212	106.9965	131	120.9700	50	134.9435		
535	40.3901	454	65.2486	373	79.2221	292	93.1955	211	107.1690	130	121.1425	49	135.1160		
534	40.9287	453	65.4211	372	79.3946	291	93.3680	210	107.3415	129	121.3150	48	135.2885		
533	41.4672	452	65.5936	371	79.5671	290	93.5406	209	107.5140	128	121.4875	47	135.4610		
532	42.0057	451	65.7661	370	79.7396	289	93.7131	208	107.6866	127	121.6600	46	135.6335		
531	42.5443	450	65.9386	369	79.9121	288	93.8856	207	107.8591	126	121.8325	45	135.8060		
530	43.0828	449	66.1111	368	80.0846	287	94.0581	206	108.0316	125	122.0051	44	135.9785		

Table3.10: Water Required to Return the Water Level to the Top of the Microcosm at the Various Depths.

3.8.1.2 Chemical measurements

The salinity (‰) was measured monthly using an Aqua Medic handheld field refractometer (Aqua Medic 2014). This was undertaken to ensure that the rainfall (primarily during the winter) had not diluted the salinity within the microcosms. The salinity was measured on the surface and at the base of the microcosm. To enable the latter measurement, a sample was extracted via the water level monitoring tube using a syringe.

The pH and temperature were measured at the same time as the salinity using a Hanna water test meter, model HI98204 (Hannah Instruments 2014a). Although this model is also capable of measuring the conductivity, the salinity levels were beyond the maximum range for this meter and as such the refractometer was utilised. The meter was calibrated prior to each use using a pH 7 (Hannah Instruments 2014b) and pH 4 Buffer Solution (Hannah Instruments 2014c).

As detailed in Section 3.6, at the beginning of each month (prior to the fresh batch of nutrients being mixed) the remaining liquid within the microcosms were tested for nutrients in the form of nitrate and ammonia. These levels were measured to determine the concentration of nutrients required to return the nutrient concentrations back to the desired levels.

The nitrate, ammonia and phosphorous levels were measured using a Hach DR/2000 Direct Reading Spectrophotometer (Hach 2014) using the following methods;

- Nitrate: The cadmium reduction method (using powder pillows);
- Ammonia: The Nessler method; and,
- Phosphate: The PhosVer3 (absorbic acid) method (using powder pillows)

3.8.1.3 Vegetation Measurements

In order to monitor the community dynamics the following common measurements were taken on a monthly basis,

- height of each species (Howard 2010);
    - maximum height;
    - general height;
- area coverage of each species (Baldwin 2013). The calculation of area coverage was facilitated through the use of a quadrant divided into area grids. These parameters were measured for both;
    - within the microcosm;

- outside of the microcosm (where the foliage went beyond the width of the microcosm); and,
- as a proportion of both inside and outside coverage, so that the total area which the above ground biomass was utilising could be determined.

The methodology originally proposed for sampling the vegetation during the operational period included randomly selecting 20 stems of each species and measuring the stem widths and heights. However, when this was implemented in the field, it became apparent that measuring stems at the centre of the microcosm was not practical, as it often resulted in snapping adjacent stems. As the loss of plant stems could have affected the competition rates by creating clear areas for different species to colonise and by removing some of the plants vigour, these measurements were discontinued.

3.8.2 Measurements during the Harvesting Phase

During November 2010 after the majority of vegetation had become dormant for the winter, the microcosms were dismantled and the biomass was harvested. The harvest was undertaken in two main phases. Phase one involved harvesting the above ground biomass and phase two involved harvesting the below ground biomass.

3.8.2.1 Phase 1: Above Ground Biomass

The above ground biomass was cut at the surface media level (top of the humus layer) using standard gardening secateurs.

With regards to *Phragmites australis* and *Lythrum salicaria* the following parameters were measured for every stem:

- stem height (mm) using a flexible tape measure which could flex along the bends within the vegetation producing an accurate stem length;
- stem diameter (mm) measured 50 mm from the base using handheld callipers. This point was selected due to the presence of a variety of swellings at the base of the plant, whereas measuring the stem diameter 50 mm from the base avoided these features and provided a consistent and comparable sampling location;
- stem intactness (whether the stem was snapped or intact);
- inflorescence (whether evidence of current or historic inflorescence was present on the stem).

With regards to *Filipendula ulmaria* and *Mentha aquatica,* since the stems differed in vegetative nature to those of *Phragmites australis* and *Lythrum salicaria,* the same measurements could not be made.

The morphology of *Filipendula ulmaria* is predominantly basal leaves with a flowering stem. During the vegetative period for this species, the central leaf-stalk of the pinnate leaf remained but the leaflets were not present. Where a vegetative flowering stem was present, the same measurements as for *Phragmites australis* and *Lythrum salicaria* were taken.

The stoloniferous nature of *Mentha aquatica* restricted the entire length of the stem from being measured. This was due to the rooting being present along the stems, the ease with which the stems snapped at the rooted sections, and their intertwining hindered the identification of the individual stems. Where a flowering stem was present the same measurements as for *Phragmites australis* and *Lythrum salicaria* were made.

For each species within each microcosm, the volume (ml) of all of the stems combined (excluding the leaf litter) was measured using the displacement method. The bundles of stems were placed into a vessel and the displaced water was then collected and measured to obtain the volume of the stems.

The dry weight (gms) of the combined stems for each individual species in each microcosm was also measured. To enable this, the samples were cut into <20 mm sections, which were placed on a mesh tray (to allow air circulation) inside aluminium trays. These were then dried in an oven set to 80^{o}C for 6 hours (Faithfull, 2002). The samples were then ground up and placed back into the aluminium tray and dried for a further 2 hours at 80^{o}C.

3.8.2.2 Phase 2: Below Ground Biomass

Prior to harvesting the below ground biomass, windows were cut into the sides of the microcosms to allow for the root systems and interactions to be observed and photographed (e.g. Figure 3.18). These windows were cut using a rotary cutting blade and were approximately 500 mm high by 200 mm wide. The window size was chosen as it enabled a clear view of the roots within the microcosm, and allowed for the root samples to be collected without collapsing the microcosm.

Figure 3.18: Window Cut within the Microcosm Container to View Root Distribution.

Once the root distributions had been photographed and observations made, the roots were then separated from the soil media. First, the larger roots were separated from the growing media by hand and subsequently sorted then into the different species.

The finer roots within the gravel media were then separated by using a 30 mm gauge sieve and a 15 mm gauge sieve. These size sieves allowed the 10 mm pea gravel to pass through. The roots were passed through each sieve three times which separated the majority of the roots from the gravel. Following this the gravel was placed in flowing water (in a container) and agitated every five minutes for 15 minutes, during which time the roots were collected from the water surface and from the overflow spout using a fine mesh (1mm diameter) sieve. After a period of 15 minutes no further roots were present in the gravel sample being washed. As a final check, the gravel was then re-inspected for any remaining roots. The use of flowing water and an overflow spout is described in Lauenroth & Whitman (1971).

A different methodology had to be used for separating the roots from the humus layer. Due to the binding nature of the humus to the roots, and the fine and fragile nature of the roots within this layer (generally only the coarser roots extended into the gravel layer) as sieving was not effective. Also due to the low density of the humus, predominantly humus and leaf litter material in this layer, the water separation method could also not be used as this material also floated in the water. Consequently, the roots within the humus layer were separated by hand using tweezers and a small paintbrush.

The separated roots were subject to a final examination by hand to ensure that no contaminants remained (i.e. growing media), and then their dry weight was measured using the same methodology as described for the above ground biomass. Due to the fine nature of the roots, it was not feasible to measure their volumes.

3.9 Statistical Analysis

When the measured vegetation parameters such as stem heights and widths were plotted the resulting distributions were skewed from the normal (Figure 3.19 and Figure 3.20). Thus to allow for parametric analysis to be undertaken (i.e. ANOVA), the data was transformed into a normal distribution using a logarithmic transformation of 10 (Fowler *et al*., 1999; Pallant, 2010).

Where more than two samples were being analysed, a One Way Analysis of Variance (ANOVA) test was undertaken (Fowler *et al*., 1999; Pallant, 2010).

Where two samples were being analysed, an independent samples *t* test was undertaken (Fowler *et al*., 1999; Pallant, 2010; Wildi, 2010). In unison with the independent samples *t* test, the Levene's tests for equality of variances was used to confirm that the data did not violate the assumption of equal variances, and effect of size was calculated using Cohan's d ETA squared. (Cohen 1988; Pallant, 2010). Cohen (1988) lists the ETA squared values as:

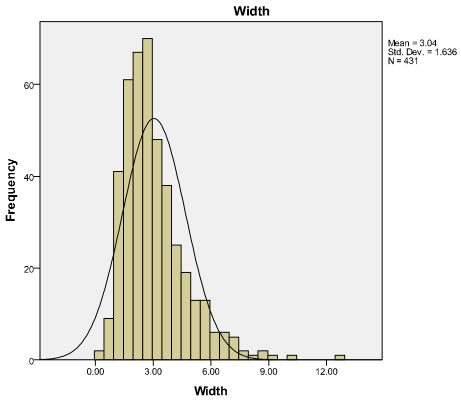
- 0.01 = Small Effect;
- 0.06 = Moderate Effect; and,
- 0.14 = Large Effect.

The thresholds chosen for the analysis to be statistically significant were (Fowler *et al*., 1999):

- P <0.05 = Significant;
- P <0.01 = Highly Significant; and,
- P <0.001 = Very Highly Significant.

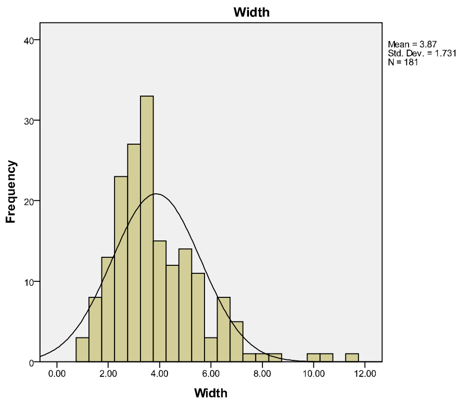
The statistical analysis was undertaken using the PAWS Statistics 18 software (IBM, 2014).

The next section (Section 4) details the results obtained from the microcosm study during the acclimatisation period, the treatment period and the post treatment harvesting. This section also provides the references to where the relevant result tables and charts are provided within the appendices. Section 4 includes a discussion on the findings and provides general recommendations from the microcosm study.



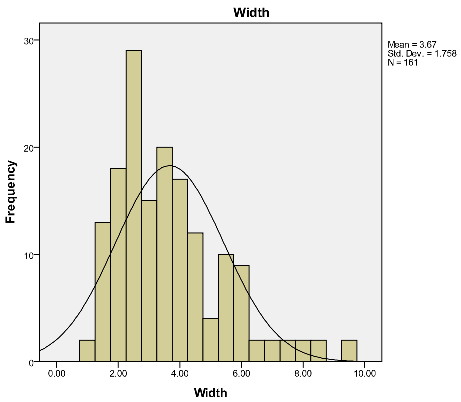
N	Valid	431
	Missing	0
Mean		3.0445
Std. Error of Mean		.07880
Median		2.7000
Std. Deviation		1.63587
Variance		2.676
Range		12.30
Minimum		.20
Maximum		12.50

10 mg/l Nitrogen and <0.05 ‰ Salinity (Microcosm 1 and 5)



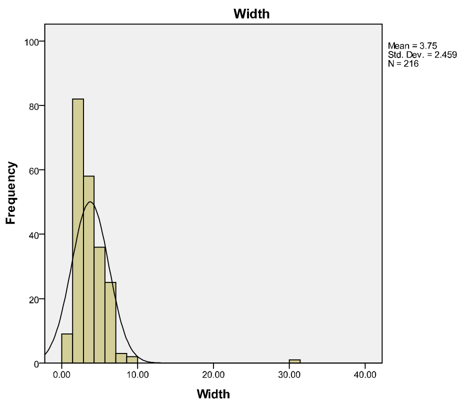
N	Valid	181
	Missing	0
Mean		3.8740
Std. Error of Mean		.12867
Median		3.5000
Std. Deviation		1.73110
Variance		2.997
Range		10.50
Minimum		1.00
Maximum		11.50

50 mg/l Nitrogen and <0.05 ‰ Salinity (Microcosm 2)



N	Valid	161
	Missing	0
Mean		3.6665
Std. Error of Mean		.13855
Median		3.3000
Std. Deviation		1.75805
Variance		3.091
Range		8.50
Minimum		1.00
Maximum		9.50

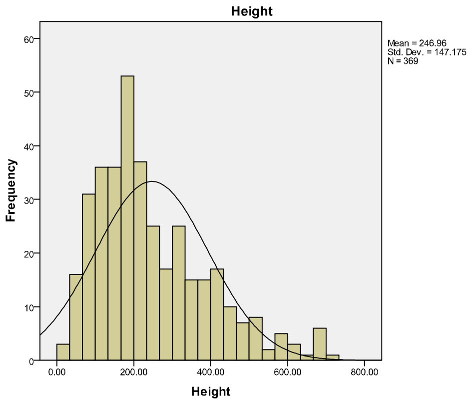
100 mg/l Nitrogen and <0.05 ‰ Salinity (Microcosm 3)



N	Valid	216
	Missing	0
Mean		3.7542
Std. Error of Mean		.16728
Median		3.3000
Std. Deviation		2.45856
Variance		6.045
Range		29.30
Minimum		.70
Maximum		30.00

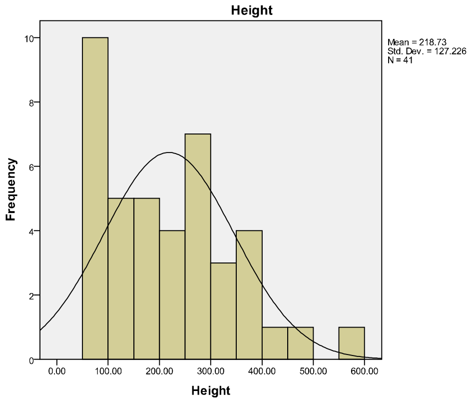
150 mg/l Nitrogen and <0.05 ‰ Salinity (Microcosm 4)

Figure 3.19: *Lythrum salicaria* Histogram and Data of Stem Widths with Increasing Nutrients for Microcosms 1-5 with Full Root Competition



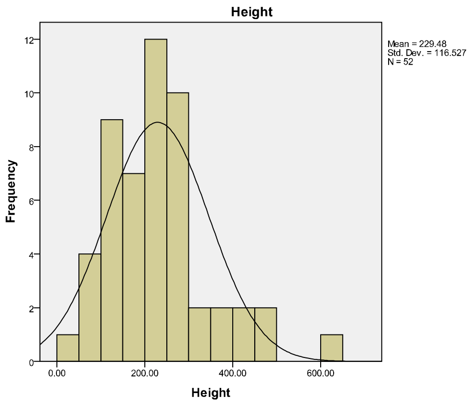
N	Valid	369
	Missing	0
Mean		246.9621
Std. Error of Mean		7.66165
Median		207.0000
Std. Deviation		147.17547
Variance		21660.618
Range		709.00
Minimum		14.00
Maximum		723.00

10 mg/l Nitrogen and <0.05 ‰ Salinity (Microcosm 1 and 5)



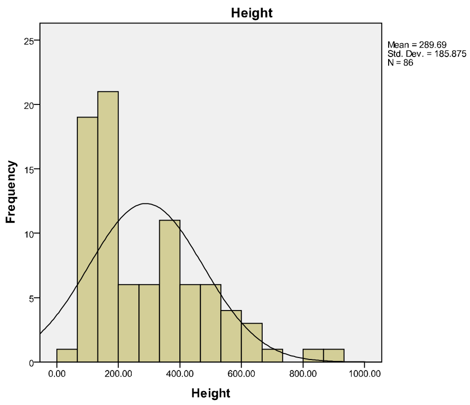
N	Valid	41
	Missing	0
Mean		218.7317
Std. Error of Mean		19.86936
Median		205.0000
Std. Deviation		127.22598
Variance		16186.451
Range		530.00
Minimum		63.00
Maximum		593.00

50 mg/l Nitrogen and <0.05 ‰ Salinity (Microcosm 2)



N	Valid	52
	Missing	0
Mean		229.4808
Std. Error of Mean		16.15938
Median		228.0000
Std. Deviation		116.52695
Variance		13578.529
Range		581.00
Minimum		40.00
Maximum		621.00

100 mg/l Nitrogen and <0.05 ‰ Salinity (Microcosm 3)



N	Valid	86
	Missing	0
Mean		289.6860
Std. Error of Mean		20.04340
Median		220.5000
Std. Deviation		185.87480
Variance		34549.441
Range		813.00
Minimum		63.00
Maximum		876.00

150 mg/l Nitrogen and <0.05 ‰ Salinity (Microcosm 4)

Figure 3.20: *Mentha aquatica* Histogram and Data of Stem Heights with Increasing Nutrients for Microcosms 1-5 with Full Root Competition

4. MICROCOSM STUDY RESULTS, DISCUSSION AND RECOMENDATIONS

Section 3 described the microcosm experiments designed to explore the interaction of the four vegetation species selected for their biodiversity enhancement potential. Section 4.1 presents the results obtained from the data collected both during the experimental period and at the end of the study.

Section 4.2 commences with an overview of each hypothesis and an outline of the analysis undertaken for each hypothesis including the relevant tables and graphs for each hypothesis. .

Section 4.3 then goes on to discus each of the four vegetation species used within the study and discusses the results obtained with respect to Hypotheses 1 to 6. Where relevant to the study, the results are compared to the findings of other researchers. As Hypothesis 7 and 8 are not species specific, they are discussed separately at the end of Section 4.3.

An overview of each of the hypothesis posed for the microcosm study in Section 1 and whether the hypothesis has been proved or disproved is provided in Section 4.4.

Section 4.5 provides general recommendations from the microcosm study.

4.1 Microcosm Study Results

4.1.1 Acclimatisation and Establishment Period: July 2007 to August 2008

The acclimatisation and establishment period lasted from when the microcosms were planted on 28th and 29th July 2007, until August 2008.

The total monthly water input during the acclimatisation period, comprising the sum of the added water and the rainfall, is presented in Appendix 3. An example of the data collected is presented in Table 4.1. A record was maintained throughout this period of vegetation heights and area coverage for all of the microcosms and this can be found in Appendix 4, an example is presented in Table 4.2.

			Total Water Added per Month (Litres)											
Year	**Microcosm Number**		**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**
2007	1	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	27.47	42.54	33.93	5.92	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	54.39	59.62	56.98	33.17	31.02
	2	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	27.47	40.93	32.85	7.00	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	54.39	58.00	55.90	34.25	31.02
	3	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	23.70	36.62	29.62	4.85	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	50.62	53.69	52.67	32.10	31.02
	4	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	32.85	51.16	40.93	7.00	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	59.78	68.23	63.98	34.25	31.02
	5	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	33.93	50.08	39.85	8.08	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	60.85	67.16	62.90	35.33	31.02
	6	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	24.77	37.16	29.08	4.85	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	51.70	54.23	52.13	32.10	31.02
	7	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	27.47	41.47	33.93	5.92	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	54.39	58.54	56.98	33.17	31.02
	8	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	22.62	35.54	28.54	5.92	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	49.55	52.61	51.59	33.17	31.02
2008	1	Artificial Water Added	0.00	0.00	0.00	71.63	153.47	177.72	197.10	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	108.46	200.76	198.45	246.33	N/A	N/A	N/A	N/A	N/A
	2	Artificial Water Added	0.00	0.00	0.00	70.93	147.32	168.02	185.79	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	107.76	194.60	188.76	235.02	N/A	N/A	N/A	N/A	N/A
	3	Artificial Water Added	0.00	0.00	0.00	77.44	143.79	169.64	189.56	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	114.27	191.07	190.37	238.79	N/A	N/A	N/A	N/A	N/A
	4	Artificial Water Added	0.00	0.00	0.00	73.47	158.90	178.79	194.95	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	110.30	206.19	199.53	244.17	N/A	N/A	N/A	N/A	N/A
	5	Artificial Water Added	0.00	0.00	0.00	68.47	152.24	171.79	188.49	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	105.30	199.52	192.53	237.71	N/A	N/A	N/A	N/A	N/A
	6	Artificial Water Added	0.00	0.00	0.00	71.09	148.17	182.02	199.26	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	107.92	195.45	202.76	248.48	N/A	N/A	N/A	N/A	N/A
	7	Artificial Water Added	0.00	0.00	0.00	78.07	155.78	182.56	195.41	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	114.91	203.06	203.30	244.63	N/A	N/A	N/A	N/A	N/A
	8	Artificial Water Added	0.00	0.00	0.00	73.24	155.47	171.79	188.49	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	110.08	202.76	192.53	237.71	N/A	N/A	N/A	N/A	N/A

Table 4.1: Microcosms 1-8 Water Input during the Acclimatisation and Establishment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1022	749	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	723	608	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	881	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	655	0	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	501	438	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	379	390	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	572	337	73
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	455	162	35
2008	*Phragmites australis*	Maximum Height	0	0	0	182	891	1281	1514	1644	N/A	N/A	N/A	N/A
		General Height	0	0	0	107	793	1109	1291	1397	N/A	N/A	N/A	N/A
	Lythrum salicaria	Maximum Height	0	0	89	165	621	1437	1651	1948	N/A	N/A	N/A	N/A
		General Height	0	0	58	142	516	1280	1549	1748	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Maximum Height	0	0	52	260	737	1443	1493	1535	N/A	N/A	N/A	N/A
		General Height	0	0	42	112	560	1207	1277	1329	N/A	N/A	N/A	N/A
	Mentha aquatica	Maximum Height	71	70	70	100	214	444	526	613	N/A	N/A	N/A	N/A
		General Height	41	37	36	67	199	292	318	328	N/A	N/A	N/A	N/A

Table 4.2: Microcosm 1 Vegetation Heights during the Acclimatisation and Establishment Period.

4.1.2 Full Competition Microcosms: August 2008 to November 2010

The study period during which nutrient and salinity treatments were undertaken lasted from the end of the acclimatisation and establishment period, at the start of August 2008, until November 2010. Throughout the duration of the experiment water input, the general and maximum heights and area coverage for each of the four study species, in each of the microcosms, was monitored as described in Section 3.8.

Data for the full competition nutrient studies are presented in Appendix 5 (water input) and Appendix 6 (vegetation measurements), and for the salinity studies in Appendix 7 (water input) and Appendix 8 (vegetation measurements). An example of the water input data during the treatment period is presented in Table 4.3, and Table 4.4 provides an example for microcosm 1 of the vegetation measurements during the treatment period.

			Total Water Added per Month (Litres)											
Year	Microcosm Number		January	February	March	April	May	June	July	August	September	October	November	December
2008	1	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	181.13	104.48	75.24	35.54	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	233.42	158.44	108.90	79.43	28.27
	2	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	171.69	94.78	78.80	31.24	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	223.99	148.74	112.45	75.13	28.27
	3	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	178.89	93.71	79.16	30.16	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	231.18	147.67	112.82	74.05	28.27
	4	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	182.46	103.94	70.47	28.54	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	234.75	157.90	104.13	72.43	28.27
2009	1	Artificial Water Added	0.00	0.00	0.00	87.68	160.85	191.72	213.25	201.41	107.71	90.90	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	107.61	186.59	217.78	269.20	225.59	115.57	117.67	52.83	30.10
	2	Artificial Water Added	0.00	0.00	0.00	84.15	164.52	209.41	231.82	209.87	120.63	90.69	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	104.08	190.27	235.47	287.78	234.05	128.49	117.45	52.83	30.10
	3	Artificial Water Added	0.00	0.00	0.00	67.24	181.04	210.40	235.96	216.71	100.71	65.39	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	87.16	206.78	236.47	291.92	240.89	108.57	92.16	52.83	30.10
	4	Artificial Water Added	0.00	0.00	0.00	72.61	193.27	242.64	265.48	239.31	112.55	74.23	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	92.54	219.01	268.71	321.43	263.49	120.42	101.00	52.83	30.10
2010	1	Artificial Water Added	0.00	0.00	0.00	80.93	162.65	192.26	207.41	194.41	110.94	64.90	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	102.26	175.90	218.75	228.84	247.30	141.85	92.42	N/A	N/A
	2	Artificial Water Added	0.00	0.00	0.00	79.20	170.30	192.26	215.33	200.34	118.48	69.39	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	100.53	183.55	218.75	236.76	253.22	149.39	96.91	N/A	N/A
	3	Artificial Water Added	0.00	0.00	0.00	64.62	144.25	197.64	219.78	206.03	103.40	47.93	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	85.95	157.50	224.14	241.22	258.91	134.31	75.45	N/A	N/A
	4	Artificial Water Added	0.00	0.00	0.00	74.31	159.78	215.71	238.19	218.78	103.94	47.93	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	95.64	173.02	242.21	259.63	271.67	134.85	75.45	N/A	N/A

Table 4.3: Microcosms 1-4 Water Input during the Nutrient Treatment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1644	1619	1575	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1397	1426	1428	0	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1948	1919	1732	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1748	1678	1433	0	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1535	1474	1367	401	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1329	1458	1354	296	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	613	618	633	624	76
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	328	341	299	227	50
2009	*Phragmites australis*	Maximum Height	0	0	0	149	687	1465	1606	1693	1731	1647	0	0
		General Height	0	0	0	81	560	1214	1436	1489	1492	1459	0	0
	Lythrum salicaria	Maximum Height	0	0	0	43	563	1538	1567	1621	1673	1624	0	0
		General Height	0	0	0	36	518	1287	1484	1542	1530	1355	0	0
	Filipendula ulmaria	Maximum Height	0	0	0	224	497	1018	1431	1462	1344	708	0	0
		General Height	0	0	0	122	394	688	916	950	935	681	0	0
	Mentha aquatica	Maximum Height	66	62	57	146	136	386	776	888	968	771	706	99
		General Height	43	43	42	58	74	137	237	514	606	618	588	77
2010	*Phragmites australis*	Maximum Height	0	0	0	170	772	1012	1488	1597	1641	1567	0	N/A
		General Height	0	0	0	96	473	814	1196	1268	1310	1313	0	N/A
	Lythrum salicaria	Maximum Height	0	0	0	49	512	927	1164	1468	1472	1460	0	N/A
		General Height	0	0	0	44	286	766	989	1130	1130	1061	0	N/A
	Filipendula ulmaria	Maximum Height	0	0	88	176	507	709	1113	1351	762	801	794	N/A
		General Height	0	0	49	149	469	537	747	766	725	720	719	N/A
	Mentha aquatica	Maximum Height	98	92	91	89	94	142	562	700	609	588	173	N/A
		General Height	69	62	50	48	62	106	229	312	305	273	112	N/A

Table 4.4: Microcosm 1 Vegetation Heights during the Nutrient Treatment Period.

4.1.3 Restricted Root Competition: August 2008 to November 2010

In parallel with the full competition study, the experiment investigating restricted root competition was undertaken with both varied salinity and varied nutrient levels, over the same period. The same parameters were also monitored (i.e. water input, the general and maximum heights and area coverage) for each of the four study species.

The measurements for the restricted competition nutrient studies are presented in Appendix 9 (water input) and Appendix 10 (vegetation measurements), and for the salinity studies in Appendix 11 (water input) and Appendix 12 (vegetation measurements). The data provided in Appendices 9 to 12 is presented in the same format as the examples presented in Table 4.3 and Table 4.4.

4.1.4 Full Competition Microcosms: Harvest

In November 2010, the experiment was terminated and the vegetation in each of the Full Competition microcosms was harvested. For each microcosm and each of the four species, the above ground total number of stems, stem heights and widths were recorded, and the dry weight and volume of the harvested stems was determined (see Section 3.8). The measurements for each individual stem can be found within Appendix 2. Within the full competition microcosms a total of 5590 stems were harvested and measured (4055 stems from the nutrient microcosms 1 to 4 and 1535 stems from the salinity microcosms 5 to 8). The below ground biomass for each species was harvested as described in Section 3.8.

A summary of the all the above and below ground harvested measurements for the nutrient studies can be found in Appendix 13, and for the salinity studies in Appendix 14, with Table 4.5 to Table 4.7 providing examples of these data. A photographic record was also made showing the root spread at the time of harvest within each of the Full Competition microcosms. Figure 4.1 to Figure 4.3 are examples of these photographs, with the complete record presented in Appendix 15 (nutrients) and Appendix 16 (salinity).

Species	Parameter		Microcosm 1	Microcosm 2	Microcosm 3	Microcosm 4
Phragmites australis	Total Stems	Total Number of Stems	286	396	557	681
		Stems with Evidence of Previous Inflorescence	33	44	67	112
	Heights (mm)	Max Height	1721.00	1742.00	2088.00	2270.00
		Min Height	86.00	97.00	92.00	15.00
		Mean Height	796.21	863.62	1141.03	1055.19
	Widths (mm)	Max Width	5.00	4.90	6.50	6.80
		Min Width	1.40	0.90	1.30	1.20
		Mean Width	2.64	2.84	3.39	3.33
Lythrum salicaria	Total Stems	Total Number of Stems	243	181	161	216
		Stems with Evidence of Previous Inflorescence	105	90	70	81
	Heights (mm)	Max Height	1937.00	2077.00	1923.00	1867.00
		Min Height	125.00	161.00	91.00	58.00
		Mean Height	922.60	1090.13	979.32	897.00
	Widths (mm)	Max Width	8.70	11.50	9.50	30.00
		Min Width	0.80	1.00	1.00	0.70
		Mean Width	3.08	3.87	3.67	3.75
Filipendula ulmaria	Total Stems	Total Number of Stems	240	233	192	235
		Stems with Evidence of Previous Inflorescence	0	9	5	7
	Heights (mm)	Max Height	677.00	1602.00	1509.00	1416.00
		Min Height	28.00	10.00	12.00	26.00
		Mean Height	281.98	345.65	292.18	354.45
	Widths (mm)	Max Width	12.00	42.00	8.70	9.10
		Min Width	0.10	0.10	0.20	0.20
		Mean Width	1.14	1.59	1.41	1.49
Mentha aquatica	Total Stems	Total Number of Stems	255	41	52	86
		Stems with Evidence of Previous Inflorescence	54	1	6	6
	Heights (mm) *	Max Height	723.00	593.00	621.00	876.00
		Min Height	14.00	63.00	40.00	63.00
		Mean Height	277.25	218.73	229.48	289.69
	Widths (mm)	Max Width	3.80	2.00	2.40	3.00
		Min Width	0.30	0.40	0.20	0.40
		Mean Width	1.36	1.00	0.90	1.14

Notes: * = this is the length of the stoloniferous live material present and is not the height above ground as the stolons had set roots along the procumbent stems.

Table 4.5: Microcosms 1-4 Nutrient Treatment Phase with Full Competition – Stem Measurements for All Stems.

Species	Parameter	Microcosm 1	2	3	4
Phragmites australis	volume (ml)	1025.00	1930.00	3050.00	4570.00
	weight (g)	253.86	418.90	629.18	997.39
	g per ml	0.248	0.217	0.206	0.218
Lythrum salicaria	volume (ml)	1840.00	1965.00	1580.00	1873.00
	weight (g)	567.44	546.97	490.79	592.09
	g per ml	0.308	0.278	0.311	0.316
Filipendula ulmaria	volume (ml)	220.00	570.00	330.00	390.00
	weight (g)	63.45	136.49	78.77	95.97
	g per ml	0.288	0.239	0.239	0.246
Mentha aquatica	volume (ml)	345.00	18.00	21.00	47.00
	weight (g)	82.91	3.72	4.87	13.58
	g per ml	0.240	0.207	0.232	0.289

Table 4.6: Microcosms 1-4 Nutrient Treatment Phase with Full Competition – Volumes and Weights for All Stems.

Species	Microcosm Number 1	2	3	4
Phragmites australis	425.89	711.97	1159.49	2168.09
Mentha aquatica	16.88	0.7	0.85	2.12
Filipendula ulmaria	186.54	360.45	199.47	221.71
Lythrum salicaria	661.24	422.72	258.48	252.65

Table 4.7: Microcosms 1-4 Nutrient Treatment Phase with Full Competition – Weights (g) for All Roots.

Figure 4.1: Microcosm 1 *Lythrum salicaria* Root Spread

Figure 4.2: Microcosm 1 *Filipendula ulmaria* Root Spread

Figure 4.3: Microcosm 1 *Mentha aquatica* Root Spread

4.1.5 Restricted Root Competition Microcosms: Harvest

At the same time as the Full Competition microcosms were harvested, so were the Restricted Competition microcosms. The process followed the same pattern as described in Section 4.1.4.

A summary of the harvested measurements for the nutrient studies can be found in Appendix 17, and for the salinity studies in Appendix 18, with Table 4.5 to Table 4.7 providing examples of the collected data. Within the restricted competition microcosms a total of 5530 stems were harvested and measured (3611 stems from the nutrient microcosms 9 to 12 and 1919 stems from the salinity microcosms 13 to 16).

As with the Full Competition microcosms, a photographic record was made of the root spread at the time of harvest with all the images presented in Appendix 19 (nutrients) and Appendix 20 (salinity).

4.2 Microcosm Study Analysis

4.2.1 Hypothesis 1 Overview

Hypothesis 1 is:

"Where all four chosen floral species survive in the chemical concentrations studied, no single floral species will take over and oust other floral species."

This is one of the key hypothesis which the study was designed to investigate. If the floral species die or are outcompeted at the higher or lower concentrations, then incorporating them into a constructed wetland for the purpose of biodiversity enhancement would not be sustainable.

In order to disprove the hypothesis, the null hypothesis is:

"Where all four chosen floral species survive in the chemical concentrations studied, a single floral species will take over and oust the other floral species."

To test this hypothesis the area percentage coverage within the microcosms with full below and above ground competition (microcosms 1-8) was used. These microcosms were chosen as this is what would be present in a typical constructed wetland treatment system without any management strategies, i.e. root barriers, which could potentially allow biodiversity enhancing species to survive.

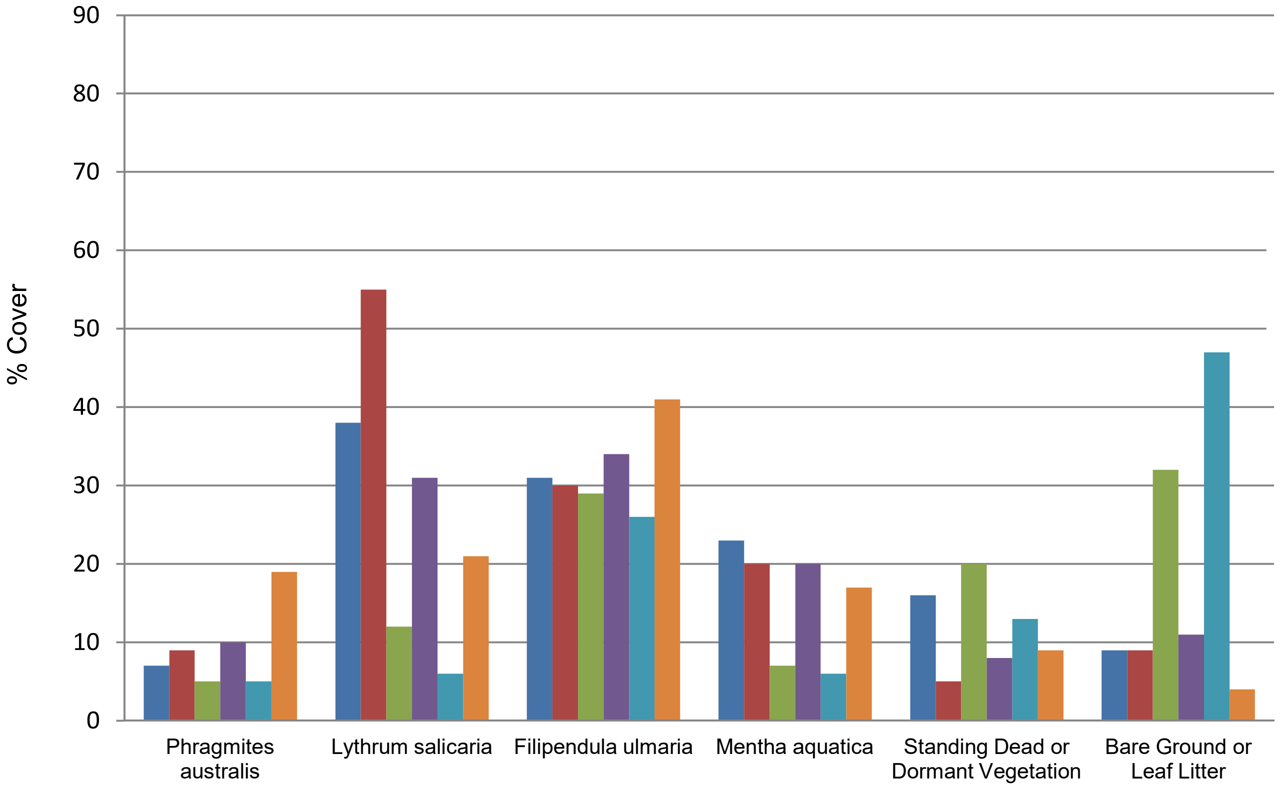
The effects of nutrient and salinity were assessed separately for Hypothesis 1. May and August were chosen for the months being assessed. These were to represent the early stages of the general flora growing season (May) and the peak flora growing season (August) when most plants are at full growth, either flowering or setting seed. The reasoning behind this was to determine if the life strategies of the different species allowed for the earlier growing plants to commence their life cycles prior to the more dominant species increasing their area coverage post dormancy season.

Due to the change in vegetation sampling at the start of the experiment (i.e. the ceasing of measuring individual stems to avoid any anthropogenic effects from snapped stems, Section 3), only the area coverage measurement was available for this hypothesis during the treatment period. Consequently, no statistical analysis could be undertaken for Hypothesis 1, and the hence the evaluation is predominantly qualitative.

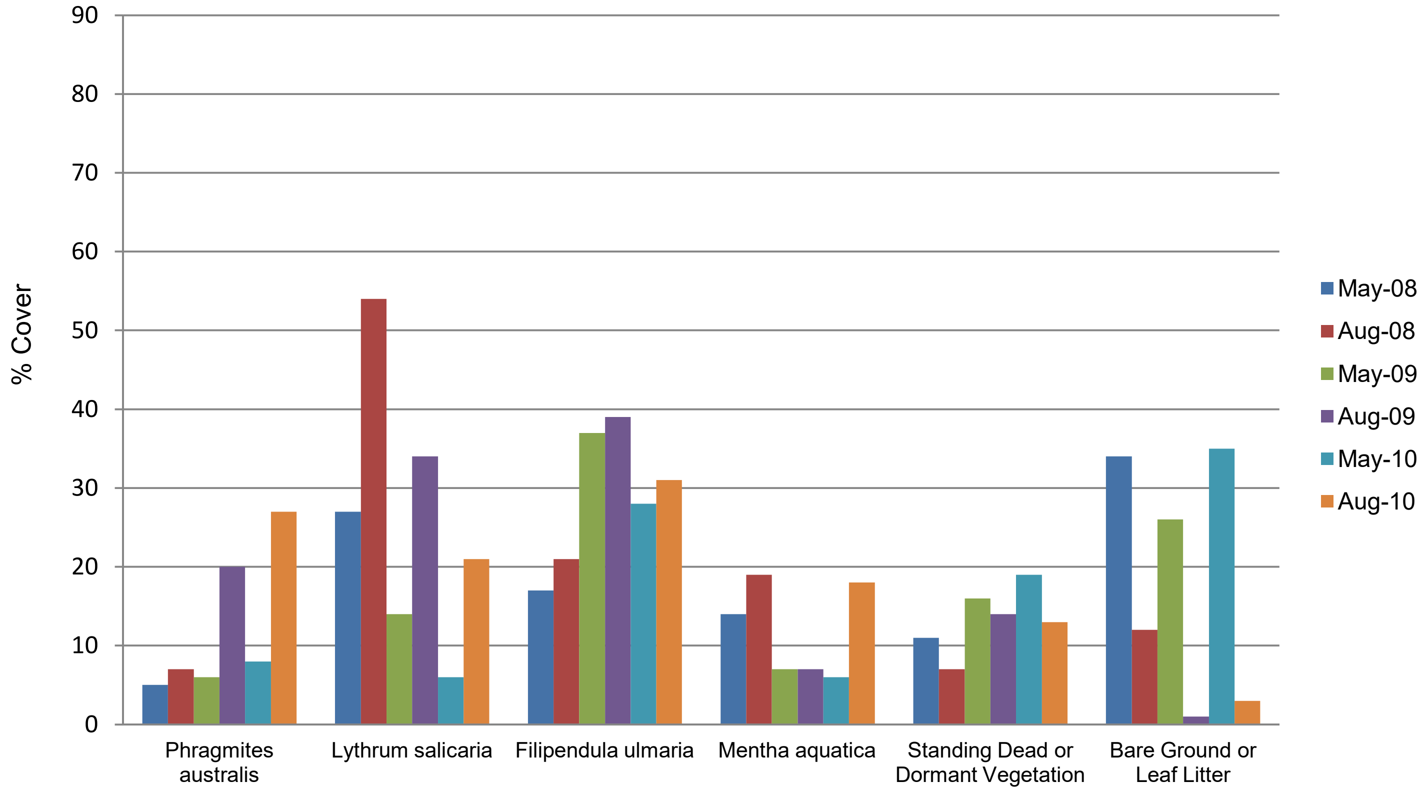
From the percentage cover results detailed within Tables A4.9 - A4.16 (area coverage for Microcosms 1 - 8 during the acclimatisation period, Appendix 4), Tables A6.5 - A6.8 (area coverage for Microcosms 1 - 4 during the nutrient treatment period, Appendix 6) and Tables A8.5 – A8.8 (area coverage for Microcosms 5 - 8 during the salinity treatment period, Appendix 8), the results for May and August each year were extracted and are presented in Table 4.8 and Table 4.9. Bar Graphs illustrating the pattern of growth within these microcosms for May and August each year are illustrated on Figure 4.4 and Figure 4.5.

Microcosm Number	Chemical Range	Species	Location	% Cover 2008		% Cover 2009		% Cover 2010	
				May	August	May	August	May	August
1 (Full Root Competition)	10 mg/l Nitrogen and <0.05 ‰ Salinity	*Phragmites australis*	Inside Microcosm	7	9	5	10	5	19
			Outside Microcosm	0	0	0	0	0	0
			Combined	7	9	5	10	5	19
		Lythrum salicaria	Inside Microcosm	23	37	11	24	6	18
			Outside Microcosm	15	18	1	7	0	3
			Combined	38	55	12	31	6	21
		Filipendula ulmaria	Inside Microcosm	24	22	26	28	24	35
			Outside Microcosm	7	8	3	6	2	6
			Combined	31	30	29	34	26	41
		Mentha aquatica	Inside Microcosm	21	18	7	19	6	15
			Outside Microcosm	2	2	0	1	0	2
			Combined	23	20	7	20	6	17
		Standing Dead or Dormant Vegetation	Inside Microcosm	16	5	19	8	12	9
			Outside Microcosm	0	0	1	0	1	0
			Combined	16	5	20	8	13	9
		Bare Ground or Leaf Litter		9	9	32	11	47	4
2 (Full Root Competition)	50 mg/l Nitrogen and <0.05 ‰ Salinity	*Phragmites australis*	Inside Microcosm	5	7	6	20	8	24
			Outside Microcosm	0	0	0	0	0	3
			Combined	5	7	6	20	8	27
		Lythrum salicaria	Inside Microcosm	21	42	13	27	6	16
			Outside Microcosm	6	12	1	7	0	5
			Combined	27	54	14	34	6	21
		Filipendula ulmaria	Inside Microcosm	15	16	32	32	27	28
			Outside Microcosm	2	5	5	7	1	3
			Combined	17	21	37	39	28	31
		Mentha aquatica	Inside Microcosm	14	16	7	6	6	16
			Outside Microcosm	0	3	0	1	0	2
			Combined	14	19	7	7	6	18
		Standing Dead or Dormant Vegetation	Inside Microcosm	11	7	16	14	18	13
			Outside Microcosm	0	0	0	0	1	0
			Combined	11	7	16	14	19	13
		Bare Ground or Leaf Litter		34	12	26	1	35	3
3 (Full Root Competition)	100 mg/l Nitrogen and <0.05 ‰ Salinity	*Phragmites australis*	Inside Microcosm	6	9	11	23	15	29
			Outside Microcosm	0	0	0	1	0	5
			Combined	6	9	11	24	15	34
		Lythrum salicaria	Inside Microcosm	18	41	12	27	9	18
			Outside Microcosm	9	14	1	9	0	5
			Combined	27	55	13	36	9	23
		Filipendula ulmaria	Inside Microcosm	15	16	18	24	23	26
			Outside Microcosm	6	5	5	6	1	2
			Combined	21	21	23	30	24	28
		Mentha aquatica	Inside Microcosm	19	19	21	14	7	14
			Outside Microcosm	0	2	0	2	0	1
			Combined	19	21	21	16	7	15
		Standing Dead or Dormant Vegetation	Inside Microcosm	4	9	17	11	27	11
			Outside Microcosm	0	0	0	0	2	0
			Combined	4	9	17	11	29	11
		Bare Ground or Leaf Litter		38	6	21	1	19	2
4 (Full Root Competition)	150 mg/l Nitrogen and <0.05 ‰ Salinity	*Phragmites australis*	Inside Microcosm	3	8	14	25	18	38
			Outside Microcosm	0	0	0	6	1	7
			Combined	3	8	14	31	19	45
		Lythrum salicaria	Inside Microcosm	21	45	15	29	8	14
			Outside Microcosm	14	12	3	8	0	7
			Combined	35	57	18	37	8	21
		Filipendula ulmaria	Inside Microcosm	17	17	24	22	28	24
			Outside Microcosm	8	8	9	6	2	2
			Combined	25	25	33	28	30	26
		Mentha aquatica	Inside Microcosm	19	18	23	18	11	11
			Outside Microcosm	3	5	0	3	0	0
			Combined	22	23	23	21	11	11
		Standing Dead or Dormant Vegetation	Inside Microcosm	12	8	9	5	32	13
			Outside Microcosm	0	0	1	1	2	0
			Combined	12	8	10	6	34	13
		Bare Ground or Leaf Litter		28	4	15	1	3	0

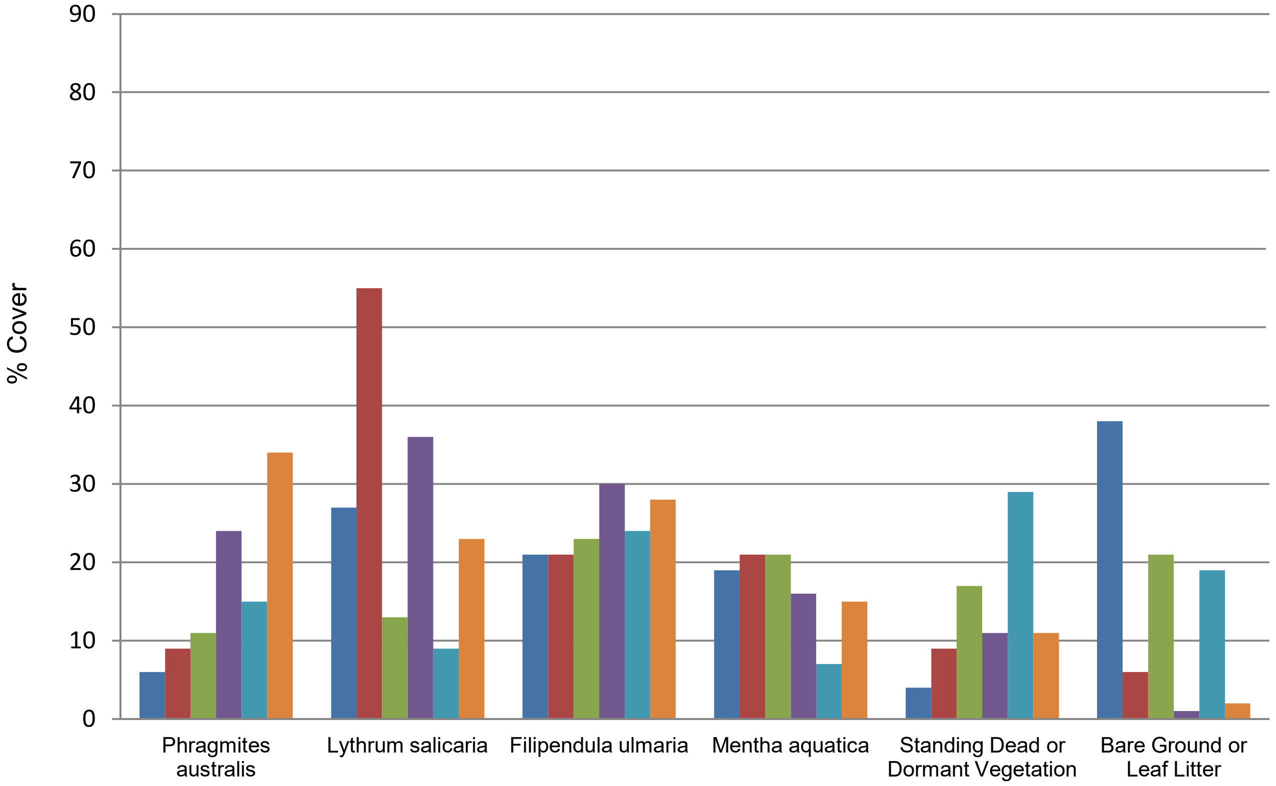
Table 4.8: % Area Coverage for the Different Nutrient Concentrations for Microcosms 1-4 in May and August 2008-2010



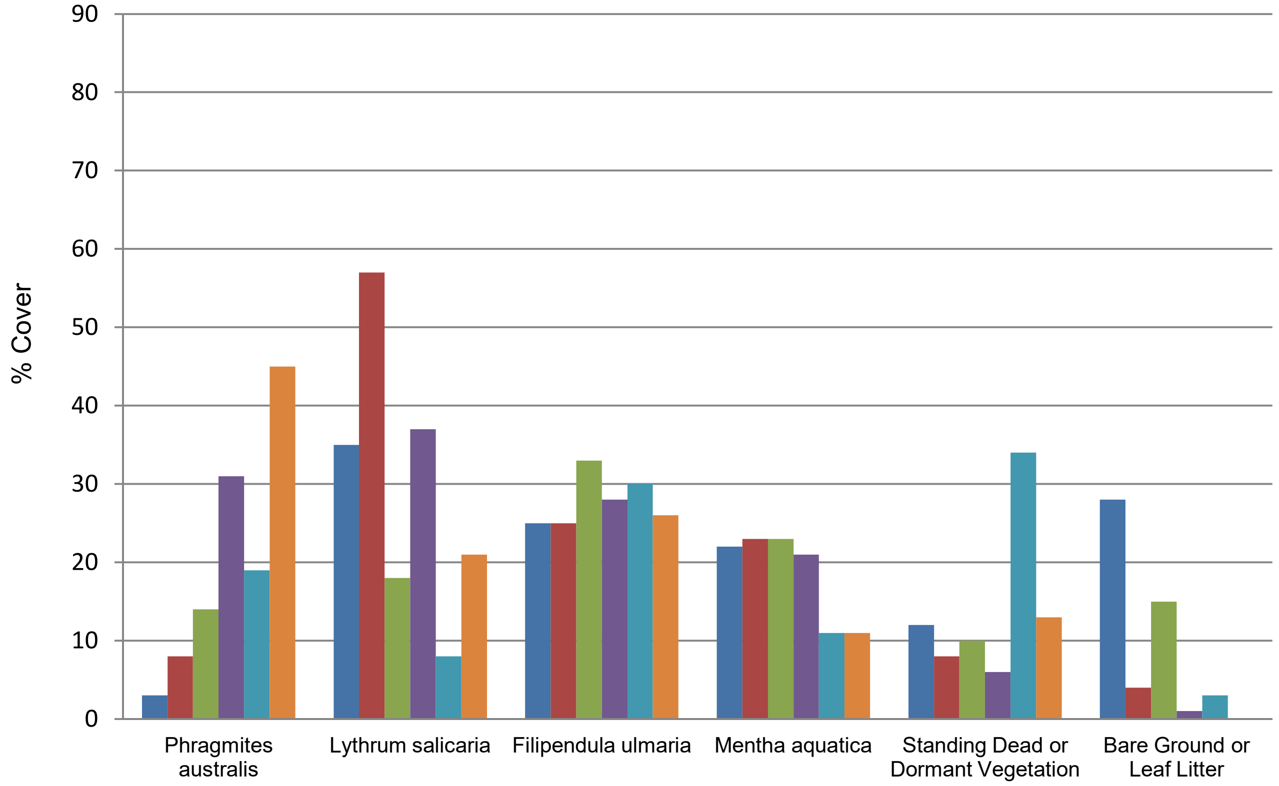
% Cover in Microcosm 1: 10 mg/l Nitrogen and <0.05 ‰ Salinity



% Cover in Microcosm 2: 50 mg/l Nitrogen and <0.05 ‰ Salinity



% Cover in Microcosm 3: 100 mg/l Nitrogen and <0.05 ‰ Salinity



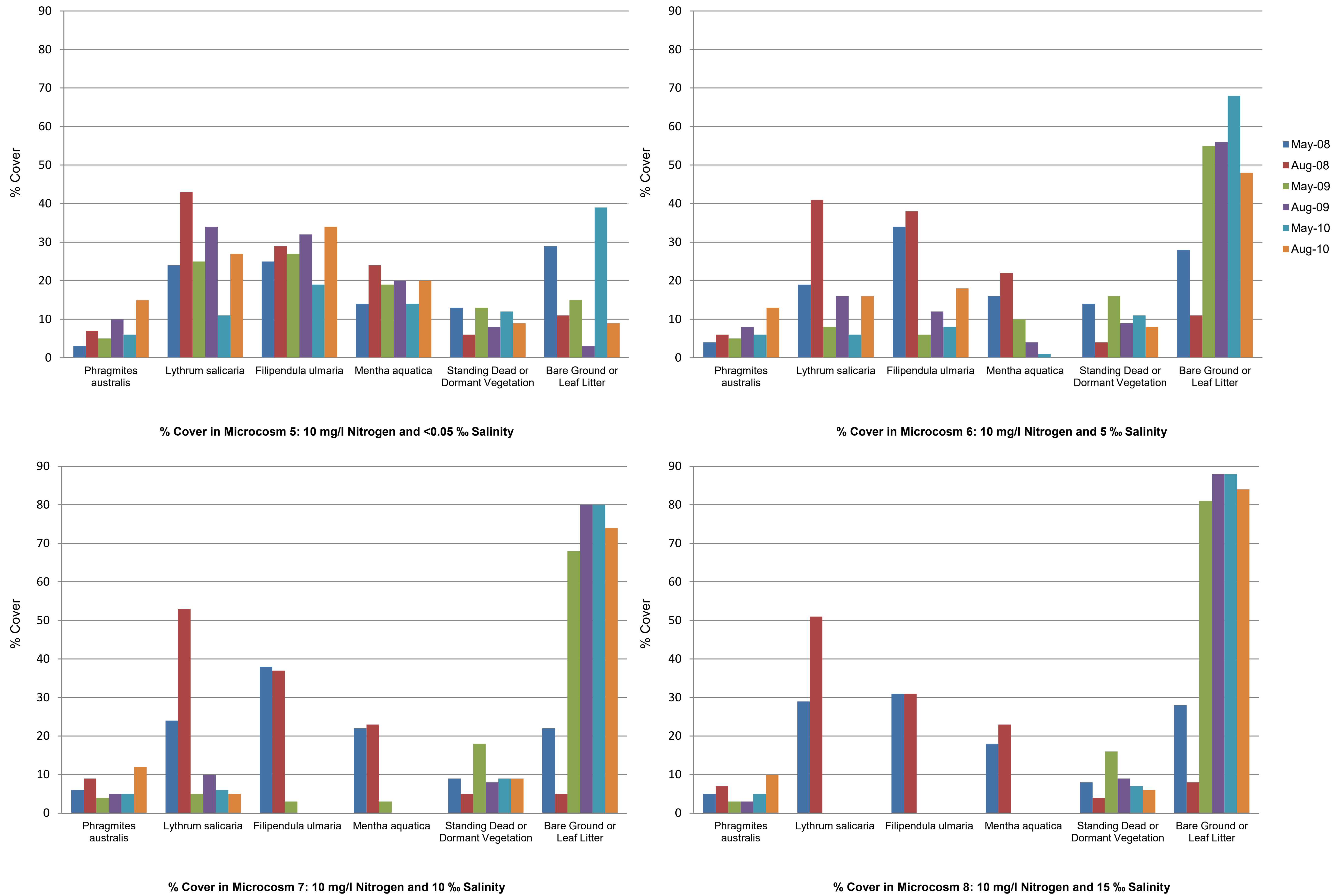
% Cover in Microcosm 4: 150 mg/l Nitrogen and <0.05 ‰ Salinity

Note: The *x* axis is species and category.
The area coverage is the combined area coverage. This includes the percentage cover of the features within the microcosm area and the percentage cover (in relation to the microcosm area) of the feature which is spilling over the edge of the microcosm.

Figure 4.4: Bar Graph Showing Combined % Area Coverage for the Different Nutrient Concentratoins for Microcosms 1-4 in May and August 2008-2010

Microcosm Number	Chemical Range	Species	Location	% Cover in 2008		% Cover in 2009		% Cover in 2010	
				May	August	May	August	May	August
5 (Full Root Competition)	10 mg/l Nitrogen and <0.05 ‰ Salinity	*Phragmites australis*	Inside Microcosm	3	7	5	10	6	14
			Outside Microcosm	0	0	0	0	0	1
			Combined	3	7	5	10	6	15
		Lythrum salicaria	Inside Microcosm	20	34	22	30	11	22
			Outside Microcosm	4	9	3	4	0	5
			Combined	24	43	25	34	11	27
		Filipendula ulmaria	Inside Microcosm	21	22	26	29	18	28
			Outside Microcosm	4	7	1	3	1	6
			Combined	25	29	27	32	19	34
		Mentha aquatica	Inside Microcosm	14	20	19	20	14	18
			Outside Microcosm	0	4	0	0	0	2
			Combined	14	24	19	20	14	20
		Standing Dead or Dormant Vegetation	Inside Microcosm	13	6	13	8	12	9
			Outside Microcosm	0	0	0	0	0	0
			Combined	13	6	13	8	12	9
		Bare Ground or Leaf Litter		29	11	15	3	39	9
6 (Full Root Competition)	10 mg/l Nitrogen and 5 ‰ Salinity	*Phragmites australis*	Inside Microcosm	4	6	5	8	6	13
			Outside Microcosm	0	0	0	0	0	0
			Combined	4	6	5	8	6	13
		Lythrum salicaria	Inside Microcosm	14	32	8	12	6	14
			Outside Microcosm	5	9	0	4	0	2
			Combined	19	41	8	16	6	16
		Filipendula ulmaria	Inside Microcosm	25	28	6	11	8	17
			Outside Microcosm	9	10	0	1	0	1
			Combined	34	38	6	12	8	18
		Mentha aquatica	Inside Microcosm	15	19	10	4	1	0
			Outside Microcosm	1	3	0	0	0	0
			Combined	16	22	10	4	1	0
		Standing Dead or Dormant Vegetation	Inside Microcosm	14	4	16	9	11	8
			Outside Microcosm	0	0	0	0	0	0
			Combined	14	4	16	9	11	8
		Bare Ground or Leaf Litter		28	11	55	56	68	48
7 (Full Root Competition)	10 mg/l Nitrogen and 10 ‰ Salinity	*Phragmites australis*	Inside Microcosm	6	9	4	5	5	12
			Outside Microcosm	0	0	0	0	0	0
			Combined	6	9	4	5	5	12
		Lythrum salicaria	Inside Microcosm	17	39	5	8	6	5
			Outside Microcosm	7	14	0	2	0	0
			Combined	24	53	5	10	6	5
		Filipendula ulmaria	Inside Microcosm	26	22	3	0	0	0
			Outside Microcosm	12	15	0	0	0	0
			Combined	38	37	3	0	0	0
		Mentha aquatica	Inside Microcosm	20	20	3	0	0	0
			Outside Microcosm	2	3	0	0	0	0
			Combined	22	23	3	0	0	0
		Standing Dead or Dormant Vegetation	Inside Microcosm	9	5	17	7	9	9
			Outside Microcosm	0	0	1	1	0	0
			Combined	9	5	18	8	9	9
		Bare Ground or Leaf Litter		22	5	68	80	80	74
8 (Full Root Competition)	10 mg/l Nitrogen and 15 ‰ Salinity	*Phragmites australis*	Inside Microcosm	5	7	3	3	5	10
			Outside Microcosm	0	0	0	0	0	0
			Combined	5	7	3	3	5	10
		Lythrum salicaria	Inside Microcosm	18	36	0	0	0	0
			Outside Microcosm	11	15	0	0	0	0
			Combined	29	51	0	0	0	0
		Filipendula ulmaria	Inside Microcosm	25	25	0	0	0	0
			Outside Microcosm	6	6	0	0	0	0
			Combined	31	31	0	0	0	0
		Mentha aquatica	Inside Microcosm	16	20	0	0	0	0
			Outside Microcosm	2	3	0	0	0	0
			Combined	18	23	0	0	0	0
		Standing Dead or Dormant Vegetation	Inside Microcosm	8	4	16	9	7	6
			Outside Microcosm	0	0	0	0	0	0
			Combined	8	4	16	9	7	6
		Bare Ground or Leaf Litter		28	8	81	88	88	84

Table 4.9: % Area Coverage for the Different Salinity Concentrations for Microcosms 5-8 in May and August 2008-2010



Note: The *x* axis is species and category.
The area coverage is the combined area coverage. This includes the percentage cover of the features within the microcosm area and the percentage cover (in relation to the microcosm area) of the feature which is spilling over the edge of the microcosm.

Figure 4.5: Bar Graph Showing Combined % Area Coverage for the Different Salinity Concentrations for Microcosms 5-8 in May and August 2008-2010

4.2.2 Hypothesis 2 Overview

Hypothesis 2 is:

“Where all four chosen floral species survive in the chemical concentrations studied, no single floral species will take over and oust other floral species, and restricting root competition between the different floral species will have an effect."

This is the second of the key hypotheses which the study was to test and builds upon the first hypothesis. This hypothesis investigates if adding barriers to restrict root competition has any effect on the floral species ability to survive and compete within the different concentrations of nutrients and salinity and thus explores whether root barriers would be worth considering as a management strategy for enhancing biodiversity.

In order to disprove the hypothesis, the null hypothesis is:

“Where all four chosen floral species survive in the chemical concentrations studied, a single floral species will take over and oust the other floral species and restricting root competition between the different floral species will not have an effect.”

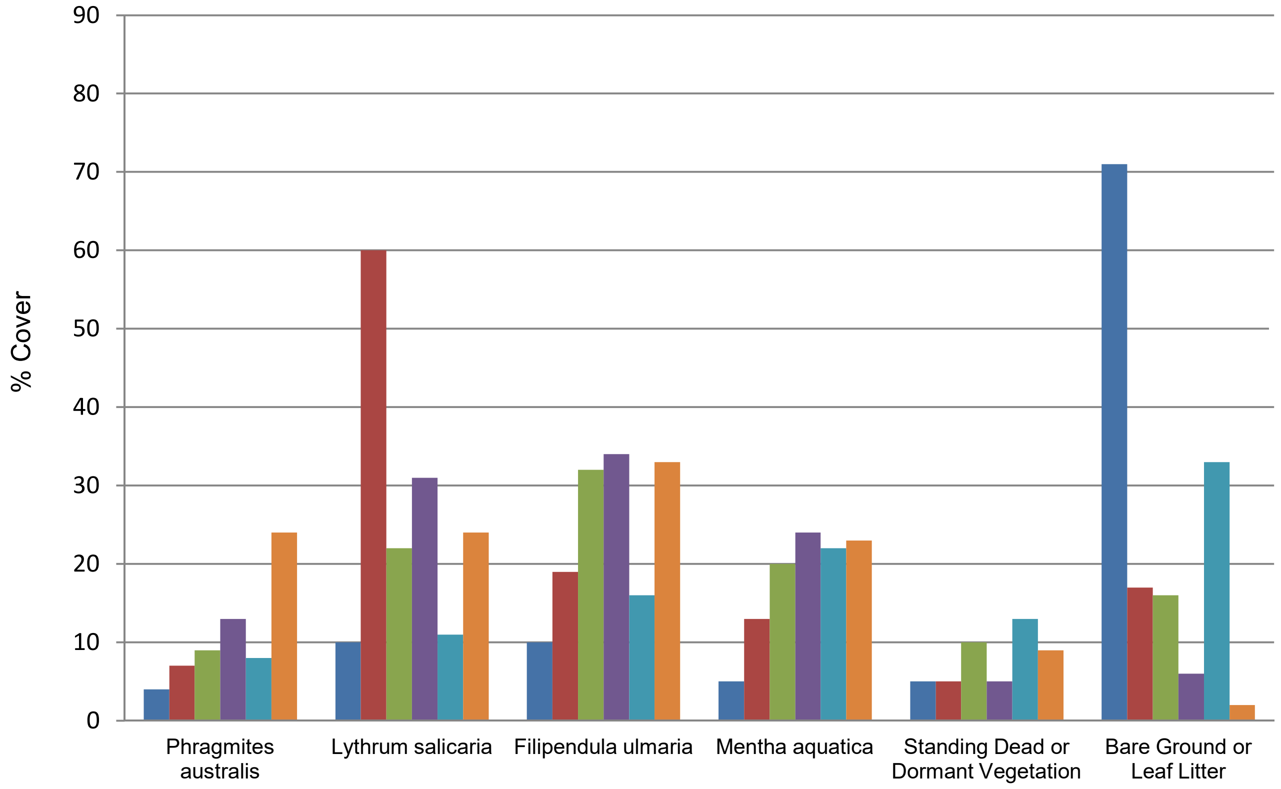
To test this hypothesis the area percentage coverage within the microcosms with restricted root competition (microcosms 9-16) was used. The effects of nutrient and salinity were assessed separately for Hypothesis 2.

In line with and to provide consistency with Hypothesis 1, May and August were chosen to assess the area coverage. However for the same reasons outlined for Hypothesis 1, no statistical analysis of the results could be undertaken.

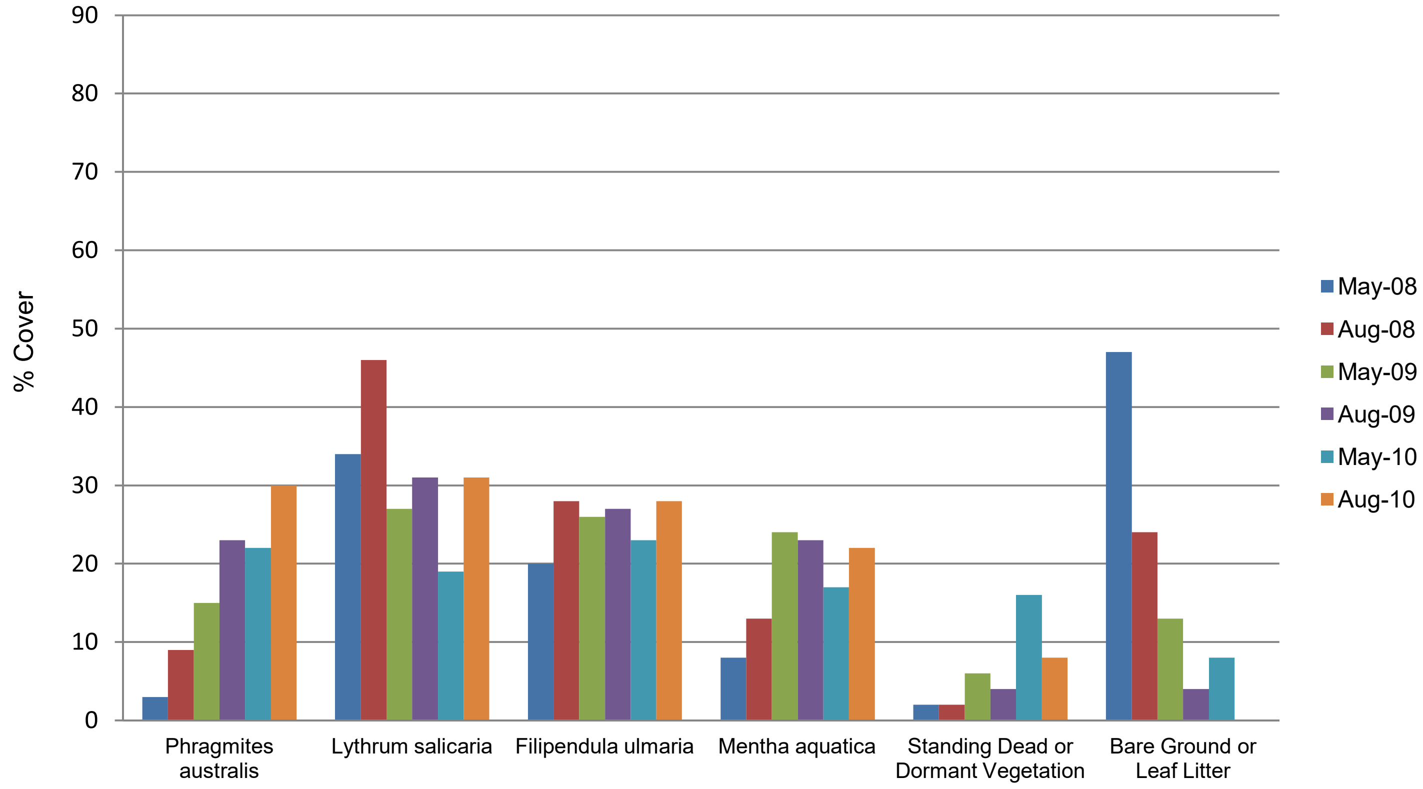
From the percentage cover results detailed within Tables A4.25 - A4.32 (area coverage for Microcosms 9 - 16 during the acclimatisation period, Appendix 4), Tables A10.5 - A10.8 (area coverage for Microcosms 9 - 12 during the nutrient treatment period, Appendix 10) and Tables A12.5 – A12.8 (area coverage for Microcosms 13 - 16 during the salinity treatment period, Appendix 12), the results for May and August each year were extracted and are presented in Table 4.10 and Table 4.11. Bar Graphs illustrating the pattern of growth within these microcosms for May and August each year are presented in Figure 4.6 and Figure 4.7.

Microcosm Number	Chemical Range	Species	Location	% Cover in 2008		% Cover in 2009		% Cover in 2010	
				May	August	May	August	May	August
9 (Restricted Root Competition)	10 mg/l Nitrogen and <0.05 ‰ Salinity	*Phragmites australis*	Inside Microcosm	4	7	9	13	8	21
			Outside Microcosm	0	0	0	0	0	3
			Combined	4	7	9	13	8	24
		Lythrum salicaria	Inside Microcosm	7	47	21	27	11	19
			Outside Microcosm	3	13	1	4	0	5
			Combined	10	60	22	31	11	24
		Filipendula ulmaria	Inside Microcosm	8	13	28	29	15	28
			Outside Microcosm	2	6	4	5	1	5
			Combined	10	19	32	34	16	33
		Mentha aquatica	Inside Microcosm	5	11	17	21	21	21
			Outside Microcosm	0	2	3	3	1	2
			Combined	5	13	20	24	22	23
		Standing Dead or Dormant Vegetation	Inside Microcosm	5	5	9	4	12	9
			Outside Microcosm	0	0	1	1	1	0
			Combined	5	5	10	5	13	9
		Bare Ground or Leaf Litter		71	17	16	6	33	2
10 (Restricted Root Competition)	50 mg/l Nitrogen and <0.05 ‰ Salinity	*Phragmites australis*	Inside Microcosm	3	9	15	21	22	27
			Outside Microcosm	0	0	0	2	0	3
			Combined	3	9	15	23	22	30
		Lythrum salicaria	Inside Microcosm	22	32	23	27	18	25
			Outside Microcosm	12	14	4	4	1	6
			Combined	34	46	27	31	19	31
		Filipendula ulmaria	Inside Microcosm	18	22	23	24	21	24
			Outside Microcosm	2	6	3	3	2	4
			Combined	20	28	26	27	23	28
		Mentha aquatica	Inside Microcosm	8	11	21	20	16	16
			Outside Microcosm	0	2	3	3	1	6
			Combined	8	13	24	23	17	22
		Standing Dead or Dormant Vegetation	Inside Microcosm	2	2	5	4	15	8
			Outside Microcosm	0	0	1	0	1	0
			Combined	2	2	6	4	16	8
		Bare Ground or Leaf Litter		47	24	13	4	8	0
11 (Restricted Root Competition)	100 mg/l Nitrogen and <0.05 ‰ Salinity	*Phragmites australis*	Inside Microcosm	6	9	22	28	17	31
			Outside Microcosm	0	0	2	5	0	6
			Combined	6	9	24	33	17	37
		Lythrum salicaria	Inside Microcosm	25	32	24	27	13	25
			Outside Microcosm	4	13	2	8	0	7
			Combined	29	45	26	35	13	32
		Filipendula ulmaria	Inside Microcosm	16	22	23	22	18	29
			Outside Microcosm	2	4	7	7	3	4
			Combined	18	26	30	29	21	33
		Mentha aquatica	Inside Microcosm	6	10	14	13	12	12
			Outside Microcosm	0	2	1	2	1	2
			Combined	6	12	15	15	13	14
		Standing Dead or Dormant Vegetation	Inside Microcosm	2	3	2	2	19	3
			Outside Microcosm	0	0	1	0	3	1
			Combined	2	3	3	2	22	4
		Bare Ground or Leaf Litter		45	24	15	8	21	0
12 (Restricted Root Competition)	150 mg/l Nitrogen and <0.05 ‰ Salinity	*Phragmites australis*	Inside Microcosm	5	9	24	28	21	39
			Outside Microcosm	0	0	9	6	0	8
			Combined	5	9	33	34	21	47
		Lythrum salicaria	Inside Microcosm	28	34	24	29	19	18
			Outside Microcosm	19	24	3	12	0	4
			Combined	47	58	27	41	19	22
		Filipendula ulmaria	Inside Microcosm	25	24	22	21	22	22
			Outside Microcosm	5	6	4	4	3	4
			Combined	30	30	26	25	25	26
		Mentha aquatica	Inside Microcosm	9	14	26	18	6	12
			Outside Microcosm	0	2	3	10	0	1
			Combined	9	16	29	28	6	13
		Standing Dead or Dormant Vegetation	Inside Microcosm	3	3	2	2	21	8
			Outside Microcosm	0	0	0	0	3	0
			Combined	3	3	2	2	24	8
		Bare Ground or Leaf Litter		30	16	2	2	11	1

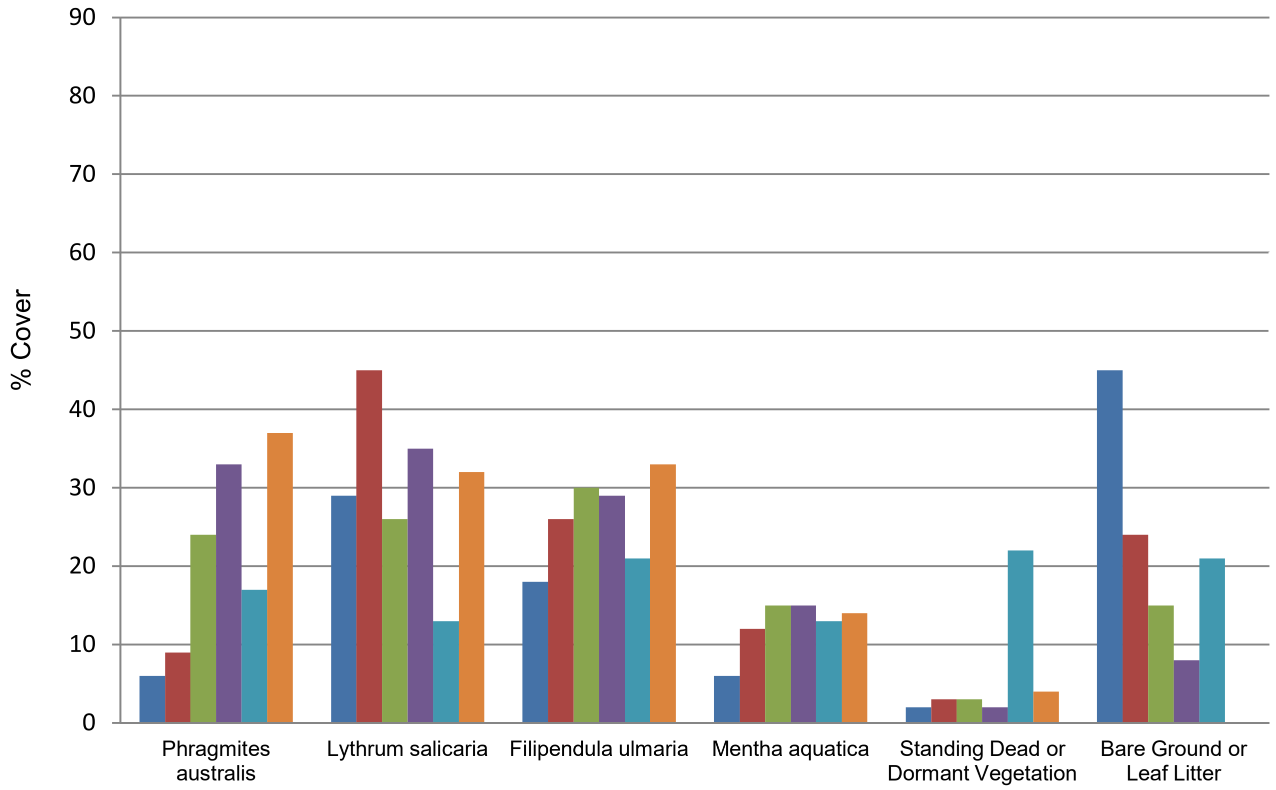
Table 4.10: % Area Coverage for the Different Nutrient Concentrations for Microcosms 9-12 in May and August 2008-2010



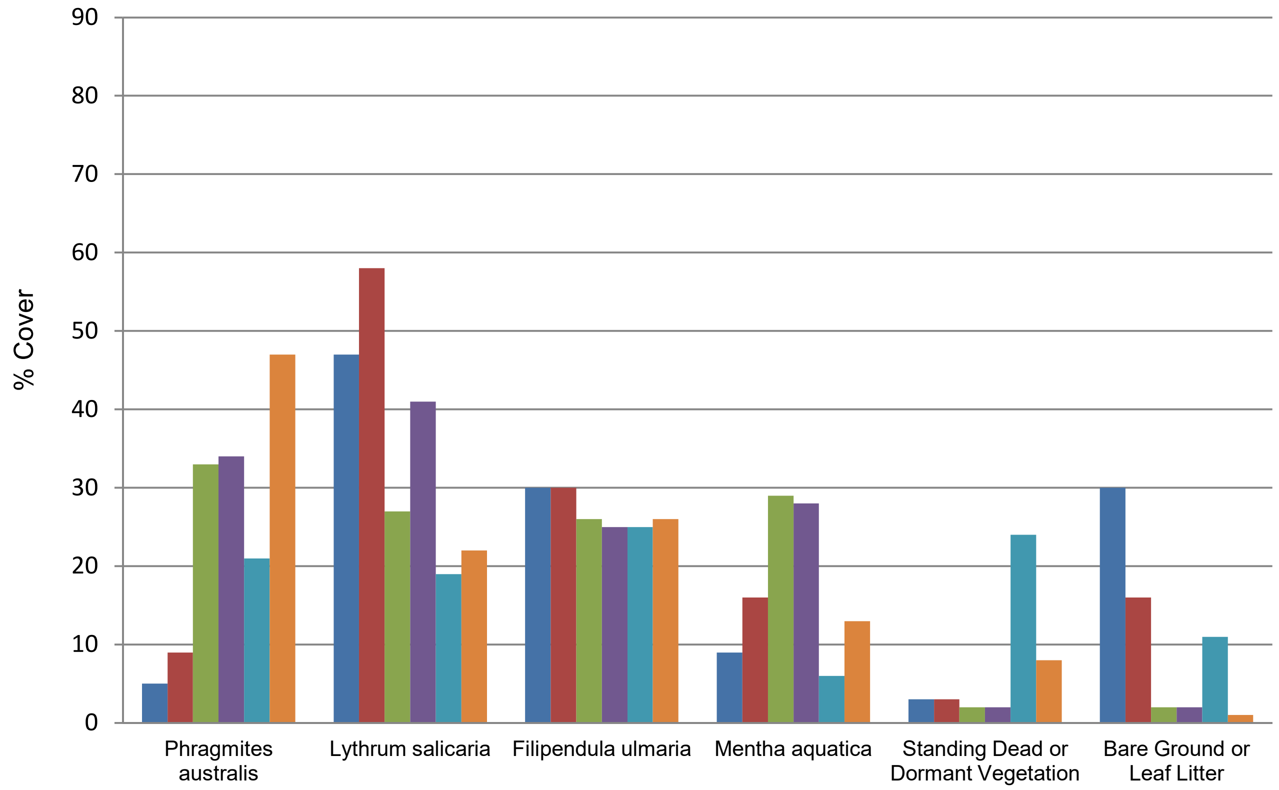
% Cover in Microcosm 9: 10 mg/l Nitrogen and <0.05 ‰ Salinity



% Cover in Microcosm 10: 50 mg/l Nitrogen and <0.05 ‰ Salinity



% Cover in Microcosm 11: 100 mg/l Nitrogen and <0.05 ‰ Salinity



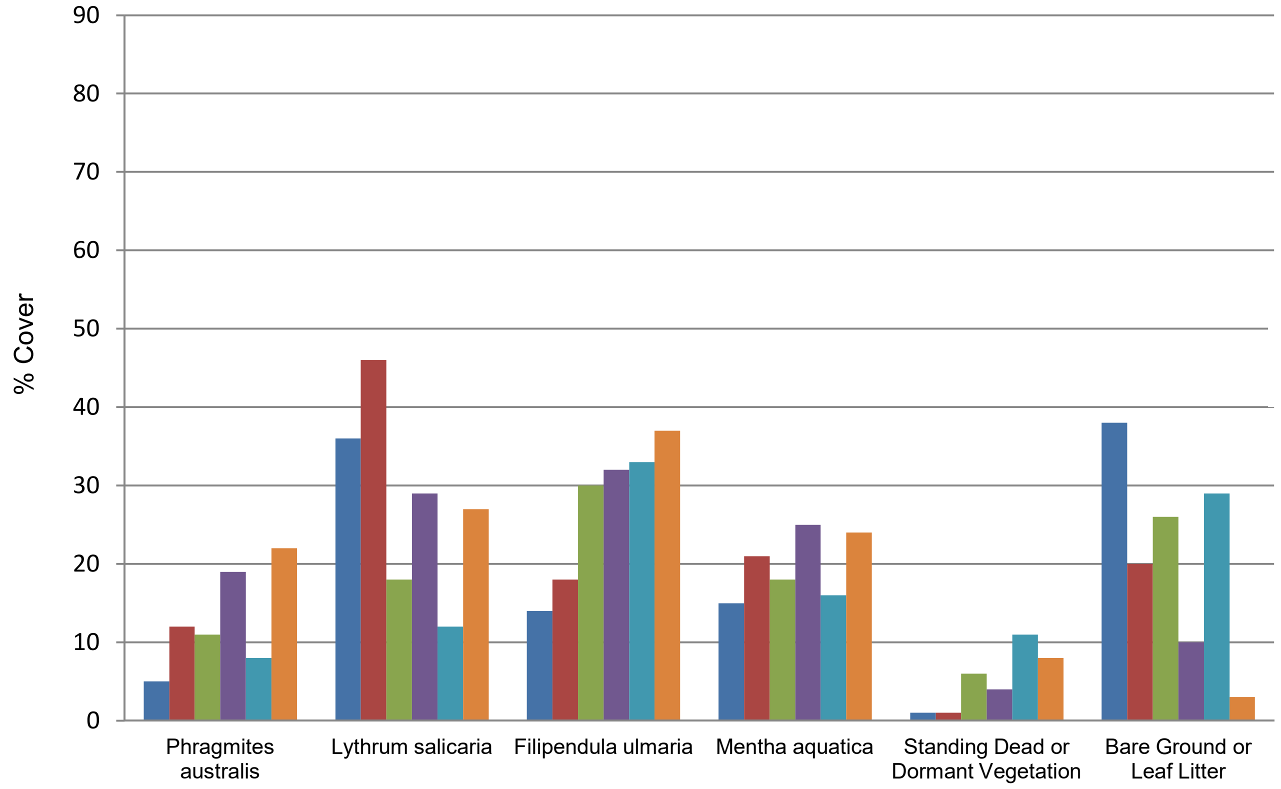
% Cover in Microcosm 12: 150 mg/l Nitrogen and <0.05 ‰ Salinity

Note: The *x* axis is species and category.
The area coverage is the combined area coverage. This includes the percentage cover of the features within the microcosm area and the percentage cover (in relation to the microcosm area) of the feature which is spilling over the edge of the microcosm.

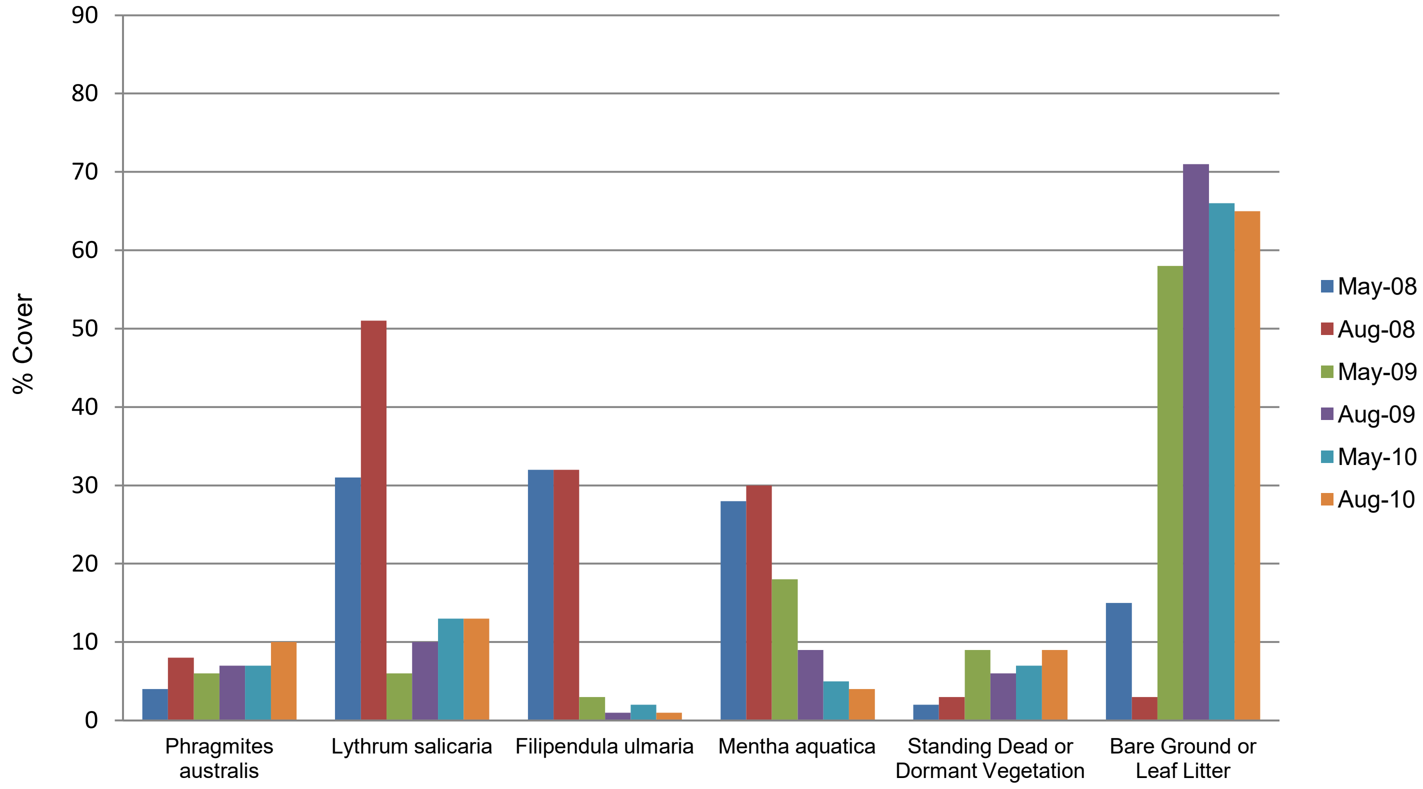
Figure 4.6: Bar Graph Showing Combined % Area Coverage for the Different Nutrient Concentrations for Microcosms 9-12 in May and August 2008-2010

Microcosm Number	Chemical Range	Species	Location	% Cover in 2008		% Cover in 2009		% Cover in 2010	
				May	August	May	August	May	August
13 (Restricted Root Competition)	10 mg/l Nitrogen and <0.05 ‰ Salinity	*Phragmites australis*	Inside Microcosm	5	12	11	17	8	19
			Outside Microcosm	0	0	0	2	0	3
			Combined	5	12	11	19	8	22
		Lythrum salicaria	Inside Microcosm	30	35	17	24	12	19
			Outside Microcosm	6	11	1	5	0	8
			Combined	36	46	18	29	12	27
		Filipendula ulmaria	Inside Microcosm	12	14	22	25	27	30
			Outside Microcosm	2	4	8	7	6	7
			Combined	14	18	30	32	33	37
		Mentha aquatica	Inside Microcosm	14	18	18	20	15	22
			Outside Microcosm	1	3	0	5	1	2
			Combined	15	21	18	25	16	24
		Standing Dead or Dormant Vegetation	Inside Microcosm	1	1	6	4	9	7
			Outside Microcosm	0	0	0	0	2	1
			Combined	1	1	6	4	11	8
		Bare Ground or Leaf Litter		38	20	26	10	29	3
14 (Restricted Root Competition)	10 mg/l Nitrogen and 5 ‰ Salinity	*Phragmites australis*	Inside Microcosm	4	8	6	7	7	10
			Outside Microcosm	0	0	0	0	0	0
			Combined	4	8	6	7	7	10
		Lythrum salicaria	Inside Microcosm	25	36	6	7	13	11
			Outside Microcosm	6	15	0	3	0	2
			Combined	31	51	6	10	13	13
		Filipendula ulmaria	Inside Microcosm	28	25	3	1	2	1
			Outside Microcosm	4	7	0	0	0	0
			Combined	32	32	3	1	2	1
		Mentha aquatica	Inside Microcosm	26	25	18	8	5	4
			Outside Microcosm	2	5	0	1	0	0
			Combined	28	30	18	9	5	4
		Standing Dead or Dormant Vegetation	Inside Microcosm	2	3	9	6	7	9
			Outside Microcosm	0	0	0	0	0	0
			Combined	2	3	9	6	7	9
		Bare Ground or Leaf Litter		15	3	58	71	66	65
15 (Restricted Root Competition)	10 mg/l Nitrogen and 10 ‰ Salinity	*Phragmites australis*	Inside Microcosm	7	11	4	7	5	9
			Outside Microcosm	0	0	0	0	0	1
			Combined	7	11	4	7	5	10
		Lythrum salicaria	Inside Microcosm	24	33	3	5	1	4
			Outside Microcosm	4	12	0	0	0	0
			Combined	28	45	3	5	1	4
		Filipendula ulmaria	Inside Microcosm	15	21	0	0	0	0
			Outside Microcosm	2	3	0	0	0	0
			Combined	17	24	0	0	0	0
		Mentha aquatica	Inside Microcosm	21	24	1	0	0	0
			Outside Microcosm	0	3	0	0	0	0
			Combined	21	27	1	0	0	0
		Standing Dead or Dormant Vegetation	Inside Microcosm	1	1	12	8	8	9
			Outside Microcosm	0	0	0	0	0	0
			Combined	1	1	12	8	8	9
		Bare Ground or Leaf Litter		32	10	80	80	86	78
16 (Restricted Root Competition)	10 mg/l Nitrogen and 15 ‰ Salinity	*Phragmites australis*	Inside Microcosm	3	7	3	3	5	8
			Outside Microcosm	0	0	0	0	0	0
			Combined	3	7	3	3	5	8
		Lythrum salicaria	Inside Microcosm	28	36	0	0	0	0
			Outside Microcosm	22	27	0	0	0	0
			Combined	50	63	0	0	0	0
		Filipendula ulmaria	Inside Microcosm	18	16	0	0	0	0
			Outside Microcosm	3	5	0	0	0	0
			Combined	21	21	0	0	0	0
		Mentha aquatica	Inside Microcosm	24	22	1	0	0	0
			Outside Microcosm	0	3	0	0	0	0
			Combined	24	25	1	0	0	0
		Standing Dead or Dormant Vegetation	Inside Microcosm	2	4	10	9	7	7
			Outside Microcosm	0	0	1	1	0	0
			Combined	2	4	11	10	7	7
		Bare Ground or Leaf Litter		25	15	86	88	88	85

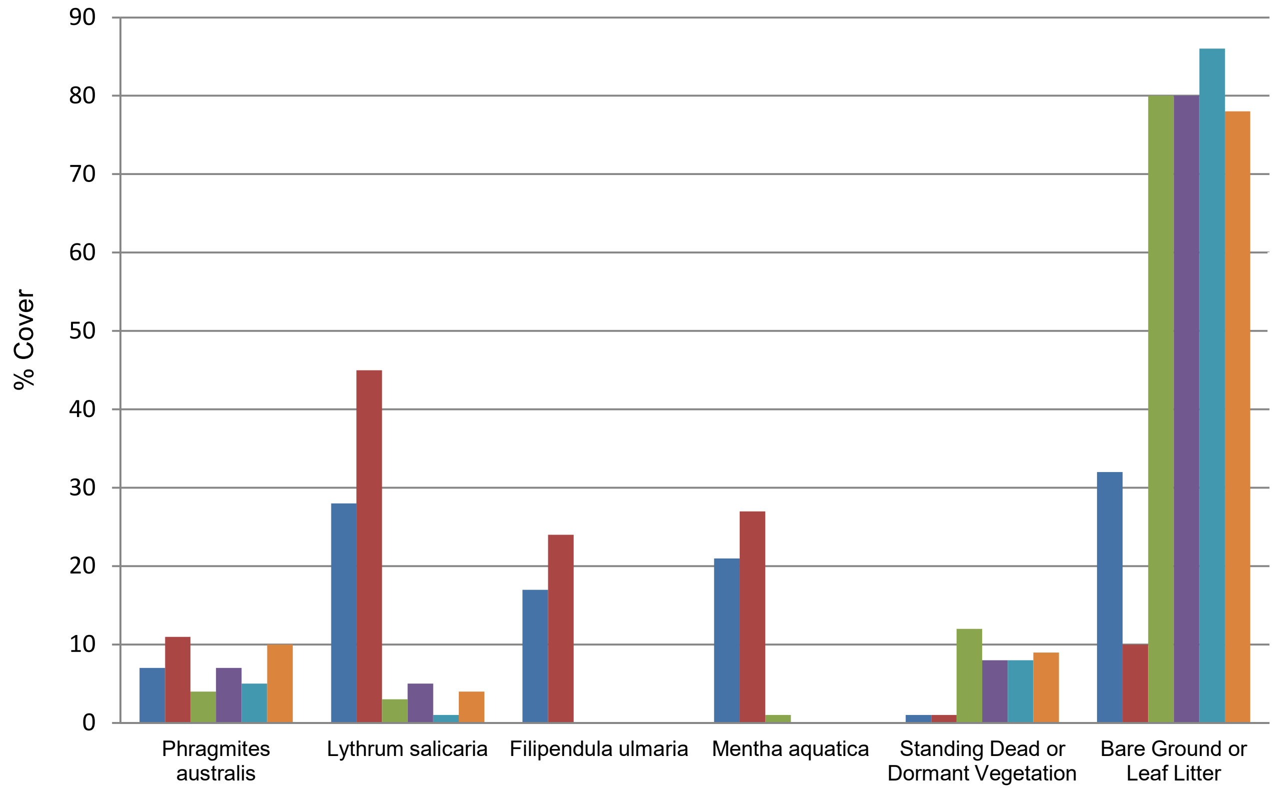
Table 4.11: % Area Coverage for the Different Salinity Concentrations for Microcosms 13-16 in May and August 2008-2010



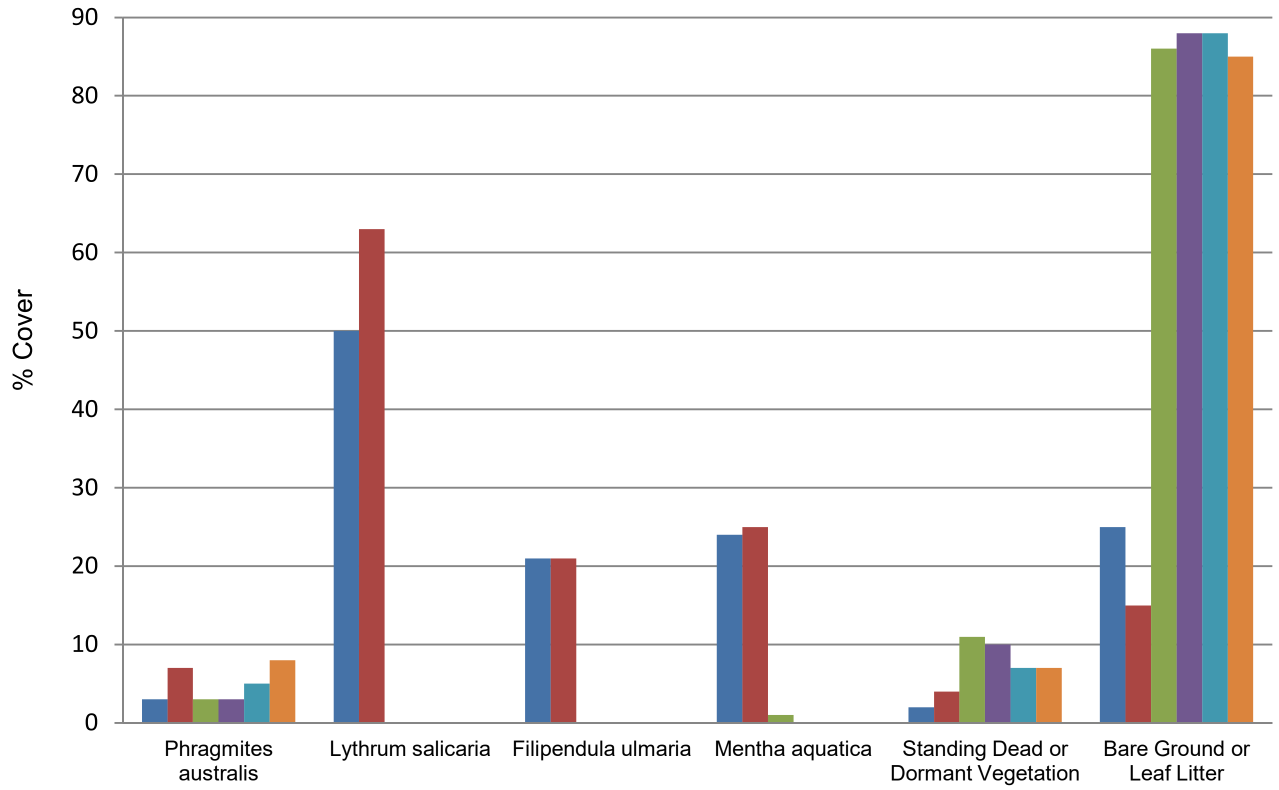
% Cover in Microcosm 13: 10 mg/l Nitrogen and <0.05 ‰ Salinity



% Cover in Microcosm 14: 10 mg/l Nitrogen and 5 ‰ Salinity



% Cover in Microcosm 15: 10 mg/l Nitrogen and 10 ‰ Salinity



% Cover in Microcosm 16: 10 mg/l Nitrogen and 15 ‰ Salinity

Note: The *x* axis is species and category.
The area coverage is the combined area coverage. This includes the percentage cover of the features within the microcosm area and the percentage cover (in relation to the microcosm area) of the feature which is spilling over the edge of the microcosm.

Figure 4.7: Bar Graph Showing Combined % Area Coverage for the Different Salinity Concentrations for Microcosms 13-16 in May and August 2008-2010

4.2.3 Hypothesis 3 Overview

Hypothesis 3 is:

"The higher concentrations of the chosen chemical ranges will have an effect on the stem heights or stem widths of the surviving plants."

This was undertaken to determine if the different concentrations had an effect on the species either by increasing or decreasing the stem measurements. This data would facilitate the management recommendations for designing biodiversity enhancements within a constructed wetland treatment system.

In order to disprove the hypothesis, the null hypothesis is:

"The higher concentrations of the chosen chemical ranges will not have an effect on the stem height or stem widths of the surviving plants."

The results for this hypothesis are split to investigate the stem heights and stem widths individually for the nutrient concentrations and the salinity concentrations. These are then further split to analysis the results where:

- both the microcosms with full and restricted competition are combined to produce overall results for the different concentration levels; and,
- the stems within the full competition microcosms are separated from the combined results, as this is representative of what would occur within a standard constructed wetland treatment system.

Hypothesis 4 analyses the microcosms where the restricted root competition was occurring. Hypothesis 4 also compares the results to see if restricting root competition has any effect on the vegetation height or widths of the surviving plants within each pollutant concentration.

The stem heights and widths were skewed, but with some species/microcosms exhibiting almost normal distributions. To allow for parametric analysis to be undertaken, the data was transformed using a logarithmic transformation of 10. The original histograms pre data transformation showing the distribution for the stem heights and for the stem widths of the four species studied for all of the microcosms can be found within Appendix 21. The data outlining the averages for the stem heights and for the stem widths for the four different species at the different loadings can be found in Table 4.12 and Table 4.13 for the nutrients and Table 4.15 and Table 4.16 for the salinity.

The One Way ANOVA test was run comparing both the heights and widths of the plant stems for each vegetation species. The results of the One Way ANOVA test including the Sum of Squares, df, Mean Square, F and Sig. including the Between Groups data and Within Groups Data can be found in Appendix 22 along with all of the remaining One Way ANOVA Results for the remaining Hypothesis. An overview of the One Way ANOVA results for the stem heights and stem widths can be found in Table 4.14 for nutrients and Table 4.17 for salinity.

With fatalities occurring within the higher two salinity concentrations for *Filipendula ulmaria* and *Mentha aquatica* two groups were available for comparison. Although they are included in the ANOVA output detailed in Table 4.17, an Independent Samples T Test was undertaken to ensure that the presence of only two groups did not affect the significance levels.

Parameter	Species	*Phragmites australis*				*Lythrum salicaria*				*Filipendula ulmaria*				*Mentha aquatica*			
	Nitrogen (mg/l)	10	50	100	150	10	50	100	150	10	50	100	150	10	50	100	150
	Salinity (‰)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Stem Heights (in mm) with Increasing Nutrients - Combined Results	Number of Stems	1148.0	800.0	1048.0	1442.0	831.0	406.0	362.0	395.0	407.0	294.0	294.0	281.0	840.0	221.0	113.0	95.0
	Mean	671.0	887.1	1031.3	1004.5	855.2	1022.5	986.2	922.6	301.1	359.7	332.1	376.3	246.9	318.2	274.3	276.6
	Std Error of Mean	9.0	14.3	15.5	12.3	13.1	21.3	23.2	21.0	8.1	16.8	14.5	12.7	5.6	14.1	17.1	19.3
	Median	646.0	900.5	1018.0	1041.0	833.0	1027.5	1014.0	913.0	277.0	283.0	267.0	350.0	205.0	252.0	228.0	212.0
	Std Deviation	306.2	405.0	502.8	466.5	377.8	492.1	441.6	417.1	162.7	288.0	249.5	212.8	163.5	208.9	181.9	187.9
	Variance	93761.5	164012.0	252764.0	217609.6	142728.2	184149.5	195039.3	173974.5	26455.4	82937.9	62236.2	45267.5	26729.1	43642.4	33076.6	35320.8
	Minimum	10.0	97.0	58.0	15.0	122.0	101.0	91.0	58.0	20.0	10.0	12.0	26.0	14.0	54.0	40.0	25.0
	Maximum	1740.0	2016.0	2088.0	2270.0	1937.0	2077.0	1923.0	1867.0	1584.0	1602.0	1509.0	1416.0	1059.0	1081.0	766.0	876.0
Stem Heights (in mm) with Increasing Nutrients - Full Competition	Number of Stems	459.0	396.0	557.0	681.0	431.0	181.0	161.0	216.0	245.0	233.0	192.0	235.0	369.0	41.0	52.0	86.0
	Mean	691.9	863.6	1141.0	1055.2	879.5	1090.1	979.3	897.0	301.3	345.7	292.2	354.4	247.0	218.7	229.5	289.7
	Std Error of Mean	15.2	19.4	21.4	18.5	19.4	34.7	38.1	30.9	11.6	18.7	18.0	13.2	7.7	19.9	16.2	20.0
	Median	694.0	874.5	1186.0	1111.0	872.0	1147.0	1017.0	882.5	276.0	273.0	236.5	335.0	207.0	205.0	228.0	220.5
	Std Deviation	326.5	386.2	505.1	482.5	403.0	467.1	484.0	454.7	182.0	285.4	248.9	203.0	147.2	127.2	116.5	185.9
	Variance	106576.6	149135.8	255100.4	232783.1	162437.5	218170.1	234292.0	206721.1	33122.4	81446.3	61964.9	41227.9	21660.6	16186.5	13578.5	34549.4
	Minimum	10.0	97.0	92.0	15.0	122.0	161.0	91.0	58.0	28.0	10.0	12.0	26.0	14.0	63.0	40.0	63.0
	Maximum	1721.0	1742.0	2088.0	2270.0	1937.0	2077.0	1923.0	1867.0	1584.0	1602.0	1509.0	1416.0	723.0	593.0	621.0	876.0
Stem Heights (in mm) with Increasing Nutrients - Restricted Competition	Number of Stems	689.0	404.0	491.0	761.0	400.0	225.0	201.0	179.0	162.0	61.0	102.0	46.0	471.0	180.0	61.0	9.0
	Mean	657.1	910.2	906.8	959.1	829.1	968.2	991.7	953.5	300.8	413.3	407.3	487.7	246.9	340.8	312.5	151.4
	Std Error of Mean	11.1	21.0	21.2	16.2	17.4	25.9	28.6	27.3	10.1	37.6	23.1	33.7	8.1	16.2	27.8	56.2
	Median	628.0	936.5	837.0	971.0	778.0	934.0	1012.0	935.0	279.5	329.0	366.5	455.0	205.0	268.5	228.0	51.0
	Std Deviation	291.3	421.8	470.5	447.2	347.2	388.6	405.6	365.6	128.5	293.9	233.7	228.3	175.4	217.3	216.7	168.7
	Variance	84882.9	177923.0	221402.3	199957.4	120522.3	150972.7	164543.3	133641.6	16515.4	86401.3	54617.9	52100.5	30754.6	47239.7	46974.9	28468.3
	Minimum	71.0	105.0	58.0	121.0	170.0	101.0	153.0	111.0	20.0	28.0	86.0	190.0	15.0	54.0	40.0	25.0
	Maximum	1740.0	2016.0	2037.0	2127.0	1778.0	1829.0	1908.0	1816.0	1049.0	1403.0	1316.0	1260.0	1059.0	1081.0	766.0	438.0

Table 4.12: Analysis of Harvest Stem Heights (in mm) with Increasing Nutrient Concentrations

Parameter	Species	*Phragmites australis*				*Lythrum salicaria*				*Filipendula ulmaria*				*Mentha aquatica*			
	Nitrogen (mg/l)	10	50	100	150	10	50	100	150	10	50	100	150	10	50	100	150
	Salinity (‰)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Stem Widths (in mm) with Increasing Nutrients - Combined Results	Number of Stems	1148.0	800.0	1048.0	1442.0	831.0	406.0	362.0	395.0	407.0	294.0	294.0	281.0	840.0	221.0	113.0	95.0
	Mean	2.2	2.7	3.1	3.0	2.9	3.3	3.3	3.6	1.2	1.6	1.4	1.5	1.1	1.3	1.1	1.1
	Std Error of Mean	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.0	0.0	0.1	0.1
	Median	2.1	2.6	3.1	2.8	2.5	3.0	3.0	3.2	1.0	1.0	1.0	1.1	1.0	1.1	1.0	1.0
	Std Deviation	0.8	0.7	1.0	0.9	1.5	1.7	1.6	2.1	1.0	2.7	1.4	1.3	0.5	0.6	0.7	0.5
	Variance	0.6	0.5	1.0	0.9	2.3	2.9	2.4	4.5	1.1	7.5	1.8	1.7	0.3	0.4	0.5	0.3
	Minimum	0.2	0.9	1.0	0.8	0.2	0.4	0.4	0.7	0.1	0.1	0.2	0.2	0.2	0.4	0.2	0.4
	Maximum	6.0	5.4	6.5	6.8	12.5	11.5	9.5	30.0	12.0	42.0	8.7	9.1	3.8	3.7	4.1	3.0
Stem Widths (in mm) with Increasing Nutrients - Full Competition	Number of Stems	459.0	396.0	557.0	681.0	431.0	181.0	161.0	216.0	245.0	233.0	192.0	235.0	369.0	41.0	52.0	86.0
	Mean	2.4	2.8	3.4	3.3	3.0	3.9	3.7	3.8	1.3	1.6	1.4	1.5	1.2	1.0	0.9	1.1
	Std Error of Mean	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.1	0.2	0.1	0.1	0.0	0.1	0.1	0.1
	Median	2.4	2.8	3.4	3.2	2.7	3.5	3.3	3.3	1.0	1.0	1.0	1.1	1.0	1.0	0.9	1.0
	Std Deviation	0.7	0.7	0.8	0.9	1.6	1.7	1.8	2.5	1.2	3.0	1.3	1.3	0.6	0.4	0.4	0.5
	Variance	0.5	0.5	0.7	0.9	2.7	3.0	3.1	6.0	1.6	8.9	1.8	1.8	0.4	0.2	0.1	0.3
	Minimum	0.7	0.9	1.3	1.2	0.2	1.0	1.0	0.7	0.1	0.1	0.2	0.2	0.2	0.4	0.2	0.4
	Maximum	5.0	4.9	6.5	6.8	12.5	11.5	9.5	30.0	12.0	42.0	8.7	9.1	3.8	2.0	2.4	3.0
Stem Widths (in mm) with Increasing Nutrients - Restricted Competition	Number of Stems	689.0	404.0	491.0	761.0	400.0	225.0	201.0	179.0	162.0	61.0	102.0	46.0	471.0	180.0	61.0	9.0
	Mean	2.1	2.6	2.7	2.7	2.7	2.8	3.1	3.4	1.0	1.4	1.3	1.6	1.0	1.4	1.2	0.9
	Std Error of Mean	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.0	0.2	0.1	0.2	0.0	0.0	0.1	0.0
	Median	2.0	2.5	2.5	2.6	2.4	2.6	2.8	3.1	0.9	0.8	0.9	1.2	0.9	1.2	1.0	0.9
	Std Deviation	0.8	0.7	1.1	0.8	1.4	1.5	1.3	1.6	0.5	1.6	1.4	1.2	0.5	0.7	0.9	0.1
	Variance	0.6	0.4	1.1	0.7	1.9	2.4	1.8	2.6	0.3	2.5	1.9	1.4	0.2	0.4	0.8	0.0
	Minimum	0.2	1.0	1.0	0.8	0.3	0.4	0.4	1.0	0.2	0.1	0.3	0.2	0.2	0.5	0.3	0.7
	Maximum	6.0	5.4	6.3	6.5	8.5	7.6	7.4	8.7	3.6	7.7	6.8	4.7	2.9	3.7	4.1	1.2

Table 4.13: Analysis of Harvest Stem Widths (in mm) with Increasing Nutrient Concentrations

			Phragmites australis	*Lythrum salicaria*	*Filipendula ulmaria*	*Mentha aquatica*
Stem Heights with Increasing Nutrients	Combined Results	F	(3, 4434) = 114.853	(3, 1990) = 11.042	(3, 1272) = 4.638	(3, 1265) = 8.644
		p	0.000	0.000	0.003	0.000
		significance	Very Highly Significant	Very Highly Significant	Highly Significant	Very Highly Significant
	Full Competition Microcosms	F	(3, 2089) = 70.003	(3, 985) = 6.607	(3, 901) = 5.028	(3, 544) = 1.729
		p	0.000	0.000	0.002	0.160
		significance	Very Highly Significant	Very Highly Significant	Highly Significant	Not Significant
	Restricted Competition Microcosms	F	(3, 2341) = 50.880	(3, 1001) = 8.705	(3, 367) = 13.383	(3, 717) = 16.664
		p	0.000	0.000	0.000	0.000
		significance	Very Highly Significant	Very Highly Significant	Very Highly Significant	Very Highly Significant
Stem Widths with Increasing Nutrients	Combined Results	F	(3, 4434) = 267.701	(3, 1990) = 21.265	(3, 1272) = 4.513	(3, 1265) = 11.125
		p	0.000	0.000	0.004	0.000
		significance	Very Highly Significant	Very Highly Significant	Highly Significant	Very Highly Significant
	Full Competition Microcosms	F	(3, 2089) = 190.716	(3, 985) = 18.532	(3, 901) = 1.238	(3, 544) = 3.201
		p	0.000	0.000	0.295	0.023
		significance	Very Highly Significant	Very Highly Significant	Not Significant	Significant
	Restricted Competition Microcosms	F	(3, 2341) = 103.244	(3, 1001) = 12.835	(3, 367) = 4.127	(3, 717) = 17.074
		p	0.000	0.000	0.007	0.000
		significance	Very Highly Significant	Very Highly Significant	Highly Significant	Very Highly Significant

Table 4.14: ANOVA Summary of Stem Heights and Widths with Different Nutrient Concentrations

Parameter	Species	*Phragmites australis*				*Lythrum salicaria*				*Filipendula ulmaria*				*Mentha aquatica*			
	Nitrogen (mg/l)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	Salinity (‰)	< 0.05	5	10	15	< 0.05	5	10	15	< 0.05	5	10	15	< 0.05	5	10	15
Stem Heights (in mm) with Increasing Salinity - Combined Results	Number of Stems	1148.0	468.0	608.0	556.0	831.0	247.0	240.0	N/A	407.0	6.0	N/A	N/A	840.0	18.0	N/A	N/A
	Mean	671.0	719.1	730.2	662.6	855.2	821.8	911.5	N/A	301.1	796.0	N/A	N/A	246.9	62.8	N/A	N/A
	Std Error of Mean	9.0	14.7	14.1	15.5	13.1	27.1	29.7	N/A	8.1	130.2	N/A	N/A	5.6	12.1	N/A	N/A
	Median	646.0	690.5	706.5	590.5	833.0	830.0	919.0	N/A	277.0	938.0	N/A	N/A	205.0	51.0	N/A	N/A
	Std Deviation	306.2	317.4	347.1	365.3	377.8	425.6	459.4	N/A	162.7	318.9	N/A	N/A	163.5	51.4	N/A	N/A
	Variance	93761.5	100715.4	120500.4	133447.2	142728.2	181174.3	211085.2	N/A	26455.4	101665.6	N/A	N/A	26729.1	2644.9	N/A	N/A
	Minimum	10.0	85.0	30.0	70.0	122.0	43.0	73.0	N/A	20.0	381.0	N/A	N/A	14.0	9.0	N/A	N/A
	Maximum	1740.0	1712.0	1774.0	1892.0	1937.0	1955.0	1926.0	N/A	1584.0	1074.0	N/A	N/A	1059.0	229.0	N/A	N/A
Stem Heights (in mm) with Increasing Salinity - Full Competition	Number of Stems	459.0	217.0	241.0	301.0	431.0	130.0	160.0	N/A	245.0	6.0	N/A	N/A	369.0	N/A	N/A	N/A
	Mean	691.9	784.6	766.9	760.6	879.5	876.9	882.4	N/A	301.3	796.0	N/A	N/A	247.0	N/A	N/A	N/A
	Std Error of Mean	15.2	23.7	25.0	23.4	19.4	39.1	34.2	N/A	11.6	130.2	N/A	N/A	7.7	N/A	N/A	N/A
	Median	694.0	814.0	812.0	756.0	872.0	914.5	919.0	N/A	276.0	938.0	N/A	N/A	207.0	N/A	N/A	N/A
	Std Deviation	326.5	348.6	388.3	406.0	403.0	445.7	432.3	N/A	182.0	318.9	N/A	N/A	147.2	N/A	N/A	N/A
	Variance	106576.6	121544.3	150812.2	164866.7	162437.5	198666.5	186853.7	N/A	33122.4	101665.6	N/A	N/A	21660.6	N/A	N/A	N/A
	Minimum	10.0	85.0	44.0	116.0	122.0	43.0	73.0	N/A	28.0	381.0	N/A	N/A	14.0	N/A	N/A	N/A
	Maximum	1721.0	1712.0	1774.0	1892.0	1937.0	1955.0	1824.0	N/A	1584.0	1074.0	N/A	N/A	723.0	N/A	N/A	N/A
Stem Heights (im mm) with Increasing Salinity - Restricted Competition	Number of Stems	689.0	251.0	367.0	255.0	400.0	117.0	80.0	N/A	162.0	N/A	N/A	N/A	471.0	18.0	N/A	N/A
	Mean	657.1	662.5	706.1	546.9	829.1	760.6	969.6	N/A	300.8	N/A	N/A	N/A	246.9	62.8	N/A	N/A
	Std Error of Mean	11.1	17.4	16.5	16.8	17.4	36.5	56.7	N/A	10.1	N/A	N/A	N/A	8.1	12.1	N/A	N/A
	Median	628.0	634.0	672.0	495.0	778.0	700.0	918.5	N/A	279.5	N/A	N/A	N/A	205.0	51.0	N/A	N/A
	Std Deviation	291.3	276.0	315.4	268.4	347.2	395.1	507.3	N/A	128.5	N/A	N/A	N/A	175.4	51.4	N/A	N/A
	Variance	84882.9	76182.3	99481.9	72038.0	120522.3	156110.3	257393.0	N/A	16515.4	N/A	N/A	N/A	30754.6	2644.9	N/A	N/A
	Minimum	71.0	110.0	30.0	70.0	170.0	148.0	160.0	N/A	20.0	N/A	N/A	N/A	15.0	9.0	N/A	N/A
	Maximum	1740.0	1413.0	1675.0	1687.0	1778.0	1753.0	1926.0	N/A	1049.0	N/A	N/A	N/A	1059.0	229.0	N/A	N/A

Note: N/A = No results due to fatalities.

Table 4.15: Analysis of Harvest Stem Heights (in mm) with Increasing Salinity Concentrations

Parameter	Species	*Phragmites australis*				*Lythrum salicaria*				*Filipendula ulmaria*				*Mentha aquatica*			
	Nitrogen (mg/l)	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
	Salinity (‰)	< 0.05	5	10	15	< 0.05	5	10	15	< 0.05	5	10	15	< 0.05	5	10	15
Stem Widths (in mm) with Increasing Salinity - Combined Results	Number of Stems	1148.0	468.0	608.0	556.0	831.0	247.0	240.0	N/A	407.0	6.0	N/A	N/A	840.0	18.0	N/A	N/A
	Mean	2.2	2.3	2.1	2.2	2.9	2.8	3.5	N/A	1.2	3.7	N/A	N/A	1.1	1.0	N/A	N/A
	Std Error of Mean	0.0	0.0	0.0	0.0	0.1	0.1	0.1	N/A	0.1	0.9	N/A	N/A	0.0	0.1	N/A	N/A
	Median	2.1	2.2	2.0	2.0	2.5	2.6	3.2	N/A	1.0	4.2	N/A	N/A	1.0	1.0	N/A	N/A
	Std Deviation	0.8	0.8	0.8	0.9	1.5	1.3	1.7	N/A	1.0	2.1	N/A	N/A	0.5	0.3	N/A	N/A
	Variance	0.6	0.6	0.6	0.8	2.3	1.6	3.0	N/A	1.1	4.5	N/A	N/A	0.3	0.1	N/A	N/A
	Minimum	0.2	0.5	0.6	0.5	0.2	0.4	0.6	N/A	0.1	1.1	N/A	N/A	0.2	0.3	N/A	N/A
	Maximum	6.0	5.1	5.6	5.4	12.5	7.4	9.5	N/A	12.0	6.1	N/A	N/A	3.8	1.8	N/A	N/A
Stem Widths (in mm) with Increasing Salinity - Full Competition	Number of Stems	459.0	217.0	241.0	301.0	431.0	130.0	160.0	N/A	245.0	6.0	N/A	N/A	369.0	N/A	N/A	N/A
	Mean	2.4	2.6	2.3	2.5	3.0	2.9	3.3	N/A	1.3	3.7	N/A	N/A	1.2	N/A	N/A	N/A
	Std Error of Mean	0.0	0.0	0.0	0.1	0.1	0.1	0.1	N/A	0.1	0.9	N/A	N/A	0.0	N/A	N/A	N/A
	Median	2.4	2.5	2.2	2.4	2.7	2.6	3.0	N/A	1.0	4.2	N/A	N/A	1.0	N/A	N/A	N/A
	Std Deviation	0.7	0.7	0.8	0.9	1.6	1.2	1.6	N/A	1.2	2.1	N/A	N/A	0.6	N/A	N/A	N/A
	Variance	0.5	0.5	0.6	0.9	2.7	1.6	2.6	N/A	1.6	4.5	N/A	N/A	0.4	N/A	N/A	N/A
	Minimum	0.7	0.9	0.7	0.5	0.2	0.5	0.6	N/A	0.1	1.1	N/A	N/A	0.2	N/A	N/A	N/A
	Maximum	5.0	5.0	4.7	5.4	12.5	7.4	9.5	N/A	12.0	6.1	N/A	N/A	3.8	N/A	N/A	N/A
Stem Widths (in mm) with Increasing Salinity - Restricted Competition	Number of Stems	689.0	251.0	367.0	255.0	400.0	117.0	80.0	N/A	162.0	N/A	N/A	N/A	471.0	18.0	N/A	N/A
	Mean	2.1	2.1	2.0	1.9	2.7	2.8	3.8	N/A	1.0	N/A	N/A	N/A	1.0	1.0	N/A	N/A
	Std Error of Mean	0.0	0.0	0.0	0.0	0.1	0.1	0.2	N/A	0.0	N/A	N/A	N/A	0.0	0.1	N/A	N/A
	Median	2.0	2.0	1.9	1.8	2.4	2.5	3.6	N/A	0.9	N/A	N/A	N/A	0.9	1.0	N/A	N/A
	Std Deviation	0.8	0.8	0.8	0.7	1.4	1.3	2.0	N/A	0.5	N/A	N/A	N/A	0.5	0.3	N/A	N/A
	Variance	0.6	0.6	0.6	0.5	1.9	1.7	3.8	N/A	0.3	N/A	N/A	N/A	0.2	0.1	N/A	N/A
	Minimum	0.2	0.5	0.6	0.5	0.3	0.4	0.9	N/A	0.2	N/A	N/A	N/A	0.2	0.3	N/A	N/A
	Maximum	6.0	5.1	5.6	4.2	8.5	6.8	9.2	N/A	3.6	N/A	N/A	N/A	2.9	1.8	N/A	N/A

Note: N/A = No results due to fatalities.

Table 4.16: Analysis of Harvest Stem Widths (in mm) with Increasing Salinity Concentrations

			Phragmites australis	*Lythrum salicaria*	*Filipendula ulmaria*	*Mentha aquatica*
Stem Heights with Increasing Salinity	Combined Results	F	(3, 2776) = 6.942	(2, 1315) = 3.417	(1, 411) = 23.073	(1, 856) = 69.985
		p	0.000	0.033	0.000	0.000
		significance	Very Highly Significant	Significant	Very Highly Significant	Very Highly Significant
	Full Competition Microcosms	F	(3, 1214) = 2.290	(2, 718) = 0.592	(1, 249) = 20.622	N/A
		p	0.077	0.553	0.000	N/A
		significance	Not Significant	Not Significant	Very Highly Significant	N/A
	Restricted Competition Microcosms	F	(3, 1558) = 16.193	(2, 594) = 5.074	N/A	(1, 487) = 59.886
		p	0.000	0.007	N/A	0.000
		significance	Very Highly Significant	Highly Significant	N/A	Very Highly Significant
Stem Widths with Increasing Salinity	Combined Results	F	(3, 2776) = 3.297	(2, 1315) = 13.961	(1, 411) = 25.404	(1, 856) = 0.473
		p	0.020	0.000	0.000	0.492
		significance	Significant	Very Highly Significant	Very Highly Significant	Not Significant
	Full Competition Microcosms	F	(3, 1214) = 5.599	(2, 718) = 2.277	(1, 249) = 20.154	N/A
		p	0.001	0.103	0.000	N/A
		significance	Very Highly Significant	Not Significant	Very Highly Significant	N/A
	Restricted Competition Microcosms	F	(3, 1558) = 5.411	(2, 594) = 15.766	N/A	(1, 487) = 0.106
		p	0.001	0.000	N/A	0.745
		significance	Very Highly Significant	Very Highly Significant	N/A	Not Significant

Table 4.17: ANOVA Summary of Stem Heights and Widths with Different Salinity Concentrations

4.2.4 Hypothesis 4 Overview

Hypothesis 4 is:

"The higher concentrations of the chosen chemical ranges will have an effect on the stem heights or stem widths of the surviving plants, and restricting root competition between the different floral species will have an effect."

Following on from Hypothesis 3, Hypothesis 4 was used to determine if restricting root competition had an effect on the surviving stem heights and widths at the chosen chemical ranges, and thus influence the management recommendations for designing biodiversity enhancements within a constructed wetland treatment system.

In order to disprove the hypothesis, the null hypothesis is:

"The higher concentrations of the chosen chemical ranges will not have an effect on the stem height or stem widths of the surviving plants, and restricting root competition between the different floral species will not have an effect."

As with Hypothesis 3, the stem heights and widths were skewed so the data was transformed using a logarithmic transformation of 10. The histograms can be found within Appendix (23). The averages of the stem heights and stem widths for the four different species at the different loadings can be found in Table 4.12 and Table 4.13 for the nutrients and Table 4.15 and Table 4.16 for the salinity.

The results were separated to enable the individual heights and widths of the species within all the restricted competition microcosms to be analysed for each pollutant concentration. As with Hypothesis 3, a One Way ANOVA test was run comparing both the heights and widths of the plant stems. An overview of the One Way ANOVA results for the stem heights and stem widths can be found in Table 4.14 for nutrients and Table 4.17 for salinity, with the full results presented in Appendix (24).

The data was further separated to compare the full competition microcosm against the restricted competition microcosm for each species and at each individual concentration of nutrients and salinity. Only two parameters, one for full competition and one for restricted competition were available for this analysis. Therefore an Independent Samples T Test was undertaken using PAWS Statistics 18 on the stems of the surviving species present. The Independent Samples T Test was run on the Log10 transformed data comparing both the heights and widths of the plant stems. This was undertaken for each individual species separately. Where the Levene's tests for equality of variances confirmed that the data violates the assumption of equal variances, the alternative T Test result produced within PAWS 18 to take account of this violation was used. An overview of the T Test results for the stem heights and stem widths can be found in Table 4.18 for nutrients and Table 4.19 for salinity.

		Phragmites australis				*Lythrum salicaria*			
		Full Competition	**Restricted Competition**	**T Test**	**Significance**	**Full Competition**	**Restricted Competition**	**T Test**	**Significance**
10 mg/l Nitrogen and <0.05 ‰ Salinity	Height	M = 2.78, SD = 0.26	M = 2.77, SD = 0.21	t (0.38) = 822.43, p = 0.69	Not Significant	M = 2.89, SD = 0.25	M = 2.88, SD = 0.20	t (813.45) = 0.57, p = 0.57	Not Significant
	Width	M = 0.36, SD = 0.14	M = 0.29, SD = 0.17	t (1097.36) = 7.54, p = 0.00	Very Highly Significant	M = 0.43, SD = 0.23	M = 0.38, SD = 0.22	t (829) = 2.91, p = 0.00	Very Highly Significant
50 mg/l Nitrogen and <0.05 ‰ Salinity	Height	M = 2.88, SD = 0.25	M = 2.90, SD = 0.25	t (798) = -1.13, p = 0.26	Not Significant	M = 2.98, SD = 0.25	M = 2.94, SD = 0.21	t (354.55) = 1.67, p = 0.10	Not Significant
	Width	M = 0.44, SD = 0.11	M = 0.40, SD = 0.12	t (798) = 5.13, p = 0.00	Very Highly Significant	M = 0.55, SD = 0.19	M = 0.38, SD = 0.26	t (399.43) = 7.45, p = 0.00	Very Highly Significant
100 mg/l Nitrogen and <0.05 ‰ Salinity	Height	M = 3.00, SD = 0.26	M = 2.89, SD = 0.27	t (1046) = 6.67, p = 0.00	Very Highly Significant	M = 2.91, SD = 0.30	M = 2.95, SD = 0.22	t (285.43) = -1.36, p = 0.18	Not Significant
	Width	M = 0.52, SD = 0.11	M = 0.40, SD = 0.17	t (806.64) = 12.79, p = 0.00	Very Highly Significant	M = 0.52, SD = 0.20	M = 0.45, SD = 0.20	t (360) = 3.35, p = 0.00	Very Highly Significant
150 mg/l Nitrogen and <0.05 ‰ Salinity	Height	M = 2.96, SD = 0.27	M = 2.92, SD = 0.25	t (1440) = 2.87, p = 0.00	Very Highly Significant	M = 236.23, SD = 7.39	M = 2.88, SD = 0.29	t (380.26) = -2.63, p = 0.01	Highly Significant
	Width	M = 0.51, SD = 0.12	M = 0.41, SD = 0.13	t (1440) = 13.53, p = 0.00	Very Highly Significant	M = 0.52, SD = 0.22	M = 0.49, SD = 0.21	t (393) = 1.27, p = 0.20	Not Significant

		Filipendula ulmaria				*Mentha aquatica*			
		Full Competition	**Restricted Competition**	**T Test**	**Significance**	**Full Competition**	**Restricted Competition**	**T Test**	**Significance**
10 mg/l Nitrogen and <0.05 ‰ Salinity	Height	M = 2.42, SD = 0.24	M = 2.44, SD = 0.19	t (405) = -0.96, p = 0.34	Not Significant	M = 2.31, SD = 0.28	M = 2.28, SD = 0.32	t (826.31) = 1.30, p = 0.20	Not Significant
	Width	M = 0.01, SD = 0.26	M = -0.05, SD = 0.21	t (405) = 2.24, p = 0.03	Significant	M = 0.01, SD = 0.22	M = -0.03, SD = 0.20	t (733.11) = 2.93, p = 0.00	Very Highly Significant
50 mg/l Nitrogen and <0.05 ‰ Salinity	Height	M = 2.42, SD = 0.34	M = 2.53, SD = 0.28	t (292) = -2.34, p = 0.02	Significant	M = 2.26, SD = 0.27	M = 2.44, SD = 0.29	t (219) = -3.71, p = 0.00	Very Highly Significant
	Width	M = 0.03, SD = 0.33	M = -0.01, SD = 0.36	t (292) = 0.81, p = 0.42	Not Significant	M = -0.03, SD = 0.17	M = 0.09, SD = 0.19	t (219) = -3.88, p = 0.00	Very Highly Significant
100 mg/l Nitrogen and <0.05 ‰ Salinity	Height	M = 2.36, SD = 0.30	M = 2.55, SD = 0.22	t (264.29) = -6.26, p = 0.00	Very Highly Significant	M = 2.30, SD = 0.24	M = 2.38, SD = 0.33	t (108.56) = -1.46, p = 0.15	Not Significant
	Width	M = 236.23, SD = 7.39	M = 0.03, SD = 0.31	t (292) = 1.00, p = 0.32	Not Significant	M = -0.08, SD = 0.18	M = -0.01, SD = 0.29	t (103.31) = -1.63, p = 0.11	Not Significant
150 mg/l Nitrogen and <0.05 ‰ Salinity	Height	M = 2.47, SD = 0.29	M = 2.65, SD = 0.19	t (90.03) = -5.19, p = 0.00	Very Highly Significant	M = 2.37, SD = 0.29	M = 1.93, SD = 0.49	t (8.59) = 2.68, p = 0.03	Significant
	Width	M = 0.06, SD = 0.30	M = 0.12, SD = 0.30	t (279) = -1.16, p = 0.25	Not Significant	M = 0.01, SD = 0.20	M = -0.04, SD = 0.07	t (25.93) = 1.76, p = 0.09	Not Significant

Table 4.18: T Test Summary of Stem Heights and Widths Between Full and Restricted Competition Microcosms with Different Nutrient Concentrations

		Phragmites australis				*Lythrum salicaria*			
		Full Competition	**Restricted Competition**	**T Test**	**Significance**	**Full Competition**	**Restricted Competition**	**T Test**	**Significance**
10 mg/l Nitrogen and <0.05 ‰ Salinity	Height	M = 2.78, SD = 0.26	M = 2.77, SD = 0.21	t (0.38) = 822.43, p = 0.69	Not Significant	M = 2.89, SD = 0.25	M = 2.88, SD = 0.20	t (813.45) = 0.57, p = 0.57	Not Significant
	Width	M = 0.36, SD = 0.14	M = 0.29, SD = 0.17	t (1097.36) = 7.54, p = 0.00	Very Highly Significant	M = 0.43, SD = 0.23	M = 0.38, SD = 0.22	t (829) = 2.91, p = 0.00	Very Highly Significant
10 mg/l Nitrogen and 5 ‰ Salinity	Height	M = 2.84, SD = 0.26	M = 2.78, SD = 0.20	t (410.54) = 2.60, p = 0.01	Highly Significant	M = 2.86, SD = 0.33	M = 2.82, SD = 0.25	t (245) = 1.07, p = 0.29	Not Significant
	Width	M = 0.39, SD = 0.12	M = 0.28, SD = 0.17	t (457.18) = 8.04, p = 0.00	Very Highly Significant	M = 0.42, SD = 0.19	M = 0.40, SD = 0.20	t (245) = 1.06, p = 0.29	Not Significant
10 mg/l Nitrogen and 10 ‰ Salinity	Height	M = 2.80, SD = 0.29	M = 2.80, SD = 0.23	t (423.81) = 0.40, p = 0.69	Not Significant	M = 2.88, SD = 0.27	M = 2.91, SD = 0.27	t (238) = -0.98, p = 0.33	Not Significant
	Width	M = 0.34, SD = 0.16	M = 0.28, SD = 0.16	t (606) = 4.22, p = 0.00	Very Highly Significant	M = 0.47, SD = 0.21	M = 0.53, SD = 0.22	t (238) = -2.08, p = 0.04	Significant
10 mg/l Nitrogen and 15 ‰ Salinity	Height	M = 2.80, SD = 0.29	M = 2.69, SD = 0.23	t (552.79) = 5.44, p = 0.00	Very Highly Significant	N/A	N/A	N/A	N/A
	Width	M = 0.37, SD = 0.17	M = 0.24, SD = 0.17	t (554) = 8.76, p = 0.00	Very Highly Significant	N/A	N/A	N/A	N/A

		Filipendula ulmaria				*Mentha aquatica*			
		Full Competition	**Restricted Competition**	**T Test**	**Significance**	**Full Competition**	**Restricted Competition**	**T Test**	**Significance**
10 mg/l Nitrogen and <0.05 ‰ Salinity	Height	M = 2.42, SD = 0.24	M = 2.44, SD = 0.19	t (405) = -0.96, p = 0.34	Not Significant	M = 2.31, SD = 0.28	M = 2.28, SD = 0.32	t (826.31) = 1.30, p = 0.20	Not Significant
	Width	M = 0.01, SD = 0.26	M = -0.05, SD = 0.21	t (405) = 2.24, p = 0.03	Significant	M = 0.01, SD = 0.22	M = -0.03, SD = 0.20	t (733.11) = 2.93, p = 0.00	Very Highly Significant
10 mg/l Nitrogen and 5 ‰ Salinity	Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Width	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10 mg/l Nitrogen and 10 ‰ Salinity	Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Width	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
10 mg/l Nitrogen and 15 ‰ Salinity	Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Width	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Note: N/A = No results due to fatalities.

Table 4.19: T Test Summary of Stem Heights and Widths Between Full and Restricted Competition Microcosms with Different Salinity Concentrations

4.2.5 Hypothesis 5 Overview

Hypothesis 5 is:

"The higher concentrations of the chosen chemical ranges will have an effect on the above and below ground total biomass of the plants."

This hypothesis was chosen to see if the biomass of the vegetation was affected by the increasing chemical concentrations, as this could impact upon future management options for constructed wetland treatment systems.

In order to disprove the hypothesis, the null hypothesis is:

"The higher concentrations of the chosen chemical ranges will not have an effect on the above and below ground total biomass of the plants."

To test this hypothesis, the above ground weight and volume was analysed along with the below ground weights for the different species, and the Root:Shoot Ratios. This was undertaken for the microcosms with full below and above ground competition (microcosms 1 - 8) and is presented in Table 4.20 and Table 4.21. Bar Graphs illustrating the pattern of above and below ground biomass within these microcosms are presented in Figure 4.8 and Figure 4.9.

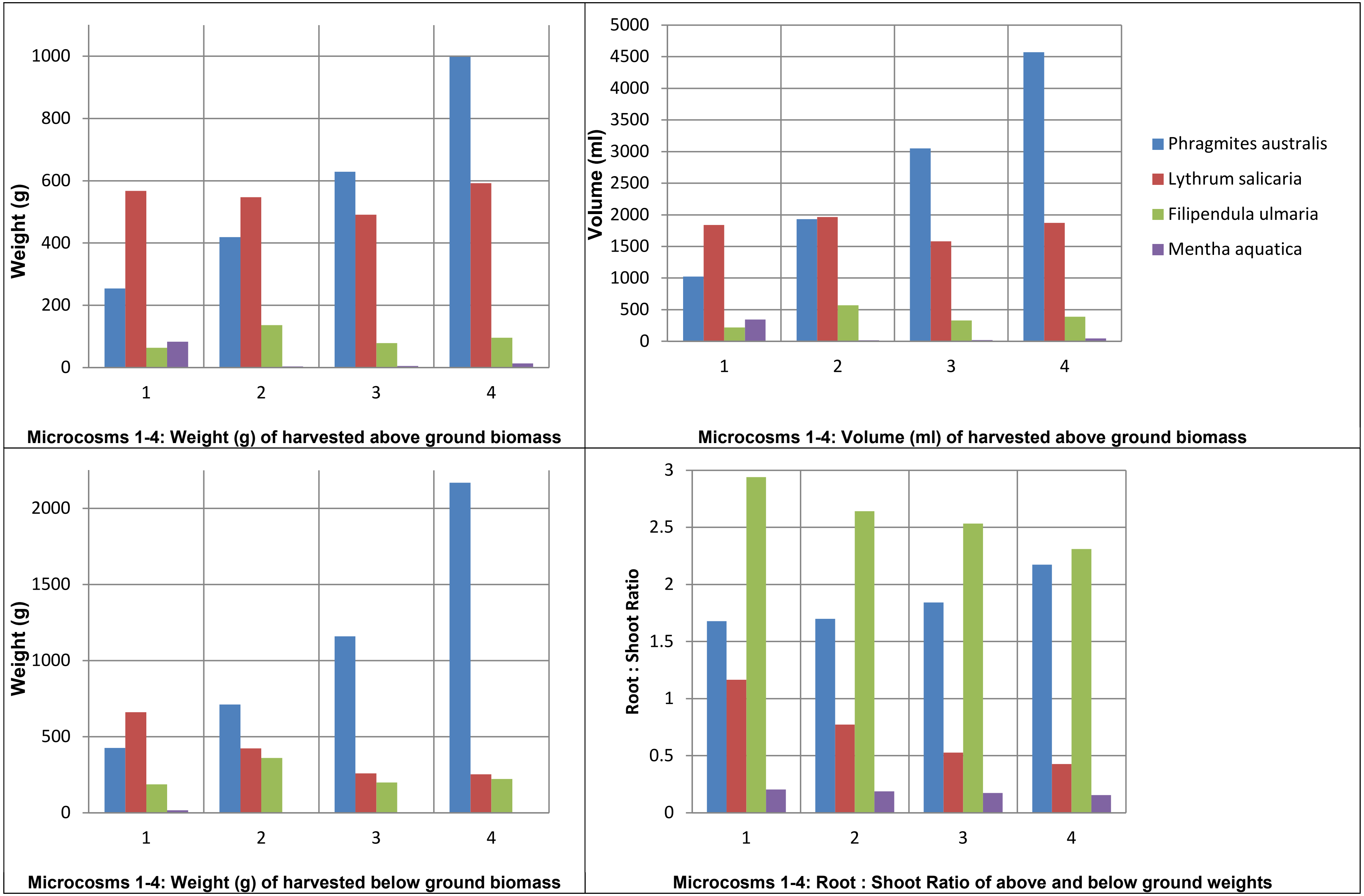
The measurements employed in the analysis were collected from the final harvest undertaken in November 2010. As only a single measurement of each parameter was available, no parametric statistical tests could be undertaken. The effects of nutrient and salinity were assessed separately for Hypothesis 5.

Species	Parameter	Microcosm Number			
		1	2	3	4
Phragmites australis	Above Ground Weight (g)	253.86	418.90	629.18	997.39
	Below Ground Weight (g)	425.89	711.97	1159.49	2168.09
	Root : Shoot Weight Ratio	1.68	1.70	1.84	2.17
	Above Ground Volume (ml)	1025.00	1930.00	3050.00	4570.00
Lythrum salicaria	Above Ground Weight (g)	567.44	546.97	490.79	592.09
	Below Ground Weight (g)	661.24	422.72	258.48	252.65
	Root : Shoot Weight Ratio	1.17	0.77	0.53	0.43
	Above Ground Volume (ml)	1840.00	1965.00	1580.00	1873.00
Filipendula ulmaria	Above Ground Weight (g)	63.45	136.49	78.77	95.97
	Below Ground Weight (g)	186.54	360.45	199.47	221.71
	Root : Shoot Weight Ratio	2.94	2.64	2.53	2.31
	Above Ground Volume (ml)	220.00	570.00	330.00	390.00
Mentha aquatica	Above Ground Weight (g)	82.91	3.72	4.87	13.58
	Below Ground Weight (g)	16.88	0.70	0.85	2.12
	Root : Shoot Weight Ratio	0.20	0.19	0.17	0.16
	Above Ground Volume (ml)	345.00	18.00	21.00	47.00

Table 4.20: Biomass Results for Microcosms 1-4 - Full Root Competition, with Increasing Nutrient Concentration

Species	Parameter	Microcosm Number			
		5	6	7	8
Phragmites australis	Above Ground Weight (g)	73.32	217.75	209.31	306.89
	Below Ground Weight (g)	121.15	308.22	277.41	418.06
	Root : Shoot Weight Ratio	1.65	1.42	1.33	1.36
	Above Ground Volume (ml)	360.00	1020.00	1110.00	1540.00
Lythrum salicaria	Above Ground Weight (g)	361.16	225.84	387.83	0.00
	Below Ground Weight (g)	430.14	192.56	314.90	0.00
	Root : Shoot Weight Ratio	1.19	0.85	0.81	0.00
	Above Ground Volume (ml)	1145.00	720.00	1330.00	0.00
Filipendula ulmaria	Above Ground Weight (g)	58.78	13.66	0.00	0.00
	Below Ground Weight (g)	176.02	39.90	0.00	0.00
	Root : Shoot Weight Ratio	2.99	2.92	0.00	0.00
	Above Ground Volume (ml)	301.00	35.00	0.00	0.00
Mentha aquatica	Above Ground Weight (g)	10.22	0.00	0.00	0.00
	Below Ground Weight (g)	2.09	0.00	0.00	0.00
	Root : Shoot Weight Ratio	0.20	0.00	0.00	0.00
	Above Ground Volume (ml)	61.00	0.00	0.00	0.00

Table 4.21: Biomass Results for Microcosms 5-8 - Full Root Competition, with Increasing Salinity Concentration



Microcosms 1-4: Weight (g) of harvested above ground biomass

Microcosms 1-4: Volume (ml) of harvested above ground biomass

Microcosms 1-4: Weight (g) of harvested below ground biomass

Microcosms 1-4: Root : Shoot Ratio of above and below ground weights

Figure 4.8: Above and Below Ground Biomass for Microcosms 1-4

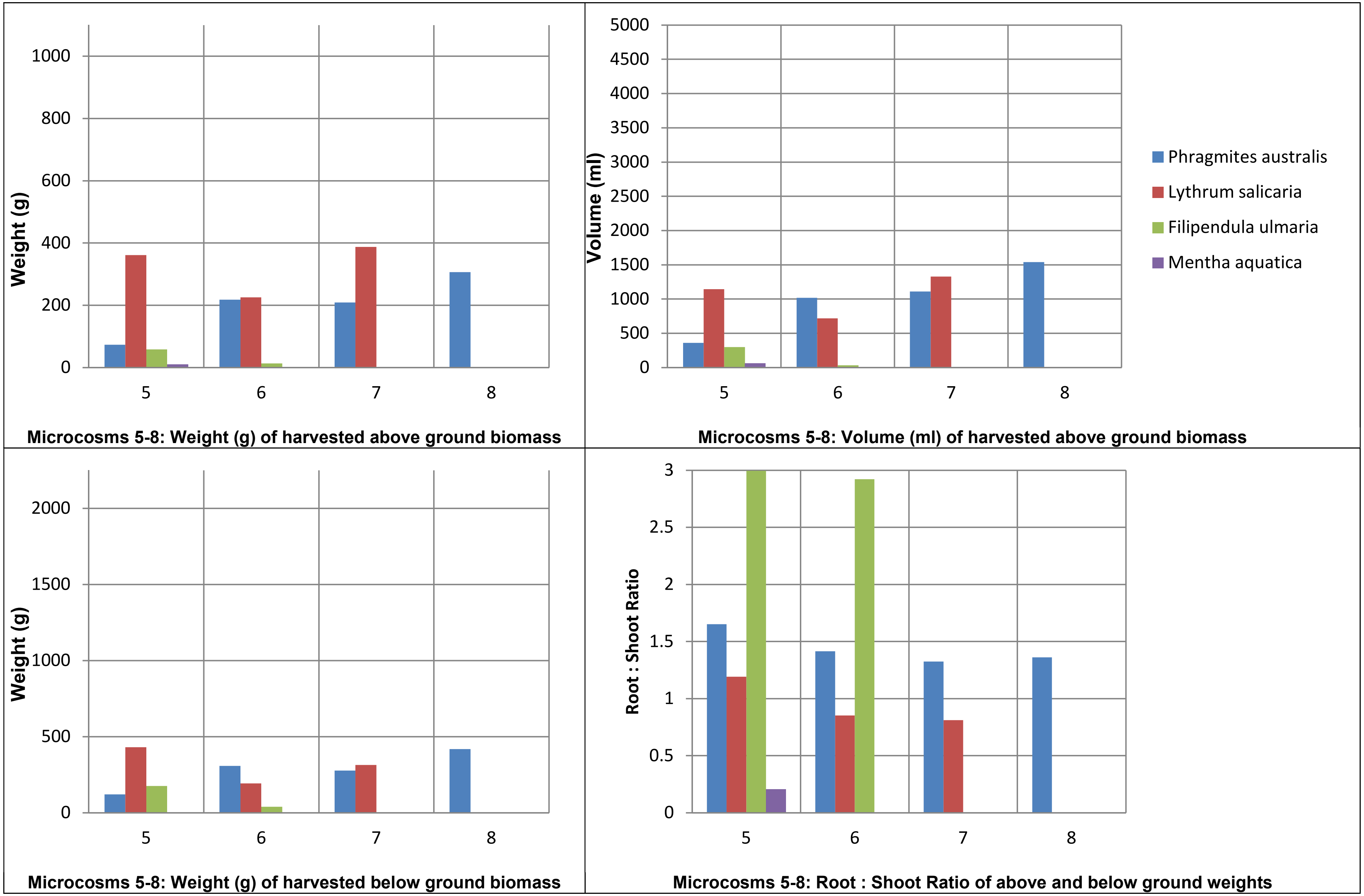


Figure 4.9: Above and Below Ground Biomass for Microcosms 5-8

4.2.6 Hypothesis 6 Overview

Hypothesis 6 is:

"The higher concentrations of the chosen chemical ranges will have an effect on the above and below ground total biomass of the plants, and restricting root competition between the different floral species will have an effect."

This hypothesis was chosen to see if the biomass of the vegetation was affected by the increasing chemical concentrations when the root competition was restricted, since this could also impact upon future management options.

In order to disprove the hypothesis, the null hypothesis is:

"The higher concentrations of the chosen chemical ranges will not have an effect on the above and below ground total biomass of the plants, and restricting root competition between the different floral species will not have an effect."

As with Hypothesis 5, the effects of nutrient and salinity were assessed, and as only a single measurement of each parameter was obtained from the final harvest, no parametric statistical tests were undertaken.

To test this hypothesis, the above ground weight and volume was analysed along with the below ground weights for the different species, and the Root:Shoot Ratios. This was undertaken for the microcosms with full below and above ground competition (microcosms 9 - 16) and is presented in Table 4.22 and Table 4.23. Bar Graphs illustrating the pattern of above and below ground biomass within these microcosms are presented in Figure 4.10 and Figure 4.11.

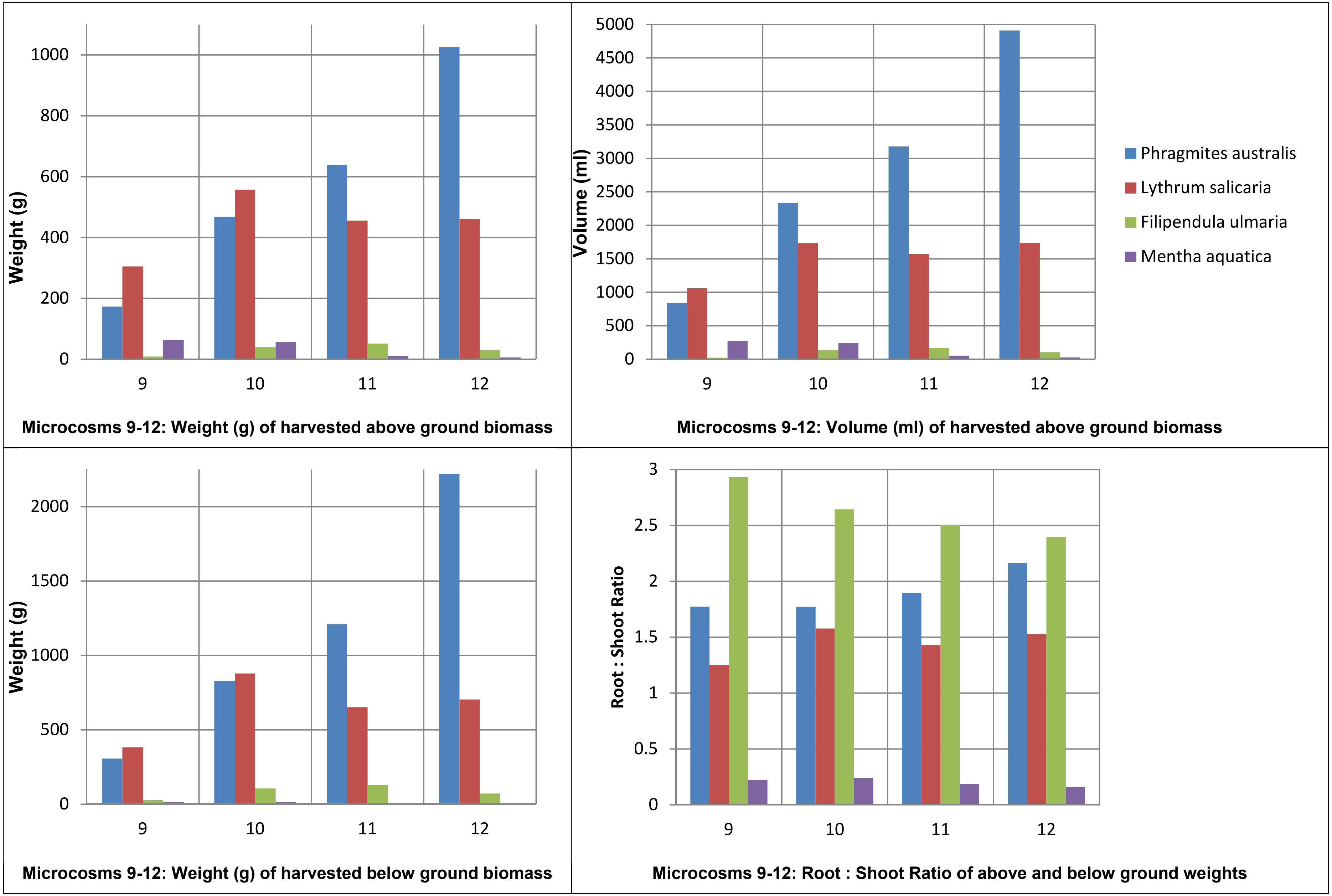
The biomass ratios of above ground and below ground weights for all of the different microcosms were plotted per species in Figure 4.12 to enable the relationships between biomass ratios to be explored.

Species	Parameter	Microcosm Number			
		9	10	11	12
Phragmites australis	Above Ground Weight (g)	173.15	468.55	638.96	1027.20
	Below Ground Weight (g)	307.04	830.04	1210.40	2220.77
	Root : Shoot Weight Ratio	1.77	1.77	1.89	2.16
	Above Ground Volume (ml)	840.00	2339.00	3180.00	4910.00
Lythrum salicaria	Above Ground Weight (g)	305.43	556.96	455.43	460.30
	Below Ground Weight (g)	382.21	878.79	652.35	703.30
	Root : Shoot Weight Ratio	1.25	1.58	1.43	1.53
	Above Ground Volume (ml)	1060.00	1735.00	1570.00	1740.00
Filipendula ulmaria	Above Ground Weight (g)	9.25	39.82	51.47	29.95
	Below Ground Weight (g)	27.09	105.17	128.86	71.77
	Root : Shoot Weight Ratio	2.93	2.64	2.50	2.40
	Above Ground Volume (ml)	25.00	135.00	169.00	104.00
Mentha aquatica	Above Ground Weight (g)	63.47	56.09	11.12	6.28
	Below Ground Weight (g)	14.22	13.45	2.07	1.01
	Root : Shoot Weight Ratio	0.22	0.24	0.19	0.16
	Above Ground Volume (ml)	272.00	244.00	55.00	27.00

Table 4.22: Biomass Results for Microcosms 9-12 - Restricted Root Competition, with Increasing Nutrient Concentration

Species	Parameter	Microcosm Number			
		13	14	15	16
Phragmites australis	Above Ground Weight (g)	284.96	163.53	265.40	121.14
	Below Ground Weight (g)	499.86	234.53	361.06	160.83
	Root : Shoot Weight Ratio	1.75	1.43	1.36	1.33
	Above Ground Volume (ml)	1480.00	810.00	1390.00	690.00
Lythrum salicaria	Above Ground Weight (g)	329.94	190.08	308.72	0.00
	Below Ground Weight (g)	403.58	201.87	296.34	0.00
	Root : Shoot Weight Ratio	1.22	1.06	0.96	0.00
	Above Ground Volume (ml)	1205.00	700.00	937.00	0.00
Filipendula ulmaria	Above Ground Weight (g)	29.21	0.00	0.00	0.00
	Below Ground Weight (g)	86.66	0.00	0.00	0.00
	Root : Shoot Weight Ratio	2.97	0.00	0.00	0.00
	Above Ground Volume (ml)	135.00	0.00	0.00	0.00
Mentha aquatica	Above Ground Weight (g)	26.98	6.31	0.00	0.00
	Below Ground Weight (g)	6.23	1.49	0.00	0.00
	Root : Shoot Weight Ratio	0.23	0.24	0.00	0.00
	Above Ground Volume (ml)	109.00	29.00	0.00	0.00

Table 4.23: Biomass Results for Microcosms 13-16 - Restricted Root Competition, with Increasing Salinity Concentration



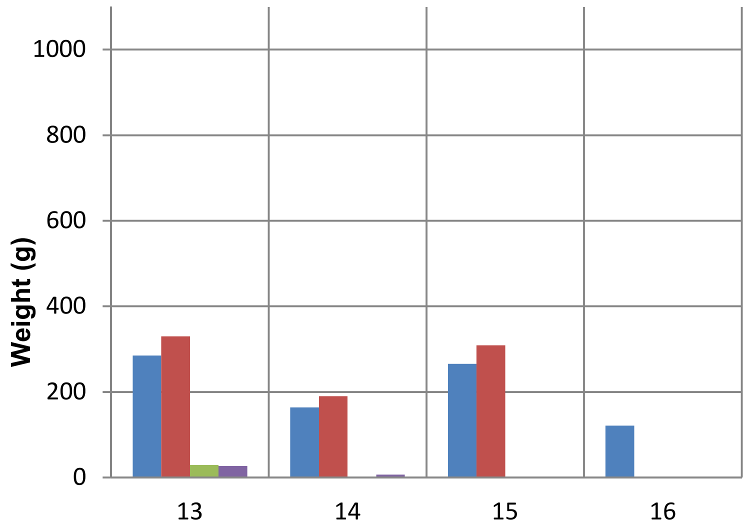
Microcosms 9-12: Weight (g) of harvested above ground biomass

Microcosms 9-12: Volume (ml) of harvested above ground biomass

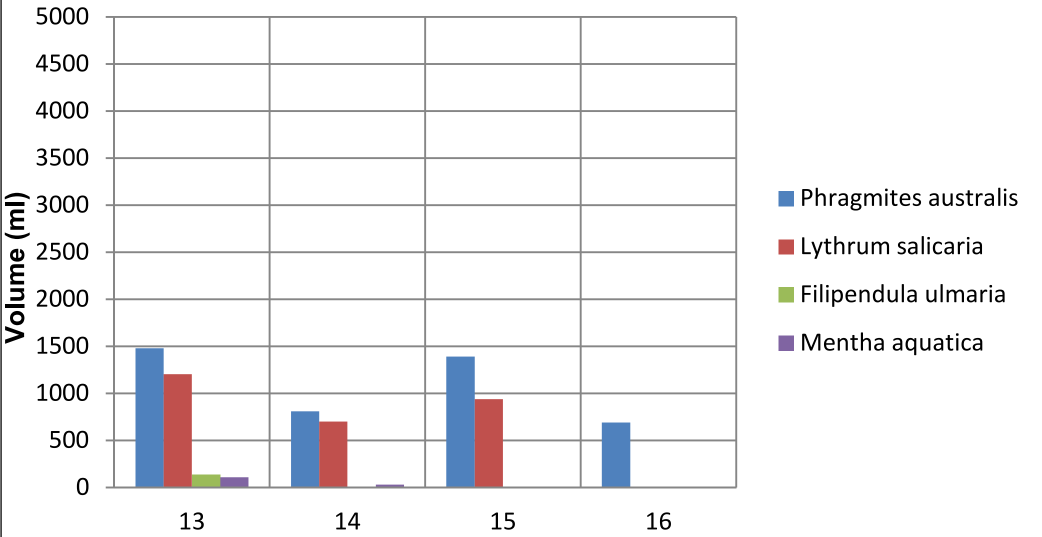
Microcosms 9-12: Weight (g) of harvested below ground biomass

Microcosms 9-12: Root : Shoot Ratio of above and below ground weights

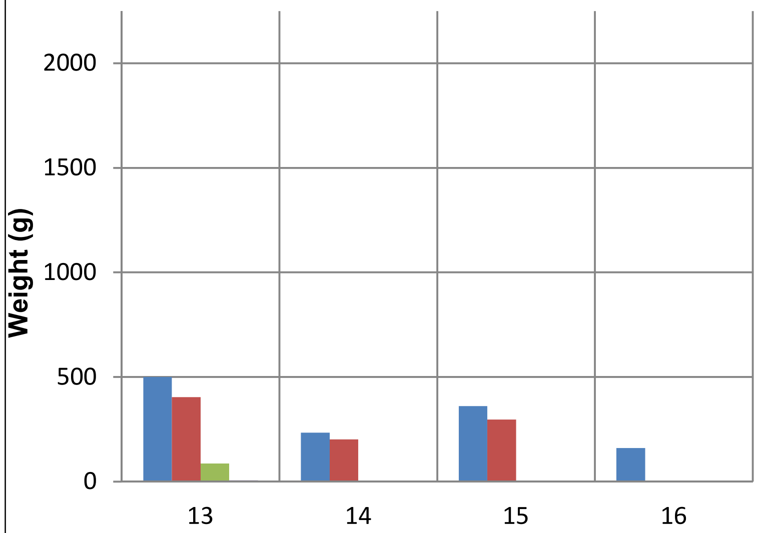
Figure 4.10: Above and Below Ground Biomass for Microcosms 9-12



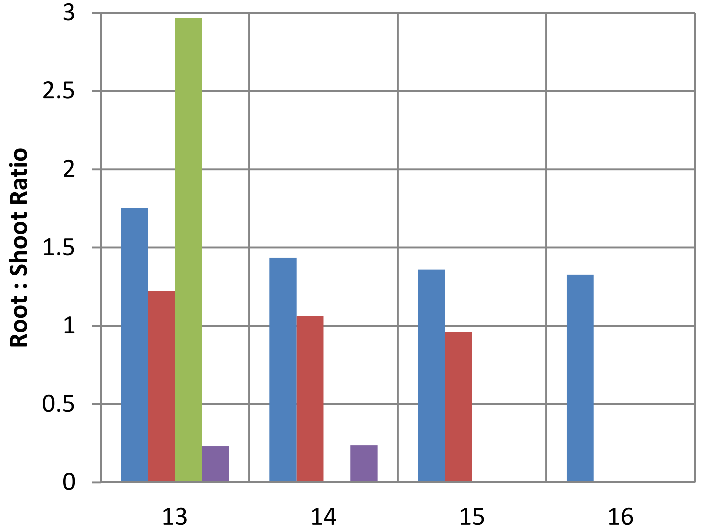
Microcosms 13-16: Weight (g) of harvested above ground biomass



Microcosms 13-16: Volume (ml) of harvested above ground biomass

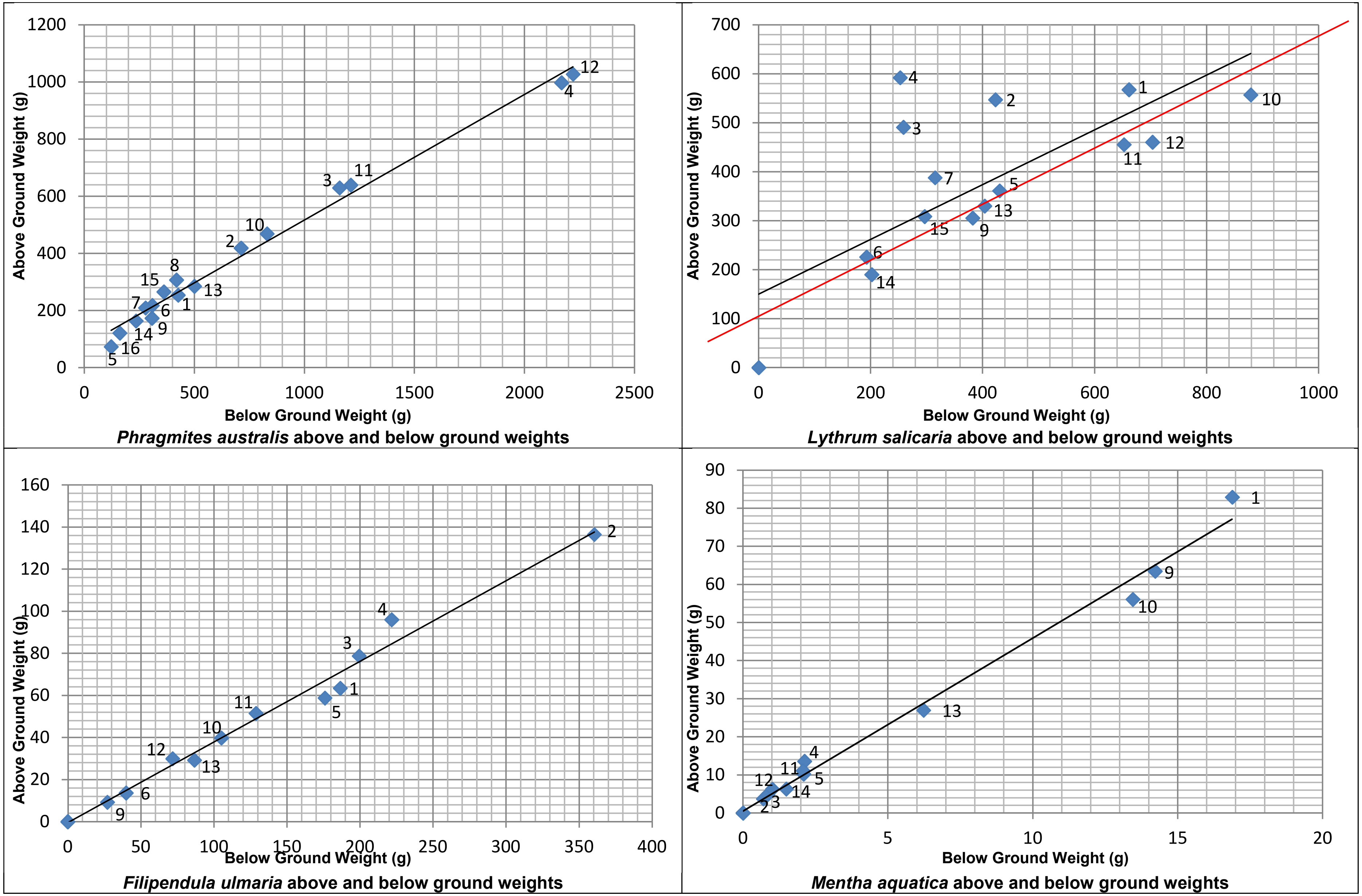


Microcosms 13-16: Weight (g) of harvested below ground biomass



Microcosms 13-16: Root : Shoot Ratio of above and below ground weights

Figure 4.11: Above and Below Ground Biomass for Microcosms 13-16



Notes: 1): The blue markers on the axis junctions represent the microcosms where the species did not survive. 2): The red line on *Lythrum salicaria* is not the linear regression line but illustrates the general separation between the restricted root competition microcosms and the full competition microcosms.

Figure 4.12: Plot Graph Showing the Above and Below Ground Harvest Weights for Microcosms 1-16

4.2.7 Hypothesis 7 Overview

Hypothesis 7 is:

"The higher concentrations of the chosen chemical ranges will have an effect on the water consumption."

This hypothesis allows the effect of increasing chemical concentrations on the vegetation water consumption to be explored,.

In order to disprove the hypothesis, the null hypothesis is:

"The higher concentrations of the chosen chemical ranges will not have an effect on the water consumption."

The measurements of water input were collected each month throughout the study period. As only a single water usage result for each parameter was obtained each month, no parametric statistical tests were undertaken on the results. The effects of nutrient and salinity were assessed separately for Hypothesis 7 to identify any trends which may be occurring.

For Hypothesis 1 and 2, May and August were chosen to assess the area coverage in the early stages of the general flora growing season (May) and in the peak flora growing season (August). For this hypothesis May was chosen as the beginning of the growing season when the plants were starting to use larger quantities of water, and the water was tabulated until the end of August when the water usage was declining. The yearly water usage totals were also assessed.

The water usage results detailed within Table A3.1 (water input for Microcosms 1 - 8 during the acclimatisation period, Appendix 3), Tables A5.1 & A7.1 (Water input for Microcosms 1 - 8 during the treatment period, Appendices 5 and 7), were utilised in the analysis.

Figure 4.13 illustrates the water usage cycles for Microcosms 1-4 during the study period. Table 4.24 details the water usage data during the peak growing season (prior to water usage decreasing) as well as the yearly totals.

Figure 4.14 illustrates the water usage cycles for Microcosms 5-8 during the study period. Table 4.25 details the water usage data during the peak growing season (prior to water usage decreasing) as well as the yearly totals.

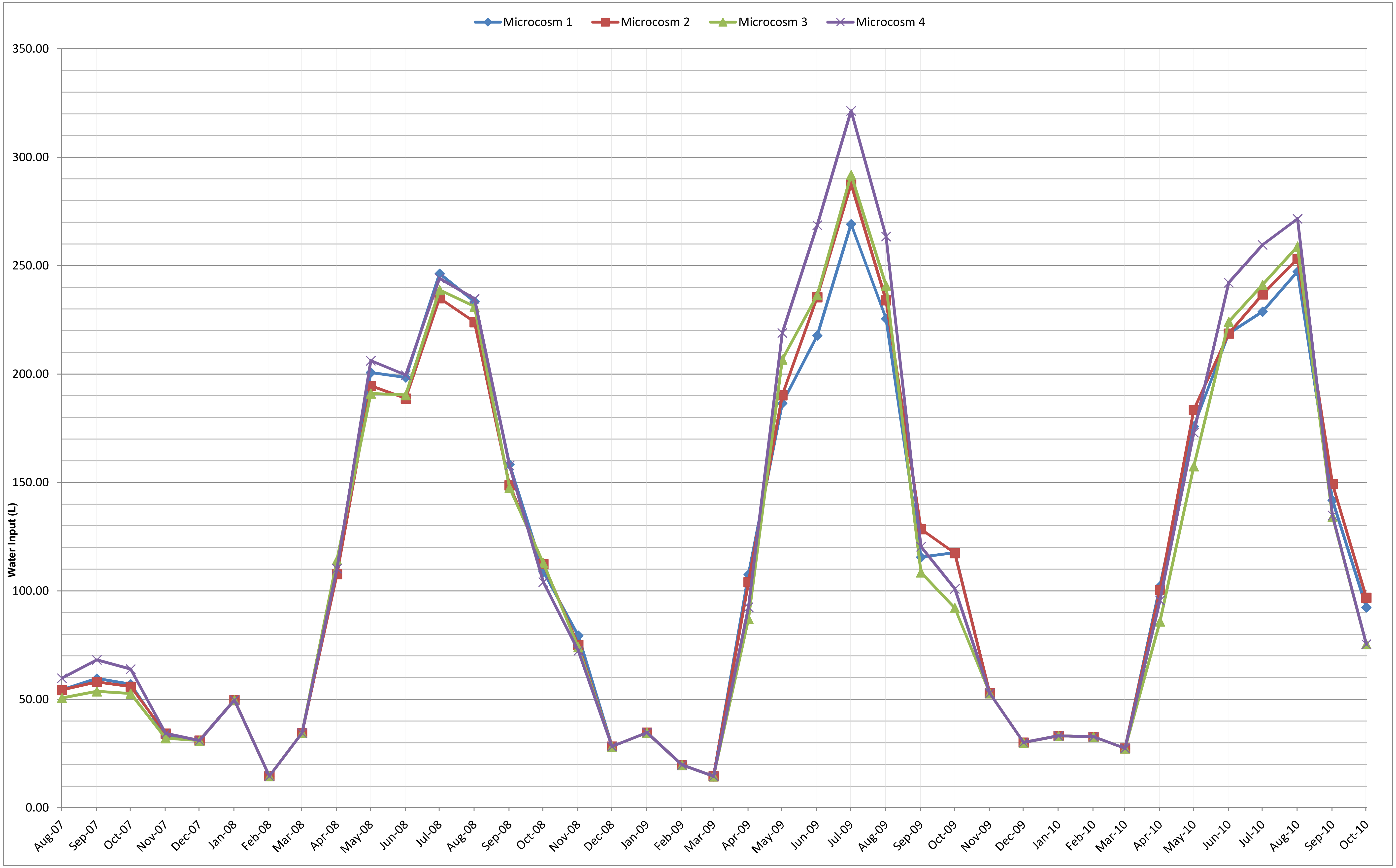


Figure 4.13: Total Monthly Water Input (L) for Microcosms 1-4

Treatment Concentration	Microcosm Number	2009					2010				
		May-09	Jun-09	Jul-09	Aug-09	Total Jan 2009 – Dec-09	May-10	Jun-10	Jul-10	Aug-10	Total Jan 2010 – Oct-10
10 mg/l Nitrogen and <0.05 ‰ Salinity	**1 (Full Root Competition)**	186.59	**217.78**	269.2	225.59	1391.88	175.9	218.75	228.84	247.3	1300.64
	9 (Restricted Root Competition)	185.29	**221.55**	266.75	220.67	1382.25	148.42	200.98	216.92	231.68	1201.64
	Difference	1.3	**-3.77**	2.45	4.92	9.63	27.48	17.77	11.92	15.62	99
50 mg/l Nitrogen and <0.05 ‰ Salinity	**2 (Full Root Competition)**	**190.27**	235.47	287.78	234.05	1449.46	183.55	218.75	236.76	253.22	1332.44
	10 (Restricted Root Competition)	**190.44**	222.63	272.67	223.74	1392.88	162.56	211.75	221.77	237.6	1241.03
	Difference	**-0.17**	12.84	15.11	10.31	56.58	20.99	7	14.99	15.62	91.41
100 mg/l Nitrogen and <0.05 ‰ Salinity	**3 (Full Root Competition)**	206.78	236.47	291.92	240.89	1415.81	**157.5**	224.14	241.22	258.91	1270.8
	11 (Restricted Root Competition)	196.37	234.7	287.24	234.82	1385.73	**164.19**	214.98	233.46	249.45	1230.88
	Difference	10.41	1.77	4.68	6.07	30.08	**-6.69**	9.16	7.76	9.46	39.92
150 mg/l Nitrogen and <0.05 ‰ Salinity	**4 (Full Root Competition)**	219.01	268.71	321.43	263.49	1538.45	**173.02**	242.21	259.63	271.67	1345.79
	12 (Restricted Root Competition)	196.42	252.07	308.09	254.34	1460.44	**175.58**	236.13	255.9	267.83	1323.79
	Difference	22.59	16.64	13.34	9.15	78.01	**-2.56**	6.08	3.73	3.84	22

Notes: Shaded cells highlight where the restricted root competition microcosm is higher than the full root microcosm with the same treatment concentration.

Table 4.24: Water Usage (L) Comparison of the Full and Restricted Root Competition Microcosms within the Nutrient Treatment Period

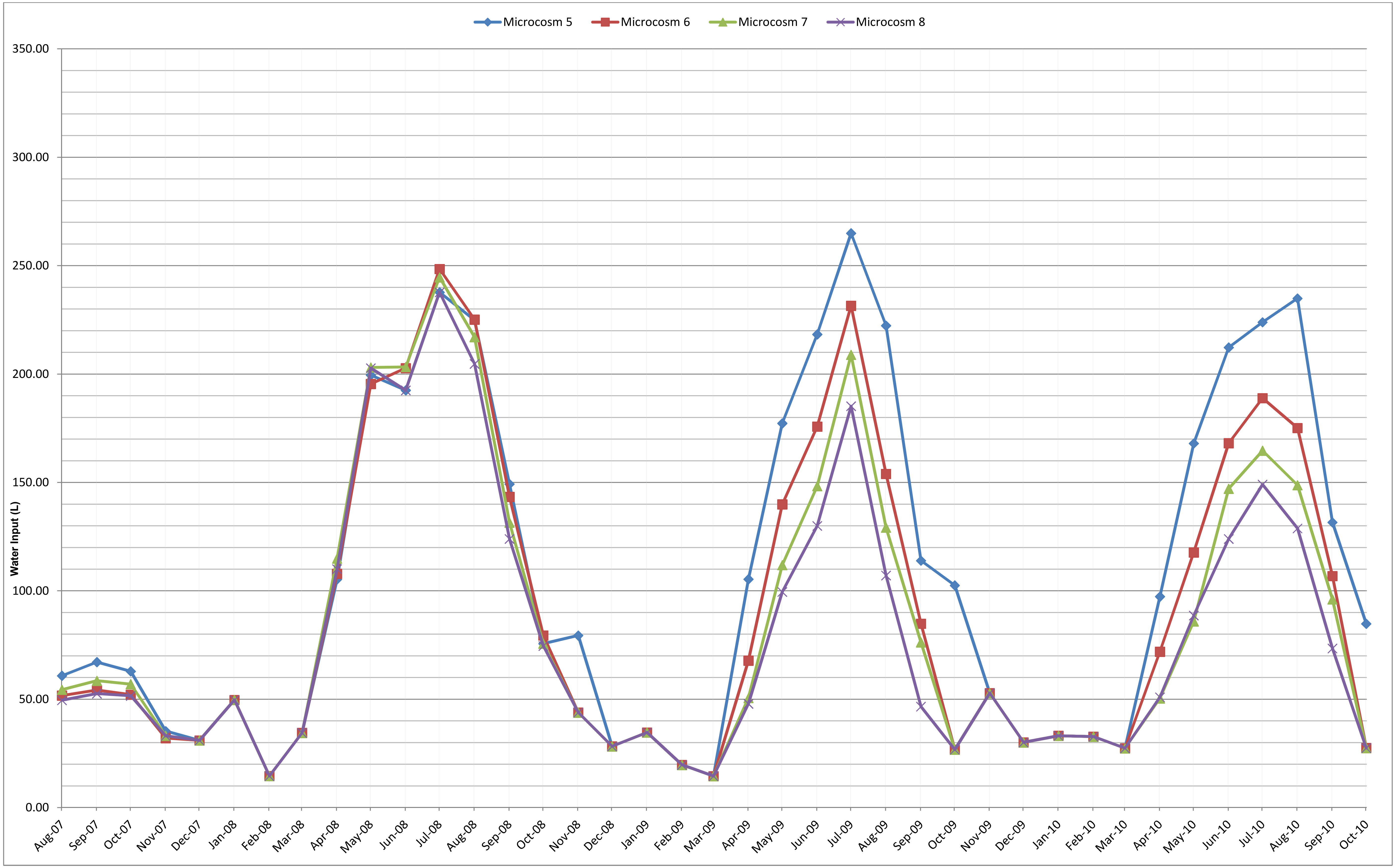


Figure 4.14: Total Monthly Water Input (L) for Microcosms 5-8

Treatment Concentration	Microcosm Number	2009					2010				
		May-09	Jun-09	Jul-09	Aug-09	Total Jan 2009 – Dec-09	May-10	Jun-10	Jul-10	Aug-10	Total Jan 2010 – Oct-10
10 mg/l Nitrogen and <0.05 ‰ Salinity	5 (Full Root Competition)	**177.3**	218.32	264.97	222.36	1356.72	168.02	212.29	223.92	234.91	1246.31
	13 (Restricted Root Competition)	**190.2**	208.63	258.98	213.21	1342.05	157.04	204.21	211	231.14	1205.64
	Difference	**-12.9**	9.69	5.99	9.15	14.67	10.98	8.08	12.92	3.77	40.67
10 mg/l Nitrogen and 5 ‰Salinity	6 (Full Root Competition)	139.91	175.78	231.52	153.97	1032.53	117.72*	168.13	188.92	175.13	949.54
	14 (Restricted Root Competition)	131.29	167.16	220.21	144.27	984.6	117.72*	166.52	182.46	173.52	930.7
	Difference	8.62	8.62	11.31	9.7	47.93	0*	1.61	6.46	1.61	18.84
10 mg/l Nitrogen and 10 ‰Salinity	7 (Full Root Competition)	111.91	148.31	208.9	129.19	903.82	**85.95**	147.13	164.68	148.74	813.83
	15 (Restricted Root Competition)	107.06	142.39	194.36	117.35	860.74	**88.64**	132.05	151.22	140.67	777.21
	Difference	4.85	5.92	14.54	11.84	43.08	**-2.69**	15.08	13.46	8.07	36.62
10 mg/l Nitrogen and 15 ‰Salinity	8 (Full Root Competition)	99.52	130	185.2	107.11	795.04	88.64	123.97	149.07	128.82	735.75
	16 (Restricted Root Competition)	94.14	121.39	174.43	94.73	762.19	72.49	117.51	137.22	120.74	683.51
	Difference	5.38	8.61	10.77	12.38	32.85	16.15	6.46	11.85	8.08	52.24

Notes: Shaded cells highlight where the restricted root competition microcosm is higher than the full root microcosm with the same treatment concentration.
* = Water Usage is the same between competition variables within the same treatment concentration

Table 4.25: Water Usage (L) Comparison of the Full and Restricted Root Competition Microcosms within the Salinity Treatment Period

4.2.8 Hypothesis 8 Overview

Hypothesis 8 is:

"The higher concentrations of the chosen chemical ranges will have an effect on the water consumption, and restricting root competition between the different floral species will also have an effect."

As with Hypothesis 7, Hypothesis 8 was chosen to explore the effect of increasing chemical concentrations on water consumption, but this time when the root competition was restricted.

In order to disprove the hypothesis, the null hypothesis is:

"The higher concentrations of the chosen chemical ranges will not have an effect on the water consumption and restricting root competition between the different floral species will not have an effect."

Hypothesis 8 was investigated using the results detailed within Table A3.2 (Water input for Microcosms 9-16 during the acclimatisation period, Appendix 3), Tables A9.1 & A11.1 (Water input for Microcosms 9-16 during the treatment period, Appendices 9 and 11).

To investigate whether the restricted root competition has an effect on water use during the acclimatisation period when all of the microcosms were receiving the same nutrient and salinity concentrations the data from the peak growing season in 2008 (May, June and July) (Table 4.26) was used for the analysis. Since the treatment experiments commenced in August 2008, this month was excluded from the analysis. To statistically analysis the data for each month, the Independent Samples T Test was used (Table 4.27). During the treatment season, the microcosms receiving the base conditions (Microcosms 1 and 9 for full competition, and Microcosms 5 and 13 for restricted competition) were assessed to investigate any trends between the different competition scenarios (Table 4.28).

The water usage of the restricted competition microcosms was assessed for trends across the different treatment period. In addition, the water usage of the restricted competition microcosms was compared with those for the full competition microcosms. This was undertaken for the months with peak vegetation growth between May to August inclusive, but as only one set of data was available for each variable, parametric statistical tests were not undertaken on the results which are illustrated on Figure 4.15 and Figure 4.16.

Competition	Microcosm Number	2008			
		May-08	Jun-08	Jul-08	Total May 2008 - July 2008
Full Root Competition	1	200.76	198.45	246.33	**645.54**
	2	194.6	188.76	235.02	**618.38**
	3	191.07	190.37	238.79	**620.23**
	4	206.19	199.53	244.17	**649.89**
	5	199.52	192.53	237.71	**629.76**
	6	195.45	202.76	248.48	**646.69**
	7	203.06	203.3	244.63	**650.99**
	8	202.76	192.53	237.71	**633.00**
	Total	**1593.41**	**1568.23**	**1932.84**	**5094.48**
Restricted Root Competition	9	184.84	188.22	231.79	**604.85**
	10	192.15	189.83	230.17	**612.15**
	11	191.22	184.45	224.25	**599.92**
	12	195.91	194.68	239.32	**629.91**
	13	200.75	193.6	235.02	**629.37**
	14	194.75	200.07	240.4	**635.22**
	15	193.92	180.68	228.02	**602.62**
	16	198.07	187.14	235.56	**620.77**
	Total	**1551.61**	**1518.67**	**1864.53**	**4934.81**
Difference		**41.8**	**49.56**	**68.31**	**159.67**

Table 4.26: Water Usage (L) Comparison of the Full and Restricted Root Competition Microcosms within the Acclimatisation Period

Month	Full Competition	Restricted Competition	T Test	Significance
May 2008	M = 194.59, SD = 6.54	M = 198.54, SD = 3.58	t (14) = -1.59, p = 0.16	Not Significant
June 2008	M = 191.79, SD =5.27	M = 194.08, SD = 7.83	t (14) = -0.69, p = 0.50	Not Significant
July 2008	M = 236.23, SD = 7.39	M = 238.44, SD = 6.24	t (14) = -0.65, p = 0.53	Not Significant

Table 4.27: T Test Summary of Water Usage Between Full and Restricted Competition Microcosms During the Acclimatisation Period

Competition	Microcosm Number	2009					2010				
		May-09	Jun-09	Jul-09	Aug-09	Total Jan 2009 – Dec-2009	May-10	Jun-10	Jul-10	Aug-10	Total Jan 2010 – Oct-2010
Full Root Competition	1	**186.59**	217.78	269.2	225.59	1391.88	175.9	218.75	228.84	247.3	1300.64
	5	**177.3**	218.32	264.97	222.36	1356.72	168.02	212.29	223.92	234.91	1246.31
	Total	**363.89**	436.1	534.17	447.95	2748.6	343.92	431.04	452.76	482.21	2546.95
Restricted Root Competition	9	**185.29**	221.55	266.75	220.67	1382.25	148.42	200.98	216.92	231.68	1201.64
	13	**190.2**	208.63	258.98	213.21	1342.05	157.04	204.21	211	231.14	1205.64
	Total	**375.49**	430.18	525.73	433.88	2724.3	305.46	405.19	427.92	462.82	2407.28
Difference		**-11.6**	5.92	8.44	14.07	24.3	38.46	25.85	24.84	19.39	139.67

Note: Shaded cells highlight where the restricted root competition microcosm is higher than the full root microcosm with the same treatment concentration.

Table 4.28: Water Usage (L) Comparison of the Full and Restricted Root Competition Microcosms for the Base Concentrations During the Treatment Period

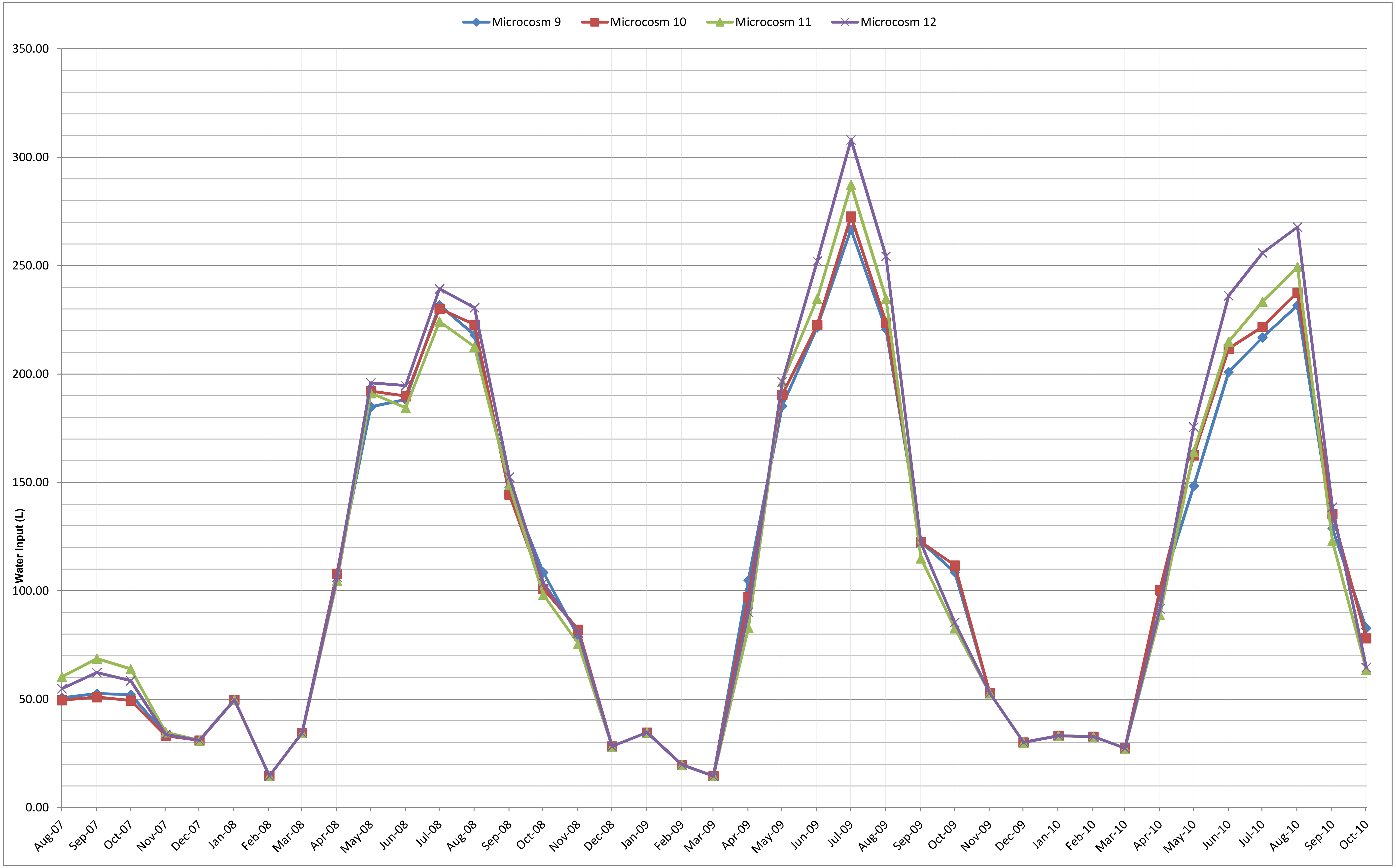


Figure 4.15: Total Monthly Water Input (L) for Microcosms 9-12

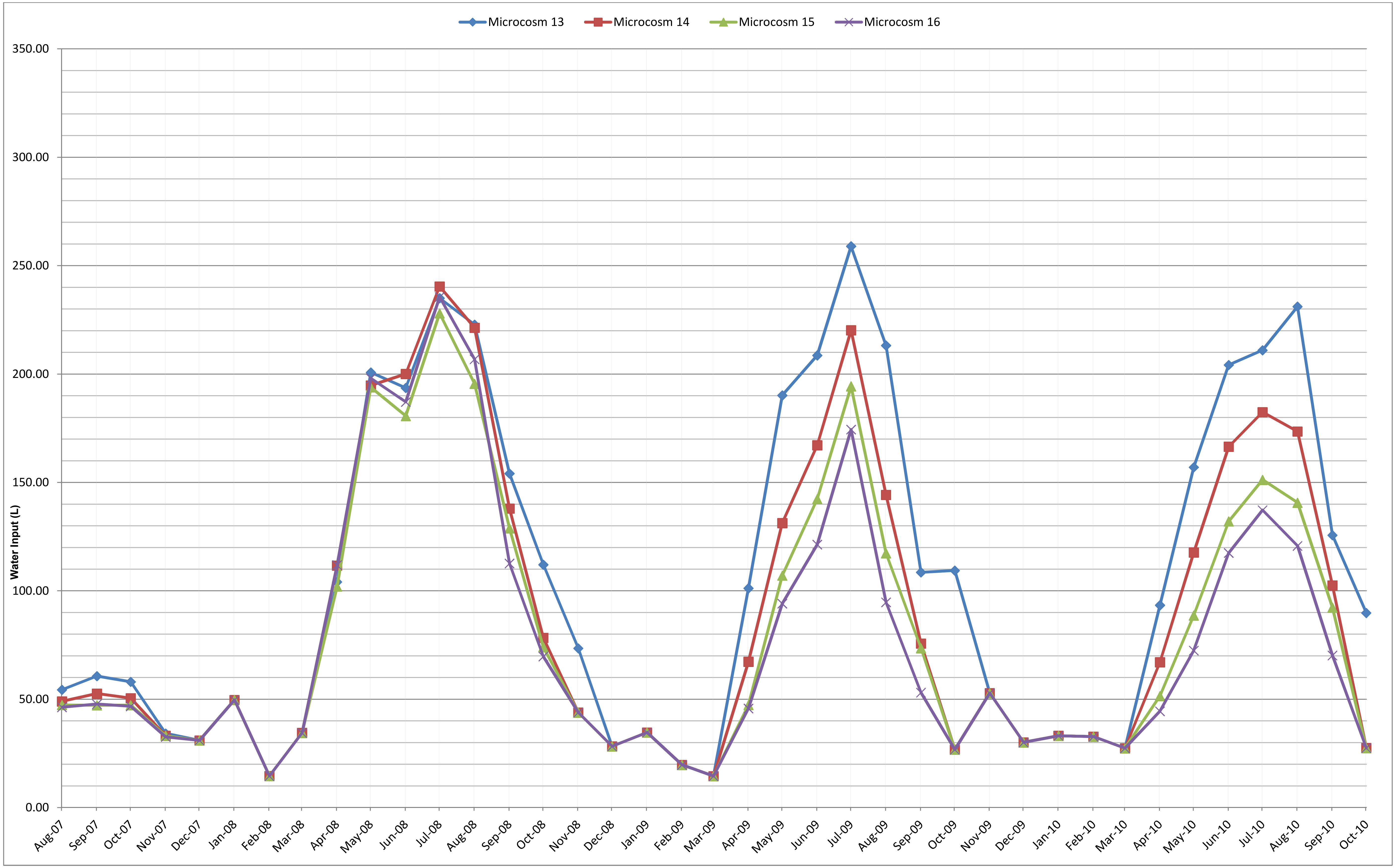


Figure 4.16: Total Monthly Water Input (L) for Microcosms 13-16

4.2.9 Control Microcosms: Natural Trends

The methodology originally proposed for sampling the vegetation during the operational period involved randomly selecting 20 stems of each species in each microcosm and measuring the stem widths and heights. This would have allowed a statistical analysis of the vegetation data to be carried out for each month during the study period, in line with other previous research where physiological plant characteristics had been measured on vegetation within smaller plant pots. However, when this approach was implemented in the field, it became apparent that this was not feasible as gaining access to the base of a stem was often not possible without snapping adjacent stems. The loss of plant stems could have affected the competition rates by creating clear areas for different species to colonise and by removing some of the plants vigour and hence, these measurements were ceased. This measurement of multiple stems through the growing periods was where the main repetition was going to be present and its loss removed this repetition and also the amount of statistical analysis which could be carried out.

The study was conducted in an outside environment and not sterile laboratory conditions, as such external factors could have an influence upon the results. Other unpredictable factors could also be present such as the vigour of the initial plug plants. Within the control microcosms, which were subject to identical treatments, there were variations in the data and as such the trends presented within this report should be focused upon rather than the detailed changes.

4.3 Microcosm Study Discussion

4.3.1 Phragmites australis

Phragmites australis survived within all of the chemical concentrations within the different competition scenarios. As detailed within Sections 2 and 3, *Phragmites australis* is the main vegetation utilised in constructed wetland treatment systems within the U.K. and as such, the study was designed so that the concentrations of chemicals used would not result in its mortality. With this species surviving within all of the microcosms, it shows that the chosen chemical concentrations and the design methodologies used in the construction and operation of the microcosms are suitable for use with *Phragmites australis*.

Hypothesis 1 & 2

These hypotheses investigated if all four species survived at the different chemical concentrations studied whether a single species would take over and oust the other species, and restricting root competition will have an effect.

Nutrients

Within the full competition microcosms, this species survived until the end of the study period (after almost 3.5 years). It increased in area as the nutrients increased to a final combined area coverage of 19 % (M1), 27 % (M2), 34 % (M3) & 45 % (M4). Although the cover of *Phragmites australis* increased it did not oust the other species, with its maximum coverage being less than half of the available area. This allowed space for other species to remain within the microcosm for which the design principles used in this study could be transferred to a treatment wetland.

As per the full competition microcosms, within the restricted competition microcosms, *Phragmites australis* survived until the end of the study period and increased in area coverage as the nutrients increased. The maximum area coverage was also less than 50 % of the quadrat allowing for other species to remain within the microcosm. At the higher nutrients, the spread plateaued slightly when the plants appeared to reached the root dividers. However, the roots eventually went under the root dividers, and towards the end of the study period started to grow within sections of the microcosm not designated for *Phragmites australis*.

The final combined area coverage for this species within the restricted competition microcosms was slightly higher than for the full competition microcosms for all nutrient levels. This would indicate that the barriers may have had a slight beneficial effect upon the *Phragmites australis* by reducing the interspecific competition in the early years prior to it breaching the root dividers.

However, the difference was only a few percent and the data gathered (being only a single area coverage measurement for each microcosm) for Hypothesis 1 and 2 was not suitable for statistical analysis to show if this was statistically significant or due to natural variation. Either way the results show that *Phragmites australis* did not become dominant in either of the competition scenarios.

Salinity

When the area coverage within the full competition microcosms was investigated, it was apparent that an increase in salinity levels did not increase the area coverage of *Phragmites australis* to a level that would oust the other species. This species preferred no salinity and tolerated the higher salinity concentrations with the final combined area coverage being 15 % (M5), 13 % (M6), 12 % (M7) & 10 % (M8).

When the area coverage within the restricted competition microcosms was investigated, this species followed the same pattern as for the full competition microcosms, reducing its area coverage as the salinity levels increased. The final combined area coverage for *Phragmites australis* within the restricted competition microcosms was 7 % higher than for the full competition microcosms at the base salinity level, but was slightly lower at the higher salinity concentrations. However, the difference is only a few percent at the higher salinity concentrations and the data gathered for Hypothesis 1 and 2 was therefore not suitable for statistical analysis to prove if this effect was statistically significant or due to natural variation. Consequently, at the higher concentrations there were no obvious beneficial effect for having root dividers for *Phragmites australis,* however this could be due to the fact that at the higher salinity concentrations within the full competition microcosms fatalities occurred for the biodiversity enhancing species, and as such there was less direct competition.

<u>Hypothesis 3 & 4</u>

Hypothesis 3 & 4, investigated if the different nutrient and salinity concentrations would have an effect on the vegetation stem heights or stem widths of the surviving plants.

Nutrients

The measurements of the harvested stems identified that when all of the data were combined to include both full competition and restricted competition microcosms, there was a *very highly significant* difference ($p = 0.000$) in both the heights and widths of the stems between the different nutrient concentrations.

When these data were separated into that for restricted and for full competition microcosms, there was a *very highly significant* difference (p = 0.000) in both the heights and widths of the stems between the different nutrient concentrations for both types of competition.

These results showed that there is a *very highly significant* difference in the stem heights and widths of *Phragmites australis* as the nutrient levels increased. This is different to the findings of previous research undertaken by Bastelova *et al*. (2004), who identified in their study that the biomass significantly increased with increasing nutrient concentrations, but not the height or basal diameter. In their study the plants were placed in different containers with no competition between individuals. Within this study there was a *very highly significant* difference in the stem heights and widths for both the full and restricted competition microcosms. However, within the restricted competition microcosms there is still above ground competition between the individual plants of both the same and different species, which is not present in Bastelova *et al*. (2004). This could suggest that the above ground competition was also having an effect on the heights and widths of *Phragmites australis stems*. When *Phragmites australis* was monitored within constructed wetlands monocultures, it was apparent that the plants nearest to the effluent inlet were taller than the plants near the outlet (which had lower nutrients levels), and as such indicates that nutrient levels have an effect on plant height. However as per this study, within a constructed wetland there is both above and below ground competition, which was not present within Bastelova *et al*. (2004). This would add further support to the findings that competition contributes an effect on the heights of *Phragmites australis* at different nutrient levels.

An overview of the statistical analysis for the stem height and width data can be found in Table 4.18. Table 4.18 it shows that at the lower nutrient concentrations there are no statistical difference between stem heights in the full and restricted competition microcosms. The opposite is true at the higher nutrient concentrations where the stem heights are statistically different.

This shows that at the lower nutrient concentrations the restriction of root competition did not have an effect on the height of *Phragmites australis*. However, at greater nutrient concentrations, the heights were affected, with the mean height of the stems decreasing when there was restricted competition. This adds further weight to the argument that competition has an effect upon the height of this species at higher nutrient concentrations and that when some of this competition is removed (i.e. by restricting root competition), the height also reduces.

Table 4.18 shows that for stem widths, there was a statistically significant difference between the full and restricted competition microcosms at each nutrient concentration, and the mean width decreases when there was restricted competition. Again, this adds further weight that competition does have an effect upon the stem width of this species as the nutrient concentrations increase and that when some of this competition is removed, the widths of this species also reduces.

Salinity

The measurements of the harvested stems for *Phragmites australis* showed that when all of the stems were combined to include both full competition and restricted competition microcosms, there was a *very highly significant* difference ($p = 0.000$) in the heights and a *highly significant* difference in widths ($p = 0.020$) of the stems between the different salinity concentrations.

When these results were separated into those for restricted and full competition microcosms, it was found that there was a *very highly significant* difference ($p = 0.001$) in the widths of the stems between the different salinity concentrations for both types of competition. However, the heights within the full competition microcosms alone were not statistically different ($p= 0.077$) being slightly above the confidence limit of 0.05. There was a *very highly significant* difference ($p = 0.000$) between the different salinity concentrations for heights within the restricted competition microcosms. This shows, that where an increase in salinity occurs, *Phragmites australis* changes both its stem heights and widths unless competition was present, in which case the height did not alter significantly. This is in agreement with Hellings & Gallagher (1992), who found that after a 30 week study, *Phragmites australis* reduces its height as the salinity increased. The short term study by Hellings & Gallagher (1992) only investigated *Phragmites australis* without any competition.

As with the nutrients, increasing salinity levels have an effect on the vegetation stem heights (excluding full competition heights) and widths, however, at the higher salinity concentrations, the interspecific competition decreased due to the fatalities occurring within the other floral species. Intraspecific competition between individuals of *Phragmites australis* remained and as such some level of competition was present, but reduced when compared with the lower salinity concentrations. This level of reduced competition at higher salinity concentrations could be the reason why the heights were just outside the significance level and could form a Type 1 statistical error.

The stem harvest data was further divided to investigate if restricting root competition had an effect on the stem height and width when compared to the same salinity concentrations within the full competition microcosm. In Table 4.19 an overview of the statistical analysis for the stem height and width can be seen.

In Table 4.19 it can be see that for stem heights, at the base concentration and the 10 ‰ salinity concentration, they found to be *not statistically* different (p = 0.69 and p = 0.69 respectively) between the full and restricted competition microcosms. However, the opposite is true for the 5 ‰ and 15 ‰ salinity concentrations where the stem heights were *very highly significantly* different (p = 0.01 and p = 0.00 respectively) between the full and restricted competition microcosms. The mean height of the stems for the 5 ‰ and 15 ‰ salinity concentrations decreased when there was restricted competition. This fluctuation in significance could be due to the patchy nature of the competition (caused by plant fatalities) within the salinity microcosms.

In Table 4.19 showing stem widths, it can be seen that there was a *very highly significant* difference between the full and restricted competition microcosms at each salinity concentration. The mean width of the stems decreased when there was restricted competition.

Hypothesis 5 & 6.

Hypothesis 5 & 6, investigated if the different concentrations had an effect on the above and below ground total biomass of the surviving plants.

Nutrients

The above and below ground biomass values for the different nutrient concentrations in the full competition microcosms and the restricted competition microcosms can be found in Table 4.29. The table shows that the above and below ground biomass increased as the nutrient concentration increased for both the full and restricted competition microcosms. This agreed with the findings of Bastelova *et al*. (2004). Although all of the biomass parameters increased, they did not increase at the same rate; with the below ground biomass increasing at a greater rate than the above ground biomass, as the nutrient levels increased.

When the full and restricted competition microcosms are compared against each other, there appears to be no large difference between the Root : Shoot ratios, with both competition parameters increasing at a similar rate, although the full competition microcosms have a slightly lower root biomass (Table 4.29). The full competition microcosms also have a slightly lower Root : Shoot ratio in the lower nutrient microcosms than the restricted competition microcosms. This indicates that the full competition microcosms put slightly more energy into the above ground biomass, and less into the below ground biomass when in full competition than when there was restricted competition. However, with the biomass forming a single measurement for each parameter within each microcosm, the data gathered for Hypothesis 5 and 6 is not suitable for statistical analysis to prove if this was statistically significant.

Within a natural wetland, Asaeda *et al.,* (2006) found that *Phragmites australis* had over three times the amount of below ground biomass compared to above ground biomass. Asaeda & Karunaratne (2000) report data which calculates a Root : Shoot Ratio of approximately 3.5 and 1.3 for two studies in Australia and approximately 3.5 for a study in Japan. Farnsworth & Meyerson (2003) found the Root : Shoot ratio to be 0.7 (± 0.04) within a freshwater tidal marsh. By comparison for this study the below ground biomass was found to be just over twice as much as the above ground biomass at the highest nutrient concentration. This shows that the Root : Shoot ratio *for Phragmites australis* varies, but as the nutrient concentrations for the above studies are not provided, a direct comparison cannot be made.

Competition	Parameter	10 mg/l Nitrogen and <0.05 ‰ Salinity	50 mg/l Nitrogen and <0.05 ‰ Salinity	100 mg/l Nitrogen and <0.05 ‰ Salinity	150 mg/l Nitrogen and <0.05 ‰ Salinity
Full Competition	Above Ground Weight (g)	253.86	418.90	629.18	997.39
	Below Ground Weight (g)	425.89	711.97	1159.49	2168.09
	Root : Shoot Weight Ratio	1.68	1.70	1.84	2.17
Restricted Competition	Above Ground Weight (g)	173.15	468.55	638.96	1027.20
	Below Ground Weight (g)	307.04	830.04	1210.40	2220.77
	Root : Shoot Weight Ratio	1.77	1.77	1.89	2.16

Table 4.29: Phragmites australis Biomass for Each Nutrient Concentration with Full Competition (Microcosms 1-4) & Restricted Competition (Microcosms 9-12)

The publication of Zhu *et al*., (2010) coincided with the harvest phase of this research. They found that when the species richness of vertical flow treatment wetlands was increased, that the biomass of the community then also increased and as did the substrate nitrogen retention. Ten seedlings per m^2 were planted in April 2006 and harvested 5 cm above the ground in September 2007. The species composition included both *Phragmites australis* and *Lythrum salicaria* along with 14 other species. When the effects of *Phragmites australis* and *Lythrum salicaria* were statistically analysed, it was found that when these species were planted in mixtures with other species, then there was no significant effect on the above ground biomass for the community. No details of below ground biomass, the above ground biomass weights or the survivability of each individual species were published, and as such, the weights of each species could not be compared to the biomass values found in this study. They did conclude, however, that due to their finding that increased biomass resulted in substrate nitrogen retention, plant biodiversity should be incorporated into constructed wetlands.

Salinity

The above and below ground biomass values for the different salinity concentrations in the full competition microcosms and the restricted competition microcosms can be found in Table 4.30.

Although there were differences in the amount of biomass produced between Microcosms 1 and 5 (both being base concentrations with full competition), the Root : Shoot Ratios were almost identical. When the higher salinity biomass values are compared against Microcosm 1, the biomass decreases slightly before increasing to above that for the base concentration at the highest salinity level. Although the biomass produced varied, the highest salinity value was greater than the biomass produced within the base concentrations. Although the biomass produced increased with the highest salinity, the Root : Shoot ratios decreased indicating that they put less energy into root development.

The above and below ground biomass for the restricted competition microcosm at the base salinity level (M13) is higher than the biomass in its counterpart with the same nutrients and restricted competition (M9). However when the Root : Shoot ratios were assessed they are almost identical, which indicates that although these microcosms contained the same nutrient and salinity parameters with differing biomass, they had similar Root ; Shoot ratios.

Although the biomass within the restricted competition microcosms fluctuated as the salinity levels increased, the Root : Shoot ratio decreased (Table 4.30) When the decrease in biomass was compared alongside the Root : Shoot ratio for the full competition microcosms, the rate of decrease was similar. This would indicate that the increase in salinity is a factor of the reduction in the Root : Shoot ratio.

Farnsworth & Meyerson (2003) found the Root : Shoot ratio to be 3.0 (± 0.4) for a brackish tidal marsh, which is noticeably higher than the Root : Shoot ratio of 0.7 (± 0.04) they reported for a freshwater tidal marsh. The opposite effect was observed for this study with the Root : Shoot ratios decreasing as the salinity levels increased. This indicates that *Phragmites australis* will vary the Root : Shoot ratio depending upon the local growing conditions. The variety in growth for the referenced studies could also be down to the geographical gradient from where the *Phragmites australis* was sourced (Bastelova *et al*., 2004 & Bastelova *et al*., 2006).

Competition	Parameter	10 mg/l Nitrogen and <0.05 ‰ Salinity	10 mg/l Nitrogen and 5 ‰ Salinity	10 mg/l Nitrogen and 10 ‰ Salinity	10 mg/l Nitrogen and 15 ‰ Salinity
Full Competition	Above Ground Weight (g)	73.32	217.75	209.31	306.89
	Below Ground Weight (g)	121.15	308.22	277.41	418.06
	Root : Shoot Weight Ratio	1.65	1.42	1.33	1.36
Restricted Competition	Above Ground Weight (g)	284.96	163.53	265.40	121.14
	Below Ground Weight (g)	499.86	234.53	361.06	160.83
	Root : Shoot Weight Ratio	1.75	1.43	1.36	1.33

Table 4.30: Phragmites australis Biomass for Each Salinity Concentration with Full Competition (Microcosms 5-8) & Restricted Competition (Microcosms 13-16)

Nutrients and Salinity

When the above and below ground biomass is plotted on a graph (Figure 4.12), the individual points representing each microcosm for *Phragmites australis* are in close proximity to the linear line but there is a slight curve towards the point of origin. The scatter points are separated into five main groups. The first group consist of the base nutrients and salinity concentrations. The second group is the 50 mg/l nutrient concentration, the third group is the 100 mg/l nutrient concentration and the fourth group is the 150 mg/l nutrient. The fifth group comprises the remainder of the salinity concentrations. Within the three groups representing the higher nutrients, the restricted competition microcosms (Microcosms 10, 11 and 12) are all slightly higher than their full competition microcosm counterparts (Microcosms 2, 3 and 4).

Phragmites australis Conclusion.

In summary, *Phragmites australis* will alter its stem height and stem width depending upon the nutrient or salinity concentration which it is subject to. In their study, using two different nutrient levels where there was no competition, Bastelova *et al*. (2004), found that only the biomass increased. Whereas for this study there was a *very highly significant* difference in the stem heights and widths for both the full and restricted competition microcosms. Comparing the findings from the two studies suggests that competition could be a key factor in the height and stem width parameters of *Phragmites australis*. Within the restricted competition microcosms, a significant difference was still apparent between the heights with increasing nutrient levels, indicating that above ground competition can play a role in the height differences.

When the full competition and restricted competition microcosms are compared against each other at the higher nutrient loadings, there was a significant difference between the heights and stem widths, with the restricted competition microcosms having slightly lower dimensions than their counterparts in the full competition microcosms. This shows that when faced with full competition with other vegetation species *Phragmites australis* will increase its size and when the root competition is restricted, it will not grow as large.

When the biomass data is assessed, as the nutrient levels increase the biomass produced increases. The above ground and below ground biomass does not increase at the same rates, with the below ground biomass increasing at a greater rate, therefore increasing the Root : Shoot ratio. The opposite was true for the salinity concentrations.

When nutrient results for the full competition and restricted competition microcosms are compared against each other, although the biomass and Root : Shoot ratios were slightly larger for the restricted competition microcosms, there was no large difference (Figure 4.12). These similar below ground biomass values show that adding the biodiversity enhancing species did not result in a large decrease of the roots biomass of *Phragmites australis*, nor did it deter their root spread, with the roots going under the growing locations of the biodiversity enhancing species. This can be viewed on the root windows plates for the full competition microcosms, Appendix 15. The majority of the treatment of effluents occurred within the root zone (for subsurface flow treatment wetlands). As similar Root : Shoot ratios were found, this should not affect the root treatment potential of *Phragmites australis* when grown alongside the biodiversity enhancing species tested within this study at similar effluent concentrations. Indeed, Zhu *et al*., (2010) found that a higher plant biodiversity resulted in higher substrate nitrogen retention.

Phragmites australis did not take over at any of the pollutant concentrations employed and areas were available for other species to utilise, combined with the root zone being not subject to a large decrease by the competition from biodiversity enhancing species, *Phragmites australis* is suitable for use as the main treatment species when planted alongside biodiversity enhancing species.

4.3.2 Lythrum salicaria

Lythrum salicaria survived within all of the nutrient concentrations within the different competition scenarios, however, fatalities were observed within the higher salinity concentrations.

<u>Hypothesis 1 & 2</u>

These hypotheses investigated if all four species would survive at the different concentrations or whether a single species would take over and oust the other species.

Nutrients

Within the full competition microcosms, this species survived until the end of the study period. It decreased in area coverage over the treatment period as the nutrients increased to a final combined area coverage of 21 % (M1), 21 % (M2), 23 % (M3) & 21 % (M4). Although the combined area coverage decreased during the treatment period from the acclimatisation period, the increase in nutrient levels and competition at these nutrient levels did not appear to have any significant effect, with *Lythrum salicaria* maintaining a constant final area coverage. When grown within these conditions, this species also appeared not to be an invasive species as reported for wetlands in other countries (Bastlova & Kvet, 2002; Blossey & Kamil, 1996; Edwards *et al*., 1998; Schooler *et al*., 2006; Thompson *et al*., 1987).

Comparing the results presented in Table 4.8 and Table 4.10, the reduced decline in area coverage for the middle nutrient loadings (where the area coverage was 9 % to 10 % greater than for the microcosms without root dividers) could indicate that the provision of root separators at these concentrations had a beneficial effect for *Lythrum salicaria*. However, as there is no clear trend, since this difference did not occur at the lower of the highest nutrient concentrations, the difference in area coverage could also be due to natural variation.

A study by Suter *et al*., 2010 (published when the harvest for this study was being undertaken) found that, when *Lythrum salicaria* was planted in fen communities containing different species mixtures, it declined. Suter *et al*'s study was undertaken within a grassland field which was being restored to a semi-natural wet grassland habitat. At the end of the study period (3 years) the final proportion was less than 0.1 within all species mixtures, including locations where *Lythrum salicaria* was originally planted as the dominant species. The species utilised within the different mixtures included the tussock species of *Carex elata*, *Carex flava, Juncus effusus and Molinia caerulea*; the upright species of *Angelica sylvestris, Epilobium parviflorum, Lythrum salicaria*; the rosette species of *Centaurea jacea* spp. *angustifolia, Myosotis nemorosa, Silene flos-cuculi*; and the stoloniferous species of *Lycopus europaeus* & *Mentha aquatica.* Within the microcosm study, although the coverage reduced during the treatment period, a higher proportion of cover remained than that found by Suter *et al*. As the habitat studied by Suter *et al*., a field which was being restored to a semi-natural wet grassland, was different to the constructed treatment bed being simulated in the microcosms, this could explain the differences identified. In addition, the different species utilised by Suter *et al*. could be better at outcompeting *Lythrum salicaria*, than the species utilised within this study.

In this study, *Lythrum salicaria* maintained a favourable final area coverage within the restricted competition microcosms and was not ousted by the other species.

Salinity

When the area coverage within the full competition microcosms was investigated, it was apparent that an increase in salinity levels had an adverse effect upon this species with the area coverage decreasing in each of the microcosms. This species preferred no salinity, it tolerated the lower salinity concentrations and did not survive in the highest salinity concentration, with the final combined area coverage of 27 % (M5), 16 % (M6), 5 % (M7) & 0 %, fatal (M8).

The decreasing trend was also true for the restricted competition microcosms with the final combined area coverage of 27 % (M13), 13 % (M14), 4 % (M15) & 0 %, fatal (M16). From these results it can be seen that the root barriers appear to have had no positive effect on the area coverage for *Lythrum salicaria* with the area either remaining the same or showing a minimal decrease.

Hypothesis 3 & 4

Hypothesis 3 & 4, investigated if the different concentrations would have an effect on the vegetation heights or the stem widths of the surviving plants.

Nutrients

The measurements of the harvested stems identified that when all of the stems were combined to include both full competition and restricted competition microcosms, there was a *very highly significant* difference ($p = 0.000$) in both the heights and widths of the stems between the different nutrient concentrations.

When these results were separated for the restricted and the unrestricted microcosms, there was a *very highly significant* difference ($p = 0.000$) in both the heights and widths of the stems between the different nutrient concentrations for both types of competition.

These results show that there was a *very highly significant* difference in the main stem heights and widths of *Lythrum salicaria* as the nutrient levels increased for both the full and restricted competition microcosms. As per the *Phragmites australis*, this is different to previous research undertaken by Bastelova *et al*. (2004) who identified in their study that the biomass of shoot dry weight significantly increased with increasing nutrients, but not the plant height, whereas this study found a *very highly significant* difference in the stem heights and widths.. Within Bastelova *et al*'s study the plants were separated into different containers with no competition between different species. However, even within the restricted competition microcosms there was still above ground competition between the individual plants of both the same and different species, which was not present within Bastelova *et al*. (2004). As occurred with *Phragmites australis*, this could suggest that the above ground competition was also having an effect on the heights and widths of *Lythrum salicaria* at different nutrient levels.

The stem harvest data was further divided to investigate if restricting root competition had an effect on the stem height and width at the different nutrient concentrations. An overview of the statistical analysis for the stem height and width can be found in Table 4.18, which shows that at the lower nutrient concentrations, the stem heights are not statistically different between the full and restricted competition microcosms, but at the highest nutrient concentration the difference is *highly significant*. This shows that the barriers did not have an effect on stem height at the lower concentrations, but they did at the highest concentration.

The opposite was found to be true for the stem widths (Table 4.18). At the lower nutrient concentrations, the stem widths were *very highly significantly* different between the full and restricted competition microcosms, until the highest nutrient concentration, where the difference was *not significant*. This showed that the barriers had an effect on stem width at the lower concentrations but did not at the highest. Taking the stem heights and widths together, the presence of barriers (thus restricting root competition) had an effect on either the stem height or stem width at each nutrient concentration.

Salinity

The measurements of the harvested stems of *Lythrum salicaria* showed that when all of the stems were combined to include both full competition and restricted competition microcosms, there was a *highly significant* difference ($p = 0.033$) in the heights and a *very highly significant* difference ($p = 0.000$) in the widths of the stems between the different salinity concentrations.

When these results were divided between the restricted and full competition microcosms, there was no statistically significant difference in either the height or the widths of the stems between the different salinity concentrations in the full competition microcosms. However, the effect on the heights and widths within the restricted competition microcosms was *highly significant* (heights, $p = 0.007$) and *very highly significant* (widths, $p = 0.000$) respectively, for the different salinity concentrations.

The stem harvest data was further divided to investigate if restricting root competition had an effect on the stem height and width at the different salinity concentrations. An overview of the statistical analysis for the stem height and width can be found in Table 4.19, which shows that for stem heights, there is no statistical difference between the restricted and full competition microcosms at any salinity concentrations. However, Table 4.19 also shows that for the stem widths, there was a statistically significant difference between the full and restricted competition microcosms for the base concentration and the 10 ‰ salinity concentration, but no statistical difference occurred for the 5 ‰ salinity concentration. The mean width of the stems decreased when there was restricted competition at the base concentration, and stayed similar at the 5 ‰ salinity concentration and increased at the 10 ‰ salinity concentration. There were full fatalities at 15 ‰ salinity concentration for both full competition and restricted competition microcosms.

<u>Hypothesis 5 & 6</u>

Hypothesis 5 & 6, investigated if the different concentrations would have an effect on the above and below ground biomass of the surviving plants.

Nutrients

The above and below ground *Lythrum salicaria* biomass values for the different nutrient concentrations in the full competition microcosms and the restricted competition microcosms can be found in Table 4.31. From this table it can be seen that there is no obvious pattern to the weights of above ground biomass as the nutrient concentration increased for both the combined full and restricted competition microcosm data. However, within the full competition microcosms, the below ground biomass showed a decrease in weights as the nutrient concentration increased. When compared to the restricted competition microcosms, it was found that the opposite was true, with the below ground biomass increasing at the higher nutrient concentrations above that of the base concentration, but with no clear relationship as the nutrient concentrations increased.

When the full and restricted competition microcosms were compared against each other there was a difference between the Root : Shoot ratios. The ratios within the full competition microcosms decreased with increasing nutrient level, with the plants having less below ground biomass to above ground biomass. The opposite was true for the restricted competition microcosms where the Root : Shoot ratios increased at the higher nutrient concentration when compared with the base nutrient concentration. This showed that where the root competition is restricted, *Lythrum salicaria* invested more energy in the roots than in the microcosms with root competition present. These opposing results suggest that the nutrients did not fully control the Root : Shoot ratios, but that the competition with other species had a distinct effect.

Shamsi & Whitehead (1977b), found that after 70 days the Root : Shoot ratio of *Lythrum salicaria* increased as the different levels of phosphorous and nitrogen increased. The approximate Root : Shoot ratios (gleaned from graph data) increased from 0.09 to 0.98 as the general nutrient levels increased, from 0.1 to 0.87 as the nitrogen levels increase, and from 0.09 to 1.17 as the phosphorus levels increased. Shamsi & Whitehead (1974b), also identified that the Root : Shoot ratios decreased as the light levels decreased from 0.32 (100 % light) to 0.22 (70 % light) and 0.19 (40 % light), however, their experiment was undertaken using small pots which would not have allowed *Lythrum salicaria* to fully develop its roots to its maximum potential.

The studies by Shamsi and Whitehead (1977a-d) were undertaken over a short period of time, usually one growing season or less. After the study presented in this thesis was harvested, a longer term study was published by Edwards *et al*., (2011). Although the small sample size restricted the statistical analysis of the plants on a latitudinal scale, the paper reports on plants which were harvested after 3 years and as such contains dry weights for the plants across a geographical gradient. Edwards *et al.,* (2011) identified that the Root : Shoot ratio for *Lythrum salicaria* varied depending upon where the seed was collected from. The Root : Shoot ratios were calculated as Finland 2.99; Czech Republic 3.40; Spain 1.81 & Turkey 2.24. Whereas from the data reported in Stevens *et al*., (2002) it was found that the Root : Shoot ratio for *Lythrum salicaria* was 2.39 which reduced to 1.15 when the phellem was removed to interrupt gas transport to the roots.

The various Root : Shoot ratios gathered from other studies illustrate the range of Root : Shoot ratios which this species is capable of varying depending upon light levels, nutrient levels or the seed source from where it originated. The ability of *Lythrum salicaria* to alter its root shoot ratio was also observed in this study through both competition and an increase in either nutrient or salinity concentrations.

Competition	Parameter	10 mg/l Nitrogen and <0.05 ‰ Salinity	50 mg/l Nitrogen and <0.05 ‰ Salinity	100 mg/l Nitrogen and <0.05 ‰ Salinity	150 mg/l Nitrogen and <0.05 ‰ Salinity
Full Competition	Above Ground Weight (g)	567.44	546.97	490.79	592.09
	Below Ground Weight (g)	661.24	422.72	258.48	252.65
	Root : Shoot Weight Ratio	1.17	0.77	0.53	0.43
Restricted Competition	Above Ground Weight (g)	305.43	556.96	455.43	460.30
	Below Ground Weight (g)	382.21	878.79	652.35	703.30
	Root : Shoot Weight Ratio	1.25	1.58	1.43	1.53

Table 4.31: *Lythrum salicaria* Biomass for Each Nutrient Concentrationwith Full Competition (Microcosms 1-4) & Restricted Competition (Microcosms 9-12)

As outlined in the *Phragmites australis* discussion (Section 4.2.2), the publication of Zhu *et al*., (2010) coincided with the harvest phase of this research. They found that when the species richness of vertical flow treatment wetlands was increased, then the biomass of the community also increased and so did the substrate nitrogen retention. The species composition included both *Phragmites australis* and *Lythrum salicaria* along with 14 other species. When the effects of *Phragmites australis* and *Lythrum salicaria* were statistically analysed, it was found that when these species were planted in mixtures with the other species, then there was no significant effect on the above ground biomass for the community. No details of below ground biomass, the above ground biomass weights or the survivability of each species were published, and as such, the weights of each species could not be compared to the biomass values identified within this study. They did however conclude that due to the increased biomass produced substrate nitrogen retention, plant biodiversity should be incorporated into constructed wetlands.

The root spread within Microcosms 1-4 can be observed on Figures A15.1 to A15.12 (Appendix 15). The roots for *Lythrum salicaria* are thin and dark, which are not obvious in the photographs. When Microcosms 1-4 were being dismantled, the roots for this species were found predominantly in the humus layer. In the lower nutrient microcosms the lower sections of the roots were just within the gravel layer. However, in the higher nutrient microcosms there were barely any of these roots within the upper gravel layer and fewer roots within the humus layer. The root spread for *Lythrum salicaria* within the restricted microcosms (Microcosms 9-12, Figures A19.1 to A19.16, Appendix 19) was observed penetrating deep into the gravel layer. This did not occur where there was a dense mat of fine hairs for *Phragmites australis* present within the full competition microcosms. In Microcosm 9 (Figure A19.1), *Phragmites australis* roots can be observed penetrating the gravel layer within the *Lythrum salicaria* section. The thick rhizome roots of *Phragmites australis* do not appear to have an effect on the *Lythrum salicaria* roots, however when the microcosms were being dismantled, where the finer roots of *Phragmites australis* were present, it was observed that these finer roots were repelling the roots of *Lythrum salicaria*. This can just be observed within Figure A19.1. However, where this occurred in other microcosms (where it was more apparent), due to a lack of roots in the zones where the *Phragmites australis* was repelling the *Lythrum salicaria,* the growing media collapsed prior to it being captured on camera. The increase in nutrients generally increased the spread density of the *Lythrum salicaria* roots (within the restricted competition microcosms). However, at the highest nutrient loading, *Phragmites australis* has penetrated the outer layer around the edge of the microcosm and so this effect cannot be observed in Figure A19.13, however the lack of *Lythrum salicaria* roots where the fine *Phragmites australis* roots are present is apparent.

The distinct separation of the roots between the full and restricted competition microcosms between the humus and gravel layers, combined with the observation of *Lythrum salicaria* roots not being observed where the finer roots of *Phragmites australis* had penetrated the root dividers, indicates that the fine roots of *Phragmites australis* have a repelling effect on the roots of *Lythrum* *salicaria*. Additional data to indicate an adverse effect of full competition on *Lythrum salicaria* is suggested by the reduction of below ground biomass and Root : Shoot ratio in the full competition microcosms, The exact reason for this was not studied within this research, however a general cause could be from the roots of *Phragmites australis* having an allelopathic affect upon the roots of *Lythrum salicaria* when they are in close quarters within a gravel substrate. If the biochemical for this allelopathy is identified then this could contribute to reducing the population of *Lythrum salicaria* in parts of the world where this species is considered invasive.

Salinity

The above and below ground biomass values for the different salinity concentrations in the full competition microcosms and the restricted competition microcosms can be found in Table 4.32.

There is no obvious pattern to the weights of above ground biomass as the salinity concentration increases for both the full and restricted competition microcosms, However the Root : Shoot ratios decrease once salinity is increased above the base concentration. When the full and restricted competition microcosms are compared against each other there is a difference between the Root : Shoot ratios. The ratios within the full competition microcosms decreases at a higher rate than the restricted root competition microcosms, with the plants having less below ground biomass to above ground biomass. This also suggests that where the root competition is restricted, as per nutrients, *Lythrum salicaria* invests more energy in the roots than in the microcosms with root competition present.

Competition	Parameter	10 mg/l Nitrogen and <0.05 ‰ Salinity	10 mg/l Nitrogen and 5 ‰ Salinity	10 mg/l Nitrogen and 10 ‰ Salinity	10 mg/l Nitrogen and 15 ‰ Salinity
Full Competition	Above Ground Weight (g)	361.16	225.84	387.83	0.00
	Below Ground Weight (g)	430.14	192.56	314.90	0.00
	Root : Shoot Weight Ratio	1.19	0.85	0.81	0.00
Restricted Competition	Above Ground Weight (g)	329.94	190.08	308.72	0.00
	Below Ground Weight (g)	403.58	201.87	296.34	0.00
	Root : Shoot Weight Ratio	1.22	1.06	0.96	0.00

Table 4.32: Lythrum salicaria Biomass for Each Salinity Concentrationwith Full Competition (Microcosms 5-8) & Restricted Competition (Microcosms 13-16)

Nutrients and Salinity

The individual scatter points in Figure 4.12 resembling each microcosm for *Lythrum salicaria* do not generally fit along the linear regression line. However, when the microcosms are separated into their respective competition groups and concentration ratings, a pattern emerges. The scatter plot can be summarised by dividing it into three main groups.

The first group, containing Microcosm numbers 1-4 (full competition microcosms, nutrients) are all located well above the linear regression line. These show that Microcosm numbers 1-4 have a lower Root : Shoot ratio producing more above ground biomass than below ground biomass. The second group, contains Microcosm numbers 10-12 which are the restricted competition microcosms with the higher nutrient concentrations. Their position shows that where there is restricted root competition, *Lythrum salicaria* has a higher Root : Shoot ratio and produces more below ground biomass than compared to the full competition microcosms. The final group comprises the salinity microcosms and three of the base nutrient microcosms.

When all of the microcosms are separated into the two competition groups, a straight line can be drawn between the two groups (shown in red on Figure 4.12). The restricted microcosms are generally below the line with the exception of Microcosm 15, which is slightly above the line. All of the full competition microcosms are above the line. This illustrates the Root : Shoot relationships and shows that root competition has an effect by reducing the below ground biomass for this species.

<u>Lythrum salicaria Conclusion.</u>

In summary, *Lythrum salicaria* (with the exclusion of the full competition salinity concentrations) will alter its stem height and width depending upon the nutrient or salinity concentration which it is subject to. As per *Phragmites australis*, this is different to previous research undertaken by Bastelova *et al*. (2004) who found that the biomass of shoot dry weight significantly increased with increasing nutrients, but not the plant height. The results of this study show that there is a *very highly significant* difference in the main stem heights and widths of *Lythrum salicaria* as the nutrient levels increase for both the full and the restricted competition microcosms.

When a comparison between the full competition microcosms and the restricted competition microcosms was made for this species, at each nutrient concentration there was a mixture of *very highly significant* differences and *highly significant* differences for either the stem heights or widths along with *no significant* differences. The restricted competition microcosms had slightly narrower stem widths than their counterparts in the full competition microcosms. The presence of significant differences demonstrates that the provision of root barriers does have a significant effect at certain nutrient concentrations. This shows that when faced with full competition with other vegetation species, *Lythrum salicaria* will increase its stem widths, and when the root competition is restricted, *Lythrum salicaria* will not grow stems as wide.

When the biomass data from the full competition microcosms is compared, the below ground biomass of *Lythrum salicaria* shows a decrease in weight as the nutrient concentration increases. When compared to the restricted competition microcosms the opposite is true, with the below ground biomass increasing at the higher nutrient concentrations, but with no obvious trend as the nutrient concentrations increase. The Root : Shoot ratios also show a similar pattern, decreasing in the full competition microcosms and increasing above the base concentration within the restricted competition microcosms. This indicates that the nutrients do not fully control the Root : Shoot ratios, but that competition with other species also has a significant effect. As discussed above, this could be down to allelopathy from *Phragmites australis*.

The coverage of above ground biomass, at all of the nutrient concentrations and for both competition levels, show that this species maintains a good level of coverage and does not oust the other species. However, due to toxicity, fatalities occurred and this species struggled at the higher two salinity concentrations, and as such it is not recommended that this species be grown in effluent with a salinity above 5 ‰.

Although the root zone of *Lythrum salicaria* was adversely affected by the presence of *Phragmites australis*, with its roots being restricted to the humus layer and extending slightly into the gravel layer, a good amount of above ground biomass was produced. The zonation of the *Lythrum salicaria* roots, with the *Phragmites australis* roots growing in the gravel layer beneath this species, should not affect the root treatment potential of *Phragmites australis*.

Due to the good above ground coverage maintained at all of the nutrient concentrations and the lower salinity concentrations, combined with the roots of *Lythrum salicaria* not adversely affecting the roots of *Phragmites australis*, this species is suitable for use as a biodiversity enhancing species within the conditions studied within this thesis.

4.3.3 Filipendula ulmaria

Filipendula ulmaria survived within all of the nutrient concentrations within the different competition scenarios, but fatalities were observed within the higher salinity concentrations.

Hypothesis 1 & 2

These hypotheses investigated if all four species would survive at the different concentrations or whether a single species would take over and oust the other species.

Nutrients

Within the full competition microcosms, this species survived until the end of the study period (after almost 3.5 years). The area coverage of *Filipendula ulmaria* decreased as the nutrients increased to a final combined area coverage of 41 % (M1), 31 % (M2), 28 % (M3) & 26 % (M4). At the lower nutrient range, this species accounts for a high proportion of the area coverage, however it does not oust the other species with its maximum coverage being less than half of the available growing area.

Filipendula ulmaria, survived until the end of the study period in the restricted competition microcosms. It stayed within the confines of its root segregation areas with only the leaves occupying space outside the allocated growing areas. The final combined area coverage was 33 % (M9), 28 % (M10), 32 % (M11) & 26 % (M12). The final combined area coverage was not significantly different to that in the full competition microcosms, however the area coverage was higher at the base nutrient level in the full competition microcosms, where no root dividers were present. These results show that at the low nutrient levels without the root barriers, *Filipendula ulmaria* can compete against the other species and that the root barriers have an adverse effect restricting its stoloniferous surface spread. When grown at the higher concentrations, the differences in area coverage are minor with the root barriers appearing to have a neutral effect on the area of *Filipendula ulmaria*. It therefore maintained a favourable final area coverage within the restricted competition microcosms and was not ousted by the other species.

Salinity

When the area coverage within the full competition microcosms was investigated, it was apparent that an increase in salinity levels had an adverse effect upon this species with the area coverage decreasing in each of the microcosms. This species preferred no salinity, it tolerated the 5 ‰ salinity concentration and did not survive at the highest two salinity concentrations, with the final combined area coverage of 34 % (M5), 18 % (M6), 0 % fatal (M7) & 0 % fatal (M8).

For the restricted competition microcosms it was clear that an increase in salinity levels above the base concentration proved fatal, giving final combined area coverage of 37 % (M13), 0 %, fatal (M14), 0 %, fatal (M15) & 0 %, fatal (M16). From these results, the root barriers appear to have no positive effect on the area coverage for *Filipendula ulmaria*.

Hypothesis 3 & 4

Hypothesis 3 & 4, investigated if the different concentrations would have an effect on the vegetation heights or stem widths of the surviving plants.

Nutrients

The measurements of the harvested stems identified that when all of the stems were combined to include both full competition and restricted competition microcosms, there was a *highly significant* difference in both the heights ($p = 0.003$) and widths ($p = 0.004$) of the stems between the different nutrient concentrations.

When these results were separated into those for the restricted and the full competition microcosms, there was a *highly significant* difference ($p = 0.002$) and a *very highly significant* difference ($p = 0.000$) in the heights of the stems between the different nutrient concentrations for both types of competition. However for the stem widths there was only a *highly significant* difference ($p = 0.007$) in the restricted competition microcosms between the different nutrient concentrations.

The stem harvest data was further divided to investigate if restricting root competition had an effect on the stem height and width at the different nutrient concentrations. An overview of the statistical analysis for the stem height and width can be found in Table 4.18. Table 4.18 shows that at the base nutrient concentrations, the stem heights is no statistical difference between the full and restricted competition microcosms, whereas the stem widths are statistically different. This reverses at the higher three nutrient concentrations showing that there is a statistical difference for the stem heights between the full and restricted competition microcosms, but the stem widths are not statistically different.

Salinity

The measurements of the harvested stems identified that when all of the stems of the microcosms where plants survived were combined to include both full competition and restricted competition microcosms, there was a *very highly significant* difference ($p = 0.000$) in both the heights and widths of the stems between the different salinity concentrations.

When these results were divided between the restricted and unrestricted microcosms, there was a *very highly significant* difference ($p = 0.000$) in the heights and widths of the stems between the different salinity concentrations for the full competition microcosms with an increase in size with the higher salinity. However, where the salinity was above base value, this species did not survive within any of the restricted competition microcosms. As this species did not survive in the restricted competition microcosms where the salinity was above base value, no statistical comparisons could be undertaken between the full and restricted competition microcosms at each salinity value.

Hypothesis 5 & 6

Hypothesis 5 & 6, investigated if the different concentrations would have an effect on the above and below ground biomass of the surviving plants.

Nutrients

The above and below ground biomass values for the different nutrient concentrations in the full competition microcosms and the restricted competition microcosms can be found in Table 4.33.

For both the full and restricted competition microcosms the above and below ground biomass fluctuates as the nutrient concentration increases. Although biomass parameters fluctuate, they do not do so at the same rate, with the below ground biomass reducing at a greater rate than the above ground biomass, resulting in a lower Root : Shoot ratio as the nutrient levels increase.

When the full and restricted competition microcosms are compared against each other there appears to be no significant difference between the Root : Shoot ratios of *Filipendula ulmaria*, with both competition parameters observed decreasing at a similar rate. The full competition microcosms have a higher total biomass than the restricted competition, however, the data gathered for Hypothesis 5 and 6 is not suitable for statistical analysis to prove if this is statistically significant.

Pauli *et al*., (2001) studied the effects of nutrient enrichment in calcareous fens, and looked at the impact of increasing nutrients on *Filipendula ulmaria*. After 16 months of growth the plants were measured during August. They found that in unfertilised plots, this species had an approximate Root : Shoot ratio of 3.33 (note that Pauli *et al*., 2001 use shoot:root, whereas this study presents the results as Root : Shoot; when converted the shoot:root ratio of 0.3 would be approximately a Root : Shoot Ratio of 3.33). The plots which were only subject to additional Nitrogen were not affected. The sites which were fertilised with a mixed NPK fertiliser had increased leaf lengths of 56% and increased above ground biomass by 78%. The below ground biomass did not alter and as such, the shoot:root ratio increased. Although Pauli *et al*., (2001) had a slightly higher Root : Shoot ratio, this is similar to the findings of this research, where an increase in nutrients resulted in a decrease of Root : Shoot ratio.

Competition	Parameter	10 mg/l Nitrogen and <0.05 ‰ Salinity	50 mg/l Nitrogen and <0.05 ‰ Salinity	100 mg/l Nitrogen and <0.05 ‰ Salinity	150 mg/l Nitrogen and <0.05 ‰ Salinity
Full Competition	Above Ground Weight (g)	63.45	136.49	78.77	95.97
	Below Ground Weight (g)	186.54	360.45	199.47	221.71
	Root : Shoot Weight Ratio	2.94	2.64	2.53	2.31
Restricted Competition	Above Ground Weight (g)	9.25	39.82	51.47	29.95
	Below Ground Weight (g)	27.09	105.17	128.86	71.77
	Root : Shoot Weight Ratio	2.93	2.64	2.50	2.40

Table 4.33: *Filipendula ulmaria* Biomass for Each Nutrient Concentration with Full Competition (Microcosms 1-4) & Restricted Competition (Microcosms 9-12)

The root spread of *Filipendula ulmaria* did not spread far from the perennating bud staying predominantly within the humus layer and only just penetrated the gravel layer within the restricted competition microcosms. This species had spread vegetatively during the study via the use of above ground stolons.

Salinity

The above and below ground biomass values for the different salinity concentrations in the full competition microcosms and the restricted competition microcosms can be found in Table 4.34. However, above the base salinity *Filipendula ulmaria* only survived within one of the full competition microcosms,.

Within the microcosms, as the salinity increases, the Root : Shoot ratio does not alter but stays the same as the base concentration. This Root : Shoot ratio is the same as the base nutrient concentrations assessed in Table 4.33 which indicates that salinity does not have an effect on this parameter (other than the fatal effects), but the nutrients do.

Competition	Parameter	10 mg/l Nitrogen and <0.05 ‰ Salinity	10 mg/l Nitrogen and 5 ‰ Salinity	10 mg/l Nitrogen and 10 ‰ Salinity	10 mg/l Nitrogen and 15 ‰ Salinity
Full Competition	Above Ground Weight (g)	58.78	13.66	0.00	0.00
	Below Ground Weight (g)	176.02	39.90	0.00	0.00
	Root : Shoot Weight Ratio	2.99	2.92	0.00	0.00
Restricted Competition	Above Ground Weight (g)	29.21	0.00	0.00	0.00
	Below Ground Weight (g)	86.66	0.00	0.00	0.00
	Root : Shoot Weight Ratio	2.97	0.00	0.00	0.00

Table 4.34: *Filipendula ulmaria* Biomass for Each Salinity Concentration with Full Competition (Microcosms 5-8) & Restricted Competition (Microcosms 13-16)

As with the nutrients, where this species survived in the single microcosm above the control concentration, the root spread of *Filipendula ulmaria* did not spread far from the perennating bud staying predominantly within the humus layer.

Nutrients and Salinity

When the above and below ground biomass of *Filipendula ulmaria* is plotted on a graph (Figure 4.12), the individual scatter points resembling each microcosm are placed in close proximity to the linear line. The linear line goes through the origin showing that the scatter points for the above ground weights and the below ground weights are almost directly proportional. It can be seen from the graph that the higher nutrient microcosms with full competition are at the higher end of the linear line and those with restricted competition, base nutrients, or the salinity concentrations, are at the lower end.

<u>Filipendula ulmaria Conclusion.</u>

In summary, *Filipendula ulmaria* will generally alter its stem height and width depending upon the nutrient or salinity concentration which it is subject to. When the heights are separated into the full competition and restricted competition microcosms, there are significant differences at the higher nutrient concentrations, which indicates that competition plays a role in the height differences.

The coverage of above ground biomass at all of the nutrient concentrations and for both competition levels show that this species maintains a good level of coverage and does not oust the other species. However due to toxicity, fatalities occurred and this species struggled at the higher three salinity concentrations, and as such it is not recommended to grow this species in a saline effluent.

When the biomass data for *Filipendula ulmaria* is compared for the various nutrient concentrations, no specific trend is observed. However when the Root : Shoot ratios are compared, the increase in nutrients result in a decrease in the Root : Shoot Ratio.

However, when the full and restricted competition microcosms are compared against each other, there is no significant difference between the Root : Shoot ratios. This would suggest that it is the nutrient levels which control the Root : Shoot ratios and not the competition with other individuals.

The root spread of *Filipendula ulmaria* did not extend far from the perennating bud staying predominantly within the humus layer, and only just penetrated the gravel layer within the restricted competition microcosms. This species had spread vegetatively during the study via the use of above ground stolons. The final combined area coverage within the restricted competition microcosms was not significantly different to the full competition microcosms, however the area coverage was higher at the base nutrient level in the full competition microcosms where no root dividers were present to restrict the spread of this species. As such, within the low nutrient concentrations the presence of root dividers (which protruded above the humus layer) had an adverse effect on the spread of this species by preventing it colonising new ground. Taking these results into account, to prevent this species from being constrained, it is not recommended that root barriers are utilised, unless the barriers are not as closely spaced as they were within this study.

The zonation of the *Filipendula ulmaria* roots, with the *Phragmites australis* roots growing in the gravel layer beneath this species, should not affect the root treatment potential of *Phragmites australis* when grown alongside the biodiversity enhancing species tested within this study and within similar pollutant concentrations.

Due to the good above ground coverage maintained for all of the nutrient concentrations and the lower salinity concentrations, combined with the roots of *Filipendula ulmaria* not adversely affecting the roots of *Phragmites australis*, this species is suitable for use as a biodiversity enhancing species for the conditions studied within this research.

4.3.4 Mentha aquatica

Mentha aquatica survived within all of the nutrient concentrations within the different competition scenarios, but fatalities were observed for the higher salinity concentrations.

Hypothesis 1 & 2

These hypotheses investigated if all four species would survive at the different concentrations or whether a single species would take over and oust the other species.

Nutrients

Within the full competition microcosms, *Mentha aquatica* survived until the end of the study period (after almost 3.5 years). It decreased slightly in area coverage at the higher nutrient concentrations with final combined area coverage of 17 % (M1), 18 % (M2), 15 % (M3) & 11 % (M4). At the lower nutrient range, this species accounts for a good proportion of the area coverage being just under 20 % of the coverage. This is slightly lower than the 25 % which could be expected if all species had the same competitive ability (i.e. it is 1 of 4 species present), however it is not ousted by the other species and remains as a viable species, even at the higher nutrient concentrations.

This species also survived until the end of the study period in the restricted competition microcosms. The final combined area coverage of *Mentha aquatica* was 23 % (M9), 22 % (M10), 14 % (M11) & 13 % (M12). The final combined area coverage within the restricted competition microcosms was slightly higher than in the full competition microcosms, however the area coverage still decreased at the higher nutrient loadings. From these results, at the low nutrient levels in the restricted root microcosms, the root barriers appear to have a beneficial effect on the area of *Mentha aquatica,* as the area coverage is marginally greater. However, at the higher nutrient levels the difference between the full and restricted microcosms is minimal.

The study by Suter *et al*., (2010), already referred to in the discussions of *Phragmites australis* and *Lythrum salicaria,* found that when *Mentha aquatica* was planted in fen communities containing different species mixtures, it declined. As with *Lythrum salicaria,* at the end of the study the final proportion was less than 0.1 within all species mixtures, including the mixture where this species was planted as the dominant species. The growing habitat studied in Suter *et al*., 2010 (a field being restored to a semi-natural wet grassland), differed from the constructed treatment wetland habitat with a gravel bed simulated in this research, which could contribute to the differences identified. In addition, the different species utilised by Suter *et al*., 2010 could be better at outcompeting *Mentha aquatica*, than the species utilised within this study.

Salinity

When the area coverage within the full competition microcosms was investigated, it was apparent that an increase in salinity levels had an adverse effect upon *Mentha aquatica*. It did not survive in the highest three salinity concentrations, with the final combined area coverage of 20 % (M5), 0 %, fatal (M6), 0 %, fatal (M7) & 0 %, fatal (M8).

From the investigation, it was apparent that an increase in salinity levels also had an adverse effect upon this species in the restricted competition microcosms. *Mentha aquatica* preferred no salinity, it just survived in the 5 ‰ salinity concentration and did not survive at the highest two salinity concentrations, with the final combined area coverage of 24 % (M13), 4 % (M14), 0 %, fatal (M15) & 0 %, fatal (M16). As per the nutrients, from these results it is seen that the root barriers appear to have a slight beneficial effect on the area coverage of *Mentha aquatic,* with the area coverage being slightly higher in the restricted competition microcosms. However, the highest two salinities still had fatal affects upon this species.

<u>Hypothesis 3 & 4</u>

Hypothesis 3 & 4, investigated if the different concentrations would have an effect on the vegetation stem heights or widths of the surviving plants.

Nutrients

The measurements of the harvested *Mentha aquatica* stems identified that when all of the stems were combined to include both full competition and restricted competition microcosms, there was a *very highly significant* difference (p = 0.000) in both the heights and widths of the stems between the different nutrient concentrations.

When investigated further, there was a *very highly significant* difference (p = 0.000) in the stem heights for restricted competition microcosms between the different nutrient concentrations, but not for the full competition microcosms. However, there was a *very highly significant* difference (p = 0.000, restricted competition microcosms) and a *significant* difference (p = 0.023, full competition microcosms) in the widths of the stems between the different nutrient concentrations for both types of competition.

The stem harvest data was further divided to investigate if restricting root competition had an effect on the stem height and width at the different nutrient concentrations, and an overview of the statistical analysis can be found in Table 4.18. Table 4.18 shows that between the full and restricted competition microcosms, the stem heights are not statistically different at the 10 mg/l and 100 mg/l concentrations, but they are for the 50 mg/l and 150 mg/l concentrations. However the stems widths are statistically different between the full and restricted competition microcosms at the lower two concentrations, but are not at the highest two nutrient concentrations. This shows that restricting the root competition had an effect upon the stem measurements.

Salinity

When all of the stem data were combined to include both full competition and restricted competition microcosms, there was a *very highly significant* difference (p = 0.000) in the *Mentha aquatica* stem heights, but no statistical difference between the widths of the stems between the different salinity concentrations.

Where the salinity was above base value, *Mentha aquatica* did not survive in any of the full competition microcosms. There was a *very highly significant* difference (p = 0.000) in the heights of the stems between the different salinity concentrations for the restricted competition microcosms, but not for the widths.

No statistical comparisons could be made between the full and restricted competition microcosms as *Mentha aquatica* did not survive in the full competition microcosms when the salinity was above the base value.

Hypothesis 5 & 6

Hypothesis 5 & 6, investigated if the different concentrations would have an effect on the above and below ground biomass of the surviving plants.

Nutrients

The above and below ground biomass values for *Mentha aquatica* at the different nutrient concentrations in the full competition microcosms and the restricted competition microcosms can be found in Table 4.35.

Fluctuations in *Mentha aquatica* above and below ground biomass occurred as the nutrient concentration increases for the full competition microcosms, where as in the restricted competition microcosms it decreases. Although biomass parameters fluctuate, they do not fluctuate at the same rate, with the below ground biomass decreasing at a greater rate than the above ground biomass. With the exception of a small spike in the restricted competition microcosms results at the 50 mg/l nutrient level, as the nutrients increase, the Root : Shoot ratio slowly decreases.

When the full and restricted competition microcosms are compared against each other the Root : Shoot ratios are almost identical with the restricted competition microcosms being ever so slightly higher for all but the greatest nutrient concentration. However, the *Mentha aquatica* data gathered for Hypothesis 5 and 6 is not suitable for statistical analysis to show whether this is statistically significant or not.

Competition	Parameter	10 mg/l Nitrogen and <0.05 ‰ Salinity	50 mg/l Nitrogen and <0.05 ‰ Salinity	100 mg/l Nitrogen and <0.05 ‰ Salinity	150 mg/l Nitrogen and <0.05 ‰ Salinity
Full Competition	Above Ground Weight (g)	82.91	3.72	4.87	13.58
	Below Ground Weight (g)	16.88	0.70	0.85	2.12
	Root : Shoot Weight Ratio	0.20	0.19	0.17	0.16
Restricted Competition	Above Ground Weight (g)	63.47	56.09	11.12	6.28
	Below Ground Weight (g)	14.22	13.45	2.07	1.01
	Root : Shoot Weight Ratio	0.22	0.24	0.19	0.16

Table 4.35:Mentha aquatica Biomass for Each Nutrient Concentration with Full Competition (Microcosms 1-4) & Restricted Competition (Microcosms 9-12)

The stolons and rhizomes of *Mentha aquatica* stayed predominantly within the humus layer and only just penetrated the gravel layer where the edges of the container or root barriers provided a small gap for access. This species had spread vegetatively during the study via the use of its stolons and rhizomes.

Salinity

The above and below ground biomass values for the different salinity concentrations in the full competition microcosms and the restricted competition microcosms can be found in Table 4.36. However, *Mentha aquatica* only survived within one of the restricted competition microcosms, above the base salinity.

Within the microcosms, as the salinity increases in the restricted competition microcosms, the Root : Shoot ratio does not alter but stays almost the same as the base concentration. This Root : Shoot ratio is almost the same as the base nutrient concentrations assessed in Table 4.35 with a slight increase in the 5 ‰ salinity concentration. This would indicate that salinity does not have an effect on this parameter other than the fatal affects which occurred.

Competition	Parameter	10 mg/l Nitrogen and <0.05 ‰ Salinity	10 mg/l Nitrogen and 5 ‰ Salinity	10 mg/l Nitrogen and 10 ‰ Salinity	10 mg/l Nitrogen and 15 ‰ Salinity
Full Competition	Above Ground Weight (g)	10.22	0.00	0.00	0.00
	Below Ground Weight (g)	2.09	0.00	0.00	0.00
	Root : Shoot Weight Ratio	0.20	0.00	0.00	0.00
Restricted Competition	Above Ground Weight (g)	26.98	6.31	0.00	0.00
	Below Ground Weight (g)	6.23	1.49	0.00	0.00
	Root : Shoot Weight Ratio	0.23	0.24	0.00	0.00

Table 4.36: Mentha aquatica Biomass for Each Salinity Concentration with Full Competition (Microcosms 5-8) & Restricted Competition (Microcosms 13-16)

Nutrients and Salinity

The individual scatter points representing each microcosm for *Mentha aquatica* are placed in close proximity to the linear line (Figure 4.12). The linear line goes through the origin showing that the scatter points for the above ground weights and the below ground weights are almost directly proportional. The graph shows that there is a slight additional pattern in that the base nutrient and salinity microcosms (Microcosm numbers 1, 5, 9 and 13) are generally higher up the linear line, with the exception of Microcosm 10 (50 mg/l nutrients with restricted root competition), which is also high up the linear line.

<u>Mentha aquatica Conclusion.</u>

In summary, *Mentha aquatica* will generally alter its stem height and width depending upon the nutrient or salinity concentration which it is subject to. When the heights are separated for the full competition and restricted competition microcosms, as the nutrient levels increase there are significant differences within some of the nutrient concentrations with a slight increase in heights for the full competition microcosms, and a slight increase then decrease in heights for the restricted competition microcosms. This indicates that competition plays a partial role in the height differences.

The coverage of above ground biomass at all nutrient concentrations and for both competition situations, show that *Mentha aquatica* maintains a good level of coverage, but this declines at the higher nutrient concentrations. It does not oust the other species, nor is it ousted by them. However, due to toxicity, fatalities occurred and this species struggled at the higher three salinity concentrations, and therefore growing this species in a saline effluent is not recommended.

When the biomass data is compared for the various nutrient concentrations, the biomass weights show no specific trend for the full competition microcosms, but a declining trend was observed for the restricted competition microcosms. A comparison of the Root : Shoot ratios found that, an increase in nutrients results in a decrease in the Root : Shot ratio. When the full and restricted competition microcosms are compared against each other, there is no significant difference between the Root : Shoot ratios, however the restricted competition ratios are slightly higher for all but the highest nutrient concentration.

Since the *Mentha aquatica* roots were found predominantly in the humus layer, with the *Phragmites australis* roots growing in the gravel layer beneath, there should be no affect on the root treatment potential of *Phragmites australis* when grown alongside this species for the similar pollutant concentrations employed in this study. This is in concurrence with the findings of Frazer-Williams (2007), who investigated the treatment of grey water from student accommodation. *Mentha aquatica* was planted within its own section at the end of a trough treatment system. This species was chosen for its aesthetic value and was not in competition with any other species. At the end of the study (2.5 years) he concluded that with regards to *Mentha aquatica*, there was no evidence that its small roots would have an adverse effect on the hydraulic flow of a trough treatment system and as such it could be a suitable species to use for its aesthetic value.

Kadewa (2010) undertook a 16 month study looking at the treatment of grey water in small scale constructed wetlands. He tested the treatment potential of a mixture of aquatic macrophytes against unplanted cells. The species he used for the planted cells and the rational for their choice was: *Iris pseudacorus* and *Iris chrysographes* for their beauty, *Mentha aquatica* for its scent, and *Carex elata aurea* for its structure. As with the Frazer-Williams (2007) study, the effluent source was grey water from student accommodation and had a BOD ranging from 28 to 185 mg/l and COD ranging from 74 to 279 mg/l. He found that there was no significant difference in treatment between the planted and unplanted systems. There was a small difference in the BOD removal, but this was put down to microbial activity on the roots and not the plants themselves. The study did not report any findings on the coverage of the various vegetation species or interactions in cover between them (which his study was not designed to do). However, it is unlikely that any significant results in population dynamics would be seen, due to the low number of reproductive seasons during the study, hence the species involved would not have had time to spread either by setting seed or by spreading vegetatively.

Due to the good above ground coverage maintained at all nutrient concentrations, combined with the roots of *Mentha aquatica* not adversely affecting the roots of *Phragmites australis*, this species is suitable for use as a biodiversity enhancing species for the conditions studied during this research. Due to the fatalities occurring at salinity concentrations above base level, this species should not be used for saline effluent.

4.3.5 Hypothesis 7 & 8

These hypotheses were designed to investigate if there was a significant difference in water usage as the pollutant concentrations increased, and whether restricting root competition had an effect upon the water usage. This information would be required to inform water budget design calculations when using the study species within a constructed wetland,

During the treatment period, for both the full and restricted competition microcosms, a trend appeared which shows that the water usage increases as the nutrient levels increase. When the water usage levels of the full competition microcosms are compared to the restricted competition microcosms, the full competition microcosms use more water than the restricted competition microcosms.

The differences in water usage between nutrient levels within both competition scenarios are generally low being less than 20 % of the monthly totals. The data presented within this thesis and the findings of Fermor *et al*., (2001) show that the evapotranspiration rate of reedbeds varies through the year and from reedbed to reedbed depending upon its geographic location. As such the greatest water usage rates should be employed when designing constructed wetland treatment systems, and water budgets should be calculated to ensure system sustainability.

With regards to salinity, the opposite is true for water usage. As the salinity concentration increases, the water usage decreases. Again the full competition microcosms utilise more water than the restricted competition microcosms. The differences in water usage between salinity levels within both competition scenarios are high, being nearly 50 % lower for the highest salinity concentrations within the monthly totals. As such the lower water usage with higher salinity concentrations could have a significant effect on the design parameters. Thus if high salinity levels are to be encountered the lower water usage rate under these circumstances should be taken into account when designing constructed wetland treatment systems.

4.4 Overview of Hypotheses

Table 4.37 provides a summary of the overall findings for each of the hypotheses. Together the analysis shows that providing toxic concentration levels are not encountered, the study species can exist successfully together, and no one species outcompetes any other.

The hypotheses presented in Section 1 were formulated to determine the viability of using each species for enhancing biodiversity within a constructed wetland treatment system. By proving the hypothesis, or in the case of Hypothesis 1 and 2 showing that no species took over and ousted the other species (though all species did not survive within the higher salinity levels due to the saline conditions and not plant competition), this shows that it is viable for biodiversity enhancing species to survive within small scale constructed wetland treatment systems. Sections 4.3 and 7 proposes guidance on the design methodologies and management options resulting from this study.

Hypothesis		Factor	Summary	Conclusion	Hypothesis Proved?
Hypothesis 1	***"Where all four chosen floral species survive in the chemical concentrations studied, no single floral species will take over and oust other floral species."***	Nutrients	The area coverage fluctuated over the study period, however the combined area coverage for any species of vegetation did not exceed 50 % and as such no single species took over and ousted the other species.	As no species took over and ousted the other species, the null hypotheses was disproved and with regards to nutrients Hypothesis 1 is proved.	As no species took over and ousted the other species, the null hypotheses was disproved Hypothesis 1 is proved.
		Salinity	The higher salinity levels caused fatalities to occur for some of the vegetation. Although fatalities occurred, this was not due to competition but due to the tolerance levels of the plants being unable to survive within the higher salinity concentrations. Although only one species (*Phragmites australis*) survived within the highest salinity concentration, it did not take over and oust the other species through direct competition.	When the hypothesis is looked at from a plant competition view, the null hypothesis is disproved as it was not down to one species taking over and ousting the other species but due to the fatal affects of the salinity concentration tested.	
Hypothesis 2	***"Where all four chosen floral species survive in the chemical concentrations studied, no single floral species will take over and oust other floral species, and restricting root competition between the different floral species will have an effect."***	Nutrients	Within the different nutrient concentrations tested under Hypothesis 2, all species survived at reasonable area coverage and one species did not fully take over and oust the other species. The results and observations of growth patterns also showed that the root barriers had an effect between the different species, which varied depending upon the nutrient concentrations by reducing competition from adjacent species. This effect came from restricting the plants spread, such as occurred with *Phragmites australis* under full competition when it intermingled across the microcosm .	As no species took over and ousted the other species, the null hypotheses was disproved and with regards to nutrients Hypothesis 2 is proved.	As no species took over and ousted the other species, the null hypotheses was disproved Hypothesis 2 is proved.
		Salinity	Within the different salinity concentrations tested under Hypothesis 2, fatalities occurred. Although there were fatalities, this was not due to competition (as root barriers were present with bare ground available for species to colonise), but due to the toxicity at higher salinity concentrations. This backs up the findings in Hypothesis 1. Although only one species (*Phragmites australis*) survived at the highest salinity concentration, it did not take over and oust the other species through direct competition. The results also showed that the root barriers had a slight effect between the different species at the low salinity concentrations.	When the hypothesis is looked at from a plant competition perspective, the null hypothesis is disproved as it was not down to one species taking over and ousting the other species but due to the fatal affects of the salinity concentration tested.	
Hypothesis 3	***"The higher concentrations of the chosen chemical ranges will have an effect on the stem heights or stem widths of the surviving plants."***	Nutrients	Within the different nutrient concentrations tested under Hypothesis 3, the statistics showed that the species exhibited a significant difference in either the stem height or their widths. This was for both the full and restricted competition microcosms combined, and also for the data which was separated to show the full competition microcosms only.	The higher nutrient concentrations had an effect on the vegetation height or widths and as such, for the nutrients, the null hypothesis is disproved, therefore Hypothesis 3 is proved.	As the higher concentrations had an effect on the vegetation height or widths, the null hypothesis is disproved, therefore Hypothesis 3 is proved.
		Salinity	Within the different salinity concentrations tested under Hypothesis 3, the statistics showed that there was a significant difference in either the stem height or stem widths for most species. *Lythrum salicaria* showed significant differences for the full and restricted microcosms combined, but no significant differences for the surviving plants within the full competition microcosms. *Mentha aquatica* showed no significant differences for the surviving plants for the full and restricted competition microcosms, but, due to fatalities occurring, the data could not be split to extract the information full competition microcosms alone. Although *Lythrum salicaria* and *Mentha aquatica* showed no significant difference for some of their statistics, the increase in salinity had an adverse effect on stem height and stem width due to fatalities occurring.	The higher salinity concentrations had an effect on the stem height or stem widths (including survival rates) and as such, for the salinity, the null hypothesis is disproved, therefore Hypothesis 3 is proved.	
Hypothesis 4	***"The higher concentrations of the chosen chemical ranges will have an effect on the stem heights or stem widths of the surviving plants, and restricting root competition between the different floral species will have an effect."***	Nutrients	Within the different nutrient concentrations tested under Hypothesis 4, the statistics showed that there was a significant difference in either the stem height or stem widths of the species within the restricted nutrient microcosms. When a comparison was undertaken between the full competition microcosms and the restricted competition microcosms at each nutrient concentration, each species had a level of significant difference for either the stem heights or stem widths. The presence of significant differences shows that the provision of root barriers does have a significant effect at certain nutrient concentrations.	The statistics showed that each species had a significant difference between the full and restricted competition microcosms at certain nutrient concentrations, therefore the provision of root barriers does result in a significant difference within certain nutrient concentrations for each species. As such, for the nutrients, the null hypothesis is disproved and therefore Hypothesis 4 is proved.	As the higher concentrations had an effect on either the vegetation stem height or widths, and where species survived within both the full and restricted competition microcosms (allowing for comparison between the two) there were significant differences present for certain salinity concentrations, the null hypothesis is disproved. Therefore Hypothesis 4 is proved.
		Salinity	As with Hypothesis 3, fatalities occurred which showed that the higher salinity concentrations had an adverse effect on stem height and stem width due to these fatalities in the restricted microcosms. Within the different salinity concentrations tested under Hypothesis 4, the statistics showed that there was a significant difference in either the stem height or stem widths of the species. When each species was compared with the full competition microcosms at each salinity concentration, each surviving species had a level of significant differences for either the stem heights or widths (due to fatalities, *Filipendula ulmaria* and *Mentha aquatica* could not be compared). The presence of significant differences shows that the provision of root barriers does have a significant effect at certain salinity concentrations.	The statistics showed that each surviving species exhibited a significant difference between the full and restricted competition microcosms within certain nutrient concentrations, therefore the provision of root barriers does have a significant difference under these circumstances. As such, for salinity, the null hypothesis is disproved, therefore Hypothesis 4 is proved.	

Table 4.37: Summary of Hypothesis Findings (Continues)

Hypothesis		Factor	Summary	Conclusion	Hypothesis Proved?
Hypothesis 5	***"The higher concentrations of the chosen chemical ranges will have an effect on the above and below ground total biomass of the plants."***	Nutrients	Within the different nutrient concentrations tested under Hypothesis 5, the results showed that the above and below ground biomass was affected by the different nutrient concentrations, with the Root : Shoot ratio either increasing or decreasing as the nutrient concentrations increase.	As biomass was affected by the increase in nutrient concentrations, the null hypothesis is disproved, therefore Hypothesis 5 is proved.	As biomass was affected by the increase in concentrations, the null hypothesis is disproved, therefore Hypothesis 5 is proved.
		Salinity	As with the different Nutrient concentrations, the results for the different salinity concentrations tested under Hypothesis 5, showed that the Root : Shoot ratios either decreased or caused fatalities as the salinity concentrations increased.	As biomass was affected by the increase in salinity concentrations, the null hypothesis is disproved, therefore Hypothesis 5 is proved.	
Hypothesis 6	***"The higher concentrations of the chosen chemical ranges will have an effect on the above and below ground total biomass of the plants, and restricting root competition between the different floral species will have an effect."***	Nutrients	The results for the different nutrient concentrations tested under Hypothesis 6, showed that within the restricted competition microcosms the above and below ground biomass was affected by the different nutrient concentrations, with the Root : Shoot ratio either increasing or decreasing as the nutrient concentrations increase. When the full and restricted competition microcosms were compared against each other, the Root : Shoot ratio for *Lythrum salicaria* were significantly different, so was the total biomass for *Filipendula ulmaria*, showing that restricting root competition for these species has a significant affect. *Phragmites australis* and *Mentha aquatica* have little discernible difference between the full and restricted competition microcosms.	As the increase in nutrients clearly has an effect on the different species and the vegetation within the plant community reacting differently to the restriction of root competition, the null hypothesis is disproved and Hypothesis 6 is proved with respect to nutrients.	As the increase in concentrations clearly has an effect on the different species and the vegetation within the plant community reacting differently to the restriction of root competition, the null hypothesis is disproved and Hypothesis 6 is proved.
		Salinity	Within the different salinity concentrations tested under Hypothesis 6, the results showed that the plant biomass was affected by the different salinity concentrations, with the Root : Shoot ratios either decreasing or causing fatalities as the salinity concentrations increase. When the full and restricted competition microcosms were compared against each other, the Root : Shoot ratio for *Lythrum salicaria* were different showing that restricting root competition for this species has a significant affect. *Filipendula ulmaria* and *Mentha aquatica* both suffered fatalities at the higher salinity concentrations so no definitive affect of restricting root competition could be determined. Phragmites australis had little discernible difference between the full and restricted competition microcosms.	As the increase in salinity clearly has an effect on the different species and the vegetation within the plant community (*Lythrum salicaria*) reacts differently to the restriction of root competition, therefore for salinity, the null hypothesis is disproved and Hypothesis 6 is proved.	
Hypothesis 7	***"The higher concentrations of the chosen chemical ranges will have an effect on the water consumption."***	Nutrients	For Hypothesis 7, the results showed that the water usage was affected by the different nutrient concentrations, with the water usage during the peak growing season increasing as the nutrient concentrations increased.	As the water usage was affected by the different nutrient concentrations, the null hypothesis is disproved, therefore Hypothesis 7 is proved.	As the water usage was affected by the different concentrations, the null hypothesis is disproved and Hypothesis 7 is proved.
		Salinity	As with the differing nutrient levels, the results showed that the water usage was affected by the different salinity concentrations, and during the growing season it decreased as the salinity concentrations increased.	As the water usage was affected by the different salinity concentrations, the null hypothesis is disproved, therefore Hypothesis 7 is proved.	
Hypothesis 8	***"The higher concentrations of the chosen chemical ranges will have an effect on the water consumption, and restricting root competition between the different floral species will also have an effect."***	Nutrients	Within the different nutrient concentrations tested under Hypothesis 8, the results showed that for the restricted competition microcosms, the water usage was affected by the different concentrations, with the water usage during the peak growing season increasing as the nutrient concentrations increased. The results also showed that the full competition microcosms used more than their counterparts in the restricted competition microcosms.	As the water usage was affected by the different nutrient concentrations, and the water usage varied between the restricted and full competition microcosms, proving that the root barriers have an effect on water consumption, the null hypothesis is disproved, therefore Hypothesis 8 is proved.	The water usage was affected by the different concentrations and the presence of root barriers had an effect on the water usage. Therefore the null hypothesis is disproved and Hypothesis 8 is proved.
		Salinity	The analysis showed that for the restricted competition microcosms, the water usage was affected by the different salinity concentrations, decreasing during the growing season as the salinity concentrations increased. The results also showed that the full competition microcosms used more than their counterparts in the restricted competition microcosms	As the water usage was affected by the different salinity concentrations, and the water usage varied between the restricted and full competition microcosms, proving that the root barriers have an effect on water consumption, the null hypothesis is disproved, therefore Hypothesis 8 is proved.	

Table 4.37(Continued): Summary of Hypothesis Findings

4.5 Design Principles and Management Recommendations Identified During The Microcosm Study

Based upon the observations made and results obtained from the microcosm studies, this section provides guidance on the requirements for biodiversity enhancing species when incorporated into small scale constructed wetlands within the U.K.

4.5.1 Species Selection and Pollutant Concentrations

<u>Nutrients</u>

The results for the full competition microcosms showed that the roots of all three of the biodiversity enhancing species did not penetrate deep into the gravel layer where *Phragmites australis* was growing and that the roots of *Phragmites australis* were successfully growing under those of the biodiversity enhancing species. Although *Lythrum salicaria* roots did penetrate into the gravel where the root dividers were present, once *Phragmites australis* was actively growing in the area the roots of *Lythrum salicaria* retreated to the humus layer and were only present just penetrating the gravel layer potentially due to allelopathy. This should therefore not affect the hydraulics or root treatment efficiency of sub-surface flow constructed wetlands which utilise *Phragmites australis* as their key treatment species.

None of the biodiversity enhancing species became dominant and out competed other species during the study. As all species survived at reasonable levels and did not prevent the roots of *Phragmites australis* from growing within the gravel layer, all three of the species studied are suitable for use for biodiversity enhancement.

All three of the biodiversity enhancing species survived in the entire range of nutrient concentrations tested. Consequently, where nutrient dosing is intermittent (such as a system treating urban run-off) and not above the levels tested, then all three of the species can be utilised. It is not recommended that these species are planted where nutrient levels which exceed 150 mg/l nitrogen, until further research has been undertaken on the species dynamics and treatment potential at these higher concentrations.

<u>Salinity</u>

The salinity levels employed in the study, had fatal consequences for all three of the biodiversity enhancing species.

The highest salinity loading of 15 ‰ was fatal to *Lythrum salicaria*, which also struggled to survive at 10 ‰ salinity. At 5 ‰ salinity the area coverage was 16 %, which is reasonable for providing biodiversity enhancing effects.

Both *Filipendula ulmaria* and *Mentha aquatica* suffered fatal effects at salinity loadings of 15 ‰ and 10 ‰. They also struggled to survive within the 5 ‰ salinity loading and some fatal effects occurred, which indicates that the 5 ‰ salinity concentration is at the upper end of their survivability limits.

Where the species survived, none of the biodiversity enhancing species became dominant and out competed the other species during the study. None of the biodiversity enhancing species prevented the roots of *Phragmites australis* from growing within the gravel layer under these conditions, and thus all three of the species studied are suitable for use for biodiversity enhancement providing salinity concentrations are below toxic levels.

<u>Summary</u>

From the pollutant concentration studies, the following recommendations are made.

- *Phragmites australis* will survive at all of the nutrient and salinity levels studied and can be planted in all of the concentrations tested.
- where the salinity levels are over 5 ‰, none of the biodiversity enhancing species studied should be planted.
- where nutrient (nitrogen) concentrations are 150 mg/l or less and salinity levels do not exceed 5 ‰, *Lythrum salicaria* can be planted as a biodiversity enhancing species.
- where nutrient concentrations are 150 mg/l or less and salinity levels do not exceed 0.05 ‰, *Lythrum salicaria, Filipendula ulmaria and Mentha aquatica* can be planted as biodiversity enhancing species.
- where nutrient concentrations are 150 mg/l or less and the salinity levels do not exceed intermittent doses of a couple of ‰ (such as infrequent urban run-off from roads following de-icing) all three of the biodiversity enhancing species can be planted as they all survived 5 ‰ salinity for a short period of time.

4.5.2 Constructed Wetland and Media Selection

The design methodology for the study was based upon a subsurface flow constructed wetland with gravel media. As all floral species survived successfully at all nutrient concentrations up to 150 mg/l, the initial recommendation would be that biodiversity enhancing species can successfully be incorporated within subsurface flow constructed wetlands. The effect of the different stem physiology and densities upon the filtration of effluents in surface flow wetlands was not explored and thus, no guidance on the use of the biodiversity enhancement as an aid to treatment can be provided for these treatment wetlands.

The 10 mm pea gravel used in the beds of constructed wetlands is an appropriate rooting medium for the biodiversity enhancing species studied. The majority of these species roots were present within the upper layers of the growing media, and thus the slightly greater bed depth of standard subsurface flow designs would not have any adverse affect on the species diversity. Consequently, the recommended designs for the depths of subsurface flow wetlands found within the standard design manuals of Cooper *et al*., (1996) and Kadlec & Wallace (2009) should continue to be followed if biodiversity enhancing species are incorporated.

This research identified that the roots of biodiversity enhancing species were found predominantly within the upper humus layer and only just penetrated into the gravel layer. When the roots of *Phragmites australis* were present the roots of *Lythrum salicaria* were predominantly found within the humus layer, however, in the absence of *Phragmites australis* roots, the roots of *Lythrum salicaria* penetrated further into the gravel layer. Due to the reliance on the humus layer by the biodiversity enhancing species, where they are employed in treatment beds, it is recommended that the 30 mm artificial litter/humus layer is installed to aid establishment when the constructed wetlands are built. Subsequently, the accumulation of leaf litter would self sustain this layer. This will also have an additional beneficial effect, due to the insulating effect this layer can provide during cold spells.

The root dividers provided some beneficial effects for the biodiversity enhancing species as discussed earlier. However, due to the fact that *Phragmites australis* eventually penetrated under the root barriers, were such barriers installed on a full scale bed, it is likely that the beneficial effect would only be a short-term one. Within the full competition microcosms, all of the species survived at sufficient levels to contribute to biodiversity enhancement, and so, the installation of root dividers is not recommended and species should be mixed together and allowed to compete with each other. However, to allow the different species to become established before full competition takes effect, they should be planted in plots each containing several individuals, rather than fully mixed.

The size of the constructed wetland varies dependant parameters employed in the design (Cooper *et al*., 1996; and Kadlec & Wallace 2009). These design parameters can range from the average daily flow and BOD values required under the Kickuth calculation, to the area based upon a population equivalent which the constructed wetland is required to cater for. The large amount of data now gathered from monitoring systems designed using the older methods outlined above, have resulted in more sophisticated design methodologies are being utilised. These take account of the inlet concentrations and the required effluent concentrations, and the hydraulic retention times. These latter are calculated using potential evapotranspiration (ET), natural precipitation input, temperature, the hydraulic efficiency of bed media, the temperature effects of microbial activity and any specific pollutants within the waste liquid being treated, that might require longer treatment times. This study demonstrated that the competition between the different species resulted in greater water usage from the plants. It also identified that where salinity was present, less water was required. If more detailed equations are being utilised in the design a treatment reedbed, including the use of ET and water budgets, then the increased water use of a competitive floral community such as that studied within this research should be taken into account. The lower water requirements for higher salinity concentrations should also be considered if the influent is likely to have any saline input (i.e. runoff from de-iced roads).

4.5.3 Planting Densities and Layout

For this research, the planting densities were increased above the recommended guidelines of Cooper *et al*., (1996). This was to allow for a rapid colonisation of all the available areas within the microcosms, and therefore to reduce the acclimatisation period required before the treatment component could commence. As no adverse effects were observed, the density employed within this study for the biodiversity enhancing species should be utilised when planting these species. It is not recommended that *Lythrum salicaria, Filipendula ulmaria and Mentha aquatica* be planted at lower densities until further research has been undertaken on the effects this would have. In accordance with the methodology utilised for this study, plug plants should be employed until further research supports the use of other sized plants. *Phragmites australis* can be planted as either plug plants or as rhizomes to the densities recommended in Cooper *et al*., (1996).

In surface flow treatment systems, stem filtration comprises part of the treatment process, and since this was not studied, the impact of planting the biodiversity enhancement species is unknown, and hence cannot be considered for this purpose. As a consequence, the use of *Lythrum salicaria, Filipendula ulmaria and Mentha aquatica* can only be recommended for subsurface flow wetlands.

As outlined above it is suggested that the different species are planted in multiple blocks. The number of blocks and their shape would depend upon the design size of the wetland. The blocks could be in the form of strips or as a mosaic formed by either a monoculture of one biodiversity enhancing species or multiple species. To ensure that the roots of *Phragmites australis* can colonise the gravel media areas below the biodiversity enhancing species (and thus maintain the treatment potential of the constructed wetland), the width of the blocks containing the biodiversity enhancing species should be designed so that the *Phragmites australis* roots can extend below these blocks. The rhizomes of *Phragmites australis* have been reported as extending 20 m (Holm *et al*., 1977). It is not recommended that the blocks should be this large due to the time period which it takes to reach this length. Curtis (1959) reports the rhizomes of *Phragmites australis* grow at an equivalent of 40 cm per year. This study did not record the length of each rhizome (due to the fragility of the rhizomes breaking when harvesting the roots in the microcosms), however, roots approaching 3 m in length were noted coiled around the base of the microcosms. This would equate to double the growth rate reported in Curtis (1959). Despite Holm *et al.* (1977) reporting that the rhizomes of *Phragmites australis* extend to 20 m, since this study shows that the rhizomes will reach 3 m in a constructed wetland with a gravel media, the planting blocks should not exceed this width when surrounded by *Phragmites australis,* until further research suggests otherwise.

4.5.4 Operational Management and Maintenance

The biodiversity enhancing species have been chosen to avoid any perceivable extra costs during the operation and maintenance of the constructed treatment wetland, and thus no additional operational or maintenance management principles above those for *Phragmites australis* are being recommended. The operation and future maintenance of the constructed treatment wetland should therefore be undertaken as set out within standard design and operation manuals.

If weeding operations are required, then these should be undertaken to avoid any adverse impacts upon the biodiversity enhancing species. Weeding operations should be undertaken by hand, and not utilise herbicides, which could kill the biodiversity enhancing species.
Harvesting of *Phragmites australis* is utilised in some constructed wetlands for various reasons including to remove nutrients. Based upon the experience of the microcosm studies, where biodiversity enhancing species have been planted, this should be avoided until further research identifies whether or not harvesting operations have an adverse effect.

A free surface water layer was added to the surface to replicate the effect of intermittent “pooling” of effluent upon the different species. The presence of this pooling layer did not have an adverse effect upon the species diversity and, should pooling occur within the subsurface flow wetland, no additional operational or maintenance recommendations are required.

Full Scale Trials

This study was undertaken using small scale microcosms. Logically the next step is the use of full scale trials over a long period to monitor the population dynamics and the effectiveness of the biodiversity enhancing species, and to identify any long term management requirements that may be necessary.

5. FIELD STUDY METHODOLOGY AND EXPERIMENTAL DESIGN

5.1 Introduction

Following on from the controlled microcosm study, a field study was designed and implemented where biodiversity enhancing species were planted within operational reedbed treatment systems which would be subject to the same trials and tribulations to which the treatment flora are exposed on a daily basis.

To determine if operational constructed wetland treatment systems can have their biodiversity increased by the addition of common floral wetland species, a two year microcosm study was devised. The study involved the use of two different scenarios to investigate the sustainability of planting the biodiversity enhancing species.

The first scenario was to investigate the survivability of planting the biodiversity enhancing species within mature reedbeds where the treatment flora were already established. Therefore, the interactions between new plug planting and mature reeds could be assessed within a fully operational reedbed.

The second scenario was to investigate the survivability of the biodiversity enhancing species within newly created/refurbished reedbeds where, as per the microcosm study, the biodiversity enhancing species would have the opportunity to gain a foothold prior to the treatment flora becoming established. In this scenario, the interactions between new plug planting and new reedbed planting could be assessed within a fully operational reedbed.

A suitable site in Staffordshire (Rugeley) was found to test the first scenario and a suitable site was found in Leicestershire (Magna Park, Lutterworth) to test the second scenario. The methodologies for the two different scenarios are discussed separately below.

5.2 Design Overview: Mature Reedbed Treatment System Field Study

5.2.1 Study Site Selection

Two companies originally offered the use of their mature reedbeds for the use in this scenario. These were ARM Ltd, who are the market leader in reedbed design and construction, and Severn Trent Water, who are the main water treatment company for the Midlands.

Positive discussions had commenced with Severn Trent Water to utilise two to three of their sites. Unfortunately, due to staff changes, the champion for the project within the company was lost immediately prior to the start of the study. The replacement manager was un-willing to give any commitment to the study until he became settled and familiar with the new sites he was now responsible for. The resulting delay, beyond the 2015 planting period, led to the Severn Trent Water sites being eliminated from further consideration.

ARM Ltd permitted the use of two of their mature reedbeds located at their headquarters in Rugeley, Staffordshire. The site was located to the northeast of Rugeley, Staffordshire, England at National Grid Reference SK 047 195.Figure 5.1 shows the location of the site within the UK and Figure 5.2 details its location within Rugeley.

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Figure 5.1: Location of Rugeley in United Kingdom

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Figure 5.2: Site Location within Rugeley (Ordnance Survey 2017b)

5.2.2 Reedbed Description

The two constructed wetlands utilised at Rugeley were both subsurface flow reedbeds with *Phragmites australis* as their main treatment species (Figure 5.3). Both were lined with a plastic liner with gravel as the growing media.

The reedbeds treat the sewage effluent from the offices and workshops at Rydal Estate, a business complex where ARM is located. The raw effluent undergoes primary treatment in a septic tank before being held in storage tanks. From the storage tanks it is divided between two different treatment routes.

The first route goes into a forced aeration bed which then feeds Reedbed 1. The second route goes into vertical flow reedbeds before feeding Reedbed 2. The two reedbeds are used to investigate new treatment opportunities by the operators whose business is to design reedbed treatment systems and consequently the reason for the two beds maturing differently was due to the effluent pre-treatment's which the reedbeds had been subject to over the years, resulting in a differing nutrient availability for the reeds.

Figure 5.3: Reedbed 1 (left) Redbed 2 (right)

5.2.3 Study Design and Planting Configuration

The microcosm study identified that the biodiversity enhancing species survived at all the nutrient concentrations employed and that they did not outcompete *Phragmites australis*. When the root structure of *Phragmites australis* was monitored at the end of the experimental period, the roots were observed to go fully under the biodiversity enhancing species, and the latter should therefore not adversely affect the hydraulic flow of the reedbeds or the treatment capacity of the microbial colonies within the subsurface layers.

An initial design recommendation was made following the microcosm study to plant the biodiversity enhancing species in no more than 3 m wide strips, so that the root growth of *Phragmites australis* can grow under the biodiversity enhancing species, as occurred in the microcosm study. Due to the design issues of retrofitting up to 3 m wide strips to existing and refurbished reedbeds, along with matter of acquiring enough sites for replicate plantings, it was decided to use 1 m^2 quadrats.

Following consultations with an academic ecologist (Besenyei, 2015) it was agreed that the experimental design for the two ARM reedbeds would involve planting a four by four grid of 1 m^2 quadrats each comprising a single species within each of the two reedbeds. The shape of a four by four grid would permit each of the four species to be placed in each row and in each position, to would ensure that each was subject to the different environmental parameters occurring; such as exposure to different wind directions and solar radiation as the sun orientates its self through the day and sub-surface flow variations. *Lythrum salicaria, Filipendula ulmaria* and *Mentha aquatica* were to be planted in 12 of the quadrats. The remaining four quadrats were to be used as controls where the mature *Phragmites australis* would be monitored. The four repetitions per reedbed (eight repetitions in total if the results for both reedbeds are combined) would permit the use of a variety of statistics including ANOVA and t test (see Section 5.4) to analyse the significance of the results.

However, due to the small size of the reedbeds and the uncertain impact this arrangement could have had on the treatment efficiency of the operational reedbeds and their discharge consent criteria, ARC only gave permission for six 1 m^2 quadrats to be planted per reedbed in a two by three grid. This reduction in the number of quadrats affected the number of possible replicates and hence limited any statistical analysis of the results.

With only six planted quadrats being installed per reedbed, the decision was taken not to plant one of the biodiversity enhancing species. The decision to sacrifice one of the biodiversity enhancing species would increase the number of replicates undertaken and avoid the pseudo-replication of the microcosm study. This left three quadrats per planted species per bed ($n = 2$) or six quadrats per planted species if both reedbeds were combined ($n = 5$). The issue of a small sample size, where n < 5, is discussed in by Vaux in Nature (2012) and by de Winter (2013), and confirmed that if the Rugeley reedbeds were to be analysed separately, then the students t test would be an appropriate statistic as long as the observed effects were large and where too much data is present to visualise.

Considering the microcosm study, it was found that *Mentha aquatica* was a robust species, since it was able to quickly colonise new openings in the reedbed due to its stoloniferous nature. In contrast, over the course of the first two years of the microcosm study, *Lythrum salicaria* and *Filipendula ulmaria* were more sessile, remaining in the locations where they were originally planted and not showing any significant signs of expanding their range until the third year when the seeds previously set started to germinate. Due to the short term (two year) duration of the field study, it was decided to compare the two species which had presented a more sessile existence in the microcosm study and consequently *Mentha aquatica* was omitted from the mature reedbed trials.

To avoid bias, the positioning of the two biodiversity enhancing species within the two by three grid was selected using a random number generator (Fowler *et al*., 1999; Wildi, 2010) with their resulting locations shown on Figure 5.4.

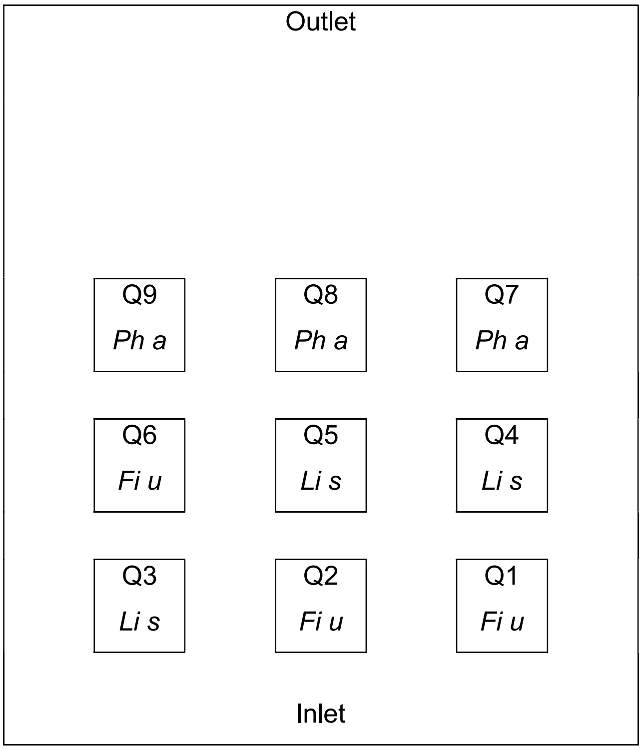
Since the permitted two by three grid (where reed cutting was accepted to enable planting) did not allow for any random control. In an effort to overcome this, quadrats of *Phragmites australis,* were marked out to the rear of the plantings, where, the undisturbed *Phragmites australis* would be monitored Figure 5.4.

Between each of the quadrats and along the edge of the reedbed a 1 m buffer strip was left where the existing mature vegetation within the reedbed remained intact. This was to enable competition with the newly planted species, see Figure 5.4.

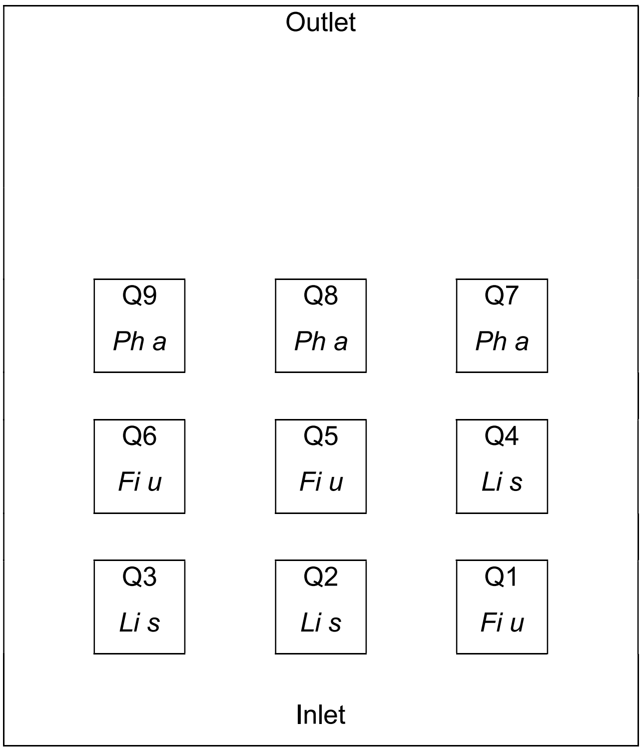
In April 2015 whilst awaiting delivery of the plug plants, the *Phragmites australis* within the mature reedbeds was harvested to ground level and any loose leaf litter removed leaving the already decayed humus layer in situ. This was undertaken as warblers and harvest mice are known to nest within the reedbeds each year and the reeds were harvested to prevent any wildlife nesting within the locations required for the quadrats, thus maintaining the design of the study. The wildlife were able to nest undisturbed within the remainder of the reedbed.

During the microcosm study, a total of four 90 mm pots per species (16 pots in total) was planted within each microcosm. Each of the four species were allocated to 1378 cm^2 growing area within the microcosm which equated to a planting density of 29 pots per m^2. A total of 16 plug plants for each species were planted within each quadrat during the field study, as illustrated on Figure 5.5. The reduced number of plants per m^2 and the reduction in size from 90 mm pots to plug plants was used to assess if a lower planting density (when compared to the microcosm study) would still make planting the biodiversity enhancing species viable. Cooper *et al*., (1996) recommend planting four plugs of *Phragmites australis* per m^2. However, a higher planting density was still used in the field study to help achieve a fully vegetated quadrat as quickly as possible, and thus shorten the time before competition interactions between the species would occur. All plants were of native provenance.

The flora within these quadrats were planted during the first week in June 2015. This accords with the preferred planting time in Western Europe of between May and August, as recommended by Cooper *et al*., (1996) for wetland treatment systems.



Reedbed 1
(nearest to the storage area)



Reedbed 2
(nearest to the non-operational reedbed)

Figure 5.4: Layout of Mature Study Reedbeds at Rugeley

Figure 5.5: Planting Configuration of a Magna Park Quadrat

5.3 Design Overview: Newly Created/Refurbished Reedbed Treatment System Field Study

5.3.1 Study Site Selection

IDI Gazeley permitted the use of their recently restored reedbeds located within their Magna Park distribution centre in Lutterworth, Leicestershire. The site was located to the west of Lutterworth, Leicestershire, England at National Grid Reference SP 506 850. Figure 5.6 shows the location of the site within the UK and Figure 5.7 details the location of the site within Lutterworth.

Figure 5.6: Location of Lutterworth within United Kingdom

Figure 5.7: Site Location at Lutterworth (Ordnance Survey 2017c)

5.3.2 Reedbed Description

The reedbed treatment system (Figure 5.8 & Figure 5.9) at Magna Park is fed by a series of Rotating Biological Contactors (RBCs'), which are used as the main treatment process for the sewage effluent from Magna Park. The effluent from the RBCs' is distributed via a single pipe which then splits to feed all of the reedbeds with the same effluent. The effluent from the reedbeds then flows into the adjacent lake, which in turn outflows into a local brook.

The treatment system was designed and constructed approximately 26 years ago, prior to the main design manuals for reedbed treatment systems first being published. In the interim, the RBCs' have had operational issues which resulted in the reedbeds being overloaded, clogged and malfunctioning (Beard, 2015). In addition, the original beds were shaded by trees and adjacent vegetation, which resulted in poor growth, with areas of the reedbeds becoming devoid of vegetation where the shading occurred.

During winter 2014/2015, the trees and scrub which shaded the reedbeds were cut back and half of the reedbeds, those on the west side of the lake, were refurbished to their original design, including replacement of the old gravel with new. The reedbeds on the east side were non operational at the start of the field study (Figure 5.10), but following a second phase of refurbishment, became operational part way through the field study in winter 2015/2016.

Originally the reedbeds were lined with clay, and this remained in situ during the refurbishment. The original gravel size was small (circa 3-6 mm) and angular, which did not permit large voids between the different pieces of gravel and consequently the permeability and hydraulic flow was limited with the small voids easily blocked and the beds becoming clogged. To increase the permeability and thus hydraulic flow, the new bed material installed was larger 10 - 16 mm washed round gravel.

Figure 5.8: Refurbished reedbeds west side (far bank) with the outlet weir from the lake (foreground).

Figure 5.9: Inlets for reedbeds fed along the top of higher ridges in the centre of the plate.

5.3.3 Study Design and Planting Configuration

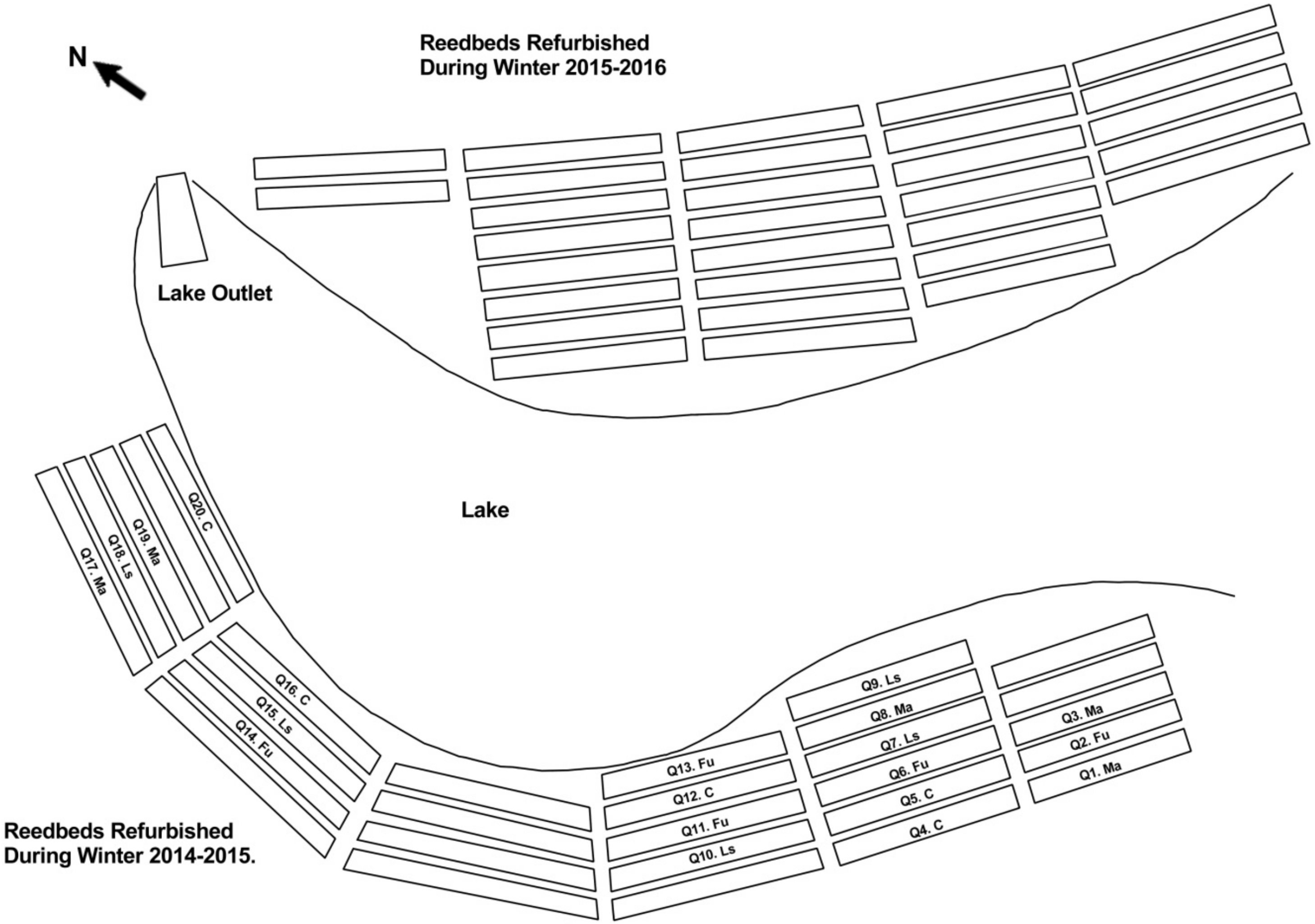
The design of the refurbished reedbeds presented a good opportunity for replicates to be included in the field study. Each of the reedbeds consists of a treatment channel separated from the adjacent channel by a soil strip (Figure 5.9). The channels were 3 m wide by approximately 16 m long. The reedbeds refurbished during the winter of 20014/2015 contained 29 channels in total.

For the field study design at Magna park, as with the Rugeley site, the wildlife enhancing species were planted in 1 m^2 quadrats, with one quadrat per channel. The quadrats were placed 1 m back from the inlet and in the centre of the channel so that the plot was surrounded by the primary treatment species. Again, as with the Rugeley site and for the same reasons, each quadrat was planted with 16 plug plants of a single species.

It was proposed to carry out five replicates of each of the biodiversity enhancing species (*Lythrum salicaria, Filipendula ulmaria* and *Mentha aquatica*). This resulted in 15 plots (one per channel) totalling 15 m^2, which is approximately 1 % of the total treatment area of the refurbished channels (≈ 1392 m^2). With the reedbeds being newly refurbished, in accordance with the design for the microcosm study, and for the same reasons, a 30 mm deep layer of compost was added to the treatment plot to simulate a humus layer. This 30 mm artificial humus layer was also a recommendation outcome from the microcosm study where, in the presence of *Phragmites australis*, it was found that the biodiversity enhancing species had a reliance on this layer. This was particularly so for *Lythrum salicaria,* which was shown to be adversely affected within the gravel root zone by the presence of *Phragmites australis roots* in what appeared to be allelopathy.

In addition to the planted biodiversity enhancing species, five quadrats were installed where no additional species were planted for use as controls.

During the reconnaissance visit to the site it was noted that some of the reedbeds appeared to be uneven and suffering from hydraulic flow issues, and these reedbeds were eliminated from the study. The remaining reedbeds, which were flooded to just below the surface of the media, were selected for use in the study. As with Rugeley, the species planted in each quadrat within the reedbeds was randomly chosen using a random number generator. The locations of the quadrats and the species planted can be found illustrated on Figure 5.10.



Note: Q = Quadrat Number, C = Control, Ls = *Lythrum salicaria*, Fu = *Filipendula ulmaria*, Ma = *Mentha aquatica*.

Figure 5.10: Layout of Newly Created/Refurbished Study Reedbeds at Magna Park

5.4 Vegetation Measurements

In order to monitor the community dynamics the following common measurements were taken on a monthly basis,

- height of each species (Howard 2010);
  - maximum height;
  - general height;
- area coverage of each species (Baldwin 2013). The calculation of area coverage was facilitated through the use of a quadrant divided into area grids. These parameters were measured for both;
  - within the microcosm; and,
  - outside of the microcosm (where the foliage went beyond the width of the microcosm). This was only undertaken for the biodiversity enhancing species planted as to measure the coverage for all species outside of the microcosm would be unfeasible. It would also cause an anthropogenic effect on the reedbed through damaging the plants (which in turn could reduce their vigour and open up new spaces for other species to grow) which are potentially competing with the biodiversity enhancing species;

5.5 Statistical Analysis

To investigate Hypothesis 9 *"Where the chosen floral species survive, there will be no difference between retro-planting these species within a mature reedbed, compared to planting these species within a newly created/restored reedbed and no single floral species will take over and oust other floral species."* The following statistical analysis was planned and undertaken using the PAWS Statistics 18 software (IBM, 2014).

The proposed statistics included using an Analysis of Variance (ANOVA) test (Fowler *et al*., 1999; Pallant, 2010) as more than two samples would have been investigated: i.e. the newly refurbished reedbed at Magna Park and the two separate reedbeds at Rugeley. If the data obtained was found to be skewed, to allow for parametric analysis to be undertaken (i.e. ANOVA), the data would be transformed into a normal distribution using a logarithmic transformation of 10 (Fowler *et al*., 1999; Pallant, 2010).

It was also proposed to merge the data from the reedbeds at Rugeley to form two samples to enable operations such as comparing the *Lythrum salicaria* in a mature bed against the same species within a newly refurbished bed. Where two samples were being analysed, an independent samples *t* test would be undertaken (Fowler *et al*., 1999; Pallant, 2010; Wildi, 2010). In unison with the independent samples *t* test, the Levene's tests for equality of variances would be used to confirm that the data did not violate the assumption of equal variances, and the effect of size would be calculated using Cohan's d ETA squared. (Cohen 1988; Pallant, 2010). The chosen thresholds for the statistical analysis to be statistically significant along with the values for Cohan's d ETA squared can be found within the statistical methods section of the microcosm study.

Unfortunately, multiple operational issues occurred at both sites, which were all outside the control of the research project, and consequently no sensible statistical analysis was possible. These issues are discussed in the next section of the thesis, but to put the lack of data for analysis into context they are briefly summarised here.

The winter storms, flooding, hydraulic blockages and a change in the operation of the two reedbeds at Rugeley had a detrimental impact upon the biodiversity enhancing species. At Magna Park the operational issues began with the contractors planting the wrong treatment species; the level changes within the reedbed affected hydraulic flow patterns resulting in periods of drought for the wetland plants; and, the restoration of the remaining reedbeds required the effluent to be diverted away from the study beds to enable vegetation establishment in the new beds, further contributing to the drought issues experienced within the study beds.

Section 6 discusses the results and observations that were obtained from the two field studies whose design is described in this section. As explained the various external natural and anthropogenic impacts on the two study sites has had the effect that no sensible statistical analysis is possible, and therefore, the evaluation in Section 6 is predominantly qualitative.

6. RESULTS

Section 5 described the field experiments designed to explore the planting the biodiversity enhancing species, within the mature reedbeds and the newly restored reedbeds, and the differences between them. This section presents the results obtained from the data collected during the two year experimental period and also includes a discussion on the findings.

6.1 Constraints Encountered During the Operational Phase

Unfortunately, multiple operational issues occurred at both sites, which were outside the control of and impacted on this study and these issues are discussed below.

6.1.1 Rugeley

During the first year (2015) of the field study at Rugeley, the biodiversity enhancing species planted within both reedbeds survived, and within some of the quadrats in Reedbed 2 *Lythrum salicaria* flowered and set seed. However, the winter storms during 2015/2016 had a detrimental effect on the biodiversity enhancing species within both of the reedbeds, but for different reasons.

Reedbed 1

During the winter storms a large proportion of the standing dead plant material from the 2015 *Phragmites australis* growth was blown over. During the same period the bed became blocked, resulting in standing water above the surface of the bed. These two factors combined to form a wet mulch akin to papier mâché, which formed a blanket on the surface of the bed. This mulch was left in-situ and not removed or harvested, as is a common practice on reedbed treatment systems, and the biodiversity enhancing species were monitored to determine how they would perform under these conditions. The operators of the reedbed undertook gentle forking to alleviate the flooding issue. During the monthly monitoring visits from February to April, the mulch within the quadrats was gently moved to the side (only for one quadrat per species to avoid increasing the level of anthropogenic affect) to see if any growth was visible. The plants remained in their dormant stage with the culms of *Filipendula ulmaria* showing green bulging, indicating that is was still alive. Unfortunately, it became apparent during the May and June visits that the plants were unable to compete with the smothering effect of the mulch and 100% fatalities occurred.

Reedbed 2

Reedbed 2 was subject to the similar fall of standing dead plant material and flooding which the winter storms brought. As with Reedbed 1, the bed was gently forked to alleviate the flooding, but it became apparent that this bed had significant hydrological issues. During 2016 this bed ceased to be used as a daily operational treatment bed. The bed was only periodically provided with effluent to keep the reeds alive for their biodiversity enhancing value, as they provided nesting locations for warblers and harvest mice *Micromys minutus*. The reduced effluent supply did not appear to cause significant fatalities to the plants directly, however the dry nature of this bed permitted the frequent use by field voles *Microtus agrestis*. These voles regularly grazed on the biodiversity enhancing species, usually grazing them back to the ground which clearly had an adverse effect on the area coverage / heights of the vegetation. In 2015, when the beds were fully operational and constantly fed effluent this grazing effect was not noticeable.

The impact of the grazing was so severe that no sensible measurements could be obtained, thus no statistical analysis could be undertaken to enable hypothesis 9 to be proven or disproved.

6.1.2 Magna Park

At Magna Park the operational issues began when the wrong treatment species were planted in the wrong place during its refurbishment. Unfortunately, when the vegetation was planted in 2015, they were small plugs/dormant and it was not noticeable that this error had been made when the biodiversity enhancing species were planted in the beds. This was only noticed once the vegetation had been growing for two months and the identifying features became apparent. At this point it was too late to change the study site, or to retrofit *Phragmites australis,* as the available study duration would not permit sufficient time for adequate competition to occur between *Phragmites australis* and the biodiversity enhancing species.

Rather than the majority of the plants being *Phragmites australis* another wetland species *Phalaris arundinacea* had been used. Although both species were due to be planted, since they can both be used in constructed wetland systems, the *Phalaris arundinacea* was located where the *Phragmites australis* should have been. This error is believed to have occurred due to a misinterpretation of the job specification, since both plant names can be abbreviated to Ph a. The combined effects of restoring these treatment beds and the cleaning out the Rotating Biological Contactors, resulted in the discharge consent levels for the site being achieved. Since this was the case, and the remaining reedbeds were due for refurbishment during Winter 2016, the operators of the site concluded that, from a treatment perspective, the planting error did not require rectifying. In addition to the *Phragmites australis* and *Phalaris arundinacea*, pockets of other aquatic species were planted which included *Carex* sp., *Iris pseudacorus, Juncus* sp., *Schoenoplectus lacustris and Typha latifolia.*

At the same time that this error was discovered, it was becoming evident that the beds were suffering from hydraulic flow issues, and vegetation within parts of the beds were found to be showing signs of drought stress. When these areas were investigated further, the water level was found to be below that of the root zone for the young plants. It was also apparent that the restored beds were not level which resulted in some of them being flooded at the inlet end, whilst the water level was below the root zone of the plants at the other.

During discussions with the operator, it was acknowledged that they were having issues fine tuning the water levels and effluent input of these beds, and consequently were having to regularly adjust the outlet controls of the different beds in order to try and keep the plants alive. These manipulations in water level management resulted in some of the biodiversity enhancing species in the quadrats showing signs of drought one month and then flooding (with a visible water level on or just below the surface) the next.

The water level and drought issue was compounded during 2016 after the remaining reedbeds were refurbished and the main effluent flow was diverted to feed and maintain them. This resulting reduction in flow to the reedbeds used in this study amplified the drought issues which had already been experienced.

The effects of the drought and the change in the main treatment species from *Phragmites australis* to *Phalaris arundinacea* effectively sabotaged the experiment which had been designed to study the biodiversity enhancing species within newly created/refurbished reedbeds. Therefore, as with the Rugeley site no sensible data was available to test hypothesis 9.

6.2 Rugeley

Since operational and external factors described above meant that no sensible data were available for statistical analysis, the following discussions in both this section and in Section 6.3 are predominantly qualitative.

6.2.1 Reedbed 1

The vegetation heights and area coverage data for the flora within the quadrats within Reedbed 1 can be found in Table 6.1 and the experimental configuration in Figure 5.4.

Lythrum salicaria

Lythrum salicaria struggled within Reedbed 1 with the area coverage declining and fatalities occurring within the first year. Where the plants reached any height (maximum height recorded of 754 mm in August 2015), the stems stayed thin as they struggled to compete for light against *Phragmites australis*. The *Phragmites australis*, which surrounded the quadrat extended its leaves to take advantage of the light provided by the open space created when it was originally harvested from the quadrat to enable *Lythrum salicaria* to be planted. Towards the end of the 2015 growing season, the spread of the *Phragmites australis* leaves had created a canopy over the *Lythrum salicaria*, and only dappled light reached the ground.

The *Lythrum salicaria* did not flower or set seed within the first year, and experienced 100% fatalities in the second.

Filipendula ulmaria

From the results provided in Table 6.1, it can be seen that during 2015 *Filipendula ulmaria* was recorded surviving until the end of the growing season after starting to senesce during September/October. It did not expand its range within the quadrats, nor did it colonise new areas outside of the quadrants. The heights generally remained low with the average ranging from 268 mm to 358 mm during September. As with the *Lythrum salicaria* quadrats, the surrounding *Phragmites australis* formed a canopy over the quadrats allowing only dappled light to reach the floor. The *Filipendula ulmaria* also did not flower or set seed during the first year.

Also, as discussed in the constraints section the *Filipendula ulmaria,* although the culms were green in the spring after the winter storms, it suffered 100 % fatalities during 2016. The majority of these occurred at the beginning of 2016, as the plants failed to regrow after the winter period. Within Quadrat 3, it was observed that two individuals started to grow at the start of the year, but their growth was weak and they had died by July.

Phragmites australis

During September 2015 the *Phragmites australis,* which were being monitored in the three quadrats behind the biodiversity enhancing species (see Table 6.1), all showed signs of good growth, achieving 100 % coverage and reaching heights of between 2434 mm and 2552 mm. These stems flowered and set seed. The good growth continued throughout 2016.

Quadrat	Species	Value (Cover = %, Height = mm)		2015					2016									
				August	September	October	November	December	January	February	March	April	May	June	July	August	September	October
1	*Phragmites australis*	% Cover	Inside Quadrat	6	94	97	0	0	0	0	0	0	6	6	93	100	100	97
		Height	Maximum	1953	2431	2280	0	0	0	0	0	0	993	2413	2570	2649	2560	2305
			General	1582	1674	1592	0	0	0	0	0	0	961	2150	2483	2558	2414	2163
	Filipendula ulmaria	% Cover	Inside Quadrat	20	22	9	0	0	0	0	0	0	0	0	0	0	0	0
			Outside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Combined	20	22	9	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	209	319	158	0	0	0	0	0	0	0	0	0	0	0	0
			General	168	268	121	0	0	0	0	0	0	0	0	0	0	0	0
2	*Phragmites australis*	% Cover	Inside Quadrat	8	86	97	0	0	0	0	0	0	10	11	92	100	100	96
		Height	Maximum	1963	2465	2285	0	0	0	0	0	0	974	2383	2534	2624	2572	2498
			General	1702	1891	1790	0	0	0	0	0	0	898	2231	2496	2594	2493	2372
	Filipendula ulmaria	% Cover	Inside Quadrat	18	23	7	0	0	0	0	0	0	0	0	0	0	0	0
			Outside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Combined	18	23	7	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	238	378	143	0	0	0	0	0	0	0	0	0	0	0	0
			General	181	296	124	0	0	0	0	0	0	0	0	0	0	0	0
	Urtica dioica	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	189	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	0	164	0	0	0	0
	Galium aparine	% Cover	Inside Quadrat	6	6	0	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	480	980	0	0	0	0	0	0	0	0	0	0	0	0	0
			General	480	980	0	0	0	0	0	0	0	0	0	0	0	0	0
	Epilobium hirsutum	% Cover	Inside Quadrat	13	11	0	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	132	263	0	0	0	0	0	0	0	0	0	0	0	0	0
			General	121	154	0	0	0	0	0	0	0	0	0	0	0	0	0
3	*Phragmites australis*	% Cover	Inside Quadrat	21	94	97	0	0	0	0	0	0	13	13	89	100	100	99
		Height	Maximum	1943	2596	2477	0	0	0	0	0	0	979	2285	2619	2657	2614	2508
			General	1845	2331	2140	0	0	0	0	0	0	935	2147	2568	2556	2597	2470
	Lythrum salicaria	% Cover	Inside Quadrat	34	8	3	0	0	0	0	0	0	3	3	0	0	0	0
			Outside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Combined	34	8	3	0	0	0	0	0	0	3	3	0	0	0	0
		Height	Maximum	643	732	612	0	0	0	0	0	0	97	211	0	0	0	0
			General	391	501	430	0	0	0	0	0	0	71	146	0	0	0	0
	Urtica dioica	% Cover	Inside Quadrat	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	0	336	1027	0	0	0	0	0	0	0	0	0	0	0	0
			General	0	336	1027	0	0	0	0	0	0	0	0	0	0	0	0
	Galium aparine	% Cover	Inside Quadrat	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	902	1043	0	0	0	0	0	0	0	0	0	0	0	0	0
			General	902	1043	0	0	0	0	0	0	0	0	0	0	0	0	0
	Epilobium hirsutum	% Cover	Inside Quadrat	11	4	0	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	131	305	0	0	0	0	0	0	0	0	0	0	0	0	0
			General	112	281	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cardamine flexuosa	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0.5	0.5	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	38	164	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	38	164	0	0	0	0
4	*Phragmites australis*	% Cover	Inside Quadrat	48	92	97	0	0	0	0	0	0	6	7	91	100	100	100
		Height	Maximum	2243	2499	2218	0	0	0	0	0	0	1035	2255	2540	2604	2580	2439
			General	1741	2385	1930	0	0	0	0	0	0	880	1881	2436	2517	2482	2357
	Lythrum salicaria	% Cover	Inside Quadrat	24	2	0	0	0	0	0	0	0	0	0	0	0	0	0
			Outside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Combined	24	2	0	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	726	408	0	0	0	0	0	0	0	0	0	0	0	0	0
			General	548	408	0	0	0	0	0	0	0	0	0	0	0	0	0
	Epilobium hirsutum	% Cover	Inside Quadrat	8	2	0	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	124	307	0	0	0	0	0	0	0	0	0	0	0	0	0
			General	115	307	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lemna minor	% Cover	Inside Quadrat	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
			General	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
5	*Phragmites australis*	% Cover	Inside Quadrat	32	96	97	0	0	0	0	0	0	12	14	99	100	100	100
		Height	Maximum	1912	2597	2572	0	0	0	0	0	0	959	2360	2597	2627	2614	2543
			General	1706	2376	2265	0	0	0	0	0	0	866	2191	2519	2580	2490	2401
	Lythrum salicaria	% Cover	Inside Quadrat	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Outside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Combined	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	754	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			General	398	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Epilobium hirsutum	% Cover	Inside Quadrat	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	141	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			General	113	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 6.1 (Continues): Vegetation Heights and Areas during the Study Period For Reedbed 1.

Quadrat	Species	Value (Cover = %, Height = mm)		2015					2016									
				August	September	October	November	December	January	February	March	April	May	June	July	August	September	October
6	*Phragmites australis*	% Cover	Inside Quadrat	45	82	97	0	0	0	0	0	0	11	13	99	100	100	99
		Height	Maximum	2304	2628	2618	0	0	0	0	0	0	1051	2325	2533	2673	2523	2436
			General	1809	2550	2480	0	0	0	0	0	0	888	2229	2453	2524	2451	2396
	Filipendula ulmaria	% Cover	Inside Quadrat	12	14	11	0	0	0	0	0	0	0	0	0	0	0	0
			Outside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Combined	12	14	11	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	321	468	284	0	0	0	0	0	0	0	0	0	0	0	0
			General	282	358	145	0	0	0	0	0	0	0	0	0	0	0	0
	Epilobium hirsutum	% Cover	Inside Quadrat	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	130	462	0	0	0	0	0	0	0	0	0	0	0	0	0
			General	109	462	0	0	0	0	0	0	0	0	0	0	0	0	0
	Lemna minor	% Cover	Inside Quadrat	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			General	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	*Phragmites australis*	% Cover	Inside Quadrat	100	100	100	0	0	0	0	0	0	60	64	100	100	100	100
		Height	Maximum	2355	2591	2230	0	0	0	0	0	0	996	2367	2596	2643	2598	2456
			General	2238	2474	2120	0	0	0	0	0	0	953	2142	2490	2554	2457	2377
8	*Phragmites australis*	% Cover	Inside Quadrat	100	100	100	0	0	0	0	0	0	38	39	97	100	100	100
		Height	Maximum	2398	2542	2310	0	0	0	0	0	0	1038	2434	2601	2652	2581	2447
			General	2237	2434	1940	0	0	0	0	0	0	872	2296	2518	2527	2482	2373
9	*Phragmites australis*	% Cover	Inside Quadrat	98	100	100	0	0	0	0	0	0	38	38	96	100	100	100
		Height	Maximum	2448	2687	2597	0	0	0	0	0	0	1005	2348	2606	2619	2549	2463
			General	2249	2552	2260	0	0	0	0	0	0	917	2185	2465	2497	2441	2385
	Urtica dioica	% Cover	Inside Quadrat	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	592	875	0	0	0	0	0	0	0	0	0	0	0	0	0
			General	592	875	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 6.1 (Continued): Vegetation Heights and Areas during the Study Period For Reedbed 1.

6.2.2 Reedbed 2

The vegetation heights and area coverage for the flora within the quadrats within Reedbed 2 can be found in Table 6.2, and the experimental layout in Figure 5.4.

The *Phragmites australis* within Reedbed 2 appeared to be less dense both in stem density and leaf coverage than Reedbed 1 during the growing season. The number of stems and stem density during the study period could not be counted or harvested without potentially influencing the competition rate between the *Phragmites australis* and the biodiversity enhancing species. As with Reedbed 1, the *Phragmites australis* formed a canopy over the quadrats by the end of the first year. Dappled light reached ground level within each quadrat, however this visually appeared to be lighter than Reedbed 1 as the canopy formed by the reeds appeared to be less dense/leafy than Reedbed 1.

<u>*Lythrum salicaria*</u>

During the first year *Lythrum salicaria* showed good levels of growth, expanding its range within the quadrat and also starting to spread its leaves out beyond the quadrat. The heights were taller than Reedbed 1 growing to a maximum height of 1272 mm in the first year compared to 754 mm in Reedbed 1. This species flowered and set seed in the first year.

During 2016 healthy growth began to occur, however the dry nature of the ground (caused by the bed now being non-operational on a daily basis) had allowed herbivores, namely field vole free access. It was observed that the field voles targeted the new growth shoots of the *Lythrum salicaria,* which resulted in the area coverage being less than that recorded in 2015. However, where shoots managed to gain height and then turn woody in nature (which the field voles did not noticeably appear to browse), these reached a maximum height of 1820 mm. The surrounding *Phragmites australis* stems did not show any signs of grazing by field vole. *Lythrum salicaria* managed to flower and set seed in all of the quadrats during the second year.

<u>*Filipendula ulmaria*</u>

As occurred with *Lythrum salicaria,* during the first year *Filipendula ulmaria* showed good levels of growth, expanding its range within the quadrat and also starting to spread its leaves beyond the quadrat.

During 2016 healthy growth began to occur, however, as with *Lythrum salicaria* the field voles targeted the shoots of the *Filipendula ulmaria* causing the overall area coverage to be less than that observed in 2015. This species does not turn woody like *Lythrum salicaria* and consequently was a permanent target of grazing by the field voles. *Filipendula ulmaria* was observed to send up flowering shoots, however these were grazed following which *Filipendula ulmaria* again sent up shoots yet to be grazed again and no seeds were set.

Phragmites australis

The *Phragmites australis* in the three quadrats being monitored all showed signs of good growth during the first year, though as noted above, the coverage was not 100%, but thinner than in Reedbed 1, permitting more light to penetrate to the ground. The general stem heights reached between 2395 mm and 2497 mm during September 2015, which was within the same range as Reedbed 1, and they also flowered and set seed.

During 2016 *Phragmites australis* was also impacted by the cessation of daily operational activities. These reeds were smaller and appeared to have thinner leaf coverage. During September 2016, the recorded general heights ranged between 1887 mm to 1934 mm, approximately half a meter smaller than the year before during the same month. During August and September 2016, the *Phragmites australis* exhibited signs of nutrient stress in the form of chlorosis (Cooper *et al*., 1996) resulting in the reeds senescing earlier than in Reedbed 1, as can be seen in Figure 6.1 and Figure 6.2.

Figure 6.1: Reedbed 1 (left), Reedbed 2 (right), September 2016

Figure 6.2: Reedbed 1 (left), Reedbed 2 (right), October 2016

Quadrat	Species	Value (Cover = %, Height = mm)		2015					2016									
				August	September	October	November	December	January	February	March	April	May	June	July	August	September	October
1	*Phragmites australis*	% Cover	Inside Quadrat	2	87	97	0	0	0	0	0	0	2	2	97	97	34	97
		Height	Maximum	1530	2486	2382	0	0	0	0	0	0	858	1750	2306	2499	2640	2597
			General	1511	2291	2210	0	0	0	0	0	0	664	1688	1813	1955	2214	2176
	Filipendula ulmaria	% Cover	Inside Quadrat	23	73	72	0	0	0	0	0	0	5	5	7	8	2	0.5
			Outside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Combined	23	73	72	0	0	0	0	0	0	5	5	7	8	2	0.5
		Height	Maximum	331	399	382	0	0	0	0	0	0	183	230	194	143	84	47
			General	228	261	97	0	0	0	0	0	0	49	65	76	108	67	42
	Epilobium hirsutum	% Cover	Inside Quadrat	6	2	0	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	142	242	0	0	0	0	0	0	0	0	0	0	0	0	0
			General	122	197	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cardamine flexuosa	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	72	135	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	39	135	0	0	0	0
2	*Phragmites australis*	% Cover	Inside Quadrat	75	97	97	0	0	0	0	0	0	7	8	97	97	97	97
		Height	Maximum	1862	2386	2329	0	0	0	0	0	0	815	1723	2446	2519	2402	1430
			General	1630	2259	1940	0	0	0	0	0	0	761	1462	2081	2118	2046	1382
	Lythrum salicaria	% Cover	Inside Quadrat	32	34	9	0	0	0	0	0	0	5	7	9	9	5	1
			Outside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Combined	32	34	9	0	0	0	0	0	0	5	7	9	9	5	1
		Height	Maximum	498	591	483	0	0	0	0	0	0	63	470	715	813	841	835
			General	221	377	360	0	0	0	0	0	0	46	374	508	557	647	835
	Epilobium hirsutum	% Cover	Inside Quadrat	5	1	0	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	141	237	0	0	0	0	0	0	0	0	0	0	0	0	0
			General	120	194	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cardamine flexuosa	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	3	2	1	1	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	93	198	181	53	0	0
			General	0	0	0	0	0	0	0	0	0	69	173	156	53	0	0
3	*Phragmites australis*	% Cover	Inside Quadrat	18	97	97	0	0	0	0	0	0	12	13	97	97	97	97
		Height	Maximum	1762	2160	2125	0	0	0	0	0	0	825	1720	2327	2476	2316	2191
			General	1361	1954	1855	0	0	0	0	0	0	768	1642	1886	2072	2113	2017
	Lythrum salicaria	% Cover	Inside Quadrat	64	58	53	0	0	0	0	0	0	9	14	17	18	19	6
			Outside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0
			Combined	64	58	53	0	0	0	0	0	0	9	14	17	21	19	6
		Height	Maximum	451	670	647	0	0	0	0	0	0	94	451	728	823	1011	952
			General	366	386	329	0	0	0	0	0	0	75	379	618	792	676	635
	Epilobium hirsutum	% Cover	Inside Quadrat	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	138	248	0	0	0	0	0	0	0	0	0	0	0	0	0
			General	119	159	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cardamine flexuosa	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0		7		0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	119	245	214	0	0	0
			General	0	0	0	0	0	0	0	0	0	97	181	129	0	0	0
4	*Phragmites australis*	% Cover	Inside Quadrat	5	89	80	0	0	0	0	0	0	2	2	91	97	30	46
		Height	Maximum	1252	2366	2182	0	0	0	0	0	0	722	1512	2272	2315	2555	2163
			General	772	1957	1768	0	0	0	0	0	0	643	1407	1898	2018	2242	2003
	Lythrum salicaria	% Cover	Inside Quadrat	65	63	87	0	0	0	0	0	0	10	11	18	18	55	32
			Outside Quadrat	0	2	3	0	0	0	0	0	0	0	0	2	3	8	11
			Combined	65	65	90	0	0	0	0	0	0	10	11	20	21	63	43
		Height	Maximum	573	1272	1114	0	0	0	0	0	0	157	465	1632	1690	1785	1820
			General	408	829	792	0	0	0	0	0	0	149	342	947	1163	906	1320
	Epilobium hirsutum	% Cover	Inside Quadrat	11	7	1	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	140	236	214	0	0	0	0	0	0	0	0	0	0	0	0
			General	122	197	214	0	0	0	0	0	0	0	0	0	0	0	0
	Cardamine flexuosa	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	78	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	0	78	0	0	0	0
5	*Phragmites australis*	% Cover	Inside Quadrat	8	92	97	0	0	0	0	0	0	5	5	94	97	56	27
		Height	Maximum	1782	2251	2100	0	0	0	0	0	0	878	1478	2441	2467	2388	2251
			General	1531	2058	1997	0	0	0	0	0	0	715	1600	2041	2139	2154	2075
	Filipendula ulmaria	% Cover	Inside Quadrat	80	87	86	0	0	0	0	0	0	3	3	3	4	2	0
			Outside Quadrat	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
			Combined	80	87	87	0	0	0	0	0	0	3	3	3	4	2	0
		Height	Maximum	349	530	486	0	0	0	0	0	0	72	193	288	297	65	0
			General	245	332	290	0	0	0	0	0	0	68	123	165	166	40	0
	Epilobium hirsutum	% Cover	Inside Quadrat	6	1	0	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	137	197	0	0	0	0	0	0	0	0	0	0	0	0	0
			General	116	197	0	0	0	0	0	0	0	0	0	0	0	0	0
	Cardamine flexuosa	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	184	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	0	184	0	0	0	0

Table 6.2 (Continues): Vegetation Heights and Areas during the Study Period For Reedbed 2.

Quadrat	Species	Value (Cover = %, Height = mm)		2015 August	2015 September	2015 October	2015 November	2015 December	2016 January	2016 February	2016 March	2016 April	2016 May	2016 June	2016 July	2016 August	2016 September	2016 October
6	*Phragmites australis*	% Cover	Inside Quadrat	3	82	60	0	0	0	0	0	0	2	2	984	97	16	9
		Height	Maximum	976	1991	1602	0	0	0	0	0	0	784	1528	2252	2325	2344	1783
			General	900	1894	1486	0	0	0	0	0	0	709	1162	1610	1838	2135	1650
	Filipendula ulmaria	% Cover	Inside Quadrat	32	74	82	0	0	0	0	0	0	5	5	8	10	8	5
			Outside Quadrat	0	1	2	0	0	0	0	0	0	0	0	1	2	0	0
			Combined	32	75	84	0	0	0	0	0	0	5	5	9	12	8	5
		Height	Maximum	301	319	286	0	0	0	0	0	0	152	494	932	942	379	173
			General	180	250	90	0	0	0	0	0	0	143	155	369	384	121	64
	Urtica dioica	% Cover	Inside Quadrat	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	0	162	403	0	0	0	0	0	0	0	0	0	0	0	0
			General	0	162	403	0	0	0	0	0	0	0	0	0	0	0	0
	Epilobium hirsutum	% Cover	Inside Quadrat	11	1	1	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	147	325	298	0	0	0	0	0	0	0	0	0	0	0	0
			General	135	325	298	0	0	0	0	0	0	0	0	0	0	0	0
	Cardamine flexuosa	% Cover	Inside Quadrat	65	32	16	0	0	0	0	0	0	3	3	0	0	3	7
		Height	Maximum	120	150	128	0	0	0	0	0	0	124	248	0	0	39	85
			General	104	128	90	0	0	0	0	0	0	87	221	0	0	21	70
7	*Phragmites australis*	% Cover	Inside Quadrat	97	97	97	0	0	0	0	0	0	36	38	85	97	93	46
		Height	Maximum	2381	2512	2481	0	0	0	0	0	0	990	2140	2469	2447	2205	1993
			General	2348	2497	2430	0	0	0	0	0	0	885	1894	1914	1991	1887	1748
8	*Phragmites australis*	% Cover	Inside Quadrat	97	97	97	0	0	0	0	0	0	34	42	88	97	97	46
		Height	Maximum	2426	2538	2401	0	0	0	0	0	0	972	1640	2337	2395	2287	2051
			General	2322	2395	2300	0	0	0	0	0	0	734	1491	2082	2101	1934	1840
	Galium aparine	% Cover	Inside Quadrat	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	983	949	0	0	0	0	0	0	0	0	0	0	0	0	0
			General	983	949	0	0	0	0	0	0	0	0	0	0	0	0	0
9	*Phragmites australis*	% Cover	Inside Quadrat	97	97	97	0	0	0	0	0	0	21	35	91	97	82	75
		Height	Maximum	2390	2574	2494	0	0	0	0	0	0	974	1888	2374	2437	2380	2218
			General	2209	2427	2380	0	0	0	0	0	0	813	1609	1835	2070	1923	1802

Table 6.2 (Continued): Vegetation Heights and Areas during the Study Period For Reedbed 2.

6.3 Magna Park

The recorded vegetation heights and area coverage for the flora within the quadrats at Magna Park can be found in Tables 6.3. to 6.6. The quadrat locations are shown in Fig 5.10.

Lythrum salicaria

The data for the quadrats where *Lythrum salicaria* was grown as the target species can be found in Table 6.3.

During the first year *Lythrum salicaria* showed exceptional levels of growth, expanding its range within the quadrat and spreading its leaves beyond, whilst also flowering and setting seed. The majority of the quadrats experienced 90 to 100% coverage with an equivalent coverage outside Quadrat 6 reaching 74 %. Quadrat 15, did not do well in the first year due to operational hydrological issues which resulted in water stress.

During the second year of study, the area coverage and height for *Lythrum salicaria* fluctuated on a monthly basis. As discussed earlier in Section 6.1.2 this was predominantly due to the operational management of the reedbeds altering the available water resources, which in turn created drought induced stress. Figure 6.3 and Figure 6.4 provide a visual example of this, where the *Lythrum salicaria* had successfully flowered, then a period of drought occurred which resulted in the *Lythrum salicaria* dying back before trying to regrow in the same year. Where *Phalaris arundinacea* and other aquatic species planted during the refurbishment were present adjacent to the quadrats, they continually struggled to survive and started to regrow during the periods when water was available, before shrivelling up during the next management period when effluent was diverted to the new beds.

Minor herbivory from rabbits, *Oryctolagus cuniculus,* and field voles was noted during the study, however this was only minor when compared to that observed in Reedbed 2 at Rugeley, which was surrounded by arable land and amenity grassland limiting the availability of other food resources. At Magna Park the variety of flora planted around the treatment beds, together with planting throughout the distribution centre, around the wildlife ponds and the lake adjacent to the reedbeds, all provided additional sources of food for the herbivores.

Although *Lythrum salicaria* was subject to varying levels of water stress throughout the study, predominantly occurring in 2016, it survived within all of the quadrats in which it was planted, and was observed successfully flowering and setting seed during both years of the study.

Quadrat	Species	Value (Cover = %, Height = mm)		2015 August	2015 September	2015 October	2015 November	2015 December	2016 January	2016 February	2016 March	2016 April	2016 May	2016 June	2016 July	2016 August	2016 September	2016 October
7	*Lythrum salicaria*	% Cover	Inside Quadrat	100	100	100	0	0	0	0	0	0	35	36	7	10	13	11
			Outside Quadrat	28	68	74	0	0	0	0	0	0	8	11	4	8	15	14
			Combined	128	168	174	0	0	0	0	0	0	43	0	0	0	0	25
		Height	Maximum	552	838	895	0	0	0	0	0	0	362	604	211	703	1975	1849
			General	419	344	309	0	0	0	0	0	0	265	562	162	638	1296	1322
	Carex pendula	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	2	8	12	12
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	337	1129	1522	1475
			General	0	0	0	0	0	0	0	0	0	0	0	257	1037	1372	1327
	Holcus lanatus	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	62	57	3	6	8	8
		Height	Maximum	0	0	0	0	0	0	0	0	0	580	396	131	283	370	340
			General	0	0	0	0	0	0	0	0	0	470	256	86	192	243	299
	Iris pseuadacorus	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	3	3	1	1	1	1
		Height	Maximum	0	0	0	0	0	0	0	0	0	840	946	597	684	670	597
			General	0	0	0	0	0	0	0	0	0	680	704	521	560	593	562
	Phalaris arundinacea	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	6	16	14	43	54	58
		Height	Maximum	0	0	0	0	0	0	0	0	0	1260	1613	829	1083	1120	1124
			General	0	0	0	0	0	0	0	0	0	1135	1479	615	666	613	587
	Ranunculus repens	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	234	292	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	234	239	0	0	0	0
	Typha latifolia	% Cover	Inside Quadrat	0	8	14	0	0	0	0	0	0	1	1	0	0	0	0
		Height	Maximum	0	984	1201	0	0	0	0	0	0	111	680	0	0	0	0
			General	0	776	1030	0	0	0	0	0	0	111	680	0	0	0	0
9	*Lythrum salicaria*	% Cover	Inside Quadrat	100	100	100	0	0	0	0	0	0	84	12	25	27	32	33
			Outside Quadrat	5	58	61	0	0	0	0	0	0	1	0	0	4	6	6
			Combined	105	158	161	0	0	0	0	0	0	85	12	25	31	38	39
		Height	Maximum	649	1145	1078	0	0	0	0	0	0	430	83	223	891	1762	1744
			General	612	653	621	0	0	0	0	0	0	210	58	149	397	721	788
	Cardamine flexuosa	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0	81	70
			General	0	0	0	0	0	0	0	0	0	0	0	0	0	62	57
	Typha latifolia	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	1069	0	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	1069	0	0	0	0	0
10	*Phragmites australis*	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	2	0	0	1	1	1
		Height	Maximum	0	0	0	0	0	0	0	0	0	315	0	0	362	1231	1198
			General	0	0	0	0	0	0	0	0	0	222	0	0	362	1231	1078
	Lythrum salicaria	% Cover	Inside Quadrat	100	97	92	0	0	0	0	0	0	15	88	100	100	99	98
			Outside Quadrat	4	35	36	0	0	0	0	0	0	1					48
			Combined	104	132	128	0	0	0	0	0	0	16	88	100	100	99	146
		Height	Maximum	573	640	575	0	0	0	0	0	0	273	877	1641	1703	1759	1717
			General	472	481	438	0	0	0	0	0	0	141	809	1054	1101	1233	1163
	Cardamine flexuosa	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	6	0	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	85	0	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	49	0	0	0	0	0
	Holcus lanatus	% Cover	Inside Quadrat	0	2	4	0	0	0	0	0	0	3	0	0	0	0	0
		Height	Maximum	0	371	501	0	0	0	0	0	0	227	0	0	0	0	0
			General	0	221	246	0	0	0	0	0	0	133	0	0	0	0	0
	Urtica dioica	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	312	0	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	233	0	0	0	0	0
15	*Lythrum salicaria*	% Cover	Inside Quadrat	100	18	23	0	0	0	0	0	0	82	7	8	19	20	16
			Outside Quadrat	15	2	4	0	0	0	0	0	0	2	0	0	1	1	1
			Combined	115	20	27	0	0	0	0	0	0	84	7	8	19	20	17
		Height	Maximum	809	61	434	0	0	0	0	0	0	688	68	85	110	173	161
			General	625	46	261	0	0	0	0	0	0	593	50	69	97	159	153
	Cardamine flexuosa	% Cover	Inside Quadrat	0	0	5	0	0	0	0	0	0	1	0	0	20	27	26
		Height	Maximum	0	0	282	0	0	0	0	0	0	196	0	0	75	275	282
			General	0	0	163	0	0	0	0	0	0	175	0	0	54	219	229
	Epilobium hirsutum	% Cover	Inside Quadrat	0	0	12	0	0	0	0	0	0	0	0	0	6	11	12
		Height	Maximum	0	0	298	0	0	0	0	0	0	0	0	0	85	415	391
			General	0	0	54	0	0	0	0	0	0	0	0	0	59	283	268
	Holcus lanatus	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0	82	129
			General	0	0	0	0	0	0	0	0	0	0	0	0	0	68	129
	Phalaris arundinacea	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	307	0	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	277	0	0	0	0	0
18	*Lythrum salicaria*	% Cover	Inside Quadrat	100	100	100	0	0	0	0	0	0	42	6	7	16	19	17
			Outside Quadrat	15	43	44	0	0	0	0	0	0	1	0	0	0	1	1
			Combined	115	143	144	0	0	0	0	0	0	43	6	7	16	20	18
		Height	Maximum	920	916	679	0	0	0	0	0	0	425	125	396	500	668	515
			General	723	698	560	0	0	0	0	0	0	328	90	257	296	301	245
	Epilobium hirsutum	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	1	6	10	12
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	90	380	643	616
			General	0	0	0	0	0	0	0	0	0	0	0	39	260	268	265
	Holcus lanatus	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	48	0	4	7	15	14
		Height	Maximum	0	0	0	0	0	0	0	0	0	441	0	64	67	316	237
			General	0	0	0	0	0	0	0	0	0	162	0	64	67	198	135
	Impatiens glandulifera	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	4	20	22
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	862	1624	1783
			General	0	0	0	0	0	0	0	0	0	0	0	0	827	1340	1408
	Urtica dioica	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	3	8
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0	96	242
			General	0	0	0	0	0	0	0	0	0	0	0	0	0	64	236

Table 6.3: Vegetation Heights and Areas during the Study Period For *Lythrum salicaria* at Magna Park

Figure 6.3: *Lythrum salicaria* flowering 2015

Figure 6.4: Lythrum salicaria regrowing after a dought induced stress episode

<u>*Filipendula ulmaria*</u>

The data for the quadrats where *Filipendula ulmaria* was grown as the target species can be found in Table 6.4.

Filipendula ulmaria had a mixed start to the first year, struggling in those quadrats where hydraulic flow issues and subsequent drought occurred, but thriving in others, where the plant just expanded its leaf coverage outside of the quadrat. *Filipendula ulmaria* survived in all of the quadrats during the first year, however no flowering occurred.

In all of the quadrats, this aquatic plant came out of dormancy and showed visible above ground growth at the start of 2016. However, at this time the owners of the site had just finished restoring the other half of the original treatment reedbeds on the opposite side of the lake and the main water flow was subsequently diverted as described in Section 6.1.2. This resulted in intermittent water stress affected the *Filipendula ulmaria* in the same way as *Lythrum salicaria* above, with the plant trying to regrow after a period of drought.

During 2015, but more so in 2016, it was observed that other species more commonly associated with colonisation of drier habitats began to colonise the channels and were expanding their coverage within the quadrats. These species included *Urtica dioica*, *Holcus lanatus* and *Persicaria maculosa*, and it was observed that their growth was predominantly limited to the compost area within the quadrats and struggled on the adjacent bare gravel. As with *Lythrum salicaria*, where *Phalaris arundinacea* and other aquatic species planted during the refurbishment were present adjacent to the quadrats, they continually struggled to survive and started to regrow during the periods when water was available, before shrivelling up during the next management period when effluent was diverted to the new beds.

Filipendula ulmaria is an early flowerer and the drought which occurred early in the season (when the plant should have been starting to flower) appeared to have had an adverse effect, with only a couple of flowers observed during 2016. It was subject to herbivory from field vole and rabbit during both years, however as with *Lythrum salicaria* this was minor when compared to the herbivory recorded within Reedbed 2 at Rugeley. During winter 2015/2016 the rabbits also dug into the compost within the quadrats in several of the reedbeds scattering it around.

Although *Filipendula ulmaria* was subject to bouts of water stress and herbivory, it managed to survive in all bar one of the quadrats, with the area coverage in two of the quadrats being 78 % and 57 % at the end of the study period. Quadrat 13 (the one quadrat which suffered 100 % fatalities) and Quadrat 2 (where *Filipendula ulmaria* was observed struggling to survive) were both affected by the water management regime imposed and not through competition with other species.

Quadrat	Species	Value (Cover = %, Height = mm)		2015					2016									
				August	September	October	November	December	January	February	March	April	May	June	July	August	September	October
2	*Filipendula ulmaria*	% Cover	Inside Quadrat	10	24	27	0	0	0	0	0	0	4	4	2	2	3	3
			Outside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Combined	10	24	27	0	0	0	0	0	0	4	4	2	2	3	3
		Height	Maximum	22	176	136	0	0	0	0	0	0	48	75	94	125	130	90
			General	18	116	103	0	0	0	0	0	0	42	61	73	90	91	77
	Cardamine flexuosa	% Cover	Inside Quadrat	0	16	17	0	0	0	0	0	0	4	2	0	0	0	0
		Height	Maximum	0	92	261	0	0	0	0	0	0	108	138	0	0	0	0
			General	0	58	122	0	0	0	0	0	0	62	86	0	0	0	0
	Geranium molle	% Cover	Inside Quadrat	0	4	5	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	0	53	49	0	0	0	0	0	0	0	0	0	0	0	0
			General	0	41	38	0	0	0	0	0	0	0	0	0	0	0	0
	Holcus lanatus	% Cover	Inside Quadrat	0	12	16	0	0	0	0	0	0	3	74	76	76	82	81
		Height	Maximum	0	193	257	0	0	0	0	0	0	55	126	179	157	238	268
			General	0	147	120	0	0	0	0	0	0	51	105	147	121	168	186
	Persicaria maculosa	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	1	3	4
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	76	292	354
			General	0	0	0	0	0	0	0	0	0	0	0	0	56	113	129
	Phalaris arundinacea	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	392
			General	0	0	0	0	0	0	0	0	0	0	0	0	0	0	221
	Ranunculus sceleratus	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	6	7	3	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	110	161	186	0	0	0
			General	0	0	0	0	0	0	0	0	0	95	100	119	0	0	0
	Typha latifolia	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0	921	1242
			General	0	0	0	0	0	0	0	0	0	0	0	0	0	768	896
6	*Filipendula ulmaria*	% Cover	Inside Quadrat	25	95	98	0	0	0	0	0	0	42	42	40	36	36	34
			Outside Quadrat	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
			Combined	25	96	99	0	0	0	0	0	0	42	42	40	36	36	34
		Height	Maximum	32	127	130	0	0	0	0	0	0	266	357	439	485	488	462
			General	49	104	116	0	0	0	0	0	0	230	261	280	297	147	164
	Cardamine flexuosa	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	5	6
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0	88	129
			General	0	0	0	0	0	0	0	0	0	0	0	0	0	57	82
	Holcus lanatus	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	46	48	46	42	44	44
		Height	Maximum	0	0	0	0	0	0	0	0	0	355	52	264	294	253	270
			General	0	0	0	0	0	0	0	0	0	254	232	216	279	214	174
	Phalaris arundinacea	% Cover	Inside Quadrat	3	3	3	0	0	0	0	0	0	17	20	19	22	17	16
		Height	Maximum	1183	1154	341	0	0	0	0	0	0	826	1106	1239	1317	1222	1213
			General	497	493	341	0	0	0	0	0	0	783	971	1150	1190	1167	1107
	Rumex obtusifolius	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	3	4	6	8	7	7
		Height	Maximum	0	0	0	0	0	0	0	0	0	180	217	229	261	290	282
			General	0	0	0	0	0	0	0	0	0	180	217	229	261	290	282
	Veronica anagallis-aquatica	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	3	2	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	152	290	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	84	113	0	0	0	0
11	*Filipendula ulmaria*	% Cover	Inside Quadrat	35	31	28	0	0	0	0	0	0	65	70	72	80	79	78
			Outside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	1	4	5
			Combined	35	31	28	0	0	0	0	0	0	65	70	72	81	83	83
		Height	Maximum	176	395	332	0	0	0	0	0	0	296	485	510	544	630	616
			General	114	236	258	0	0	0	0	0	0	277	429	458	506	593	590
	Cardamine flexuosa	% Cover	Inside Quadrat	0	82	83	0	0	0	0	0	0	35	6	0	0	0	0
		Height	Maximum	0	349	401	0	0	0	0	0	0	185	306	0	0	0	0
			General	0	301	305	0	0	0	0	0	0	147	216	0	0	0	0
	Epilobium hirsutum	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	9	0	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	185	0	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	157	0	0	0	0	0
	Persicaria maculosa	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0	365	745
			General	0	0	0	0	0	0	0	0	0	0	0	0	0	365	745
	Phalaris arundinacea	% Cover	Inside Quadrat	1	0	0	0	0	0	0	0	0	0	0	1	8	20	22
		Height	Maximum	175	0	0	0	0	0	0	0	0	0	0	318	717	995	930
			General	153	0	0	0	0	0	0	0	0	0	0	228	654	917	875
	Veronica anagallis-aquatica	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	223	0	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	206	0	0	0	0	0
13	*Filipendula ulmaria*	% Cover	Inside Quadrat	40	70	68	0	0	0	0	0	0	12	0	0	0	0	0
			Outside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
			Combined	40	70	68	0	0	0	0	0	0	12	0	0	0	0	0
		Height	Maximum	168	235	203	0	0	0	0	0	0	174	0	0	0	0	0
			General	74	153	144	0	0	0	0	0	0	99	0	0	0	0	0
	Cardamine flexuosa	% Cover	Inside Quadrat	0	12	13	0	0	0	0	0	0	16	28	61	76	80	79
		Height	Maximum	0	179	208	0	0	0	0	0	0	143	198	197	169	154	156
			General	0	115	128	0	0	0	0	0	0	76	165	160	156	149	149
	Holcus lanatus	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	6	1	1	2	3	3
		Height	Maximum	0	0	0	0	0	0	0	0	0	123	86	85	94	191	178
			General	0	0	0	0	0	0	0	0	0	65	37	66	84	136	139
	Veronica anagallis-aquatica	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	13	0	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	127	0	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	106	0	0	0	0	0
14	*Filipendula ulmaria*	% Cover	Inside Quadrat	78	48	22	0	0	0	0	0	0	10	6	18	55	59	57
			Outside Quadrat	2		5	0	0	0	0	0	0	0	0	0	1	2	2
			Combined	80	48	27	0	0	0	0	0	0	10	6	18	55	59	59
		Height	Maximum	398	494	489	0	0	0	0	0	0	246	179	314	508	525	439
			General	235	457	452	0	0	0	0	0	0	132	84	271	346	319	296
	Cardamine flexuosa	% Cover	Inside Quadrat	2	0	0	0	0	0	0	0	0	0	0	0	0	24	18
		Height	Maximum	44	0	0	0	0	0	0	0	0	0	0	0	0	72	65
			General	29	0	0	0	0	0	0	0	0	0	0	0	0	52	49
	Epilobium hirsutum	% Cover	Inside Quadrat	0	1	1	0	0	0	0	0	0	4	0	1	1	3	3
		Height	Maximum	0	63	349	0	0	0	0	0	0	52	0	69	305	762	691
			General	0	48	349	0	0	0	0	0	0	47	0	50	261	395	366
	Phalaris arundinacea	% Cover	Inside Quadrat	0	59	80	0	0	0	0	0	0	4	0	2	5	9	11
		Height	Maximum	0	873	1521	0	0	0	0	0	0	780	0	369	1407	1718	1508
			General	0	489	642	0	0	0	0	0	0	691	0	319	874	1035	870
	Urtica dioica	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	96	0	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	96	0	0	0	0	0

Table 6.4: Vegetation Heights and Areas during the Study Period For *Filipendula ulmaria* at Magna Park

Mentha aquatica

The data for the quadrats where *Mentha aquatica* was grown as the target species can be found in Table 6.4.

During the first year *Mentha aquatica* showed exceptional levels of growth, expanding its range within the quadrats and spreading its leaves beyond, whilst also flowering and setting seed. All of the quadrats experienced 100 % coverage (Figure 6.5) with an equivalent coverage outside of Quadrat 19, reaching 480 %.

During the second year of study, the area coverage and height for *Mentha aquatica* fluctuated on a monthly basis. As discussed earlier, this was predominantly due to the operational management on the reedbeds and the resulting drought induced stress. Figure 6.5 and Figure 6.6 are of the same bed before and after periods of drought, as are Figure 6.7 and Figure 6.8.

When subject to drought induced stress, *Mentha aquatica* died back to the rhizomes and stolons before re-growing. As with *Filipendula ulmaria*, this species survived in all but one of the quadrats. Again the quadrat which suffered 100 % fatalities was due to water stress and not competition with adjacent vegetation. This latter included flora more commonly associated with dry habitats which started to colonise the channels.

Mentha aquatica flowered and set seed during both years of the study period, but no grazing was observed on this species, though rabbits had dug within the compost layer during the winter of 2015/2016.

Quadrat	Species	Value (Cover = %, Height = mm)		2015					2016									
				August	September	October	November	December	January	February	March	April	May	June	July	August	September	October
1	*Mentha aquatica*	% Cover	Inside Quadrat	100	100	100	0	0	0	0	0	0	1	3	7	10	11	11
			Outside Quadrat	17	99	135	0	0	0	0	0	0	14	19	21	22	24	24
			Combined	117	199	235	0	0	0	0	0	0	15	22	28	32	35	35
		Height	Maximum	568	518	448	0	0	0	0	0	0	53	194	350	612	349	352
			General	241	252	209	0	0	0	0	0	0	53	122	263	352	335	311
	Holcus lanatus	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	2	35	71	77	84	88
		Height	Maximum	0	0	0	0	0	0	0	0	0	68	278	362	413	463	469
			General	0	0	0	0	0	0	0	0	0	64	207	255	331	338	327
	Persicaria maculosa	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	2	3	3
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	109	365	396
			General	0	0	0	0	0	0	0	0	0	0	0	0	89	218	249
	Phalaris arundinacea	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	1	2	8
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	966	1355	1205
			General	0	0	0	0	0	0	0	0	0	0	0	0	556	811	747
3	*Mentha aquatica*	% Cover	Inside Quadrat	100	100	100	0	0	0	0	0	0	76	66	53	45	41	31
			Outside Quadrat	24	74	83	0	0	0	0	0	0	179	141	86	54	29	14
			Combined	124	174	183	0	0	0	0	0	0	255	207	139	99	70	45
		Height	Maximum	387	935	1182	0	0	0	0	0	0	572	682	767	832	867	891
			General	331	351	389	0	0	0	0	0	0	315	371	385	412	449	462
	Carex pendula	% Cover	Inside Quadrat	0	2	2	0	0	0	0	0	0	3	3	3	3	4	4
		Height	Maximum	0	887	1322	0	0	0	0	0	0	744	987	1205	1108	1067	1061
			General	0	815	1194	0	0	0	0	0	0	607	855	936	314	374	384
	Holcus lanatus	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	5	11	16	18
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	85	140	277	246
			General	0	0	0	0	0	0	0	0	0	0	0	65	131	214	180
	Typha latifolia	% Cover	Inside Quadrat	0	2	3	0	0	0	0	0	0	26	29	31	4	5	5
		Height	Maximum	0	971	1296	0	0	0	0	0	0	1028	1374	1569	786	1592	1619
			General	0	882	1007	0	0	0	0	0	0	890	1240	1507	589	1592	1619
	Veronica anagallis-aquatica	% Cover	Inside Quadrat	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	359	403	0	0	0	0	0	0	0	0	0	0	0	0	0
			General	359	318	0	0	0	0	0	0	0	0	0	0	0	0	0
8	*Phragmites australis*	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	1	1	1	5	6	6
		Height	Maximum	0	0	0	0	0	0	0	0	0	433	1226	1510	1176	1156	1011
			General	0	0	0	0	0	0	0	0	0	433	1125	1465	1064	1051	690
	Mentha aquatica	% Cover	Inside Quadrat	100	100	100	0	0	0	0	0	0	87	75	72	24	26	24
			Outside Quadrat	31	63	68	0	0	0	0	0	0	28	33	31	13	10	7
			Combined	131	163	168	0	0	0	0	0	0	115	108	103	37	36	31
		Height	Maximum	561	560	592	0	0	0	0	0	0	405	590	727	861	949	912
			General	422	472	490	0	0	0	0	0	0	235	342	391	208	173	147
	Holcus lanatus	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	1	3	4
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	91	247	391
			General	0	0	0	0	0	0	0	0	0	0	0	0	61	183	250
	Schoenoplectus lacustris	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	38	41	43	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	1320	1833	2150	0	0	0
			General	0	0	0	0	0	0	0	0	0	1115	1690	1998	0	0	0
17	*Mentha aquatica*	% Cover	Inside Quadrat	100	100	100	0	0	0	0	0	0	12	0	0	0	0	0
			Outside Quadrat	28	129	138	0	0	0	0	0	0	14	0	0	0	0	0
			Combined	128	229	238	0	0	0	0	0	0	26	0	0	0	0	0
		Height	Maximum	562	577	361	0	0	0	0	0	0	246	0	0	0	0	0
			General	438	469	258	0	0	0	0	0	0	141	0	0	0	0	0
	Carex pendula	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	2	2	2	2	2	3
		Height	Maximum	0	0	0	0	0	0	0	0	0	435	439	464	566	582	544
			General	0	0	0	0	0	0	0	0	0	373	319	352	395	367	373
	Geranium robertianum	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	5	6
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0	108	112
			General	0	0	0	0	0	0	0	0	0	0	0	0	0	59	51
	Urtica dioica	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	6	21	24
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	63	371	383
			General	0	0	0	0	0	0	0	0	0	0	0	0	63	183	190
19	*Phragmites australis*	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	1	5	6	6
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	470	1371	1689	1740
			General	0	0	0	0	0	0	0	0	0	0	0	416	1252	1348	1325
	Mentha aquatica	% Cover	Inside Quadrat	100	100	100	0	0	0	0	0	0	94	96	95	97	90	82
			Outside Quadrat	48	382	480	0	0	0	0	0	0	245	241	248	237	213	185
			Combined	148	482	580	0	0	0	0	0	0	339	337	343	334	303	267
		Height	Maximum	631	649	652	0	0	0	0	0	0	596	717	968	964	886	315
			General	410	434	349	0	0	0	0	0	0	282	312	495	798	581	226
	Carex pendula	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	8	1	1	1	1	1
		Height	Maximum	0	0	0	0	0	0	0	0	0	713	67	324	738	1122	1032
			General	0	0	0	0	0	0	0	0	0	585	46	306	672	1085	999

Table 6.5: Vegetation Heights and Areas during the Study Period For *Mentha aquatica* at Magna Park

Figure 6.5: Mentha aquatica during 2015

Figure 6.6: *Mentha aquatica* after a dought induced stress episode. Note this is the same bed as Figure 6.5

Figure 6.7: ***Mentha aquatica*** **growing well and competeing againts the main treatent species at the end of 2015. Note the two beds to the right having suffered from drought stress and recently filled with effluent.**

Figure 6.8: ***Mentha aquatica*** **after a dought induced stress episode at the end of 2016 Note this is the same bed as illustrated in Figure 6.7**

Control

The control quadrats were not planted with any target species and contained only plants already present within the reedbeds (*Phalaris arundinacea*). The data for the control quadrats, and a comprehensive list of the species present in each can be found in Table 6.4. This table also shows that as with the quadrats containing the biodiversity enhancing species, the control quadrats experienced the same trials and tribulations with drought induced stress.

During the first year, *Phalaris arundinacea* survived in all quadrats until the end of the first growing season. The area coverage reached 100 % in one quadrat, however the hydraulic issues in the remaining quadrats appeared to limit its spread.

During the second year the effects caused by the hydraulic issues continued, with *Phalaris arundinacea* dying back to the base, before re-growing once the hydrology permitted. Again, during and after these periods of drought, flora more associated with colonising dry habitats started to colonise the channel, and quadrats.

With regards to herbivory, very minor grazing was observed on *Phalaris arundinacea*, though rabbits had dug within the compost layer during the winter of 2015/2016. *Phalaris arundinacea* survived in all of the quadrats, flowering and setting seed both years.

Quadrat	Species	Value (Cover = %, Height = mm)		2015					2016									
				August	September	October	November	December	January	February	March	April	May	June	July	August	September	October
4	*Agrostis stolonifera*	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	13	14	11	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	175	290	201	0	0	0
			General	0	0	0	0	0	0	0	0	0	159	170	139	0	0	0
	Cardamine flexuosa	% Cover	Inside Quadrat	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1
		Height	Maximum	0	0	126	0	0	0	0	0	0	0	0	0	0	53	84
			General	0	0	126	0	0	0	0	0	0	0	0	0	0	48	68
	Holcus lanatus	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	6	5	5	5	4	3
		Height	Maximum	0	0	0	0	0	0	0	0	0	72	70	71	81	188	224
			General	0	0	0	0	0	0	0	0	0	63	63	64	61	159	198
	Lolium perenne	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	4	4	3	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	54	319	401	0	0	0
			General	0	0	0	0	0	0	0	0	0	88	97	168	0	0	0
	Phalaris arundinacea	% Cover	Inside Quadrat	10	12	13	0	0	0	0	0	0	7	17	25	33	34	36
		Height	Maximum	1124	1182	1192	0	0	0	0	0	0	762	1060	1270	1506	1680	1679
			General	729	969	1029	0	0	0	0	0	0	680	922	994	961	998	1045
	Ranunculus repens	% Cover	Inside Quadrat	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	0	0	38	0	0	0	0	0	0	0	0	0	0	0	0
			General	0	0	38	0	0	0	0	0	0	0	0	0	0	0	0
	Urtica dioica	% Cover	Inside Quadrat	0	0	2	0	0	0	0	0	0	0	0	0	6	42	51
		Height	Maximum	0	0	52	0	0	0	0	0	0	0	0	0	177	413	455
			General	0	0	52	0	0	0	0	0	0	0	0	0	146	348	361
5	*Cardamine flexuosa*	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	4	5
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0	37	73
			General	0	0	0	0	0	0	0	0	0	0	0	0	0	28	59
	Carex pendula	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0	908	948
			General	0	0	0	0	0	0	0	0	0	0	0	0	0	908	948
	Holcus lanatus	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	12	11	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	138	92	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	76	63	0	0	0	0
	Iris pseuadacorus	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
		Height	Maximum	0	0	0	0	0	0	0	0	0	595	612	638	639	635	614
			General	0	0	0	0	0	0	0	0	0	595	612	638	639	635	614
	Phalaris arundinacea	% Cover	Inside Quadrat	5	100	100	0	0	0	0	0	0	18	11	12	8	8	6
		Height	Maximum	1281	1848	1853	0	0	0	0	0	0	570	989	1397	926	1042	992
			General	741	1657	1694	0	0	0	0	0	0	553	839	992	996	977	947
	Urtica dioica	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	17	39	70	73	89	92
		Height	Maximum	0	0	0	0	0	0	0	0	0	510	635	862	590	738	727
			General	0	0	0	0	0	0	0	0	0	475	541	839	550	649	595
12	*Carex pendula*	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0	349	60
			General	0	0	0	0	0	0	0	0	0	0	0	0	0	285	60
	Holcus lanatus	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	57	0	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	57	0	0	0	0	0
	Iris pseuadacorus	% Cover	Inside Quadrat	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0
		Height	Maximum	0	303	283	0	0	0	0	0	0	0	0	0	0	0	0
			General	0	303	283	0	0	0	0	0	0	0	0	0	0	0	0
	Persicaria maculosa	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	48	0	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	48	0	0	0	0	0
	Phalaris arundinacea	% Cover	Inside Quadrat	22	9	8	0	0	0	0	0	0	1	0	1	2	2	2
		Height	Maximum	822	1152	1164	0	0	0	0	0	0	249	0	305	743	1082	60
			General	648	769	750	0	0	0	0	0	0	234	0	257	675	820	60
	Urtica dioica	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	9	64	72	72
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	86	417	716	60
			General	0	0	0	0	0	0	0	0	0	0	0	43	345	669	60
16	*Cardamine flexuosa*	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	7	7
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0	157	177
			General	0	0	0	0	0	0	0	0	0	0	0	0	0	126	142
	Carex pendula	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	1	3	3
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	74	260	243
			General	0	0	0	0	0	0	0	0	0	0	0	0	57	241	223
	Iris pseuadacorus	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	1	0	0	1	1	1
		Height	Maximum	0	0	0	0	0	0	0	0	0	371	0	0	64	183	179
			General	0	0	0	0	0	0	0	0	0	245	0	0	64	183	179
	Phalaris arundinacea	% Cover	Inside Quadrat	25	6	8	0	0	0	0	0	0	1	0	0	2	5	5
		Height	Maximum	933	201	636	0	0	0	0	0	0	132	0	0	74	589	539
			General	640	159	470	0	0	0	0	0	0	116	0	0	48	297	140
20	*Cardamine flexuosa*	% Cover	Inside Quadrat	0	0	1	0	0	0	0	0	0	0	0	0	0	11	14
		Height	Maximum	0	0	69	0	0	0	0	0	0	0	0	0	0	126	201
			General	0	0	30	0	0	0	0	0	0	0	0	0	0	97	114
	Carex pendula	% Cover	Inside Quadrat	0	1	4	0	0	0	0	0	0	2	6	27	32	29	32
		Height	Maximum	0	99	235	0	0	0	0	0	0	215	626	987	1067	1294	1036
			General	0	85	206	0	0	0	0	0	0	153	328	431	478	489	388
	Holcus lanatus	% Cover	Inside Quadrat	0	1	4	0	0	0	0	0	0	0	0	0	0	1	2
		Height	Maximum	0	61	293	0	0	0	0	0	0	0	0	0	0	77	134
			General	0	49	190	0	0	0	0	0	0	0	0	0	0	54	134
	Iris pseuadacorus	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	2	2	2	2	2	2
		Height	Maximum	0	0	0	0	0	0	0	0	0	372	653	667	641	669	668
			General	0	0	0	0	0	0	0	0	0	281	538	562	586	585	0
	Lolium perenne	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	64	36	4	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	196	64	61	0	0	0
			General	0	0	0	0	0	0	0	0	0	124	55	46	0	0	0
	Phalaris arundinacea	% Cover	Inside Quadrat	35	16	18	0	0	0	0	0	0	11	23	37	38	40	41
		Height	Maximum	1497	776	1524	0	0	0	0	0	0	574	947	1470	1757	1725	1693
			General	930	617	918	0	0	0	0	0	0	260	618	1278	1352	1328	1300
	Schoenoplectus lacustris	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	727	0	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	378	0	0	0	0	0
	Urtica dioica	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	0	0	0	0	7	11
		Height	Maximum	0	0	0	0	0	0	0	0	0	0	0	0	0	71	176
			General	0	0	0	0	0	0	0	0	0	0	0	0	0	54	154
	Veronica anagallis-aquatica	% Cover	Inside Quadrat	0	0	0	0	0	0	0	0	0	2	5	0	0	0	0
		Height	Maximum	0	0	0	0	0	0	0	0	0	168	427	0	0	0	0
			General	0	0	0	0	0	0	0	0	0	160	339	0	0	0	0

Table 6.6: Vegetation Heights and Areas during the Study Period For Control Quadrats at Magna Park

6.4 Field Study Discussion

The field study was undertaken in an operational setting to investigate Hypothesis 9: *“Where the chosen floral species survive, there will be no difference between retro-planting these species within a mature reedbed, compared to planting these species within a newly created/restored reedbed and no single floral species will take over and oust other floral species"*.

As described in Section 5, the two field studies were designed to permit replication and thus to enable statistical analysis the results. However, given all of the issues described in Sections 6.2 and 6.3 no sensible statistical analysis has been possible, and the following evaluation is therefore predominantly qualitative.

6.4.1 Mature Reedbeds

The two mature reedbeds studied at Rugeley resulted in differing results. Within Reedbed 1 both *Lythrum salicaria* and *Filipendula ulmaria* had individuals surviving until the end of the first year. However, these individuals struggled to compete for light against the mature *Phragmites australis* stands. *Lythrum salicaria* appeared to fair worse with its stems remaining thin and weak. Though the *Filipendula ulmaria* did not fare much better, this species was putting energy into its culms (observed by the culms becoming visibly larger) ready to regrow the following year. Unfortunately, the dense mulch created by the standing dead *Phragmites australis* litter collapsing during the winter storm of 2015/2016 smothered the biodiversity enhancing species to such an extent that they failed to recover.

Reedbed 2 on the other hand had different issues and hence results. During the first year the biodiversity enhancing species looked visibly healthier and *Lythrum salicaria* was growing taller than in Reedbed 1. This could be due to the *Phragmites australis* cover being visibly less dense and letting more dappled light reach the ground. The two reedbeds are used to investigate new treatment opportunities by the operators whose business is to design reedbed treatment systems and consequently the reason for the two beds maturing differently was due to the effluent pre-treatment's which the reedbeds had been subject to over the years, resulting in a differing nutrient availability for the reeds.

Although Reedbed 2 was subjected to the same winter storms as Reedbed 1, the management of the reedbed in forking the substrate to permit drainage, combined with the cessation of effluent input, allowed the bed to dry out. This prevented the thick wet mulch of Reedbed 1 from forming and as such the biodiversity enhancing species were not smothered. In 2016, both of the biodiversity enhancing species started to grow well, however the dry nature of the reedbed permitted herbivores access and a sustained grazing pressure followed, which limited their growth. *Lythrum salicaria* where it managed to gain some height and turn woody managed to flower and set seed. *Filipendula ulmaria* on the other hand did not manage to flower, with the flower shoots it produced grazed when they appeared.

From the results of the mature and established reedbeds, it is recommended that the biodiversity enhancing species should not be retrofitted, particularly where the mature reeds are dense and where limited management is undertaken. It may be feasible to retrofit mature reedbeds with biodiversity enhancing species where the reeds are dense and appropriate management, such as harvesting at the end of the growing season, is undertaken. However this would require further research and is discussed further in Section 7 and 8.

Where the established reeds are not dense and the beds are intermittently used to treat effluent, this study showed that the biodiversity enhancing species survived. However, in this study their growth was effected through herbivory and an appropriate management recommendation is made in Section 7.

6.4.2 Newly Refurbished Reedbeds

Although the newly refurbished reedbeds at Magna Park were predominantly planted with *Phalaris arundinacea* rather than *Phragmites australis,* around the quadrats, this permitted an insight of how the biodiversity enhancing species interacted with a different treatment species.

Where the biodiversity enhancing species were planted within the newly refurbished reedbeds in 2015, they all managed to survive their first year and spread their range. In the quadrats where they did not do too well, the plants were subject to drought induced stress caused by the uneven construction of the bed surface and the water management of the reedbeds, rather than through competition from other flora. This was substantiated by the main treatment species also dying back at the same time as the biodiversity enhancing species.

The 2016 results were affected even more by the hydraulic issues, and were compounded by the operators for Magna Park diverting the main flow to the newly refurbished reedbeds on the opposite side of the lake.

Even though the water management regime employed resulted in intermittent drought induced stress, the biodiversity enhancing species survived where the water management permitted, and they actively competed with the treatment species (Figure 6.7) and expanded their ranges. This shows that it is possible to plant biodiversity enhancing species within reedbeds planted with *Phalaris arundinacea* and that they can survive for the first two years. Vymazal (2015), which was published after the start of this study, notes that *Phragmites australis* can be resilient to invasion by other wetland flora, whilst *Phalaris arundinacea* is commonly invaded. This would indicate that the biodiversity enhancing species could survive over a longer period and as such further research would be required to substantiate this and is recommended in Section 7.

Due to the external influencing factors which occurred at the experimental sites, the field studies did not provide enough data to statistically prove or disprove Hypothesis 9 as had been planned. However, results obtained indicate that it is feasible to add biodiversity enhancing species to newly created/refurbished reedbeds containing *Phalaris arundinacea,* and that it may be possible under certain circumstances to retrofit existing reedbeds containing *Phragmites australis* providing specific management practices are in place.

The next Section, Section 7, provides recommendations for design principles and management procedures, and this is followed by Section 7 where further supporting research is discussed.

7. DESIGN PRINCIPLES AND MANAGEMENT RECOMMENDATIONS

7.1 Introduction

Based upon the results obtained from this study, this section provides guidance on the parameters required for biodiversity enhancing species to be incorporated into a small scale constructed wetlands within the U.K.

7.2 Species Selection and Pollutant Concentrations

7.2.1 Nutrients

The results for the full competition microcosms showed that the roots of all three of the biodiversity enhancing species, *Lythrum salicaria* , *Filipendula ulmaria* and *Mentha aquatic*, did not penetrate deep into the gravel layer and that the roots of *Phragmites australis* were successfully growing under those of the biodiversity enhancing species. Therefore the introduction of these species should not affect the hydraulics or root treatment efficiency of sub-surface flow constructed wetlands which utilise *Phragmites australis* as their key treatment species. Vymazal (2015) reported that where reedbeds containing *Phalaris arundinacea* have been overgrown at the inlet and outlets by weed species, there was no difference in discharge quality. With *Phragmites australis* having a large rhizome system, the same should apply.

None of the biodiversity enhancing species became dominant and out competed the other species during the microcosm study. As all species survived at reasonable nutrient concentrations and did not prevent the roots of *Phragmites australis* from growing within the gravel layer, all three of the species studied are suitable for use for biodiversity enhancement.

All three of the biodiversity enhancing species survived in the entire range of nutrient concentrations tested in the microcosm study. Therefore, it can be extrapolated that where nutrient dosing is intermittent (such as within a system treating urban run-off) and providing that nutrient levels do not exceed those levels tested, then all three of the species can be utilised in such a system. It is not recommended that these species be planted in nutrient levels which exceed 150 mg/l nitrogen until further research has been undertaken on the species dynamics and treatment potential at these higher concentrations.

7.2.2 Salinity

The salinity levels employed in the microcosm study, had fatal consequences for all three of the biodiversity enhancing species. The highest salinity loading of 15 ‰ was fatal to *Lythrum salicaria,* which also struggled to survive at 10 ‰ salinity. At 5 ‰ salinity the area coverage was 16 %, which is a reasonable for providing biodiversity enhancing effects. *Filipendula ulmaria* and *Mentha aquatica* suffered fatal effects at salinity loadings of 15 ‰ and 10 ‰. They struggled to survive within the 5 ‰ salinity loading and some fatal effects occurred which indicates that the 5 ‰ salinity concentration is at the upper end of their survivability limits.

Where the species survived, none of the biodiversity enhancing species became dominant and out competed the other species during the study. Furthermore, none of the biodiversity enhancing species prevented the roots of *Phragmites australis* from growing within the gravel layer, and therefore all three of the species studied are suitable for use for biodiversity enhancement providing salinity concentrations are below toxic levels.

7.2.3 Summary

From the pollutant concentration studies, the following species recommendations are made:

- *Phragmites australis* will survive at all of the nutrient and salinity levels studied and can be planted for all concentrations tested;
- where the salinity levels are over 5 ‰, none of the biodiversity enhancing species studied within this research should be planted;
- where nutrient (nitrogen) concentrations are 150 mg/l or less and salinity levels do not exceed 5 ‰, *Lythrum salicaria* can be planted as a biodiversity enhancing species;
- where nutrient concentrations are 150 mg/l or less and salinity levels do not exceed 0.05 ‰, *Lythrum salicaria, Filipendula ulmaria and Mentha aquatica* can be planted as biodiversity enhancing species;
- where nutrient concentrations are 150 mg/l or less and the salinity levels do not exceed intermittent doses of a couple of ‰ (such as infrequent urban run-off from roads following de-icing) all three of the biodiversity enhancing species can be planted as they all survived 5 ‰ salinity for a short period of time.

7.3 Constructed Wetland and Media Selection

The design methodology for the microcosm study was based upon a subsurface flow constructed wetland with gravel media. The 10 mm pea gravel used in the beds of constructed wetlands is an appropriate rooting medium for the biodiversity enhancing species studied. The majority of these species roots were present within the upper layers of the growing media, and thus the slightly greater bed depth of standard subsurface flow designs would not have any adverse affect on the species diversity. Consequently, the recommended designs for the depths of subsurface flow wetlands found within the standard design manuals of Cooper *et al*., (1996) and Kadlec & Wallace (2009) should continue to be followed.

As discussed in Section 7.2, all floral species survived successfully at all nutrient concentrations up to 150 mg/l, the initial recommendation would be for their incorporation within subsurface flow constructed wetlands. However, the effect of the different stem physiology and densities upon the filtration of effluents in surface flow wetlands was not explored, and thus no guidance on the use of the biodiversity enhancement as an aid to treatment can be provided for surface flow wetlands.

The microcosm study demonstrated that the roots of the biodiversity enhancing species occurred predominantly within the upper humus layer and only just penetrated into the gravel layer. This was the case for *Lythrum salicaria* when the roots of *Phragmites australis* were present, however, in the absence of *Phragmites australis* roots, they penetrated further into the gravel layer. Due to the reliance on the humus layer by the biodiversity enhancing species, when they are employed in treatment beds, it is recommended that a 30 mm artificial litter/humus layer is installed when the constructed wetlands are built to aid establishment. Subsequently the accumulation of leaf litter should self sustain this layer. This will also have an additional beneficial effect due to the insulation it can provide during cold spells.

The root dividers employed in the microcosm study provided some beneficial effects for the biodiversity enhancing species as discussed in Section 6. However, due to the fact that *Phragmites australis* eventually penetrated beneath the root barriers, were such barriers installed on a full scale bed, it is likely that the beneficial effect would only be a short-term one. Within the full competition microcosms, all of the species survived at sufficient levels to contribute to biodiversity enhancement. Thus, the installation of root dividers is not recommended and species should be mixed into the same bed and allowed to compete with each other. To allow the different species to become established before full competition takes effect, each species should be planted in groups of several individuals, rather than fully mixed.

The more in-depth design methodologies take account of the inlet concentrations and the required effluent concentrations, hydraulic retention times which are calculated using ET, natural input, temperature, the hydraulic efficiency of bed media, the temperature effects of microbial activity and any specific pollutants within the waste liquid being treated which might require longer retention times (Section 4.5). The microcosm study identified that the competition between the different species resulted in greater water usage from the plants. It also identified that where salinity was present, less water was required. If more detailed equations are being utilised to design the reedbed then the increased water use rate for a competitive floral community should be taken into account. The lower water requirements for higher salinity values should also be considered if the influent is likely to have any saline input (i.e. runoff from de-iced roads).

7.4 Planting Densities and Layout

In the microcosms and field study quadrats the planting densities were increased above those recommended for *Phragmites australis* in guidelines, such as those of Cooper *et al*., (1996). In the microcosms, this was to allow for a more rapid colonisation of all the available areas and therefore to reduce the acclimatisation period required before the treatment research could commence. As no adverse effects were observed, the density employed (29 90mm pots per m^2) within the microcosm study for the biodiversity enhancing species can be utilised when planting these species.

A lower density of plug plants (16 plug plants per m^2) was used within the field study, but still above the recommended guidelines for *Phragmites australis* (Cooper *et al*., (1996) recommend planting four plugs of *Phragmites australis* per m^2). The results indicate that when the biodiversity enhancing species are planted within newly created/refurbished reedbeds containing *Phalaris arundinacea*, they will survive. However, in the mature reedbeds, the biodiversity enhancing species suffered fatal effects or were adversely impacted. Given the different effects experienced, such as herbivory and variable water management regimes, it is not possible to say if the lower planting densities used in the field study relative to the microcosm study contributed to the adverse effects.

Where *Phragmites australis* is the key treatment species, it is not recommended that *Lythrum salicaria, Filipendula ulmaria and Mentha aquatica* are planted at lower densities than those used in the microcosm study until further research has been undertaken on the effects this would have. Where *Phalaris arundinacea* is the key treatment species, the results indicate that within newly created/restored reedbeds, the lower planting density used in the field study will be appropriate. It is also not recommended that planting densities go below this for these beds until further research has been undertaken on the effects this would have. In accordance with the methodology presented within this study, pot and plug plants should be employed until further research supports the use of other size plants. *Phragmites australis* can be planted as either plug plants or as rhizomes to the densities recommended in Cooper *et al*., (1996).

As discussed in Section 4.5 to ensure that the roots of *Phragmites australis* can colonise the gravel media areas below the biodiversity enhancing species (and thus maintain the treatment potential of the constructed wetland), the width of the groups containing the biodiversity enhancing species should not exceed 3 m until further research suggests otherwise.

Vymazal (2015) found that when weed species colonise the inlet and outlet zones of *Phalaris arundinacea* beds, there was no difference in discharge water quality. This would indicate that planting the groups of biodiversity enhancing species (either as single species or multiple species) as strips across the inlet and outlet zones would not adversely affect the treatment capacity of the wetlands. Clearly this is dependent upon the size of the reedbed treatment system and further research should be undertaken to confirm this.

Where strips of biodiversity enhancing species are being retrofitted to existing reedbeds, it is recommended to locally remove the *Phragmites australis* (and rhizomes where feasible) from the strip being planted. This will give the biodiversity enhancing species time to become established before having to compete with fully mature plants.

7.5 Operational Management and Maintenance

The biodiversity enhancing species have been chosen to avoid any perceivable extra costs required in the operation and future maintenance of the constructed treatment wetland, above those required or *Phragmites australis*. The operation and future maintenance of the constructed treatment wetland should therefore be undertaken as set out within the standard design and operation manuals.

Maintenance activities should avoid any adverse impacts to the biodiversity enhancing species. Weeding operations should be undertaken by hand, and no herbicides which could kill the biodiversity enhancing species utilised. Harvesting of *Phragmites australis* is undertaken in some constructed wetlands for various reasons including to remove nutrients. Where biodiversity enhancing species have been planted in a newly created/refurbished reedbed, this should be avoided until further research identifies whether or not harvesting operations have an adverse effect.

When retrofitting to mature reedbeds, it may be beneficial to harvest the *Phragmites australis* immediately adjacent to the biodiversity enhancing groups until they become established. The affects of the harvesting on the humus layer, the species establishment and the duration over which it is undertaken will require further research.

A free surface water layer was added to the surface of the microcosms to replicate the effect of intermittent “pooling” of effluent upon the different species. The presence of this pooling layer had no adverse effect upon the species diversity and, should it occur within a subsurface flow wetland, no additional operational or maintenance is recommended.

The pooling and occasional flooding are employed in conventional constructed reedbeds to control weed species (Cooper *et al*., 1996; Vymazal 2015) and herbivores (Cooper *et al*., 1996). Given the impact of voles on the biodiversity enhancing species at Reedbed 2 of the Rugeley study, it is recommended that this management option is utilised should weed species and herbivory become an issue. Action should also be taken to ensure that any standing dead vegetation which collapse into pooled water on the surface of a bed does not cause the formation of a thick impenetrable mulch blanket, such as that which occurred in Reedbed 1.

7.6 Summary of Recommended Design Principles and Management Practices

For ease of access the recommended design principles and management practices that have emerged from this research project s discussed in Sections 4.5 and 7 are summarised in Table 7.1.

	Parameters		Concentration	Suitable for use		
				Lythrum salicaria	***Filipendula ulmaria***	***Mentha aquatica***
Biodiversity Enhancing Species Suitable for Planting in Differing Pollutant Concentration Levels.	**Potential Pollutant**	**Nitrogen**	Intermittent dosing up to 150 mg/l	Yes	Yes	Yes
		Salinity	Salinity levels greater than 5 ‰	No	No	No
			Salinity levels do not exceed 5 ‰	Yes	No	No
			Salinity levels do not exceed 0.05 ‰	Yes	Yes	Yes
			Salinity levels do not exceed intermittent doses of a couple of ‰ (such as infrequent urban run-off from roads following de-icing)	Yes	Yes	Yes
Treatment Reedbed Design for Horizontal Subsurface Flow Reedbeds	**Growing Media**		10 mm pea gravel with 30 mm humus layer.			
	Depth of Growing Media and Reedbed Dimensions		The standard design manuals e.g. Cooper *et al*., (1996) and Kadlec & Wallace (2009) should continue to be followed.			
	Sizing Using Hydraulic Retention Times to Treat Pollutants		The microcosm study identified that the competition between the different species resulted in greater water usage from the plants. It also identified that where salinity was present, less water was required. If more detailed equations are being utilised to design the reedbed then the increased water use rate for a competitive floral community should be taken into account. The lower water requirements for higher salinity values should also be considered.			
	Root Dividers		In the absence of intensive management, root dividers are only likely to have a short term beneficial effect for the biodiversity enhancing species and as such are not recommended for use in low maintenance reedbed treatment wetlands.			
	Retrofitting Mature Beds		It is recommended to locally remove the *Phragmites australis* (and rhizomes where feasible) from the strip being planted. This will give the biodiversity enhancing species time to become established before having to compete with fully mature plants.			
Planting Densities and Layout	**Planting Densities**	***Phragmites australis***	The standard design manuals e.g. Cooper *et al*., (1996) and Kadlec & Wallace (2009) should continue to be followed. Four plug plants per m^2 were used in the microcosm study.			
		Lythrum salicaria, Filipendula ulmaria and Mentha aquatica	Where *Phalaris arundinacea* is the main treatment species, sixteen plug plants per m^2 were used in the field study. With the wrong treatment species being planted in the newly refurbished reedbeds where *Phragmites australis* is the key reedbed treatment species being utilised, the lower planting density of sixteen plug plants per m^2 cannot be fully recommended until further research is undertaken. Although the lower planting density should be appropriate, until the further research has been undertaken the minimum tested planting density used in the microcosm study of 29 90 mm pots per m^2 should be used.			
	Planting Arrangement	**Grouping**	To allow the different species to become established before full competition takes effect, each species should be planted in groups of several individuals rather than fully mixed. The groups of different species could be combined to make blocks or strips of multiple species in a mosaic or kept as single species groups.			
		Size Of Grouping	The width of the strips or blocks containing the biodiversity enhancing species should not exceed 3 m until further research suggests otherwise, however the length can be longer.			
Operational Management and Maintenance	**Weed Species and Herbivory**		The pooling and occasional flooding are employed in conventional constructed reedbeds to control weed species (Cooper *et al*., 1996; Vymazal 2015) and herbivores (Cooper *et al*., 1996). Given the impact of voles on the biodiversity enhancing species at Reedbed 2 of the Rugeley study, it is recommended that this management option is utilised should weed species and herbivory become an issue.			
	Harvesting	**New Reedbeds**	Harvesting should be avoided until further research identifies whether or not harvesting operations have an adverse effect on the humus layer which the biodiversity enhancing species use to become established.			
		Mature Reedbeds	When retrofitting to mature reedbeds with an established humus layer, it may be beneficial to harvest the *Phragmites australis* immediately adjacent to the biodiversity enhancing groups until they become established. Action should also be taken to ensure that any standing dead vegetation which collapse into pooled water on the surface of a bed does not cause the formation of a thick impenetrable mulch blanket which could smother the biodiversity enhancing species.			

Table 7.1: Summary of Design Principles and Management Practices

8. PROJECT EVALUATION AND FURTHER RESEARCH REQUIREMENTS

8.1 Introduction

This section provides an evaluation of the successes and limitations of the project (Section 8.2) and highlights areas of study which require further research (Section 8.3).

8.2 Project evaluation

8.2.1 The project

The original project aim was to design and implement an experimental hybrid constructed wetland treatment system to ameliorate the pollutants found within the leachate of old landfills. Due to issues associated with obtaining a waste licence for the experimental system, as discussed in Section 1, the original study was cancelled when four years of negotiations between the landfill owners and the Environment Agency collapsed. Prior to its cancellation, a microcosm system had been fully designed as described in Steggall *et al*., (2005), and full planning permission had been granted by the county council, with full support from the local parish council. Since the original project was ceased, the Environment Agency have developed mechanisms to facilitate such research without the requirement of a waste management licence. This includes the Environment Agency providing confirmation that they will not prosecute certain studies on a case by case basis. As such if the original project was proposed today, it is likely that it would be given the go ahead by the Environment Agency.

When the subsequent literature search identified there to be a lack of knowledge concerning the use of biodiversity enhancing species, and their survivability within small scale constructed treatment wetlands, a new project involving microcosms was formulated to explore this subject. This new study was completed on a part-time basis, which permitted a long-term plant competition study to be undertaken within the microcosms. This study took place over a period of three and a half growing seasons, contributing to the long-term survivability knowledge of the biodiversity enhancing species, whereas previous studies on these species were generally short term, over a maximum duration of two years or less (Kadewa, 2010; Pauli *et al*., 2001 and Zhu *et al*., 2010).

Situating the microcosm study site within a single readily accessible area reduced the requirement for travelling to field sites (thus reducing costs) and allowed for the water requirements to be maintained on a frequent (sometimes weekly) basis. This level of control was not required during the subsequent field study within operational sites (see Section 5) as they were being managed by the site owners. However, other unforeseen issues occurred which would have been easier to overcome had control been in the hands of the researcher.

8.2.2 Experimental Design - Microcosm Study

Vegetation Measurements and Replication

Since the resources were not available to allow for large scale replicates of each microcosm, the experimental design allowed for the planting of four of each of the chosen species per microcosm to provide some degree of repetition. Besides recording the area coverage of each species, the planned sampling regime for the vegetation during the operational period in the microcosm study, was to randomly select samples from each species in each microcosm and measure the stem widths and heights. This would have allowed for statistical analysis of the data to be carried out for each month during the study period, and would have been in line with previous research where physiological plant characteristics had been monitored for vegetation within smaller plant pots. However, when this approach was attempted, it became apparent that it was not practical, since gaining access to the base of a selected stem often resulted in the snapping adjacent stems. Consequently, since the loss of plant stems could have affected the competition rates by both creating clear areas for different species to colonise, and reducing some of the plants vigour, these measurements were abandoned. The measurement of multiple stems throughout the growing periods was where consideration of replicates was going to occur, and its loss both removed this possibility, and also the amount of statistical analysis which could be carried out. Although the opportunity for statistical analysis of replicates was lost, trends were identified within the data.

During the summer growing season, the extensive and frequent watering of microcosms required a significant amount of resource and water. The site where the microcosms were located was next to a fresh water tap. However, had the microcosms been located away from a suitable freshwater supply, then the experiment would not have been practical without the resource of an alternative water source. The supply of water should therefore be a key consideration when designing any follow-up study and could include the use of rainwater rather than tap water.

Choice of pollutants

The two pollutants chosen for the research are both common components of effluents from domestic, industrial effluents and road runoff sources that require treatment. The choice of these two pollutants enabled a baseline to be set in identifying whether individual biodiversity enhancing floral species will survive at various nutrient and salinity concentrations, and also whether they will outcompete each other or not. In reality, the range of components which make up the pollutants in a given effluent varies along with their concentrations which is dependent upon numerous factors, including diurnal and seasonal variations and the use to which the water supply is put at any specific time. Now that it has been shown that these species are suitable to use at the nutrient concentrations studied and at what salinity levels fatal effects occur, different and more complex effluents could be tested to determine if these species are suitable for use within a wider range of chemical cocktails.

Project Evaluation Summary

Given the constraints of time, funding and space, combined with the reduced repetition measurements, the microcosm study design and implementation is judged to have been a success. It has shown that the chosen species have the potential to survive together within small scale constructed wetlands within a wide range of nutrient concentrations, though toxic levels of salinity need to be avoided. Differing water usage variations and growth have been identified along with differing root interactions caused by competition.

8.2.3 Experimental Design - Field Study

The original design for the field studies would have permitted several replicates within the same reedbed all receiving the same effluent and subject to the same environmental conditions. However, once it became apparent that Severn Trent Water were unwilling to partner the research, two alternative constructed wetland treatment systems were identified. The first at Rugeley comprised two mature reedbeds, whilst the second at Magna Park was a series of newly refurbished and planted reedbed channels.

At Rugeley, due to the reedbeds small size, concern was raised over the space required for the experimental plots of the proposed design and the potentially adverse effect this could have had on the treatment capabilities of the reedbeds. Consequently the number of quadrats had to be reduced. Furthermore, one of the biodiversity enhancing species (*Mentha aquatica*) was omitted from the study to facilitate the collection of adequate data from the remaining species for statistical analysis.

The main issues that occurred at Rugeley were operational and outside the control of the researcher. The plants within Reedbed 1 died during the second year of the study when they were smothered by a thick mulch created by the standing dead leaf litter collapsing, in the winter storms, into standing water. As the researcher had no control over the operation of the beds the water level could not be lowered to alleviate the problem. Reedbed 2 became hydraulically blocked during the second year and its daily operational use was stopped. Subsequently, the reedbed was only intermittently dosed with effluent to keep the reeds alive. This in turn resulted in damage to the biodiversity enhancing species planted in the experimental plots through herbivory. In addition, the lack of nutrient availability and water resulted in early senescence of the reeds and an unrealistic water regime for the biodiversity enhancing species.

The operational difficulties encountered in the newly refurbished reedbeds at Magna Park commenced with *Phalaris arundinacea* being planted in place of the main treatment species, *Phragmites australis* by the sub-contractor during the bed refurbishment. This was not apparent until the plants became mature enough to develop identifying characteristics, by which time it was too late to restart the study. Hydrological issues soon followed caused by poor workmanship resulting in uneven bed surface and consequently some sections of the beds became flooded whilst other sections became dry, resulting in drought stress to the plants. The drought issue was further compounded in the second year when the main flow of feeder effluent was diverted to phase two of the reedbed refurbishment programme which came on line at that time.

Despite all of the setbacks described above, and the consequent loss of opportunity to collect data, valuable management lessons were learnt. These have been discussed in Section 7 and incorporated into the recommendations and guidance for the incorporation of biodiversity enhancing species into small constructed wetland treatment systems. It is also believed that the experimental design proposed in Section 5 for validating the conclusions drawn from the microcosm studies in the field, was sound.

8.3 Requirements for Further Research

Throughout this study, through literature reviews and the results from the experimental work, requirements for future research have been identified, and are discussed below.

8.3.1 Nutrient Concentration

The current study was undertaken using four different nutrient concentrations, which were based upon reported tertiary effluent values. The use of higher concentrations, more frequent or intermittent dosing (to provide consistent nutrient levels or to replicate storm water runoff), were not explored due to the resource demand this would have required. To extend the options for waste effluent treatment systems where biodiversity enhancing species could be utilised, further research should investigate stronger nutrient concentrations, together with differing chemicals/effluent compositions (where the nutrient levels can be controlled independently), alongside increased and intermittent dosing.

8.3.2 Treatment and Hydraulic Efficiency

The microcosm study did not explore the treatment capabilities of the biodiversity enhancing species or their hydraulic effects, but focused on their survivability. These aspects should therefore be investigated in different types of small scale constructed wetland, especially surface flow reedbeds, where the stems of the vegetation have a filtration potential and hence effect on overall treatment efficiency.

8.3.3 Species Selection

The experimental study using the three wetland species, *Lythrum salicaria, Filipendula ulmaria and Mentha aquatic,* which were chosen to be representative of the vegetation groups present within the National Vegetation Classification S24, S25 & S26 communities (Rodwell, 2000) has proved that they can successfully compete with *Phragmites australis* within a small scale constructed wetland. This study should be extended further to investigate the potential of using additional species to further enhance the biodiversity value of small scale constructed wetlands.

8.3.4 Planting Densities

A higher planting density was employed in the microcosm and field study than those recommended for use with *Phragmites australis* (e.g. by Cooper *et al*., 1996) to expedite the establishment and acclimatisation of the vegetation. Further research should be undertaken to determine the effects of differing planting densities and species source material (e.g. alternative size plug plants, rhizomes and seeding) on both the establishment and sustainability of the biodiversity enhancing species and their cost effectiveness.

8.3.5 Allelopathy

Lythrum salicaria was shown to be adversely affected within the gravel root zone of the microcosms by the presence of *Phragmites australis* roots. Research should be undertaken to determine whether this is allelopathy caused by *Phragmites australis* and if it is, then to identify the chemicals involved. The identification of an allelopathic chemical which reduces the vigour of *Lythrum salicaria,* either on its own or in conjunction with another control method, could help in controlling this species in countries where it is regarded as invasive.

8.3.6 Full Scale Trials

This first study was undertaken using small scale microcosms which was logically to be followed by trials in operational beds over a short period. Since issues arose, particularly associated with the lack of control over the operational management of the reedbeds, it is recommended that full scale trials over a long period are undertaken on both established and newly refurbished/new small constructed wetland treatment systems. The aim of this research should be to study the population dynamics and the effectiveness of the biodiversity enhancing species, and to trial the design and management recommendations made in this thesis. Ideally in this longer term field study the bed operation and management should both be fully controlled by the researcher.

8.3.7 Fauna

During both the microcosm and field study it was observed that a range of invertebrates and birds were using the reedbeds. Future work should be undertaken to quantify the benefits of including the biodiversity enhancing species within a reedbed particularly focusing on the invertebrate population and how far up the food chain any beneficial effects are encountered.

9. CONCLUSIONS

9.1 Introduction

This section provides a summary of the conclusions that have been reached during this research project including a review of how the project's aims and objectives have been met.

Species have been successfully identified, that are not considered to be the typical robust treatment species, but which can be used for biodiversity enhancement within a small scale constructed wetland. It has successfully explored the effect of two different pollutants at varied concentrations, together with the effects of restricting competition on these species. It has also identified operational difficulties when the biodiversity enhancing species were installed in field trials. This data has been used to recommend design and management principles for use with these biodiversity enhancing species within small scale constructed wetlands.

9.2 Aim and Objectives

9.2.1 Aim

The overall aim of the project as stated in Section 1.2 was;

> *'to produce design principles for the implementation, creation and management of biodiversity sections/corridors within monoculture phytoremediation treatment systems.'*

This aim has been achieved through the identification of biodiversity enhancing flora which can compete with the robust treatment species, *Phragmites australis,* at differing pollutant concentrations. The results obtained from, and observations made during both the microcosm study and field experiments has enabled further design principles and management guidance to be produced.

9.2.2 Objectives

This section provides an assessment of the extent to which each of the five objectives outlined in Section 1.2.2 have been achieved.

Objective 1

> *'Undertake a literature review focusing upon the design, management and floral species requirements of horizontal flow constructed wetlands. A literature review of effluents and their parameters will also be undertaken.'*

The literature review provided a brief overview of the types of constructed wetlands, the general floral species utilised and the range of effluents and their pollutants which could be treated. The extensive review undertaken for the original research question, included a study of the comprehensive design manuals for constructed treatment wetlands, and the associated design parameters and equations employed for different pollutants. This informed the subsequent microcosm and field experiment designs employed. The literature review also identified a dearth of published works relating to biodiversity enhancement within constructed treatment wetlands.

The literature review enabled the range of effluents and their associated parameters experienced by constructed wetland systems to be identified. From this nutrients and salinity were selected as the focus of the microcosm study, being two parameters commonly found in domestic and industrial wastewater. The nutrient concentrations used in the microcosms were identified through this study, and appropriate salinity concentrations were selected both in this manner and through the literature review of plants and their tolerance limits.

Objective 2

> *' From the literature review, a range of floral species will be chosen which could prove beneficial in increasing the biodiversity value of constructed wetlands.'*

Because it is commonly used in phytoremediation systems and has been studied extensively, there was a plethora of information on *Phragmites australis*, However, as discussed below relevant information relating to potential biodiversity enhancing species was very limited.

Once the physiological types of flora found in natural wetlands had been explored, emergent and marsh species (i.e. woody perennial, upright herbaceous perennial and creeping perennial) were selected as the groups appropriate for biodiversity enhancement. The final biodiversity enhancing species were then chosen through consultation with community lists of British plant species found in naturally occurring reedbeds.

A further literature review (predominantly presented within Section 3) was undertaken on these species, *Lythrum salicaria, Filipendula ulmaria* and *Mentha aquatic,* for their growth characteristics, their tolerances to pollution and the effects which plant competition has upon them. The literature review found that the majority of papers were not relevant, being focused upon homeopathic oils for *Mentha aquatica* and *Filipendula ulmaria*. Minimal to no relevant information was present for the chosen species tolerances to pollutants, with the data usually consisting of the salinity value of the site which had been surveyed. The species usually formed part of a long list of floral identified within the site and minimal further detailed information for the chosen species was present.

When population dynamics was investigated for the chosen species, again the reference to the species usually formed part of a larger species list for a specific site, such as investigating the long term effect of atmospheric pollution and did not have any significant contribution to this research.

Where studies had been undertaken which measured parameters such as shoot length and root weights, very few of these were of a quality which could be used to inform this research. The majority of sources found were old and undertaken in sub-optimal growing conditions, which would not permit the natural plant structure to develop (i.e. the plants were grown within small pots, thus restricting their root growth and over short periods of time).

Lythrum salicaria was a slight exception to this rule, in that due to its invasive nature within Northern America, recent relevant research has been undertaken to study its growth characteristic and geographical distribution. This has been detailed within Section 3 and Section 6.

Overall the desk study provided a range of information of differing volumes and quality for the individual species. However, useful information was gleaned from the literature review such as the salinity tolerance of *Phragmites australis* which contributed to Objective 3.

Objective 3

> *'Design and implement an experimental microcosm study to identify the suitability of the selected species and their interactions, when subject to different contaminant ranges.'*

Following the literature review a microcosm study was designed to look at the suitability of the biodiversity enhancing species and their interactions when subject to different contaminant ranges.

This study further investigated the interactions of the species through a comparison of unrestricted and restricted root competition.

Although the measurements of the vegetation during the operational phase had to be curtailed to reduce potential damage to the plants and thus invalidating the study, enough data was gathered to identify either statistical differences or trends.

To achieve Objective 3, the following hypotheses were tested for the microcosm study

Hypothesis 1 – *"Where all four chosen floral species survive in the chemical concentrations studied, no single floral species will take over and oust other floral species."*

All species survived the different nutrient concentrations tested under Hypothesis 1 at reasonable area coverage, and one species did not fully take over and oust the other species. As such, Hypothesis 1 was proved.

Within the different salinity concentrations tested under Hypothesis 1, fatalities occurred. Although fatalities occurred, this was not due to competition but due to the tolerance levels of the plants and their inability to survive at the higher salinity concentrations. Although only one species (*Phragmites australis*) survived the highest salinity concentration, it did not take over and oust the other species (at the lower salinity concentrations) through direct competition. As such, for the salinity, Hypothesis 1 was also proved.

Hypothesis 2 – *"Where all four chosen floral species survive in the chemical concentrations studied, no single floral species will take over and oust other floral species, and restricting root competition between the different floral species will have an effect."*

As with Hypotheses 1, all species survived at reasonable area coverage and one species did not fully take over and oust the other species. The results also showed that the root barriers had an effect on the interaction between the different species which varied depending upon the nutrient concentration. As such, for the nutrients, Hypothesis 2 was proved.

Again, as with Hypotheses 1, with the exception of *Phragmites australis,* fatalities occurred at salinity concentrations above the control level, but this was not due to competition but due to the tolerance levels of the plants. Consequently, for the salinity, Hypothesis 2 was proved.

Hypothesis 3 – *"The higher concentrations of the chosen chemical ranges will have an effect on the stem heights or stem widths of the surviving plants."*

For the conditions explored during the microcosm studies, the statistics showed that there was a significant difference in either species stem heights or widths. Hypothesis 3 was therefore proved.

Hypothesis 4 – *"The higher concentrations of the chosen chemical ranges will have an effect on the stem heights or stem widths of the surviving plants, and restricting root competition between the different floral species will have an effect."*

Within both the different nutrient and salinity concentrations tested under Hypothesis 4, the statistics again showed that there was a significant difference in either the stem height or widths of the species within the restricted root microcosms. When a comparison was made for each species between the full competition microcosms and the restricted competition microcosms at each pollutant concentration, there was a mixture of *very highly significant* differences, *highly significant* differences and *significant* differences for either the stem heights or widths along with *no significant* differences. The presence of significant differences shows that the provision of root barriers has a significant effect at certain concentrations. As such, for both nutrients and salinity, Hypothesis 4 was proved.

Hypothesis 5 – *"The higher concentrations of the chosen chemical ranges will have an effect on the above and below ground total biomass of the plants."*

At the different concentrations tested under Hypothesis 5, the results showed that the above and below ground biomass was affected by the different nutrient and salinity concentrations. For nutrients, the Root : Shoot ratio either increased or decreased as the concentrations increased. Whereas it either decreased or caused fatalities as the salinity concentrations increased. Hypothesis 5 was therefore proved for both nutrients and salinity.

Hypothesis 6 – *"The higher concentrations of the chosen chemical ranges will have an effect on the above and below ground total biomass of the plants, and restricting root competition between the different floral species will have an effect."*

The Root : Shoot ratios for both the nutrient and salinity under restricted root competition conditions mirrored those observed for the Hypotheses 5 tests. A comparison of Root : Shoot ratios under full competition and restricted root competition showed that the root barriers had had an effect. Therefore, for both nutrients and salinity, Hypothesis 6 was proved.

Hypothesis 7 – *"The higher concentrations of the chosen chemical ranges will have an effect on the water consumption."*

Within the different nutrient concentrations tested under Hypothesis 7, the results showed that the water usage was affected by the different nutrient concentrations, with the water usage during the peak growing season increasing as the nutrient concentrations increased. Conversely, with increasing salinity concentration, the water usage declined. Thus Hypothesis 7 was proved for both nutrient and salinity as an effect on water consumption was observed.

Hypothesis 8 – *"The higher concentrations of the chosen chemical ranges will have an effect on the water consumption, and restricting root competition between the different floral species will also have an effect."*

For Hypothesis 8, as with hypotheses 7, the results showed that with increasing nutrient and salinity concentrations, the water usage during the peak growing season increased for nutrients, but decreased for salinity. The results also showed that the full competition microcosms used more than their counterparts in the restricted competition microcosms for both nutrient and salinity concentrations. Therefore, for both the nutrients and salinity, Hypothesis 8 was proved.

<u>Objective 4</u>

> *'From results of the microcosm study in Objective 3, implement a field study to investigate the survivability of the floral species when planted within a newly refurbished/created constructed wetland treatment system and also when retrofitting the floral species into an established constructed wetland treatment system.'*

The two field studies were undertaken to investigate Hypothesis 9 in an operational setting *"Where the chosen floral species survive, there will be no difference between retro-planting these species within a mature reedbed, compared to planting these species within a newly created/restored reedbed and no single floral species will take over and oust other floral species"* in an operational setting.

The field studies were designed to enable data to be collected from replicate quadrats for statistical analysis. However, with the operational management of the reedbeds being outside the control of the researcher and the negative issues experienced at both sites, as discussed in Section 6, no sensible data were obtained and thus it was not possible to statistically prove or disprove Hypothesis 9.

However, the results which were obtained, together with regular observation of each of the sites would indicate that it is feasible to incorporate biodiversity enhancing species in newly created/refurbished reedbeds containing *Phalaris arundinacea*. It may also be possible under certain circumstances to retrofit existing reedbeds containing *Phragmites australis* providing specific management recommendations (Section 7) are adhered to. However, the further research as put forward in Section 8 is recommended to confirm these conclusions.

<u>Objective 5</u>

> *'Use the findings of both the microcosm and the field studies to develop design principles to ensure the chosen floral species will be sustainable within a constructed wetland treatment system.'*

The results obtained whilst meeting Objectives 1 to 4 informed the design and management recommendations detailed in Section 7 for successfully incorporating the biodiversity enhancing species studied within a small scale constructed wetland. Section 8 highlighted areas where further research could be undertaken to take this research forward to further explore the effects of different effluent chemicals and concentrations, additional potential biodiversity enhancing species and planting regimes, together with the need for full scale trials.

9.3 Summation

The overall aim of this unique project has been successfully achieved. The literature review, followed by the three and a half year microcosm study and subsequent field experiments, have allowed the identification of suitable species for biodiversity enhancement and the pollution concentrations at which they can be utilised within small constructed wetland effluent treatment systems. The research also identified design principles, that included the use of specific growing media and whether restricting root competition is required, together with operational management guidance. These outcomes have been summarised and presented in Table 7.1.

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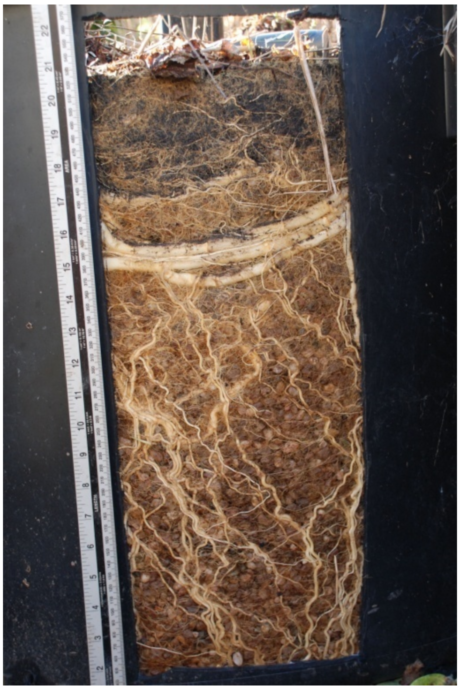

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Figure A19.7: Microcosm 10 *Mentha aquatica* Root Spread

Figure A19.8: Microcosm 10 *Phragmites australis* Root Spread

Figure A19.9: Microcosm 11 *Lythrum salicaria* Root Spread

Figure A19.10: Microcosm 11 *Filipendula ulmaria* Root Spread

Figure A19.11: Microcosm 11 *Mentha aquatica* Root Spread

Figure A19.12: Microcosm 11 *Phragmites australis* Root Spread

Figure A19.13: Microcosm 12 *Lythrum salicaria* Root Spread

Figure A19.14: Microcosm 12 *Filipendula ulmaria* Root Spread

Figure A19.15: Microcosm 12 *Mentha aquatica* Root Spread

Figure A19.16: Microcosm 12 *Phragmites australis* Root Spread

Appendix 20: Root Spread Photographs for the Restricted Competition Microcosms with Salinity Treatment

Figure A20.1: Microcosm 13 *Lythrum salicaria* Root Spread

Figure A20.2: Microcosm 13 *Filipendula ulmaria* Root Spread

Figure A20.3: Microcosm 13 *Mentha aquatica* Root Spread

Figure A20.4: Microcosm 13 *Phragmites australis* Root Spread

Figure A20.5: Microcosm 14 *Lythrum salicaria* Root Spread

Figure A20.6: Microcosm 14 *Filipendula ulmaria* Root Spread

Figure A20.7: Microcosm 14 *Mentha aquatica* Root Spread (Humus Layer Bottom Right)

Figure A20.8: Microcosm 14 *Phragmites australis* Root Spread

Figure A20.9: Microcosm 15 *Lythrum salicaria* Root Spread

Figure A20.10: Microcosm 15 *Filipendula ulmaria* Root Spread

Figure A20.11: Microcosm 15 *Mentha aquatica* Root Spread

Figure A20.12: Microcosm 15 *Phragmites australis* Root Spread

Figure A20.13: Microcosm 16 *Lythrum salicaria* Root Spread

Figure A20.14: Microcosm 16 *Filipendula ulmaria* Root Spread

Figure A20.15: Microcosm 16 *Mentha aquatica* Root Spread (Right Hand Side)

Figure A20.16: Microcosm 16 *Phragmites australis* Root Spread

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Doctor of Philosophy

ASTON UNIVERISTY

January 2017

CD Appendices Contents

Appendices Table List

Appendices Figure List

Appendix 1 Monthly Weather Data August 2007 to October 2010

Please see separate electronic folder within the appendices CD.

Table A1.1: Average and Combined Monthly Weather Data. August 2007 to October 2010.

	Temp. (°C)			**Humidity** (%)			**Pressure** (hPa)			**Wind** (km/h)		**Precip.** (mm)
Date	High	Average	Low	High	Average	Low	High	Average	Low	High	Average	Precipitation
August 2007	28	15.81	8	100	71.90	27	1030	1015.42	991	37	5	50
September 2007	24	14.10	5	100	75.33	37	1033	1020.50	998	45	5	31.7
October 2007	18	10.71	0	100	83.32	48	1038	1023.65	1009	93	2	42.8
November 2007	17	6.77	-4	100	83.90	49	1035	1019.87	992	35	3	50.6
December 2007	15	4.68	-4	100	87.10	58	1041	1019.35	975	52	2	57.6
January 2008	13	6.35	-1	100	86.45	50	1035	1010.29	975	53	5	92.3
February 2008	14	5.21	-6	100	80.86	42	1044	1022.14	988	47	3	27.1
March 2008	13	6.10	-1	100	75.71	39	1036	1005.81	958	58	6	64.1
April 2008	19	7.83	-2	100	79.93	40	1031	1010.13	988	45	5	68.4
May 2008	25	13.48	3	100	74.68	28	1026	1015.65	997	52	5	87.8
June 2008	25	14.63	7	100	70.47	34	1026	1015.80	1002	47	5	38.5
July 2008	28	16.45	7	100	77.90	36	1026	1012.68	994	35	5	91.4
August 2008	24	16.48	7	100	81.16	43	1022	1009.16	986	37	3	97.1
September 2008	21	13.40	4	100	82.70	46	1038	1016.57	985	40	3	100.2
October 2008	20	9.10	-4	100	82.39	44	1031	1013.61	994	40	5	62.5
November 2008	14	6.77	0	100	86.17	42	1034	1013.30	990	37	5	81.5
December 2008	12	3.68	-4	100	87.10	62	1041	1017.87	976	45	5	52.5
January 2009	10	2.61	-7	100	86.61	56	1033	1009.87	970	35	1	64.4
February 2009	13	4.57	-4	100	82.32	50	1033	1014.93	982	32	3	36.6
March 2009	15	8.00	-2	100	72.13	38	1037	1013.84	981	47	3	27
April 2009	19	10.77	4	100	70.93	32	1028	1012.57	992	39	3	37
May 2009	25	13.45	6	100	67.55	33	1032	1017.06	998	42	5	47.8
June 2009	29	16.20	7	100	68.03	28	1029	1017.13	1000	34	6	48.4
July 2009	30	17.19	9	100	72.03	33	1023	1010.77	999	35	6	103.9
August 2009	27	17.42	10	100	73.42	38	1023	1014.42	1003	40	3	44.9
September 2009	24	14.97	6	100	71.60	41	1039	1021.80	990	42	5	14.6
October 2009	20	11.94	2	100	80.26	48	1035	1015.45	994	52	2	49.7
November 2009	17	9.07	2	100	86.27	62	1021	998.73	982	55	5	98.1
December 2009	12	3.19	-5	100	91.84	72	1036	1006.58	985	43	3	55.9
January 2010	9	1.42	-7	100	90.94	59	1044	1016.48	992	41	0	61.6
February 2010	9	2.57	-2	100	91.21	62	1027	1004.14	980	54	5	60.8
March 2010	16	5.90	-6	100	82.03	37	1037	1017.23	981	56	4	50.9
April 2010	19	9.27	0	100	72.17	34	1036	1020.33	999	41	3	39.6
May 2010	27	11.03	0	100	72.90	38	1034	1018.74	1005	37	3	24.6
June 2010	27	15.83	5	100	72.57	29	1031	1018.67	1001	34	1	49.2
July 2010	28	17.39	10	97	73.58	37	1028	1015.61	998	43	2	39.8
August 2010	24	16.84	10	100	74.65	41	1027	1014.13	997	46	3	98.2
September 2010	21	14.70	5	100	76.03	45	1025	1014.13	999	40	3	57.4
October 2010	20	11.32	-1	100	80.29	43	1029	1012.16	989	34	3	51.1

Appendix 2 Harvest Stem Measurements

Please see separate electronic folder within the appendices CD.

Table A2.1: Microcosm 1: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	3.1	1399
2	3.4	467
3	1.5	712
4	1.9	820
5	2.4	448
6	2.9	835
7	4	1087
8	4	1313
9	3.1	819
10	2	642
11	2.7	799
12	2.8	991
13	2.4	1096
14	2.7	290
15	3.2	752
16	2.6	902
17	3.6	458
18	1.9	637
19	3.5	292
20	2.8	485
21	5	1199
22	2.5	863
23	2.2	764
24	2	712
25	2.4	1135
26	2	651
27	2.5	838
28	2.4	582
29	3.1	497
30	2.6	743
31	4.1	767
32	3.1	405
33	1.9	400
34	2.5	231
35	2	741
36	3	1067
37	3.1	1015
38	2.3	844
39	2.4	933
40	2.3	536
41	3.6	621
42	3.2	1091
43	2.4	974
44	1.6	464
45	2.8	1081
46	2.1	352
47	2.8	523
48	2.2	500
49	3.9	1017
50	3	1175
51	3.2	678
52	2.6	628
53	2.5	901
54	3.3	853
55	2.5	805
56	3.5	1236
57	2.8	675
58	2.3	1004
59	2.5	874
60	1.9	711
61	2.4	306
62	2.2	880
63	1.4	380
64	2.8	372
65	2	778

Table A2.1: Microcosm 1: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
66	2.7	800
67	2.9	604
68	2.9	755
69	2.4	786
70	3.5	1166
71	2.3	776
72	2.4	406
73	2.7	941
74	2.8	1060
75	4.5	1127
76	2.9	1184
77	2.4	246
78	2.9	215
79	3.5	993
80	2.3	649
81	1.8	616
82	2.2	764
83	1.6	539
84	2.1	785
85	2.7	671
86	2.7	263
87	2.7	942
88	2.7	999
89	2.7	1149
90	4	1200
91	2.7	662
92	2.2	734
93	3.2	886
94	4.2	926
95	3.7	1031
96	1.9	563
97	3.4	233
98	3	1350
99	2.4	862
100	2.1	694
101	2	730
102	2.1	639
103	2.1	588
104	2.1	514
105	3.9	1721
106	2.6	1204
107	1.9	981
108	2.7	912
109	1.8	1013
110	2.5	1137
111	1.8	864
112	1.7	486
113	2.5	1040
114	2.3	878
115	1.6	504
116	2.2	249
117	2.5	507
118	2.1	1060
119	2	855
120	2.2	459
121	2.7	980
122	2.8	1114
123	2.1	847
124	3.1	1398
125	3	1337
126	2	1106
127	1.6	604
128	2.4	1030
129	2	1022
130	1.8	257

Table A2.1: Microcosm 1: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
131	1.7	834
132	2.1	329
133	2	411
134	2.5	269
135	1.5	622
136	2.5	539
137	2.2	376
138	1.8	644
139	3.3	1586
140	3.3	1068
141	3.1	1052
142	2.5	602
143	2.6	859
144	3.3	796
145	2.4	830
146	2.5	1070
147	3.4	1319
148	3	1489
149	2.1	439
150	2.5	851
151	2.4	1216
152	2.6	1185
153	3.5	761
154	2.2	1228
155	2.1	1096
156	3.4	1007
157	4.2	453
158	3.2	547
159	2.7	1020
160	2.9	1385
161	2.9	1118
162	2.2	972
163	2.2	875
164	2.5	348
165	3.1	532
166	3.5	560
167	2.1	778
168	2.7	1104
169	2.6	906
170	3.3	1199
171	2.4	1015
172	2.7	430
173	2.3	904
174	2	681
175	2.8	1095
176	2	1042
177	1.8	727
178	3.1	817
179	2.5	559
180	2.5	571
181	2.5	1139
182	2.8	1261
183	1.7	840
184	3.4	1318
185	2.5	792
186	3.4	453
187	1.5	631
188	2.5	716
189	2.8	1219
190	2	1064
191	2.4	374
192	2.4	427
193	2.2	367
194	1.9	675
195	4.1	1208

Table A2.1: Microcosm 1: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
196	3	830
197	3	899
198	2.7	995
199	2.8	648
200	2.3	1048
201	2.5	605
202	2.5	791
203	2.5	1025
204	3.1	375
205	1.8	697
206	2.4	1013
207	1.9	815
208	2.4	697
209	3.8	1286
210	1.9	959
211	3	570
212	3	1146
213	1.5	732
214	1.9	760
215	3.2	1391
216	2.5	1147
217	2.8	1111
218	3.1	1259
219	3.3	563
220	2.6	201
221	3.5	943
222	1.4	768
223	3	1005
224	3.1	1131
225	2	857
226	2.5	648
227	3.7	1039
228	2.8	945
229	2.9	867
230	2	983
231	2.8	891
232	3	990
233	3.1	1242
234	3.1	1267
235	1.8	941
236	2.5	767
237	2.3	725
238	3.5	1050
239	3.8	1327
240	3.2	1300
241	2.4	1021
242	2.9	883
243	4	1259
244	2.9	1101
245	2.5	324
246	1.4	576
247	1.8	476
248	3.4	637

Table A2.1: Microcosm 1: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
249	2.9	252
250	3	976
251	1.8	497
252	2.7	1023
253	2.4	1445
254	3	1446
255	2.3	311
256	2.4	882
257	2.6	722
258	2.5	1287
259	2.4	825
260	2.2	692
261	2.7	707
262	3.1	930
263	3	1444
264	2.9	Median Height
265	2.6	480
266	2.6	1305
267	3	357
268	2.5	769
269	3.1	939
270	3.6	550
271	2.8	557
272	3.6	265
273	2	230
274	2	375
275	4.8	141
276	2.5	433
277	3.6	291
278	2.4	257
279	2.5	311
280	2.8	159
281	2.4	179
282	2.8	86
283	1.4	392
284	2.8	127
285	2.1	217
286	1.7	183

Stems	Total Stems	Total Number of Stems	286
		Stems with Inflorescence	33
	Heights (mm)	Max Height	1721
		Min Height	86
		Mean Height	796.2097902
		Mode Height	712
		Median Height	810
	Widths (mm)	Max Width	5
		Min Width	1.4
		Mean Width	2.635314685
		Mode Width	2.5
		Median Width	2.5

Table A2.2: Microcosm 2: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	2.7	808
2	3.4	1248
3	2.9	1032
4	2.6	1053
5	3.5	1206
6	2.9	896
7	3.5	1134
8	3.7	1281
9	3.5	510
10	3.5	1070
11	2.8	485
12	2.5	957
13	3.5	1042
14	3	1116
15	2	758
16	3.2	1111
17	4.9	1285
18	3.8	732
19	3.2	551
20	2.7	1039
21	3.4	1566
22	3.3	1325
23	4.4	1515
24	4.2	1491
25	3.7	1001
26	3.3	1482
27	3.5	1408
28	3.5	1450
29	4.1	1669
30	3.2	1387
31	1.8	839
32	3.1	1370
33	3.5	988
34	2.9	1090
35	2.9	537
36	2.9	1361
37	2.7	1151
38	3	867
39	3.2	720
40	3.2	528
41	2.4	562
42	2.4	97
43	2.6	1080
44	2.5	756
45	3.3	1188
46	2.6	509
47	2.4	762
48	2.4	454
49	1.9	891
50	2.4	1051
51	3.1	1214
52	3.1	905
53	1.8	332
54	3.2	1426
55	1.7	276
56	3.1	656
57	3.5	1477
58	3.7	532
59	2.4	644
60	3	898
61	2.8	419
62	3	871
63	3.5	331
64	2.5	380

Table A2.2: Microcosm 2: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	2.6	675
66	4	1365
67	3.4	704
68	2	425
69	2.2	318
70	2.9	1095
71	3.2	1316
72	4.7	1393
73	2.9	1197
74	3.4	1019
75	2.3	557
76	3.4	1051
77	3.2	230
78	3.6	441
79	3.2	602
80	2	932
81	2.3	776
82	3.1	652
83	3	911
84	2.6	134
85	3.8	1447
86	2.5	1121
87	3	260
88	3.1	1279
89	3.3	1501
90	2.2	806
91	2.4	1196
92	3.8	232
93	2.7	438
94	3	1156
95	2	341
96	2	182
97	3.4	947
98	2.2	609
99	2.3	126
100	2.6	846
101	2.7	704
102	2.4	668
103	2.5	959
104	2.8	540
105	2.1	1270
106	2.6	1188
107	4.3	1424
108	2.5	461
109	3.3	399
110	2	833
111	2.6	1207
112	2.7	1150
113	2.1	602
114	2.3	1045
115	2.6	831
116	2.6	718
117	1.9	792
118	2.3	1021
119	2.8	236
120	3.2	956
121	2.6	1276
122	2.6	588
123	2.4	1267
124	3.4	1280
125	2.9	1175
126	2.1	644
127	2	701
128	1.7	843

Table A2.2: Microcosm 2: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	2.5	1332
130	3.5	622
131	3.4	1562
132	2	920
133	3.6	718
134	3	1241
135	2.5	1069
136	3.1	245
137	2.9	1362
138	2	1048
139	3.4	891
140	2.5	1429
141	2.5	829
142	2.5	1018
143	3	1323
144	3	1475
145	4	618
146	2.6	1616
147	2.7	819
148	2.9	1067
149	2	583
150	2.6	1383
151	1.7	561
152	3.9	274
153	2.9	367
154	2.8	323
155	2.4	529
156	1.6	479
157	2.3	604
158	3.4	1266
159	3.9	1027
160	3.4	1257
161	3.2	445
162	1.6	496
163	2.4	1064
164	3	1293
165	2.5	1288
166	3.1	1194
167	3.9	852
168	3.4	474
169	3	604
170	3.5	643
171	2.5	329
172	4.1	1525
173	4	671
174	3.9	860
175	2.4	955
176	3.4	1228
177	2	936
178	1.6	608
179	2.5	996
180	2.8	789
181	3.2	550
182	4.4	1605
183	4.1	1359
184	3.1	1109
185	2.9	985
186	3.1	1404
187	2.6	1100
188	3.5	646
189	3	923
190	3	720
191	3.5	147
192	3.4	1008

Table A2.2: Microcosm 2: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	2.4	1078
194	3.1	1058
195	2.5	708
196	3.8	1454
197	4.4	1308
198	2.5	902
199	3.1	444
200	2	972
201	3.7	403
202	1.8	609
203	2.5	321
204	3.4	1109
205	2.6	743
206	3.3	1077
207	2.2	921
208	4	1261
209	4.6	973
210	3.1	1334
211	2.4	975
212	2.6	1089
213	4.2	1513
214	2.6	1014
215	3	1111
216	2.7	1176
217	2.9	717
218	1.9	611
219	3.6	1321
220	2.3	941
221	2.4	1071
222	3.4	1656
223	4.8	262
224	2.8	1062
225	4.1	1372
226	2	899
227	3	1205
228	1.7	611
229	3.4	1335
230	2.9	360
231	1.9	390
232	1.9	1082
233	2.1	861
234	2.3	1121
235	3.5	507
236	1.8	585
237	1.4	320
238	2	934
239	2.5	268
240	2.6	1042
241	4.2	1371
242	2.2	910
243	3.8	514
244	2.9	807
245	1.7	721
246	2.5	912
247	3	1285
248	2	351
249	1.5	392
250	1.5	516
251	1.5	608
252	2.2	922
253	3.6	1452
254	0.9	304
255	3.1	132
256	1.9	798

Table A2.2: Microcosm 2: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
257	1.3	491
258	3	1283
259	3.2	1274
260	3.2	1473
261	4.9	1094
262	3.8	1708
263	3.1	1459
264	1.9	Median Height
265	2.9	809
266	3	1141
267	3.3	1169
268	2.2	893
269	2.5	918
270	2.6	916
271	1.8	460
272	2.2	579
273	2.9	1394
274	2.5	1097
275	3	1170
276	2.2	968
277	3.2	1518
278	3.4	1121
279	2.8	1113
280	3	804
281	2.2	458
282	1.9	534
283	2.6	828
284	2.9	814
285	2.2	688
286	2.4	541
287	2.1	619
288	2.5	888
289	4.5	1539
290	4.4	1742
291	2.1	432
292	2.3	258
293	2.9	146
294	2.6	1204
295	2.5	1063
296	3	1192
297	4.3	1486
298	2.4	1121
299	2.1	815
300	3	1416
301	2	812
302	2.5	1134
303	3.9	1536
304	4.2	1431
305	2.1	878
306	1.8	380
307	2.8	975
308	4.1	1220
309	4.1	780
310	2.1	504
311	3	1452
312	2.6	335
313	3.5	174
314	2.2	884
315	2.2	808
316	2.5	382
317	2.9	1195
318	2.7	1253
319	2.4	777
320	2.6	843

Table A2.2: Microcosm 2: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
321	2.3	658
322	4.8	1265
323	2.5	718
324	2.8	823
325	2.6	851
326	2.2	890
327	3	1224
328	1.8	339
329	2.8	796
330	2.5	871
331	3.2	1291
332	2.6	939
333	3.3	1304
334	2.9	1296
335	2.8	432
336	3.2	1502
337	2.1	267
338	2.4	562
339	3.1	1144
340	2.8	491
341	2.9	332
342	3.6	332
343	2	701
344	3	361
345	3.5	952
346	4.1	1409
347	3.9	1414
348	2.7	468
349	3.1	532
350	2.4	1497
351	2.7	1009
352	3.4	1046
353	4.1	1199
354	2.4	185
355	3.3	318
356	2.9	221
357	3.4	217
358	2.2	393
359	3.1	325
360	4.6	590
361	2.1	798
362	1.7	604
363	2.5	691
364	2.7	397
365	2.8	1021
366	2.3	947
367	2.1	853
368	2	852
369	2.3	854
370	3.8	1211
371	2.2	701
372	2.2	728
373	1.6	816
374	2.4	861
375	2.5	896
376	4.3	159
377	2	478
378	2.2	827
379	3.3	911
380	3.4	314
381	2.5	804
382	1.9	362
383	4	377
384	3.3	352

Table A2.2: Microcosm 2: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
385	2.1	367
386	2.4	191
387	2.4	266
388	3.7	170
389	2.2	125
390	1.8	361
391	2.4	388
392	3.4	522
393	3.5	518
394	2	618
395	3.6	280
396	1.7	334

Stems	Total Stems	Total Number of Stems	396
		Stems with Inflorescence	44
	Heights (mm)	Max Height	1742
		Min Height	97
		Mean Height	863.6186869
		Mode Height	1121
		Median Height	874.5
	Widths (mm)	Max Width	4.9
		Min Width	0.9
		Mean Width	2.842929293
		Mode Width	2.5
		Median Width	2.8

Table A2.3: Microcosm 3: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	3	1287
2	2.7	1374
3	3.2	1215
4	3.6	1691
5	3.6	1689
6	1.9	716
7	2.4	886
8	2.2	899
9	3.4	1086
10	4.3	1924
11	4.3	1686
12	3.6	1932
13	4	1382
14	3	594
15	2.6	1062
16	3.4	1628
17	3.9	1578
18	4.4	953
19	2.3	1068
20	2.5	1018
21	2.4	1116
22	2.2	1008
23	3	888
24	2.9	1339
25	2.6	1124
26	3.7	1724
27	2.6	518
28	4.8	1524
29	3.3	649
30	3	1109
31	2.4	1020
32	3.6	1892
33	3.7	92
34	3.4	1152
35	2.9	1601
36	3.9	1266
37	4	1806
38	3.6	1544
39	2.9	1278
40	3	1263
41	3.4	1401
42	2.9	1371
43	4	926
44	3.6	1359
45	3.2	1609
46	4.1	1842
47	2.9	1356
48	3.3	1709
49	3.4	1399
50	3.8	1855
51	4.3	1733
52	4.9	1519
53	2.9	739
54	2.9	1168
55	2.9	637
56	2.4	1062
57	3.5	1371
58	2.7	992
59	3.5	1573
60	3.1	830
61	4.1	926
62	3.4	1620
63	3.6	1692
64	5.5	2088

Table A2.3: Microcosm 3: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	1.3	627
66	3.7	1525
67	2.7	753
68	3.1	882
69	3.9	1891
70	3.7	1522
71	4.1	647
72	2.3	958
73	3.3	918
74	2.6	1282
75	3.7	1671
76	3.3	1195
77	3.8	1729
78	3.1	797
79	2.9	804
80	3.3	821
81	4.2	1504
82	3.1	971
83	3.1	1402
84	3.2	314
85	2.6	810
86	3	1295
87	4.6	1467
88	3.5	1736
89	3.6	1596
90	3.8	1878
91	2.3	786
92	3.6	667
93	2.8	874
94	2.5	894
95	3.8	1815
96	4.3	1710
97	3.3	723
98	2.4	966
99	1.9	919
100	3.8	707
101	3.1	469
102	4.1	1778
103	3.1	301
104	3.3	885
105	4.3	698
106	2.6	640
107	3.1	1099
108	2.1	800
109	1.4	416
110	3.6	724
111	2.9	1019
112	3.9	1660
113	4.3	1792
114	4	1835
115	3.6	1402
116	3.8	1839
117	4	1772
118	3.5	824
119	4.2	1484
120	4.3	1731
121	5	1981
122	3.6	1500
123	3.1	448
124	4.2	685
125	3.8	1620
126	4.2	754
127	3.8	1718
128	4.5	1911

Table A2.3: Microcosm 3: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	4.4	810
130	3.8	771
131	3.3	1295
132	3.8	1371
133	4.2	1660
134	1.5	507
135	4.6	1069
136	3.8	910
137	3.6	1249
138	4.2	1576
139	3.3	1571
140	4.8	1911
141	3.5	1025
142	1.9	444
143	4	1450
144	3.6	1435
145	4	1797
146	2.4	564
147	4.1	1508
148	2.6	1331
149	2.9	911
150	3.6	1463
151	3.5	1328
152	3.6	686
153	4.1	1834
154	3.7	972
155	4	699
156	4.3	1501
157	3.9	1581
158	5.1	1732
159	3.6	1070
160	5.1	1752
161	4	1698
162	3.2	1056
163	3.9	811
164	3.5	695
165	3.6	615
166	3.7	1574
167	5.4	1978
168	4.1	1468
169	3.8	1661
170	4.6	1868
171	3.4	1302
172	3.7	1592
173	3.7	1520
174	3.5	1292
175	3.7	1672
176	4.5	2011
177	3.6	681
178	3.2	1310
179	3.2	1563
180	3.6	1420
181	4.6	904
182	4.4	1575
183	3.3	899
184	3.5	823
185	4	941
186	3.5	1104
187	4.6	1055
188	3.4	1756
189	3	863
190	4.1	906
191	4.2	1636
192	3.4	1422

Table A2.3: Microcosm 3: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	3.8	1470
194	4.2	1518
195	4	1170
196	2.4	824
197	4	1209
198	3.3	1393
199	3.8	1882
200	2.8	1128
201	5	1836
202	3.8	1686
203	3.7	1667
204	3.7	1154
205	3.4	1501
206	4.1	1455
207	3	680
208	4.2	1675
209	3.5	1621
210	3.4	1497
211	3.6	1616
212	3.9	1253
213	3.3	1287
214	3.8	1752
215	3.9	2021
216	4.1	1495
217	3	1736
218	4.5	2055
219	3.4	1259
220	3.6	1293
221	4.1	1534
222	3.8	1665
223	4.5	1012
224	4.2	1393
225	4	1769
226	3.2	1014
227	4	1506
228	5	1887
229	4.5	1832
230	3.2	1231
231	2.8	1221
232	3.5	1697
233	2	329
234	3.6	1521
235	4.6	1564
236	4.5	1292
237	3.4	1680
238	5	1925
239	3.5	1711
240	3.7	1744
241	3.6	1435
242	3.8	1608
243	2.7	1051
244	4.5	578
245	3.7	546
246	4.2	304
247	3.6	786
248	3.9	2004
249	3.5	1438
250	4	1220
251	4.1	1579
252	2.2	888
253	3.5	1678
254	4.9	1263
255	2.5	720
256	3.1	1170

Table A2.3: Microcosm 3: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
257	2.8	677
258	3.4	819
259	3.1	1001
260	3.6	995
261	2.8	1125
262	3.1	1393
263	3.6	502
264	4.5	Median Height
265	2.4	1079
266	3.6	1403
267	3.6	1539
268	3.2	1432
269	3.6	1770
270	3.5	527
271	3.3	299
272	3	515
273	2.1	467
274	3.1	500
275	1.6	193
276	3.5	1229
277	4.2	1114
278	2.7	997
279	3.4	1018
280	2.4	636
281	4.7	435
282	3.3	1822
283	5	701
284	2.4	1041
285	3.3	1552
286	2.1	448
287	2.1	706
288	3.3	1681
289	4.2	1249
290	2.8	1236
291	3.5	1186
292	3.5	1574
293	3.7	1595
294	2.5	1365
295	3.7	1642
296	4.4	2021
297	5.2	1860
298	3.8	1671
299	3.5	1599
300	4.1	1720
301	3.1	1223
302	3.7	1744
303	2.8	1450
304	3.5	1266
305	3.5	1648
306	3.6	1272
307	3	1282
308	2.9	1020
309	4	1853
310	3.6	1941
311	2.7	918
312	2	1209
313	3	1304
314	5	1850
315	3.5	1473
316	3.6	1811
317	2.7	920
318	2.8	1591
319	4.1	1945
320	2.2	1351

Table A2.3: Microcosm 3: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
321	3.5	1876
322	3	1481
323	4.2	1812
324	2.6	921
325	4.1	589
326	2.3	297
327	2.9	945
328	2.9	1005
329	2.8	1442
330	3	745
331	3.1	1403
332	3.6	1717
333	3.1	952
334	4.6	1692
335	4.5	1632
336	4	1745
337	3.3	1620
338	4.3	1697
339	2.7	1014
340	3.3	1710
341	1.9	333
342	2.5	604
343	4.2	1887
344	3.1	1451
345	3.4	1446
346	2.2	1415
347	4.2	1435
348	3.2	1057
349	2.5	1045
350	3.4	1570
351	4.5	508
352	3.9	577
353	3.3	1097
354	3.6	1163
355	2.6	1186
356	2.7	908
357	2.4	901
358	3.4	1317
359	4	1686
360	2.7	453
361	3.5	650
362	2.1	467
363	6.5	1640
364	3	925
365	2.6	1197
366	3.1	1650
367	3.5	502
368	4.1	904
369	2.7	1278
370	3	409
371	2.3	1057
372	3.1	1232
373	3.4	1527
374	2.3	1117
375	3.1	524
376	2.5	912
377	3	374
378	2.6	1649
379	3.4	1832
380	3.5	1827
381	3.1	1514
382	3.3	1501
383	2.5	841
384	3.7	1926

Table A2.3: Microcosm 3: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
385	2.9	1659
386	2.8	887
387	3.4	1696
388	2.5	1516
389	2	1231
390	4	1748
391	2.8	1007
392	2.4	659
393	3.9	1334
394	2.2	1293
395	3.1	1152
396	2.8	660
397	5.3	1981
398	2.5	317
399	2.7	987
400	3.1	839
401	2.9	1295
402	3.6	241
403	4	480
404	5	870
405	5.7	1340
406	4	504
407	3	1609
408	3.1	586
409	3	1805
410	2.4	955
411	3.5	1468
412	4.7	790
413	3	468
414	4.8	189
415	3.3	215
416	4.2	1740
417	3.1	166
418	2.5	1105
419	2.5	940
420	3.7	1275
421	2.7	1192
422	2.4	1049
423	3	1005
424	1.9	795
425	1.8	1141
426	2	326
427	2.8	358
428	2	491
429	4.5	638
430	2.6	1143
431	3.4	1753
432	2.6	400
433	2.5	1075
434	2.5	588
435	3.7	206
436	4.9	603
437	3	1543
438	2.9	1641
439	3	1396
440	2.8	406
441	2.4	1065
442	2.4	1206
443	3.1	1245
444	2.4	1042
445	3.5	501
446	1.8	1194
447	2.2	1404
448	2.7	1358

Table A2.3: Microcosm 3: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
449	2.6	1758
450	2.7	1646
451	2.3	802
452	5	755
453	2.6	1624
454	2.1	1005
455	2.7	1205
456	3	1379
457	2.4	1315
458	2.1	765
459	1.7	1185
460	2.7	911
461	2.3	530
462	4.5	873
463	2.8	257
464	4.5	762
465	3.8	1060
466	2	578
467	2.6	695
468	2.6	110
469	1.9	526
470	3.5	280
471	2	704
472	2.9	445
473	3.3	333
474	3.5	373
475	4.5	428
476	2.5	255
477	2.9	247
478	4.3	270
479	3.2	285
480	3.3	277
481	4.1	495
482	2.3	310
483	2.2	988
484	2.7	1533
485	2.8	1485
486	3.4	1056
487	3	1183
488	5.1	1806
489	5.4	1882
490	5	1439
491	2.7	1475
492	6.2	1992
493	2.3	581
494	3.2	1626
495	3.7	1577
496	4	1730
497	4.2	1590
498	5.1	838
499	3.5	962
500	3	1498
501	3	1350
502	4.6	1110
503	3.1	930
504	3.7	1963
505	3.8	1842
506	5.4	1978
507	3.4	1543
508	2.9	1545
509	5.3	1964
510	3.3	1362
511	3.5	1488
512	2.6	1061

Table A2.3: Microcosm 3: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
513	3	1243
514	3.5	1570
515	2.3	1519
516	2.2	1058
517	1.8	655
518	2.2	546
519	2.7	321
520	2.8	818
521	3.4	459
522	2.4	682
523	3.3	546
524	4.2	364
525	3	744
526	3.2	318
527	2.2	301
528	4	123
529	2	451
530	3.6	300
531	3.9	499
532	3.4	192
533	4.5	276
534	3.6	181
535	4.9	513
536	3.8	602
537	2.3	612
538	2	690
539	2.6	470
540	5	170
541	4.5	128
542	4.3	194
543	3.2	172
544	2.9	285
545	3.3	209
546	3.5	432
547	3.4	472
548	2.6	158
549	3.1	392
550	3.7	316
551	2.2	211
552	3.6	215
553	3.6	246
554	3	427
555	4.9	366
556	2.6	652
557	3.3	349

Table A2.3: Microcosm 3: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)

Stems	Total Stems	Total Number of Stems	557
		Stems with Inflorescence	67
	Heights (mm)	Max Height	2088
		Min Height	92
		Mean Height	1141.030521
		Mode Height	1686
		Median Height	1186
	Widths (mm)	Max Width	6.5
		Min Width	1.3
		Mean Width	3.385251799
		Mode Width	3.6
		Median Width	3.4

Table A2.4: Microcosm 4: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	3.8	1473
2	4.8	1067
3	2.6	968
4	3.2	1021
5	1.9	479
6	5.1	874
7	4	1541
8	5.1	1178
9	3.5	1382
10	4.3	848
11	3.5	1646
12	3.2	1547
13	4	348
14	3.2	1303
15	2.7	374
16	4.7	1851
17	5.1	2131
18	3.5	1704
19	4.1	1047
20	2.6	1311
21	3.6	1713
22	3.6	1129
23	5.6	928
24	5.2	1791
25	2.6	1076
26	3.9	1543
27	3.9	547
28	3	432
29	4.2	1584
30	4.5	934
31	2.9	1246
32	4	1394
33	4.4	837
34	2.7	1267
35	4	1029
36	4.3	688
37	4.2	1308
38	3.7	710
39	2.9	636
40	3.2	1311
41	4.4	1391
42	3.4	1445
43	3	1509
44	4.8	1962
45	3.4	1344
46	3.5	1414
47	6.5	1967
48	3.3	1226
49	4.3	1411
50	5.6	995
51	5.5	1647
52	3.7	1535
53	3.5	1562
54	2.4	537
55	1.9	906
56	2.3	560
57	2.1	652
58	3.5	1159
59	3.2	2035
60	3.6	1177
61	3.3	1185
62	3.5	1580
63	4.6	1727
64	1.8	908

Table A2.4: Microcosm 4: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	3	1310
66	3	1193
67	4	649
68	3.6	1675
69	3.5	1238
70	3.2	1286
71	3.4	1742
72	3.2	653
73	3.6	1842
74	3.3	1411
75	3.4	1584
76	4.5	1654
77	3.9	1534
78	3.3	1644
79	3.9	1801
80	5.4	1709
81	2.9	1589
82	3.2	902
83	2.3	1465
84	3.7	710
85	4.8	2129
86	5.4	1139
87	3	1101
88	4.2	1947
89	5.6	2270
90	2.8	538
91	4.1	1557
92	2.9	1535
93	2.6	1278
94	2.5	612
95	4.5	1228
96	5.1	1630
97	2.5	980
98	4.2	1471
99	3.4	1214
100	5.4	1651
101	5.3	1400
102	4.1	1401
103	3.9	1631
104	4.5	1686
105	2.7	921
106	5.2	1689
107	5.2	1811
108	3.4	1157
109	5.1	1747
110	1.7	597
111	3.6	1494
112	2.5	1073
113	2.5	412
114	3.3	687
115	4	1185
116	4.2	1487
117	3.3	682
118	4.2	1225
119	2.5	1269
120	2.7	642
121	3.5	149
122	4.2	869
123	3.8	1211
124	4.4	1260
125	2.5	935
126	3.5	716
127	3.2	541
128	5.2	1673

Table A2.4: Microcosm 4: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	4.6	1721
130	4.3	1879
131	3.9	1504
132	4.9	1877
133	2	665
134	2.7	1383
135	4.5	291
136	3	840
137	2.3	798
138	2.5	612
139	3.9	1368
140	3.6	1067
141	3.2	1506
142	3	1447
143	2.6	1251
144	3	1111
145	3.7	1442
146	2.8	1192
147	4.9	2088
148	2.2	1101
149	3.4	1220
150	2.8	1134
151	3.3	1592
152	2.7	1143
153	2.8	1972
154	3	1453
155	2.8	1246
156	4.3	2051
157	4.7	1504
158	6.8	2253
159	2.7	622
160	3.7	538
161	4.6	2037
162	5.2	374
163	3.6	1650
164	4.5	717
165	3.5	1541
166	3.5	1632
167	5.8	2178
168	5.8	2038
169	3.5	1417
170	2.1	362
171	3.2	288
172	3.2	814
173	4.3	1993
174	4.8	1891
175	4.8	960
176	2.4	1280
177	2.5	1125
178	2.7	836
179	2.6	932
180	3.2	1015
181	3.1	1218
182	3.1	1634
183	5.7	172
184	3.8	441
185	5.6	1391
186	3.3	801
187	2.9	425
188	4	1217
189	3.2	1342
190	2.5	876
191	3.2	1014
192	3.1	1040

Table A2.4: Microcosm 4: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	2.1	691
194	3.2	968
195	2.5	537
196	3.8	580
197	2.7	671
198	2.7	523
199	2.6	919
200	3.6	1179
201	4.3	1111
202	2.8	1354
203	3.2	1087
204	2.8	1257
205	3.9	1140
206	4.3	651
207	5.8	2096
208	2.7	499
209	2.5	990
210	4.1	1571
211	3.4	1068
212	2.2	291
213	1.7	1123
214	3	361
215	2.9	1345
216	2.2	430
217	2.4	403
218	2.7	1321
219	2.5	1142
220	3.5	290
221	1.6	341
222	3	744
223	2.8	1256
224	2.5	399
225	3.8	1652
226	1.7	945
227	4.3	647
228	5.7	2233
229	3.7	891
230	3.5	1189
231	2.8	1255
232	4.4	1445
233	3.1	365
234	5	291
235	2.2	359
236	2	307
237	3.5	450
238	2.5	195
239	1.5	320
240	5.4	1321
241	2.1	377
242	2.6	358
243	2.7	1103
244	3	1433
245	4.5	914
246	3.5	1405
247	3.7	1321
248	3.2	1563
249	3.1	1437
250	2.5	1335
251	2.5	1360
252	3.3	1631
253	2.5	1191
254	1.2	335
255	1.8	264
256	3	1380

Table A2.4: Microcosm 4: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
257	3.5	1524
258	3.5	1261
259	3.1	316
260	3.5	1205
261	3.5	807
262	3.7	1470
263	3.8	1331
264	2.5	Median Height
265	1.9	317
266	2.2	243
267	3.4	1565
268	3.3	1154
269	3.5	1200
270	3.6	1485
271	2.8	1198
272	4.3	1442
273	2.3	252
274	3.3	1143
275	2.3	602
276	3.1	971
277	5.5	1368
278	3.6	1009
279	4.5	197
280	5.8	1409
281	3	1464
282	1.7	384
283	2.8	944
284	3.4	1231
285	3.7	575
286	3.5	1550
287	2.7	1517
288	2.8	278
289	2.8	301
290	2.1	1083
291	4.6	975
292	2.9	1297
293	4.3	956
294	2.3	548
295	2.6	1061
296	3	1427
297	3.1	1609
298	4	1866
299	2.5	1471
300	1.8	1077
301	3.1	1294
302	4.6	1025
303	3.7	1534
304	3	974
305	2.1	742
306	3.3	489
307	2.3	874
308	2.4	505
309	3.2	1027
310	2.5	967
311	2.6	498
312	3.6	799
313	3.9	1487
314	4	1383
315	4.9	1693
316	4	1451
317	3	1097
318	4.3	1483
319	4.6	1362
320	3.5	1133

Table A2.4: Microcosm 4: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
321	5	1141
322	4	1500
323	3	1015
324	3.5	1106
325	2.1	504
326	3.1	950
327	2.2	372
328	3.7	1258
329	1.8	1012
330	2.6	864
331	4.2	1263
332	3.5	677
333	3.7	1448
334	2	692
335	2.2	807
336	3.2	989
337	4.2	679
338	3.8	1259
339	3.4	1743
340	3.3	1250
341	2.1	264
342	3.6	478
343	4.5	1292
344	3.7	1583
345	2.6	1245
346	1.4	634
347	2.6	664
348	3.1	615
349	3.3	495
350	2.3	1071
351	3.6	1865
352	3.4	1539
353	2.6	1761
354	4.4	1536
355	3.6	168
356	4.7	1935
357	3.9	1869
358	4	2007
359	2.3	1154
360	2.8	786
361	3.8	1700
362	2.2	473
363	2.9	1151
364	1.9	478
365	1.8	1115
366	2.9	641
367	4	1633
368	3.3	1596
369	3.3	1159
370	2.6	1284
371	2.7	1231
372	2.8	1209
373	5.7	1838
374	2.9	951
375	5.4	1929
376	2.8	1386
377	3	1527
378	3.1	1401
379	4.2	1249
380	2.9	1311
381	2.8	1486
382	2.5	876
383	2.5	1363
384	3.9	1422

Table A2.4: Microcosm 4: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
385	3.5	1724
386	4.4	1782
387	4.6	1744
388	2.2	1100
389	3	1503
390	3.1	1771
391	3	1635
392	3.9	1035
393	2.5	1361
394	2.7	1181
395	3.5	1298
396	4.9	345
397	3	664
398	2.4	757
399	3.8	1132
400	3.8	708
401	3.1	1754
402	2.5	1231
403	5	1781
404	4	1661
405	3	1302
406	4	1539
407	3.9	1692
408	4.5	1722
409	3.8	397
410	3.2	1634
411	3.5	682
412	4.5	1626
413	4	1091
414	4.9	797
415	2.8	459
416	3	271
417	3.1	1467
418	2.3	567
419	2.8	921
420	3.4	1614
421	3.2	617
422	3.4	1395
423	3.1	1451
424	2.6	888
425	4.5	869
426	3.1	1001
427	2.6	650
428	2.5	468
429	4	571
430	3.1	802
431	2.5	1007
432	3.6	1372
433	3.9	760
434	3.1	331
435	4.6	1325
436	2.7	1103
437	3.9	1294
438	2.5	1013
439	3.2	947
440	2.3	1039
441	4.2	1080
442	3.4	1600
443	3.5	371
444	2.5	568
445	2.2	1237
446	3.3	775
447	2	1094
448	3.6	1372

Table A2.4: Microcosm 4: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
449	2	668
450	4	921
451	2.4	1029
452	5.1	1407
453	3	1375
454	3.7	1411
455	3.9	1632
456	2.4	432
457	3.8	441
458	3	1384
459	3.7	1356
460	3.4	1567
461	2.2	579
462	3.9	1289
463	1.8	433
464	3.4	1344
465	3.3	375
466	2.4	955
467	3.7	1509
468	2.4	274
469	2.7	562
470	3.7	870
471	1.7	469
472	2.8	1205
473	2.2	842
474	4.2	1273
475	2.6	844
476	2.6	15
477	2	711
478	2	233
479	2.6	471
480	4.9	1627
481	2.4	883
482	4.3	1646
483	2.7	859
484	4.3	1430
485	3.1	592
486	3.7	1111
487	2.4	392
488	4.3	1527
489	3.7	1481
490	3.9	1047
491	4.3	1582
492	3.5	1132
493	3.7	855
494	2.3	1182
495	3.4	1508
496	4.7	1583
497	3.7	1386
498	2.7	578
499	4.5	1417
500	5.1	1715
501	3.6	456
502	5.4	611
503	5.6	1371
504	3.2	1444
505	3.5	1062
506	4.2	665
507	3.8	1499
508	4.2	723
509	3.3	1265
510	5.3	1331
511	3	1377
512	3	1287

Table A2.4: Microcosm 4: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
513	2.4	1060
514	3.6	1332
515	3.2	1312
516	4.7	661
517	4.2	1116
518	5.1	1674
519	3.5	1254
520	4.2	1682
521	4.1	1281
522	1.7	358
523	2.6	988
524	2.8	912
525	3.9	1530
526	3	1002
527	2.5	1073
528	2.1	618
529	3.6	1271
530	4.1	452
531	3.8	289
532	2.6	1146
533	3.2	934
534	2.6	781
535	2.5	606
536	4.2	1277
537	2.8	703
538	2.5	792
539	1.9	651
540	4	1231
541	3.7	558
542	1.9	259
543	2.8	1463
544	3.1	397
545	2.7	1451
546	3.1	397
547	3.4	1562
548	2.8	994
549	3.2	1625
550	2.8	313
551	1.9	248
552	3.1	1304
553	2.5	312
554	2.5	607
555	1.9	789
556	3	1090
557	4.2	1544
558	2.4	1073
559	2.4	313
560	2	392
561	2.8	291
562	2.4	231
563	2.2	445
564	2.5	369
565	2.6	811
566	2.7	1047
567	1.4	271
568	2.5	1442
569	3.6	1280
570	3.1	450
571	3.9	1487
572	2.8	1275
573	2.1	712
574	2.5	1311
575	2.5	653
576	2.6	1150

Table A2.4: Microcosm 4: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
577	2.8	1395
578	2.9	691
579	2.2	1090
580	2.2	262
581	2.4	132
582	2.4	347
583	1.8	289
584	5.2	1272
585	3	1321
586	3.4	1215
587	3.6	1302
588	2.1	911
589	2.6	552
590	3.8	470
591	1.8	211
592	1.8	278
593	2.2	291
594	2.9	146
595	2.2	164
596	2.1	281
597	2.1	286
598	1.7	172
599	2.2	731
600	4.1	1532
601	4.9	1315
602	2.5	1363
603	2	994
604	4	356
605	1.8	864
606	2.5	842
607	3.2	1307
608	2.6	847
609	3.1	1113
610	3.4	427
611	2.1	659
612	3.1	431
613	4.9	1171
614	3	1112
615	2.5	801
616	3.1	1287
617	2.4	395
618	3.1	521
619	3.5	1345
620	2.5	556
621	4.8	373
622	2.6	1220
623	2	241
624	3.3	344
625	2.4	345
626	2.7	1187
627	4	1607
628	4.3	1020
629	3.5	1286
630	2.4	405
631	2.7	433
632	3.3	1066
633	4.5	1299
634	3.7	1500
635	3.9	1418
636	4.7	1552
637	3.7	1314
638	2.4	704
639	3.3	1455
640	3.5	1036

Table A2.4: Microcosm 4: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
641	3.4	917
642	3.3	690
643	4.3	560
644	3.6	201
645	5.3	417
646	4.3	422
647	4.6	1231
648	4	1327
649	3.5	1039
650	4.1	1574
651	4.8	1567
652	3.1	1343
653	3	1725
654	2.8	686
655	3.5	1274
656	4.4	711
657	2.4	413
658	2.8	997
659	2.1	414
660	2.3	639
661	2.7	734
662	3	675
663	3.7	1364
664	3.6	1444
665	4.4	1286
666	3.7	1530
667	3.6	594
668	2.7	1084
669	2.8	599
670	3.7	935
671	2.3	406
672	3.2	560
673	2.9	327
674	3.1	304
675	2.5	132
676	2.2	143
677	2.7	297
678	2	277
679	3.4	184
680	2.4	221
681	3.2	194

Table A2.4: Microcosm 4: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)

Stems	Total Stems	Total Number of Stems	681
		Stems with Inflorescence	112
	Heights (mm)	Max Height	2270
		Min Height	15
		Mean Height	1055.18649
		Mode Height	291
		Median Height	1111
	Widths (mm)	Max Width	6.8
		Min Width	1.2
		Mean Width	3.328193833
		Mode Width	2.5
		Median Width	3.2

Table A2.5: Microcosm 5: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	2.8	1141
2	3.2	343
3	1.6	235
4	1.8	283
5	3.2	619
6	1	175
7	2.4	933
8	2	552
9	3.7	1145
10	2	333
11	1.8	601
12	1.5	503
13	1.8	752
14	1.6	725
15	2	175
16	1.8	941
17	1.6	781
18	1.9	766
19	1.3	261
20	2.6	855
21	1.1	651
22	0.8	485
23	1.6	250
24	1.2	513
25	2.9	765
26	1.6	593
27	1.5	493
28	1.4	530
29	3	255
30	1.9	528
31	1.5	500
32	2.3	800
33	2.2	832
34	2.4	503
35	1.8	397
36	1.6	430
37	2.2	371
38	2.5	323
39	2.2	455
40	2	640
41	3.2	1184
42	1.5	718
43	1.8	376
44	1.5	595
45	2.5	379
46	2	746
47	1.7	778
48	1.7	853
49	2	508
50	2.4	740
51	1.8	642
52	1.5	708
53	1.9	730
54	1.3	548
55	1.8	785
56	3.3	1034
57	1.5	596
58	2.4	743
59	1.4	566
60	2.3	735
61	2.2	633
62	2.2	760
63	1.5	857
64	2.5	708

Table A2.5: Microcosm 5: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	2.2	221
66	1.5	581
67	2.3	710
68	2.1	636
69	2.8	282
70	1.8	634
71	2.2	640
72	2.5	395
73	2.2	249
74	1.5	355
75	2.3	728
76	2.2	819
77	3.1	336
78	2.5	827
79	3.7	900
80	1.9	243
81	1.8	577
82	2.4	721
83	1.4	569
84	1.1	316
85	2.2	615
86	2	736
87	2	923
88	2.8	896
89	1.6	583
90	2.1	712
91	2.1	635
92	2.5	951
93	3.2	940
94	1.5	319
95	2.3	510
96	2.2	471
97	1.7	832
98	2	740
99	1.7	185
100	1.4	526
101	2	234
102	1.9	552
103	1.2	224
104	2.1	432
105	1.8	513
106	2.5	364
107	3.7	233
108	2.3	850
109	2.1	415
110	2.9	132
111	3	561
112	2.2	705
113	1.6	732
114	1.5	806
115	1.9	565
116	1.8	554
117	2.1	687
118	1.6	274
119	2	498
120	1.8	586
121	2.7	917
122	1.7	643
123	2.1	710
124	1.5	443
125	1.8	559
126	2.3	719
127	2.9	364
128	1.1	412

Table A2.5: Microcosm 5: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	2.5	683
130	2.2	464
131	2.1	318
132	1.7	474
133	3.4	131
134	0.7	455
135	1.4	683
136	1.5	706
137	2.8	293
138	1.7	531
139	0.7	703
140	1.3	261
141	2.4	155
142	1.4	599
143	1.3	587
144	1.8	466
145	1.5	578
146	2	306
147	2.7	23
148	1	309
149	2	204
150	3.1	248
151	2.6	264
152	1.8	271
153	1.4	276
154	1	244
155	1.2	286
156	1.6	259
157	2.4	168
158	1.1	343
159	1	147
160	1.6	150
161	1.1	186
162	1.2	201
163	0.7	365
164	1.7	192
165	1.8	266
166	1.2	234
167	1.6	10
168	1.3	330
169	2.3	190
170	2.2	168
171	1.4	217
172	1.4	357
173	1.4	206

Table A2.5: Microcosm 5: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)

Stems	Total Stems	Total Number of Stems	173
		Stems with Inflorescence	20
	Heights (mm)	Max Height	1184
		Min Height	10
		Mean Height	519.416185
		Mode Height	343
		Median Height	528
	Widths (mm)	Max Width	3.7
		Min Width	0.7
		Mean Width	1.955491329
		Mode Width	1.8
		Median Width	1.9

Table A2.6: Microcosm 6: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	4.4	1712
2	2.9	1201
3	1.6	333
4	2.6	753
5	3.5	610
6	1.9	126
7	3.9	1185
8	2.3	616
9	4.3	590
10	2.7	831
11	2.3	732
12	3	1211
13	3	520
14	2.4	943
15	2	496
16	3.8	215
17	4.1	1461
18	2.6	775
19	1.2	175
20	3.1	85
21	1.6	571
22	3.6	1205
23	2.3	496
24	2.7	1143
25	4.4	591
26	3.5	1465
27	3.7	1183
28	1.5	239
29	3.3	686
30	3.8	569
31	2.1	1084
32	2.8	1069
33	2.3	1015
34	3.3	1094
35	2.7	884
36	2.2	869
37	3.3	1442
38	4.1	1024
39	2.2	555
40	1.8	319
41	1.7	577
42	3	1472
43	2.6	1396
44	2.6	1215
45	2	632
46	2.1	1004
47	1.7	212
48	1.6	357
49	2.5	647
50	2.2	948
51	2.3	912
52	2.8	226
53	2.4	575
54	2.7	800
55	2.4	261
56	2.6	470
57	2	561
58	4.2	605
59	3.9	1134
60	2.2	529
61	2.5	1090
62	2.2	622
63	3.9	1215
64	2.5	939

Table A2.6: Microcosm 6: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	2.1	642
66	2.7	1186
67	1.6	679
68	1.7	250
69	2.5	789
70	2.7	1007
71	2.4	730
72	2.3	159
73	2.3	442
74	3.2	1266
75	4.9	982
76	1.2	297
77	2.7	1081
78	1.7	286
79	1.6	667
80	2.8	1071
81	3.4	620
82	2.9	452
83	3.1	1185
84	2.8	943
85	2.2	960
86	2.4	699
87	3.1	1034
88	2.8	963
89	2.4	1001
90	3.4	939
91	2.1	814
92	2.6	306
93	3.4	1266
94	2.5	965
95	3.1	1257
96	2.8	1141
97	2.7	450
98	3.1	977
99	2.6	1099
100	3.9	1376
101	3.3	1222
102	2.9	1076
103	2.1	850
104	2.5	1087
105	2.6	943
106	2.4	914
107	2.4	294
108	2.6	1061
109	2.3	852
110	1.8	456
111	5	524
112	2.3	1000
113	2.9	1265
114	3.2	1075
115	2.5	655
116	2.7	843
117	2.5	746
118	1.8	375
119	2.5	882
120	3.4	1207
121	2.4	970
122	3.4	645
123	2.9	1237
124	2.4	1013
125	2.6	551
126	2.7	1023
127	2.4	610
128	1.7	355

Table A2.6: Microcosm 6: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	2.7	1037
130	1.9	526
131	2.4	697
132	1.5	367
133	2.3	1011
134	3.3	1368
135	3.3	1411
136	2.8	1060
137	2.1	866
138	2.5	889
139	2	714
140	2.9	236
141	3.2	1019
142	2.6	1094
143	2.1	912
144	3.4	509
145	2.5	1112
146	3.1	710
147	2.3	219
148	3.5	1242
149	2	310
150	2.4	555
151	3.1	1156
152	2.2	896
153	1.6	341
154	2.5	515
155	2.8	905
156	2.1	293
157	1.9	508
158	3	1124
159	2.6	1187
160	2.7	943
161	1.9	416
162	3.1	1100
163	3.4	988
164	2.8	711
165	3.2	619
166	3.2	1014
167	3.4	649
168	2.9	577
169	2.3	1012
170	2	379
171	2.4	834
172	1.9	171
173	2	1173
174	2.2	193
175	1.8	677
176	1.3	532
177	1.8	583
178	2	461
179	3.1	1137
180	2.4	964
181	1.9	815
182	2.5	618
183	1.5	680
184	2.5	980
185	2.4	1312
186	1.9	474
187	1.4	598
188	2.2	625
189	2.9	1212
190	3	1131
191	2.4	1109
192	3	895

Table A2.6: Microcosm 6: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	2.6	1314
194	2.9	1174
195	3.2	632
196	2.6	1068
197	2.6	866
198	3	1100
199	2.4	656
200	2.1	904
201	2.4	917
202	2.7	1223
203	1.6	568
204	1.9	786
205	1.7	589
206	1.8	676
207	1.9	535
208	1.7	407
209	2.2	565
210	0.9	429
211	1.8	372
212	1.6	286
213	1.9	102
214	1.2	184
215	1	137
216	1.9	104
217	1.2	105

Stems	Total Stems	Total Number of Stems	217
		Stems with Inflorescence	30
	Heights (mm)	Max Height	1712
		Min Height	85
		Mean Height	784.5806452
		Mode Height	943
		Median Height	814
	Widths (mm)	Max Width	5
		Min Width	0.9
		Mean Width	2.553456221
		Mode Width	2.4
		Median Width	2.5

Table A2.7: Microcosm 7: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	2.5	438
2	2.9	1668
3	2	1164
4	2.5	1232
5	4.2	1774
6	2.9	1595
7	3	1638
8	4.7	1641
9	4.1	1683
10	2.4	896
11	1.8	436
12	2.5	344
13	2.9	950
14	2.7	354
15	1.8	414
16	3	860
17	3.4	1420
18	2.4	432
19	1.2	394
20	1.9	824
21	2.5	948
22	3.6	621
23	4.2	1132
24	3.7	527
25	1.4	519
26	3.4	695
27	2.2	792
28	2.6	1091
29	2.2	1092
30	2.6	1245
31	3.2	1102
32	2.8	520
33	2.6	1059
34	3.5	1214
35	1	984
36	2.3	942
37	2.5	474
38	3.4	521
39	2.2	1160
40	1.5	327
41	2.1	751
42	2.5	1034
43	3.2	398
44	1.4	592
45	3	1112
46	2.5	933
47	2	593
48	2.6	638
49	1.8	913
50	3.7	177
51	3.2	378
52	3	925
53	1.7	144
54	1.5	372
55	3	1194
56	3	1376
57	2.4	1181
58	3.2	1013
59	1.8	775
60	1.9	838
61	2.4	1162
62	2.5	364
63	2.3	317
64	1.9	267

Table A2.7: Microcosm 7: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	3.5	931
66	3.5	1054
67	1.9	812
68	2.2	873
69	2.4	656
70	4.1	143
71	2.6	125
72	2.4	949
73	3.9	375
74	3.2	823
75	2.6	218
76	2.7	210
77	1.5	533
78	2	1002
79	1.6	321
80	2.3	876
81	3.1	306
82	2	931
83	2	685
84	2.7	521
85	3.5	1412
86	2.6	1354
87	1.8	510
88	2.6	1093
89	2.3	549
90	1.7	643
91	2.4	942
92	1.9	667
93	2.3	379
94	2	804
95	2.5	849
96	2	303
97	2.4	577
98	1.9	309
99	1.6	902
100	2	329
101	1.7	366
102	2.6	499
103	2.8	1024
104	2.2	851
105	1.2	167
106	3.8	1434
107	3	816
108	2.1	884
109	1.6	196
110	2.2	1000
111	1.4	420
112	3	1052
113	2.5	678
114	1.9	995
115	3.3	810
116	3.1	847
117	2.8	1095
118	1.4	813
119	1.6	806
120	2.1	1194
121	2.3	1204
122	2.5	1115
123	0.8	331
124	2.7	1122
125	1.6	44
126	1.6	852
127	1.5	494
128	0.9	241

Table A2.7: Microcosm 7: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	2	1085
130	1.2	505
131	1	470
132	2.2	1218
133	0.8	360
134	1.2	483
135	3.3	552
136	2.9	780
137	3.7	170
138	1.7	262
139	1.6	220
140	1.1	280
141	2	1045
142	3.1	1287
143	0.8	265
144	2.9	1362
145	1.7	351
146	2.3	918
147	2.8	1232
148	1.9	622
149	2.4	1312
150	2.6	95
151	2.5	1145
152	1	170
153	1.2	481
154	0.8	328
155	0.7	322
156	3	991
157	2.8	717
158	3.2	1362
159	2.2	1164
160	3.2	1327
161	2.2	1083
162	1.9	772
163	2.9	1193
164	2.9	250
165	2.9	1017
166	3	318
167	2	551
168	1.8	906
169	2	1015
170	2.4	1169
171	1.3	587
172	2	540
173	1.5	450
174	1.2	818
175	2.2	1233
176	3.3	1182
177	1.8	1093
178	3.5	812
179	1.5	653
180	3.3	694
181	2.2	708
182	2.2	995
183	2.3	819
184	1.5	924
185	2.3	1200
186	2.8	1238
187	1.1	208
188	2.9	1261
189	2.7	1146
190	2.7	680
191	2.4	426
192	3.7	937

Table A2.7: Microcosm 7: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	3.3	1316
194	2.3	1032
195	1.9	517
196	2.1	365
197	2.6	1312
198	1.7	716
199	3.2	1240
200	2	976
201	2.9	1277
202	2.6	1091
203	2.1	1016
204	3.2	1222
205	2.1	1043
206	2.2	485
207	1.8	816
208	2.2	1173
209	2.1	1303
210	2	951
211	2.6	1128
212	1.9	1092
213	2.9	773
214	2.5	396
215	2.2	1033
216	1.7	529
217	1.8	932
218	2	478
219	1.9	971
220	1.8	861
221	2.7	74
222	2.3	1098
223	1.7	641
224	2.2	946
225	1.8	967
226	1.8	724
227	1.1	442
228	1.6	806
229	2.5	1009
230	1.2	268
231	1.7	177
232	1.8	150
233	1.7	170
234	1.5	129
235	1.5	174
236	1.5	274
237	1	290
238	1.3	172
239	1.4	195
240	0.9	262
241	1.2	171

Table A2.7: Microcosm 7: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)

Stems	Total Stems	Total Number of Stems	241
		Stems with Inflorescence	13
	Heights (mm)	Max Height	1774
		Min Height	44
		Mean Height	766.9170124
		Mode Height	170
		Median Height	812
	Widths (mm)	Max Width	4.7
		Min Width	0.7
		Mean Width	2.294190871
		Mode Width	2
		Median Width	2.2

Table A2.8: Microcosm 8: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	2.5	1157
2	2	800
3	2.3	190
4	2.2	551
5	2	370
6	3.5	278
7	3.9	342
8	2.2	365
9	2.2	309
10	4.1	230
11	2.9	166
12	3.6	1415
13	2.5	1260
14	3.3	224
15	2.1	940
16	2.7	1370
17	1.8	1124
18	1.9	118
19	3.1	350
20	1.8	1035
21	1.4	391
22	1.7	292
23	3.7	840
24	2.3	315
25	2.6	1245
26	4	782
27	4.6	681
28	2.8	404
29	1.8	566
30	1.9	744
31	3.2	435
32	2.1	670
33	1.8	195
34	1.9	906
35	1.1	374
36	4	877
37	2.7	1254
38	2.6	1364
39	2.9	1086
40	3.8	1100
41	3.5	1381
42	4.8	1002
43	1.5	735
44	2.1	961
45	2.5	216
46	2.4	904
47	1.8	858
48	2	559
49	1.5	406
50	2.4	415
51	4.4	1515
52	3	1284
53	3.4	267
54	1.3	339
55	2.9	1102
56	4.4	697
57	2.5	1246
58	2.7	1181
59	2.1	921
60	3	214
61	3.4	572
62	3.6	310
63	3.4	1375
64	2.1	645

Table A2.8: Microcosm 8: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	3.2	892
66	2.2	985
67	2.1	881
68	3	1280
69	2.8	1892
70	4	348
71	4.1	454
72	5.4	519
73	2.5	1046
74	3.8	527
75	5.1	718
76	3.4	822
77	3.4	1425
78	3	1418
79	2.9	1192
80	1.9	562
81	2.7	1173
82	3.9	300
83	3.9	479
84	3.1	1549
85	2.7	1161
86	3.3	389
87	2.1	929
88	3.3	1468
89	2.7	1328
90	2.9	1301
91	3.3	1265
92	3	429
93	3.2	658
94	3	292
95	3	1474
96	3.4	301
97	2.2	460
98	2.6	635
99	1.3	288
100	1.9	470
101	2	555
102	1.3	623
103	1.9	821
104	1.3	571
105	1.4	767
106	3.5	1112
107	1.5	756
108	1.8	616
109	0.8	354
110	1.9	712
111	1.3	516
112	1.6	816
113	2.5	552
114	4.8	1522
115	2.8	608
116	1.4	300
117	1.6	388
118	1.3	542
119	2.8	1231
120	4.7	1105
121	2.7	1245
122	2.6	458
123	2.6	236
124	3.5	565
125	2.6	956
126	2.5	911
127	3.8	1273
128	2.7	1053

Table A2.8: Microcosm 8: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	2.5	936
130	3.7	1519
131	2.5	1065
132	2.5	298
133	3.6	661
134	2.8	588
135	3.7	1027
136	3.1	1228
137	1.6	520
138	2.6	171
139	2.1	885
140	1.9	610
141	2.2	1000
142	3.3	1180
143	2.1	850
144	1.8	911
145	2.6	1183
146	1.1	444
147	2.7	358
148	1	368
149	1.6	402
150	3.6	823
151	2.5	947
152	2.5	1172
153	3.1	1404
154	3.4	118
155	2.7	1116
156	4.4	1430
157	2.2	941
158	1.8	1024
159	1.1	383
160	2.1	1356
161	3	1464
162	2.4	1193
163	4	1522
164	1.9	1064
165	1.8	483
166	1.8	920
167	2.3	1255
168	2.6	142
169	1.9	953
170	1.6	575
171	2.8	812
172	2.2	1118
173	0.7	474
174	2	1138
175	4.7	899
176	5.4	498
177	3.7	1614
178	1.8	1121
179	1.6	1123
180	1.6	693
181	2.1	1083
182	2.3	1209
183	4.5	1612
184	3.1	1483
185	4.4	1403
186	3.2	1387
187	3.2	1253
188	3.4	1464
189	4.6	1475
190	2.3	1164
191	1.4	330
192	3.2	360

Table A2.8: Microcosm 8: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	3.4	1366
194	2.3	1054
195	4.1	342
196	2.2	648
197	2.1	847
198	3	1272
199	4.7	939
200	1.6	247
201	2.8	1231
202	2	326
203	1.2	492
204	2	677
205	2	576
206	1.2	375
207	2.5	450
208	4.8	1163
209	2.7	968
210	3	1310
211	0.5	433
212	3	1309
213	3	1304
214	2.4	205
215	2.6	1051
216	2.3	1098
217	1.6	852
218	2.2	1214
219	1.9	1193
220	1.4	595
221	1.1	310
222	3.4	1165
223	1.9	595
224	2.1	596
225	0.9	412
226	2.5	780
227	2	375
228	4.3	412
229	1.8	524
230	1.3	726
231	2.5	912
232	2.8	1225
233	1.9	585
234	1.8	938
235	2.9	268
236	1.4	446
237	1.1	200
238	1	583
239	2.3	794
240	2	987
241	1.9	782
242	1.8	750
243	1.7	794
244	3.3	593
245	4.8	851
246	2.4	1014
247	2.9	1258
248	2.6	885
249	2.8	522
250	2.9	210
251	3.1	1194
252	3.2	1040
253	2.5	1181
254	1.6	200
255	1.9	232
256	1.9	203

Table A2.8: Microcosm 8: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
257	3.1	1076
258	3.5	813
259	3	790
260	1.6	945
261	1.8	832
262	2.5	417
263	2.1	163
264	2	Median Height
265	2	1062
266	1.9	679
267	1.9	239
268	2.1	679
269	1.6	719
270	1.2	671
271	2	640
272	1.7	880
273	2	315
274	1.6	866
275	1.6	841
276	2.9	877
277	2.6	849
278	1.8	780
279	1.5	860
280	2.4	338
281	1.8	344
282	2.1	373
283	2.2	117
284	1.5	545
285	3	170
286	1.5	154
287	1.2	159
288	1.7	267
289	1.5	251
290	2.2	217
291	1.4	211
292	1.3	147
293	1.3	173
294	1	181
295	1.1	173
296	2.2	116
297	2.3	120
298	2.4	254
299	1.7	201
300	1.3	222
301	1	196

Table A2.8: Microcosm 8: *Phragmites australis* Stem Measurements.

Stem Number	**Stem Width (mm)**	**Stem Height (mm)**

Stems	Total Stems	Total Number of Stems	301
		Stems with Inflorescence	12
	Heights (mm)	Max Height	1892
		Min Height	116
		Mean Height	760.5946844
		Mode Height	342
		Median Height	756
	Widths (mm)	Max Width	5.4
		Min Width	0.5
		Mean Width	2.5
		Mode Width	1.9
		Median Width	2.4

Table A2.9: Microcosm 9: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	3	1187
2	2.8	1046
3	1.5	561
4	1	326
5	1.9	344
6	1.5	341
7	2.7	350
8	1.8	351
9	2.1	142
10	1.9	283
11	1.7	200
12	2.1	478
13	1.7	738
14	1.4	646
15	2	718
16	1.5	643
17	1.5	653
18	1.1	476
19	1.8	598
20	2	609
21	1.6	767
22	2	691
23	3.7	1269
24	2.6	1168
25	2.4	1207
26	2.4	886
27	2.4	899
28	2.5	876
29	2.3	853
30	2.1	865
31	2.6	1131
32	2.4	1114
33	2.5	1108
34	2.6	1119
35	2.6	669
36	2	1063
37	1.3	543
38	2.1	910
39	2.4	904
40	3.3	1208
41	2.4	967
42	2	958
43	2.5	932
44	2.6	926
45	2	800
46	2.9	924
47	1.9	978
48	0.9	342
49	2.7	976
50	2.8	996
51	2.1	866
52	2.3	891
53	1.8	723
54	1.9	912
55	2	877
56	1.9	831
57	1.9	640
58	2.1	862
59	2	832
60	3	826
61	1.8	822
62	1.5	643
63	2.3	617
64	1.9	799

Table A2.9: Microcosm 9: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	2.3	771
66	2.1	841
67	1.7	609
68	1.8	575
69	1.7	695
70	1.3	416
71	1.1	445
72	1.8	573
73	2.4	661
74	2.1	358
75	1.8	474
76	2.2	865
77	2.4	799
78	2.2	479
79	1.1	353
80	1.3	413
81	2.1	606
82	1.7	832
83	2	510
84	2	772
85	2	794
86	2.1	821
87	2.3	580
88	1.6	486
89	1.9	435
90	1.6	709
91	1.9	771
92	2	618
93	1.4	511
94	1.9	789
95	2	769
96	1.8	660
97	2	489
98	1.8	740
99	1.8	722
100	1.5	411
101	2.8	541
102	2.6	803
103	2	573
104	2.1	792
105	2.3	782
106	2.6	784
107	2.3	761
108	1.3	612
109	1.9	763
110	2.8	646
111	2.6	811
112	1.6	639
113	2.3	450
114	1.2	574
115	2.2	652
116	2.1	679
117	1.8	641
118	1.5	696
119	1.5	679
120	2	764
121	1.2	434
122	1.9	687
123	2.1	813
124	1.7	567
125	1.8	829
126	1.7	635
127	1.6	702
128	1.4	603

Table A2.9: Microcosm 9: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	1.9	307
130	1.5	328
131	1.7	675
132	1.9	560
133	2.6	536
134	2	689
135	1.4	503
136	2.3	761
137	2	691
138	1.4	400
139	1.8	622
140	2.4	731
141	2.1	765
142	2.1	818
143	1.2	535
144	1.9	656
145	2.2	740
146	2	496
147	1	280
148	1.3	592
149	1.8	382
150	1.6	732
151	2.1	763
152	1.8	543
153	1.3	704
154	1.4	544
155	1.3	415
156	1.8	570
157	1.5	660
158	2.3	837
159	2.1	628
160	1.2	602
161	2	747
162	1.9	755
163	1.6	725
164	1.5	624
165	2.3	768
166	1.6	432
167	1.5	300
168	0.7	341
169	1.3	550
170	2	608
171	2.2	727
172	1.9	689
173	1.9	696
174	2.2	764
175	1.7	446
176	2	747
177	1.1	335
178	1	371
179	1.6	589
180	1.9	480
181	2.3	478
182	1.6	608
183	1.6	581
184	1.7	559
185	1.8	709
186	1.7	660
187	1.7	749
188	2.8	571
189	1.7	775
190	2.4	883
191	2.1	716
192	1.1	443

Table A2.9: Microcosm 9: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	1.7	657
194	1.4	520
195	2.5	868
196	1.2	481
197	2.3	455
198	1.4	379
199	1.2	421
200	2.4	494
201	1.2	558
202	3.1	538
203	1.3	600
204	1.9	304
205	1.6	393
206	1.8	682
207	1.8	712
208	0.4	354
209	1.2	444
210	1.7	645
211	1.3	391
212	1.6	676
213	1	194
214	2.1	540
215	1.8	605
216	1.8	369
217	1.4	460
218	1.7	480
219	2.2	487
220	1.8	477
221	1.4	601
222	1.9	571
223	2.3	715
224	1.7	707
225	1.3	542
226	1.3	348
227	1.8	493
228	1.4	672
229	1.8	721
230	1.5	437
231	2.6	637
232	1.9	472
233	2.1	365
234	1.3	195
235	1.7	688
236	1.7	290
237	1.3	389
238	2.2	597
239	1.9	572
240	1.5	695
241	1.2	535
242	1.2	479
243	1.7	580
244	1.8	533
245	1.9	620
246	2.1	362
247	2	398
248	1.7	528
249	1.5	506
250	1	440
251	1.1	498
252	1.8	471
253	1.9	569
254	1.7	431
255	1.4	380
256	1.5	435

Table A2.9: Microcosm 9: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
257	1.5	512
258	1.6	271
259	1.4	285
260	3	333
261	2	622
262	1.5	295
263	1.3	401
264	1.6	Median Height
265	2.4	344
266	1	386
267	1.4	501
268	1.3	444
269	2	556
270	1.8	382
271	1	280
272	1.9	638
273	1.1	374
274	1.7	271
275	1.5	478
276	2.3	435
277	1	342
278	0.7	246
279	1.8	281
280	1.1	365
281	1.6	454
282	1.1	409
283	1.4	377
284	1.9	407
285	1.2	434
286	2.7	211
287	1.8	305
288	1.8	447
289	4.1	341
290	1.8	266
291	2	381
292	1.8	223
293	1.4	476
294	1.4	465
295	1.7	386
296	0.9	398
297	2.2	352
298	1.4	390
299	1.8	329
300	2.1	440
301	1.8	243
302	1	342
303	2	243
304	1.9	431
305	1.4	438
306	1.6	329
307	2.4	477
308	1.4	439
309	1.2	283
310	1.4	366
311	0.9	321
312	1.6	295
313	1.6	456
314	0.6	251
315	1.3	472
316	1.5	326
317	2.9	281
318	1.9	384
319	1.6	566
320	1.3	342

Table A2.9: Microcosm 9: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
321	1.2	352
322	1.2	339
323	1.1	262
324	1.8	354
325	2.6	301
326	1.3	380
327	1.7	223
328	2.2	295
329	2.8	244
330	1.2	385
331	2.5	377
332	1.1	365
333	1.4	537
334	2.7	338
335	1.5	511
336	0.5	446
337	2.2	317
338	1.4	387
339	1.8	184
340	1.3	428
341	1.3	307
342	1.3	317
343	1	316
344	0.8	256
345	1.1	296
346	2.3	306
347	1.4	253
348	1.3	396
349	2.5	429
350	1.1	297
351	0.6	209
352	2	360
353	2.2	396
354	2.8	221
355	2.1	172
356	2.3	198
357	1.2	198
358	1.3	362
359	2.4	280
360	2.9	256
361	1.3	377
362	1	245
363	1.1	254
364	1.2	270
365	0.7	275
366	1.9	368
367	2.4	235
368	1.4	370
369	2.2	71
370	1.6	393
371	1	224
372	1.4	334
373	1.2	254
374	2	256
375	2.7	216
376	2	178
377	1.3	359
378	0.8	240
379	1.9	305
380	0.7	175
381	1.3	235
382	1.4	316
383	1.4	368
384	0.5	221

Table A2.9: Microcosm 9: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)

Stems	Total Stems	Total Number of Stems	384
		Stems with Inflorescence	10
	Heights (mm)	Max Height	1269
		Min Height	71
		Mean Height	536.6328125
		Mode Height	342
		Median Height	499.5
	Widths (mm)	Max Width	4.1
		Min Width	0.4
		Mean Width	1.78359375
		Mode Width	1.8
		Median Width	1.8

Table A2.10: Microcosm 10: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	3.9	2016
2	3.6	1879
3	4	1701
4	3	1725
5	3.4	1740
6	5.4	1902
7	2.6	1574
8	2.7	1608
9	2.8	1016
10	3.4	917
11	2.8	1325
12	2.6	1013
13	3.5	723
14	2.2	837
15	2.2	623
16	3.1	589
17	2.8	1168
18	2.5	1237
19	2.8	1290
20	2.7	1153
21	3.7	1342
22	3.9	1570
23	3.8	1522
24	3	1399
25	2.6	1158
26	2	728
27	3.5	1470
28	2.1	756
29	3.1	1724
30	3.3	1716
31	2.4	1173
32	2.4	1104
33	4.1	1769
34	2.8	1644
35	3	1580
36	3.5	1612
37	3.8	1778
38	3.9	1526
39	2.6	1040
40	3.8	1366
41	3.5	1314
42	3	1137
43	2.7	1087
44	2.6	911
45	2.3	827
46	4	1411
47	2.9	1443
48	3.8	1474
49	1.6	338
50	3	1684
51	3.8	1565
52	3.7	1604
53	3.3	1718
54	3.5	1675
55	2.6	1603
56	3.2	1670
57	3	1588
58	2.6	1497
59	2.8	1406
60	2.5	1548
61	2.6	589
62	3.2	948
63	2.6	1106
64	2.2	849

Table A2.10: Microcosm 10: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	4	515
66	4	547
67	2.5	1073
68	3.2	1560
69	2.7	1388
70	3.5	937
71	2	1029
72	2.1	1009
73	2.4	1143
74	2.5	1093
75	2.5	1184
76	3.3	1450
77	3.3	1560
78	2.6	1263
79	2.9	724
80	2.2	1228
81	2.9	1329
82	2.4	772
83	3.4	1040
84	3.6	1095
85	2.5	1027
86	2.2	973
87	2.2	886
88	2.7	1166
89	2.5	902
90	1.8	661
91	2	926
92	2	562
93	3	1335
94	2.8	936
95	2.3	800
96	2.5	1325
97	1.8	765
98	1.8	604
99	2.5	1233
100	2.3	1239
101	2.7	1200
102	3.3	462
103	2.4	1169
104	2.5	1262
105	2.8	1306
106	2.4	1227
107	2.7	1176
108	2.3	424
109	2.5	1071
110	2.7	1351
111	3.3	1215
112	3	1296
113	3.4	808
114	2.1	585
115	1.5	832
116	2	913
117	3.5	1548
118	2.6	999
119	2.2	1304
120	1	521
121	1.8	845
122	2.6	1488
123	3.6	1271
124	2.9	1222
125	1	520
126	2.4	972
127	2.7	1419
128	4.1	1390

Table A2.10: Microcosm 10: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	2.2	975
130	1.9	910
131	2.3	1043
132	1.9	1276
133	2.6	1274
134	2.7	389
135	2.7	1345
136	4	1332
137	2.7	1011
138	2.2	1372
139	4.3	1461
140	2.5	965
141	3.3	1422
142	2.6	649
143	1.8	866
144	2.5	1231
145	3	1386
146	2.9	1375
147	2.8	1095
148	2.6	1416
149	2.4	1089
150	2.8	1181
151	4.5	1555
152	2.4	761
153	3.5	1410
154	3.7	1514
155	3.1	1260
156	2.8	1234
157	4.1	1478
158	3.4	962
159	2.4	868
160	2	1131
161	2.2	974
162	2.6	1120
163	3.2	1294
164	2.9	1196
165	2.5	1244
166	1.7	535
167	3.1	1214
168	2.1	516
169	2.3	956
170	2.1	885
171	1.5	316
172	2.3	940
173	2.9	665
174	3.2	1457
175	2.5	976
176	2.4	1139
177	1.9	618
178	2.8	1089
179	2.8	1144
180	2.3	1001
181	2	1015
182	2.5	864
183	3.5	871
184	2.6	983
185	2.4	567
186	2.7	989
187	2.6	1328
188	3.1	1411
189	4.8	1346
190	3.1	1228
191	3	1331
192	2.7	1282

Table A2.10: Microcosm 10: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	3.2	1425
194	1.2	496
195	2.1	1276
196	1.7	796
197	2.4	1065
198	2.9	1095
199	2.1	981
200	2.5	1177
201	2.1	1058
202	3	1505
203	2.5	1015
204	2.5	1297
205	3.4	1213
206	2.1	980
207	2.5	1525
208	2.2	1002
209	2.5	815
210	2.1	576
211	2.5	925
212	3.2	1385
213	2.8	1256
214	2.1	814
215	1.9	805
216	2.1	980
217	3.2	1456
218	1.8	1020
219	2.4	949
220	3.6	893
221	2.3	1071
222	2.4	1127
223	2.7	1270
224	2.2	621
225	3.1	669
226	2.9	1311
227	2.9	1129
228	2.8	979
229	2.7	718
230	2.7	1253
231	2.2	1121
232	3.5	1237
233	1.5	871
234	2.6	1010
235	2.3	1075
236	2.7	990
237	3.2	948
238	2.2	1050
239	2.5	1149
240	2.9	760
241	2.3	1154
242	2.4	1143
243	2.9	1332
244	2.4	1124
245	2.2	1162
246	2.3	1133
247	2.1	725
248	3.3	1300
249	2.3	881
250	1.5	342
251	1.6	805
252	3.6	1224
253	2.9	1286
254	3.4	1137
255	2.5	1069
256	3	1286

Table A2.10: Microcosm 10: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
257	1.8	423
258	2.3	741
259	2.2	1066
260	4	1437
261	2.7	1228
262	3	1315
263	2.9	1260
264	3.3	Median Height
265	3.7	932
266	3.2	1310
267	4.1	999
268	2.6	1006
269	2.5	1127
270	2.1	1086
271	2	969
272	2.8	816
273	3.3	762
274	3	418
275	2.3	502
276	2	701
277	2.5	684
278	3.2	815
279	2.1	903
280	1.9	813
281	3.3	742
282	2.1	752
283	2.2	756
284	2.7	710
285	2.5	817
286	2	575
287	2.6	797
288	2.3	721
289	2.2	715
290	2.4	673
291	2	810
292	1.5	453
293	2.1	289
294	1.6	670
295	3.1	634
296	1.9	493
297	3.6	454
298	1.8	497
299	2.8	626
300	1.8	353
301	2.3	880
302	2.6	590
303	3.4	407
304	2.5	488
305	1.7	411
306	1.9	502
307	2.2	285
308	2.9	480
309	1.1	432
310	3	587
311	2	650
312	2.7	365
313	2.6	774
314	2.1	707
315	2.4	471
316	1.6	555
317	1.8	447
318	1.7	312
319	1.3	582
320	1.1	444

Table A2.10: Microcosm 10: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
321	2.6	524
322	3.7	774
323	2	544
324	2.6	758
325	1.8	454
326	3.3	410
327	2.3	457
328	1.3	563
329	2.4	516
330	2.4	370
331	2.4	407
332	2.9	560
333	2.2	744
334	1.7	408
335	2.5	297
336	1.9	614
337	1.9	320
338	2.5	313
339	2	567
340	2.3	266
341	1.2	270
342	2.6	530
343	1.5	218
344	1.9	281
345	1.1	309
346	2.2	259
347	2.3	353
348	2	493
349	2	427
350	2.6	687
351	2	660
352	2	401
353	2.5	406
354	1.9	465
355	1.7	269
356	2.2	411
357	1.2	432
358	2.6	474
359	2.6	657
360	2.9	656
361	3.1	248
362	2.6	233
363	3.7	146
364	1.6	224
365	2.5	105
366	3.2	704
367	2.8	634
368	2.7	354
369	2.2	159
370	2.8	623
371	2.7	362
372	2.8	243
373	2.1	539
374	2.7	626
375	1.8	229
376	2.5	436
377	2	234
378	2	419
379	2.3	272
380	2.6	313
381	2.1	287
382	2.8	322
383	2.2	131
384	2.5	299

Table A2.10: Microcosm 10: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
385	3.8	162
386	1.9	239
387	1.8	265
388	3.1	331
389	2.6	466
390	2.5	516
391	2.9	385
392	2.2	340
393	1.6	215
394	1.7	481
395	2.9	346
396	1.4	261
397	2.3	228
398	2.7	264
399	1.6	209
400	1.9	175
401	1.4	160
402	1.4	230
403	2.9	909
404	1.2	355

Stems	Total Stems	Total Number of Stems	404
		Stems with Inflorescence	36
	Heights (mm)	Max Height	2016
		Min Height	105
		Mean Height	910.2054455
		Mode Height	1228
		Median Height	936.5
	Widths (mm)	Max Width	5.4
		Min Width	1
		Mean Width	2.59009901
		Mode Width	2.5
		Median Width	2.5

Table A2.11: Microcosm 11: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	4.7	1615
2	5.1	1748
3	3.2	1294
4	3.9	486
5	3.8	1754
6	4.8	1476
7	5.3	1118
8	3.9	534
9	4.5	386
10	1.7	801
11	3.6	495
12	2.3	1246
13	3.4	1446
14	2.3	923
15	2.3	1037
16	2.4	932
17	3.5	1692
18	3.3	1401
19	1.7	518
20	2.1	1168
21	3	1364
22	3.3	1551
23	3.2	1482
24	1.6	400
25	2.1	1024
26	2.5	837
27	2	249
28	2.7	768
29	4.2	1674
30	1.8	1034
31	2.5	1168
32	1.8	984
33	4	1687
34	2	768
35	1.7	580
36	1.7	990
37	2.2	677
38	1.5	528
39	5.9	1490
40	2	463
41	5.2	1873
42	2.7	914
43	1.9	718
44	3.5	1233
45	3	1453
46	3.7	709
47	4.9	1291
48	2.5	974
49	2.9	1327
50	3.8	616
51	1.8	555
52	2.1	646
53	2.5	145
54	3.8	382
55	2.8	1294
56	2.2	390
57	2.5	1333
58	4.2	1718
59	4.6	755
60	4.4	567
61	2.9	1151
62	3.6	1434
63	2.4	511
64	2.7	1125

Table A2.11: Microcosm 11: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	3.7	927
66	2.6	1264
67	5.4	677
68	3.5	1668
69	2.5	1108
70	1.9	637
71	2.7	1277
72	4.6	1817
73	1.6	729
74	3.3	1346
75	1.8	779
76	3.9	1665
0	1.4	561
78	1	490
79	1.7	560
80	2	956
81	1.8	764
82	2.7	1000
83	2.6	934
84	3.2	1357
85	2.1	667
86	4.5	1407
87	4.7	1975
88	2.9	1268
89	5	1829
90	4.3	317
91	3.4	574
92	2.7	1382
93	3.9	1605
94	4.4	1657
95	3.3	1415
96	3.1	1516
97	4	774
98	2.7	1275
99	4	1685
100	2.9	1314
101	2.8	691
102	1.6	58
103	1.4	825
104	1.3	749
105	1.8	857
106	2.2	1043
107	2	746
108	1.4	506
109	1.8	1011
110	2.1	866
111	2.8	974
112	4.9	1900
113	2.1	519
114	3.5	1334
115	2.3	1198
116	1.7	825
117	3.2	1344
118	2.8	912
119	2.3	1072
120	1.3	753
121	3.5	1576
122	4.8	1810
123	2	836
124	5.6	1992
125	3.1	872
126	4.6	1768
127	4.2	479
128	2.6	456

Table A2.11: Microcosm 11: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	1.4	678
130	4	1546
131	4.5	1820
132	5.6	1594
133	2.1	1059
134	3.5	1394
135	4.1	1689
136	4.8	2037
137	6.3	1512
138	4	1201
139	4.1	1699
140	4.7	1886
141	4	573
142	3.6	1548
143	3	1283
144	3.3	1387
145	2.1	449
146	4.8	2037
147	3.2	1194
148	1.2	355
149	1.8	526
150	2.5	1279
151	4.6	1248
152	4	1864
153	4.2	1699
154	3.4	1386
155	5.4	1818
156	4.4	1896
157	4.2	1539
158	1.8	731
159	3	560
160	3.5	1489
161	4.3	1546
162	3.3	1239
163	1.4	451
164	1.3	329
165	1.2	379
166	3.3	1493
167	2.5	974
168	3	1642
169	4.4	1724
170	4.6	1889
171	4.1	1764
172	4.8	1457
173	5.2	1052
174	3.9	1573
175	3.1	806
176	3.9	1774
177	3.5	1662
178	2.2	1227
179	2.4	1134
180	2.3	966
181	1.9	724
182	1.8	874
183	3	1219
184	1.6	437
185	3.1	1373
186	2.8	1104
187	2.1	1354
188	3.4	1436
189	4	1568
190	4.2	986
191	2.2	1207
192	3.8	1818

Table A2.11: Microcosm 11: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	3.6	1476
194	2.8	1239
195	2.3	929
196	2	1156
197	2	480
198	3.2	1538
199	4.5	1674
200	3.8	1779
201	4	1719
202	2.9	931
203	2.5	1149
204	2.9	1418
205	3.5	1490
206	5	1731
207	4.5	1231
208	6.2	1850
209	3	1164
210	4	1594
211	4	1792
212	3.5	1554
213	4.3	1779
214	3.5	1583
215	3.4	1464
216	3.9	1622
217	3.8	1702
218	2.7	1178
219	2	468
220	2.1	731
221	4	1384
222	3	1329
223	2.8	1538
224	2.5	1012
225	2.9	1232
226	3.4	1618
227	1.5	818
228	3	1063
229	3.5	980
230	2.6	1136
231	2.2	1124
232	3.9	1365
233	5.1	1387
234	3.2	1327
235	3.7	1618
236	2.1	1064
237	3.1	1373
238	2	969
239	3.5	1612
240	3.3	1286
241	2.7	1112
242	3.3	779
243	3	1072
244	4.3	1224
245	3	1236
246	3.2	1428
247	3.3	1296
248	2.4	1172
249	2.2	1069
250	2.8	1078
251	2.3	984
252	2.7	1075
253	2.5	1178
254	1.8	780
255	3.3	1274
256	2.8	985

Table A2.11: Microcosm 11: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
257	1.5	782
258	4	566
259	2.8	1147
260	1.8	1065
261	3.1	1225
262	2.7	1288
263	2	827
264	2.8	Median Height
265	2.1	750
266	3.2	1436
267	1.7	917
268	4.8	761
269	3.8	1324
270	2.9	1065
271	1.8	774
272	3.6	1347
273	2.2	828
274	2.7	1237
275	2.6	1024
276	2.6	1135
277	2.2	1114
278	2.7	1262
279	2.5	1314
280	2.8	1390
281	2.4	1276
282	2.3	1015
283	2.4	1322
284	2.5	1138
285	3.1	1354
286	1.9	1108
287	3.3	1125
288	4.2	578
289	2.2	882
290	4.1	1055
291	2.6	1034
292	2.1	758
293	3.3	837
294	2.2	856
295	2.2	710
296	1.1	677
297	2.1	1094
298	2	636
299	1.5	832
300	1.6	655
301	2.7	995
302	2.5	773
303	1.4	773
304	2.5	1212
305	2	984
306	2	1004
307	1.9	1036
308	2	992
309	2.1	485
310	3.5	1117
311	2.5	1104
312	2.5	1029
313	1.8	898
314	2.1	1051
315	1.4	518
316	2.2	871
317	1.5	894
318	2.3	1009
319	1.8	887
320	2.3	663

Table A2.11: Microcosm 11: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
321	2	395
322	1.6	639
323	4.1	755
324	3.1	240
325	3.4	268
326	3.4	423
327	2.6	874
328	2.7	935
329	2.1	598
330	1.6	463
331	1.5	619
332	1.7	668
333	1.7	736
334	1.3	686
335	2.4	760
336	2.6	959
337	1.7	715
338	1.5	572
339	1.7	458
340	1.5	464
341	1.8	665
342	1.4	570
343	3	793
344	1.8	825
345	1.2	376
346	1.7	885
347	2.6	788
348	1	322
349	1.8	567
350	2.7	503
351	1.9	283
352	1.8	746
353	1.4	337
354	1.3	272
355	1.4	256
356	1.9	1005
357	1.5	412
358	1.6	589
359	1.9	261
360	1.8	555
361	2.4	302
362	2	193
363	2.8	524
364	1.8	623
365	5.6	810
366	2	804
367	3.1	1140
368	1.9	701
369	2.3	524
370	1.9	662
371	2.7	761
372	3.8	469
373	2	362
374	1.2	423
375	1.8	434
376	1.7	609
377	1.8	556
378	2	346
379	1.6	250
380	1	294
381	2.1	287
382	3.4	553
383	2.4	314
384	1.3	571

Table A2.11: Microcosm 11: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
385	2.4	922
386	1.2	359
387	1.2	352
388	2.4	452
389	1.3	385
390	3.9	418
391	1.5	400
392	4.6	426
393	2.6	710
394	2.7	634
395	2.5	657
396	1.7	395
397	3.5	481
398	2.1	882
399	3.1	640
400	1.3	322
401	1.4	736
402	1.7	479
403	2.5	773
404	2.2	720
405	2.8	638
406	1.7	636
407	2.6	350
408	1.8	400
409	1.8	679
410	1.8	411
411	2.3	937
412	1.4	574
413	2	521
414	1.4	427
415	3.6	305
416	1.9	425
417	3.8	370
418	2.5	295
419	1	264
420	2.6	325
421	1.3	447
422	3	416
423	1.4	283
424	2.8	1489
425	2.2	506
426	3.8	421
427	1.7	373
428	3.4	458
429	2	586
430	4.7	207
431	3.9	315
432	1.8	323
433	1.3	515
434	2	452
435	2.4	355
436	2.3	543
437	3	695
438	1.8	919
439	1.9	585
440	3.3	467
441	2.6	425
442	1.8	682
443	1.8	470
444	2.8	375
445	2.3	565
446	2.5	423
447	1.4	545
448	1.1	284

Table A2.11: Microcosm 11: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
449	1	416
450	1.4	618
451	1.4	232
452	1.3	310
453	1.5	489
454	1.9	570
455	1.9	506
456	2.6	205
457	1.6	407
458	2.1	160
459	2	262
460	3.9	91
461	2.3	180
462	1.8	110
463	4.2	341
464	2.1	361
465	3.4	318
466	1.5	409
467	4.4	85
468	1.8	192
469	4.2	118
470	1.9	349
471	2.3	526
472	4.7	262
473	1.2	410
474	1.4	461
475	3.5	387
476	3.3	289
477	1.5	415
478	2.9	144
479	2.1	186
480	2.1	1491
481	1	216
482	1.3	465
483	2.7	193
484	2.8	375
485	1.8	351
486	1.8	281
487	2	219
488	2.1	449
489	2.1	1158
490	2.3	571
491	1.7	771

Table A2.11: Microcosm 11: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)

Stems	Total Stems	Total Number of Stems	491
		Stems with Inflorescence	29
	Heights (mm)	Max Height	2037
		Min Height	58
		Mean Height	906.7678208
		Mode Height	400
		Median Height	837
	Widths (mm)	Max Width	6.3
		Min Width	1
		Mean Width	2.723625255
		Mode Width	1.8
		Median Width	2.5

Table A2.12: Microcosm 12: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	5.1	2127
2	2.8	1875
3	2.3	944
4	5	1333
5	5.3	1749
6	3	1459
7	2.8	1200
8	3.4	929
9	4.9	1445
10	2.6	1245
11	4.9	1458
12	3.8	793
13	2.8	1092
14	4	1463
15	2.1	887
16	2.6	445
17	4.7	1475
18	3.3	1617
19	2.4	1243
20	2	905
21	2.5	873
22	1.8	639
23	2.1	716
24	5.1	1255
25	4.7	1088
26	2.5	1156
27	2.8	1568
28	2.7	901
29	4.8	1323
30	5	1772
31	2.2	885
32	3.2	1354
33	4.6	1929
34	3	1485
35	3.2	1373
36	3.7	1652
37	2.4	785
38	2.8	1149
39	2.8	1245
40	1.8	621
41	4.2	1087
42	2.4	974
43	1.9	322
44	2.2	1253
45	2.8	812
46	1.6	284
47	3.4	1328
48	3	1341
49	2.3	1374
50	3.7	1152
51	3.9	791
52	3	1455
53	3	1936
54	2.9	1671
55	1.6	594
56	2	1132
57	1.5	245
58	1.6	319
59	2.5	1447
60	2.3	1048
61	3.2	915
62	2.1	774
63	1.7	666
64	2.6	1273

Table A2.12: Microcosm 12: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	2.7	1609
66	2.9	1347
67	3.3	1431
68	2.2	902
69	2.2	1286
70	2.7	1236
71	2.6	1189
72	2.6	160
73	3	406
74	2.7	304
75	2.5	1017
76	1.3	396
77	2.2	1053
78	2.4	992
79	2.1	659
80	2.5	135
81	4.7	1362
82	2.4	1165
83	1.8	352
84	3	973
85	2.8	485
86	2	452
87	2	135
88	3.7	121
89	2.5	1150
90	3.9	1302
91	2.6	1451
92	3.4	783
93	2	521
94	2.1	863
95	2.2	965
96	2.2	1085
97	2.1	953
98	2.3	971
99	4.2	1669
100	2.1	199
101	3.3	1098
102	2.4	1074
103	4.7	814
104	2.4	1384
105	3	1538
106	2.2	1282
107	2.2	1120
108	3.3	1630
109	1.4	927
110	2.5	1146
111	2.4	1472
112	2.9	1544
113	2.4	1419
114	2.8	1066
115	2.3	1034
116	1.9	427
117	2.4	704
118	2.7	1241
119	2.5	432
120	2.9	460
121	2	441
122	1	439
123	2.8	763
124	2.1	1136
125	1.7	447
126	2.3	1303
127	2.4	1239
128	2.2	711

Table A2.12: Microcosm 12: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	2.4	1616
130	1.7	736
131	2.3	1189
132	3	816
133	2.2	530
134	3.9	744
135	2.5	657
136	3.1	1468
137	2.6	662
138	2.4	456
139	2.7	437
140	2.5	706
141	3	1304
142	2.8	1226
143	2.2	1333
144	3.3	1613
145	2.9	1147
146	2.3	695
147	3.2	1139
148	2.2	1149
149	2.2	695
150	2.7	708
151	2.5	1252
152	3.4	1482
153	3.3	1562
154	2.7	1059
155	3.2	1329
156	2.9	1022
157	2.6	808
158	2.7	618
159	3	1394
160	3.1	1524
161	2.3	1148
162	1.9	594
163	2.5	290
164	1.6	382
165	2.3	300
166	1.5	287
167	3.8	374
168	4.2	982
169	3	1234
170	2.9	669
171	4.3	872
172	2.7	699
173	2.6	1629
174	2.1	695
175	1.6	473
176	2.2	1235
177	2.3	1314
178	2	800
179	3	967
180	3.9	1171
181	2.2	1211
182	3.6	1136
183	3.8	1386
184	2.3	1163
185	2.2	1111
186	4.1	1581
187	2.6	1815
188	2.3	1276
189	2.4	1134
190	1.7	244
191	2.5	1246
192	2.1	346

Table A2.12: Microcosm 12: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	2.4	1260
194	3.5	1529
195	5.5	1775
196	3.1	1606
197	3.8	1644
198	1.9	1128
199	2.3	1041
200	4.4	1345
201	2.4	1533
202	2.5	1282
203	5.6	1865
204	3.3	1303
205	3.2	392
206	2.6	518
207	2.1	882
208	1.7	736
209	1.6	271
210	1.9	791
211	2.1	1157
212	2.3	714
213	2.3	507
214	3.7	1505
215	2	975
216	2.7	1371
217	3.2	390
218	2.4	1426
219	2.4	1121
220	3.1	1239
221	2.4	726
222	2.8	1146
223	2.8	321
224	2.4	1340
225	2.9	1212
226	2.2	1423
227	4	1252
228	2.6	1159
229	3.7	723
230	3	526
231	2.8	919
232	2.2	821
233	2.6	593
234	3.5	635
235	2.2	375
236	2.8	1009
237	1.8	262
238	2.5	572
239	2	826
240	1.7	784
241	2.1	916
242	4.1	1338
243	2.8	1156
244	2.5	1132
245	3.1	1328
246	2.8	1164
247	3.3	1378
248	3.2	1047
249	1.7	333
250	4.6	1676
251	3.4	475
252	3.1	846
253	2.6	824
254	3.5	894
255	2.9	602
256	3.1	1471

Table A2.12: Microcosm 12: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
257	2.8	1375
258	2.7	1582
259	4.6	1540
260	2.7	1386
261	3	1212
262	3.6	1236
263	3	1454
264	3.5	Median Height
265	3.3	372
266	2.8	1708
267	2.8	1374
268	4	1465
269	3.1	1364
270	2.8	1351
271	2.9	1696
272	4.1	1194
273	1.7	952
274	1.8	327
275	1.2	529
276	2.1	1058
277	1.8	1105
278	3.7	1298
279	2.8	1213
280	2.2	212
281	1.2	321
282	2.3	354
283	1.9	364
284	2.1	734
285	1.6	690
286	2.3	322
287	1.4	277
288	2.2	642
289	2.5	927
290	2.9	979
291	2.4	1433
292	3.4	1272
293	2.4	1379
294	2	500
295	1.8	661
296	2.7	739
297	2.4	542
298	2.2	250
299	2.2	1055
300	1.8	696
301	1.4	262
302	2.1	857
303	2.2	323
304	2.1	994
305	2.2	746
306	2.5	811
307	2.2	857
308	1.8	291
309	2.2	300
310	1	178
311	1.3	527
312	3	1187
313	1.7	642
314	2.1	802
315	2	599
316	2.2	382
317	2.2	865
318	2.3	672
319	2	878
320	2.2	1691

Table A2.12: Microcosm 12: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
321	2.2	1325
322	2.8	642
323	3	751
324	2.4	539
325	2.9	1109
326	2.5	1638
327	2.6	1174
328	2.2	754
329	1.4	614
330	2.6	1012
331	2.9	1208
332	4.8	962
333	2.1	721
334	1.3	279
335	3	912
336	2	806
337	1.2	280
338	0.9	407
339	3.5	994
340	1.3	467
341	2.6	1024
342	2.3	924
343	1.5	562
344	2.1	460
345	3	1191
346	2.1	510
347	2.6	1179
348	3.1	1297
349	1.8	835
350	2.5	1017
351	2	509
352	2.5	663
353	2.6	632
354	1.7	570
355	2.1	561
356	2.5	506
357	1.9	625
358	2.1	1086
359	1.7	527
360	1.8	833
361	2.3	233
362	2.2	707
363	2.3	714
364	2.1	723
365	4.1	1372
366	2.5	1652
367	3.6	1437
368	3.5	1509
369	3.7	1667
370	3	1491
371	3.7	1343
372	2.2	1402
373	2.4	985
374	2.6	1717
375	3.4	804
376	2.2	564
377	2.5	751
378	2.8	1016
379	2.3	1104
380	4.3	771
381	4.5	757
382	4.1	1689
383	2.3	1406
384	3.7	1242

Table A2.12: Microcosm 12: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
385	3.1	610
386	2.8	1086
387	3.3	1331
388	2.8	1453
389	2	603
390	2.1	703
391	3.1	690
392	2.3	1272
393	2.9	1365
394	2	400
395	1.9	575
396	2.9	1012
397	2.8	1124
398	4.8	1679
399	3	1114
400	2.2	768
401	1.9	710
402	2.4	771
403	4	1560
404	2.7	1372
405	1.6	319
406	2.5	1665
407	2.1	603
408	1.8	503
409	2.6	901
410	2.9	789
411	2	1060
412	3.3	620
413	2.2	1349
414	2.1	680
415	1	220
416	1.6	544
417	2	306
418	2	502
419	1.9	685
420	1.9	445
421	3.5	1253
422	2.8	1275
423	2.2	816
424	2.4	558
425	4.1	1712
426	2.2	1042
427	1.9	728
428	2.6	616
429	2.1	813
430	2.6	1116
431	3.4	1345
432	2.1	335
433	2.7	315
434	3.7	937
435	3.1	1097
436	3.3	1261
437	2.9	1246
438	3.5	748
439	3.6	1332
440	2.5	761
441	2.5	723
442	1.3	414
443	2.1	240
444	2	1225
445	2.1	850
446	2.3	388
447	2.3	869
448	2.7	1086

Table A2.12: Microcosm 12: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
449	2.6	523
450	3.5	592
451	2.9	639
452	2.6	1708
453	3	710
454	2.7	911
455	2.8	275
456	1	211
457	3.2	603
458	2.3	795
459	2.8	827
460	3.2	366
461	2.3	895
462	1.4	436
463	3	673
464	3	1536
465	2.9	684
466	2.6	1272
467	2.2	802
468	2.2	516
469	2.1	513
470	3.2	864
471	1.9	726
472	2.6	1299
473	2.6	929
474	2.5	1304
475	3.1	1404
476	2.3	1153
477	3.5	1719
478	2.1	1596
479	3.1	1215
480	2.7	732
481	4.1	770
482	3.3	1638
483	2.4	1315
484	3.1	765
485	4.9	1516
486	3.1	1653
487	3.9	1468
488	2.3	1586
489	2.2	985
490	2.4	1129
491	3.5	1714
492	2.1	911
493	2.4	520
494	2.1	955
495	2.9	1674
496	2	1045
497	1.6	1054
498	1.2	426
499	4.3	1710
500	2.3	705
501	1.2	306
502	2	966
503	2.1	622
504	3	1218
505	1.9	286
506	3.1	444
507	2	348
508	3.2	1357
509	1.6	515
510	2.6	461
511	3.3	515
512	1.1	182

Table A2.12: Microcosm 12: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
513	3.3	234
514	1.1	294
515	0.8	435
516	2.7	297
517	1.4	294
518	2	866
519	2.5	1354
520	2	1134
521	1.6	260
522	2.6	251
523	1.6	299
524	1.8	481
525	1.9	215
526	2.6	460
527	2.3	441
528	3.6	1202
529	2.7	271
530	1.2	225
531	3.7	1615
532	2.7	881
533	2.8	1294
534	3	1304
535	1.8	232
536	2	1150
537	1.1	255
538	4.3	1216
539	2.3	1016
540	2.7	586
541	3.1	1224
542	3.3	437
543	3.3	1255
544	2.5	532
545	1.7	398
546	1.7	246
547	2.9	1533
548	2.6	1023
549	3.1	542
550	2.8	1251
551	2	785
552	2.3	1015
553	2.5	1543
554	2.6	1263
555	2.3	1330
556	2.7	442
557	2.4	1380
558	3.7	578
559	2.1	1050
560	3.1	459
561	2.9	1430
562	4.4	1735
563	3	668
564	2.7	1851
565	2.8	1775
566	3.2	1074
567	2.7	1192
568	2.6	807
569	4.5	687
570	2.5	1375
571	2.9	1644
572	2.9	488
573	2.3	1625
574	3.6	1718
575	3	841
576	1.9	922

Table A2.12: Microcosm 12: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
577	2.1	222
578	3.5	1192
579	3.2	1686
580	2.7	1078
581	3.1	630
582	2.9	1381
583	4.1	1778
584	3.4	1329
585	2.5	1132
586	6.2	1712
587	2.8	1520
588	4.1	1535
589	2.8	696
590	4.8	1846
591	2.2	1084
592	4.2	1284
593	5.3	1677
594	2.4	1336
595	2.8	804
596	6.2	1792
597	6.5	1894
598	2.2	975
599	2.9	534
600	5	1504
601	2.8	1503
602	4.1	765
603	3.2	1258
604	2.3	673
605	2.3	1245
606	2.7	1618
607	3.4	1533
608	2.3	1389
609	3.4	1193
610	2.7	738
611	1.6	325
612	3.3	688
613	2.9	1099
614	1.9	193
615	2.7	1091
616	2.4	1324
617	1.6	687
618	2.3	1235
619	3.8	525
620	2.6	1206
621	1.7	527
622	2.2	284
623	3.4	1073
624	3.5	386
625	3.6	985
626	3.9	1283
627	3.7	1452
628	2.8	1166
629	2	947
630	2.1	875
631	2.7	1756
632	4	1701
633	3.3	1575
634	4.6	986
635	2.1	696
636	2.7	1258
637	2.7	1794
638	3.3	1372
639	2.8	1367
640	3.5	1041

Table A2.12: Microcosm 12: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
641	1.6	720
642	2.4	1050
643	4.2	1572
644	3.6	1202
645	2.5	1192
646	3.3	1518
647	2.7	407
648	4	1504
649	3.5	1711
650	2.5	1134
651	3.1	1472
652	2.2	814
653	2.4	398
654	2.6	927
655	4	1476
656	4.7	1675
657	2.6	716
658	2	901
659	3.7	1486
660	2.8	457
661	3	1565
662	2.2	822
663	2.5	237
664	2.5	287
665	2.6	171
666	3	776
667	2.7	1349
668	2.6	1273
669	2.8	727
670	2.3	1146
671	3.5	198
672	2.6	890
673	2.4	693
674	2.4	1315
675	3.1	1237
676	3.3	1242
677	2.5	1622
678	2.7	1712
679	2	1016
680	2.4	204
681	1.7	813
682	3	253
683	3	1195
684	3.9	1011
685	3	973
686	4	1672
687	3	359
688	4.1	1015
689	1.1	797
690	2.5	1476
691	2.9	1444
692	2.6	1266
693	3	1499
694	2	1006
695	3.2	1826
696	3.1	1630
697	3.7	1252
698	2.8	1307
699	3.1	273
700	3.2	675
701	3.8	1736
702	2.9	1727
703	3.3	1476
704	3	1668

Table A2.12: Microcosm 12: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
705	2.4	1292
706	2	1253
707	2.5	1550
708	2.8	1685
709	2.7	1197
710	3.7	1530
711	3.7	336
712	2.6	1258
713	2.7	684
714	2.6	1348
715	1.8	816
716	1.9	472
717	2.7	627
718	3.6	1399
719	2.8	1223
720	2.8	1283
721	2	819
722	2	1295
723	2.9	901
724	4	605
725	2.4	555
726	1.9	389
727	2.5	1016
728	2.1	1183
729	1.9	933
730	2.2	902
731	3.1	772
732	2.6	450
733	3.6	567
734	3.2	334
735	5.5	177
736	3.6	555
737	2.3	658
738	3.7	524
739	1.7	242
740	2.1	600
741	2.7	292
742	2.7	399
743	2.7	426
744	1.6	402
745	3.8	821
746	3.7	309
747	2	482
748	5.2	348
749	1.7	261
750	2.2	317
751	2.8	386
752	1.3	410
753	3.1	319
754	2.5	438
755	2.8	153
756	2.9	283
757	2.6	309
758	2.5	300
759	2.6	300
760	1.9	284
761	1.3	339

	Total Stems	Total Number of Stems	761
		Stems with Inflorescence	84
	Heights (mm)	Max Height	2127
		Min Height	121
		Mean Height	959.1419185

Table A2.12: Microcosm 12: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)	
Stems		Mode Height	901
		Median Height	971
	Widths (mm)	Max Width	6.5
		Min Width	0.8
		Mean Width	2.714323259
		Mode Width	2.2
		Median Width	2.6

Table A2.13: Microcosm 13: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	3	464
2	2.5	1264
3	3.3	522
4	3	1196
5	2.5	917
6	5.3	1054
7	2	452
8	2.5	1093
9	3.5	1118
10	4.5	1328
11	2.3	794
12	1.3	475
13	0.7	416
14	3.9	520
15	2.4	417
16	2.6	794
17	1.4	629
18	2	1115
19	2	856
20	2.4	1013
21	2.6	762
22	2.2	937
23	1.5	444
24	2.3	902
25	3.2	1647
26	3	1303
27	2.2	604
28	4.1	1014
29	2.9	1146
30	2.3	997
31	3.1	831
32	4.1	1312
33	4.6	588
34	2.5	1087
35	3.2	1248
36	3.6	1174
37	2	727
38	3.1	1280
39	2.2	572
40	1.3	526
41	2.6	1098
42	2.4	1047
43	3.1	1175
44	2.5	692
45	1.9	837
46	2.4	687
47	3.1	1207
48	2.6	341
49	2	708
50	2.2	1017
51	3.4	1053
52	2	431
53	2.1	643
54	1.7	853
55	3.1	1020
56	1.9	774
57	2.8	1284
58	1.4	609
59	2.1	866
60	2	831
61	2.3	542
62	2.7	859
63	2.4	839
64	1.7	655

Table A2.13: Microcosm 13: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	2	746
66	1.7	365
67	1.9	671
68	4.6	347
69	3.1	601
70	2.5	718
71	2.5	1188
72	1.6	787
73	1.9	890
74	3.2	461
75	1.7	354
76	2.7	1175
77	2.1	631
78	3.1	1102
79	2.1	811
80	2	718
81	1.5	351
82	1	421
83	2.4	693
84	3.5	808
85	2.5	1009
86	2.2	1017
87	2.3	1033
88	3.1	954
89	3.6	1134
90	3	659
91	1.9	706
92	3.1	979
93	2.6	1056
94	2.6	878
95	2.1	773
96	4.2	733
97	2.5	1237
98	1.8	642
99	2.2	415
100	2.5	1067
101	2.3	359
102	2.2	915
103	2.9	1168
104	3	932
105	1.4	423
106	0.9	420
107	1.9	939
108	2.5	695
109	1.2	386
110	2.5	873
111	4.1	1740
112	2.4	932
113	2.8	1123
114	1.7	795
115	3	249
116	2.6	851
117	5.4	1657
118	3	1331
119	4.6	1541
120	3.1	1490
121	3	1342
122	2.7	1453
123	2.6	1115
124	3.6	1162
125	3.5	1018
126	2.1	995
127	3.5	406
128	2.2	391

Table A2.13: Microcosm 13: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	3.4	1124
130	2.3	830
131	1.1	329
132	2.5	1195
133	1.8	888
134	2.9	810
135	2.6	787
136	2.8	539
137	6	578
138	5.7	809
139	1.8	521
140	1.4	334
141	1	355
142	2.3	476
143	2.5	1125
144	2.9	1265
145	2.8	1144
146	2.8	1215
147	3.9	1159
148	2.4	1163
149	2	1061
150	3.1	1201
151	3.3	1311
152	2.9	1112
153	2.1	985
154	3	1025
155	2.6	930
156	2.4	1166
157	3	1057
158	2	1052
159	2.7	1119
160	3.1	1141
161	2.6	1016
162	2.1	1182
163	2.2	967
164	2.5	1141
165	2	1014
166	2.5	1198
167	1.8	891
168	2.6	1129
169	3	1170
170	2.7	1039
171	2	952
172	3.5	940
173	3.9	1074
174	2.6	927
175	2.2	1039
176	1.5	792
177	2.9	1105
178	2.1	842
179	3.6	1034
180	2.1	837
181	2.4	926
182	2.1	1004
183	3.1	1034
184	3.7	1025
185	2.7	1087
186	4.2	1189
187	3.7	959
188	3.2	1006
189	3.4	997
190	2.5	862
191	2.2	878
192	2.9	891

Table A2.13: Microcosm 13: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	3.5	847
194	2.6	1083
195	2.1	801
196	1.9	953
197	2.7	1085
198	2.4	771
199	1.9	847
200	5.2	1016
201	2.1	677
202	2.8	986
203	2.3	911
204	2	542
205	1.7	745
206	2.4	901
207	2.8	611
208	1.8	655
209	2.1	865
210	2.2	736
211	5.4	1032
212	2.4	679
213	4	974
214	1.5	700
215	2.3	595
216	4.3	342
217	1.9	686
218	4.7	464
219	3.2	698
220	1.1	546
221	2.3	1093
222	1.9	740
223	1.5	799
224	2.5	980
225	3.3	546
226	3	924
227	2	795
228	2	1056
229	2.3	849
230	3.1	1005
231	2.4	699
232	2.4	575
233	3.3	675
234	1.8	851
235	1.4	587
236	2.3	577
237	1.8	692
238	0.9	489
239	2	697
240	1.7	721
241	1.2	556
242	1.4	500
243	1.7	767
244	1.4	330
245	1.2	382
246	2.3	690
247	2.2	967
248	2.5	817
249	2	674
250	2.8	587
251	2.4	846
252	2.1	823
253	3.7	1027
254	2.8	740
255	3.4	790
256	1.9	892

Table A2.13: Microcosm 13: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
257	1.7	676
258	1.9	530
259	2	734
260	2.6	670
261	2.3	792
262	1.6	726
263	1.6	582
264	1.6	Median Height
265	1.7	445
266	2.3	782
267	2.3	676
268	1.7	585
269	2.2	538
270	1.4	373
271	1.6	635
272	2.8	623
273	1.6	302
274	2.3	751
275	2	369
276	1.5	352
277	1.6	510
278	1.4	399
279	0.8	262
280	3	1038
281	2.5	947
282	1.2	554
283	1.9	593
284	2.7	585
285	1.2	697
286	2	879
287	1.7	619
288	1.3	510
289	1.9	422
290	3.1	535
291	2.4	327
292	0.8	475
293	1.1	469
294	1	307
295	2.6	514
296	3.4	218
297	3.5	274
298	2	294
299	1.8	394
300	1.3	320
301	1.4	273
302	1.9	391
303	1.2	352
304	1.2	364
305	0.2	261

Table A2.13: Microcosm 13: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)

Stems	Total Stems	Total Number of Stems	305
		Stems with Inflorescence	32
	Heights (mm)	Max Height	1740
		Min Height	218
		Mean Height	808.8098361
		Mode Height	464
		Median Height	811
	Widths (mm)	Max Width	6
		Min Width	0.2
		Mean Width	2.459344262
		Mode Width	2
		Median Width	2.4

Table A2.14: Microcosm 14: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	4.4	1413
2	3.1	1248
3	2.9	1135
4	2.5	1112
5	3.8	1364
6	3.2	1226
7	2.9	1089
8	2.4	1060
9	1.7	842
10	2.2	523
11	2.7	1124
12	2.6	1042
13	3	1258
14	3.9	1115
15	3.4	1270
16	3.6	1323
17	3.1	1102
18	2.9	1075
19	3.6	1206
20	3.7	1220
21	2.2	973
22	2.2	903
23	3	1139
24	3.1	1068
25	2.2	891
26	4.1	1147
27	2.9	1108
28	1.9	952
29	2.2	886
30	2.5	935
31	1.7	859
32	1.8	815
33	3	1139
34	2.7	982
35	1.7	778
36	2.4	1082
37	1.5	631
38	1.8	861
39	2.9	1061
40	3.2	934
41	2.4	971
42	2.4	878
43	2.8	805
44	2.6	912
45	2.5	996
46	2.2	903
47	2.7	876
48	1.4	735
49	3	916
50	2.5	520
51	1.2	421
52	1	365
53	0.8	321
54	2	381
55	5.1	969
56	2.2	826
57	2.7	977
58	3.1	1007
59	2.5	922
60	2	865
61	2.1	783
62	1.1	295
63	2.3	1055
64	2.7	988

Table A2.14: Microcosm 14: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	2.5	977
66	1.8	800
67	3.2	992
68	2	731
69	2	940
70	2.2	790
71	3.2	910
72	1.6	689
73	2.2	852
74	2.6	965
75	2.4	935
76	2.1	1007
77	2.6	970
78	2.2	762
79	1.7	946
80	2.1	862
81	1.7	856
82	1.7	515
83	1.7	726
84	2.7	926
85	2	951
86	2	885
87	2.1	692
88	2.9	785
89	2.2	705
90	2.7	774
91	2	828
92	2.8	887
93	2.5	801
94	2.3	881
95	1.8	830
96	2.4	862
97	2.1	835
98	2.6	683
99	1.7	623
100	1.5	770
101	3.7	844
102	2.2	758
103	2.1	639
104	2	492
105	2.6	437
106	3.4	775
107	1.8	676
108	1.5	711
109	2.6	481
110	0.9	281
111	1.3	556
112	1.7	791
113	1.6	467
114	2.2	840
115	3.2	584
116	2.2	572
117	2.1	831
118	1.9	349
119	2.2	881
120	2.5	771
121	2.3	685
122	1.9	694
123	1.3	559
124	1.5	643
125	1.4	589
126	1.9	659
127	0.5	364
128	1.6	527

Table A2.14: Microcosm 14: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	1.7	615
130	2.4	568
131	1.8	634
132	1.7	831
133	2.1	865
134	2.8	698
135	1.5	480
136	4.5	834
137	2.3	871
138	1	299
139	1.8	641
140	1.8	766
141	2.9	725
142	2	754
143	1.6	535
144	0.9	416
145	2.1	663
146	1.8	613
147	1.8	632
148	1.8	476
149	1.5	539
150	2.9	685
151	1.8	602
152	1.6	604
153	2	532
154	1.5	239
155	1.4	397
156	1.4	523
157	1.5	662
158	1.7	677
159	2.3	598
160	1.9	595
161	1.9	581
162	2.9	561
163	1.6	700
164	1.4	480
165	3	249
166	2.2	240
167	1.9	531
168	2.1	596
169	1.4	560
170	1.4	547
171	1	470
172	1.2	463
173	1.9	489
174	2.3	433
175	1.1	364
176	1.9	788
177	1	392
178	2	444
179	1.5	567
180	1.6	439
181	0.8	227
182	2.1	397
183	1.8	310
184	3.1	237
185	1.8	770
186	1.2	623
187	1.3	486
188	2	519
189	2.2	425
190	1.8	670
191	1.7	727
192	1.5	547

Table A2.14: Microcosm 14: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	1.2	440
194	1.2	539
195	1.4	447
196	1.4	481
197	1.1	424
198	1.5	346
199	1.5	416
200	2.1	154
201	3.8	385
202	1.8	593
203	2.5	392
204	0.8	306
205	1.2	506
206	1	442
207	1.9	374
208	0.9	394
209	1.1	405
210	2	717
211	1.6	397
212	2	465
213	1	505
214	1.5	385
215	1.4	524
216	1.3	465
217	1	242
218	1.7	331
219	0.7	154
220	1.7	697
221	1	557
222	2.9	537
223	3.8	110
224	2.7	203
225	1.3	417
226	2.6	461
227	1.2	382
228	1.9	312
229	2	338
230	1.2	259
231	2.2	522
232	2.4	630
233	1.6	501
234	1	357
235	1.3	228
236	1.1	319
237	2.5	225
238	1.1	439
239	1	374
240	1.4	324
241	1.2	322
242	1.4	418
243	2.4	419
244	2.3	234
245	1.1	262
246	2	193
247	1.3	350
248	1.1	349
249	1.2	442
250	1.6	282
251	0.8	214

	Total Stems	Total Number of Stems	251
		Stems with Inflorescence	9
		Max Height	1413

Table A2.14: Microcosm 14: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)	
Stems	Heights (mm)	Min Height	110
		Mean Height	662.4860558
		Mode Height	397
		Median Height	634
	Widths (mm)	Max Width	5.1
		Min Width	0.5
		Mean Width	2.052191235
		Median Height	2.2
		Median Width	2

Table A2.31: Microcosm 15: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	2.5	933
2	2.4	971
3	5	431
4	4.3	941
5	5.7	1656
6	5.3	1015
7	4.6	1525
8	5.3	1581
9	3.7	591
10	4.3	1448
11	8.3	1665
12	5.1	1677
13	5.2	1294
14	2.7	579
15	4.3	715
16	4	1258
17	6.3	1651
18	3.2	815
19	6.4	1729
20	5.7	1634
21	4.4	1332
22	2.8	1079
23	2.6	1111
24	1.8	437
25	5.6	1510
26	4.5	1359
27	7.8	1926
28	8.5	1578
29	4.1	1360
30	6.7	1408
31	4.1	788
32	8.4	1696
33	8.7	1780
34	9.2	1643
35	6.9	1799
36	2.9	855
37	3.7	1198
38	3.7	700
39	3.9	772
40	5.8	1524
41	4.3	1339
42	1.8	853
43	3.5	406
44	3.9	1675
45	5.2	1372
46	2.4	1034
47	4.3	1545
48	2.6	393
49	4.9	1509
50	1.6	614
51	0.9	337
52	3.8	713
53	3.1	438
54	1.7	717
55	3.6	1280
56	3.4	1352
57	1.6	343
58	3.6	1275
59	2	708
60	1.8	1025
61	1.8	609
62	2.9	681
63	2.6	472
64	2	904

Table A2.31: Microcosm 15: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	2.3	560
66	5	488
67	2.9	636
68	2.4	376
69	2.1	266
70	2.6	312
71	3	302
72	1.4	303
73	1.8	524
74	1.3	302
75	3.2	608
76	2	424
77	1.5	230
78	2	300
79	2.1	160
80	1.7	221

Stems	Total Stems	Total Number of Stems	80
		Stems with Inflorescence	32
	Heights (mm)	Max Height	1926
		Min Height	160
		Mean Height	969.625
		Mode Height	302
		Median Height	918.5
	Widths (mm)	Max Width	9.2
		Min Width	0.9
		Mean Width	3.8375
		Mode Width	4.3
		Median Width	3.6

Table A2.16: Microcosm 16: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	2.4	1065
2	2.1	1082
3	4.2	1068
4	2.9	1186
5	2.4	1687
6	3.6	1287
7	3.5	1253
8	3.7	1145
9	2.6	1125
10	3.3	1170
11	2.5	1035
12	3.5	1141
13	2.7	993
14	3.2	1067
15	2.5	1047
16	3	934
17	2.1	957
18	3.1	967
19	2.4	954
20	3	996
21	2.7	897
22	2.2	976
23	1.8	906
24	2.2	929
25	1.8	879
26	2.1	896
27	1.5	736
28	1.6	706
29	2.2	799
30	3.8	848
31	2.4	904
32	2.8	827
33	2.1	740
34	1.9	860
35	2.7	981
36	1.7	661
37	2	917
38	1.7	671
39	1.7	827
40	3.9	843
41	1.3	654
42	1.7	863
43	2	817
44	2.7	804
45	2.8	880
46	2.2	265
47	1.5	560
48	1.9	665
49	2	790
50	2.2	804
51	1.7	790
52	2	580
53	1.7	682
54	1.4	227
55	2.7	760
56	3.5	649
57	1.8	812
58	2.7	814
59	1.9	762
60	3.5	757
61	1.1	350
62	2.8	804
63	1.6	634
64	1.9	765

Table A2.16: Microcosm 16: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	1.4	604
66	1.1	420
67	1.3	496
68	3	812
69	1.8	731
70	1.8	692
71	2	815
72	1.9	429
73	1.2	399
74	1	590
75	1.2	623
76	1.8	293
77	1.2	255
78	1.2	437
79	1.5	563
80	2	691
81	1.8	602
82	1.4	340
83	1.2	744
84	1.5	570
85	0.8	417
86	1.1	465
87	1.6	599
88	1.8	572
89	1.6	566
90	1	365
91	1.1	297
92	1.6	368
93	2.1	731
94	1.2	446
95	1.2	361
96	0.9	283
97	1.3	523
98	2.2	580
99	1.7	406
100	1.7	498
101	2.2	315
102	1.4	550
103	1.8	760
104	1.1	445
105	1.6	569
106	1.3	254
107	1	472
108	1.2	443
109	2	362
110	1.5	510
111	1.1	390
112	1	398
113	1	362
114	2.1	288
115	0.9	310
116	1.2	375
117	1.9	305
118	2	846
119	1.1	292
120	1.3	212
121	2.9	478
122	1.3	513
123	1.1	221
124	2.1	800
125	1.6	231
126	1	217
127	2.2	688
128	1.2	523

Table A2.16: Microcosm 16: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	1.5	561
130	1.8	520
131	2	741
132	2	291
133	1.4	253
134	3.6	389
135	1.9	768
136	1.3	249
137	1	432
138	2	567
139	0.8	326
140	4.1	804
141	1.3	329
142	1.1	333
143	0.5	487
144	1.8	324
145	2.3	758
146	1.5	707
147	1.6	762
148	1.3	540
149	1.6	542
150	2.2	786
151	1	461
152	2.2	702
153	0.7	215
154	1.8	777
155	2.9	560
156	1.4	168
157	0.9	245
158	1.3	230
159	1.7	274
160	1.8	341
161	1.9	472
162	1.2	303
163	1.1	395
164	2	276
165	1.1	406
166	0.6	250
167	1.9	712
168	1.3	349
169	3.4	490
170	1	245
171	2	696
172	1.3	402
173	1.5	753
174	2.2	591
175	1.2	294
176	1.6	599
177	1.6	481
178	0.9	486
179	1	451
180	3	647
181	2.1	732
182	2.5	578
183	2.2	724
184	1.7	457
185	1.7	679
186	2.3	824
187	1.7	647
188	2.4	495
189	1.9	704
190	2.7	412
191	1.6	512
192	1.4	179

Table A2.16: Microcosm 16: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	1.5	639
194	1.3	580
195	3.4	780
196	1.4	595
197	1.5	567
198	1.5	476
199	1	443
200	2.8	560
201	0.9	560
202	1.4	444
203	1.6	476
204	2.7	364
205	1.8	317
206	1.5	407
207	3.8	331
208	2.9	203
209	1.8	317
210	2.4	232
211	2.4	362
212	1.3	274
213	3.7	97
214	2.6	523
215	1.4	361
216	2.6	315
217	2	398
218	1.5	304
219	2.4	304
220	2	226
221	2	391
222	3.3	70
223	2	394
224	2.6	454
225	1.2	220
226	1.1	328
227	1.4	241
228	1.4	253
229	0.9	451
230	1.6	218
231	2.2	271
232	1.9	321
233	1	265
234	1.4	325
235	1.4	194
236	1	316
237	3.1	339
238	2.5	266
239	1.3	395
240	1	431
241	3	230
242	1.4	481
243	1.8	77
244	2.5	105
245	2.1	232
246	1.2	431
247	1.4	195
248	2.2	362
249	1	437
250	2.1	274
251	1.6	248
252	1.2	185
253	1.1	294
254	1.5	136
255	1.4	323

Table A2.16: Microcosm 16: *Phragmites australis* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)	
Stems	Total Stems	Total Number of Stems	255
		Stems with Inflorescence	4
	Heights (mm)	Max Height	1687
		Min Height	70
		Mean Height	546.8745098
		Mode Height	804
		Median Height	495
	Widths (mm)	Max Width	4.2
		Min Width	0.5
		Mean Width	1.872941176
		Mode Width	2
		Median Width	1.8

Table A2.17: Microcosm 1: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	5.4	305
2	2.9	1202
3	2	806
4	6.1	1322
5	3.4	1515
6	4.1	1362
7	7.4	1569
8	4.7	1643
9	3.1	688
10	6.8	571
11	7.2	1725
12	2.5	1298
13	4	1673
14	4.6	1376
15	3.8	1342
16	7.8	875
17	6.2	1175
18	4.7	1129
19	3	1262
20	5.1	1565
21	3.8	1437
22	5.6	1496
23	8	1454
24	3.5	1310
25	2.9	544
26	6.5	1472
27	3.6	289
28	3.6	1149
29	5.5	795
30	4	1640
31	6.1	1617
32	5.8	1772
33	2.1	894
34	2.7	1459
35	2	935
36	1.9	1172
37	1.9	601
38	1.8	623
39	5.5	139
40	5	1682
41	8.7	1937
42	3.4	1296
43	4.7	1429
44	5.9	1076
45	1.5	685
46	4.2	1423
47	2.1	968
48	2.6	1131
49	3.3	1057
50	6.6	1637
51	2	1081
52	1.5	682
53	1.5	661
54	3.1	1062
55	6.8	1777
56	1.9	822
57	7.2	1778
58	4.6	1349
59	2.9	1306
60	2.7	1242
61	5.8	1415

Table A2.17: Microcosm 1: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
62	7.3	1572
63	5	1694
64	1.9	1115
65	1.8	565
66	2	769
67	2.6	1199
68	3.8	1348
69	1.6	836
70	2.8	475
71	2.3	950
72	2.7	595
73	2.2	578
74	1.4	612
75	3.5	989
76	2.2	326
77	3.5	1434
78	2.1	947
79	4	361
80	2.3	912
81	1.3	772
82	4.3	476
83	2.9	1345
84	2.2	839
85	3.4	1209
86	3.3	1457
87	3.5	1346
88	3.2	1382
89	1.5	911
90	3.9	1739
91	1.9	1136
92	3.3	1191
93	1.7	685
94	2.6	1002
95	3.8	125
96	3.4	1179
97	2.1	640
98	2.7	1006
99	1.7	804
100	4.3	1511
101	2.8	830
102	1.4	736
103	7.6	1525
104	2.4	1086
105	7	1820
106	3.1	1217
107	3.3	1366
108	2.4	812
109	4	1360
110	2.3	914
111	2.3	671
112	1.8	901
113	3.3	1235
114	5.9	1436
115	3.4	625
116	2	632
117	2.6	1071
118	4.1	934
119	2	742
120	2.6	969
121	3.4	1450
122	2	1106

Table A2.17: Microcosm 1: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
123	2.6	1162
124	2.1	983
125	3.5	1146
126	4	1280
127	5.8	1668
128	1.7	879
129	2.9	1260
130	3.4	1364
131	2.7	1174
132	3.2	1058
133	4.9	1378
134	4.3	1483
135	3	1231
136	2.7	881
137	6.1	1542
138	6	270
139	5.3	1693
140	3.3	1523
141	5	1556
142	4.8	1486
143	4.9	1253
144	3.1	1602
145	4.4	1213
146	5.3	515
147	4.6	1176
148	2.5	1317
149	4.3	502
150	3.3	617
151	2.5	1388
152	3.5	578
153	2.8	966
154	3.5	437
155	2.7	702
156	1.9	817
157	3.6	1321
158	3.5	1496
159	1.5	898
160	2.1	851
161	1.8	993
162	2.2	587
163	1.8	1197
164	1.8	900
165	2.4	286
166	2.8	784
167	1.4	525
168	4	382
169	2.8	1124
170	2.8	295
171	2.5	203
172	3	897
173	1.4	717
174	2.3	1055
175	2.1	1060
176	1.8	690
177	1.9	489
178	1.7	572
179	2.6	1180
180	3	1175
181	2.1	967
182	1.5	811
183	3.5	375

Table A2.17: Microcosm 1: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
184	2.8	929
185	2	946
186	3.1	1206
187	2.8	1003
188	2	734
189	1.8	838
190	4	254
191	2.2	739
192	2.5	134
193	3.5	428
194	2	331
195	2.6	349
196	2	872
197	1.6	285
198	2	575
199	2.8	282
200	2.1	370
201	2.4	229
202	1.5	591
203	3.2	201
204	2.4	818
205	1.6	571
206	2	784
207	2	661
208	1.8	371
209	1.7	805
210	2.7	308
211	1.5	539
212	1.8	736
213	1.8	637
214	2	461
215	2	756
216	1.8	160
217	2.5	199
218	1.6	662
219	1.5	765
220	2	779
221	1.6	469
222	1.3	672
223	1.2	524
224	1.4	686
225	2	336
226	1.4	740
227	1.3	533
228	1.2	470
229	1	579
230	1.7	611
231	1.4	320
232	1.1	440
233	1.6	258
234	1.8	319
235	1.2	175
236	2.3	160
237	0.8	338
238	1.1	145
239	1.9	171
240	1.1	142
241	1.5	296
242	0.9	215
243	1.4	188

Table A2.17: Microcosm 1: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)	
Stems	Total Stems	Total Number of Stems	243
		Stems with Inflorescence	105
	Heights (mm)	Max Height	1937
		Min Height	125
		Mean Height	922.600823
		Mode Height	571
		Median Height	900
	Widths (mm)	Max Width	8.7
		Min Width	0.8
		Mean Width	3.07654321
		Mode Width	2
		Median Width	2.7

Table A2.18: Microcosm 2: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	3.6	456
2	1.7	247
3	2.2	328
4	1.9	522
5	3.4	315
6	2.9	846
7	2.4	362
8	5	1472
9	5.2	839
10	3.6	1481
11	2.7	788
12	3.9	1454
13	3.6	924
14	3.1	1162
15	4.3	1153
16	4.3	1440
17	5.3	1522
18	6.4	1644
19	4.2	505
20	3	1380
21	3.5	1139
22	3.5	1060
23	6.8	1817
24	4.8	1651
25	5.5	1665
26	5.5	1578
27	2.7	1383
28	7.8	1758
29	8.5	1727
30	5	1152
31	4.6	1418
32	3.8	1519
33	3.6	977
34	7	1293
35	6.4	1440
36	2.4	1102
37	6.5	1702
38	3.2	1169
39	2.5	1176
40	3.5	850
41	2.9	1220
42	3	1057
43	3.3	1008
44	4	265
45	4.1	1460
46	3.6	1197
47	3.6	1569
48	4	1848
49	2.6	435
50	2.8	1411
51	1.3	738
52	3	1321
53	3.5	1369
54	4.3	1507
55	6.3	1103
56	2.4	1233
57	4	1522
58	6.9	1644
59	5.7	1816
60	4.7	1647
61	1.1	614
62	11.5	271
63	2.7	961
64	2.3	641

Table A2.18: Microcosm 2: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	2.3	597
66	3.2	756
67	9.8	2007
68	6.8	1592
69	3.3	584
70	1.5	353
71	3.2	852
72	4	1541
73	3.3	1248
74	5.5	1443
75	3.2	976
76	4.2	1435
77	1.9	609
78	3.2	953
79	3.2	1022
80	5.2	743
81	3.1	310
82	4.5	1147
83	2	421
84	2.3	572
85	6.3	2005
86	3.6	1123
87	2.8	1042
88	1.6	867
89	6.7	1504
90	4.8	1633
91	3	1022
92	4.5	1216
93	2.6	1118
94	2.6	1301
95	4.1	1431
96	3.5	1290
97	5.2	1257
98	6.5	1752
99	4.6	1277
100	2.8	317
101	5.2	1672
102	4.4	1426
103	6.6	1851
104	10.6	1311
105	3.7	634
106	3	1071
107	3	1401
108	2.1	1027
109	2.5	977
110	5.2	1463
111	3.4	817
112	5.5	2077
113	1.9	909
114	3.6	1416
115	3.7	267
116	4.8	1749
117	4.4	1353
118	3.4	1321
119	5.3	1547
120	3.4	1099
121	4.6	1414
122	4.2	1477
123	2.5	888
124	3.4	1504
125	5.6	1672
126	3.4	901
127	3.7	651
128	4.1	1191

Table A2.18: Microcosm 2: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	4.9	709
130	5.3	1504
131	2.7	1147
132	3.5	1223
133	7.2	1914
134	6	1472
135	5.1	1499
136	3.8	1334
137	3.3	1237
138	7.6	1684
139	6.1	1852
140	6	1713
141	2.2	918
142	3.4	1072
143	5.7	1757
144	5.7	1331
145	3.6	1427
146	5	1318
147	2.3	641
148	2.9	477
149	2.7	997
150	3.8	1412
151	4.3	928
152	5	1280
153	3.7	1323
154	2.5	1081
155	1.6	897
156	1.7	674
157	2	489
158	1.5	317
159	2	557
160	1.1	362
161	4.1	222
162	3.5	947
163	3.4	1151
164	1	582
165	1.4	679
166	3.1	451
167	2.9	788
168	2	724
169	2	507
170	3.2	511
171	2.8	742
172	2.5	960
173	2.9	771
174	2.7	1025
175	2.1	689
176	3.4	251
177	2.8	232
178	2.5	210
179	2.8	161
180	2.6	162
181	1.8	327

Table A2.18: Microcosm 2: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)

Stems	Total Stems	Total Number of Stems	181
		Stems with Inflorescence	90
	Heights (mm)	Max Height	2077
		Min Height	161
		Mean Height	1090.127072
		Mode Height	1504
		Median Height	1147
	Widths (mm)	Max Width	11.5
		Min Width	1
		Mean Width	3.874033149
		Mode Width	3.6
		Median Width	3.5

Table A2.19: Microcosm 3: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	3	606
2	1.9	298
3	2	216
4	5.8	261
5	5.1	1666
6	2.2	947
7	4.4	1459
8	4.1	1129
9	6.1	1433
10	7.5	1478
11	5.6	1437
12	5.1	836
13	4.1	1051
14	1.9	1121
15	4.7	1034
16	1.8	956
17	3	1388
18	2	974
19	4.1	1301
20	2.2	875
21	5.8	1427
22	1.9	847
23	1.8	343
24	2.5	1054
25	2.9	1147
26	2.3	914
27	2.8	91
28	2	718
29	4.6	1080
30	5.4	1432
31	1.5	402
32	2	623
33	2.5	1171
34	4.5	1383
35	3.4	935
36	3.3	1131
37	1.7	752
38	3.7	944
39	2.4	1162
40	5.8	1689
41	3.7	522
42	5.3	1428
43	2.6	1047
44	1.4	792
45	3.5	343
46	4.4	446
47	2.7	249
48	2.4	1017
49	1.7	282
50	4	1580
51	2.2	968
52	3.6	1406
53	3.1	949
54	6.1	1455
55	4	1171
56	4.6	1356
57	3.8	1389
58	2.5	821
59	7	1619
60	5.7	1687
61	3.8	1444
62	2.7	591
63	2.8	402
64	4.7	1539

Table A2.19: Microcosm 3: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	3.5	1078
66	4.7	1311
67	3.9	1129
68	2.6	1046
69	3.6	914
70	3.2	1190
71	2.5	531
72	2.6	1053
73	2.4	1151
74	3.3	1187
75	2.6	741
76	4	312
77	1	627
78	3.3	604
79	8.1	1875
80	8.3	1619
81	2.8	974
82	9.3	1805
83	6.4	1490
84	4.1	407
85	3.9	1317
86	4.5	777
87	1.1	334
88	2.4	1138
89	9.5	1923
90	6.1	1634
91	2.3	799
92	3.7	934
93	6.1	1512
94	7.6	1795
95	5.7	989
96	4.3	1348
97	6.8	1582
98	2.7	1289
99	1.3	294
100	2.7	1176
101	2.7	814
102	2.5	181
103	2.4	261
104	3.6	186
105	3.3	257
106	2.4	263
107	2.6	1072
108	4	557
109	3.5	1184
110	4.4	920
111	4.5	1539
112	3.4	280
113	5.5	367
114	1.5	824
115	1.8	199
116	1.9	146
117	1.6	163
118	1.6	244
119	1.5	182
120	2.4	215
121	2.8	709
122	4.2	1431
123	5.5	1450
124	6.2	1530
125	4.1	1117
126	5.7	1693
127	4.1	1554
128	3.5	921

Table A2.19: Microcosm 3: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	1.6	667
130	6.1	1463
131	5.5	1666
132	5.2	1571
133	3.5	1382
134	1.5	816
135	2	183
136	4.8	1677
137	3.5	896
138	2.8	1442
139	3	1311
140	4.1	1254
141	3.3	1468
142	6.5	1463
143	8.7	1748
144	3.7	1462
145	5.3	1499
146	8.1	1697
147	3	1184
148	2.3	842
149	3.9	876
150	1.3	648
151	2.5	748
152	3.1	919
153	2.9	1012
154	2.6	1187
155	1.7	517
156	2.5	346
157	2.1	534
158	2.5	291
159	2.8	205
160	2.2	147
161	1.9	192

Stems	Total Stems	Total Number of Stems	161
		Stems with Inflorescence	70
	Heights (mm)	Max Height	1923
		Min Height	91
		Mean Height	979.3229814
		Mode Height	261
		Median Height	1017
	Widths (mm)	Max Width	9.5
		Min Width	1
		Mean Width	3.666459627
		Mode Width	2.5
		Median Width	3.3

Table A2.20: Microcosm 4: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	5	117
2	4.1	954
3	2.8	594
4	4.8	1091
5	1.4	428
6	2.4	718
7	2.6	484
8	3.9	744
9	3.8	1329
10	4.2	1159
11	5.5	1609
12	2.2	1349
13	4.2	1236
14	5	1208
15	1.9	865
16	4.2	921
17	3.8	1283
18	2.7	883
19	2.3	547
20	3	202
21	4.3	415
22	2.7	1283
23	0.7	719
24	3.2	1103
25	3.9	857
26	2.7	1276
27	5.2	1407
28	2.8	779
29	4.1	1178
30	3.8	1202
31	1.6	581
32	2.2	968
33	4.8	1322
34	5.5	1361
35	1.9	351
36	6.2	1215
37	2.4	530
38	1.8	402
39	2.4	969
40	5	381
41	2.4	865
42	4.1	313
43	6.9	1300
44	8.9	1468
45	3.9	767
46	1.8	420
47	5.8	1489
48	1.6	716
49	3.6	930
50	1.5	455
51	1.7	432
52	8.7	1528
53	4.3	404
54	4.1	1286
55	2.6	401
56	6.4	1317
57	3.9	1141
58	2.6	1021
59	2.3	264
60	4.5	1513
61	5.2	254
62	1.2	348
63	6.4	1651
64	5.9	1285

Table A2.20: Microcosm 4: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	2.9	653
66	3.3	819
67	3.9	1271
68	4	1282
69	3.4	882
70	1.7	954
71	2.1	842
72	5.4	1317
73	6.8	1560
74	2.3	991
75	2.5	1189
76	3.5	476
77	4.2	583
78	4	1324
79	2.4	1007
80	4.2	684
81	3.6	1659
82	3.9	1294
83	2	1132
84	4.3	889
85	4.8	1190
86	2.8	867
87	5.1	1534
88	7.2	1567
89	6.2	1156
90	6.1	1234
91	2.7	540
92	2.9	1131
93	5.8	1391
94	2.6	702
95	7	1365
96	3.2	1317
97	3.4	1221
98	2.8	1313
99	1.1	602
100	5	888
101	5.9	1376
102	5.3	1387
103	2.5	934
104	6.1	1490
105	6.8	1226
106	3.5	1517
107	3.3	1514
108	2.7	360
109	1.4	298
110	3.5	438
111	2	681
112	1.5	475
113	1.7	910
114	3	832
115	3.4	1218
116	5.7	1622
117	5.8	777
118	2.7	1473
119	4	597
120	4.2	632
121	8.4	1429
122	4.2	872
123	3.7	1031
124	4	713
125	3.5	1121
126	2.4	1161
127	2.4	381
128	5.7	1200

Table A2.20: Microcosm 4: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	2.2	592
130	5.6	1707
131	5.8	1026
132	4.3	1362
133	4	1196
134	1.7	245
135	2.2	448
136	0.8	559
137	4.3	1184
138	4.7	1365
139	3.5	1204
140	1.1	744
141	2.5	586
142	1.8	747
143	5	1465
144	4.4	1827
145	3.3	1365
146	2.8	606
147	1.8	828
148	8.4	1719
149	1.8	1097
150	2.6	1003
151	2	514
152	2.2	1223
153	2	609
154	2.8	538
155	2.1	554
156	3.5	490
157	5.6	1757
158	1.8	731
159	0.9	572
160	1.8	475
161	6.8	417
162	5.8	1503
163	3.9	1394
164	3.2	58
165	6.7	1867
166	6.2	1808
167	5.3	1350
168	5.2	979
169	6.9	1778
170	2.6	812
171	1.8	901
172	2.9	602
173	3	217
174	1.8	189
175	2.1	131
176	1.9	847
177	4.6	182
178	3.3	259
179	4.9	1636
180	6	1055
181	6.3	1711
182	4.8	177
183	1.8	374
184	4.8	105
185	2.5	267
186	2.9	293
187	2.7	181
188	2.6	215
189	2	308
190	1.8	251
191	2.7	223
192	1.8	212

Table A2.20: Microcosm 4: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	3.3	472
194	1.2	721
195	6.7	856
196	2.7	1040
197	6	1272
198	2.6	306
199	5.2	1224
200	4.6	1248
201	5.6	1697
202	3.3	249
203	2.5	565
204	2.4	1087
205	1.6	644
206	30	467
207	2.3	798
208	3.2	581
209	3.6	904
210	3	374
211	2.4	485
212	2.8	136
213	3.7	212
214	1.9	810
215	1.6	690
216	2.1	185

Stems	Total Stems	Total Number of Stems	216
		Stems with Inflorescence	81
	Heights (mm)	Max Height	1867
		Min Height	58
		Mean Height	887.7472527
		Mode Height	1317
		Median Height	866
	Widths (mm)	Max Width	30
		Min Width	0.7
		Mean Width	3.754166667
		Mode Width	1.8
		Median Width	3.3

Table A2.21: Microcosm 5: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	3.5	1253
2	2.5	1075
3	4.2	954
4	5.9	1595
5	2.7	884
6	5.3	871
7	3.8	1214
8	3.6	1244
9	3.9	756
10	3.7	1326
11	2.8	919
12	5.6	1425
13	3.2	1162
14	3.8	1384
15	3.4	948
16	3.1	1069
17	2.2	775
18	5.7	1137
19	3.8	864
20	1.9	467
21	2.8	995
22	5.2	643
23	2.5	1037
24	3.6	1174
25	4.1	1344
26	5.3	804
27	1.3	691
28	1.3	565
29	1.8	665
30	1.4	598
31	1.7	460
32	4.9	515
33	4.1	919
34	3.3	936
35	6.5	799
36	4.2	1186
37	3.1	1672
38	3.8	1009
39	1.4	586
40	4	1106
41	4.9	1535
42	4.8	1526
43	2.8	1099
44	5.4	1644
45	2.5	1045
46	5.7	1488
47	4.2	1006
48	4.5	1529
49	4.9	898
50	3.1	1017
51	9	872
52	2.7	1114
53	6.8	869
54	3.7	1228
55	4.8	918
56	5.5	935
57	10.1	1514
58	6	1494
59	1.2	537
60	2.5	1051
61	5.1	632
62	2.1	625
63	1.6	597
64	2.4	845

Table A2.21: Microcosm 5: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	3.1	1117
66	1.9	849
67	1.2	699
68	2.4	977
69	2.9	1133
70	2.9	184
71	3.8	834
72	4.9	864
73	3.6	625
74	1.7	629
75	2.7	1009
76	2.8	1016
77	0.5	374
78	3.8	883
79	8.7	1013
80	3.4	330
81	3.1	906
82	1.2	516
83	3.1	939
84	3	1031
85	3.7	1234
86	2.2	836
87	1.6	826
88	2.1	575
89	3.5	979
90	3.5	1128
91	1.9	388
92	2.9	834
93	2.6	886
94	2.3	677
95	2.5	686
96	3.4	961
97	2.8	803
98	0.9	477
99	1	596
100	1	296
101	1.8	476
102	1.1	499
103	1	413
104	2.4	1015
105	3.4	1192
106	2.3	964
107	3.2	940
108	2	553
109	0.4	290
110	2.4	901
111	2.3	791
112	2.6	845
113	3.4	874
114	4.4	909
115	4.9	913
116	2.5	915
117	4.2	914
118	1.3	904
119	3.3	957
120	1.1	567
121	2.8	1094
122	2.2	122
123	3.4	1126
124	3.5	1357
125	4.8	866
126	2.9	1112
127	3.9	1404
128	2.7	339

Table A2.21: Microcosm 5: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	4.4	1182
130	2.5	326
131	2.4	627
132	2.4	742
133	2.3	771
134	3.2	1012
135	3.6	497
136	0.2	284
137	2.5	819
138	1.1	167
139	3	977
140	4.1	973
141	3.2	1136
142	5	959
143	2.9	706
144	0.8	446
145	3.2	1198
146	3.8	1358
147	3	841
148	1.2	553
149	0.8	472
150	0.9	597
151	2.2	358
152	2.5	893
153	0.9	349
154	4.8	1086
155	2.8	461
156	1.7	772
157	1.6	196
158	2.4	859
159	2	796
160	2.5	926
161	1.5	831
162	1.4	231
163	2.4	849
164	1.5	635
165	1.9	837
166	2	710
167	2.4	797
168	2.5	891
169	2.7	915
170	1.4	446
171	1.9	447
172	1.5	264
173	1.7	305
174	1.4	431
175	0.9	311
176	2.7	736
177	2.5	787
178	2.4	571
179	2.1	561
180	2.6	772
181	2.8	354
182	1.4	502
183	1.3	445
184	1.2	422
185	1.8	451
186	1.2	234
187	1.1	252
188	12.5	140

	Total Stems	Total Number of Stems	188
		Stems with Inflorescence	55

Table A2.21: Microcosm 5: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)	
Stems	Heights (mm)	Max Height	1672
		Min Height	122
		Mean Height	823.787234
		Mode Height	919
		Median Height	854
	Widths (mm)	Max Width	12.5
		Min Width	0.2
		Mean Width	3.003191489
		Mode Width	2.5
		Median Width	2.7

Table A2.22: Microcosm 6: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	3.6	206
2	5.7	1723
3	2.5	916
4	3.2	1137
5	4.3	1146
6	3.2	1267
7	2.5	920
8	5.3	1055
9	3.5	45
10	5.3	1457
11	3.7	1168
12	1.1	662
13	2.3	986
14	4.4	1154
15	1.8	202
16	5	1360
17	2.2	627
18	3.3	1088
19	5.7	1683
20	2.1	941
21	2.6	1137
22	2.6	1097
23	2.6	836
24	2.7	921
25	1.6	160
26	4.6	1650
27	5.5	1107
28	1.8	572
29	6	1728
30	2.6	1110
31	2.7	1120
32	4.2	1437
33	3.8	1215
34	2.9	1319
35	2.4	1070
36	1.7	724
37	3	856
38	2.2	449
39	4.7	1696
40	2	720
41	5.9	1800
42	1.1	371
43	4	1525
44	3.5	1440
45	4.2	1105
46	2.1	402
47	0.5	155
48	1.1	402
49	1.9	927
50	1.5	695
51	5.6	655
52	2.8	1387
53	2.1	936
54	2.7	1108
55	3.3	837
56	4.6	1472
57	2.7	858
58	4	1048
59	4	1593
60	2.7	1257
61	3.4	1392
62	7.4	1955
63	3.2	736
64	1.2	52

Table A2.22: Microcosm 6: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	5.4	1742
66	2.4	835
67	1.2	432
68	1.7	841
69	4	1126
70	3.1	1083
71	2.6	982
72	3.2	425
73	3.2	1255
74	2	913
75	2.7	875
76	2.1	749
77	3.1	1202
78	3	1235
79	2.7	421
80	4.5	1228
81	2.3	965
82	1.3	480
83	2.2	671
84	1.5	330
85	2.1	754
86	1.4	411
87	3.6	1358
88	3.6	1314
89	2.2	886
90	1.9	349
91	3.8	1376
92	3.1	1079
93	2.4	394
94	3.8	505
95	3.3	1226
96	3.9	1220
97	2	904
98	2.1	1114
99	2.6	1076
100	1.6	698
101	3.3	1170
102	1.3	505
103	5.1	1312
104	3.7	1047
105	2.6	381
106	3.3	1142
107	2.6	269
108	2.3	980
109	2.4	1004
110	3	395
111	2	524
112	2.1	807
113	2.4	256
114	2.5	369
115	3.1	174
116	2.4	892
117	3	85
118	3	897
119	2.5	340
120	1.1	611
121	1.7	763
122	2.3	705
123	1.9	336
124	2.1	311
125	1.9	422
126	2.2	334
127	1.3	268
128	1.6	232

Table A2.22: Microcosm 6: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	2.1	190
130	1.4	43

Stems	Total Stems	Total Number of Stems	130
		Stems with Inflorescence	47
	Heights (mm)	Max Height	1955
		Min Height	43
		Mean Height	876.8692308
		Mode Height	1137
		Median Height	914.5
	Widths (mm)	Max Width	7.4
		Min Width	0.5
		Mean Width	2.909230769
		Mode Width	2.1
		Median Width	2.6

Table A2.23: Microcosm 7: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	3.2	1060
2	2.8	830
3	2.4	220
4	2.2	640
5	2.2	996
6	2.7	623
7	3.5	1158
8	3	412
9	1.7	532
10	3.3	1073
11	3.9	1312
12	3	1095
13	4	1009
14	2	922
15	4.9	1204
16	2.8	1070
17	2.8	1054
18	5.7	1528
19	3.5	1314
20	3.8	1237
21	3.5	1064
22	2.7	559
23	6.4	1423
24	3.5	1131
25	3.8	132
26	2.4	902
27	3.2	1109
28	2	728
29	2.4	1037
30	4.7	423
31	3.9	1129
32	2.8	924
33	4.9	1492
34	3.3	1048
35	2.3	1146
36	3.4	1382
37	2.1	938
38	7.5	1714
39	3.1	977
40	3.2	554
41	2.9	1135
42	6.8	1721
43	6.3	1556
44	3.6	964
45	4	485
46	2.6	1036
47	6.1	1549
48	2.3	73
49	1.7	734
50	1.8	376
51	1.5	602
52	3.6	1568
53	1.7	781
54	4.3	1312
55	1.5	312
56	2	906
57	2.5	908
58	3.8	1215
59	2.2	916
60	9.5	1723
61	5.2	1437
62	7.4	1673
63	2.9	1052
64	4.9	1485
65	3.5	1158
66	3.9	1198
67	3.2	1338
68	3.1	1028
69	6	1399

Table A2.23: Microcosm 7: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
70	5.6	1684
71	2.5	516
72	6.2	1658
73	6.4	1316
74	3.1	963
75	2.5	1270
76	3.2	942
77	3.3	945
78	1.8	451
79	3.5	1034
80	2.8	420
81	4.3	1263
82	3.6	1584
83	7.1	1550
84	3.6	878
85	1.8	293
86	3.2	1132
87	1.1	510
88	6.2	1824
89	5.3	721
90	2.6	1042
91	5.4	1316
92	8.6	1296
93	3.5	1346
94	3.4	1234
95	3	700
96	4.4	1222
97	1.8	183
98	4.2	1478
99	5.3	1568
100	4.1	881
101	3.7	1134
102	5.4	1506
103	3.7	1338
104	6	622
105	4.1	1397
106	4.4	1250
107	3.3	1224
108	4.2	531
109	2.8	1232
110	3	981
111	2	708
112	4.4	558
113	1.1	510
114	2	245
115	1.6	424
116	4	817
117	2	588
118	2.6	873
119	1.2	497
120	2.6	874
121	2.7	724
122	1.8	526
123	0.8	460
124	3	861
125	2.9	417
126	4.1	782
127	1.8	595
128	2.8	716
129	2	960
130	3.9	927
131	3.7	502
132	1.9	689
133	5	102
134	3.4	411
135	1.8	716
136	2.3	992
137	2.6	1023
138	6.2	649

Table A2.23: Microcosm 7: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
139	3.1	595
140	2.1	342
141	1.5	352
142	2.1	430
143	2.6	235
144	3.4	910
145	1.8	371
146	1.7	333
147	0.9	324
148	1.4	409
149	0.9	377
150	1.6	223
151	3	219
152	1.1	327
153	1.2	457
154	0.6	340
155	2.5	286
156	2.1	262
157	2	339
158	1.1	208
159	1.5	282
160	2.9	244

Stems	Total Stems	Total Number of Stems	160
		Stems with Inflorescence	50
	Heights (mm)	Max Height	1824
		Min Height	73
		Mean Height	882.41875
		Mode Height	1158
		Median Height	919
	Widths (mm)	Max Width	9.5
		Min Width	0.6
		Mean Width	3.29125
		Mode Width	2
		Median Width	3

Table A2.24: Microcosm 8 *Lythrum salicaria* Stem Measurements.

There were no surviving *Lythrum salicaria* within Microcosm 8.

Table A2.25: Microcosm 9: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	3.6	1544
2	4	1346
3	1.9	1045
4	6.2	1607
5	2	930
6	5.2	1674
7	5.7	1402
8	4.5	1577
9	4.5	1550
10	2.6	1066
11	4.8	1397
12	3.1	1129
13	4.7	1174
14	3.1	1232
15	3.3	1190
16	6.4	1381
17	3.4	825
18	2	620
19	2.4	466
20	2.4	870
21	3.2	805
22	5.9	1085
23	4.4	1337
24	3	1011
25	5.5	1267
26	2.5	925
27	3.7	1224
28	1.1	516
29	2	351
30	2.4	865
31	1.7	551
32	3	833
33	8.5	1244
34	2.7	1136
35	4.2	845
36	1	422
37	0.9	330
38	1.5	413
39	1	468
40	3.4	440
41	1.6	536
42	2.2	605
43	0.8	327
44	2.1	271
45	1.8	966
46	2.3	917
47	1.9	592
48	2.8	904
49	3.3	1022
50	1.6	707
51	1.4	515
52	2.3	943
53	3	1128
54	5.7	1079
55	2.6	673
56	1.9	595
57	1.5	605
58	1.4	645
59	1.4	524
60	2	756
61	4.1	1336
62	1.2	170
63	1.5	719
64	2.5	1001

Table A2.25: Microcosm 9: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	2.9	1260
66	2.9	1122
67	2.4	1036
68	4.4	1228
69	3.2	1252
70	5	1209
71	5	811
72	1.1	370
73	1.7	713
74	2.4	467
75	2.3	766
76	1.9	630
77	2.9	1117
78	5.3	1191
79	1.8	992
80	2.7	1100
81	1	460
82	1.7	817
83	2.6	793
84	2.2	844
85	3.6	1263
86	4.7	308
87	1.4	494
88	0.7	300
89	4	1249
90	6	1016
91	2.2	263
92	2.1	877
93	3.3	1145
94	1.9	522
95	2	957
96	4.1	1358
97	6.6	1404
98	1.2	605
99	4.6	1267
100	2.8	386
101	3.3	1466
102	1.5	672
103	2	673
104	3.6	1397
105	3	1158
106	4	1396
107	3	620
108	2.9	1178
109	3.9	1030
110	4.5	1385
111	2.1	919
112	1.6	788
113	3.8	1387
114	1.8	885
115	3.5	1134
116	1.2	510
117	2	609
118	2.3	880
119	4.3	1444
120	2.1	817
121	8.2	1334
122	5.1	1181
123	2.8	1176
124	2.4	1091
125	2.5	986
126	2.1	849
127	5	1193
128	3	1241

Table A2.25: Microcosm 9: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	1.6	578
130	2.8	945
131	2.2	607
132	1.7	725
133	2.9	1080
134	2.3	693
135	1.7	868
136	3.5	1079
137	1.9	644
138	2.1	628
139	2.8	1077
140	1.9	796
141	2.9	1007
142	2.7	960
143	2.7	1000
144	1.6	549
145	2.6	946
146	3.5	740
147	3.2	347
148	1.9	701
149	1.8	820
150	3.7	953
151	4	744
152	4.4	699
153	0.7	345
154	1.2	360
155	2.2	420
156	2.5	540
157	1.9	594
158	1.3	569
159	1.2	486
160	2.2	654
161	1.1	466
162	1.9	557
163	1.3	320
164	0.8	382
165	1.7	367
166	1.6	876
167	2.3	616
168	2.3	688
169	2.5	710
170	1.6	822
171	2.1	550
172	2.4	708
173	1	415
174	0.7	473
175	1.2	516
176	0.9	288
177	1.3	220
178	2.5	852
179	2.2	875
180	2	740
181	1.4	646
182	1.9	547
183	2	528
184	1.3	429
185	1.6	355
186	4.6	253
187	1.1	416
188	1.5	195
189	0.9	188
190	3.1	443

Table A2.25: Microcosm 9: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)	
Stems	Total Stems	Total Number of Stems	190
		Stems with Inflorescence	63
	Heights (mm)	Max Height	1674
		Min Height	170
		Mean Height	827.4473684
		Mode Height	605
		Median Height	817
	Widths (mm)	Max Width	8.5
		Min Width	0.7
		Mean Width	2.698947368
		Mode Width	1.9
		Median Width	2.35

Table A2.26: Microcosm 10: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	2.5	1192
2	0.8	550
3	4.1	1416
4	6.9	1734
5	6.1	1366
6	6.7	1608
7	7.6	1625
8	5.5	1264
9	4.2	1334
10	3.1	950
11	1.6	796
12	0.5	411
13	4.7	1592
14	4.5	1658
15	0.9	492
16	2.1	934
17	3.4	1278
18	3.2	1120
19	3.3	918
20	4.5	1084
21	6.6	1762
22	2.2	1150
23	2.4	1126
24	3.6	1339
25	5.1	1586
26	2.9	1251
27	2	972
28	4.8	1563
29	6.5	1385
30	3.6	1058
31	6.6	1514
32	3	823
33	1.6	583
34	2	1064
35	2.1	1103
36	6.6	1529
37	2.2	442
38	2.6	768
39	0.6	362
40	2.8	789
41	2.9	874
42	2.4	906
43	2.4	914
44	2.2	629
45	3.2	867
46	2.1	822
47	1.6	602
48	1.8	757
49	2.9	1112
50	1.7	863
51	4.1	934
52	4.2	1089
53	1.3	746
54	3.7	1387
55	3.5	1303
56	3.2	721
57	3.5	972
58	3.2	1018
59	1	513
60	0.8	485
61	2.2	997
62	1.6	531
63	2.7	857
64	2.8	1278

Table A2.26: Microcosm 10: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	2.4	1140
66	2.5	913
67	5.4	1510
68	6.5	1344
69	1.5	335
70	1.5	422
71	2.5	785
72	4.8	1028
73	2	698
74	3.2	798
75	6	1825
76	3.1	655
77	2.5	1051
78	1.7	1125
79	1.4	458
80	6.1	1632
81	7.3	1405
82	4.9	1382
83	2.7	846
84	3	1386
85	2.1	1012
86	1.4	857
87	3.2	1215
88	5.5	1829
89	4	1266
90	0.5	737
91	1.5	715
92	1.2	412
93	3	1194
94	4.3	1578
95	3.2	1530
96	3.7	1493
97	4	1665
98	3.5	1674
99	4.1	1432
100	4	1249
101	4.8	1648
102	5.2	1525
103	3.7	1275
104	2.2	1288
105	1.5	101
106	4	1263
107	2.5	857
108	5.8	1678
109	2.6	1348
110	4.7	1172
111	3.5	1458
112	4	1512
113	3	1458
114	3.5	1354
115	2.1	1364
116	3.7	1496
117	2.6	1108
118	2.6	1532
119	4.6	1337
120	3.5	1104
121	2.4	1364
122	2.9	905
123	3.3	907
124	1.7	818
125	4.2	584
126	2.7	952
127	2.3	894
128	2.9	823

Table A2.26: Microcosm 10: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	2	917
130	3.4	1261
131	4.3	1158
132	4.3	1338
133	2.7	1402
134	1.8	1052
135	5.6	1389
136	3.7	1420
137	5.7	1237
138	3.8	1434
139	2	972
140	1.9	1134
141	1.6	884
142	2.9	1284
143	3.8	1266
144	5.5	1225
145	3.9	1104
146	3.7	1204
147	5.5	1532
148	4.3	1299
149	1.2	472
150	1.2	633
151	2.5	952
152	3.6	1355
153	2.1	1045
154	4.2	741
155	2.7	1100
156	1.3	627
157	1.4	809
158	0.9	650
159	1.2	735
160	1.3	635
161	2	735
162	1.4	517
163	2.4	846
164	4.4	1183
165	3.4	1034
166	2.7	922
167	2.6	916
168	2.2	641
169	1.1	934
170	1.4	946
171	3.9	1064
172	2.6	883
173	2.3	1107
174	3.7	1042
175	2.6	1221
176	2.3	1042
177	2.2	1164
178	2.5	752
179	2.5	934
180	3.4	785
181	0.7	691
182	1.3	668
183	2.4	957
184	0.5	381
185	1.2	821
186	1.8	964
187	2.2	714
188	1.6	630
189	1.3	591
190	2.1	651
191	0.8	540
192	1.4	539

Table A2.26: Microcosm 10: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	0.8	405
194	1.2	458
195	3.2	912
196	3	705
197	3.1	816
198	0.8	465
199	1.6	844
200	1	657
201	1	318
202	1.4	781
203	0.9	553
204	2.1	556
205	1.7	481
206	2	580
207	2	418
208	2.9	348
209	0.5	131
210	1.5	757
211	1.6	493
212	1.7	439
213	2.1	364
214	1.4	580
215	1.2	596
216	3	525
217	1	408
218	0.7	487
219	2.6	395
220	0.7	407
221	1	315
222	0.7	339
223	0.4	379
224	1.6	235
225	0.6	220

Stems	Total Stems	Total Number of Stems	225
		Stems with Inflorescence	78
	Heights (mm)	Max Height	1829
		Min Height	101
		Mean Height	968.1644444
		Mode Height	934
		Median Height	934
	Widths (mm)	Max Width	7.6
		Min Width	0.4
		Mean Width	2.824888889
		Mode Width	1.6
		Median Width	2.6

Table A2.27: Microcosm 11: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	5.2	1908
2	6.7	1776
3	6.7	1783
4	7.4	1704
5	5.6	1390
6	3.9	1785
7	4.1	1144
8	3.7	1487
9	2.4	1316
10	2.8	815
11	5.5	1189
12	3	947
13	4.3	1200
14	3.8	1159
15	5	814
16	4.5	1366
17	3.7	849
18	3.2	1024
19	2.6	1384
20	2.7	1153
21	2	946
22	2.8	671
23	2.5	376
24	4.8	1138
25	3.5	1337
26	2.7	1110
27	2.8	1347
28	5.1	1317
29	3.6	1112
30	2.1	567
31	3.9	1428
32	2.7	973
33	3.2	1182
34	3	1159
35	1.5	699
36	5.1	1540
37	1.8	1302
38	3.4	1335
39	3.4	1275
40	1.8	948
41	2.8	1463
42	3.4	1144
43	3.2	932
44	3.8	941
45	2.5	338
46	2.7	1155
47	2.2	1425
48	5	1286
49	5.7	1385
50	1.6	656
51	2.4	761
52	1.2	704
53	2.2	1052
54	2	459
55	3.4	949
56	3.7	1080
57	2.5	1415
58	3.6	946
59	3.7	946
60	2	624
61	3.2	1384
62	2.5	1012
63	4.7	1302
64	2.6	870

Table A2.27: Microcosm 11: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	1.9	745
66	4.6	1127
67	7.1	1704
68	5.6	1419
69	5	1482
70	4.9	1549
71	3	1093
72	4.7	1673
73	5.4	1609
74	3.6	1215
75	2.1	1001
76	3.7	1158
77	5	1325
78	2.4	1225
79	4.6	153
80	2	964
81	2.5	1129
82	2	1143
83	3.3	1018
84	2.1	421
85	4.1	1435
86	2.2	1212
87	4.4	1421
88	3.6	1208
89	3.7	1449
90	5	1462
91	2.9	1152
92	4.7	1426
93	3	1444
94	5.1	1442
95	4	1556
96	3.8	974
97	3.1	1293
98	2.4	1205
99	5.3	1389
100	3.7	1523
101	2.7	1401
102	2.7	1371
103	2.6	1225
104	3	554
105	2.2	1061
106	5.7	1688
107	3.2	871
108	1.6	972
109	2.5	515
110	2.1	407
111	3.2	640
112	1.2	815
113	1.1	894
114	3.3	1016
115	3.9	1327
116	3.4	975
117	2.7	955
118	3.4	840
119	3.2	1215
120	4.6	1598
121	5	1368
122	2.5	764
123	2.7	1432
124	1.5	739
125	4.1	1457
126	2.5	847
127	6.3	1558
128	4.3	1487

Table A2.27: Microcosm 11: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	5.2	1412
130	3.1	1049
131	4	275
132	2.4	474
133	1.8	772
134	2.8	502
135	2.9	989
136	2.7	397
137	1.6	299
138	2.1	282
139	2.9	1084
140	2.6	1405
141	2.8	648
142	1.4	440
143	1.6	831
144	2.4	295
145	3.5	528
146	5.2	1468
147	1.7	808
148	3.3	1086
149	3.8	862
150	2.8	849
151	1.9	832
152	2	276
153	1.6	598
154	1.8	389
155	2.2	472
156	2.6	1063
157	1.5	332
158	4.7	1318
159	4	1382
160	2.2	712
161	2.4	928
162	2.7	1012
163	2.8	1476
164	5.5	1382
165	3.5	1318
166	0.9	442
167	3.6	1047
168	2.9	479
169	2.6	437
170	2.8	927
171	3.2	1228
172	4	1314
173	1.8	1010
174	1.6	978
175	2.1	1257
176	2	411
177	2.2	812
178	1.7	683
179	1.4	337
180	1.7	420
181	1	551
182	1.6	559
183	1.4	725
184	1.4	572
185	2.1	358
186	3.2	596
187	1.8	447
188	1.9	677
189	2.2	372
190	1.6	698
191	1.8	694
192	1.3	596

Table A2.27: Microcosm 11: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	1.8	418
194	2.1	489
195	1.6	536
196	1	677
197	1.7	314
198	1.6	286
199	1.4	342
200	0.4	333
201	1.8	154

Stems	Total Stems	Total Number of Stems	201
		Stems with Inflorescence	69
	Heights (mm)	Max Height	1908
		Min Height	153
		Mean Height	991.7462687
		Mode Height	946
		Median Height	1012
	Widths (mm)	Max Width	7.4
		Min Width	0.4
		Mean Width	3.074626866
		Mode Width	2.7
		Median Width	2.8

Table A2.28: Microcosm 12: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	3.4	1064
2	5.9	1446
3	4.6	1494
4	3.5	486
5	4.8	973
6	5.4	1206
7	8	1628
8	2.2	694
9	7.6	1654
10	7	1584
11	4.1	1372
12	4.7	1380
13	6.8	1709
14	2.6	664
15	1.8	691
16	2.4	334
17	2.7	594
18	5	611
19	4.2	111
20	5.5	1354
21	3.9	1058
22	2.7	456
23	1.3	492
24	3.7	890
25	1.5	847
26	1.5	554
27	3.5	871
28	1.8	913
29	2.5	433
30	3.3	857
31	3.5	907
32	3.7	834
33	3	1014
34	3.4	525
35	3.2	971
36	5.4	1230
37	5.5	1816
38	6	841
39	3.7	1153
40	8.7	1605
41	3.2	544
42	2.7	813
43	3	1243
44	2.8	1106
45	3.1	1134
46	1.5	566
47	5.1	782
48	6.4	1525
49	3.9	936
50	4	1158
51	5.9	1496
52	2.9	678
53	1.1	784
54	6	1396
55	2.2	283
56	2.9	906
57	3.2	1013
58	1.2	310
59	5.8	921
60	2	707
61	3.8	932
62	2	506
63	1.8	450
64	3.9	1206

Table A2.28: Microcosm 12: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	3.7	1087
66	5.2	1007
67	4.7	1328
68	4	1430
69	1.7	431
70	2.1	975
71	2.6	791
72	2.1	960
73	3.8	1090
74	1.8	586
75	4	1163
76	1.7	1018
77	7.2	1458
78	2.6	1308
79	3	1106
80	2.8	890
81	1.3	643
82	3.8	572
83	4.4	1209
84	3.6	1214
85	3.5	1203
86	4.9	1338
87	4.7	1800
88	6.9	1303
89	4.3	1052
90	3.7	1629
91	1.4	777
92	2.6	824
93	4.7	1289
94	2.6	977
95	6.3	1174
96	2.4	965
97	2.8	756
98	3.8	1011
99	5.1	1625
100	2	764
101	6.4	1572
102	4.2	1345
103	6.9	1713
104	4	1211
105	3.2	758
106	3.4	1589
107	5	971
108	8.1	1262
109	5.8	1001
110	3.2	624
111	4.6	1601
112	5	1086
113	2.2	861
114	7.1	1331
115	3	443
116	5.5	490
117	2.5	883
118	1.8	1109
119	5.8	1542
120	2.3	1086
121	1.9	694
122	1.6	600
123	1.9	910
124	2.2	612
125	4.5	1378
126	1.4	167
127	2.9	931
128	4.7	1172

Table A2.28: Microcosm 12: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	3	1019
130	2.8	1208
131	3	1108
132	3.2	917
133	3.6	990
134	3.7	1134
135	1.1	464
136	1.8	369
137	3.3	1208
138	2.2	774
139	1.3	621
140	3.4	1142
141	2.8	729
142	2.7	1165
143	1.5	790
144	2.3	790
145	2.4	461
146	4.3	1448
147	5	756
148	2.2	917
149	1.2	625
150	1.8	935
151	2.7	684
152	2.4	355
153	1.5	432
154	5.2	1054
155	3.8	1189
156	2.5	1135
157	4	1156
158	2.4	1154
159	2.6	784
160	2.8	867
161	2	667
162	1.8	832
163	1.8	905
164	3.2	1425
165	1	631
166	4.2	987
167	1.7	520
168	2.5	604
169	1.7	449
170	2.7	337
171	1.7	829
172	2.5	1069
173	2.7	911
174	3	795
175	1.8	490
176	1.8	586
177	1.4	381
178	2.2	294
179	3.8	1174

Table A2.28: Microcosm 12: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)	
Stems	Total Stems	Total Number of Stems	179
		Stems with Inflorescence	48
	Heights (mm)	Max Height	1816
		Min Height	111
		Mean Height	953.4748603
		Mode Height	1206
		Median Height	935
	Widths (mm)	Max Width	8.7
		Min Width	1
		Mean Width	3.437430168
		Mode Width	1.8
		Median Width	3.1

Table A2.29: Microcosm 13: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	2.7	867
2	2	607
3	4.7	1337
4	2.4	680
5	4.2	1204
6	4.2	919
7	5.9	1184
8	2.4	705
9	4	1286
10	5.6	1300
11	3.6	1254
12	4.9	1529
13	4	1051
14	3.3	1181
15	4.3	1376
16	3.2	1121
17	2.2	727
18	2.2	506
19	3.8	1124
20	1.8	577
21	3.2	1213
22	4.9	1643
23	3	974
24	6.7	1542
25	2.5	1002
26	3.7	911
27	7.4	1778
28	3.3	1257
29	2.4	986
30	5.7	1219
31	5.4	1638
32	3.1	1057
33	1.5	948
34	1.5	436
35	1.3	513
36	1.1	684
37	3	1005
38	1.8	535
39	3	1010
40	2.5	802
41	2.5	883
42	1.7	624
43	5.6	1734
44	3.8	1443
45	2.3	483
46	3.6	1337
47	1.9	656
48	2.6	865
49	5.5	1658
50	3.2	1672
51	2.5	697
52	2	567
53	2.3	792
54	1.9	783
55	2	749
56	2.1	479
57	2.9	964
58	2	480
59	2.2	385
60	2.2	836
61	1.9	667
62	6.1	1612
63	4.8	1605
64	3.3	1109

Table A2.29: Microcosm 13: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	4.5	1010
66	3.8	1164
67	1.8	640
68	2.6	839
69	1.8	596
70	2	735
71	2	801
72	2.4	1208
73	1.5	524
74	4	365
75	2.9	691
76	5.4	973
77	4.8	1536
78	1.9	684
79	1	566
80	1.8	742
81	4.2	1335
82	3.6	1266
83	2.2	972
84	2.2	768
85	0.8	418
86	1.9	769
87	2	532
88	3.3	1081
89	3.2	538
90	2.7	874
91	2.4	1070
92	5.6	1481
93	3.6	587
94	1.4	570
95	2.2	500
96	3	984
97	2.4	731
98	1.7	871
99	2.6	630
100	3.4	1153
101	1.7	713
102	1.2	746
103	1.8	714
104	2.7	1232
105	2.4	921
106	2.2	1118
107	4.5	1115
108	3.6	1067
109	1.3	653
110	2	692
111	1.5	677
112	1.1	441
113	2.1	769
114	1.7	705
115	5.8	1580
116	3	990
117	3.1	505
118	1.8	796
119	2.6	858
120	2.9	1115
121	3.6	1162
122	2.9	937
123	3.2	1140
124	2.5	853
125	4.8	1402
126	4.2	1223
127	2	471
128	5	718

Table A2.29: Microcosm 13: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	1.9	893
130	1.5	481
131	0.7	421
132	2.8	980
133	3.5	937
134	1.1	316
135	1.9	574
136	1.6	431
137	1.4	741
138	2.2	532
139	4.2	1341
140	2.3	811
141	2.5	763
142	1.8	587
143	1.3	672
144	2	578
145	1.4	680
146	0.9	587
147	2.5	805
148	3.2	755
149	2.4	470
150	3.2	790
151	2.5	954
152	1.5	702
153	2.3	827
154	2.8	682
155	1.6	527
156	2.3	615
157	2.1	470
158	1.5	764
159	1.1	506
160	2.4	744
161	2.9	769
162	0.9	446
163	2.2	571
164	2.4	773
165	1.7	666
166	0.9	366
167	2.8	499
168	3.9	958
169	2.5	514
170	3	1113
171	2.2	626
172	2.5	1122
173	4	1299
174	2.3	706
175	2.2	745
176	5.6	797
177	2	659
178	1.7	595
179	1.5	597
180	7.6	545
181	1.8	587
182	6.5	662
183	1.6	601
184	2.6	1012
185	1.5	311
186	1.3	476
187	3.6	232
188	0.5	485
189	2.6	1012
190	1.6	706
191	2.6	906
192	1.8	677

Table A2.29: Microcosm 13: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	3	306
194	3	1104
195	4	1317
196	1.2	281
197	2.5	865
198	1	350
199	1.6	327
200	3.5	1270
201	3.7	566
202	2.5	1069
203	4.3	707
204	2	242
205	1.3	378
206	2	250
207	0.6	384
208	0.9	244
209	1.3	290
210	0.3	204

Stems	Total Stems	Total Number of Stems	210
		Stems with Inflorescence	54
	Heights (mm)	Max Height	1778
		Min Height	204
		Mean Height	830.5142857
		Mode Height	587
		Median Height	763.5
	Widths (mm)	Max Width	7.6
		Min Width	0.3
		Mean Width	2.728571429
		Mode Width	2
		Median Width	2.4

Table A2.30: Microcosm 14: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	1.1	414
2	2.4	445
3	4.3	1517
4	3	700
5	4.9	1357
6	6.4	1753
7	2.2	719
8	2.6	909
9	6.8	1624
10	3.2	1044
11	3.2	1161
12	6.1	1404
13	3	1048
14	3.7	1322
15	2.2	699
16	5.5	1469
17	5.7	1515
18	5.7	1512
19	5.2	1481
20	2.4	830
21	1.7	649
22	5.3	1517
23	4.1	1387
24	3.8	1357
25	4.2	1302
26	4.2	1358
27	3.5	1377
28	2.7	1045
29	3.6	895
30	2.4	949
31	2.8	1031
32	4.2	1286
33	3.3	1353
34	2.6	597
35	3.1	1036
36	2.2	753
37	1.9	725
38	2.6	754
39	3.2	793
40	2.3	896
41	3.1	975
42	2.5	835
43	2.7	714
44	1.9	576
45	2.9	937
46	4.9	1160
47	1.5	527
48	3.9	1272
49	1.9	564
50	3.2	1061
51	4	368
52	5.8	1287
53	3.4	1066
54	2.1	615
55	3.4	1117
56	1.9	695
57	3	1080
58	2.5	285
59	2.8	1001
60	3.8	956
61	6.1	875
62	2.4	593
63	2.5	827
64	2.5	1010

Table A2.30: Microcosm 14: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	1.9	564
66	2.6	735
67	2.1	911
68	3.2	863
69	2.5	608
70	2	554
71	2.8	433
72	2.1	401
73	2.5	580
74	2.3	543
75	2.5	755
76	1.6	640
77	1.9	507
78	1.7	450
79	1.9	771
80	2.2	540
81	1.2	645
82	2.2	836
83	2.9	987
84	2.6	387
85	2.1	568
86	2	394
87	2.8	517
88	1.3	407
89	1.7	382
90	1.5	761
91	1.5	401
92	2	329
93	1.9	465
94	2.6	565
95	4.1	375
96	2.5	587
97	3.2	424
98	1.9	417
99	2.5	204
100	1.9	266
101	1.7	296
102	1	315
103	1.5	405
104	1.5	350
105	1.9	274
106	0.9	300
107	2	376
108	2.6	199
109	1.7	240
110	0.4	402
111	1.6	289
112	1.1	204
113	2.1	259
114	1.8	185
115	1.1	250
116	1.4	350
117	1.2	148

Table A2.30: Microcosm 14: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)	

Stems	Total Stems	Total Number of Stems	117
		Stems with Inflorescence	44
	Heights (mm)	Max Height	1753
		Min Height	148
		Mean Height	760.6239316
		Mode Height	1517
		Median Height	700
	Widths (mm)	Max Width	6.8
		Min Width	0.4
		Mean Width	2.766666667
		Mode Width	1.9
		Median Width	2.5

Table A2.31: Microcosm 15: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	2.5	933
2	2.4	971
3	5	431
4	4.3	941
5	5.7	1656
6	5.3	1015
7	4.6	1525
8	5.3	1581
9	3.7	591
10	4.3	1448
11	8.3	1665
12	5.1	1677
13	5.2	1294
14	2.7	579
15	4.3	715
16	4	1258
17	6.3	1651
18	3.2	815
19	6.4	1729
20	5.7	1634
21	4.4	1332
22	2.8	1079
23	2.6	1111
24	1.8	437
25	5.6	1510
26	4.5	1359
27	7.8	1926
28	8.5	1578
29	4.1	1360
30	6.7	1408
31	4.1	788
32	8.4	1696
33	8.7	1780
34	9.2	1643
35	6.9	1799
36	2.9	855
37	3.7	1198
38	3.7	700
39	3.9	772
40	5.8	1524
41	4.3	1339
42	1.8	853
43	3.5	406
44	3.9	1675
45	5.2	1372
46	2.4	1034
47	4.3	1545
48	2.6	393
49	4.9	1509
50	1.6	614
51	0.9	337
52	3.8	713
53	3.1	438
54	1.7	717
55	3.6	1280
56	3.4	1352
57	1.6	343
58	3.6	1275
59	2	708
60	1.8	1025
61	1.8	609
62	2.9	681
63	2.6	472
64	2	904

Table A2.31: Microcosm 15: *Lythrum salicaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	2.3	560
66	5	488
67	2.9	636
68	2.4	376
69	2.1	266
70	2.6	312
71	3	302
72	1.4	303
73	1.8	524
74	1.3	302
75	3.2	608
76	2	424
77	1.5	230
78	2	300
79	2.1	160
80	1.7	221

Stems	Total Stems	Total Number of Stems	80
		Stems with Inflorescence	32
	Heights (mm)	Max Height	1926
		Min Height	160
		Mean Height	969.625
		Mode Height	302
		Median Height	918.5
	Widths (mm)	Max Width	9.2
		Min Width	0.9
		Mean Width	3.8375
		Mode Width	4.3
		Median Width	3.6

Table A2.32: Microcosm 16 *Lythrum salicaria* Stem Measurements.

There were no surviving *Lythrum salicaria* within Microcosm 16.

Table A2.33: Microcosm 1: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	5.7	649
2	1.6	486
3	1.9	447
4	1.2	208
5	1.2	425
6	0.5	284
7	1	372
8	3.2	546
9	1.1	468
10	1.1	274
11	1.1	677
12	1	134
13	3.3	384
14	0.8	450
15	1.1	225
16	0.3	189
17	1	189
18	1.1	462
19	1.2	285
20	1.8	521
21	1.1	340
22	0.7	73
23	0.7	179
24	1	559
25	0.5	324
26	1.1	400
27	0.5	235
28	1.8	424
29	0.6	311
30	1.2	327
31	1	344
32	0.5	205
33	1.7	222
34	1.1	355
35	1.1	382
36	1.3	521
37	0.7	265
38	1.2	277
39	1.3	357
40	1	264
41	0.5	331
42	1.5	478
43	1	366
44	1.1	327
45	0.4	170
46	1.2	197
47	0.7	203
48	1	135
49	1.1	423
50	12	182
51	0.9	401
52	1.7	332
53	0.8	137
54	1.2	387
55	0.8	232
56	0.8	256
57	1.3	461
58	1.3	338
59	1.2	392
60	1	254
61	0.7	119
62	1	312
63	1.2	346
64	1.5	506

Table A2.33: Microcosm 1: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	0.9	231
66	1.2	198
67	2.4	440
68	0.4	48
69	0.8	514
70	0.9	274
71	2	442
72	1.5	406
73	1.1	428
74	1.3	230
75	0.6	293
76	0.7	325
77	1.3	444
78	0.8	405
79	0.9	419
80	0.9	96
81	0.8	337
82	0.7	302
83	1.2	351
84	1.2	426
85	1.5	312
86	0.6	239
87	1.2	276
88	1.4	291
89	1.7	389
90	1.7	547
91	0.9	291
92	1	444
93	1.2	376
94	1.1	234
95	1.1	295
96	1.2	325
97	0.5	311
98	1.5	496
99	0.7	292
100	0.9	411
101	0.9	301
102	1.5	493
103	0.5	275
104	0.8	368
105	0.8	421
106	1.5	341
107	1	328
108	1.3	373
109	1.3	429
110	4.8	189
111	0.6	279
112	1.2	397
113	0.5	231
114	0.5	236
115	0.8	393
116	0.9	312
117	0.8	239
118	1.1	238
119	1.1	292
120	1.2	352
121	1.4	398
122	1	140
123	0.7	262
124	1	256
125	1.6	409
126	1.2	295
127	0.9	231
128	0.9	212

Table A2.33: Microcosm 1: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	1.1	186
130	1	138
131	1.1	33
132	0.6	279
133	0.7	208
134	1.1	180
135	0.5	145
136	0.3	166
137	1.1	206
138	0.7	185
139	1	236
140	0.6	219
141	1.1	276
142	3	452
143	2.2	244
144	2	390
145	2.4	228
146	1.2	367
147	1	198
148	1.6	395
149	0.5	256
150	0.9	169
151	0.5	231
152	1.3	225
153	1.5	401
154	0.6	244
155	0.9	279
156	1	419
157	0.8	192
158	0.7	201
159	1.2	385
160	1.5	397
161	1.4	231
162	1.4	165
163	1.7	345
164	0.8	310
165	0.5	180
166	0.6	359
167	1.1	401
168	0.9	224
169	1.4	284
170	0.6	300
171	1.1	233
172	1.2	313
173	0.7	333
174	2.9	318
175	1	284
176	0.1	112
177	1.2	412
178	0.9	205
179	1.3	264
180	1.5	399
181	1.5	389
182	0.7	175
183	0.8	201
184	1.1	183
185	0.5	301
186	0.6	115
187	2.1	305
188	0.9	197
189	1	240
190	1.8	191
191	0.3	182
192	0.5	88

Table A2.33: Microcosm 1: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	0.4	186
194	0.9	123
195	0.7	241
196	0.6	120
197	0.8	145
198	1.6	381
199	1.2	346
200	1.7	219
201	1.1	237
202	1.2	205
203	1	58
204	0.1	75
205	1.1	304
206	1.1	245
207	1	158
208	0.9	40
209	0.7	43
210	0.8	235
211	0.7	227
212	0.9	165
213	2	141
214	1.1	317
215	1	266
216	1.3	232
217	0.5	216
218	0.9	325
219	1.5	171
220	0.3	285
221	1.1	278
222	0.6	193
223	1	157
224	0.8	149
225	0.8	141
226	0.6	164
227	0.9	186
228	0.5	28
229	0.4	64
230	1.2	167
231	0.7	187
232	0.6	182
233	0.9	239
234	0.9	204
235	1.1	174
236	1.8	152
237	0.6	178
238	1.5	224
239	0.4	169
240	0.6	211

Table A2.33: Microcosm 1: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)

Stems	Total Stems	Total Number of Stems	240
		Stems with Inflorescence	0
	Heights (mm)	Max Height	677
		Min Height	28
		Mean Height	281.975
		Mode Height	231
		Median Height	274.5
	Widths (mm)	Max Width	12
		Min Width	0.1
		Mean Width	1.13625
		Mode Width	1.1
		Median Width	1

Table A2.34: Microcosm 2: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	5.5	515
2	5.9	1487
3	6.3	1602
4	1	144
5	1	621
6	1.7	592
7	2.3	219
8	1.7	67
9	1	441
10	1.7	200
11	3.9	99
12	1.2	138
13	1.1	444
14	5.6	1484
15	1.6	310
16	1.1	645
17	1.1	578
18	0.9	391
19	1.2	300
20	3.8	1252
21	5.2	1402
22	0.7	449
23	0.7	423
24	2.2	244
25	1.4	386
26	1.2	352
27	4.3	1072
28	0.8	248
29	4.7	1168
30	9.2	67
31	1.2	256
32	3.3	1174
33	0.9	283
34	5.7	1349
35	3.6	985
36	1.1	73
37	1.4	345
38	0.7	347
39	0.7	345
40	0.8	377
41	1.2	461
42	4.1	1215
43	5	1078
44	4.3	436
45	1.1	517
46	0.9	215
47	1.2	582
48	0.8	481
49	1	296
50	0.6	250
51	0.6	141
52	1	326
53	1.5	356
54	0.7	362
55	0.4	223
56	1.5	495
57	1	513
58	1.2	361
59	1.2	459
60	1.8	164
61	0.9	206
62	0.5	104
63	0.9	322
64	0.9	304

Table A2.34: Microcosm 2: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	3.9	1114
66	0.5	446
67	1.7	821
68	4.7	263
69	0.7	302
70	7.3	1598
71	1.4	269
72	1.1	396
73	1.7	213
74	1.2	463
75	1.1	492
76	0.5	86
77	0.4	122
78	0.8	84
79	1.1	126
80	0.5	214
81	0.9	226
82	1	452
83	0.1	328
84	1	314
85	0.6	493
86	0.5	90
87	1.2	171
88	1.2	459
89	2.1	646
90	1.2	507
91	0.4	325
92	1.3	221
93	1.2	409
94	3.7	503
95	1.1	332
96	1.5	185
97	1	356
98	0.7	173
99	0.9	384
100	0.4	285
101	1.2	171
102	0.5	283
103	0.7	184
104	2.6	639
105	4.8	247
106	0.2	101
107	1	438
108	2.8	209
109	2.9	360
110	0.8	347
111	2.7	942
112	0.7	354
113	2.6	372
114	0.9	412
115	0.6	398
116	0.7	342
117	0.9	84
118	1.7	182
119	1.9	419
120	1.5	616
121	0.9	52
122	1.3	595
123	3.1	220
124	1.3	536
125	1.1	322
126	1.8	610
127	0.5	251
128	0.7	387

Table A2.34: Microcosm 2: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	1.4	427
130	1	513
131	0.9	291
132	0.7	264
133	1.8	26
134	42	160
135	5.8	10
136	0.5	245
137	1.1	332
138	1.1	244
139	0.8	179
140	1.4	452
141	0.6	363
142	0.3	205
143	0.6	216
144	0.3	196
145	0.4	314
146	1	485
147	0.6	238
148	0.7	538
149	1.5	42
150	1	185
151	0.6	16
152	3.2	134
153	1	239
154	0.7	257
155	1.7	14
156	0.5	227
157	2.6	168
158	0.6	170
159	0.8	222
160	1.8	226
161	1.1	243
162	1.2	442
163	1.5	314
164	0.6	497
165	0.6	266
166	1.1	460
167	1.5	170
168	1.2	394
169	0.6	192
170	1.1	246
171	0.8	179
172	0.5	275
173	0.4	82
174	0.1	61
175	1.1	158
176	0.3	174
177	0.7	218
178	0.7	86
179	0.5	139
180	1.1	298
181	1.2	302
182	0.6	166
183	0.7	280
184	0.8	207
185	0.9	304
186	0.5	82
187	0.6	285
188	0.4	147
189	0.9	215
190	1.2	226
191	0.7	206
192	1.6	314

Table A2.34: Microcosm 2: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	0.6	155
194	0.9	274
195	0.8	114
196	1	276
197	1.1	356
198	1.5	233
199	1.1	263
200	1.2	272
201	2.9	119
202	0.7	272
203	1.1	161
204	0.5	273
205	1.1	297
206	1.2	192
207	0.6	269
208	0.7	156
209	0.2	86
210	1.6	161
211	1.4	155
212	0.7	143
213	0.4	62
214	0.4	513
215	0.6	44
216	0.6	312
217	1.2	242
218	0.5	319
219	0.5	264
220	0.8	219
221	1.5	134
222	1.4	160
223	1.2	226
224	0.5	111
225	0.8	189
226	0.5	115
227	1.3	294
228	0.6	156
229	1.2	418
230	1.1	221
231	0.8	156
232	0.4	122
233	1.1	125

Stems	Total Stems	Total Number of Stems	233
		Stems with Inflorescence	9
	Heights (mm)	Max Height	1602
		Min Height	10
		Mean Height	345.6523605
		Mode Height	226
		Median Height	273
	Widths (mm)	Max Width	42
		Min Width	0.1
		Mean Width	1.591416309
		Mode Width	1.2
		Median Width	1

Table A2.35: Microcosm 3: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	3.6	1001
2	8.7	978
3	5.5	1164
4	7.1	1509
5	5.4	1258
6	4.9	1466
7	8.7	665
8	5.5	1100
9	5.1	1184
10	4.3	605
11	4.9	1419
12	3.2	688
13	3	925
14	5.2	311
15	2	338
16	1.2	382
17	2.7	696
18	3.7	310
19	2	204
20	2.3	269
21	2.5	191
22	1.6	213
23	2.2	162
24	1.8	312
25	1.4	184
26	2.5	368
27	1.3	194
28	1.8	188
29	2	82
30	1.6	121
31	2.2	91
32	1.2	378
33	2	126
34	1.6	240
35	2.3	194
36	1.8	242
37	2.4	277
38	1.1	383
39	1.5	226
40	3.1	236
41	0.9	246
42	1.6	271
43	2	316
44	1.8	244
45	2	134
46	1.6	95
47	2	161
48	2.6	291
49	1.9	163
50	1.5	130
51	1.9	285
52	1.7	17
53	1.4	462
54	1.2	227
55	1.4	214
56	1.9	688
57	0.8	142
58	2	228
59	1.5	413
60	1.3	266
61	0.5	376
62	0.6	267
63	1.1	335
64	0.5	256

Table A2.35: Microcosm 3: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	1.2	412
66	1.1	408
67	1.9	290
68	1.1	267
69	1	334
70	0.6	270
71	0.7	255
72	0.7	402
73	0.6	314
74	0.9	355
75	1.2	380
76	0.5	264
77	1	413
78	0.5	212
79	0.5	276
80	0.9	374
81	0.8	385
82	1.6	440
83	1.3	12
84	0.6	198
85	0.9	341
86	1.1	241
87	1.1	375
88	0.8	212
89	1.1	365
90	1.1	454
91	0.5	151
92	1.1	258
93	0.7	71
94	0.7	201
95	0.6	342
96	0.8	169
97	1.3	36
98	1.6	430
99	0.7	315
100	1	252
101	0.4	132
102	0.5	296
103	0.7	323
104	0.7	462
105	0.7	139
106	0.5	214
107	0.3	228
108	0.5	206
109	0.9	85
110	1.2	268
111	1.3	366
112	1	237
113	1	122
114	0.8	237
115	0.9	192
116	0.8	195
117	0.5	205
118	0.8	307
119	0.6	197
120	0.4	188
121	1	241
122	1.9	462
123	0.8	294
124	0.7	206
125	1	119
126	0.8	109
127	0.9	405
128	0.8	293

Table A2.35: Microcosm 3: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	0.9	189
130	1.3	223
131	1.3	149
132	1.5	372
133	1.2	285
134	0.5	267
135	0.9	308
136	0.9	209
137	1.2	192
138	1.5	339
139	0.6	245
140	1.5	390
141	0.9	161
142	0.4	192
143	1	132
144	0.5	241
145	0.5	250
146	0.4	109
147	0.4	286
148	1	262
149	0.8	253
150	1.6	225
151	0.7	246
152	0.5	148
153	0.9	145
154	1.2	260
155	0.6	395
156	1.2	117
157	1.5	181
158	1.3	140
159	1	187
160	0.6	90
161	0.5	119
162	0.5	141
163	0.4	105
164	0.6	106
165	0.7	99
166	0.8	205
167	0.5	34
168	0.5	151
169	0.6	97
170	0.7	215
171	0.5	223
172	0.4	91
173	0.3	139
174	0.7	151
175	0.3	87
176	0.9	121
177	0.4	93
178	0.5	224
179	0.2	192
180	1.4	196
181	1.4	181
182	0.7	133
183	0.5	143
184	0.2	191
185	1.6	172
186	0.4	97
187	1	182
188	0.6	163
189	2.2	239
190	0.5	119
191	0.4	140
192	0.3	52

Table A2.35: Microcosm 3: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)

Stems	Total Stems	Total Number of Stems	192
		Stems with Inflorescence	5
	Heights (mm)	Max Height	1509
		Min Height	12
		Mean Height	292.1770833
		Mode Height	192
		Median Height	236.5
	Widths (mm)	Max Width	8.7
		Min Width	0.2
		Mean Width	1.4078125
		Mode Width	0.5
		Median Width	1

Table A2.36: Microcosm 4: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	6.3	889
2	4.7	751
3	4.6	506
4	7.2	1416
5	9.1	1385
6	6.1	1288
7	6.1	365
8	4.3	341
9	4.3	534
10	3.5	595
11	5.1	152
12	3.3	700
13	3.4	437
14	2.8	255
15	7.3	492
16	2	172
17	0.6	262
18	3	456
19	2.3	407
20	1.5	723
21	0.7	455
22	0.7	469
23	1	625
24	3.9	175
25	5	310
26	2.3	385
27	1.2	552
28	2	199
29	1.7	218
30	1.2	522
31	0.4	414
32	1.9	417
33	0.2	282
34	1.3	483
35	1.5	896
36	3.1	310
37	1.2	380
38	1	434
39	0.8	395
40	0.7	345
41	0.8	302
42	0.9	310
43	0.6	555
44	1.2	620
45	0.5	112
46	0.7	557
47	1.1	551
48	1	560
49	1.1	591
50	1.8	432
51	1.4	520
52	1.1	574
53	1.1	562
54	1.3	397
55	1.4	200
56	1.8	465
57	1.5	428
58	1.6	492
59	1.6	652
60	1.4	482
61	0.7	465
62	1.2	205
63	0.7	419
64	1.3	160

Table A2.36: Microcosm 4: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	1.2	212
66	2.6	349
67	1.3	75
68	1.1	561
69	1.8	394
70	1.1	605
71	0.8	503
72	0.3	270
73	3.2	173
74	1.2	512
75	0.3	146
76	2.4	177
77	1.2	375
78	1.4	371
79	0.8	265
80	1.5	401
81	1.3	221
82	0.7	56
83	0.5	206
84	0.6	335
85	0.7	416
86	1	326
87	1	272
88	1.1	265
89	1	498
90	0.5	213
91	0.5	203
92	0.8	118
93	1.8	113
94	0.5	205
95	1	345
96	1.1	330
97	1.8	387
98	1.5	271
99	1.9	350
100	0.9	456
101	1.3	300
102	0.3	212
103	1.1	576
104	1	282
105	0.8	504
106	0.9	335
107	1	538
108	0.5	168
109	1.2	364
110	1.1	112
111	0.8	211
112	0.9	373
113	0.8	82
114	1.4	654
115	2.2	171
116	0.9	328
117	0.6	64
118	0.7	302
119	0.9	309
120	0.9	46
121	1	291
122	1.2	444
123	1.2	134
124	0.6	365
125	2.6	315
126	1.1	473
127	0.7	396
128	1.5	600

Table A2.36: Microcosm 4: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	1.7	512
130	1	334
131	0.9	503
132	0.7	402
133	1.2	540
134	2.1	531
135	1.2	322
136	2.3	86
137	1.4	558
138	0.7	380
139	0.5	41
140	1.2	290
141	1.2	525
142	0.8	392
143	0.3	312
144	0.8	269
145	0.9	520
146	1	312
147	3.7	566
148	4.6	208
149	5.8	165
150	3	174
151	0.8	365
152	0.9	614
153	1.7	410
154	1.4	506
155	0.5	191
156	0.5	213
157	0.8	486
158	1.6	594
159	0.8	569
160	0.7	301
161	1.2	332
162	1.1	407
163	0.7	391
164	0.7	312
165	0.7	216
166	1	524
167	2.8	535
168	1	175
169	1.5	132
170	2.9	359
171	1	450
172	0.6	481
173	0.5	106
174	1.1	168
175	0.7	376
176	1	516
177	1.6	418
178	1	243
179	0.9	223
180	1.9	306
181	2	289
182	0.4	77
183	0.7	453
184	0.6	207
185	1	467
186	1	552
187	1.5	486
188	1	189
189	1.1	325
190	0.7	314
191	2.1	250
192	1.2	273

Table A2.36: Microcosm 4: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	1.2	316
1.5	1.4	120
195	0.6	297
196	0.7	287
197	1.6	234
198	0.5	82
199	1	264
200	3.6	169
201	1.2	91
202	0.4	52
203	1	371
204	1.1	384
205	0.7	256
206	0.5	90
207	0.6	318
208	0.3	26
209	1.4	459
210	0.8	362
211	0.4	247
212	2.6	179
213	0.5	51
214	0.3	192
215	1.9	146
216	4.3	185
217	1.2	153
218	0.4	33
219	0.5	112
220	1.5	481
221	1.3	493
222	1.4	361
223	1.6	150
224	0.2	143
225	0.8	145
226	2.5	345
227	0.2	91
228	1.3	482
229	0.6	281
230	0.9	338
231	0.6	242
232	1.1	232
233	0.6	192
234	1.6	127
235	0.5	46

Stems	Total Stems	Total Number of Stems	235
		Stems with Inflorescence	7
	Heights (mm)	Max Height	1416
		Min Height	26
		Mean Height	354.4468085
		Mode Height	365
		Median Height	335
	Widths (mm)	Max Width	9.1
		Min Width	0.2
		Mean Width	1.489361702
		Mode Width	1
		Median Width	1.1

Table A2.37: Microcosm 5: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	8.6	1555
2	5.6	1171
3	8.4	1584
4	6.3	969
5	5.5	862

Stems	Total Stems	Total Number of Stems	5
		Stems with Inflorescence	0
	Heights (mm)	Max Height	1584
		Min Height	862
		Mean Height	1228.2
		Mode Height	#N/A
		Median Height	1171
	Widths (mm)	Max Width	8.6
		Min Width	5.5
		Mean Width	6.88
		Mode Width	#N/A
		Median Width	6.3

Table A2.38: Microcosm 6: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	5.1	1041
2	5.2	889
3	6.1	987
4	3.2	1074
5	1.1	404
6	1.4	381

Stems	Total Stems	Total Number of Stems	6
		Stems with Inflorescence	0
	Heights (mm)	Max Height	1074
		Min Height	381
		Mean Height	796
		Mode Height	#N/A
		Median Height	938
	Widths (mm)	Max Width	6.1
		Min Width	1.1
		Mean Width	3.683333333
		Mode Width	#N/A
		Median Width	4.15

Table A2.39: Microcosm 7 *Filipendula ulmaria* Stem Measurements.

There were no surviving *Filipendula ulmaria* within Microcosm 7.

Table A2.40: Microcosm 8 *Filipendula ulmaria* Stem Measurements.

There were no surviving *Filipendula ulmaria* within Microcosm 8.

Table A2.41: Microcosm 9: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	0.5	238
2	1	228
3	1.2	386
4	1	437
5	0.5	296
6	0.8	324
7	2	571
8	1.8	472
9	1	370
10	0.5	345
11	1.1	388
12	0.7	393
13	0.4	344
14	1.1	262
15	0.8	258
16	3.6	716
17	1	211
18	1.1	266
19	1.2	336
20	0.5	267
21	0.9	312
22	0.7	335
23	1.1	277
24	1.2	284
25	1.4	268
26	0.5	266
27	1	219
28	0.7	268
29	1	236
30	0.3	288
31	0.9	239
32	0.9	293
33	0.3	251
34	0.7	207
35	0.8	310
36	0.6	280
37	0.6	243
38	0.5	373
39	1.5	239
40	0.7	216
41	0.7	141
42	1	180
43	0.6	158
44	0.4	169
45	0.7	152
46	1	307
47	0.7	192
48	0.6	222
49	0.7	132
50	1	234
51	0.8	186
52	0.5	174
53	0.9	199
54	0.2	120
55	0.4	149
56	0.8	137
57	0.7	185
58	0.4	139
59	0.8	155

Table A2.41: Microcosm 9: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)

Stems	Total Stems	Total Number of Stems	59
		Stems with Inflorescence	2
	Heights (mm)	Max Height	716
		Min Height	120
		Mean Height	268.5254237
		Mode Height	266
		Median Height	258
	Widths (mm)	Max Width	3.6
		Min Width	0.2
		Mean Width	0.86440678
		Mode Width	0.7
		Median Width	0.8

Table A2.42: Microcosm 10: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	5.9	1403
2	4.3	821
3	3	925
4	7.7	1062
5	4.1	1344
6	3.5	484
7	4	1265
8	6.3	850
9	1.8	871
10	0.4	279
11	1.1	204
12	0.3	200
13	4.1	646
14	2.7	554
15	0.7	209
16	1.8	697
17	0.5	417
18	0.6	415
19	0.8	475
20	1.3	428
21	0.9	368
22	0.8	438
23	1.1	274
24	0.4	296
25	0.8	329
26	0.7	245
27	0.9	340
28	0.6	154
29	0.8	396
30	0.8	210
31	0.7	357
32	1.6	364
33	1.2	423
34	0.6	221
35	0.1	154
36	0.9	252
37	0.7	467
38	0.7	402
39	1.1	336
40	0.6	340
41	0.7	269
42	1	294
43	1.1	288
44	0.8	225
45	0.6	251
46	0.6	28
47	0.9	488
48	0.8	247
49	2.3	279
50	0.7	186
51	0.5	263
52	0.8	208
53	1.1	179
54	1.1	139
55	0.5	215
56	0.3	339
57	0.4	329
58	0.9	325
59	0.5	158
60	0.7	255
61	0.6	331

Table A2.42: Microcosm 10: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)

Stems	Total Stems	Total Number of Stems	61
		Stems with Inflorescence	0
	Heights (mm)	Max Height	1403
		Min Height	28
		Mean Height	413.295082
		Mode Height	279
		Median Height	329
	Widths (mm)	Max Width	7.7
		Min Width	0.1
		Mean Width	1.439344262
		Mode Width	0.7
		Median Width	0.8

Table A2.43: Microcosm 11: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	5.6	944
2	5.9	1102
3	3.6	973
4	6.8	895
5	3.4	585
6	3.5	1053
7	6.6	944
8	4.5	1251
9	6.5	1316
10	4.2	751
11	2.5	822
12	2.8	733
13	1	425
14	3.1	558
15	1.6	583
16	1.1	199
17	1.6	402
18	1.5	462
19	1.6	300
20	0.9	448
21	1.8	350
22	1.4	485
23	1.2	460
24	1.3	370
25	1	421
26	1.2	399
27	1.2	495
28	0.8	384
29	0.6	413
30	0.6	330
31	0.8	452
32	1.1	400
33	0.4	396
34	1.1	332
35	0.7	375
36	1	376
37	0.5	464
38	0.6	346
39	1	250
40	0.9	315
41	1	418
42	0.7	470
43	1.3	430
44	1	506
45	1	105
46	0.6	337
47	1.2	325
48	0.6	461
49	1	429
50	0.7	302
51	1.3	487
52	1.2	456
53	1	218
54	1	325
55	0.7	432
56	1.1	412
57	0.9	480
58	1	475
59	0.5	340
60	0.5	300
61	0.4	279
62	1.2	224
63	0.7	410
64	1.3	254

Table A2.43: Microcosm 11: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	1.3	275
66	1	454
67	0.7	332
68	0.8	221
69	0.9	414
70	0.5	270
71	0.3	342
72	1	363
73	0.5	203
74	0.5	338
75	0.8	190
76	0.8	253
77	0.3	312
78	0.9	154
79	0.6	141
80	0.9	387
81	0.5	410
82	0.7	220
83	0.5	372
84	0.5	246
85	1	241
86	0.4	251
87	0.7	339
88	0.3	246
89	0.7	200
90	0.7	386
91	0.8	159
92	0.5	200
93	0.8	291
94	0.4	296
95	0.7	86
96	0.8	203
97	0.6	135
98	0.4	329
99	0.5	202
100	0.3	212
101	1	195
102	0.8	247

Stems	Total Stems	Total Number of Stems	102
		Stems with Inflorescence	0
	Heights (mm)	Max Height	1316
		Min Height	86
		Mean Height	407.3431373
		Mode Height	944
		Median Height	366.5
	Widths (mm)	Max Width	6.8
		Min Width	0.3
		Mean Width	1.321568627
		Mode Width	1
		Median Width	0.9

Table A2.44: Microcosm 12: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	0.7	527
2	0.6	231
3	0.9	571
4	0.5	413
5	1	520
6	1	251
7	0.5	471
8	1.1	350
9	0.5	429
10	1	640
11	0.7	323
12	1.2	513
13	0.2	305
14	1.1	350
15	1.1	447
16	0.9	540
17	1.7	294
18	1.3	388
19	1.6	489
20	1.1	274
21	0.9	190
22	1.2	318
23	2.6	654
24	0.5	326
25	1.9	242
26	1.1	801
27	1.5	315
28	1.9	417
29	0.5	437
30	1.4	519
31	0.7	216
32	1	370
33	1.2	467
34	4.6	1260
35	4.7	487
36	3.7	863
37	2.8	909
38	4.7	842
39	1.9	875
40	4	985
41	2.7	456
42	2.9	518
43	1.9	502
44	1.8	454
45	1.8	492
46	2.8	193

Stems	Total Stems	Total Number of Stems	46
		Stems with Inflorescence	0
	Heights (mm)	Max Height	1260
		Min Height	190
		Mean Height	487.6956522
		Mode Height	350
		Median Height	455
	Widths (mm)	Max Width	4.7
		Min Width	0.2
		Mean Width	1.639130435
		Mode Width	0.5
		Median Width	1.2

Table A2.45: Microcosm 13: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	1	430
2	0.7	340
3	0.9	469
4	0.8	413
5	0.7	426
6	1.1	363
7	1.4	484
8	1.7	433
9	1.7	644
10	1	437
11	1.7	521
12	1.9	428
13	0.6	485
14	1.2	522
15	1	395
16	2	421
17	1	473
18	0.7	238
19	0.8	292
20	0.8	401
21	1.4	503
22	1	346
23	1.1	300
24	1.5	439
25	0.6	397
26	0.9	343
27	2.5	311
28	0.8	309
29	1.8	502
30	1.7	402
31	1.2	410
32	0.8	339
33	1.3	297
34	1.5	400
35	3	458
36	1	564
37	3.6	1049
38	1.7	487
39	1	412
40	1.1	340
41	0.5	392
42	0.5	230
43	1.1	409
44	1.1	334
45	0.5	190
46	0.2	279
47	1.5	285
48	1.3	292
49	0.7	246
50	1.2	225
51	2.2	190
52	0.5	310
53	0.7	276
54	1.5	214
55	1	450
56	0.7	326
57	1.5	408
58	0.7	228
59	0.5	243
60	1	243
61	1.2	353
62	0.8	176
63	0.7	155
64	0.9	147

Table A2.45: Microcosm 13: *Filipendula ulmaria* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	1	248
66	1.2	240
67	0.9	193
68	1.2	257
69	0.9	362
70	0.7	206
71	1.4	340
72	1.3	355
73	1.2	274
74	0.7	233
75	1.3	231
76	0.5	339
77	0.6	356
78	2.8	246
79	0.9	199
80	0.5	225
81	0.8	320
82	0.9	287
83	1.2	200
84	0.9	95
85	1	384
86	0.9	258
87	0.6	168
88	0.5	174
89	0.8	257
90	0.3	233
91	0.8	153
92	1.5	202
93	0.9	204
94	0.9	302
95	0.8	193
96	0.7	20
97	1.1	288
98	0.9	219
99	1.2	196
100	0.5	180
101	1.1	149
102	0.9	126
103	1.1	145

Stems	Total Stems	Total Number of Stems	103
		Stems with Inflorescence	6
	Heights (mm)	Max Height	1049
		Min Height	20
		Mean Height	319.2330097
		Mode Height	340
		Median Height	302
	Widths (mm)	Max Width	3.6
		Min Width	0.2
		Mean Width	1.088349515
		Mode Width	0.9
		Median Width	1

Table A2.46: Microcosm 14 *Filipendula ulmaria* Stem Measurements.

There were no surviving *Filipendula ulmaria* within Microcosm 14.

Table A2.47: Microcosm 15 *Filipendula ulmaria* Stem Measurements.

There were no surviving *Filipendula ulmaria* within Microcosm 15.

Table A2.48: Microcosm 16 *Filipendula ulmaria* Stem Measurements.

There were no surviving *Filipendula ulmaria* within Microcosm 16.

Table A2.49: Microcosm 1: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	1.3	435
2	1.5	508
3	2	584
4	1.5	411
5	1.5	486
6	1.8	452
7	1.2	301
8	1.1	314
9	2.1	387
10	1.9	402
11	1.3	201
12	1.4	186
13	1.4	377
14	1.1	494
15	0.8	185
16	0.8	624
17	3.8	295
18	2.6	413
19	0.8	320
20	1	433
21	1.6	694
22	2.2	498
23	2.1	375
24	1.7	375
25	1.2	276
26	1.3	190
27	0.8	193
28	0.9	14
29	0.6	115
30	0.8	255
31	1.5	370
32	1.8	346
33	1.4	517
34	3.3	247
35	1.3	201
36	1.3	472
37	1.7	299
38	1.2	362
39	1.2	320
40	1.9	531
41	0.7	203
42	1.7	691
43	1.4	588
44	2.1	723
45	1.3	455
46	0.8	145
47	1.4	677
48	0.5	215
49	1.9	100
50	0.7	280
51	0.8	543
52	1.3	175
53	0.7	183
54	2.2	209
55	1.6	285
56	1.4	357
57	1	344
58	0.7	265
59	2.1	201
60	1.5	414
61	1.2	161
62	1.2	71
63	1	376
64	0.5	59

Table A2.49: Microcosm 1: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	1.3	182
66	0.8	233
67	0.8	421
68	1.1	531
69	1.3	223
70	1.9	220
71	0.9	190
72	2.2	143
73	1.4	287
74	3.3	170
75	1.2	189
76	3.4	202
77	0.9	695
78	1.3	370
79	1.4	262
80	0.6	142
81	0.9	309
82	1.1	598
83	0.8	596
84	0.4	306
85	1.1	295
86	0.5	171
87	1	243
88	1.3	435
89	1	401
90	0.9	405
91	0.8	178
92	1.3	209
93	0.7	68
94	0.6	53
95	1.8	374
96	0.8	135
97	1.2	385
98	0.8	159
99	1.9	342
100	0.8	217
101	0.3	20
102	0.8	207
103	1.4	344
104	0.8	284
105	1.7	410
106	1.6	252
107	1.2	307
108	2	324
109	1.3	230
110	1.7	349
111	1.4	322
112	1.3	255
113	1.2	235
114	2.7	228
115	1.2	234
116	0.7	233
117	0.8	152
118	1.1	326
119	1.1	192
120	0.8	245
121	0.8	308
122	0.8	323
123	1.5	309
124	1.1	269
125	1.2	409
126	1.3	431
127	1	302
128	0.8	108

Table A2.49: Microcosm 1: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	0.7	73
130	0.8	245
131	1.8	405
132	1.6	409
133	2	527
134	1	324
135	1.3	202
136	2.8	109
137	0.7	151
138	1.5	113
139	1	225
140	1.3	368
141	0.7	185
142	1.2	624
143	1.1	470
144	1.1	290
145	1.1	213
146	1.6	191
147	3	218
148	0.6	183
149	1.3	168
150	0.7	271
151	1.5	241
152	1.8	265
153	2.8	181
154	1.9	133
155	1.3	152
156	0.6	192
157	0.9	199
158	1.7	136
159	1.1	268
160	2.8	145
161	0.7	165
162	3	427
163	1.7	526
164	1.6	461
165	1.2	618
166	1.2	671
167	1.8	565
168	1.5	577
169	0.9	671
170	3.4	362
171	1.3	331
172	2.8	385
173	1.9	250
174	1	199
175	1.2	305
176	3	110
177	1.4	482
178	1.6	239
179	0.8	76
180	1.2	502
181	0.9	168
182	1.3	189
183	1.4	406
184	0.7	310
185	1.7	171
186	0.5	182
187	1.6	426
188	1.4	338
189	0.9	332
190	1.7	462
191	1.4	456
192	1.9	634

Table A2.49: Microcosm 1: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	1.2	259
194	1	200
195	1.4	336
196	1.4	462
197	1	305
198	1.2	382
199	1.3	261
200	0.9	195
201	3.7	148
202	2.2	185
203	2.1	140
204	1.1	210
205	0.9	284
206	1.1	166
207	1.3	172
208	1.3	205
209	0.7	199
210	0.9	142
211	1.2	145
212	0.8	316
213	1.3	164
214	1.3	95
215	0.8	207
216	1	144
217	1.2	121
218	1	109
219	0.8	196
220	1	96
221	1.4	126
222	1.4	216
223	2.2	353
224	1.4	119
225	1.2	231
226	1.6	151
227	1.9	120
228	0.5	96
229	1.4	153
230	2.9	59
231	1	143
232	1.6	160
233	0.7	123
234	1	225
235	1	122
236	0.9	181
237	0.7	131
238	0.6	262
239	1.9	127
240	0.7	143
241	2.6	134
242	2.1	82
243	1.9	137
244	1.7	101
245	2.5	91
246	1.6	90
247	1.2	180
248	2.9	83
249	1	126
250	1.4	86
251	1.3	86
252	1.1	93
253	0.7	62
254	0.8	190
255	0.4	75

Table A2.49: Microcosm 1: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)	
Stems	Total Stems	Total Number of Stems	255
		Stems with Inflorescence	54
	Heights (mm)	Max Height	723
		Min Height	14
		Mean Height	277.2470588
		Mode Height	201
		Median Height	239
	Widths (mm)	Max Width	3.8
		Min Width	0.3
		Mean Width	1.355686275
		Mode Width	1.3
		Median Width	1.3

Table A2.50: Microcosm 2: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	1.2	414
2	0.5	74
3	0.7	63
4	1.4	282
5	1.2	395
6	1.2	466
7	0.7	76
8	1	264
9	0.7	252
10	1.1	376
11	1.2	350
12	1.7	593
13	1.3	221
14	0.5	173
15	1.5	317
16	1.5	172
17	0.8	129
18	0.7	347
19	0.8	394
20	1.1	312
21	1.8	212
22	1.2	205
23	1.1	274
24	0.6	288
25	1.2	252
26	1	135
27	1	164
28	1.2	160
29	2	69
30	0.8	65
31	0.7	85
32	0.6	266
33	0.4	209
34	0.7	175
35	0.6	128
36	0.6	140
37	1.8	94
38	1	93
39	0.7	94
40	0.6	124
41	0.7	66

Stems	Total Stems	Total Number of Stems	41
		Stems with Inflorescence	1
	Heights (mm)	Max Height	593
		Min Height	63
		Mean Height	218.7317073
		Mode Height	252
		Median Height	205
	Widths (mm)	Max Width	2
		Min Width	0.4
		Mean Width	1.002439024
		Mode Width	0.7
		Median Width	1

Table A2.51: Microcosm 3: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	1.3	437
2	1.1	205
3	1	281
4	1.5	154
5	0.7	235
6	0.7	227
7	0.7	254
8	0.8	372
9	0.8	437
10	0.6	323
11	0.9	240
12	0.9	207
13	0.7	360
14	1.2	239
15	1.2	461
16	1.1	282
17	1.3	283
18	1.5	315
19	1	466
20	1	621
21	1	272
22	1.2	265
23	1.2	287
24	1	296
25	1.1	219
26	1.1	299
27	0.8	256
28	0.5	175
29	0.9	125
30	0.5	96
31	1.1	229
32	0.8	225
33	0.8	137
34	1	240
35	0.6	87
36	0.6	237
37	0.7	241
38	1	176
39	1.2	60
40	0.5	106
41	0.3	148
42	0.6	168
43	0.6	161
44	0.5	128
45	0.8	165
46	0.6	176
47	0.6	119
48	0.2	115
49	1.3	55
50	0.6	115
51	2.4	40
52	0.6	116

Table A2.51: Microcosm 3: *Mentha aquatica* Stem Measurements.

Stem Number	**Stem Width (mm)**	**Stem Height (mm)**	
Stems	Total Stems	Total Number of Stems	52
		Stems with Inflorescence	6
	Heights (mm)	Max Height	621
		Min Height	40
		Mean Height	229.4807692
		Mode Height	437
		Median Height	228
	Widths (mm)	Max Width	2.4
		Min Width	0.2
		Mean Width	0.898076923
		Mode Width	0.6
		Median Width	0.85

Table A2.52: Microcosm 4: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	1.7	478
2	1.6	623
3	1.2	530
4	0.8	267
5	1.2	368
6	0.7	579
7	0.9	245
8	1.2	446
9	2.6	163
10	1.3	562
11	1.5	294
12	0.5	179
13	1.5	447
14	0.8	353
15	1.2	379
16	1.4	381
17	2.4	396
18	0.9	405
19	0.9	680
20	0.4	152
21	1.5	539
22	0.4	215
23	2	610
24	1.3	582
25	1.1	529
26	1	876
27	1.3	812
28	0.9	521
29	1.8	315
30	1	189
31	1.3	389
32	1.2	615
33	2	262
34	1	335
35	1.2	393
36	1.1	484
37	0.7	436
38	1.1	142
39	0.5	128
40	1.5	348
41	1.7	413
42	1.1	484
43	0.9	235
44	0.8	212
45	1.8	278
46	1	460
47	0.5	337
48	0.8	149
49	0.6	226
50	1	180
51	1	77
52	0.5	74
53	1.5	185
54	3	170
55	0.9	185
56	0.6	183
57	0.4	159
58	1	120
59	0.9	184
60	1	166
61	1.2	322
62	1.1	140
63	0.8	192
64	2.8	99

Table A2.52: Microcosm 4: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	1.5	97
66	0.6	87
67	1.7	142
68	1.5	144
69	1	133
70	0.6	382
71	1	132
72	0.6	186
73	1.5	318
74	1.7	110
75	1.2	63
76	1.5	87
77	0.7	87
78	0.4	177
79	1.3	169
80	1	116
81	1	95
82	0.5	111
83	0.8	102
84	1.3	82
85	0.7	109
86	0.6	107

Stems	Total Stems	Total Number of Stems	86
		Stems with Inflorescence	6
	Heights (mm)	Max Height	876
		Min Height	63
		Mean Height	289.6860465
		Mode Height	87
		Median Height	220.5
	Widths (mm)	Max Width	3
		Min Width	0.4
		Mean Width	1.141860465
		Mode Width	1
		Median Width	1

Table A2.53: Microcosm 5: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	1.2	164
2	0.8	105
3	0.8	119
4	0.6	116
5	0.2	23
6	0.4	86
7	0.5	91
8	0.4	64
9	0.6	175
10	0.6	358
11	0.5	106
12	0.4	175
13	0.5	48
14	0.8	214
15	1.1	442
16	0.6	73
17	0.3	382
18	0.5	156
19	0.7	188
20	0.6	55
21	0.3	43
22	0.5	182
23	1.1	257
24	0.5	208
25	0.4	53
26	0.9	532
27	0.6	188
28	1.5	114
29	1.6	356
30	0.9	60
31	1.1	250
32	0.5	312
33	0.9	159
34	0.5	186
35	0.8	221
36	0.9	256
37	0.9	266
38	1.4	381
39	1.2	165
40	0.7	83
41	0.7	205
42	0.6	226
43	0.5	190
44	1.3	167
45	1.3	410
46	0.5	136
47	0.6	175
48	1.1	434
49	0.6	123
50	1.1	348
51	0.8	313
52	0.6	187
53	0.7	500
54	0.7	326
55	0.8	216
56	1.2	298
57	0.9	105
58	0.8	306
59	0.9	233
60	0.9	272
61	1.6	392
62	1	99
63	0.5	60
64	1.2	276

Table A2.53: Microcosm 5: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	0.8	185
66	1.9	121
67	0.5	241
68	0.9	141
69	0.9	245
70	0.9	194
71	0.3	94
72	0.5	170
73	0.3	44
74	0.5	218
75	0.8	183
76	0.8	170
77	0.5	133
78	0.8	218
79	0.9	81
80	0.7	131
81	0.8	84
82	1	134
83	0.5	41
84	0.9	150
85	0.6	122
86	0.5	185
87	0.6	107
88	0.7	174
89	0.9	354
90	0.7	89
91	0.5	108
92	0.5	44
93	0.7	154
94	0.3	195
95	0.5	85
96	0.5	130
97	0.9	218
98	0.7	120
99	0.3	86
100	0.8	131
101	0.5	69
102	0.7	52
103	0.5	284
104	0.9	235
105	0.2	72
106	0.7	68
107	0.7	181
108	0.7	53
109	0.9	129
110	0.4	123
111	0.7	142
112	0.4	175
113	0.5	89
114	0.7	70

Table A2.53: Microcosm 5: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)

Stems	Total Stems	Total Number of Stems	114
		Stems with Inflorescence	0
	Heights (mm)	Max Height	532
		Min Height	23
		Mean Height	179.2192982
		Mode Height	175
		Median Height	166
	Widths (mm)	Max Width	1.9
		Min Width	0.2
		Mean Width	0.733333333
		Mode Width	0.5
		Median Width	0.7

Table A2.54: Microcosm 6 *Mentha aquatica* Stem Measurements.

There were no surviving *Mentha aquatica* within Microcosm 6.

Table A2.55: Microcosm 7 *Mentha aquatica* Stem Measurements.

There were no surviving *Mentha aquatica* within Microcosm 7.

Table A2.56: Microcosm 8 *Mentha aquatica* Stem Measurements.

There were no surviving *Mentha aquatica* within Microcosm 8.

Table A2.57: Microcosm 9: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	2.1	772
2	1.1	498
3	0.8	408
4	1.7	444
5	0.9	235
6	0.7	312
7	2.1	459
8	1.5	723
9	2.6	477
10	1.4	751
11	1.3	518
12	1.6	435
13	2.6	843
14	0.6	286
15	1.8	512
16	1.3	250
17	1.6	472
18	1.5	440
19	2.7	740
20	1	622
21	1.5	538
22	1.2	426
23	1.3	500
24	1.9	433
25	1.2	394
26	1.3	422
27	1.8	365
28	1.2	276
29	1.4	386
30	1.9	540
31	1.3	408
32	0.7	329
33	0.9	434
34	2.1	691
35	1.1	523
36	1.5	656
37	1.3	488
38	1.4	338
39	2.1	649
40	1.7	388
41	1.2	390
42	1.5	478
43	1	653
44	1.7	746
45	2.9	350
46	1	465
47	1	472
48	1.8	309
49	1.2	376
50	1.1	747
51	1.9	702
52	1.8	679
53	1.8	429
54	1.4	726
55	1.7	129
56	1.5	765
57	1.5	519
58	1.2	646
59	1.5	293
60	1.6	317
61	0.6	343
62	1.3	492
63	0.6	398
64	1.4	466

Table A2.57: Microcosm 9: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	2	702
66	1.6	173
67	1.6	403
68	1.3	514
69	1.3	424
70	1.7	180
71	2.7	459
72	1.5	587
73	1.3	382
74	1.5	306
75	1.9	265
76	1.1	385
77	1.1	244
78	2.3	211
79	0.6	463
80	1.3	290
81	0.9	276
82	1.1	191
83	0.9	225
84	0.9	319
85	1.4	424
86	1.4	204
87	0.9	310
88	0.4	570
89	0.9	485
90	1.4	412
91	1	371
92	1.3	167
93	1	216
94	1.2	155
95	1	400
96	0.7	227
97	0.4	285
98	0.6	185
99	1.2	145
100	1.6	210
101	1.5	163
102	1.2	315
103	0.4	165
104	0.7	268
105	0.8	201
106	1.1	145
107	0.7	194
108	0.8	15
109	0.6	194
110	0.7	139
111	1.1	137
112	1	264
113	1.5	146
114	1	116
115	1	195
116	0.6	234
117	0.6	231
118	1	96
119	1.1	148
120	0.7	166
121	0.9	165
122	0.9	368
123	0.8	1012
124	0.5	250
125	0.8	243
126	1	100
127	0.9	274
128	0.8	123

Table A2.57: Microcosm 9: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	0.6	48
130	0.4	46
131	0.8	94
132	0.2	60
133	0.6	53
134	0.8	53
135	1.1	198
136	0.8	281
137	0.5	129
138	0.7	115
139	0.7	218
140	0.7	68
141	0.6	280
142	0.6	119
143	0.4	121
144	0.4	171
145	0.9	265
146	0.5	68
147	1	119
148	0.9	106
149	1	119
150	0.5	172
151	0.7	252
152	0.7	76
153	0.6	137
154	0.8	125
155	0.8	214
156	1.1	76
157	0.6	122
158	0.8	130
159	0.7	88
160	0.5	131
161	0.9	165
162	1.6	265
163	0.5	144
164	1	94
165	1.1	183
166	0.8	169
167	1.3	114
168	1.2	396
169	1.1	133
170	0.7	336
171	0.7	170
172	0.9	254
173	1.2	255
174	0.7	194
175	0.8	70
176	0.7	135
177	0.6	147
178	0.8	185
179	0.7	168
180	0.7	76
181	0.7	179
182	0.9	221
183	0.3	300
184	1	162
185	0.7	119
186	1	207
187	0.7	189
188	0.6	218
189	0.7	242
190	0.4	140
191	0.9	118
192	0.9	220

Table A2.57: Microcosm 9: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
193	0.5	154
194	0.7	287
195	1.1	133
196	1	66
197	0.8	69
198	0.6	304
199	1.1	328
200	0.6	244
201	0.9	323
202	1.5	167
203	1.3	412
204	0.8	216
205	0.7	272
206	0.8	149
207	0.9	186
208	1.3	236
209	0.7	158
210	0.7	291
211	0.5	487
212	1.2	182
213	1.3	407
214	0.7	132
215	0.3	190
216	0.4	53
217	1	162
218	1.2	163
219	0.6	60
220	0.3	215
221	0.7	143
222	0.8	145
223	0.7	194
224	1.1	123
225	0.7	210
226	0.6	205
227	0.7	116
228	0.5	119
229	1	193
230	0.4	198
231	0.8	95
232	0.8	1059
233	0.4	197
234	0.4	89
235	0.7	84
236	0.7	125
237	0.5	66
238	1	255
239	0.9	211
240	0.4	226
241	0.9	394
242	0.9	308
243	1.6	115
244	0.7	94
245	0.5	195
246	0.6	234
247	0.4	173
248	0.6	163
249	0.9	56
250	1.5	104
251	1.4	197
252	0.7	71
253	0.7	81
254	0.5	125
255	0.6	63
256	0.7	40

Table A2.57: Microcosm 9: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
257	0.8	60
258	1.1	43

Stems	Total Stems	Total Number of Stems	258
		Stems with Inflorescence	22
	Heights (mm)	Max Height	1059
		Median Height	15
		Mean Height	278.8372093
		Mode Height	119
		Median Height	218
	Widths (mm)	Max Width	2.9
		Min Width	0.2
		Mean Width	1.026356589
		Mode Width	0.7
		Median Width	0.9

Table A2.58: Microcosm 10: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	1.2	467
2	1.8	1081
3	2.5	621
4	1.9	383
5	1.2	251
6	1	221
7	0.8	295
8	1	130
9	1	98
10	1.8	495
11	0.5	123
12	0.9	230
13	2.6	684
14	0.7	160
15	1.8	627
16	1.8	188
17	1.1	101
18	2.5	598
19	1.3	386
20	0.8	190
21	0.8	83
22	0.6	182
23	0.7	258
24	0.9	144
25	1.4	501
26	1.4	270
27	1.1	69
28	1.4	115
29	1.5	807
30	1.6	904
31	2.1	769
32	1	955
33	3.3	857
34	1.6	718
35	1.9	736
36	1	842
37	2.8	802
38	2	747
39	2.7	927
40	2	900
41	2.8	634
42	1.3	658
43	2.9	742
44	1.7	633
45	2.9	595
46	1.5	613
47	3.2	612
48	1.9	643
49	2.3	528
50	1.7	583
51	1.4	664
52	1.9	424
53	1.1	490
54	1.8	415
55	3.4	498
56	2.3	484
57	0.8	602
58	0.8	541
59	1	546
60	2.5	549
61	0.8	450
62	1	512
63	0.7	421
64	2.3	556

Table A2.58: Microcosm 10: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
65	3.6	252
66	3.7	348
67	2.4	505
68	1.4	515
69	1	504
70	0.7	482
71	2	314
72	1.6	570
73	1.6	430
74	1.6	421
75	1.2	556
76	1	300
77	1.8	278
78	3	213
79	2.4	330
80	1.9	400
81	1.1	405
82	1.7	501
83	2.9	174
84	0.8	235
85	1.4	130
86	1.1	226
87	1.5	185
88	1.6	369
89	1.3	386
90	1.2	512
91	1.6	296
92	1.2	232
93	1.8	194
94	2	433
95	1.1	273
96	0.7	418
97	0.7	463
98	1.3	594
99	1.4	126
100	1	287
101	0.9	205
102	1.2	237
103	1	346
104	1.1	331
105	0.7	307
106	1.2	256
107	1	382
108	1.3	240
109	1.1	232
110	1.3	246
111	0.7	137
112	1.4	240
113	1	285
114	1.1	230
115	1.4	187
116	1.3	332
117	0.6	175
118	0.7	206
119	0.8	234
120	0.7	228
121	0.7	197
122	0.9	217
123	1	175
124	1.1	118
125	1.2	367
126	1.1	209
127	1.1	274
128	1.3	70

Table A2.58: Microcosm 10: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
129	1.1	173
130	0.9	235
131	1.6	189
132	1.3	234
133	0.8	117
134	1.1	184
135	1	190
136	0.9	255
137	1	112
138	1	223
139	1.3	233
140	1.1	277
141	1	282
142	0.8	190
143	1	132
144	0.9	124
145	0.8	156
146	0.7	224
147	1.5	200
148	0.7	132
149	0.9	165
150	0.7	163
151	0.7	78
152	1	79
153	0.7	239
154	1	105
155	0.9	277
156	1.2	144
157	2	379
158	1.2	115
159	0.8	143
160	0.6	142
161	1	242
162	1.2	178
163	1.4	160
164	0.9	112
165	0.7	62
166	1.1	112
167	1	73
168	0.8	80
169	0.8	54
170	0.9	173
171	0.9	150
172	1.2	97
173	0.8	162
174	1	302
175	1.5	304
176	1.6	267
177	1.4	300
178	1.3	370
179	1.5	210
180	0.5	225

Table A2.58: Microcosm 10: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)

Stems	Total Stems	Total Number of Stems	180
		Stems with Inflorescence	11
	Heights (mm)	Max Height	1081
		Min Height	54
		Mean Height	340.8444444
		Mode Height	190
		Median Height	268.5
	Widths (mm)	Max Width	3.7
		Min Width	0.5
		Mean Width	1.360555556
		Mode Width	1
		Median Width	1.2

Table A2.59: Microcosm 11: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	2.2	674
2	0.9	177
3	1.1	77
4	1	502
5	0.6	180
6	1.9	766
7	1.2	591
8	1	158
9	0.5	140
10	0.7	286
11	1	139
12	2.5	756
13	3	484
14	0.5	265
15	0.8	395
16	1.4	182
17	2.2	728
18	4.1	462
19	0.4	228
20	1	596
21	1.7	628
22	0.8	136
23	1	251
24	1	157
25	2.9	628
26	1.1	562
27	1	440
28	0.6	97
29	0.5	132
30	0.4	96
31	0.4	75
32	1.1	502
33	0.5	107
34	2.2	427
35	1.1	230
36	1.4	106
37	1	378
38	1.6	618
39	1	220
40	0.7	191
41	0.5	70
42	0.4	331
43	1	294
44	0.5	134
45	0.7	145
46	2.6	734
47	0.9	160
48	3.5	356
49	4.1	224
50	1	519
51	0.5	55
52	0.3	131
53	2.5	706
54	1.3	194
55	1.5	80
56	0.5	138
57	1	40
58	0.5	243
59	0.6	208
60	0.4	97
61	0.4	438

Table A2.59: Microcosm 11: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)

Stems	Total Stems	Total Number of Stems	61
		Stems with Inflorescence	6
	Heights (mm)	Max Height	766
		Min Height	40
		Mean Height	312.5245902
		Mode Height	502
		Median Height	228
	Widths (mm)	Max Width	4.1
		Min Width	0.3
		Mean Width	1.224590164
		Mode Width	1
		Median Width	1

Table A2.60: Microcosm 12: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	0.9	391
2	0.9	51
3	0.8	48
4	1.2	438
5	0.9	25
6	0.7	58
7	1.1	279
8	0.9	32
9	0.9	41

Stems	Total Stems	Total Number of Stems	9
		Stems with Inflorescence	0
	Heights (mm)	Max Height	438
		Min Height	25
		Mean Height	151.4444444
		Mode Height	#N/A
		Median Height	51
	Widths (mm)	Max Width	1.2
		Min Width	0.7
		Mean Width	0.922222222
		Mode Width	0.9
		Median Width	0.9

Table A2.61: Microcosm 13: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)	213
1	0.9	480	7
2	1.9	674	1049
3	2.2	581	33
4	2.6	551	208.1173709
5	2	435	63
6	2.1	481	180
7	1.1	1049	2.6
8	1.6	476	0.2
9	1.7	447	1.009389671
10	0.7	377	1
11	1.3	300	1
12	1.3	421	
13	1	586	
14	1.2	306	
15	2	260	
16	1.4	355	
17	1.8	300	
18	1	266	
19	1.2	350	
20	1.7	353	
21	1.6	229	
22	1.6	382	
23	1.3	507	
24	1	544	
25	1.2	407	
26	1.2	297	
27	1.4	297	
28	1.6	393	
29	1.2	367	
30	1.5	527	
31	1.3	259	
32	1.4	369	
33	1.7	272	
34	1.2	540	
35	1	324	
36	1.1	420	
37	1.2	324	
38	1.4	208	
39	1.7	218	
40	1.4	267	
41	1	260	
42	1.2	344	
43	1.1	243	
44	0.7	156	
45	0.8	218	
46	0.8	257	
47	1	269	
48	1.1	244	
49	1.6	386	
50	1.2	252	
51	0.5	213	
52	0.8	339	
53	1	207	
54	1.5	316	
55	1.2	511	
56	1.5	319	
57	0.9	412	
58	0.7	290	
59	0.9	370	
60	1.3	422	
61	1.6	268	
62	1.6	246	
63	0.6	281	
64	0.9	226	

Table A2.61: Microcosm 13: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)	213
65	1.5	315	
66	0.9	186	
67	0.8	205	
68	0.7	189	
69	1	302	
70	0.8	174	
71	0.7	194	
72	1.2	408	
73	1.5	211	
74	1.6	149	
75	0.8	357	
76	1	213	
77	0.9	250	
78	0.5	255	
79	0.7	268	
80	0.5	259	
81	0.6	282	
82	0.4	142	
83	1	311	
84	0.7	404	
85	2	201	
86	1	187	
87	0.7	224	
88	1.4	114	
89	0.8	186	
90	0.6	43	
91	0.5	63	
92	1.4	193	
93	0.6	101	
94	0.7	92	
95	0.5	111	
96	0.8	110	
97	0.6	212	
98	0.5	249	
99	1.2	222	
100	0.6	142	
101	0.5	45	
102	0.5	45	
103	1	297	
104	0.8	254	
105	1.1	178	
106	0.6	76	
107	0.9	243	
108	1	75	
109	0.7	172	
110	0.6	46	
111	0.7	336	
112	1.1	337	
113	0.5	424	
114	0.8	135	
115	1.1	232	
116	0.8	127	
117	0.8	63	
118	1.3	154	
119	0.7	255	
120	0.4	63	
121	1.3	152	
122	0.9	118	
123	0.5	167	
124	0.9	225	
125	1.1	312	
126	0.5	164	
127	1.5	92	
128	1.1	128	

Table A2.61: Microcosm 13: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)	213
129	0.5	79	
130	0.6	188	
131	0.9	285	
132	0.5	180	
133	1.4	76	
134	1.6	124	
135	1	53	
136	0.5	47	
137	0.3	280	
138	1.4	60	
139	1.1	55	
140	0.3	154	
141	1.4	94	
142	0.3	188	
143	1	307	
144	1.1	140	
145	1.6	124	
146	1	47	
147	1.5	69	
148	0.9	56	
149	0.6	71	
150	0.5	156	
151	0.7	98	
152	1.6	117	
153	0.6	95	
154	1.2	87	
155	1.1	64	
156	0.7	80	
157	1.2	122	
158	0.6	124	
159	0.9	112	
160	0.8	52	
161	1.5	74	
162	0.4	49	
163	1.1	103	
164	0.9	148	
165	1.4	37	
166	0.9	108	
167	1.9	96	
168	1.1	149	
169	1.1	63	
170	0.8	63	
171	0.8	60	
172	0.5	183	
173	1	96	
174	1	65	
175	0.5	94	
176	1.2	127	
177	0.8	120	
178	0.7	53	
179	0.6	112	
180	0.7	243	
181	1.1	55	
182	1.3	110	
183	1.2	42	
184	0.8	48	
185	0.9	122	
186	0.8	170	
187	0.6	119	
188	0.7	224	
189	0.5	70	
190	0.7	114	
191	0.9	82	
192	0.4	33	

Table A2.61: Microcosm 13: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)	213
193	0.6	146	
194	0.4	50	
195	1.3	74	
196	0.7	160	
197	0.9	63	
198	1	42	
199	1.2	70	
200	1.3	78	
201	0.8	70	
202	1.5	65	
203	1.1	46	
204	0.3	158	
205	1	51	
206	1	61	
207	0.2	120	
208	0.8	46	
209	1.4	52	
210	1	74	
211	0.5	61	
212	0.6	85	
213	0.6	54	

Stems	Total Stems	Total Number of Stems
		Stems with Inflorescence
	Heights (mm)	Max Height
		Min Height
		Mean Height
		Mode Height
		Median Height
	Widths (mm)	Max Width
		Min Width
		Mean Width
		Mode Width
		Median Width

Table A2.62: Microcosm 14: *Mentha aquatica* Stem Measurements.

Stem Number	Stem Width (mm)	Stem Height (mm)
1	0.7	138
2	0.9	75
3	1.3	69
4	0.6	25
5	1	18
6	1	76
7	1	95
8	1	42
9	0.9	52
10	0.8	46
11	0.9	24
12	1.8	229
13	1	54
14	1.1	42
15	1.4	52
16	0.7	50
17	0.7	34
18	0.3	9

Stems	Total Stems	Total Number of Stems	18
		Stems with Inflorescence	0
	Heights (mm)	Max Height	229
		Min Height	9
		Mean Height	62.77777778
		Mode Height	42
		Median Height	51
	Widths (mm)	Max Width	1.8
		Min Width	0.3
		Mean Width	0.95
		Mode Width	1
		Median Width	0.95

Table A2.63: Microcosm 15 *Mentha aquatica* Stem Measurements.

There were no surviving *Mentha aquatica* within Microcosm 15.

Table A2.64: Microcosm 16 *Mentha aquatica* Stem Measurements.

There were no surviving *Mentha aquatica* within Microcosm 16.

Appendix 3 Water Input during the Acclimatisation and Establishment Period

Year	Microcosm Number		January	February	March	April	May	June	July	August	September	October	November	December
			Total Water Added per Month (Litres)											
2007	1	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	27.47	42.54	33.93	5.92	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	54.39	59.62	56.98	33.17	31.02
	2	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	27.47	40.93	32.85	7.00	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	54.39	58.00	55.90	34.25	31.02
	3	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	23.70	36.62	29.62	4.85	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	50.62	53.69	52.67	32.10	31.02
	4	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	32.85	51.16	40.93	7.00	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	59.78	68.23	63.98	34.25	31.02
	5	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	33.93	50.08	39.85	8.08	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	60.85	67.16	62.90	35.33	31.02
	6	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	24.77	37.16	29.08	4.85	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	51.70	54.23	52.13	32.10	31.02
	7	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	27.47	41.47	33.93	5.92	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	54.39	58.54	56.98	33.17	31.02
	8	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	22.62	35.54	28.54	5.92	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	49.55	52.61	51.59	33.17	31.02
2008	1	Artificial Water Added	0.00	0.00	0.00	71.63	153.47	177.72	197.10	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	108.46	200.76	198.45	246.33	N/A	N/A	N/A	N/A	N/A
	2	Artificial Water Added	0.00	0.00	0.00	70.93	147.32	168.02	185.79	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	107.76	194.60	188.76	235.02	N/A	N/A	N/A	N/A	N/A
	3	Artificial Water Added	0.00	0.00	0.00	77.44	143.79	169.64	189.56	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	114.27	191.07	190.37	238.79	N/A	N/A	N/A	N/A	N/A
	4	Artificial Water Added	0.00	0.00	0.00	73.47	158.90	178.79	194.95	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	110.30	206.19	199.53	244.17	N/A	N/A	N/A	N/A	N/A
	5	Artificial Water Added	0.00	0.00	0.00	68.47	152.24	171.79	188.49	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	105.30	199.52	192.53	237.71	N/A	N/A	N/A	N/A	N/A
	6	Artificial Water Added	0.00	0.00	0.00	71.09	148.17	182.02	199.26	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	107.92	195.45	202.76	248.48	N/A	N/A	N/A	N/A	N/A
	7	Artificial Water Added	0.00	0.00	0.00	78.07	155.78	182.56	195.41	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	114.91	203.06	203.30	244.63	N/A	N/A	N/A	N/A	N/A
	8	Artificial Water Added	0.00	0.00	0.00	73.24	155.47	171.79	188.49	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	110.08	202.76	192.53	237.71	N/A	N/A	N/A	N/A	N/A

Table A 3.1: Microcosms 1-8 Water Input during the Acclimatisation and Establishment Period.

Year	Microcosm Number		Total Water Added per Month (Litres)											
			January	February	March	April	May	June	July	August	September	October	November	December
2007	9	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	23.70	35.54	29.08	6.46	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	50.62	52.61	52.13	33.71	31.02
	10	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	22.62	33.93	26.39	5.92	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	49.55	51.00	49.44	33.17	31.02
	11	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	33.39	51.70	40.93	7.54	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	60.32	68.77	63.98	34.79	31.02
	12	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	28.00	45.24	35.54	6.46	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	54.93	62.31	58.59	33.71	31.02
	13	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	27.47	43.62	35.00	7.00	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	54.39	60.69	58.05	34.25	31.02
	14	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	22.08	35.54	27.47	5.92	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	49.01	52.61	50.51	33.17	31.02
	15	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	20.46	30.16	24.23	5.92	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	47.39	47.23	47.28	33.17	31.02
	16	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	19.39	30.70	23.70	5.39	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.93	17.07	23.05	27.25	31.02
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	46.31	47.77	46.74	32.64	31.02
2008	9	Artificial Water Added	0.00	0.00	0.00	71.63	137.56	167.48	182.56	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	108.46	184.84	188.22	231.79	N/A	N/A	N/A	N/A	N/A
	10	Artificial Water Added	0.00	0.00	0.00	71.09	144.87	169.10	180.95	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	107.92	192.15	189.83	230.17	N/A	N/A	N/A	N/A	N/A
	11	Artificial Water Added	0.00	0.00	0.00	67.85	143.94	163.71	175.02	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	104.68	191.22	184.45	224.25	N/A	N/A	N/A	N/A	N/A
	12	Artificial Water Added	0.00	0.00	0.00	69.47	148.63	173.95	190.10	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	106.31	195.91	194.68	239.32	N/A	N/A	N/A	N/A	N/A
	13	Artificial Water Added	0.00	0.00	0.00	67.32	153.47	172.87	185.79	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	104.15	200.75	193.60	235.02	N/A	N/A	N/A	N/A	N/A
	14	Artificial Water Added	0.00	0.00	0.00	74.86	147.47	179.33	191.18	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	111.69	194.75	200.07	240.40	N/A	N/A	N/A	N/A	N/A
	15	Artificial Water Added	0.00	0.00	0.00	65.16	146.63	159.94	178.79	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	102.00	193.92	180.68	228.02	N/A	N/A	N/A	N/A	N/A
	16	Artificial Water Added	0.00	0.00	0.00	75.08	150.79	166.41	186.33	N/A	N/A	N/A	N/A	N/A
		Natural Rainfall Added	49.71	14.59	34.52	36.84	47.28	20.73	49.22	N/A	N/A	N/A	N/A	N/A
		Total Input	49.71	14.59	34.52	111.92	198.07	187.14	235.56	N/A	N/A	N/A	N/A	N/A

Table A 3.2: Microcosms 9-16 Water Input during the Acclimatisation and Establishment Period.

Appendix 4 Vegetation Heights and Area Coverage during the Acclimatisation and Establishment Period

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1022	749	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	723	608	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	881	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	655	0	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	501	438	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	379	390	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	572	337	73
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	455	162	35
2008	*Phragmites australis*	Maximum Height	0	0	0	182	891	1281	1514	1644	N/A	N/A	N/A	N/A
		General Height	0	0	0	107	793	1109	1291	1397	N/A	N/A	N/A	N/A
	Lythrum salicaria	Maximum Height	0	0	89	165	621	1437	1651	1948	N/A	N/A	N/A	N/A
		General Height	0	0	58	142	516	1280	1549	1748	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Maximum Height	0	0	52	260	737	1443	1493	1535	N/A	N/A	N/A	N/A
		General Height	0	0	42	112	560	1207	1277	1329	N/A	N/A	N/A	N/A
	Mentha aquatica	Maximum Height	71	70	70	100	214	444	526	613	N/A	N/A	N/A	N/A
		General Height	41	37	36	67	199	292	318	328	N/A	N/A	N/A	N/A

Table A 4.1: Microcosm 1 Vegetation Heights during the Acclimatisation and Establishment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	810	264	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	592	515	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	861	821	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	654	736	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	489	420	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	427	228	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	739	246	67
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	317	188	35
2008	*Phragmites australis*	Maximum Height	0	0	50	194	922	1303	1503	1587	N/A	N/A	N/A	N/A
		General Height	0	0	50	101	813	1103	1308	1398	N/A	N/A	N/A	N/A
	Lythrum salicaria	Maximum Height	0	0	76	171	645	1398	1734	1983	N/A	N/A	N/A	N/A
		General Height	0	0	50	105	588	1235	1509	1639	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Maximum Height	0	0	86	265	732	1370	1591	1633	N/A	N/A	N/A	N/A
		General Height	0	0	75	100	645	1208	1358	1482	N/A	N/A	N/A	N/A
	Mentha aquatica	Maximum Height	66	58	55	95	246	392	524	643	N/A	N/A	N/A	N/A
		General Height	34	30	30	66	152	291	348	381	N/A	N/A	N/A	N/A

Table A 4.2: Microcosm 2 Vegetation Heights during the Acclimatisation and Establishment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	842	827	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	585	582	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	721	850	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	530	652	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	491	516	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	417	219	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	393	446	68
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	164	203	42
2008	*Phragmites australis*	Maximum Height	0	0	85	178	916	1296	1607	1682	N/A	N/A	N/A	N/A
		General Height	0	0	65	102	805	1187	1429	1586	N/A	N/A	N/A	N/A
	Lythrum salicaria	Maximum Height	0	0	75	155	688	1403	1684	1829	N/A	N/A	N/A	N/A
		General Height	0	0	57	136	614	1263	1521	1646	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Maximum Height	0	0	119	202	734	1356	1706	1808	N/A	N/A	N/A	N/A
		General Height	0	0	102	176	551	1063	1320	1504	N/A	N/A	N/A	N/A
	Mentha aquatica	Maximum Height	70	62	58	82	291	417	544	778	N/A	N/A	N/A	N/A
		General Height	41	33	32	64	187	332	361	379	N/A	N/A	N/A	N/A

Table A 4.3: Microcosm 3 Vegetation Heights during the Acclimatisation and Establishment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	811	726	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	612	612	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	861	819	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	654	713	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	482	502	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	404	384	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	406	420	64
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	264	316	43
2008	*Phragmites australis*	Maximum Height	0	0	50	185	919	1308	1531	1677	N/A	N/A	N/A	N/A
		General Height	0	0	50	114	807	1104	1435	1603	N/A	N/A	N/A	N/A
	Lythrum salicaria	Maximum Height	0	0	88	170	672	1297	1635	1804	N/A	N/A	N/A	N/A
		General Height	0	0	56	107	545	1251	1442	1692	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Maximum Height	0	0	153	293	721	1427	1703	1762	N/A	N/A	N/A	N/A
		General Height	0	0	134	119	672	1101	1418	1640	N/A	N/A	N/A	N/A
	Mentha aquatica	Maximum Height	70	62	56	82	223	430	689	826	N/A	N/A	N/A	N/A
		General Height	44	43	41	65	170	308	402	485	N/A	N/A	N/A	N/A

Table A 4.4: Microcosm 4 Vegetation Heights during the Acclimatisation and Establishment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	857	851	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	614	599	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	849	868	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	603	774	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	518	564	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	398	431	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	354	489	64
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	190	187	42
2008	*Phragmites australis*	Maximum Height	0	0	0	169	894	1295	1428	1498	N/A	N/A	N/A	N/A
		General Height	0	0	0	95	791	1100	1215	1304	N/A	N/A	N/A	N/A
	Lythrum salicaria	Maximum Height	0	0	73	151	644	1398	1681	1877	N/A	N/A	N/A	N/A
		General Height	0	0	40	106	577	1258	1354	1607	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Maximum Height	0	0	75	217	705	1445	1881	1921	N/A	N/A	N/A	N/A
		General Height	0	0	65	127	644	1119	1434	1649	N/A	N/A	N/A	N/A
	Mentha aquatica	Maximum Height	60	58	53	87	214	465	511	316	N/A	N/A	N/A	N/A
		General Height	45	37	37	62	185	248	263	282	N/A	N/A	N/A	N/A

Table A 4.5: Microcosm 5 Vegetation Heights during the Acclimatisation and Establishment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	841	839	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	645	643	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	817	924	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	698	826	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	579	623	402
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	566	561	341
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	676	337	73
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	285	251	46
2008	*Phragmites australis*	Maximum Height	0	0	40	201	928	1321	1430	1501	N/A	N/A	N/A	N/A
		General Height	0	0	40	116	823	1120	1182	1331	N/A	N/A	N/A	N/A
	Lythrum salicaria	Maximum Height	0	0	73	175	629	1353	1749	1912	N/A	N/A	N/A	N/A
		General Height	0	0	42	98	608	1265	1501	1638	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Maximum Height	0	0	91	235	660	1338	1832	1870	N/A	N/A	N/A	N/A
		General Height	0	0	68	140	629	1248	1472	1592	N/A	N/A	N/A	N/A
	Mentha aquatica	Maximum Height	75	70	66	98	249	475	573	740	N/A	N/A	N/A	N/A
		General Height	53	47	46	53	165	296	331	356	N/A	N/A	N/A	N/A

Table A 4.6: Microcosm 6 Vegetation Heights during the Acclimatisation and Establishment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	797	679	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	585	536	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	943	948	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	634	855	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	493	498	182
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	415	399	144
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	745	372	98
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	161	248	42
2008	*Phragmites australis*	Maximum Height	0	0	40	177	904	1292	1453	1506	N/A	N/A	N/A	N/A
		General Height	0	0	40	99	801	1094	1218	1299	N/A	N/A	N/A	N/A
	Lythrum salicaria	Maximum Height	0	0	82	155	624	1349	1530	1735	N/A	N/A	N/A	N/A
		General Height	0	0	53	132	547	1294	1458	1612	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Maximum Height	0	0	145	253	748	1477	1895	1983	N/A	N/A	N/A	N/A
		General Height	0	0	108	134	624	1126	1410	1661	N/A	N/A	N/A	N/A
	Mentha aquatica	Maximum Height	85	80	73	95	232	443	563	705	N/A	N/A	N/A	N/A
		General Height	43	38	37	55	163	330	351	390	N/A	N/A	N/A	N/A

Table A 4.7: Microcosm 7 Vegetation Heights during the Acclimatisation and Establishment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	784	609	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	602	550	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	903	850	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	593	767	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	497	523	209
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	385	414	209
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	375	268	73
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	199	179	34
2008	*Phragmites australis*	Maximum Height	0	0	40	178	913	1296	1447	1685	N/A	N/A	N/A	N/A
		General Height	0	0	40	102	808	1108	1271	1325	N/A	N/A	N/A	N/A
	Lythrum salicaria	Maximum Height	0	0	92	153	665	1283	1634	1804	N/A	N/A	N/A	N/A
		General Height	0	0	43	115	524	1209	1505	1646	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Maximum Height	0	0	147	293	644	1418	1821	1855	N/A	N/A	N/A	N/A
		General Height	0	0	111	173	665	1104	1456	1479	N/A	N/A	N/A	N/A
	Mentha aquatica	Maximum Height	75	66	59	90	256	412	519	670	N/A	N/A	N/A	N/A
		General Height	31	39	34	62	181	282	392	429	N/A	N/A	N/A	N/A

Table A 4.8: Microcosm 8 Vegetation Heights during the Acclimatisation and Establishment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	5	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	5	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	37	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	45	0	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	30	17	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4	4	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	34	21	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	23	14	11
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6	2	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	29	16	11
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	19	22
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	1	1
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	20	23
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	45	67
2008	*Phragmites australis*	Inside Microcosm	0	0	0	1	7	9	9	9	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	0	0	0	1	7	9	9	9	N/A	N/A	N/A	N/A
	Lythrum salicaria	Inside Microcosm	0	0	2	6	23	26	37	37	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	15	14	17	18	N/A	N/A	N/A	N/A
		Combined	0	0	2	6	38	40	54	55	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	2	14	24	25	22	22	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	7	8	8	8	N/A	N/A	N/A	N/A
		Combined	0	0	2	14	31	33	30	30	N/A	N/A	N/A	N/A
	Mentha aquatica	Inside Microcosm	11	11	12	28	21	22	19	18	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	2	3	2	2	N/A	N/A	N/A	N/A
		Combined	11	11	12	28	23	25	21	20	N/A	N/A	N/A	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	22	22	22	22	16	9	4	5	N/A	N/A	N/A	N/A
		Outside Microcosm	1	1	1	1	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	23	23	23	23	16	9	4	5	N/A	N/A	N/A	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	67	67	62	29	9	9	9	9	N/A	N/A	N/A	N/A

Table A 4.9: Microcosm 1 Vegetation Areas during the Acclimatisation and Establishment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	5	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	5	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52	24	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	14	4	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	66	28	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	19	19	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	6	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26	25	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	18	19	8
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	20	19	8
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	14	21
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	1	1
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	15	22
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6	19	71
2008	*Phragmites australis*	Inside Microcosm	0	0	1	1	5	7	7	7	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	0	0	1	1	5	7	7	7	N/A	N/A	N/A	N/A
	Lythrum salicaria	Inside Microcosm	0	0	1	4	21	27	42	42	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	6	7	11	12	N/A	N/A	N/A	N/A
		Combined	0	0	1	4	27	34	53	54	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	2	5	15	17	17	16	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	2	4	5	5	N/A	N/A	N/A	N/A
		Combined	0	0	2	5	17	21	22	21	N/A	N/A	N/A	N/A
	Mentha aquatica	Inside Microcosm	8	7	8	12	14	18	18	16	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	3	3	3	N/A	N/A	N/A	N/A
		Combined	8	7	8	12	14	21	21	19	N/A	N/A	N/A	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	21	20	20	20	11	4	4	7	N/A	N/A	N/A	N/A
		Outside Microcosm	1	1	1	1	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	22	21	21	21	11	4	4	7	N/A	N/A	N/A	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	71	73	68	58	34	27	12	12	N/A	N/A	N/A	N/A

Table A 4.10: Microcosm 2 Vegetation Areas during the Acclimatisation and Establishment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	5	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	5	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	44	11	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11	2	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	55	13	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	21	18	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	14	5	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	35	23	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	22	18	15
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	1	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	25	19	15
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	14	16
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	3	2
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	17	18
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8	34	69
2008	*Phragmites australis*	Inside Microcosm	0	0	1	1	6	9	9	9	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	0	0	1	1	6	9	9	9	N/A	N/A	N/A	N/A
	Lythrum salicaria	Inside Microcosm	0	0	2	4	18	26	41	41	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	9	13	14	14	N/A	N/A	N/A	N/A
		Combined	0	0	2	4	27	39	55	55	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	2	15	15	19	19	16	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	6	7	7	5	N/A	N/A	N/A	N/A
		Combined	0	0	2	15	21	26	26	21	N/A	N/A	N/A	N/A
	Mentha aquatica	Inside Microcosm	15	14	14	17	19	20	21	19	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	1	2	2	N/A	N/A	N/A	N/A
		Combined	15	14	14	17	19	21	23	21	N/A	N/A	N/A	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	16	12	12	12	4	4	4	9	N/A	N/A	N/A	N/A
		Outside Microcosm	2	1	1	1	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	18	13	13	13	4	4	4	9	N/A	N/A	N/A	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	69	74	69	51	38	22	6	6	N/A	N/A	N/A	N/A

Table A 4.11: Microcosm 3 Vegetation Areas during the Acclimatisation and Establishment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	5	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	5	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	66	6	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11	2	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	77	8	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	16	16	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12	8	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	28	24	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11	13	13
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4	2	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	15	15	13
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	24	29
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	5	3
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	29	32
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	36	58
2008	*Phragmites australis*	Inside Microcosm	0	0	1	1	3	6	8	8	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	0	0	1	1	3	6	8	8	N/A	N/A	N/A	N/A
	Lythrum salicaria	Inside Microcosm	0	0	1	4	21	27	45	45	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	14	8	12	12	N/A	N/A	N/A	N/A
		Combined	0	0	1	4	35	35	57	57	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	3	14	17	22	20	17	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	8	8	8	8	N/A	N/A	N/A	N/A
		Combined	0	0	3	14	25	30	28	25	N/A	N/A	N/A	N/A
	Mentha aquatica	Inside Microcosm	13	12	15	18	19	21	18	18	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	3	4	5	5	N/A	N/A	N/A	N/A
		Combined	13	12	15	18	22	25	23	23	N/A	N/A	N/A	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	26	24	24	21	12	7	4	8	N/A	N/A	N/A	N/A
		Outside Microcosm	2	1	1	1	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	28	25	25	22	12	7	4	8	N/A	N/A	N/A	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	61	64	56	42	28	17	5	4	N/A	N/A	N/A	N/A

Table A 4.12: Microcosm 4 Vegetation Areas during the Acclimatisation and Establishment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	5	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	5	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	41	26	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	15	8	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	56	34	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26	26	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	7	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	33	33	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	24	24	11
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	25	25	11
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	9	24
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	2	3
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	11	27
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4	10	65
2008	*Phragmites australis*	Inside Microcosm	0	0	0	1	3	6	7	7	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	0	0	0	1	3	6	7	7	N/A	N/A	N/A	N/A
	Lythrum salicaria	Inside Microcosm	0	0	1	5	20	29	34	34	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	4	8	9	9	N/A	N/A	N/A	N/A
		Combined	0	0	1	5	24	37	43	43	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	3	28	21	25	24	22	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	1	4	7	7	7	N/A	N/A	N/A	N/A
		Combined	0	0	3	29	25	32	31	29	N/A	N/A	N/A	N/A
	Mentha aquatica	Inside Microcosm	9	7	8	12	14	18	19	20	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	2	3	4	N/A	N/A	N/A	N/A
		Combined	9	7	8	12	14	20	22	24	N/A	N/A	N/A	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	22	21	21	21	13	6	5	6	N/A	N/A	N/A	N/A
		Outside Microcosm	2	2	2	2	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	24	23	23	23	13	6	5	6	N/A	N/A	N/A	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	69	72	67	33	29	16	11	11	N/A	N/A	N/A	N/A

Table A 4.13: Microcosm 5 Vegetation Areas during the Acclimatisation and Establishment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6	6	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6	6	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	41	2	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	54	2	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	27	26	4
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12	8	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	39	34	4
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	21	20	13
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	1	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	24	21	13
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	19	26
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	4	4
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	23	30
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	27	57
2008	*Phragmites australis*	Inside Microcosm	0	0	1	1	4	5	6	6	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	0	0	1	1	4	5	6	6	N/A	N/A	N/A	N/A
	Lythrum salicaria	Inside Microcosm	0	0	2	5	14	19	32	32	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	5	7	9	9	N/A	N/A	N/A	N/A
		Combined	0	0	2	5	19	26	41	41	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	3	26	25	29	29	28	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	1	9	10	10	10	N/A	N/A	N/A	N/A
		Combined	0	0	3	27	34	39	39	38	N/A	N/A	N/A	N/A
	Mentha aquatica	Inside Microcosm	12	11	11	11	15	18	18	19	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	1	1	2	3	N/A	N/A	N/A	N/A
		Combined	12	11	11	11	16	19	20	22	N/A	N/A	N/A	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	25	24	24	24	14	6	4	4	N/A	N/A	N/A	N/A
		Outside Microcosm	2	1	1	1	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	27	25	25	25	14	6	4	4	N/A	N/A	N/A	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	63	65	59	33	28	23	11	11	N/A	N/A	N/A	N/A

Table A 4.14: Microcosm 6 Vegetation Areas during the Acclimatisation and Establishment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	5	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	5	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	51	22	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	63	22	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	21	21	5
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	32	21	5
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	19	22	21
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	1	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	21	23	21
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	15	22
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	3	3
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	18	25
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4	15	52
2008	*Phragmites australis*	Inside Microcosm	0	0	1	1	6	9	9	9	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	0	0	1	1	6	9	9	9	N/A	N/A	N/A	N/A
	Lythrum salicaria	Inside Microcosm	0	0	2	8	17	28	39	39	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	7	10	14	14	N/A	N/A	N/A	N/A
		Combined	0	0	2	8	24	38	53	53	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	3	21	26	24	23	22	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	1	12	14	15	15	N/A	N/A	N/A	N/A
		Combined	0	0	3	22	38	38	38	37	N/A	N/A	N/A	N/A
	Mentha aquatica	Inside Microcosm	18	17	18	19	20	21	21	20	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	2	2	2	3	N/A	N/A	N/A	N/A
		Combined	18	17	18	19	22	23	23	23	N/A	N/A	N/A	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	19	17	17	17	9	4	3	5	N/A	N/A	N/A	N/A
		Outside Microcosm	2	1	1	1	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	21	18	18	18	9	4	3	5	N/A	N/A	N/A	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	63	66	59	34	22	14	5	5	N/A	N/A	N/A	N/A

Table A 4.15: Microcosm 7 Vegetation Areas during the Acclimatisation and Establishment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6	6	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	32	6	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	46	6	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	3	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	53	9	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	27	27	5
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	7	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	34	34	5
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	19	19	11
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	3	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	19	22	11
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	19	22
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	8	4
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	27	26
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	23	62
2008	*Phragmites australis*	Inside Microcosm	0	0	1	1	5	7	7	7	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	0	0	1	1	5	7	7	7	N/A	N/A	N/A	N/A
	Lythrum salicaria	Inside Microcosm	0	0	2	5	18	28	36	36	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	11	12	14	15	N/A	N/A	N/A	N/A
		Combined	0	0	2	5	29	40	50	51	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	3	16	25	26	26	25	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	6	7	7	6	N/A	N/A	N/A	N/A
		Combined	0	0	3	16	31	33	33	31	N/A	N/A	N/A	N/A
	Mentha aquatica	Inside Microcosm	9	9	11	12	16	19	20	20	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	2	2	3	3	N/A	N/A	N/A	N/A
		Combined	9	9	11	12	18	21	23	23	N/A	N/A	N/A	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	19	18	18	18	8	4	3	4	N/A	N/A	N/A	N/A
		Outside Microcosm	3	1	1	1	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	22	19	19	19	8	4	3	4	N/A	N/A	N/A	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	72	73	65	48	28	16	8	8	N/A	N/A	N/A	N/A

Table A 4.16: Microcosm 8 Vegetation Areas during the Acclimatisation and Establishment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	661	532	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	470	484	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	718	798	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	610	615	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	519	464	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	424	409	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	304	582	80
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	168	227	33
2008	*Phragmites australis*	Maximum Height	0	0	0	202	849	1342	1512	1601	N/A	N/A	N/A	N/A
		General Height	0	0	0	186	583	1163	1289	1368	N/A	N/A	N/A	N/A
	Lythrum salicaria	Maximum Height	0	0	109	156	627	1408	1613	1752	N/A	N/A	N/A	N/A
		General Height	0	0	51	92	511	1288	1438	1584	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Maximum Height	0	0	69	199	671	1395	1534	1626	N/A	N/A	N/A	N/A
		General Height	0	0	60	194	627	1248	1431	1551	N/A	N/A	N/A	N/A
	Mentha aquatica	Maximum Height	72	67	67	100	256	395	531	652	N/A	N/A	N/A	N/A
		General Height	37	38	36	58	169	316	309	298	N/A	N/A	N/A	N/A

Table A 4.17: Microcosm 9 Vegetation Heights during the Acclimatisation and Establishment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	809	491	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	624	453	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	950	860	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	593	706	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	459	398	201
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	411	285	175
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	485	555	77
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	194	234	41
2008	*Phragmites australis*	Maximum Height	0	0	0	225	839	1331	1518	1677	N/A	N/A	N/A	N/A
		General Height	0	0	0	197	578	1138	1410	1578	N/A	N/A	N/A	N/A
	Lythrum salicaria	Maximum Height	0	0	76	158	596	1408	1722	1878	N/A	N/A	N/A	N/A
		General Height	0	0	52	135	497	1193	1517	1630	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Maximum Height	0	0	81	261	584	1368	1535	1684	N/A	N/A	N/A	N/A
		General Height	0	0	61	112	521	1055	1262	1398	N/A	N/A	N/A	N/A
	Mentha aquatica	Maximum Height	72	67	66	98	276	415	538	729	N/A	N/A	N/A	N/A
		General Height	39	38	34	67	164	288	375	372	N/A	N/A	N/A	N/A

Table A 4.18: Microcosm 10 Vegetation Heights during the Acclimatisation and Establishment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	811	559	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	593	479	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	813	810	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	641	604	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	626	611	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	392	362	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	349	357	72
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	237	198	36
2008	*Phragmites australis*	Maximum Height	0	0	0	212	822	1347	1700	1828	N/A	N/A	N/A	N/A
		General Height	0	0	0	179	569	1162	1428	1607	N/A	N/A	N/A	N/A
	Lythrum salicaria	Maximum Height	0	0	72	178	685	1381	1614	1859	N/A	N/A	N/A	N/A
		General Height	0	0	60	111	563	1249	1538	1647	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Maximum Height	0	0	91	283	707	1376	1436	1500	N/A	N/A	N/A	N/A
		General Height	0	0	68	173	632	1237	1322	1361	N/A	N/A	N/A	N/A
	Mentha aquatica	Maximum Height	69	68	62	95	231	458	613	702	N/A	N/A	N/A	N/A
		General Height	35	33	33	55	181	307	385	381	N/A	N/A	N/A	N/A

Table A 4.19: Microcosm 11 Vegetation Heights during the Acclimatisation and Establishment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	820	796	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	643	581	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	785	789	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	671	594	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	487	499	248
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	430	431	206
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	360	196	64
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	244	133	36
2008	*Phragmites australis*	Maximum Height	0	0	0	231	851	1334	1530	1664	N/A	N/A	N/A	N/A
		General Height	0	0	0	204	590	1139	1377	1455	N/A	N/A	N/A	N/A
	Lythrum salicaria	Maximum Height	0	0	110	173	643	1534	1762	2043	N/A	N/A	N/A	N/A
		General Height	0	0	57	130	519	1220	1699	1869	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Maximum Height	0	0	122	290	757	1438	1532	1693	N/A	N/A	N/A	N/A
		General Height	0	0	97	193	632	1188	1399	1606	N/A	N/A	N/A	N/A
	Mentha aquatica	Maximum Height	66	60	55	94	246	432	505	613	N/A	N/A	N/A	N/A
		General Height	39	36	15	63	170	325	381	431	N/A	N/A	N/A	N/A

Table A 4.20: Microcosm 12 Vegetation Heights during the Acclimatisation and Establishment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	783	748	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	616	598	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	806	901	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	533	783	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	447	319	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	410	265	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	599	257	83
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	269	166	39
2008	*Phragmites australis*	Maximum Height	0	0	0	183	809	1340	1480	1552	N/A	N/A	N/A	N/A
		General Height	0	0	0	171	565	1142	1261	1339	N/A	N/A	N/A	N/A
	Lythrum salicaria	Maximum Height	0	0	94	169	670	1408	1582	1641	N/A	N/A	N/A	N/A
		General Height	0	0	55	94	575	1170	1409	1520	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Maximum Height	0	0	0	193	755	1352	1537	1668	N/A	N/A	N/A	N/A
		General Height	0	0	0	122	685	1136	1291	1430	N/A	N/A	N/A	N/A
	Mentha aquatica	Maximum Height	88	78	62	90	255	442	551	717	N/A	N/A	N/A	N/A
		General Height	40	39	33	57	159	293	337	364	N/A	N/A	N/A	N/A

Table A 4.21: Microcosm 13 Vegetation Heights during the Acclimatisation and Establishment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	803	660	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	639	582	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	766	921	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	584	681	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	504	487	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	401	432	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	571	518	116
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	314	275	59
2008	*Phragmites australis*	Maximum Height	0	0	0	210	837	1353	1462	1534	N/A	N/A	N/A	N/A
		General Height	0	0	0	176	593	1157	1298	1371	N/A	N/A	N/A	N/A
	Lythrum salicaria	Maximum Height	0	0	67	159	667	1306	1582	1674	N/A	N/A	N/A	N/A
		General Height	0	0	47	138	544	1253	1493	1575	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Maximum Height	0	0	146	239	680	1457	1558	1596	N/A	N/A	N/A	N/A
		General Height	0	0	86	185	643	1177	1273	1410	N/A	N/A	N/A	N/A
	Mentha aquatica	Maximum Height	112	87	78	89	247	388	608	717	N/A	N/A	N/A	N/A
		General Height	60	54	46	59	152	288	310	389	N/A	N/A	N/A	N/A

Table A 4.22: Microcosm 14 Vegetation Heights during the Acclimatisation and Establishment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	822	726	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	685	640	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	810	820	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	607	611	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	494	451	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	427	376	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	683	338	82
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	319	254	55
2008	*Phragmites australis*	Maximum Height	0	0	30	199	828	1339	1478	1543	N/A	N/A	N/A	N/A
		General Height	0	0	30	169	562	1149	1291	1352	N/A	N/A	N/A	N/A
	Lythrum salicaria	Maximum Height	0	0	83	154	647	1408	1673	1817	N/A	N/A	N/A	N/A
		General Height	0	0	56	117	610	1227	1505	1601	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Maximum Height	0	0	74	279	734	1493	1543	1690	N/A	N/A	N/A	N/A
		General Height	0	0	58	188	670	1054	1255	1397	N/A	N/A	N/A	N/A
	Mentha aquatica	Maximum Height	73	63	61	97	253	421	676	793	N/A	N/A	N/A	N/A
		General Height	44	41	35	57	162	346	361	413	N/A	N/A	N/A	N/A

Table A 4.23: Microcosm 15 Vegetation Heights during the Acclimatisation and Establishment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	799	619	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	592	511	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	919	599	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	616	486	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	510	388	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	424	290	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	565	231	79
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	220	129	42
2008	*Phragmites australis*	Maximum Height	0	0	0	170	840	1329	1492	1544	N/A	N/A	N/A	N/A
		General Height	0	0	0	161	573	1132	1331	1445	N/A	N/A	N/A	N/A
	Lythrum salicaria	Maximum Height	0	0	111	178	643	1408	1638	1694	N/A	N/A	N/A	N/A
		General Height	0	0	47	136	543	1265	1490	1543	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Maximum Height	0	0	125	283	739	1449	1618	1676	N/A	N/A	N/A	N/A
		General Height	0	0	84	104	667	1183	1268	1448	N/A	N/A	N/A	N/A
	Mentha aquatica	Maximum Height	72	67	61	84	212	401	674	896	N/A	N/A	N/A	N/A
		General Height	54	42	40	56	168	324	350	442	N/A	N/A	N/A	N/A

Table A 4.24: Microcosm 16 Vegetation Heights during the Acclimatisation and Establishment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26	17	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	14	4	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	40	21	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26	24	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	6	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	33	30	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	25	8	6
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	1	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	28	9	6
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	6	13
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	2	1
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	8	14
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	14	36	81
2008	*Phragmites australis*	Inside Microcosm	0	0	0	1	4	6	7	7	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	0	0	0	1	4	6	7	7	N/A	N/A	N/A	N/A
	Lythrum salicaria	Inside Microcosm	0	0	1	2	7	31	47	47	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	3	8	11	13	N/A	N/A	N/A	N/A
		Combined	0	0	1	2	10	39	58	60	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	1	2	8	14	14	13	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	2	6	6	6	N/A	N/A	N/A	N/A
		Combined	0	0	1	2	10	20	20	19	N/A	N/A	N/A	N/A
	Mentha aquatica	Inside Microcosm	4	3	3	3	5	9	11	11	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	0	2	2	N/A	N/A	N/A	N/A
		Combined	4	3	3	3	5	9	13	13	N/A	N/A	N/A	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	10	8	8	8	5	4	4	5	N/A	N/A	N/A	N/A
		Outside Microcosm	1	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	11	8	8	8	5	4	4	5	N/A	N/A	N/A	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	86	89	87	84	71	36	17	17	N/A	N/A	N/A	N/A

Table A 4.25: Microcosm 9 Vegetation Areas during the Acclimatisation and Establishment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8	8	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8	8	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	27	6	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11	2	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	38	8	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	27	27	3
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	7	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	36	34	3
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	25	21	10
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	1	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	27	22	10
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	15	10
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	5	2
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	20	12
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13	23	77
2008	*Phragmites australis*	Inside Microcosm	0	0	0	1	3	6	6	9	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	0	0	0	1	3	6	6	9	N/A	N/A	N/A	N/A
	Lythrum salicaria	Inside Microcosm	0	0	1	10	22	28	32	32	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	12	13	14	14	N/A	N/A	N/A	N/A
		Combined	0	0	1	10	34	41	46	46	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	2	10	18	22	22	22	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	2	6	6	6	N/A	N/A	N/A	N/A
		Combined	0	0	2	10	20	28	28	28	N/A	N/A	N/A	N/A
	Mentha aquatica	Inside Microcosm	6	5	6	6	8	9	11	11	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	1	2	2	N/A	N/A	N/A	N/A
		Combined	6	5	6	6	8	10	13	13	N/A	N/A	N/A	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	8	7	7	7	2	2	2	2	N/A	N/A	N/A	N/A
		Outside Microcosm	1	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	9	7	7	7	2	2	2	2	N/A	N/A	N/A	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	86	88	84	66	47	33	27	24	N/A	N/A	N/A	N/A

Table A 4.26: Microcosm 10 Vegetation Areas during the Acclimatisation and Establishment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8	8	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8	8	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	29	8	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	14	2	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	43	10	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	25	21	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12	7	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	37	28	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26	14	8
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4	1	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	30	15	8
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	16	14
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	5	1
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	21	15
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12	33	78
2008	*Phragmites australis*	Inside Microcosm	0	0	0	1	6	9	9	9	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	0	0	0	1	6	9	9	9	N/A	N/A	N/A	N/A
	Lythrum salicaria	Inside Microcosm	0	0	1	10	25	27	32	32	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	4	9	13	13	N/A	N/A	N/A	N/A
		Combined	0	0	1	10	29	36	45	45	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	3	8	16	24	23	22	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	1	2	6	5	4	N/A	N/A	N/A	N/A
		Combined	0	0	3	9	18	30	28	26	N/A	N/A	N/A	N/A
	Mentha aquatica	Inside Microcosm	3	2	2	4	6	7	9	10	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	1	2	2	N/A	N/A	N/A	N/A
		Combined	3	2	2	4	6	8	11	12	N/A	N/A	N/A	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	10	8	8	8	2	2	3	3	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	10	8	8	8	2	2	3	3	N/A	N/A	N/A	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	87	90	86	69	45	31	24	24	N/A	N/A	N/A	N/A

Table A 4.27: Microcosm 11 Vegetation Areas during the Acclimatisation and Establishment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	27	12	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11	6	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	38	18	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	29	29	4
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12	10	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	41	39	4
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	22	13	6
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	22	13	6
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	10	13
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	2	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	12	13
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13	27	77
2008	*Phragmites australis*	Inside Microcosm	0	0	0	1	5	9	9	9	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	0	0	0	1	5	9	9	9	N/A	N/A	N/A	N/A
	Lythrum salicaria	Inside Microcosm	0	0	1	10	28	32	34	34	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	19	20	23	24	N/A	N/A	N/A	N/A
		Combined	0	0	1	10	47	52	57	58	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	2	12	25	25	25	24	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	5	6	6	6	N/A	N/A	N/A	N/A
		Combined	0	0	2	12	30	31	31	30	N/A	N/A	N/A	N/A
	Mentha aquatica	Inside Microcosm	5	2	2	4	9	10	14	14	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	1	2	2	N/A	N/A	N/A	N/A
		Combined	5	2	2	4	9	11	16	16	N/A	N/A	N/A	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	12	8	8	8	3	2	2	3	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	1	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	12	8	8	9	3	2	2	3	N/A	N/A	N/A	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	83	90	87	65	30	22	16	16	N/A	N/A	N/A	N/A

Table A 4.28: Microcosm 12 Vegetation Areas during the Acclimatisation and Establishment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8	8	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8	8	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	29	10	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4	4	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	33	14	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	29	27	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6	6	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	35	33	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	24	18	11
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	25	19	11
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	13	15
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	3
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	13	18
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10	24	74
2008	*Phragmites australis*	Inside Microcosm	0	0	0	1	5	11	12	12	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	0	0	0	1	5	11	12	12	N/A	N/A	N/A	N/A
	Lythrum salicaria	Inside Microcosm	0	0	1	8	30	31	36	35	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	6	8	11	11	N/A	N/A	N/A	N/A
		Combined	0	0	1	8	36	39	47	46	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	0	1	12	14	14	14	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	2	4	4	4	N/A	N/A	N/A	N/A
		Combined	0	0	0	1	14	18	18	18	N/A	N/A	N/A	N/A
	Mentha aquatica	Inside Microcosm	7	5	7	12	14	16	17	18	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	1	1	3	3	N/A	N/A	N/A	N/A
		Combined	7	5	7	12	15	17	20	21	N/A	N/A	N/A	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	8	4	4	4	1	1	1	1	N/A	N/A	N/A	N/A
		Outside Microcosm	3	1	1	1	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	11	5	5	5	1	1	1	1	N/A	N/A	N/A	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	85	91	88	74	38	27	20	20	N/A	N/A	N/A	N/A

Table A 4.29: Microcosm 13 Vegetation Areas during the Acclimatisation and Establishment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	7	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	7	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	28	9	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	6	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	35	15	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	28	24	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	7	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	35	31	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	25	21	18
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	2	2
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	27	23	20
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	14	17
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	2
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	14	19
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12	25	65
2008	*Phragmites australis*	Inside Microcosm	0	0	0	1	4	7	8	8	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	0	0	0	1	4	7	8	8	N/A	N/A	N/A	N/A
	Lythrum salicaria	Inside Microcosm	0	0	2	11	25	31	36	36	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	6	12	15	15	N/A	N/A	N/A	N/A
		Combined	0	0	2	11	31	43	51	51	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	2	11	28	27	26	25	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	4	7	7	7	N/A	N/A	N/A	N/A
		Combined	0	0	2	11	32	34	33	32	N/A	N/A	N/A	N/A
	Mentha aquatica	Inside Microcosm	16	15	18	24	26	25	25	25	N/A	N/A	N/A	N/A
		Outside Microcosm	1	1	1	0	2	4	5	5	N/A	N/A	N/A	N/A
		Combined	17	16	19	24	28	29	30	30	N/A	N/A	N/A	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	9	7	7	7	2	2	2	3	N/A	N/A	N/A	N/A
		Outside Microcosm	1	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	10	7	7	7	2	2	2	3	N/A	N/A	N/A	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	75	78	71	46	15	8	3	3	N/A	N/A	N/A	N/A

Table A 4.30: Microcosm 14 Vegetation Areas during the Acclimatisation and Establishment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	28	19	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	3	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	31	22	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26	26	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6	6	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	32	32	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	25	25	19
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	3	1
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	25	28	20
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	4	12
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	3
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	4	15
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12	17	69
2008	*Phragmites australis*	Inside Microcosm	0	0	1	1	7	8	11	11	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	0	0	1	1	7	8	11	11	N/A	N/A	N/A	N/A
	Lythrum salicaria	Inside Microcosm	0	0	2	8	24	27	33	33	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	4	8	12	12	N/A	N/A	N/A	N/A
		Combined	0	0	2	8	28	35	45	45	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	1	7	15	21	21	21	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	2	4	3	3	N/A	N/A	N/A	N/A
		Combined	0	0	1	7	17	25	24	24	N/A	N/A	N/A	N/A
	Mentha aquatica	Inside Microcosm	13	12	12	14	21	22	24	24	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	2	2	3	N/A	N/A	N/A	N/A
		Combined	13	12	12	14	21	24	26	27	N/A	N/A	N/A	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	9	8	8	8	1	1	1	1	N/A	N/A	N/A	N/A
		Outside Microcosm	2	1	1	1	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	11	9	9	9	1	1	1	1	N/A	N/A	N/A	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	78	80	76	62	32	21	10	10	N/A	N/A	N/A	N/A

Table A 4.31: Microcosm 15 Vegetation Areas during the Acclimatisation and Establishment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2007	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	7	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	7	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	32	14	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	19	8	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	51	22	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	29	22	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	3	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	32	25	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	25	19	15
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	2	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26	21	15
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	11	14
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	2	3
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	13	17
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	27	71
2008	*Phragmites australis*	Inside Microcosm	0	0	0	2	3	6	7	7	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	0	0	0	2	3	6	7	7	N/A	N/A	N/A	N/A
	Lythrum salicaria	Inside Microcosm	0	0	2	8	28	34	37	36	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	22	26	27	27	N/A	N/A	N/A	N/A
		Combined	0	0	2	8	50	60	64	63	N/A	N/A	N/A	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	2	10	18	17	17	16	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	3	5	5	5	N/A	N/A	N/A	N/A
		Combined	0	0	2	10	21	22	22	21	N/A	N/A	N/A	N/A
	Mentha aquatica	Inside Microcosm	13	13	13	18	24	21	22	22	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	1	1	3	N/A	N/A	N/A	N/A
		Combined	13	13	13	18	24	22	23	25	N/A	N/A	N/A	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	8	7	7	7	2	2	2	4	N/A	N/A	N/A	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	N/A	N/A	N/A	N/A
		Combined	8	7	7	7	2	2	2	4	N/A	N/A	N/A	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	79	80	76	55	25	20	15	15	N/A	N/A	N/A	N/A

Table A 4.32: Microcosm 16 Vegetation Areas during the Acclimatisation and Establishment Period.

Appendix 5 Water Input during the Nutrient Treatment Period for the Full Competition Microcosms

Year	Microcosm Number		Total Water Added per Month (Litres)											
			January	February	March	April	May	June	July	August	September	October	November	December
2008	1	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	181.13	104.48	75.24	35.54	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	233.42	158.44	108.90	79.43	28.27
	2	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	171.69	94.78	78.80	31.24	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	223.99	148.74	112.45	75.13	28.27
	3	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	178.89	93.71	79.16	30.16	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	231.18	147.67	112.82	74.05	28.27
	4	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	182.46	103.94	70.47	28.54	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	234.75	157.90	104.13	72.43	28.27
2009	1	Artificial Water Added	0.00	0.00	0.00	87.68	160.85	191.72	213.25	201.41	107.71	90.90	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	107.61	186.59	217.78	269.20	225.59	115.57	117.67	52.83	30.10
	2	Artificial Water Added	0.00	0.00	0.00	84.15	164.52	209.41	231.82	209.87	120.63	90.69	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	104.08	190.27	235.47	287.78	234.05	128.49	117.45	52.83	30.10
	3	Artificial Water Added	0.00	0.00	0.00	67.24	181.04	210.40	235.96	216.71	100.71	65.39	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	87.16	206.78	236.47	291.92	240.89	108.57	92.16	52.83	30.10
	4	Artificial Water Added	0.00	0.00	0.00	72.61	193.27	242.64	265.48	239.31	112.55	74.23	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	92.54	219.01	268.71	321.43	263.49	120.42	101.00	52.83	30.10
2010	1	Artificial Water Added	0.00	0.00	0.00	80.93	162.65	192.26	207.41	194.41	110.94	64.90	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	102.26	175.90	218.75	228.84	247.30	141.85	92.42	N/A	N/A
	2	Artificial Water Added	0.00	0.00	0.00	79.20	170.30	192.26	215.33	200.34	118.48	69.39	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	100.53	183.55	218.75	236.76	253.22	149.39	96.91	N/A	N/A
	3	Artificial Water Added	0.00	0.00	0.00	64.62	144.25	197.64	219.78	206.03	103.40	47.93	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	85.95	157.50	224.14	241.22	258.91	134.31	75.45	N/A	N/A
	4	Artificial Water Added	0.00	0.00	0.00	74.31	159.78	215.71	238.19	218.78	103.94	47.93	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	95.64	173.02	242.21	259.63	271.67	134.85	75.45	N/A	N/A

Table A 5.1: Microcosms 1-4 Water Input during the Nutrient Treatment Period.

Appendix 6 Vegetation Heights and Area Coverage during the Nutrient Treatment Period for the Full Competition Microcosms

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1644	1619	1575	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1397	1426	1428	0	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1948	1919	1732	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1748	1678	1433	0	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1535	1474	1367	401	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1329	1458	1354	296	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	613	618	633	624	76
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	328	341	299	227	50
2009	*Phragmites australis*	Maximum Height	0	0	0	149	687	1465	1606	1693	1731	1647	0	0
		General Height	0	0	0	81	560	1214	1436	1489	1492	1459	0	0
	Lythrum salicaria	Maximum Height	0	0	0	43	563	1538	1567	1621	1673	1624	0	0
		General Height	0	0	0	36	518	1287	1484	1542	1530	1355	0	0
	Filipendula ulmaria	Maximum Height	0	0	0	224	497	1018	1431	1462	1344	708	0	0
		General Height	0	0	0	122	394	688	916	950	935	681	0	0
	Mentha aquatica	Maximum Height	66	62	57	146	136	386	776	888	968	771	706	99
		General Height	43	43	42	58	74	137	237	514	606	618	588	77
2010	*Phragmites australis*	Maximum Height	0	0	0	170	772	1012	1488	1597	1641	1567	0	N/A
		General Height	0	0	0	96	473	814	1196	1268	1310	1313	0	N/A
	Lythrum salicaria	Maximum Height	0	0	0	49	512	927	1164	1468	1472	1460	0	N/A
		General Height	0	0	0	44	286	766	989	1130	1130	1061	0	N/A
	Filipendula ulmaria	Maximum Height	0	0	88	176	507	709	1113	1351	762	801	794	N/A
		General Height	0	0	49	149	469	537	747	766	725	720	719	N/A
	Mentha aquatica	Maximum Height	98	92	91	89	94	142	562	700	609	588	173	N/A
		General Height	69	62	50	48	62	106	229	312	305	273	112	N/A

Table A 6.1: Microcosm 1 Vegetation Heights during the Nutrient Treatment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1587	1572	1496	1479	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1398	1463	1447	1311	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1983	2082	1634	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1639	1699	1355	0	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1633	1751	1739	322	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1482	1552	1522	208	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	643	844	881	409	81
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	381	378	417	111	50
2009	*Phragmites australis*	Maximum Height	0	0	0	182	789	1709	1832	1861	1877	1801	0	0
		General Height	0	0	0	116	603	1316	1554	1615	1620	1575	0	0
	Lythrum salicaria	Maximum Height	0	0	0	47	733	1547	1753	1791	1789	1780	0	0
		General Height	0	0	0	35	648	1372	1604	1629	1608	1601	0	0
	Filipendula ulmaria	Maximum Height	0	0	0	210	472	1510	1638	1692	1675	869	0	0
		General Height	0	0	0	109	383	1118	1266	1328	1284	680	0	0
	Mentha aquatica	Maximum Height	71	66	56	137	142	246	420	628	665	583	570	105
		General Height	43	41	37	48	68	172	325	431	444	357	168	76
2010	*Phragmites australis*	Maximum Height	0	0	0	153	618	1196	1484	1643	1684	1665	0	N/A
		General Height	0	0	0	115	471	918	1337	1430	1481	1478	0	N/A
	Lythrum salicaria	Maximum Height	0	0	0	50	455	928	1390	1516	1524	1485	0	N/A
		General Height	0	0	0	39	303	773	1178	1303	1297	1103	0	N/A
	Filipendula ulmaria	Maximum Height	0	0	92	175	430	652	1101	725	786	775	777	N/A
		General Height	0	0	55	145	358	524	594	573	556	550	546	N/A
	Mentha aquatica	Maximum Height	100	100	99	84	88	148	199	262	326	343	88	N/A
		General Height	63	61	58	52	55	109	114	156	164	150	65	N/A

Table A 6.2: Microcosm 2 Vegetation Heights during the Nutrient Treatment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1682	1790	1843	1826	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1586	1667	1669	1567	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1829	1926	1356	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1646	1802	1157	0	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1808	1881	1810	884	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1504	1536	1493	618	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	778	804	816	546	92
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	379	381	470	455	48
2009	*Phragmites australis*	Maximum Height	0	0	0	193	953	1749	2027	2095	2118	2113	0	0
		General Height	0	0	0	124	809	1588	1748	1816	1857	1803	0	0
	Lythrum salicaria	Maximum Height	0	0	0	53	721	1184	1744	1793	1798	0	0	0
		General Height	0	0	0	42	687	1103	1602	1665	1639	0	0	0
	Filipendula ulmaria	Maximum Height	0	0	0	186	622	1184	1396	1467	1461	0	0	0
		General Height	0	0	0	141	497	729	957	1008	1000	0	0	0
	Mentha aquatica	Maximum Height	71	71	66	72	144	458	712	784	779	296	192	109
		General Height	47	43	41	61	93	225	305	319	281	178	132	78
2010	*Phragmites australis*	Maximum Height	0	0	0	241	657	1371	1771	1884	1904	1853	0	N/A
		General Height	0	0	0	145	628	1074	1518	1672	1719	1706	0	N/A
	Lythrum salicaria	Maximum Height	0	0	0	53	356	976	1314	1482	1473	0	0	N/A
		General Height	0	0	0	55	268	794	1263	1372	1370	0	0	N/A
	Filipendula ulmaria	Maximum Height	0	0	70	192	475	662	529	588	607	600	518	N/A
		General Height	0	0	52	157	411	534	526	542	495	491	428	N/A
	Mentha aquatica	Maximum Height	103	97	96	91	124	209	219	389	400	392	99	N/A
		General Height	71	61	53	51	82	58	68	62	52	48	40	N/A

Table A 6.3: Microcosm 3 Vegetation Heights during the Nutrient Treatment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1677	1789	1740	1683	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1603	1686	1682	1466	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1804	1882	1831	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1692	1709	1403	0	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1762	1598	1537	1333	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1640	1583	1478	1295	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	826	1051	1022	527	86
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	485	539	561	162	50
2009	*Phragmites australis*	Maximum Height	0	0	0	207	919	1824	2062	2189	2272	2091	0	0
		General Height	0	0	0	155	772	1640	1877	1956	1982	1935	0	0
	Lythrum salicaria	Maximum Height	0	0	0	52	814	1256	1691	1732	1727	0	0	0
		General Height	0	0	0	39	728	1162	1582	1611	1583	0	0	0
	Filipendula ulmaria	Maximum Height	0	0	0	247	679	819	1103	1164	1135	0	0	0
		General Height	0	0	0	198	611	673	684	703	697	0	0	0
	Mentha aquatica	Maximum Height	78	71	65	58	233	497	750	825	732	327	311	104
		General Height	35	30	35	43	157	244	315	304	212	149	129	70
2010	*Phragmites australis*	Maximum Height	0	0	0	111	719	1266	1703	2015	2061	2030	0	N/A
		General Height	0	0	0	64	580	1127	1398	1718	1842	1829	0	N/A
	Lythrum salicaria	Maximum Height	0	0	0	49	402	958	1487	1486	1461	0	0	N/A
		General Height	0	0	0	44	264	863	1192	1307	1302	0	0	N/A
	Filipendula ulmaria	Maximum Height	0	0	98	175	573	697	659	685	737	890	884	N/A
		General Height	0	0	45	165	447	632	647	656	674	670	670	N/A
	Mentha aquatica	Maximum Height	96	92	85	85	119	206	244	459	483	427	249	N/A
		General Height	66	64	64	63	78	54	63	69	52	45	43	N/A

Table A 6.4: Microcosm 4 Vegetation Heights during the Nutrient Treatment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	9	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	9	0	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	37	37	35	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	18	16	15	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	55	53	50	0	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	22	20	20	19	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8	6	6	4	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	30	26	26	23	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	18	16	16	14	11
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	2	2	2	1
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	20	18	18	16	12
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	7	8	41	44
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	4	5
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	7	8	45	49
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	11	12	26	45
2009	*Phragmites australis*	Inside Microcosm	0	0	0	1	5	8	10	10	10	8	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	1	5	8	10	10	10	8	0	0
	Lythrum salicaria	Inside Microcosm	0	0	0	1	11	19	23	24	22	12	0	0
		Outside Microcosm	0	0	0	0	1	4	7	7	6	2	0	0
		Combined	0	0	0	1	12	23	30	31	28	14	0	0
	Filipendula ulmaria	Inside Microcosm	0	0	0	6	26	27	28	28	27	25	0	0
		Outside Microcosm	0	0	0	0	3	5	6	6	5	3	0	0
		Combined	0	0	0	6	29	32	34	34	32	28	0	0
	Mentha aquatica	Inside Microcosm	6	2	2	6	7	14	17	19	15	11	10	8
		Outside Microcosm	0	0	0	0	0	0	1	1	1	1	1	1
		Combined	6	2	2	6	7	14	18	20	16	12	11	9
	Standing Dead or Dormant Vegetation	Inside Microcosm	39	38	38	38	19	8	8	8	8	11	24	17
		Outside Microcosm	3	3	3	2	1	1	0	0	0	3	4	3
		Combined	42	41	41	40	20	9	8	8	8	14	28	20
	Bare Ground or Leaf Litter	Inside Microcosm	55	60	60	48	32	24	14	11	18	33	66	75
2010	*Phragmites australis*	Inside Microcosm	0	0	0	1	5	12	19	19	19	8	0	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	0	0	0	1	5	12	19	19	19	8	0	N/A
	Lythrum salicaria	Inside Microcosm	0	0	0	1	6	16	18	18	16	3	0	N/A
		Outside Microcosm	0	0	0	0	0	2	3	3	1	0	0	N/A
		Combined	0	0	0	1	6	18	21	21	17	3	0	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	1	8	24	31	35	35	32	21	12	N/A
		Outside Microcosm	0	0	0	1	2	3	6	6	4	3	1	N/A
		Combined	0	0	1	9	26	34	41	41	36	24	13	N/A
	Mentha aquatica	Inside Microcosm	6	5	5	6	6	8	14	15	12	12	9	N/A
		Outside Microcosm	0	0	0	0	0	0	3	2	1	1	1	N/A
		Combined	6	5	5	6	6	8	17	17	13	13	10	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	14	12	12	12	12	9	9	9	13	32	48	N/A
		Outside Microcosm	2	1	1	1	1	0	0	0	0	1	2	N/A
		Combined	16	13	13	13	13	9	9	9	13	33	50	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	80	83	82	72	47	24	5	4	8	24	31	N/A

Table A 6.5: Microcosm 1 Vegetation Areas during the Nutrient Treatment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	7	7	3	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	7	7	3	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	42	41	35	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12	11	8	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	54	52	43	0	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	16	13	13	10	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	4	3	1	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	21	17	16	11	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	16	15	15	15	9
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	3	2	1	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	19	18	17	16	9
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	8	12	51	55
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	2	4	4
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	8	14	55	59
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12	16	18	21	36
2009	*Phragmites australis*	Inside Microcosm	0	0	0	1	6	19	20	20	20	18	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	1	6	19	20	20	20	18	0	0
	Lythrum salicaria	Inside Microcosm	0	0	0	2	13	27	27	27	24	14	0	0
		Outside Microcosm	0	0	0	0	1	6	7	7	6	2	0	0
		Combined	0	0	0	2	14	33	34	34	30	16	0	0
	Filipendula ulmaria	Inside Microcosm	0	0	0	8	32	33	33	32	28	15	0	0
		Outside Microcosm	0	0	0	0	5	7	7	7	7	1	0	0
		Combined	0	0	0	8	37	40	40	39	35	16	0	0
	Mentha aquatica	Inside Microcosm	5	3	3	5	7	5	5	6	6	5	6	4
		Outside Microcosm	0	0	0	0	0	0	0	1	1	0	0	0
		Combined	5	3	3	5	7	5	5	7	7	5	6	4
	Standing Dead or Dormant Vegetation	Inside Microcosm	41	38	37	37	16	14	14	14	15	33	53	42
		Outside Microcosm	3	2	2	2	0	0	0	0	0	3	4	3
		Combined	44	40	39	39	16	14	14	14	15	36	57	45
	Bare Ground or Leaf Litter	Inside Microcosm	54	59	60	47	26	2	1	1	7	15	41	54
2010	*Phragmites australis*	Inside Microcosm	0	0	0	3	8	10	24	24	24	10	0	N/A
		Outside Microcosm	0	0	0	0	0	0	3	3	3	1	0	N/A
		Combined	0	0	0	3	8	10	27	27	27	11	0	N/A
	Lythrum salicaria	Inside Microcosm	0	0	0	1	6	9	16	16	15	5	0	N/A
		Outside Microcosm	0	0	0	0	0	1	5	5	2	0	0	N/A
		Combined	0	0	0	1	6	10	21	21	17	5	0	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	1	9	27	27	28	28	24	22	17	N/A
		Outside Microcosm	0	0	0	0	1	2	3	3	1	1	1	N/A
		Combined	0	0	1	9	28	29	31	31	25	23	18	N/A
	Mentha aquatica	Inside Microcosm	4	4	4	5	6	7	15	16	13	13	11	N/A
		Outside Microcosm	0	0	0	0	0	0	2	2	1	0	0	N/A
		Combined	4	4	4	5	6	7	17	18	14	13	11	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	36	29	28	24	18	13	13	13	19	37	51	N/A
		Outside Microcosm	1	1	1	1	1	1	0	0	0	3	4	N/A
		Combined	37	30	29	25	19	14	13	13	19	40	55	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	60	67	67	58	35	34	4	3	5	13	21	N/A

Table A 6.6: Microcosm 2 Vegetation Areas during the Nutrient Treatment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	9	7	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	9	7	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	41	40	24	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	14	14	6	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	55	54	30	0	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	16	13	13	13	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	4	4	4	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	21	17	17	17	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	19	18	18	16	9
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	2	2	1	1
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	21	20	20	17	10
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	16	41	50
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	3	5	6
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	19	46	56
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6	11	20	23	41
2009	*Phragmites australis*	Inside Microcosm	0	0	0	1	11	22	23	23	23	17	0	0
		Outside Microcosm	0	0	0	0	0	1	1	1	1	1	0	0
		Combined	0	0	0	1	11	23	24	24	24	18	0	0
	Lythrum salicaria	Inside Microcosm	0	0	0	3	12	26	27	27	13	0	0	0
		Outside Microcosm	0	0	0	0	1	8	9	9	8	0	0	0
		Combined	0	0	0	3	13	34	36	36	21	0	0	0
	Filipendula ulmaria	Inside Microcosm	0	0	0	9	18	23	24	24	9	0	0	0
		Outside Microcosm	0	0	0	0	5	6	6	6	4	0	0	0
		Combined	0	0	0	9	23	29	30	30	13	0	0	0
	Mentha aquatica	Inside Microcosm	6	3	3	8	21	14	14	14	11	5	5	5
		Outside Microcosm	0	0	0	0	0	2	3	2	2	0	0	0
		Combined	6	3	3	8	21	16	17	16	13	5	5	5
	Standing Dead or Dormant Vegetation	Inside Microcosm	48	48	48	46	17	11	11	11	35	68	85	69
		Outside Microcosm	5	5	4	3	0	0	0	0	0	4	5	3
		Combined	53	53	52	49	17	11	11	11	35	72	90	72
	Bare Ground or Leaf Litter	Inside Microcosm	46	49	49	33	21	4	1	1	9	10	10	26
2010	*Phragmites australis*	Inside Microcosm	0	0	0	4	15	24	29	29	29	8	0	N/A
		Outside Microcosm	0	0	0	0	0	3	5	5	4	4	0	N/A
		Combined	0	0	0	4	15	27	34	34	33	12	0	N/A
	Lythrum salicaria	Inside Microcosm	0	0	0	2	9	12	18	18	10	0	0	N/A
		Outside Microcosm	0	0	0	0	0	4	5	5	1	0	0	N/A
		Combined	0	0	0	2	9	16	23	23	11	0	0	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	1	9	23	21	26	26	11	8	6	N/A
		Outside Microcosm	0	0	0	0	1	1	2	2	0	0	0	N/A
		Combined	0	0	1	9	24	22	28	28	11	8	6	N/A
	Mentha aquatica	Inside Microcosm	5	5	6	6	7	10	13	14	10	8	6	N/A
		Outside Microcosm	0	0	0	0	0	0	1	1	1	1	0	N/A
		Combined	5	5	6	6	7	10	14	15	11	9	6	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	43	40	38	35	27	15	11	11	26	52	62	N/A
		Outside Microcosm	2	2	2	2	2	2	0	0	4	4	6	N/A
		Combined	45	42	40	37	29	17	11	11	30	56	68	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	52	55	55	44	19	18	3	2	14	24	26	N/A

Table A 6.7: Microcosm 3 Vegetation Areas during the Nutrient Treatment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8	8	8	7	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8	8	8	7	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	45	42	17	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12	11	5	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	57	53	22	0	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	17	17	17	16	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8	7	7	2	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	25	24	24	18	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	18	18	18	16	7
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	5	5	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	23	23	23	16	7
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8	8	21	41	51
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	3	5	5
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8	8	24	46	56
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4	7	19	20	42
2009	*Phragmites australis*	Inside Microcosm	0	0	0	1	14	25	25	25	25	22	0	0
		Outside Microcosm	0	0	0	0	0	6	6	6	6	5	0	0
		Combined	0	0	0	1	14	31	31	31	31	27	0	0
	Lythrum salicaria	Inside Microcosm	0	0	0	5	15	29	29	29	14	0	0	0
		Outside Microcosm	0	0	0	0	3	8	8	8	3	0	0	0
		Combined	0	0	0	5	18	37	37	37	17	0	0	0
	Filipendula ulmaria	Inside Microcosm	0	0	0	17	24	22	22	22	6	0	0	0
		Outside Microcosm	0	0	0	0	9	6	6	6	2	0	0	0
		Combined	0	0	0	17	33	28	28	28	8	0	0	0
	Mentha aquatica	Inside Microcosm	6	5	5	13	23	18	18	18	8	6	6	6
		Outside Microcosm	0	0	0	0	0	3	3	3	3	0	0	0
		Combined	6	5	5	13	23	21	21	21	11	6	6	6
	Standing Dead or Dormant Vegetation	Inside Microcosm	45	42	41	39	9	5	5	5	41	61	83	62
		Outside Microcosm	5	4	4	3	1	1	1	1	2	3	6	4
		Combined	50	46	45	42	10	6	6	6	43	64	89	66
	Bare Ground or Leaf Litter	Inside Microcosm	49	53	54	25	15	1	1	1	6	11	11	32
2010	*Phragmites australis*	Inside Microcosm	0	0	0	3	18	31	38	38	38	3	0	N/A
		Outside Microcosm	0	0	0	0	1	4	7	7	7	7	0	N/A
		Combined	0	0	0	3	19	35	45	45	45	10	0	N/A
	Lythrum salicaria	Inside Microcosm	0	0	0	1	8	11	14	14	11	0	0	N/A
		Outside Microcosm	0	0	0	0	0	5	7	7	4	0	0	N/A
		Combined	0	0	0	1	8	16	21	21	15	0	0	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	1	13	28	27	24	24	22	18	12	N/A
		Outside Microcosm	0	0	0	1	2	2	2	2	2	2	1	N/A
		Combined	0	0	1	14	30	29	26	26	24	20	13	N/A
	Mentha aquatica	Inside Microcosm	6	6	7	9	11	10	11	11	11	9	8	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	6	6	7	9	11	10	11	11	11	9	8	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	53	49	42	37	32	18	13	13	15	31	39	N/A
		Outside Microcosm	3	3	2	2	2	2	0	0	0	2	9	N/A
		Combined	56	52	44	39	34	20	13	13	15	33	48	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	41	45	50	37	3	3	0	0	3	39	41	N/A

Table A 6.8: Microcosm 4 Vegetation Areas during the Nutrient Treatment Period.

Appendix 7 Water Input during the Salinity Treatment Period for the Full Competition Microcosms

Year	Microcosm Number		Total Water Added per Month (Litres)											
			January	February	March	April	May	June	July	August	September	October	November	December
2008	5	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	172.62	95.32	42.01	35.54	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	224.91	149.28	75.66	79.43	28.27
	6	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	172.85	89.40	45.78	0.00	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	225.14	143.36	79.43	43.89	28.27
	7	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	164.78	77.55	42.01	0.00	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	217.07	131.51	75.66	43.89	28.27
	8	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	152.41	70.01	40.93	0.00	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	204.70	123.97	74.59	43.89	28.27
2009	5	Artificial Water Added	0.00	0.00	0.00	85.47	151.56	192.26	209.02	198.18	106.09	75.78	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	105.40	177.30	218.32	264.97	222.36	113.95	102.54	52.83	30.10
	6	Artificial Water Added	0.00	0.00	0.00	47.93	114.17	149.71	175.56	129.79	77.01	0.00	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	67.86	139.91	175.78	231.52	153.97	84.87	26.77	52.83	30.10
	7	Artificial Water Added	0.00	0.00	0.00	30.70	86.17	122.25	152.94	105.01	68.39	0.00	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	50.62	111.91	148.31	208.90	129.19	76.26	26.77	52.83	30.10
	8	Artificial Water Added	0.00	0.00	0.00	28.00	73.78	103.94	129.25	82.93	38.77	0.00	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	47.93	99.52	130.00	185.20	107.11	46.64	26.77	52.83	30.10
2010	5	Artificial Water Added	0.00	0.00	0.00	76.06	154.78	185.79	202.49	182.02	100.71	57.31	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	97.39	168.02	212.29	223.92	234.91	131.62	84.83	N/A	N/A
	6	Artificial Water Added	0.00	0.00	0.00	50.62	104.48	141.63	167.48	122.25	75.93	0.00	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	71.95	117.72	168.13	188.92	175.13	106.85	27.52	N/A	N/A
	7	Artificial Water Added	0.00	0.00	0.00	29.08	72.70	120.63	143.25	95.86	65.16	0.00	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	50.41	85.95	147.13	164.68	148.74	96.07	27.52	N/A	N/A
	8	Artificial Water Added	0.00	0.00	0.00	29.62	75.39	97.47	127.63	75.93	42.54	0.00	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	50.95	88.64	123.97	149.07	128.82	73.46	27.52	N/A	N/A

Table A 7.1: Microcosms 5-8 Water Input during the Salinity Treatment Period.

Appendix 8 Vegetation Heights and Area Coverage during the Salinity Treatment Period for the Full Competition Microcosms

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1498	1437	1416	1319	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1304	1358	1326	1294	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1877	1859	1613	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1607	1672	1399	0	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1921	1829	1769	449	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1649	1636	1539	368	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	316	363	462	320	97
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	282	319	334	189	56
2009	*Phragmites australis*	Maximum Height	0	0	0	97	491	1461	1692	1773	1820	1793	0	0
		General Height	0	0	0	53	435	1287	1448	1546	1589	1512	0	0
	Lythrum salicaria	Maximum Height	0	0	0	42	518	1254	1577	1631	1620	1620	0	0
		General Height	0	0	0	34	426	1023	1448	1552	1549	1474	0	0
	Filipendula ulmaria	Maximum Height	0	0	52	182	414	879	1386	1430	1402	697	0	0
		General Height	0	0	45	66	357	581	823	901	893	566	0	0
	Mentha aquatica	Maximum Height	86	86	77	58	103	378	528	586	684	660	331	120
		General Height	46	43	43	45	59	170	408	473	482	479	177	70
2010	*Phragmites australis*	Maximum Height	0	0	0	147	329	959	1366	1431	1444	1409	0	N/A
		General Height	0	0	0	94	261	589	1107	1237	1291	1288	0	N/A
	Lythrum salicaria	Maximum Height	0	0	0	52	416	836	1192	1243	1228	1225	0	N/A
		General Height	0	0	0	44	276	755	977	1232	1207	1135	0	N/A
	Filipendula ulmaria	Maximum Height	0	0	90	195	406	648	698	710	729	730	725	N/A
		General Height	0	0	46	143	285	513	554	607	612	604	597	N/A
	Mentha aquatica	Maximum Height	118	116	112	112	151	163	331	449	467	462	426	N/A
		General Height	57	47	34	42	79	103	152	222	247	241	132	N/A

Table A 8.1: Microcosm 5 Vegetation Heights during the Salinity Treatment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1501	1661	1641	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1331	1620	1610	0	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1912	1965	1537	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1638	1689	1133	0	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1870	1648	1328	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1592	1595	1194	0	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	740	706	749	341	89
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	356	397	438	63	47
2009	*Phragmites australis*	Maximum Height	0	0	0	116	687	1291	1652	1732	1790	1787	0	0
		General Height	0	0	0	63	563	1215	1475	1550	1596	1584	0	0
	Lythrum salicaria	Maximum Height	0	0	0	46	465	1209	1596	1653	1730	1722	0	0
		General Height	0	0	0	35	326	1105	1442	1511	1574	1485	0	0
	Filipendula ulmaria	Maximum Height	0	0	0	124	301	619	961	1065	1072	0	0	0
		General Height	0	0	0	57	204	461	818	901	899	0	0	0
	Mentha aquatica	Maximum Height	73	66	57	58	102	310	761	1003	1104	1167	593	105
		General Height	44	43	40	45	67	139	249	365	439	449	441	77
2010	*Phragmites australis*	Maximum Height	0	0	0	96	630	1210	1467	1547	1484	1458	0	N/A
		General Height	0	0	0	48	485	956	1185	1382	1396	1388	0	N/A
	Lythrum salicaria	Maximum Height	0	0	0	127	437	859	1334	1339	1348	1117	0	N/A
		General Height	0	0	0	64	384	761	1142	1251	1267	863	0	N/A
	Filipendula ulmaria	Maximum Height	0	0	84	146	376	411	618	704	693	691	681	N/A
		General Height	0	0	61	122	296	238	471	514	464	427	314	N/A
	Mentha aquatica	Maximum Height	0	0	0	0	38	69	138	0	0	0	0	N/A
		General Height	0	0	0	0	38	46	102	0	0	0	0	N/A

Table A 8.2: Microcosm 6 Vegetation Heights during the Salinity Treatment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1506	1582	1513	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1299	1455	1438	0	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1735	1845	1469	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1612	1722	1380	0	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1983	1996	940	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1661	1671	796	0	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	705	614	309	68	65
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	390	303	124	68	65
2009	*Phragmites australis*	Maximum Height	0	0	0	139	653	1437	1621	1676	1705	1709	0	0
		General Height	0	0	0	85	523	1252	1433	1489	1512	1498	0	0
	Lythrum salicaria	Maximum Height	0	0	0	61	219	901	1302	1476	1491	1420	0	0
		General Height	0	0	0	35	121	652	1224	1371	1388	1267	0	0
	Filipendula ulmaria	Maximum Height	0	0	0	0	109	569	0	0	0	0	0	0
		General Height	0	0	0	0	58	299	0	0	0	0	0	0
	Mentha aquatica	Maximum Height	65	65	82	86	93	0	0	0	0	0	0	0
		General Height	65	65	76	736	81	0	0	0	0	0	0	0
2010	*Phragmites australis*	Maximum Height	0	0	0	103	819	1334	1714	1776	1774	1600	0	N/A
		General Height	0	0	0	64	763	1109	1397	1496	1491	1488	0	N/A
	Lythrum salicaria	Maximum Height	0	0	0	157	429	612	987	1110	1161	1006	0	N/A
		General Height	0	0	0	105	238	476	925	1084	1123	954	0	N/A
	Filipendula ulmaria	Maximum Height	0	0	0	0	0	0	0	0	0	0	0	N/A
		General Height	0	0	0	0	0	0	0	0	0	0	0	N/A
	Mentha aquatica	Maximum Height	0	0	0	0	0	0	0	0	0	0	0	N/A
		General Height	0	0	0	0	0	0	0	0	0	0	0	N/A

Table A 8.3: Microcosm 7 Vegetation Heights during the Salinity Treatment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1685	1896	1765	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1325	1441	1433	0	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1804	1856	0	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1646	1669	0	0	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1855	1724	0	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1479	1496	0	0	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	670	552	0	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	429	275	0	0	0
2009	*Phragmites australis*	Maximum Height	0	0	0	148	609	1077	1341	1420	1462	1305	0	0
		General Height	0	0	0	76	548	975	1151	1232	1230	1219	0	0
	Lythrum salicaria	Maximum Height	0	0	0	0	0	0	0	0	0	0	0	0
		General Height	0	0	0	0	0	0	0	0	0	0	0	0
	Filipendula ulmaria	Maximum Height	0	0	0	0	0	0	0	0	0	0	0	0
		General Height	0	0	0	0	0	0	0	0	0	0	0	0
	Mentha aquatica	Maximum Height	0	0	0	0	0	0	0	0	0	0	0	0
		General Height	0	0	0	0	0	0	0	0	0	0	0	0
2010	*Phragmites australis*	Maximum Height	0	0	0	71	721	1209	1523	1588	1609	1581	0	N/A
		General Height	0	0	0	29	642	1084	1235	1372	1365	1350	0	N/A
	Lythrum salicaria	Maximum Height	0	0	0	0	0	0	0	0	0	0	0	N/A
		General Height	0	0	0	0	0	0	0	0	0	0	0	N/A
	Filipendula ulmaria	Maximum Height	0	0	0	0	0	0	0	0	0	0	0	N/A
		General Height	0	0	0	0	0	0	0	0	0	0	0	N/A
	Mentha aquatica	Maximum Height	0	0	0	0	0	0	0	0	0	0	0	N/A
		General Height	0	0	0	0	0	0	0	0	0	0	0	N/A

Table A 8.4: Microcosm 8 Vegetation Heights during the Salinity Treatment Period.

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Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	7	7	4	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	7	7	4	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	34	31	26	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	8	6	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	43	39	32	0	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	22	20	20	8	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	6	6	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	29	26	26	8	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	20	18	18	11	9
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4	2	2	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	24	20	20	11	9
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6	12	15	24	33
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	3	3	5	5
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6	15	18	29	38
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11	12	14	53	58
2009	*Phragmites australis*	Inside Microcosm	0	0	0	1	5	8	9	10	10	9	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	1	5	8	9	10	10	9	0	0
	Lythrum salicaria	Inside Microcosm	0	0	0	1	22	29	30	30	28	12	0	0
		Outside Microcosm	0	0	0	0	3	5	5	4	3	3	0	0
		Combined	0	0	0	1	25	34	35	34	31	15	0	0
	Filipendula ulmaria	Inside Microcosm	0	0	1	6	26	28	29	29	24	22	0	0
		Outside Microcosm	0	0	0	0	1	3	3	3	2	1	0	0
		Combined	0	0	1	6	27	31	32	32	26	23	0	0
	Mentha aquatica	Inside Microcosm	7	6	6	10	19	19	20	20	17	11	11	11
		Outside Microcosm	0	0	0	0	0	0	0	0	0	1	0	0
		Combined	7	6	6	10	19	19	20	20	17	12	11	11
	Standing Dead or Dormant Vegetation	Inside Microcosm	32	32	32	31	13	8	8	8	11	23	33	27
		Outside Microcosm	3	2	2	0	0	0	0	0	1	1	2	2
		Combined	35	34	34	31	13	8	8	8	12	24	35	29
	Bare Ground or Leaf Litter	Inside Microcosm	61	62	61	51	15	8	4	3	10	23	56	62
2010	*Phragmites australis*	Inside Microcosm	0	0	0	1	6	6	14	14	14	13	0	N/A
		Outside Microcosm	0	0	0	0	0	0	1	1	1	1	0	N/A
		Combined	0	0	0	1	6	6	15	15	15	14	0	N/A
	Lythrum salicaria	Inside Microcosm	0	0	0	2	11	20	21	22	18	11	0	N/A
		Outside Microcosm	0	0	0	0	0	3	5	5	4	1	0	N/A
		Combined	0	0	0	2	11	23	26	27	22	12	0	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	1	7	18	31	28	28	26	22	12	N/A
		Outside Microcosm	0	0	0	0	1	3	6	6	2	1	1	N/A
		Combined	0	0	1	7	19	34	34	34	28	23	13	N/A
	Mentha aquatica	Inside Microcosm	11	11	11	12	14	15	16	18	15	14	9	N/A
		Outside Microcosm	0	0	0	0	0	0	2	2	2	1	1	N/A
		Combined	11	11	11	12	14	15	18	20	17	15	10	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	21	21	19	19	12	9	9	9	11	21	53	N/A
		Outside Microcosm	1	1	1	0	0	0	0	0	0	2	3	N/A
		Combined	22	22	20	19	12	9	9	9	11	23	56	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	68	68	69	59	39	19	12	9	16	19	26	N/A

Table A 8.5: Microcosm 5 Vegetation Areas during the Salinity Treatment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6	6	6	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6	6	6	0	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	32	27	15	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	6	3	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	41	33	18	0	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	28	12	8	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	38	12	8	0	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	19	16	16	16	9
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	22	16	16	16	9
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4	13	21	29	32
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	5	6	3	3
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4	18	27	32	35
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11	26	34	55	59
2009	*Phragmites australis*	Inside Microcosm	0	0	0	1	5	7	8	8	8	6	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	1	5	7	8	8	8	6	0	0
	Lythrum salicaria	Inside Microcosm	0	0	0	1	8	13	15	12	7	4	0	0
		Outside Microcosm	0	0	0	0	0	3	4	4	3	0	0	0
		Combined	0	0	0	1	8	16	19	16	10	4	0	0
	Filipendula ulmaria	Inside Microcosm	0	0	0	1	6	16	21	11	1	0	0	0
		Outside Microcosm	0	0	0	0	0	1	1	1	1	0	0	0
		Combined	0	0	0	1	6	17	22	12	2	0	0	0
	Mentha aquatica	Inside Microcosm	8	6	6	9	10	3	6	4	3	2	1	1
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	8	6	6	9	10	3	6	4	3	2	1	1
	Standing Dead or Dormant Vegetation	Inside Microcosm	31	31	31	31	16	8	8	9	10	12	19	19
		Outside Microcosm	1	1	1	0	0	0	0	0	0	0	0	0
		Combined	32	32	32	31	16	8	8	9	10	12	19	19
	Bare Ground or Leaf Litter	Inside Microcosm	61	63	63	57	55	53	42	56	71	76	80	80
2010	*Phragmites australis*	Inside Microcosm	0	0	0	1	6	6	13	13	13	13	0	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	0	0	0	1	6	6	13	13	13	13	0	N/A
	Lythrum salicaria	Inside Microcosm	0	0	0	1	6	9	14	14	14	11	0	N/A
		Outside Microcosm	0	0	0	0	0	1	2	2	0	0	0	N/A
		Combined	0	0	0	1	6	10	16	16	14	11	0	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	1	3	8	25	19	17	17	17	8	N/A
		Outside Microcosm	0	0	0	0	0	0	1	1	1	0	0	N/A
		Combined	0	0	1	3	8	25	20	18	18	17	8	N/A
	Mentha aquatica	Inside Microcosm	0	0	0	0	1	1	1	0	0	0	0	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	0	0	0	0	1	1	1	0	0	0	0	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	18	18	18	17	11	8	8	8	9	11	21	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	18	18	18	17	11	8	8	8	9	11	21	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	82	82	81	78	68	51	45	48	47	48	71	N/A

Table A 8.6: Microcosm 6 Vegetation Areas during the Salinity Treatment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	7	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	7	0	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	39	10	4	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	14	4	1	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	53	14	5	0	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	22	8	4	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	15	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	37	8	4	0	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	20	7	4	4	3
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	23	7	4	4	3
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	11	19	26	26
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	6	7	4	4
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	17	26	30	30
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	55	62	70	71
2009	*Phragmites australis*	Inside Microcosm	0	0	0	1	4	5	5	5	5	5	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	1	4	5	5	5	5	5	0	0
	Lythrum salicaria	Inside Microcosm	0	0	0	1	5	6	8	8	5	1	0	0
		Outside Microcosm	0	0	0	0	0	2	2	2	2	0	0	0
		Combined	0	0	0	1	5	8	10	10	7	1	0	0
	Filipendula ulmaria	Inside Microcosm	0	0	0	0	3	1	0	0	0	0	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	0	3	1	0	0	0	0	0	0
	Mentha aquatica	Inside Microcosm	2	2	2	5	3	0	0	0	0	0	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	2	2	2	5	3	0	0	0	0	0	0	0
	Standing Dead or Dormant Vegetation	Inside Microcosm	23	23	23	21	17	7	7	7	10	10	15	15
		Outside Microcosm	3	3	3	1	1	1	1	1	1	1	1	0
		Combined	26	26	26	22	18	8	8	8	11	11	16	15
	Bare Ground or Leaf Litter	Inside Microcosm	75	75	75	72	68	81	80	80	80	84	85	85
2010	*Phragmites australis*	Inside Microcosm	0	0	0	1	5	5	12	12	12	10	0	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	0	0	0	1	5	5	12	12	12	10	0	N/A
	Lythrum salicaria	Inside Microcosm	0	0	0	1	6	7	7	5	4	2	0	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	0	0	0	1	6	7	7	5	4	2	0	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	0	0	0	0	0	0	0	0	0	0	0	N/A
	Mentha aquatica	Inside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	0	0	0	0	0	0	0	0	0	0	0	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	15	12	12	12	9	9	8	9	9	12	22	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	15	12	12	12	9	9	8	9	9	12	22	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	85	88	88	86	80	79	73	74	75	76	78	N/A

Table A 8.7: Microcosm 7 Vegetation Areas during the Salinity Treatment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	7	7	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	7	7	0	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	36	8	0	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	15	4	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	51	12	0	0	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	25	6	0	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	31	6	0	0	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	20	2	0	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	23	2	0	0	0
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4	19	21	28	28
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	6	7	2	2
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4	25	28	30	30
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8	58	72	72	72
2009	*Phragmites australis*	Inside Microcosm	0	0	0	1	3	3	5	3	3	3	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	1	3	3	5	3	3	3	0	0
	Lythrum salicaria	Inside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	0	0	0	0	0	0	0	0	0
	Filipendula ulmaria	Inside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	0	0	0	0	0	0	0	0	0
	Mentha aquatica	Inside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	0	0	0	0	0	0	0	0	0
	Standing Dead or Dormant Vegetation	Inside Microcosm	25	24	24	21	16	7	7	9	9	9	12	12
		Outside Microcosm	1	1	1	0	0	0	0	0	0	0	0	0
		Combined	26	25	25	21	16	7	7	9	9	9	12	12
	Bare Ground or Leaf Litter	Inside Microcosm	75	76	76	78	81	90	88	88	88	88	88	88
2010	*Phragmites australis*	Inside Microcosm	0	0	0	1	5	6	10	10	10	10	0	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	0	0	0	1	5	6	10	10	10	10	0	N/A
	Lythrum salicaria	Inside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	0	0	0	0	0	0	0	0	0	0	0	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	0	0	0	0	0	0	0	0	0	0	0	N/A
	Mentha aquatica	Inside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	0	0	0	0	0	0	0	0	0	0	0	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	9	9	9	9	7	7	6	6	6	6	16	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	9	9	9	9	7	7	6	6	6	6	16	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	91	91	91	90	88	87	84	84	84	84	84	N/A

Table A 8.8: Microcosm 8 Vegetation Areas during the Salinity Treatment Period.

Appendix 9 Water Input during the Nutrient Treatment Period for the Restricted Competition Microcosms

Year	Microcosm Number		January	February	March	April	May	June	July	August	September	October	November	December
			Total Water Added per Month (Litres)											
2008	9	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	165.70	93.71	74.86	35.00	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	217.99	147.67	108.51	78.90	28.27
	10	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	170.54	90.47	67.32	38.24	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	222.83	144.44	100.98	82.13	28.27
	11	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	160.25	94.78	64.62	31.77	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	212.54	148.74	98.28	75.66	28.27
	12	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	178.29	98.55	70.01	36.62	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	230.58	152.51	103.67	80.51	28.27
2009	9	Artificial Water Added	0.00	0.00	0.00	85.07	159.55	195.49	210.80	196.49	114.71	81.79	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	105.00	185.29	221.55	266.75	220.67	122.57	108.56	52.83	30.10
	10	Artificial Water Added	0.00	0.00	0.00	77.32	164.70	196.57	216.71	199.56	114.71	84.96	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	97.24	190.44	222.63	272.67	223.74	122.57	111.73	52.83	30.10
	11	Artificial Water Added	0.00	0.00	0.00	63.01	170.63	208.64	231.28	210.64	107.17	56.01	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	82.93	196.37	234.70	287.24	234.82	115.03	82.77	52.83	30.10
	12	Artificial Water Added	0.00	0.00	0.00	70.24	170.68	226.01	252.14	230.15	114.17	58.70	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	90.16	196.42	252.07	308.09	254.34	122.03	85.47	52.83	30.10
2010	9	Artificial Water Added	0.00	0.00	0.00	77.31	135.17	174.49	195.49	178.79	98.01	55.24	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	98.63	148.42	200.98	216.92	231.68	128.93	82.75	N/A	N/A
	10	Artificial Water Added	0.00	0.00	0.00	79.16	149.32	185.26	200.34	184.72	104.48	50.62	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	100.49	162.56	211.75	221.77	237.60	135.39	78.14	N/A	N/A
	11	Artificial Water Added	0.00	0.00	0.00	67.55	150.94	188.49	212.02	196.57	92.09	36.08	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	88.87	164.19	214.98	233.46	249.45	123.00	63.60	N/A	N/A
	12	Artificial Water Added	0.00	0.00	0.00	70.39	162.33	209.64	234.47	214.95	107.71	37.16	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	91.71	175.58	236.13	255.90	267.83	138.62	64.68	N/A	N/A

Table A 9.1: Microcosms 9-12 Water Input during the Nutrient Treatment Period.

Appendix 10 Vegetation Heights and Area Coverage during the Nutrient Treatment Period for the Restricted Competition Microcosms

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1601	1698	1650	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1368	1562	1557	0	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1752	1788	1682	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1584	1637	1366	0	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1626	1590	1507	738	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1551	1516	1381	327	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	652	981	801	710	86
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	298	291	295	257	47
2009	*Phragmites australis*	Maximum Height	0	0	0	102	560	1428	1666	1737	1782	1742	0	0
		General Height	0	0	0	55	423	1293	1521	1613	1635	1594	0	0
	Lythrum salicaria	Maximum Height	0	0	0	42	518	1182	1475	1592	1643	1623	0	0
		General Height	0	0	0	38	421	892	1379	1507	1496	1464	0	0
	Filipendula ulmaria	Maximum Height	0	0	58	146	442	1067	1385	1409	1388	1209	0	0
		General Height	0	0	52	117	366	632	862	913	926	549	0	0
	Mentha aquatica	Maximum Height	81	76	70	103	119	245	559	768	809	810	793	86
		General Height	53	50	48	63	78	104	190	398	537	558	489	75
2010	*Phragmites australis*	Maximum Height	0	0	0	221	532	1032	1263	1457	1548	1460	0	N/A
		General Height	0	0	0	100	441	827	999	1165	1261	1248	0	N/A
	Lythrum salicaria	Maximum Height	0	0	0	46	337	776	1199	1260	1269	1265	0	N/A
		General Height	0	0	0	36	280	544	903	1197	1168	1038	0	N/A
	Filipendula ulmaria	Maximum Height	0	0	90	159	326	673	682	738	657	642	462	N/A
		General Height	0	0	60	118	258	482	519	560	584	585	411	N/A
	Mentha aquatica	Maximum Height	82	81	79	75	154	197	602	874	871	855	318	N/A
		General Height	72	61	46	44	103	154	469	463	412	343	47	N/A

Table A 10.1: Microcosm 9 Vegetation Heights during the Nutrient Treatment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1677	1801	1786	1419	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1578	1756	1745	936	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1878	1896	1674	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1630	1684	1156	0	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1684	1589	1588	759	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1398	1455	1334	604	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	729	792	842	544	96
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	372	342	328	281	53
2009	*Phragmites australis*	Maximum Height	0	0	0	251	937	1984	2080	2088	2119	2108	0	0
		General Height	0	0	0	147	661	1540	1737	1801	1832	1806	0	0
	Lythrum salicaria	Maximum Height	0	0	0	56	551	1376	1726	1820	1815	1814	0	0
		General Height	0	0	0	44	498	1085	1519	1594	1565	1550	0	0
	Filipendula ulmaria	Maximum Height	0	0	74	172	494	1214	1545	1724	1683	0	0	0
		General Height	0	0	52	143	398	860	1158	1214	1224	0	0	0
	Mentha aquatica	Maximum Height	79	79	78	104	243	706	830	824	811	747	604	97
		General Height	47	45	40	64	165	305	453	487	496	487	381	79
2010	*Phragmites australis*	Maximum Height	0	0	0	135	616	1124	1508	1720	1640	1639	0	N/A
		General Height	0	0	0	74	532	1072	1366	1503	1547	1536	0	N/A
	Lythrum salicaria	Maximum Height	0	0	0	53	372	1016	1378	1391	1395	1387	0	N/A
		General Height	0	0	0	37	319	784	1135	1252	1251	1131	0	N/A
	Filipendula ulmaria	Maximum Height	0	0	76	161	368	681	701	755	761	756	682	N/A
		General Height	0	0	58	110	305	574	592	572	553	545	515	N/A
	Mentha aquatica	Maximum Height	96	92	90	90	257	343	528	659	677	641	226	N/A
		General Height	72	57	54	56	134	224	353	437	453	360	53	N/A

Table A 10.2: Microcosm 10 Vegetation Heights during the Nutrient Treatment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1828	2083	2071	2031	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1607	1760	1757	1244	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1859	1916	1580	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1647	1672	1341	0	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1500	1530	1498	468	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1361	1369	1240	394	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	702	725	751	680	91
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	381	382	374	359	61
2009	*Phragmites australis*	Maximum Height	0	0	0	338	895	1789	2091	2163	2185	2176	0	0
		General Height	0	0	0	197	804	1640	1820	1859	1889	1882	0	0
	Lythrum salicaria	Maximum Height	0	0	0	62	668	1535	1804	1892	1889	0	0	0
		General Height	0	0	0	48	555	1302	1718	1786	1714	0	0	0
	Filipendula ulmaria	Maximum Height	0	0	68	229	503	1038	1439	1568	1534	0	0	0
		General Height	0	0	61	187	472	757	1002	1055	1031	0	0	0
	Mentha aquatica	Maximum Height	74	66	62	89	246	465	635	659	611	418	340	92
		General Height	53	46	43	63	128	249	329	336	334	183	130	72
2010	*Phragmites australis*	Maximum Height	0	0	0	140	641	1511	1863	1927	1960	1838	0	N/A
		General Height	0	0	0	106	572	1159	1455	1742	1795	1790	0	N/A
	Lythrum salicaria	Maximum Height	0	0	0	50	415	999	1562	1498	1491	0	0	N/A
		General Height	0	0	0	37	326	780	1246	1371	1368	0	0	N/A
	Filipendula ulmaria	Maximum Height	0	0	97	195	429	628	810	901	887	886	673	N/A
		General Height	0	0	54	153	348	602	698	719	703	640	564	N/A
	Mentha aquatica	Maximum Height	82	78	73	70	158	317	827	776	822	799	63	N/A
		General Height	61	55	52	51	94	193	206	231	237	218	35	N/A

Table A 10.3: Microcosm 11 Vegetation Heights during the Nutrient Treatment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1664	1891	1862	1506	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1455	1515	1502	1268	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2043	1909	1778	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1869	1783	1469	0	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1693	1674	1666	491	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1606	1563	1410	362	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	613	678	720	719	110
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	431	443	536	352	58
2009	*Phragmites australis*	Maximum Height	0	0	0	269	868	1832	2141	2229	2289	2274	0	0
		General Height	0	0	0	231	819	1728	1865	1919	1930	1922	0	0
	Lythrum salicaria	Maximum Height	0	0	0	63	636	1517	1883	1963	1948	0	0	0
		General Height	0	0	0	47	564	1365	1727	1820	1746	0	0	0
	Filipendula ulmaria	Maximum Height	0	0	55	317	598	996	1193	1254	1210	0	0	0
		General Height	0	0	51	224	473	584	621	636	630	0	0	0
	Mentha aquatica	Maximum Height	70	65	63	132	324	854	905	1012	688	341	208	107
		General Height	47	47	46	68	196	640	625	579	391	169	116	78
2010	*Phragmites australis*	Maximum Height	0	0	0	123	781	1377	1784	1957	2051	1938	0	N/A
		General Height	0	0	0	81	669	1281	1556	1790	1894	1875	0	N/A
	Lythrum salicaria	Maximum Height	0	0	0	48	570	1160	1397	1504	1489	0	0	N/A
		General Height	0	0	0	48	365	1114	1318	1387	1338	0	0	N/A
	Filipendula ulmaria	Maximum Height	0	0	97	180	527	751	918	726	841	832	715	N/A
		General Height	0	0	45	150	415	598	641	648	615	608	591	N/A
	Mentha aquatica	Maximum Height	101	97	91	85	93	289	812	753	840	831	273	N/A
		General Height	75	61	58	53	61	185	239	235	183	133	54	N/A

Table A 10.4: Microcosm 12 Vegetation Heights during the Nutrient Treatment Period.

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Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	7	7	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	7	7	0	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	47	43	41	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13	12	12	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	60	55	53	0	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13	11	11	8	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6	5	5	2	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	19	16	16	10	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11	11	11	12	12
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	1	1	1	1
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13	12	12	13	13
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	9	10	33	36
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	1	1	3	3
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	10	11	36	39
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	17	19	20	47	52
2009	*Phragmites australis*	Inside Microcosm	0	0	0	2	9	11	13	13	13	13	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	2	9	11	13	13	13	13	0	0
	Lythrum salicaria	Inside Microcosm	0	0	0	2	21	26	27	27	25	9	0	0
		Outside Microcosm	0	0	0	0	1	4	4	4	4	1	0	0
		Combined	0	0	0	2	22	30	31	31	29	10	0	0
	Filipendula ulmaria	Inside Microcosm	0	0	1	7	28	28	29	29	28	23	0	0
		Outside Microcosm	0	0	0	0	4	5	5	5	5	3	0	0
		Combined	0	0	1	7	32	33	34	34	33	26	0	0
	Mentha aquatica	Inside Microcosm	11	11	11	13	17	20	22	21	23	17	17	17
		Outside Microcosm	0	0	0	0	3	2	2	3	3	3	0	0
		Combined	11	11	11	13	20	22	24	24	26	20	17	17
	Standing Dead or Dormant Vegetation	Inside Microcosm	36	36	36	28	9	4	4	4	5	15	32	28
		Outside Microcosm	3	3	3	1	1	1	1	1	1	1	2	2
		Combined	39	39	39	29	10	5	5	5	6	16	34	30
	Bare Ground or Leaf Litter	Inside Microcosm	53	53	52	48	16	11	5	6	6	23	51	55
2010	*Phragmites australis*	Inside Microcosm	0	0	0	2	8	13	21	21	21	15	0	N/A
		Outside Microcosm	0	0	0	0	0	0	3	3	3	3	0	N/A
		Combined	0	0	0	2	8	13	24	24	24	18	0	N/A
	Lythrum salicaria	Inside Microcosm	0	0	0	1	11	17	19	19	18	13	0	N/A
		Outside Microcosm	0	0	0	0	0	3	5	5	2	0	0	N/A
		Combined	0	0	0	1	11	20	24	24	20	13	0	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	1	6	15	27	28	28	26	21	6	N/A
		Outside Microcosm	0	0	0	0	1	4	5	5	2	0	1	N/A
		Combined	0	0	1	6	16	31	33	33	28	21	7	N/A
	Mentha aquatica	Inside Microcosm	15	15	16	18	21	22	20	21	20	18	12	N/A
		Outside Microcosm	0	0	0	0	1	2	2	2	2	1	0	N/A
		Combined	15	15	16	18	22	24	22	23	22	19	12	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	24	23	21	21	12	9	9	9	11	33	52	N/A
		Outside Microcosm	2	1	1	1	1	1	0	0	0	2	5	N/A
		Combined	26	24	22	22	13	10	9	9	11	35	57	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	61	62	62	52	33	12	3	2	4	0	30	N/A

Table A 10.5: Microcosm 9 Vegetation Areas during the Nutrient Treatment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	9	5	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	9	5	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	32	29	23	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	14	11	6	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	46	40	29	0	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	22	21	19	12	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6	5	4	2	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	28	26	23	14	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11	10	10	11	11
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	1	1	1	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13	11	11	12	11
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	6	8	28	33
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	3	4	4	4
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	9	12	32	37
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	24	25	31	44	56
2009	*Phragmites australis*	Inside Microcosm	0	0	0	3	15	18	21	21	21	14	0	0
		Outside Microcosm	0	0	0	0	0	2	2	2	2	1	0	0
		Combined	0	0	0	3	15	20	23	23	23	15	0	0
	Lythrum salicaria	Inside Microcosm	0	0	0	3	23	26	27	27	15	4	0	0
		Outside Microcosm	0	0	0	0	4	4	5	4	2	1	0	0
		Combined	0	0	0	3	27	30	32	31	17	5	0	0
	Filipendula ulmaria	Inside Microcosm	0	0	1	13	23	23	24	24	12	0	0	0
		Outside Microcosm	0	0	0	1	3	3	3	3	1	0	0	0
		Combined	0	0	1	14	26	26	27	27	13	0	0	0
	Mentha aquatica	Inside Microcosm	11	11	12	14	21	19	21	20	16	11	11	11
		Outside Microcosm	0	0	0	0	3	2	2	3	2	0	0	0
		Combined	11	11	12	14	24	21	23	23	18	11	11	11
	Standing Dead or Dormant Vegetation	Inside Microcosm	32	29	29	16	5	4	4	4	13	24	39	34
		Outside Microcosm	3	3	3	1	1	0	0	0	1	3	3	2
		Combined	35	32	32	17	6	4	4	4	14	27	42	36
	Bare Ground or Leaf Litter	Inside Microcosm	57	60	58	51	13	10	3	4	23	47	50	55
2010	*Phragmites australis*	Inside Microcosm	0	0	0	6	22	26	27	27	27	19	0	N/A
		Outside Microcosm	0	0	0	0	0	0	3	3	3	3	0	N/A
		Combined	0	0	0	6	22	26	30	30	30	22	0	N/A
	Lythrum salicaria	Inside Microcosm	0	0	0	5	18	24	25	25	24	10	0	N/A
		Outside Microcosm	0	0	0	0	1	4	6	6	6	3	0	N/A
		Combined	0	0	0	5	19	28	31	31	30	13	0	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	2	12	21	22	24	24	23	19	14	N/A
		Outside Microcosm	0	0	0	1	2	3	4	4	2	1	2	N/A
		Combined	0	0	2	13	23	25	28	28	25	20	16	N/A
	Mentha aquatica	Inside Microcosm	11	11	12	14	16	19	17	16	16	12	9	N/A
		Outside Microcosm	0	0	0	0	1	6	5	6	6	3	2	N/A
		Combined	11	11	12	14	17	25	22	22	22	15	11	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	27	26	23	23	15	9	7	8	7	31	57	N/A
		Outside Microcosm	1	1	1	1	1	1	0	0	0	3	7	N/A
		Combined	28	27	24	24	16	10	7	8	7	34	64	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	62	63	63	40	8	0	0	0	3	9	20	N/A

Table A 10.6: Microcosm 10 Vegetation Areas during the Nutrient Treatment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	9	7	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	9	7	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	32	26	13	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13	8	5	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	45	34	18	0	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	22	17	15	12	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4	1	1	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26	18	16	12	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10	8	10	11	11
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	0	0	1	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12	8	10	12	11
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	7	13	24	31
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	5	5	3	3
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	12	18	27	34
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	24	33	40	46	58
2009	*Phragmites australis*	Inside Microcosm	0	0	0	4	22	25	27	28	28	21	0	0
		Outside Microcosm	0	0	0	0	2	4	5	5	5	1	0	0
		Combined	0	0	0	4	24	29	32	33	33	22	0	0
	Lythrum salicaria	Inside Microcosm	0	0	0	3	24	24	27	27	11	0	0	0
		Outside Microcosm	0	0	0	0	2	6	8	8	3	0	0	0
		Combined	0	0	0	3	26	30	35	35	14	0	0	0
	Filipendula ulmaria	Inside Microcosm	0	0	1	12	23	22	22	22	8	0	0	0
		Outside Microcosm	0	0	0	1	7	6	7	7	2	0	0	0
		Combined	0	0	1	13	30	28	29	29	10	0	0	0
	Mentha aquatica	Inside Microcosm	11	11	12	15	14	13	13	13	9	8	8	8
		Outside Microcosm	0	0	0	1	1	2	2	2	2	0	0	0
		Combined	11	11	12	16	15	15	15	15	11	8	8	8
	Standing Dead or Dormant Vegetation	Inside Microcosm	26	24	24	14	2	2	2	2	18	27	48	46
		Outside Microcosm	3	3	3	2	1	0	0	0	2	7	8	6
		Combined	29	27	27	16	3	2	2	2	20	34	56	52
	Bare Ground or Leaf Litter	Inside Microcosm	63	65	63	52	15	14	9	8	26	44	44	46
2010	*Phragmites australis*	Inside Microcosm	0	0	0	7	17	27	31	31	31	10	0	N/A
		Outside Microcosm	0	0	0	0	0	4	6	6	6	4	0	N/A
		Combined	0	0	0	7	17	31	37	37	37	14	0	N/A
	Lythrum salicaria	Inside Microcosm	0	0	0	2	13	25	25	25	17	0	0	N/A
		Outside Microcosm	0	0	0	0	0	5	7	7	3	0	0	N/A
		Combined	0	0	0	2	13	30	32	32	20	0	0	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	1	8	18	31	29	29	27	21	12	N/A
		Outside Microcosm	0	0	0	1	3	4	4	4	1	1	1	N/A
		Combined	0	0	1	9	21	35	33	33	28	22	13	N/A
	Mentha aquatica	Inside Microcosm	8	8	9	11	12	14	12	12	13	11	11	N/A
		Outside Microcosm	0	0	0	0	1	2	3	2	2	1	1	N/A
		Combined	8	8	9	11	13	16	15	14	15	12	12	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	36	33	32	29	19	3	3	3	9	45	59	N/A
		Outside Microcosm	4	3	3	3	3	2	1	1	2	2	4	N/A
		Combined	40	36	35	32	22	5	4	4	11	47	63	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	56	59	58	43	21	0	0	0	3	13	18	N/A

Table A 10.7: Microcosm 11 Vegetation Areas during the Nutrient Treatment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	9	9	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9	9	9	9	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	34	26	8	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	24	17	6	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	58	43	14	0	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	24	16	16	15	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6	0	0	1	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	30	16	16	16	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	14	15	16	18	18
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	3	3	1	1
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	16	18	19	19	19
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	9	12	16	25
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	6	8	4	4
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	15	20	20	29
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	16	25	39	42	57
2009	*Phragmites australis*	Inside Microcosm	0	0	0	6	24	27	28	28	21	3	0	0
		Outside Microcosm	0	0	0	0	9	6	6	6	4	0	0	0
		Combined	0	0	0	6	33	33	34	34	25	3	0	0
	Lythrum salicaria	Inside Microcosm	0	0	0	4	24	29	29	29	12	0	0	0
		Outside Microcosm	0	0	0	0	3	12	12	12	4	0	0	0
		Combined	0	0	0	4	27	41	41	41	16	0	0	0
	Filipendula ulmaria	Inside Microcosm	0	0	1	17	22	21	21	21	7	0	0	0
		Outside Microcosm	0	0	0	1	4	4	4	4	2	0	0	0
		Combined	0	0	1	18	26	25	25	25	9	0	0	0
	Mentha aquatica	Inside Microcosm	18	18	20	26	26	19	18	18	8	5	4	4
		Outside Microcosm	0	0	1	1	3	10	10	10	3	0	0	0
		Combined	18	18	21	27	29	29	28	28	11	5	4	4
	Standing Dead or Dormant Vegetation	Inside Microcosm	22	20	19	6	2	2	2	2	36	63	66	54
		Outside Microcosm	2	2	2	0	0	0	0	0	6	11	10	8
		Combined	24	22	21	6	2	2	2	2	42	74	76	62
	Bare Ground or Leaf Litter	Inside Microcosm	60	62	60	41	2	2	2	2	16	29	30	42
2010	*Phragmites australis*	Inside Microcosm	0	0	0	7	21	32	39	39	39	8	0	N/A
		Outside Microcosm	0	0	0	0	0	8	8	8	7	2	0	N/A
		Combined	0	0	0	7	21	40	47	47	46	10	0	N/A
	Lythrum salicaria	Inside Microcosm	0	0	0	6	19	18	18	18	7	0	0	N/A
		Outside Microcosm	0	0	0	0	0	6	4	4	1	0	0	N/A
		Combined	0	0	0	6	19	24	22	22	8	0	0	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	2	9	22	23	22	22	13	10	3	N/A
		Outside Microcosm	0	0	0	1	3	3	4	4	2	0	0	N/A
		Combined	0	0	2	10	25	26	26	26	15	10	3	N/A
	Mentha aquatica	Inside Microcosm	4	4	5	6	6	12	12	12	10	8	8	N/A
		Outside Microcosm	0	0	0	0	0	0	1	1	0	0	0	N/A
		Combined	4	4	5	6	6	12	13	13	10	8	8	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	41	35	34	31	21	14	8	8	24	57	67	N/A
		Outside Microcosm	6	5	3	3	3	0	0	0	3	9	11	N/A
		Combined	47	40	37	34	24	14	8	8	27	66	78	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	55	61	59	41	11	1	1	1	7	17	22	N/A

Table A 10.8: Microcosm 12 Vegetation Areas during the Nutrient Treatment Period.

Appendix 11 Water Input during the Salinity Treatment Period for the Restricted Competition Microcosms

			Total Water Added per Month (Litres)											
Year	Microcosm Number		January	February	March	April	May	June	July	August	September	October	November	December
2008	13	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	170.54	100.17	78.43	29.62	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	222.83	154.13	112.09	73.51	28.27
	14	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	169.08	84.01	44.70	0.00	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	221.38	137.97	78.36	43.89	28.27
	15	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	143.25	74.86	40.39	0.00	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	195.54	128.82	74.05	43.89	28.27
	16	Artificial Water Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	154.56	58.70	36.08	0.00	0.00
		Natural Rainfall Added	N/A	N/A	N/A	N/A	N/A	N/A	N/A	52.29	53.96	33.66	43.89	28.27
		Total Input	N/A	N/A	N/A	N/A	N/A	N/A	N/A	206.85	112.66	69.74	43.89	28.27
2009	13	Artificial Water Added	0.00	0.00	0.00	81.30	164.46	182.56	203.03	189.03	100.71	82.61	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	101.23	190.20	208.63	258.98	213.21	108.57	109.38	52.83	30.10
	14	Artificial Water Added	0.00	0.00	0.00	47.39	105.55	141.10	164.25	120.09	67.86	0.00	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	67.32	131.29	167.16	220.21	144.27	75.72	26.77	52.83	30.10
	15	Artificial Water Added	0.00	0.00	0.00	27.47	81.32	116.32	138.40	93.17	65.70	0.00	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	47.39	107.06	142.39	194.36	117.35	73.56	26.77	52.83	30.10
	16	Artificial Water Added	0.00	0.00	0.00	25.85	68.39	95.32	118.48	70.55	45.24	0.00	0.00	0.00
		Natural Rainfall Added	34.68	19.71	14.54	19.93	25.74	26.07	55.95	24.18	7.86	26.77	52.83	30.10
		Total Input	34.68	19.71	14.54	45.78	94.14	121.39	174.43	94.73	53.10	26.77	52.83	30.10
2010	13	Artificial Water Added	0.00	0.00	0.00	72.07	143.79	177.72	189.56	178.26	94.78	62.32	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	93.40	157.04	204.21	211.00	231.14	125.69	89.84	N/A	N/A
	14	Artificial Water Added	0.00	0.00	0.00	45.78	104.48	140.02	161.02	120.63	71.63	0.00	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	67.10	117.72	166.52	182.46	173.52	102.54	27.52	N/A	N/A
	15	Artificial Water Added	0.00	0.00	0.00	30.16	75.39	105.55	129.79	87.78	61.39	0.00	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	51.48	88.64	132.05	151.22	140.67	92.30	27.52	N/A	N/A
	16	Artificial Water Added	0.00	0.00	0.00	23.16	59.24	91.01	115.79	67.86	39.31	0.00	N/A	N/A
		Natural Rainfall Added	33.17	32.74	27.41	21.33	13.25	26.50	21.43	52.88	30.91	27.52	N/A	N/A
		Total Input	33.17	32.74	27.41	44.48	72.49	117.51	137.22	120.74	70.22	27.52	N/A	N/A

Table A 11.1: Microcosms 13-16 Water Input during the Salinity Treatment Period.

Appendix 12 Vegetation Heights and Area Coverage during the Salinity Treatment Period for the Restricted Competition Microcosms.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1552	1807	1801	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1339	1467	1460	0	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1641	1668	1627	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1520	1573	1536	0	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1668	1672	1593	463	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1430	1489	1312	331	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	717	695	932	912	86
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	364	342	416	405	70
2009	*Phragmites australis*	Maximum Height	0	0	0	250	567	1529	1729	1811	1819	1732	0	0
		General Height	0	0	0	72	485	1206	1444	1509	1527	1511	0	0
	Lythrum salicaria	Maximum Height	0	0	0	41	517	1318	1682	1762	1779	1740	0	0
		General Height	0	0	0	35	378	1100	1542	1622	1621	1599	0	0
	Filipendula ulmaria	Maximum Height	0	0	57	199	478	745	1386	1467	1481	831	0	0
		General Height	0	0	53	93	435	606	865	935	941	392	0	0
	Mentha aquatica	Maximum Height	77	69	68	65	162	462	622	758	861	865	674	108
		General Height	56	55	54	53	116	409	461	545	561	546	366	73
2010	*Phragmites australis*	Maximum Height	0	0	0	143	528	1151	1553	1630	1482	1465	0	N/A
		General Height	0	0	0	107	478	908	1198	1261	1301	1289	0	N/A
	Lythrum salicaria	Maximum Height	0	0	0	59	351	777	1036	1201	1209	1206	0	N/A
		General Height	0	0	0	36	210	667	958	1082	1065	980	0	N/A
	Filipendula ulmaria	Maximum Height	0	0	83	192	488	786	1078	1105	1030	1028	682	N/A
		General Height	0	0	58	123	350	651	749	755	679	671	566	N/A
	Mentha aquatica	Maximum Height	101	97	96	76	84	259	434	798	821	804	718	N/A
		General Height	59	53	42	40	63	177	322	509	520	487	52	N/A

Table A 12.1: Microcosm 13 Vegetation Heights during the Salinity Treatment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1534	1595	1590	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1371	1448	1442	0	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1674	1763	1471	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1575	1535	1369	0	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1596	1981	1637	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1410	1523	993	0	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	717	766	928	914	104
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	389	513	533	494	74
2009	*Phragmites australis*	Maximum Height	0	0	0	174	682	1294	1746	1812	1830	1749	0	0
		General Height	0	0	0	58	449	992	1470	1613	1656	1648	0	0
	Lythrum salicaria	Maximum Height	0	0	0	68	244	1012	1522	1612	1668	1637	0	0
		General Height	0	0	0	41	209	778	1418	1579	1606	1561	0	0
	Filipendula ulmaria	Maximum Height	0	0	0	0	222	563	1282	1431	1415	0	0	0
		General Height	0	0	0	0	159	350	645	833	841	0	0	0
	Mentha aquatica	Maximum Height	85	85	76	81	132	144	172	208	286	278	218	92
		General Height	45	45	41	47	109	121	139	180	178	159	138	72
2010	*Phragmites australis*	Maximum Height	0	0	0	98	689	1241	1430	1502	1514	1493	0	N/A
		General Height	0	0	0	55	516	693	978	1344	1427	1426	0	N/A
	Lythrum salicaria	Maximum Height	0	0	0	124	311	758	1408	1413	1399	1190	0	N/A
		General Height	0	0	0	57	241	594	1253	1287	1295	963	0	N/A
	Filipendula ulmaria	Maximum Height	0	0	85	137	168	208	249	433	0	0	0	N/A
		General Height	0	0	54	78	103	167	213	240	0	0	0	N/A
	Mentha aquatica	Maximum Height	85	84	81	79	109	94	254	285	279	230	89	N/A
		General Height	62	60	54	52	69	63	136	162	105	61	46	N/A

Table A 12.2: Microcosm 14 Vegetation Heights during the Salinity Treatment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1543	1686	1685	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1352	1428	1401	0	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1817	1933	1392	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1601	1713	1169	0	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1690	0	0	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1397	0	0	0	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	793	747	0	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	413	365	0	0	0
2009	*Phragmites australis*	Maximum Height	0	0	0	134	525	1193	1547	1610	1651	1503	0	0
		General Height	0	0	0	73	346	933	1335	1459	1478	1558	0	0
	Lythrum salicaria	Maximum Height	0	0	0	0	71	531	915	1013	1055	1067	0	0
		General Height	0	0	0	0	43	497	872	926	964	913	0	0
	Filipendula ulmaria	Maximum Height	0	0	0	0	0	0	0	0	0	0	0	0
		General Height	0	0	0	0	0	0	0	0	0	0	0	0
	Mentha aquatica	Maximum Height	0	0	0	0	98	0	0	0	0	0	0	0
		General Height	0	0	0	0	98	0	0	0	0	0	0	0
2010	*Phragmites australis*	Maximum Height	0	0	0	86	748	1322	1593	1660	1670	1627	0	N/A
		General Height	0	0	0	29	691	1053	1223	1472	1540	1534	0	N/A
	Lythrum salicaria	Maximum Height	0	0	0	123	398	584	711	848	862	718	0	N/A
		General Height	0	0	0	55	232	391	559	741	756	609	0	N/A
	Filipendula ulmaria	Maximum Height	0	0	0	0	0	0	0	0	0	0	0	N/A
		General Height	0	0	0	0	0	0	0	0	0	0	0	N/A
	Mentha aquatica	Maximum Height	0	0	0	0	0	0	0	0	0	0	0	N/A
		General Height	0	0	0	0	0	0	0	0	0	0	0	N/A

Table A 12.3: Microcosm 15 Vegetation Heights during the Salinity Treatment Period.

Year	Species	Height (mm)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1544	1609	1557	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1445	1512	1516	0	0
	Lythrum salicaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1694	1792	0	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1543	1613	0	0	0
	Filipendula ulmaria	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1676	0	0	0	0
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1448	0	0	0	0
	Mentha aquatica	Maximum Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	896	764	491	342	61
		General Height	N/A	N/A	N/A	N/A	N/A	N/A	N/A	442	351	109	74	61
2009	*Phragmites australis*	Maximum Height	0	0	0	182	539	975	1288	1410	1439	1440	0	0
		General Height	0	0	0	139	431	653	1117	1205	1228	1223	0	0
	Lythrum salicaria	Maximum Height	0	0	0	0	0	57	0	0	0	0	0	0
		General Height	0	0	0	0	0	49	0	0	0	0	0	0
	Filipendula ulmaria	Maximum Height	0	0	0	0	0	0	0	0	0	0	0	0
		General Height	0	0	0	0	0	0	0	0	0	0	0	0
	Mentha aquatica	Maximum Height	54	46	48	51	49	0	0	0	0	0	0	0
		General Height	54	46	48	51	49	0	0	0	0	0	0	0
2010	*Phragmites australis*	Maximum Height	0	0	0	81	715	1160	1515	1696	1504	1486	0	N/A
		General Height	0	0	0	26	604	847	1236	1274	1291	1277	0	N/A
	Lythrum salicaria	Maximum Height	0	0	0	0	0	0	0	0	0	0	0	N/A
		General Height	0	0	0	0	0	0	0	0	0	0	0	N/A
	Filipendula ulmaria	Maximum Height	0	0	0	0	0	0	0	0	0	0	0	N/A
		General Height	0	0	0	0	0	0	0	0	0	0	0	N/A
	Mentha aquatica	Maximum Height	0	0	0	0	0	0	0	0	0	0	0	N/A
		General Height	0	0	0	0	0	0	0	0	0	0	0	N/A

Table A 12.4: Microcosm 16 Vegetation Heights during the Salinity Treatment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12	12	12	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12	12	12	0	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	35	32	31	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11	9	9	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	46	41	40	0	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	14	13	13	13	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4	2	2	1	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	18	15	15	14	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	18	17	16	14	10
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	3	3	1	1
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	21	20	19	15	11
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	3	4	22	25
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	3	3	4	4
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	6	7	26	29
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	20	23	24	51	65
2009	*Phragmites australis*	Inside Microcosm	0	0	0	1	11	15	17	17	17	15	0	0
		Outside Microcosm	0	0	0	0	0	2	2	2	2	2	0	0
		Combined	0	0	0	1	11	17	19	19	19	17	0	0
	Lythrum salicaria	Inside Microcosm	0	0	0	1	17	22	24	24	22	8	0	0
		Outside Microcosm	0	0	0	0	1	4	5	5	4	2	0	0
		Combined	0	0	0	1	18	26	29	29	26	10	0	0
	Filipendula ulmaria	Inside Microcosm	0	0	1	8	22	23	25	25	25	21	0	0
		Outside Microcosm	0	0	0	0	8	6	7	7	7	6	0	0
		Combined	0	0	1	8	30	29	32	32	32	27	0	0
	Mentha aquatica	Inside Microcosm	8	8	9	19	18	18	19	20	20	15	13	12
		Outside Microcosm	0	0	0	0	0	4	5	5	5	2	1	0
		Combined	8	8	9	19	18	22	24	25	25	17	14	12
	Standing Dead or Dormant Vegetation	Inside Microcosm	23	23	23	13	6	4	4	4	5	14	37	33
		Outside Microcosm	3	3	2	0	0	0	0	0	1	2	5	3
		Combined	26	26	25	13	6	4	4	4	6	16	42	36
	Bare Ground or Leaf Litter	Inside Microcosm	69	69	67	58	26	18	11	10	11	27	50	55
2010	*Phragmites australis*	Inside Microcosm	0	0	0	2	8	10	19	19	19	17	0	N/A
		Outside Microcosm	0	0	0	0	0	1	3	3	3	3	0	N/A
		Combined	0	0	0	2	8	11	22	22	22	20	0	N/A
	Lythrum salicaria	Inside Microcosm	0	0	0	3	12	17	19	19	8	6	0	N/A
		Outside Microcosm	0	0	0	0	0	4	8	8	8	6	0	N/A
		Combined	0	0	0	3	12	21	27	27	16	12	0	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	1	11	27	32	31	30	30	28	11	N/A
		Outside Microcosm	0	0	0	2	6	7	8	7	7	6	3	N/A
		Combined	0	0	1	13	33	39	39	37	37	34	14	N/A
	Mentha aquatica	Inside Microcosm	12	11	12	14	15	22	20	22	21	20	16	N/A
		Outside Microcosm	0	0	0	0	1	2	2	2	3	3	1	N/A
		Combined	12	11	12	14	16	24	22	24	24	23	17	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	22	19	18	16	9	9	7	7	11	15	41	N/A
		Outside Microcosm	2	2	2	2	2	1	1	1	2	5	9	N/A
		Combined	24	21	20	18	11	10	8	8	13	20	50	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	66	70	69	54	29	10	4	3	11	14	32	N/A

Table A 12.5: Microcosm 13 Vegetation Areas during the Salinity Treatment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8	8	8	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	8	8	8	0	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	36	31	17	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	15	12	7	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	51	43	24	0	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	25	17	11	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	3	2	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	32	20	13	0	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	25	19	16	13	13
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	5	5	3	2
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	30	24	21	16	15
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	5	13	21	21
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	5	6	3	3
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	10	19	24	24
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	20	35	66	66
2009	*Phragmites australis*	Inside Microcosm	0	0	0	1	6	6	7	7	6	6	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	1	6	6	7	7	6	6	0	0
	Lythrum salicaria	Inside Microcosm	0	0	0	1	6	7	9	7	6	3	0	0
		Outside Microcosm	0	0	0	0	0	2	3	3	2	1	0	0
		Combined	0	0	0	1	6	9	12	10	8	4	0	0
	Filipendula ulmaria	Inside Microcosm	0	0	0	0	3	3	3	1	1	0	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	0	3	3	3	1	1	0	0	0
	Mentha aquatica	Inside Microcosm	13	13	15	17	18	6	9	8	8	7	6	6
		Outside Microcosm	0	0	0	0	0	1	1	1	1	1	0	0
		Combined	13	13	15	17	18	7	10	9	9	8	6	6
	Standing Dead or Dormant Vegetation	Inside Microcosm	21	19	19	11	9	6	6	6	7	8	15	15
		Outside Microcosm	2	2	2	2	0	0	0	0	0	0	0	0
		Combined	23	21	21	13	9	6	6	6	7	8	15	15
	Bare Ground or Leaf Litter	Inside Microcosm	66	68	66	70	58	72	66	71	72	76	79	79
2010	*Phragmites australis*	Inside Microcosm	0	0	0	1	7	7	10	10	10	7	0	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	0	0	0	1	7	7	10	10	10	7	0	N/A
	Lythrum salicaria	Inside Microcosm	0	0	0	4	13	13	13	11	9	6	0	N/A
		Outside Microcosm	0	0	0	0	0	3	3	2	2	0	0	N/A
		Combined	0	0	0	4	13	16	16	13	11	6	0	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	1	1	2	5	1	1	0	0	0	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	0	0	1	1	2	5	1	1	0	0	0	N/A
	Mentha aquatica	Inside Microcosm	5	5	5	5	5	9	7	4	3	3	3	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	5	5	5	5	5	9	7	4	3	3	3	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	14	14	14	14	7	7	7	9	9	15	24	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	1	N/A
		Combined	14	14	14	14	7	7	7	9	9	15	25	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	81	81	80	75	66	59	62	65	69	69	73	N/A

Table A 12.6: Microcosm 14 Vegetation Areas during the Salinity Treatment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11	11	11	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	11	11	11	0	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	33	26	9	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	12	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	45	26	9	0	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	21	0	0	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	24	0	0	0	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	24	18	0	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	3	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	27	21	0	0	0
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	8	16	30	29
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	8	9	4	3
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	16	25	34	32
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	10	37	64	70	71
2009	*Phragmites australis*	Inside Microcosm	0	0	0	1	4	6	7	7	7	7	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	1	4	6	7	7	7	7	0	0
	Lythrum salicaria	Inside Microcosm	0	0	0	0	3	1	5	5	4	4	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	0	3	1	5	5	4	4	0	0
	Filipendula ulmaria	Inside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	0	0	0	0	0	0	0	0	0
	Mentha aquatica	Inside Microcosm	0	0	0	0	1	0	0	0	0	0	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	0	1	0	0	0	0	0	0	0
	Standing Dead or Dormant Vegetation	Inside Microcosm	25	22	22	17	12	8	8	8	9	9	16	15
		Outside Microcosm	2	1	1	0	0	0	0	0	0	0	0	0
		Combined	27	23	23	17	12	8	8	8	9	9	16	15
	Bare Ground or Leaf Litter	Inside Microcosm	75	78	78	82	80	85	80	80	80	80	84	85
2010	*Phragmites australis*	Inside Microcosm	0	0	0	1	5	8	9	9	9	7	0	N/A
		Outside Microcosm	0	0	0	0	0	1	1	1	1	0	0	N/A
		Combined	0	0	0	1	5	9	10	10	10	7	0	N/A
	Lythrum salicaria	Inside Microcosm	0	0	0	1	1	5	6	4	3	1	0	N/A
		Outside Microcosm	0	0	0	0	0	1	1	0	0	0	0	N/A
		Combined	0	0	0	1	1	6	7	4	3	1	0	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	0	0	0	0	0	0	0	0	0	0	0	N/A
	Mentha aquatica	Inside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	0	0	0	0	0	0	0	0	0	0	0	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	13	13	13	13	8	8	8	9	9	11	19	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	1	1	N/A
		Combined	13	13	13	13	8	8	8	9	9	12	20	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	87	87	87	85	86	79	77	78	79	81	81	N/A

Table A 12.7: Microcosm 15 Vegetation Areas during the Salinity Treatment Period.

Year	Species	Cover (%)	January	February	March	April	May	June	July	August	September	October	November	December
2008	*Phragmites australis*	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	7	7	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7	7	7	0	0
	Lythrum salicaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	36	18	0	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	27	11	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	63	29	0	0	0
	Filipendula ulmaria	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	16	0	0	0	0
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	5	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	21	0	0	0	0
	Mentha aquatica	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	22	4	4	2	2
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3	0	0	0	0
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	25	4	4	2	2
	Standing Dead or Dormant Vegetation	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4	31	36	37	23
		Outside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	9	12	6	6
		Combined	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4	40	48	43	29
	Bare Ground or Leaf Litter	Inside Microcosm	N/A	N/A	N/A	N/A	N/A	N/A	N/A	15	40	53	61	75
2009	*Phragmites australis*	Inside Microcosm	0	0	0	1	3	3	3	3	3	3	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	1	3	3	3	3	3	3	0	0
	Lythrum salicaria	Inside Microcosm	0	0	0	0	0	1	0	0	0	0	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	0	0	1	0	0	0	0	0	0
	Filipendula ulmaria	Inside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	0	0	0	0	0	0	0	0	0	0	0	0
	Mentha aquatica	Inside Microcosm	2	2	2	1	1	0	0	0	0	0	0	0
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	0
		Combined	2	2	2	1	1	0	0	0	0	0	0	0
	Standing Dead or Dormant Vegetation	Inside Microcosm	18	16	12	11	10	9	9	9	9	9	12	12
		Outside Microcosm	4	2	2	1	1	1	1	1	1	1	1	1
		Combined	22	18	14	12	11	10	10	10	10	10	13	13
	Bare Ground or Leaf Litter	Inside Microcosm	80	82	86	87	86	87	88	88	88	88	88	88
2010	*Phragmites australis*	Inside Microcosm	0	0	0	1	5	7	8	8	8	4	0	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	0	0	0	1	5	7	8	8	8	4	0	N/A
	Lythrum salicaria	Inside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	0	0	0	0	0	0	0	0	0	0	0	N/A
	Filipendula ulmaria	Inside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	0	0	0	0	0	0	0	0	0	0	0	N/A
	Mentha aquatica	Inside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	0	0	0	0	0	0	0	0	0	0	0	N/A
	Standing Dead or Dormant Vegetation	Inside Microcosm	10	10	10	10	7	7	7	7	7	11	15	N/A
		Outside Microcosm	0	0	0	0	0	0	0	0	0	0	0	N/A
		Combined	10	10	10	10	7	7	7	7	7	11	15	N/A
	Bare Ground or Leaf Litter	Inside Microcosm	90	90	90	89	88	86	85	85	85	85	85	N/A

Table A 12.8: Microcosm 16 Vegetation Areas during the Salinity Treatment Period.

Appendix 13 Harvest Measurements for the Full Competition Microcosms with Nutrient Treatment

Species	Parameter		Microcosm			
			1	2	3	4
Phragmites australis	Total Stems	Total Number of Stems	286	396	557	681
		Stems with Evidence of Previous Inflorescence	33	44	67	112
	Heights (mm)	Max Height	1721.00	1742.00	2088.00	2270.00
		Min Height	86.00	97.00	92.00	15.00
		Mean Height	796.21	863.62	1141.03	1055.19
	Widths (mm)	Max Width	5.00	4.90	6.50	6.80
		Min Width	1.40	0.90	1.30	1.20
		Mean Width	2.64	2.84	3.39	3.33
Lythrum salicaria	Total Stems	Total Number of Stems	243	181	161	216
		Stems with Evidence of Previous Inflorescence	105	90	70	81
	Heights (mm)	Max Height	1937.00	2077.00	1923.00	1867.00
		Min Height	125.00	161.00	91.00	58.00
		Mean Height	922.60	1090.13	979.32	897.00
	Widths (mm)	Max Width	8.70	11.50	9.50	30.00
		Min Width	0.80	1.00	1.00	0.70
		Mean Width	3.08	3.87	3.67	3.75
Filipendula ulmaria	Total Stems	Total Number of Stems	240	233	192	235
		Stems with Evidence of Previous Inflorescence	0	9	5	7
	Heights (mm)	Max Height	677.00	1602.00	1509.00	1416.00
		Min Height	28.00	10.00	12.00	26.00
		Mean Height	281.98	345.65	292.18	354.45
	Widths (mm)	Max Width	12.00	42.00	8.70	9.10
		Min Width	0.10	0.10	0.20	0.20
		Mean Width	1.14	1.59	1.41	1.49
Mentha aquatica	Total Stems	Total Number of Stems	255	41	52	86
		Stems with Evidence of Previous Inflorescence	54	1	6	6
	Heights (mm) *	Max Height	723.00	593.00	621.00	876.00
		Min Height	14.00	63.00	40.00	63.00
		Mean Height	277.25	218.73	229.48	289.69
	Widths (mm)	Max Width	3.80	2.00	2.40	3.00
		Min Width	0.30	0.40	0.20	0.40
		Mean Width	1.36	1.00	0.90	1.14

Notes: * = this is the length of the stoloniferous live material present and is not the height above ground as the stolons had set roots along the procumbent stems.

Table A 13.1: Microcosms 1-4 Nutrient Treatment Phase with Full Competition – Stem Measurements for All Stems.

		Microcosm			
Species	**Parameter**	**1**	**2**	**3**	**4**
Phragmites australis	volume (ml)	1025.00	1930.00	3050.00	4570.00
	weight (g)	253.86	418.90	629.18	997.39
	g per ml	0.248	0.217	0.206	0.218
Lythrum salicaria	volume (ml)	1840.00	1965.00	1580.00	1873.00
	weight (g)	567.44	546.97	490.79	592.09
	g per ml	0.308	0.278	0.311	0.316
Filipendula ulmaria	volume (ml)	220.00	570.00	330.00	390.00
	weight (g)	63.45	136.49	78.77	95.97
	g per ml	0.288	0.239	0.239	0.246
Mentha aquatica	volume (ml)	345.00	18.00	21.00	47.00
	weight (g)	82.91	3.72	4.87	13.58
	g per ml	0.240	0.207	0.232	0.289

Table A 13.2: Microcosms 1-4 Nutrient Treatment Phase with Full Competition – Volumes and Weights for All Stems.

	Microcosm Number			
Species	**1**	**2**	**3**	**4**
Phragmites australis	425.89	711.97	1159.49	2168.09
Mentha aquatica	16.88	0.7	0.85	2.12
Filipendula ulmaria	186.54	360.45	199.47	221.71
Lythrum salicaria	661.24	422.72	258.48	252.65

Table A 13.3: Microcosms 1-4 Nutrient Treatment Phase with Full Competition – Weights (g) for All Roots.

Appendix 14 Harvest Measurements for the Full Competition Microcosms with Salinity Treatment

Species	Parameter		Microcosm			
			5	6	7	8
Phragmites australis	Total Stems	Total Number of Stems	173	217	241	301
		Stems with Evidence of Previous Inflorescence	20	30	13	12
	Heights (mm)	Max Height	1184.00	1712.00	1774.00	1892.00
		Min Height	10.00	85.00	44.00	116.00
		Mean Height	519.42	784.58	766.92	760.59
	Widths (mm)	Max Width	3.70	5.00	4.70	5.40
		Min Width	0.70	0.90	0.70	0.50
		Mean Width	1.96	2.55	2.29	2.50
Lythrum salicaria	Total Stems	Total Number of Stems	188	130	160	b
		Stems with Evidence of Previous Inflorescence	55	47	50	b
	Heights (mm)	Max Height	1672.00	1955.00	1824.00	b
		Min Height	122.00	43.00	73.00	b
		Mean Height	823.79	876.87	882.42	b
	Widths (mm)	Max Width	12.50	7.40	9.50	b
		Min Width	0.20	0.50	0.60	b
		Mean Width	3.00	2.91	3.29	b
Filipendula ulmaria	Total Stems	Total Number of Stems	5	6	b	b
		Stems with Evidence of Previous Inflorescence	0	0	b	b
	Heights (mm)	Max Height	1584.00	1074.00	b	b
		Min Height	862.00	381.00	b	b
		Mean Height	1228.20	796.00	b	b
	Widths (mm)	Max Width	8.60	6.10	b	b
		Min Width	5.50	1.10	b	b
		Mean Width	6.88	3.68	b	b
Mentha aquatica	Total Stems	Total Number of Stems	114	b	b	b
		Stems with Evidence of Previous Inflorescence	0	b	b	b
	Heights (mm) *	Max Height	532.00	b	b	b
		Min Height	23.00	b	b	b
		Mean Height	179.22	b	b	b
	Widths (mm)	Max Width	1.90	b	b	b
		Min Width	0.20	b	b	b
		Mean Width	0.73	b	b	b

Notes: * = this is the length of the stoloniferous live material present and is not the height above ground as the stolons had set roots along the procumbent stems.

b = no plants present

Table A 14.1: Microcosms 5-8 Salinity Treatment Phase with Full Root Competition – Stem Measurements for All Stems.

		Microcosm			
Species	**Parameter**	**5**	**6**	**7**	**8**
Phragmites australis	volume (ml)	360.00	1020.00	1110.00	1540.00
	weight (g)	73.32	217.75	209.31	306.89
	g per ml	0.204	0.213	0.189	0.199
Mentha aquatica	volume (ml)	61.00	no stems	no stems	no stems
	weight (g)	10.22	no stems	no stems	no stems
	g per ml	0.168	no stems	no stems	no stems
Filipendula ulmaria	volume (ml)	301.00	35.00	no stems	no stems
	weight (g)	58.78	13.66	no stems	no stems
	g per ml	0.195	0.390	no stems	no stems
Lythrum salicaria	volume (ml)	1145.00	720.00	1330.00	no stems
	weight (g)	361.16	225.84	387.83	no stems
	g per ml	0.315	0.314	0.292	no stems

Table A 14.2: Microcosms 5-8 Salinity Treatment Phase with Full Competition – Volumes and Weights for All Stems.

	Microcosm Number			
Species	**5**	**6**	**7**	**8**
Phragmites australis	121.15	308.22	277.41	418.06
Mentha aquatica	2.09	0	0	0
Filipendula ulmaria	176.02	39.9	0	0
Lythrum salicaria	430.14	192.56	314.9	0

Table A 14.3: Microcosms 5-8 Salinity Treatment Phase with Full Competition – Weights (g) for All Roots.

Appendix 15 Root Spread Photographs for the Full Competition Microcosms with Nutrient Treatment

Figure A 15.1: Microcosm 1 *Lythrum salicaria* Root Spread

Figure A 15.2: Microcosm 1 *Filipendula ulmaria* Root Spread

Figure A 15.3: Microcosm 1 *Mentha aquatica* Root Spread

Figure A 15.4: Microcosm 2 *Lythrum salicaria* Root Spread

Figure A 15.5: Microcosm 2 *Filipendula ulmaria* Root Spread

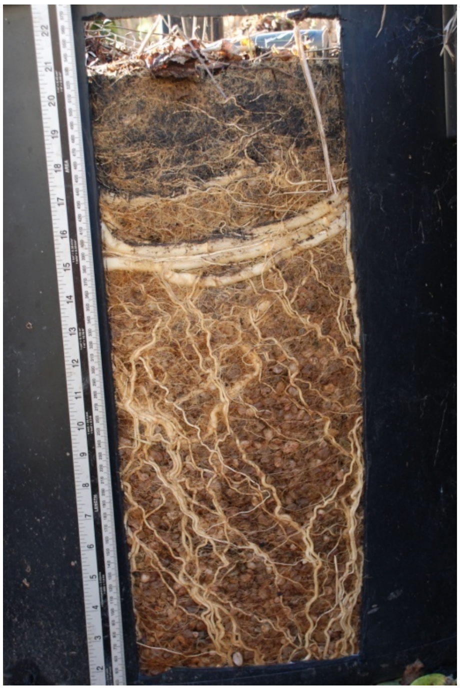


Figure A 15.6: Microcosm 2 *Mentha aquatica* Root Spread

Figure A 15.7: Microcosm 3 *Lythrum salicaria* Root Spread

Figure A 15.8: Microcosm 3 *Filipendula ulmaria* Root Spread

Figure A 15.9: Microcosm 3 *Mentha aquatica* Root Spread

Figure A 15.10: Microcosm 4 *Lythrum salicaria* Root Spread

Figure A 15.11: Microcosm 4 *Filipendula ulmaria* Root Spread

Figure A 15.12: Microcosm 4 *Mentha aquatica* Root Spread

Appendix 16 Root Spread Photographs for the Full Competition Microcosms with Salinity Treatment

Figure A 16.1: Microcosm 5 *Lythrum salicaria* Root Spread

Figure A 16.2: Microcosm 5 *Filipendula ulmaria* Root Spread

Figure A 16.3: Microcosm 5 *Mentha aquatica* Root Spread

Figure A 16.4: Microcosm 6 *Lythrum salicaria* Root Spread

Figure A 16.5: Microcosm 6 *Filipendula ulmaria* Root Spread

Figure A 16.6: Microcosm 6 *Mentha aquatica* Root Spread

Figure A 16.7: Microcosm 7 *Lythrum salicaria* Root Spread

Figure A 16.8: Microcosm 7 *Filipendula ulmaria* Root Spread

Figure A 16.9: Microcosm 7 *Mentha aquatica* Root Spread

Figure A 16.10: Microcosm 8 *Lythrum salicaria* Root Spread

Figure A 16.11: Microcosm 8 *Filipendula ulmaria* Root Spread

Figure A 16.12: Microcosm 8 *Mentha aquatica* Root Spread

Appendix 17 Harvest Measurements for the Restricted Competition Microcosms with Nutrient Treatment

Species	Parameter		Microcosm			
			9	10	11	12
Phragmites australis	Total Stems	Total Number of Stems	384	404	491	761
		Stems with Evidence of Previous Inflorescence	10	36	29	84
	Heights (mm)	Max Height	1269.00	2016.00	2037.00	2127.00
		Min Height	71.00	105.00	58.00	121.00
		Mean Height	536.63	910.21	906.77	959.14
	Widths (mm)	Max Width	4.10	5.40	6.30	6.50
		Min Width	0.40	1.00	1.00	0.80
		Mean Width	1.78	2.59	2.72	2.71
Lythrum salicaria	Total Stems	Total Number of Stems	190	225	201	179
		Stems with Evidence of Previous Inflorescence	63	78	69	48
	Heights (mm)	Max Height	1674.00	1829.00	1908.00	1816.00
		Min Height	170.00	101.00	153.00	111.00
		Mean Height	827.45	968.16	991.75	935.47
	Widths (mm)	Max Width	8.50	7.60	7.40	8.70
		Min Width	0.70	0.40	0.40	1.00
		Mean Width	2.70	2.82	3.07	3.44
Filipendula ulmaria	Total Stems	Total Number of Stems	59	61	102	46
		Stems with Evidence of Previous Inflorescence	2	0	0	0
	Heights (mm)	Max Height	716.00	1403.00	1316.00	1260.00
		Min Height	120.00	28.00	86.00	190.00
		Mean Height	268.53	413.30	407.34	487.70
	Widths (mm)	Max Width	3.60	7.70	6.80	4.70
		Min Width	0.20	0.10	0.30	0.20
		Mean Width	0.86	1.44	1.32	1.64
Mentha aquatica	Total Stems	Total Number of Stems	258	180	61	9
		Stems with Evidence of Previous Inflorescence	22	11	6	0
	Heights (mm) *	Max Height	1059.00	1081.00	766.00	438.00
		Min Height	15.00	54.00	40.00	25.00
		Mean Height	278.83	340.84	312.52	151.44
	Widths (mm)	Max Width	2.90	3.70	4.10	1.20
		Min Width	0.20	0.50	0.30	0.70
		Mean Width	1.03	1.36	1.22	0.92

Notes: * = this is the length of the stoloniferous live material present and is not the height above ground as the stolons had set roots along the procumbent stems.

Table A 17.1: Microcosms 9-12 Nutrient Treatment Phase with Restricted Root Competition – Stem Measurements for All Stems.

		Microcosm			
Species	**Parameter**	**9**	**10**	**11**	**12**
Phragmites australis	volume (ml)	840.00	2339.00	3180.00	4910.00
	weight (g)	173.15	468.55	638.96	1027.20
	g per ml	0.206	0.200	0.201	0.209
Mentha aquatica	volume (ml)	272.00	244.00	55.00	27.00
	weight (g)	63.47	56.09	11.12	6.28
	g per ml	0.233	0.230	0.202	0.233
Filipendula ulmaria	volume (ml)	25.00	135.00	169.00	104.00
	weight (g)	9.25	39.82	51.47	29.95
	g per ml	0.370	0.295	0.305	0.288
Lythrum salicaria	volume (ml)	1060.00	1735.00	1570.00	1740.00
	weight (g)	305.43	556.96	455.43	460.30
	g per ml	0.288	0.321	0.290	0.265

Table A 17.2: Microcosms 9-12 Nutrient Treatment Phase with Restricted Root Competition – Volumes and Weights for All Stems.

	Microcosm Number			
Species	**9**	**10**	**11**	**12**
Phragmites australis	307.04	830.04	1210.4	2220.77
Mentha aquatica	14.22	13.45	2.07	1.01
Filipendula ulmaria	27.09	105.17	128.86	71.77
Lythrum salicaria	382.21	878.79	652.35	703.3

Table A 17.3: Microcosms 9-12 Nutrient Treatment Phase with Restricted Root Competition – Weights (g) for All Roots.

Appendix 18 Harvest Measurements for the Restricted Competition Microcosms with Salinity Treatment

Species	Parameter		Microcosm			
			13	14	15	16
Phragmites australis	Total Stems	Total Number of Stems	305	251	367	255
		Stems with Evidence of Previous Inflorescence	32	9	19	4
	Heights (mm)	Max Height	1740.00	1413.00	1675.00	1687.00
		Min Height	218.00	110.00	30.00	70.00
		Mean Height	808.81	662.49	706.08	546.87
	Widths (mm)	Max Width	6.00	5.10	5.60	4.20
		Min Width	0.20	0.50	0.60	0.50
		Mean Width	2.46	2.05	2.04	1.87
Lythrum salicaria	Total Stems	Total Number of Stems	210	117	80	b
		Stems with Evidence of Previous Inflorescence	54	44	32	b
	Heights (mm)	Max Height	1778.00	1753.00	1926.00	b
		Min Height	204.00	148.00	160.00	b
		Mean Height	830.51	760.62	969.63	b
	Widths (mm)	Max Width	7.60	6.80	9.20	b
		Min Width	0.30	0.40	0.90	b
		Mean Width	2.73	2.77	3.84	b
Filipendula ulmaria	Total Stems	Total Number of Stems	103	b	b	b
		Stems with Evidence of Previous Inflorescence	6	b	b	b
	Heights (mm)	Max Height	1049.00	b	b	b
		Min Height	20.00	b	b	b
		Mean Height	319.23	b	b	b
	Widths (mm)	Max Width	3.60	b	b	b
		Min Width	0.20	b	b	b
		Mean Width	1.09	b	b	b
Mentha aquatica	Total Stems	Total Number of Stems	213	18	b	b
		Stems with Evidence of Previous Inflorescence	7	0	b	b
	Heights (mm) *	Max Height	1049.00	229.00	b	b
		Min Height	33.00	9.00	b	b
		Mean Height	208.12	62.78	b	b
	Widths (mm)	Max Width	2.60	1.80	b	b
		Min Width	0.20	0.30	b	b
		Mean Width	1.01	0.95	b	b

Notes: * = this is the length of the stoloniferous live material present and is not the height above ground as the stolons had set roots along the procumbent stems.

b = no plants present

Table A 18.1: Microcosms 13-16 Salinity Treatment Phase with Restricted Root Competition – Stem Measurements for All Stems.

		Microcosm			
Species	**Parameter**	**13**	**14**	**15**	**16**
Phragmites australis	volume (ml)	1480.00	810.00	1390.00	690.00
	weight (g)	284.96	163.53	265.40	121.14
	g per ml	0.193	0.202	0.191	0.176
Mentha aquatica	volume (ml)	109.00	29.00	no stems	no stems
	weight (g)	26.98	6.31	no stems	no stems
	g per ml	0.248	0.218	no stems	no stems
Filipendula ulmaria	volume (ml)	135.00	no stems	no stems	no stems
	weight (g)	29.21	no stems	no stems	no stems
	g per ml	0.216	no stems	no stems	no stems
Lythrum salicaria	volume (ml)	1205.00	700.00	937.00	no stems
	weight (g)	329.94	190.08	308.72	no stems
	g per ml	0.274	0.272	0.329	no stems

Table A 18.2: Microcosms 13-16 Salinity Treatment Phase with Restricted Root Competition – Volumes and Weights for All Stems.

	Microcosm Number			
Species	**13**	**14**	**15**	**16**
Phragmites australis	499.86	234.53	361.06	160.83
Mentha aquatica	6.23	1.49	0	0
Filipendula ulmaria	86.66	0	0	0
Lythrum salicaria	403.58	201.87	296.34	0

Table A 18.3: Microcosms 13-16 Salinity Treatment Phase with Restricted Root Competition – Weights (g) for All Roots.

Appendix 19 Root Spread Photographs for the Restricted Competition Microcosms with Nutrient Treatment

Figure A 19.1: Microcosm 9 *Lythrum salicaria* Root Spread

Figure A 19.2: Microcosm 9 *Filipendula ulmaria* Root Spread

Figure A 19.3: Microcosm 9 *Mentha aquatica* Root Spread

Figure A 19.4: Microcosm 9 *Phragmites australis* Root Spread

Figure A 19.5: Microcosm 10 *Lythrum salicaria* Root Spread

Figure A 19.6: Microcosm 10 *Filipendula ulmaria* Root Spread

Figure A 19.7: Microcosm 10 *Mentha aquatica* Root Spread

Figure A 19.8: Microcosm 10 *Phragmites australis* Root Spread

Figure A 19.9: Microcosm 11 *Lythrum salicaria* Root Spread

Figure A 19.10: Microcosm 11 *Filipendula ulmaria* Root Spread

Figure A 19.11: Microcosm 11 *Mentha aquatica* Root Spread

Figure A 19.12: Microcosm 11 *Phragmites australis* Root Spread

Figure A 19.13: Microcosm 12 *Lythrum salicaria* Root Spread

Figure A 19.14: Microcosm 12 *Filipendula ulmaria* Root Spread

Figure A 19.15: Microcosm 12 *Mentha aquatica* Root Spread

Figure A 19.16: Microcosm 12 *Phragmites australis* Root Spread

Appendix 20 Root Spread Photographs for the Restricted Competition Microcosms with Salinity Treatment

Figure A 20.1: Microcosm 13 *Lythrum salicaria* Root Spread

Figure A 20.2: Microcosm 13 *Filipendula ulmaria* Root Spread

Figure A 20.3: Microcosm 13 *Mentha aquatica* Root Spread

Figure A 20.4: Microcosm 13 *Phragmites australis* Root Spread

Figure A 20.5: Microcosm 14 *Lythrum salicaria* Root Spread

Figure A 20.6: Microcosm 14 *Filipendula ulmaria* Root Spread

Figure A 20.7: Microcosm 14 *Mentha aquatica* Root Spread (Humus Layer Bottom Right)

Figure A 20.8: Microcosm 14 *Phragmites australis* Root Spread

Figure A 20.9: Microcosm 15 *Lythrum salicaria* Root Spread

Figure A 20.10: Microcosm 15 *Filipendula ulmaria* Root Spread

Figure A 20.11: Microcosm 15 *Mentha aquatica* Root Spread

Figure A 20.12: Microcosm 15 *Phragmites australis* Root Spread

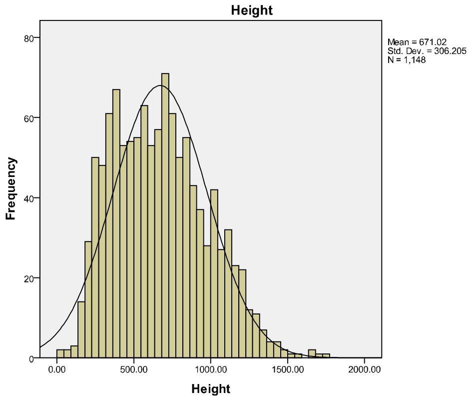
Figure A 20.13: Microcosm 16 *Lythrum salicaria* Root Spread

Figure A 20.14: Microcosm 16 *Filipendula ulmaria* Root Spread

Figure A 20.15: Microcosm 16 *Mentha aquatica* Root Spread (Right Hand Side)

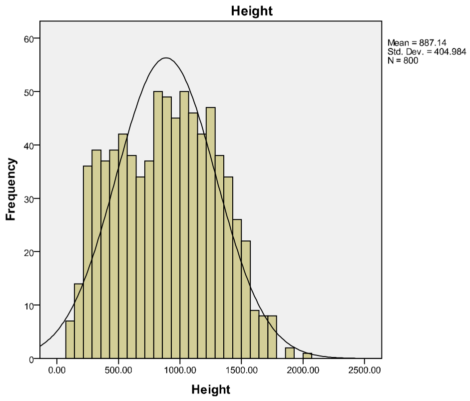
Figure A 20.16: Microcosm 16 *Phragmites australis* Root Spread

Appendix 21 Histogram and Data Heights for All Microcosms and Full Competition Microcosms



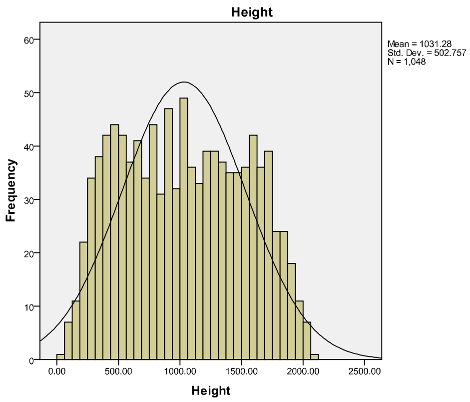
N	Valid	1148
	Missing	0
Mean		671.0183
Std. Error of Mean		9.03736
Median		646.0000
Std. Deviation		306.20503
Variance		93761.519
Range		1730.00
Minimum		10.00
Maximum		1740.00

10 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	800
	Missing	0
Mean		887.1450
Std. Error of Mean		14.31835
Median		900.5000
Std. Deviation		404.98402
Variance		164012.059
Range		1919.00
Minimum		97.00
Maximum		2016.00

50 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	1048
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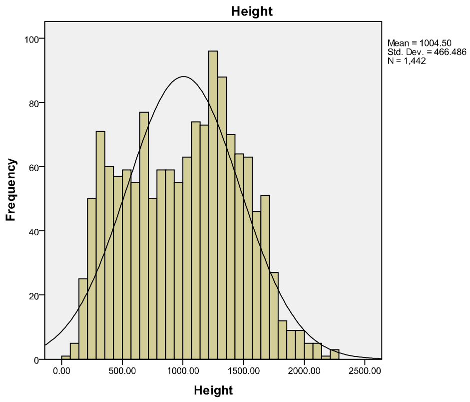
Mean		1031.2758
Std. Error of Mean		15.53021
Median		1018.0000
Std. Deviation		502.75673
Variance		252764.328
Range		2030.00
Minimum		58.00
Maximum		2088.00

100 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	1442
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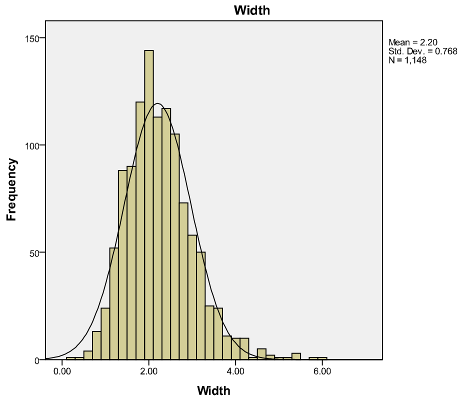
Mean		1004.5000
Std. Error of Mean		12.28447
Median		1041.0000
Std. Deviation		466.48642
Variance		217609.577
Range		2255.00
Minimum		15.00
Maximum		2270.00

150 mg/L Nitrogen and <0.05 ‰ Salinity

Figure A 21.1: *Phragmites australis* Histogram and Data of Stem Heights with Increasing Nutrients



N	Valid	1148
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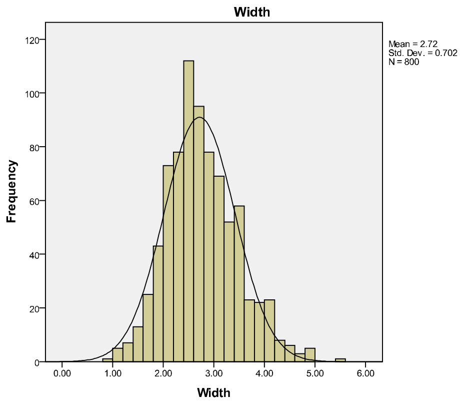
Mean		2.2012
Std. Error of Mean		.02266
Median		2.1000
Std. Deviation		.76768
Variance		.589
Range		5.80
Minimum		.20
Maximum		6.00

10 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	800
	Missing	0
Mean		2.7152
Std. Error of Mean		.02481
Median		2.6000
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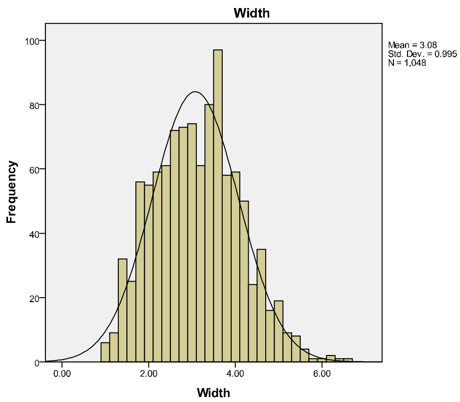
Variance		.492
Range		4.50
Minimum		.90
Maximum		5.40

50 mg/L Nitrogen and <0.05 ‰ Salinity



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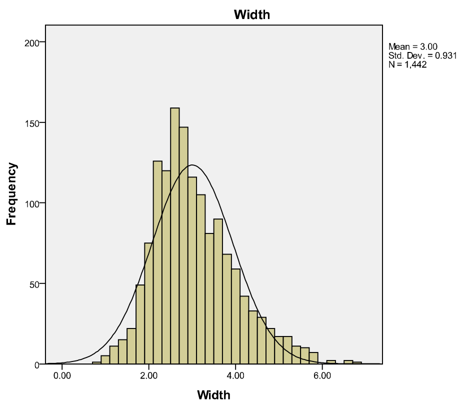
Mean		3.0752
Std. Error of Mean		.03074
Median		3.1000
Std. Deviation		.99499
Variance		.990
Range		5.50
Minimum		1.00
Maximum		6.50

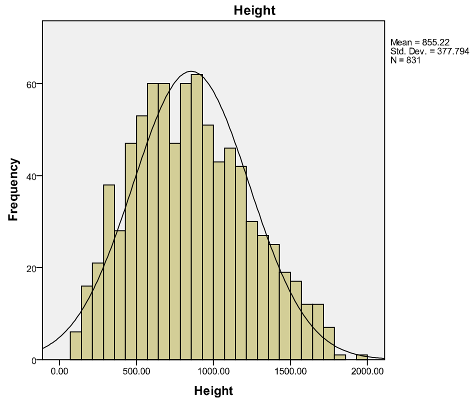
100 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	1442
	Missing	0
Mean		3.0042
Std. Error of Mean		.02453
Median		2.8000
Std. Deviation		.93137
Variance		.867
Range		6.00
Minimum		.80
Maximum		6.80

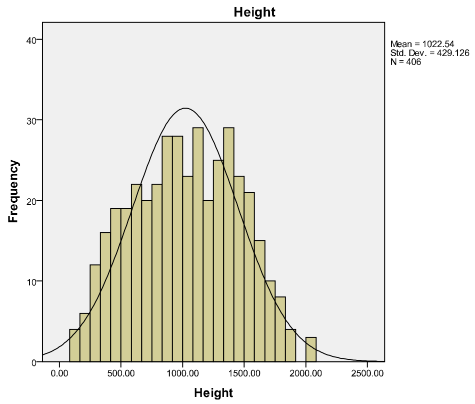
150 mg/L Nitrogen and <0.05 ‰ Salinity

Figure A 21.2: *Phragmites australis* Histogram and Data of Stem Widths with Increasing Nutrients



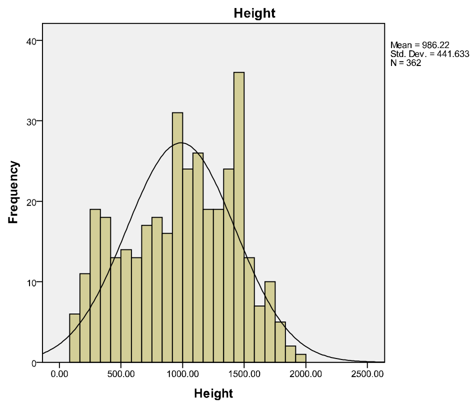
N	Valid	831
	Missing	0
Mean		855.2190
Std. Error of Mean		13.10552
Median		833.0000
Std. Deviation		377.79381
Variance		142728.162
Range		1815.00
Minimum		122.00
Maximum		1937.00

10 mg/L Nitrogen and <0.05 ‰ Salinity



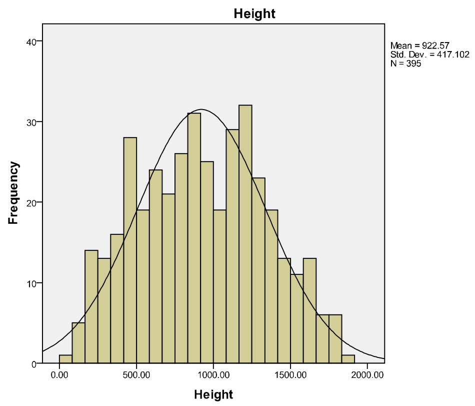
N	Valid	406
	Missing	0
Mean		1022.5369
Std. Error of Mean		21.29719
Median		1027.5000
Std. Deviation		429.12650
Variance		184149.553
Range		1976.00
Minimum		101.00
Maximum		2077.00

50 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	362
	Missing	0
Mean		986.2210
Std. Error of Mean		23.21169
Median		1014.0000
Std. Deviation		441.63255
Variance		195039.308
Range		1832.00
Minimum		91.00
Maximum		1923.00

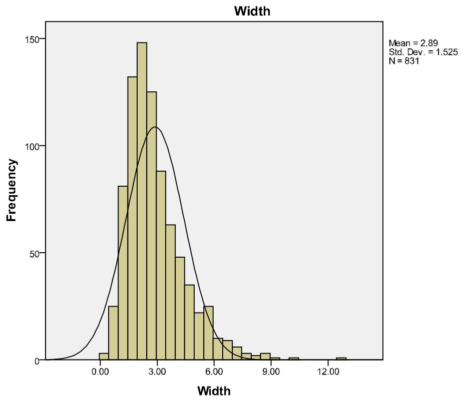
100 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	395
	Missing	0
Mean		922.5671
Std. Error of Mean		20.98670
Median		913.0000
Std. Deviation		417.10249
Variance		173974.490
Range		1809.00
Minimum		58.00
Maximum		1867.00

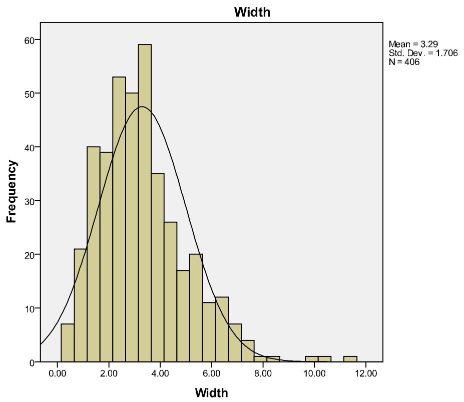
150 mg/L Nitrogen and <0.05 ‰ Salinity

Figure A 21.3: *Lythrum salicaria* Histogram and Data of Stem Heights with Increasing Nutrients



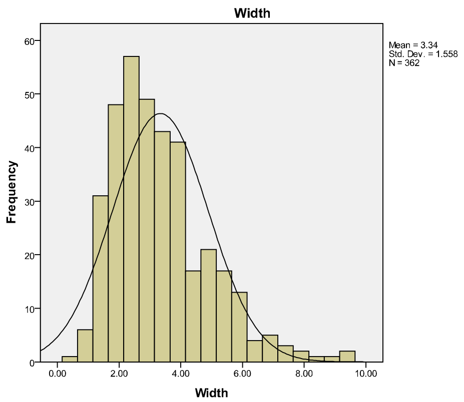
N	Valid	831
	Missing	0
Mean		2.8857
Std. Error of Mean		.05290
Median		2.5000
Std. Deviation		1.52494
Variance		2.325
Range		12.30
Minimum		.20
Maximum		12.50

10 mg/L Nitrogen and <0.05 ‰ Salinity



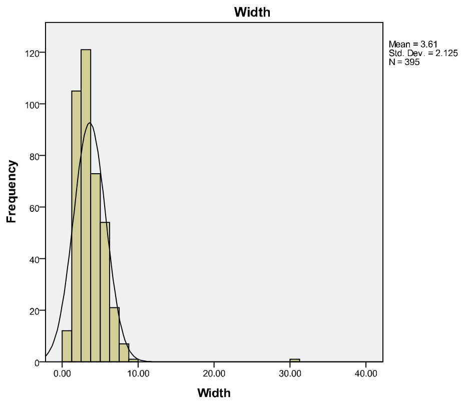
N	Valid	406
	Missing	0
Mean		3.2926
Std. Error of Mean		.08466
Median		3.0000
Std. Deviation		1.70595
Variance		2.910
Range		11.10
Minimum		.40
Maximum		11.50

50 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	362
	Missing	0
Mean		3.3378
Std. Error of Mean		.08190
Median		3.0000
Std. Deviation		1.55817
Variance		2.428
Range		9.10
Minimum		.40
Maximum		9.50

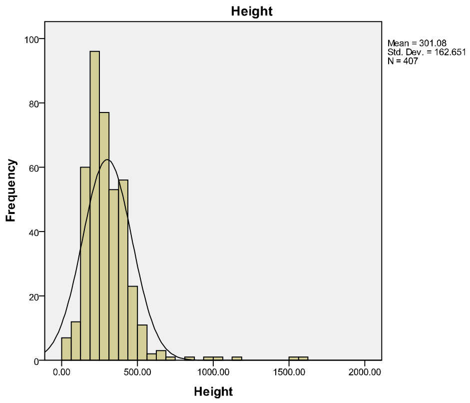
100 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	395
	Missing	0
Mean		3.6106
Std. Error of Mean		.10691
Median		3.2000
Std. Deviation		2.12477
Variance		4.515
Range		29.30
Minimum		.70
Maximum		30.00

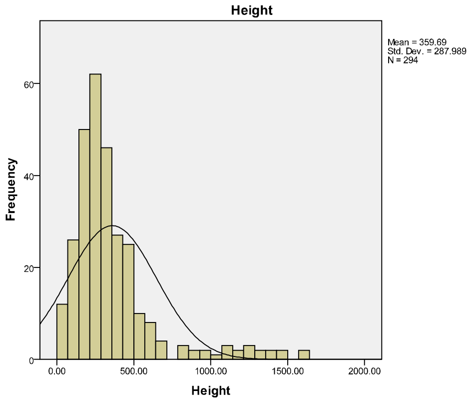
150 mg/L Nitrogen and <0.05 ‰ Salinity

Figure A 21.4: *Lythrum salicaria* Histogram and Data of Stem Widths with Increasing Nutrients



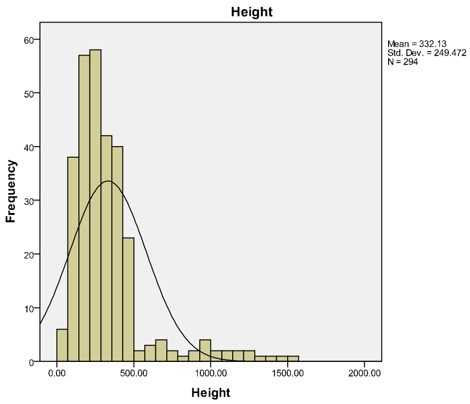
N	Valid	407
	Missing	0
Mean		301.0786
Std. Error of Mean		8.06232
Median		277.0000
Std. Deviation		162.65112
Variance		26455.388
Range		1564.00
Minimum		20.00
Maximum		1584.00

10 mg/L Nitrogen and <0.05 ‰ Salinity



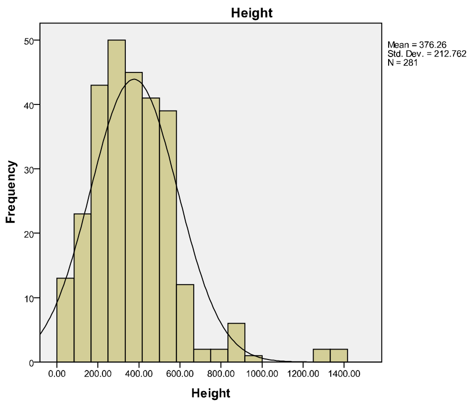
N	Valid	294
	Missing	0
Mean		359.6871
Std. Error of Mean		16.79588
Median		283.0000
Std. Deviation		287.98941
Variance		82937.902
Range		1592.00
Minimum		10.00
Maximum		1602.00

50 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	294
	Missing	0
Mean		332.1327
Std. Error of Mean		14.54949
Median		267.0000
Std. Deviation		249.47177
Variance		62236.163
Range		1497.00
Minimum		12.00
Maximum		1509.00

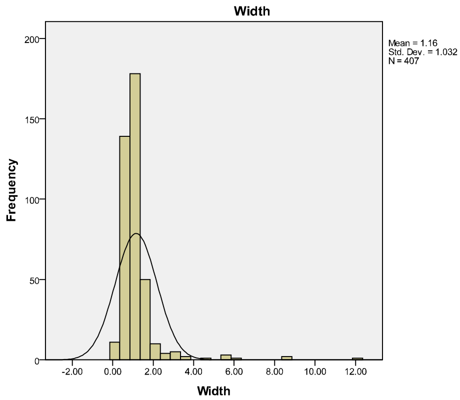
100 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	281
	Missing	0
Mean		376.2598
Std. Error of Mean		12.69229
Median		350.0000
Std. Deviation		212.76160
Variance		45267.500
Range		1390.00
Minimum		26.00
Maximum		1416.00

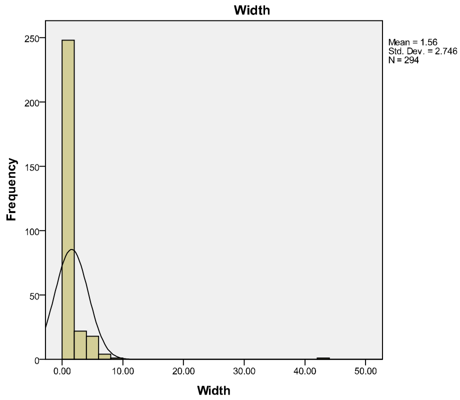
150 mg/L Nitrogen and <0.05 ‰ Salinity

Figure A 21.5: *Filipendula ulmaria* Histogram and Data of Stem Heights with Increasing Nutrients



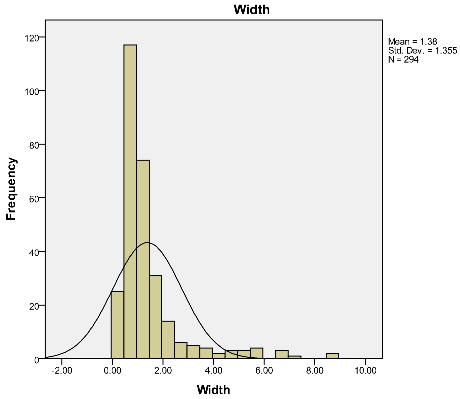
N	Valid	407
	Missing	0
Mean		1.1553
Std. Error of Mean		.05115
Median		1.0000
Std. Deviation		1.03201
Variance		1.065
Range		11.90
Minimum		.10
Maximum		12.00

10 mg/L Nitrogen and <0.05 ‰ Salinity



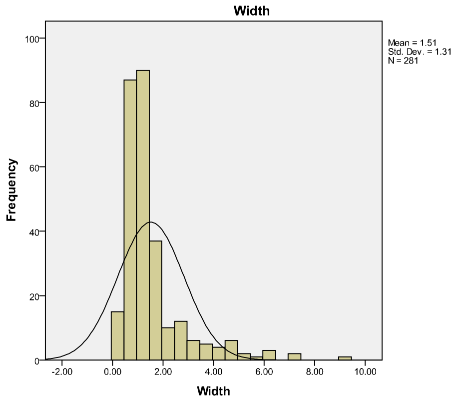
N	Valid	294
	Missing	0
Mean		1.5599
Std. Error of Mean		.16015
Median		1.0000
Std. Deviation		2.74596
Variance		7.540
Range		41.90
Minimum		.10
Maximum		42.00

50 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	294
	Missing	0
Mean		1.3779
Std. Error of Mean		.07903
Median		1.0000
Std. Deviation		1.35511
Variance		1.836
Range		8.50
Minimum		.20
Maximum		8.70

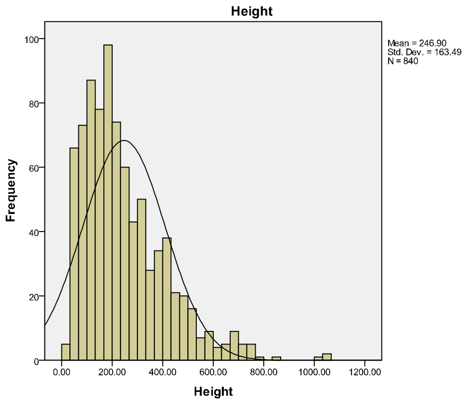
100 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	281
	Missing	0
Mean		1.5139
Std. Error of Mean		.07812
Median		1.1000
Std. Deviation		1.30952
Variance		1.715
Range		8.90
Minimum		.20
Maximum		9.10

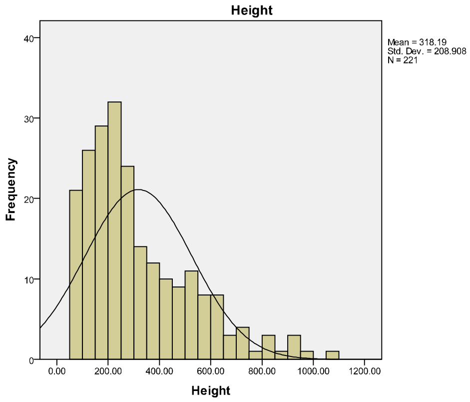
150 mg/L Nitrogen and <0.05 ‰ Salinity

Figure A 21.6: *Filipendula ulmaria* Histogram and Data of Stem Widths with Increasing Nutrients



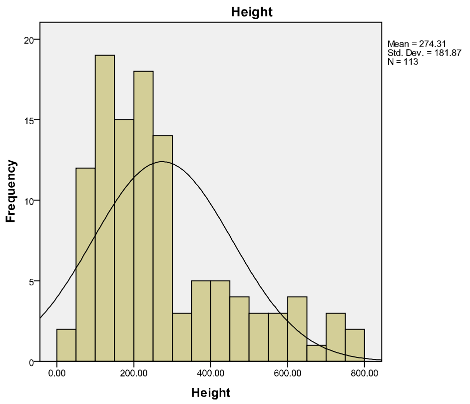
N	Valid	840
	Missing	0
Mean		246.9024
Std. Error of Mean		5.64096
Median		205.0000
Std. Deviation		163.49049
Variance		26729.142
Range		1045.00
Minimum		14.00
Maximum		1059.00

10 mg/L Nitrogen and <0.05 ‰ Salinity



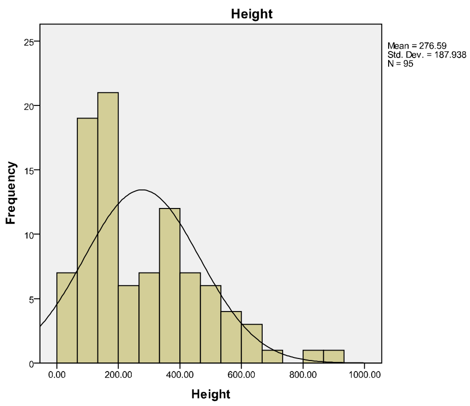
N	Valid	221
	Missing	0
Mean		318.1900
Std. Error of Mean		14.05264
Median		252.0000
Std. Deviation		208.90753
Variance		43642.355
Range		1027.00
Minimum		54.00
Maximum		1081.00

50 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	113
	Missing	0
Mean		274.3097
Std. Error of Mean		17.10888
Median		228.0000
Std. Deviation		181.86986
Variance		33076.644
Range		726.00
Minimum		40.00
Maximum		766.00

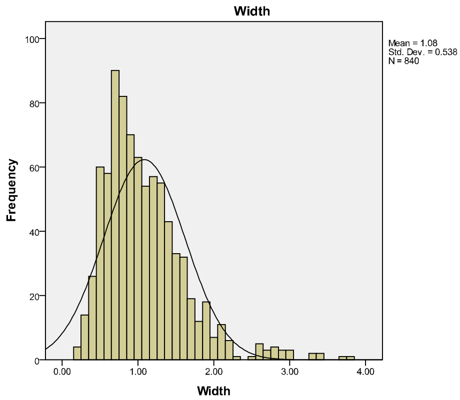
100 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	95
	Missing	0
Mean		276.5895
Std. Error of Mean		19.28205
Median		212.0000
Std. Deviation		187.93817
Variance		35320.755
Range		851.00
Minimum		25.00
Maximum		876.00

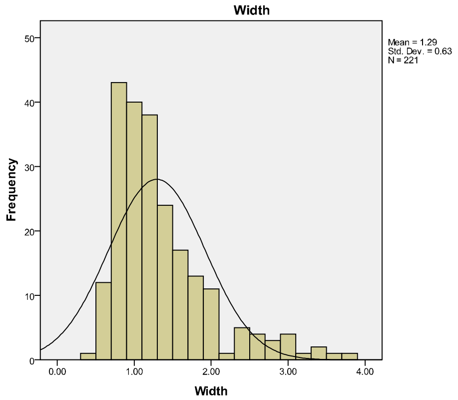
150 mg/L Nitrogen and <0.05 ‰ Salinity

Figure A 21.7: *Mentha aquatica* Histogram and Data of Stem Heights with Increasing Nutrients



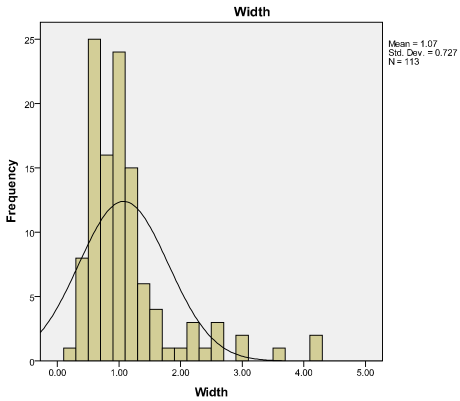
N	Valid	840
	Missing	0
Mean		1.0823
Std. Error of Mean		.01856
Median		1.0000
Std. Deviation		.53798
Variance		.289
Range		3.60
Minimum		.20
Maximum		3.80

10 mg/L Nitrogen and <0.05 ‰ Salinity



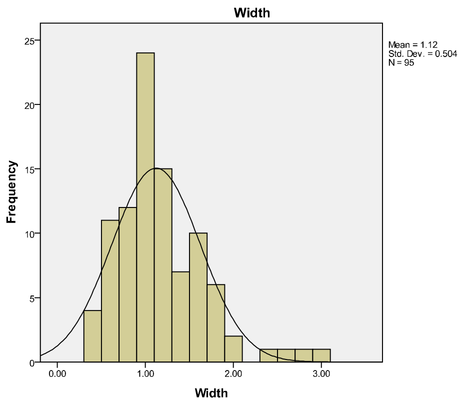
N	Valid	221
	Missing	0
Mean		1.2941
Std. Error of Mean		.04236
Median		1.1000
Std. Deviation		.62965
Variance		.396
Range		3.30
Minimum		.40
Maximum		3.70

50 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	113
	Missing	0
Mean		1.0743
Std. Error of Mean		.06843
Median		1.0000
Std. Deviation		.72737
Variance		.529
Range		3.90
Minimum		.20
Maximum		4.10

100 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	95
	Missing	0
Mean		1.1211
Std. Error of Mean		.05167
Median		1.0000
Std. Deviation		.50358
Variance		.254
Range		2.60
Minimum		.40
Maximum		3.00

150 mg/L Nitrogen and <0.05 ‰ Salinity

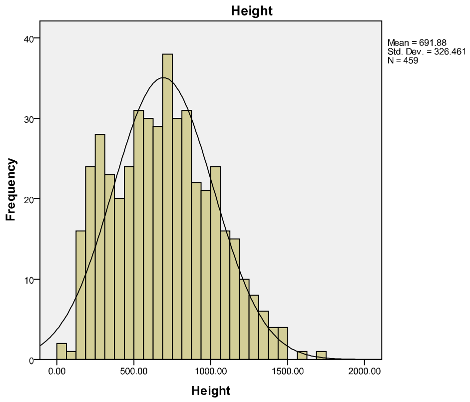
Figure A 21.8: *Mentha aquatica* Histogram and Data of Stem Widths with Increasing Nutrients

Stem Heights of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	76.432	3	25.477	217.991	.000
	Within Groups	1048.699	8973	.117		
	Total	1125.130	8976			
Phragmites australis	Between Groups	22.053	3	7.351	114.853	.000
	Within Groups	283.790	4434	.064		
	Total	305.842	4437			
Lythrum salicaria	Between Groups	1.891	3	.630	11.042	.000
	Within Groups	113.579	1990	.057		
	Total	115.470	1993			
Filipendula ulmaria	Between Groups	1.069	3	.356	4.638	.003
	Within Groups	97.672	1272	.077		
	Total	98.741	1275			
Mentha aquatica	Between Groups	2.395	3	.798	8.644	.000
	Within Groups	116.855	1265	.092		
	Total	119.251	1268			

Table A 21.1: One Way ANOVA results for effects of different nutrient ratios on stem harvest heights (Log10) for all microcosms not subject to increased salinity levels

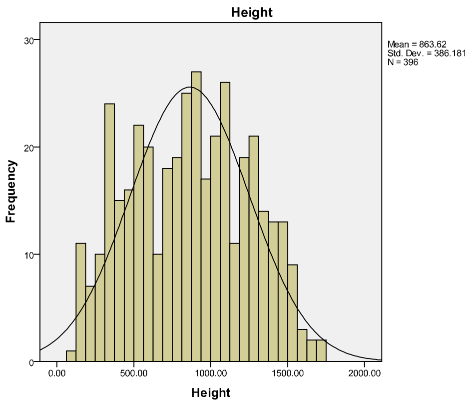
Stem widths of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	53.491	3	17.830	249.840	.000
	Within Groups	640.382	8973	.071		
	Total	693.873	8976			
Phragmites australis	Between Groups	16.351	3	5.450	267.701	.000
	Within Groups	90.273	4434	.020		
	Total	106.623	4437			
Lythrum salicaria	Between Groups	3.211	3	1.070	21.265	.000
	Within Groups	100.173	1990	.050		
	Total	103.384	1993			
Filipendula ulmaria	Between Groups	1.162	3	.387	4.513	.004
	Within Groups	109.159	1272	.086		
	Total	110.321	1275			
Mentha aquatica	Between Groups	1.444	3	.481	11.125	.000
	Within Groups	54.743	1265	.043		
	Total	56.188	1268			

Table A 21.2: One Way ANOVA results for effects of different nutrient ratios on stem harvest widths (Log10) for all microcosms not subject to increased salinity levels



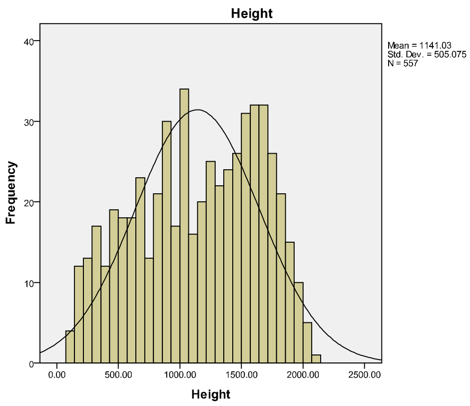
N	Valid	459
	Missing	0
Mean		691.8845
Std. Error of Mean		15.23788
Median		694.0000
Std. Deviation		326.46064
Variance		106576.552
Range		1711.00
Minimum		10.00
Maximum		1721.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 1 and 5)



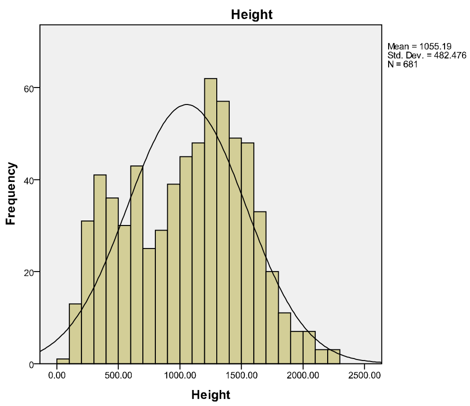
N	Valid	396
	Missing	0
Mean		863.6187
Std. Error of Mean		19.40633
Median		874.5000
Std. Deviation		386.18103
Variance		149135.791
Range		1645.00
Minimum		97.00
Maximum		1742.00

50 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 2)



N	Valid	557
	Missing	0
Mean		1141.0305
Std. Error of Mean		21.40070
Median		1186.0000
Std. Deviation		505.07469
Variance		255100.447
Range		1996.00
Minimum		92.00
Maximum		2088.00

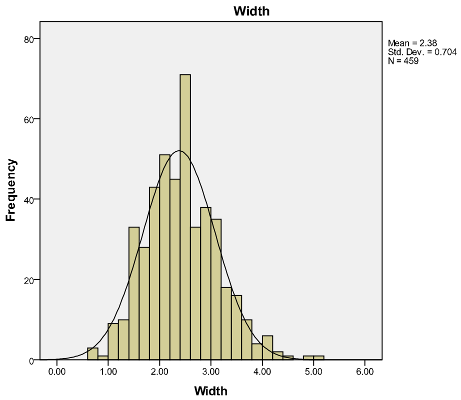
100 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 3)



N	Valid	681
	Missing	0
Mean		1055.1865
Std. Error of Mean		18.48852
Median		1111.0000
Std. Deviation		482.47604
Variance		232783.125
Range		2255.00
Minimum		15.00
Maximum		2270.00

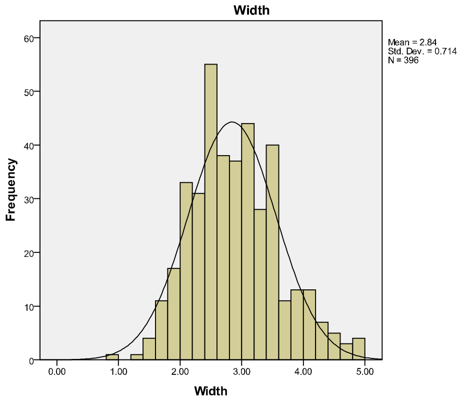
150 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 4)

Figure A 21.9: *Phragmites australis* Histogram and Data of Stem Heights with Increasing Nutrients for Microcosms 1-5 with Full Root Competition



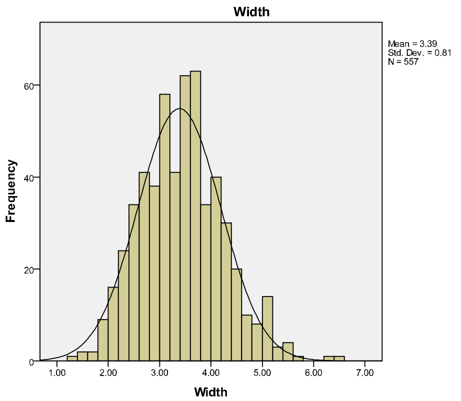
N	Valid	459
	Missing	0
Mean		2.3791
Std. Error of Mean		.03284
Median		2.4000
Std. Deviation		.70358
Variance		.495
Range		4.30
Minimum		.70
Maximum		5.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 1 and 5)



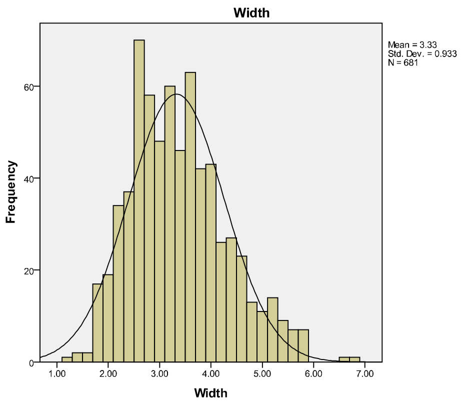
N	Valid	396
	Missing	0
Mean		2.8429
Std. Error of Mean		.03586
Median		2.8000
Std. Deviation		.71361
Variance		.509
Range		4.00
Minimum		.90
Maximum		4.90

50 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 2)



N	Valid	557
	Missing	0
Mean		3.3851
Std. Error of Mean		.03432
Median		3.4000
Std. Deviation		.80997
Variance		.656
Range		5.20
Minimum		1.30
Maximum		6.50

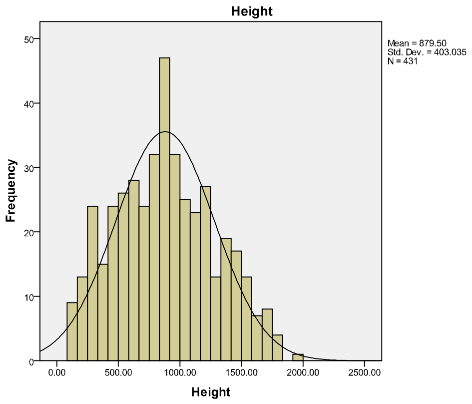
100 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 3)



N	Valid	681
	Missing	0
Mean		3.3282
Std. Error of Mean		.03575
Median		3.2000
Std. Deviation		.93286
Variance		.870
Range		5.60
Minimum		1.20
Maximum		6.80

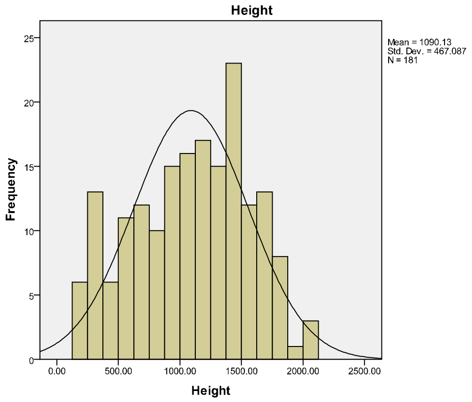
150 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 4)

Figure A 21.10: *Phragmites australis* Histogram and Data of Stem Widths with Increasing Nutrients for Microcosms 1-5 with Full Root Competition



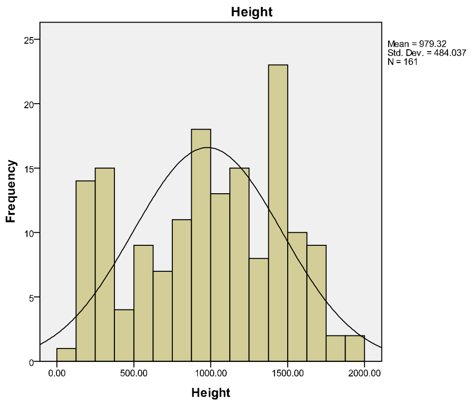
N	Valid	431
	Missing	0
Mean		879.4988
Std. Error of Mean		19.41353
Median		872.0000
Std. Deviation		403.03533
Variance		162437.478
Range		1815.00
Minimum		122.00
Maximum		1937.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 1 and 5)



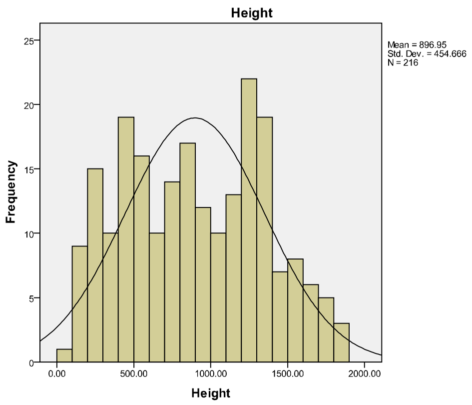
N	Valid	181
	Missing	0
Mean		1090.1271
Std. Error of Mean		34.71829
Median		1147.0000
Std. Deviation		467.08685
Variance		218170.123
Range		1916.00
Minimum		161.00
Maximum		2077.00

50 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 2)



N	Valid	161
	Missing	0
Mean		979.3230
Std. Error of Mean		38.14748
Median		1017.0000
Std. Deviation		484.03722
Variance		234292.033
Range		1832.00
Minimum		91.00
Maximum		1923.00

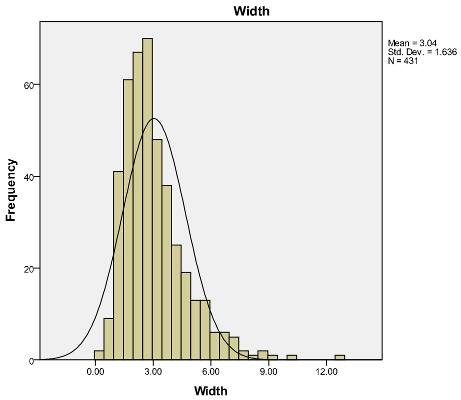
100 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 3)



N	Valid	216
	Missing	0
Mean		896.9537
Std. Error of Mean		30.93610
Median		882.5000
Std. Deviation		454.66594
Variance		206721.114
Range		1809.00
Minimum		58.00
Maximum		1867.00

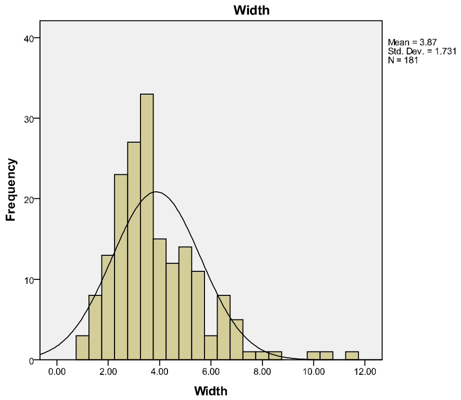
150 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 4)

Figure A 21.11: *Lythrum salicaria* Histogram and Data of Stem Heights with Increasing Nutrients for Microcosms 1-5 with Full Root Competition



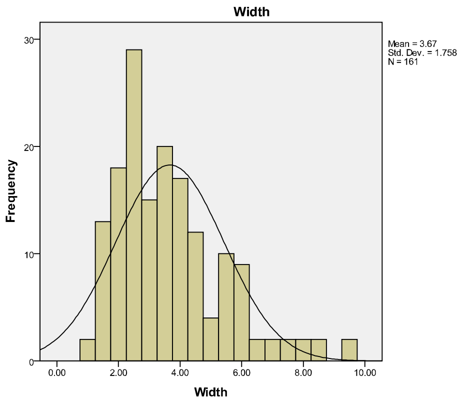
N	Valid	431
	Missing	0
Mean		3.0445
Std. Error of Mean		.07880
Median		2.7000
Std. Deviation		1.63587
Variance		2.676
Range		12.30
Minimum		.20
Maximum		12.50

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 1 and 5)



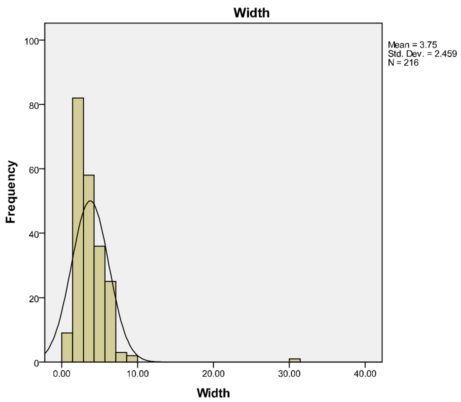
N	Valid	181
	Missing	0
Mean		3.8740
Std. Error of Mean		.12867
Median		3.5000
Std. Deviation		1.73110
Variance		2.997
Range		10.50
Minimum		1.00
Maximum		11.50

50 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 2)



N	Valid	161
	Missing	0
Mean		3.6665
Std. Error of Mean		.13855
Median		3.3000
Std. Deviation		1.75805
Variance		3.091
Range		8.50
Minimum		1.00
Maximum		9.50

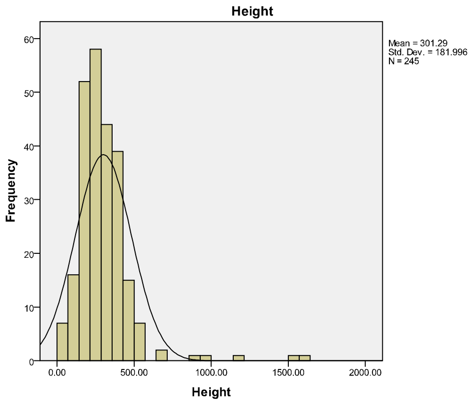
100 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 3)



N	Valid	216
	Missing	0
Mean		3.7542
Std. Error of Mean		.16728
Median		3.3000
Std. Deviation		2.45856
Variance		6.045
Range		29.30
Minimum		.70
Maximum		30.00

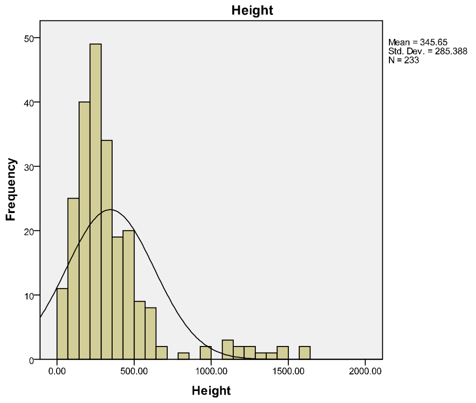
150 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 4)

Figure A 21.12: *Lythrum salicaria* Histogram and Data of Stem Widths with Increasing Nutrients for Microcosms 1-5 with Full Root Competition



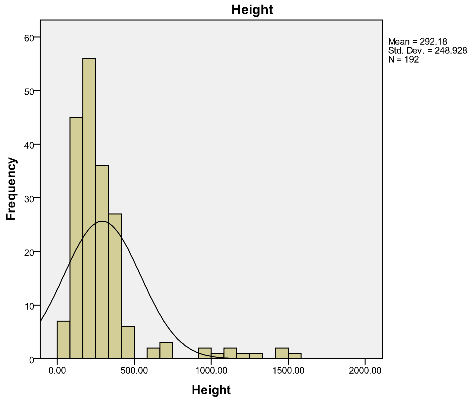
N	Valid	245
	Missing	0
Mean		301.2857
Std. Error of Mean		11.62728
Median		276.0000
Std. Deviation		181.99572
Variance		33122.443
Range		1556.00
Minimum		28.00
Maximum		1584.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 1 and 5)



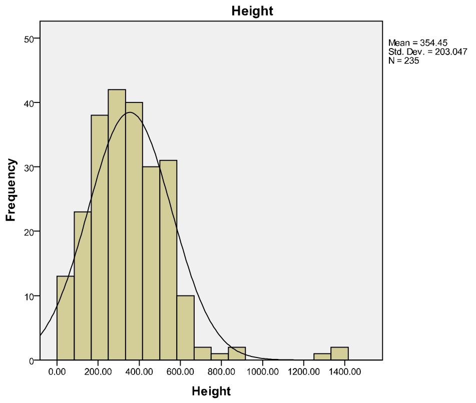
N	Valid	233
	Missing	0
Mean		345.6524
Std. Error of Mean		18.69638
Median		273.0000
Std. Deviation		285.38790
Variance		81446.254
Range		1592.00
Minimum		10.00
Maximum		1602.00

50 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 2)



N	Valid	192
	Missing	0
Mean		292.1771
Std. Error of Mean		17.96480
Median		236.5000
Std. Deviation		248.92754
Variance		61964.921
Range		1497.00
Minimum		12.00
Maximum		1509.00

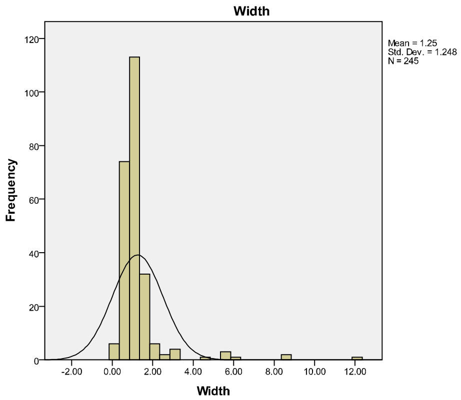
100 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 3)



N	Valid	235
	Missing	0
Mean		354.4468
Std. Error of Mean		13.24530
Median		335.0000
Std. Deviation		203.04663
Variance		41227.932
Range		1390.00
Minimum		26.00
Maximum		1416.00

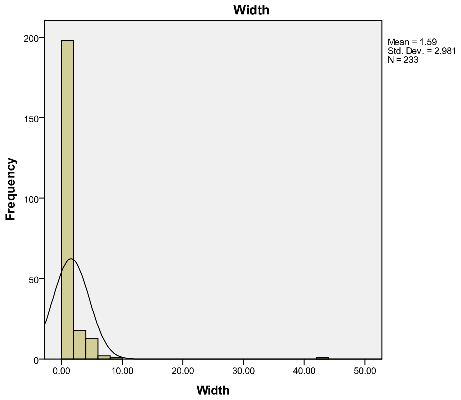
150 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 4)

Figure A 21.13: *Filipendula ulmaria* Histogram and Data of Stem Heights with Increasing Nutrients for Microcosms 1-5 with Full Root Competition



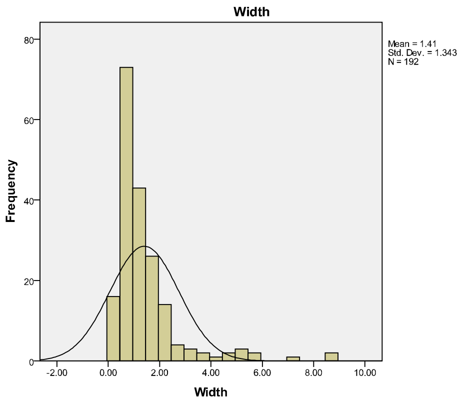
N	Valid	245
	Missing	0
Mean		1.2535
Std. Error of Mean		.07973
Median		1.0000
Std. Deviation		1.24790
Variance		1.557
Range		11.90
Minimum		.10
Maximum		12.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 1 and 5)



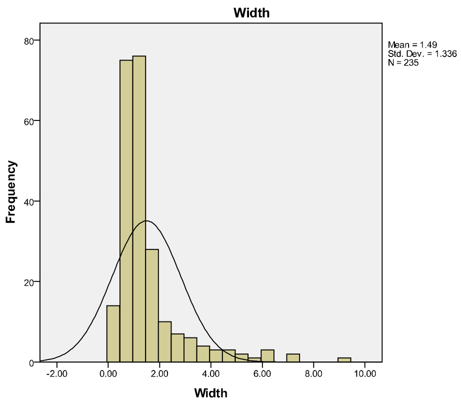
N	Valid	233
	Missing	0
Mean		1.5914
Std. Error of Mean		.19527
Median		1.0000
Std. Deviation		2.98063
Variance		8.884
Range		41.90
Minimum		.10
Maximum		42.00

50 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 2)



N	Valid	192
	Missing	0
Mean		1.4078
Std. Error of Mean		.09694
Median		1.0000
Std. Deviation		1.34324
Variance		1.804
Range		8.50
Minimum		.20
Maximum		8.70

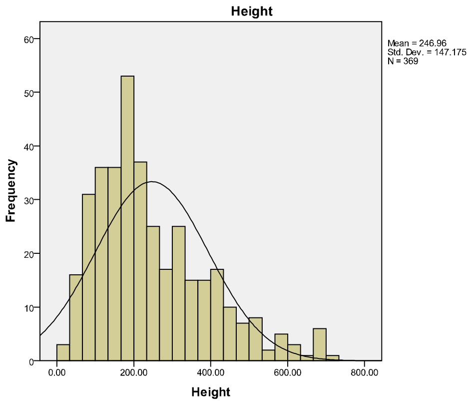
100 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 3)



N	Valid	235
	Missing	0
Mean		1.4894
Std. Error of Mean		.08714
Median		1.1000
Std. Deviation		1.33577
Variance		1.784
Range		8.90
Minimum		.20
Maximum		9.10

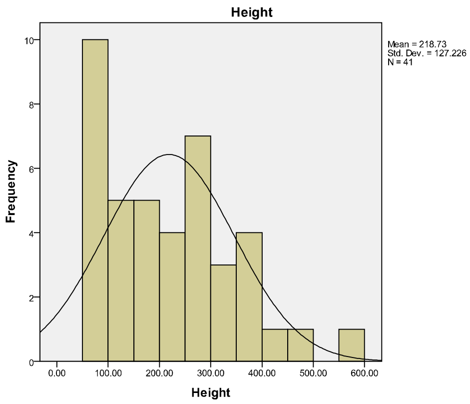
150 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 4)

Figure A 21.14: *Filipendula ulmaria* Histogram and Data of Stem Widths with Increasing Nutrients for Microcosms 1-5 with Full Root Competition



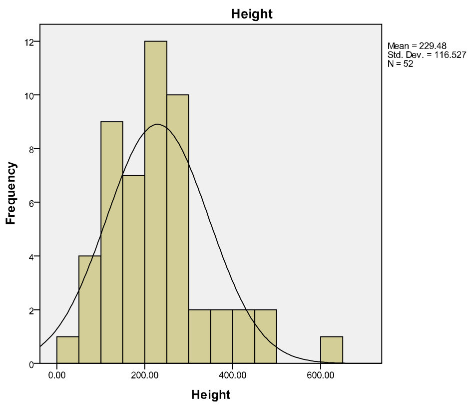
N	Valid	369
	Missing	0
Mean		246.9621
Std. Error of Mean		7.66165
Median		207.0000
Std. Deviation		147.17547
Variance		21660.618
Range		709.00
Minimum		14.00
Maximum		723.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 1 and 5)



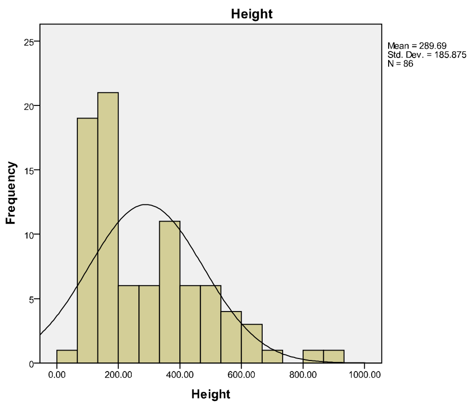
N	Valid	41
	Missing	0
Mean		218.7317
Std. Error of Mean		19.86936
Median		205.0000
Std. Deviation		127.22598
Variance		16186.451
Range		530.00
Minimum		63.00
Maximum		593.00

50 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 2)



N	Valid	52
	Missing	0
Mean		229.4808
Std. Error of Mean		16.15938
Median		228.0000
Std. Deviation		116.52695
Variance		13578.529
Range		581.00
Minimum		40.00
Maximum		621.00

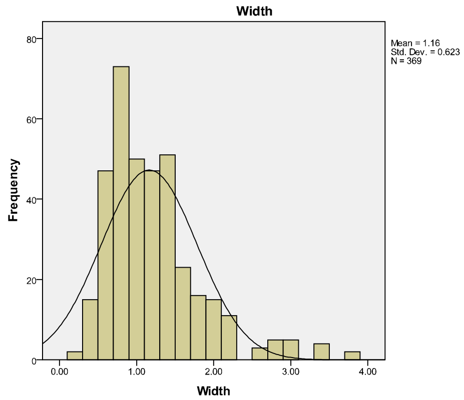
100 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 3)



N	Valid	86
	Missing	0
Mean		289.6860
Std. Error of Mean		20.04340
Median		220.5000
Std. Deviation		185.87480
Variance		34549.441
Range		813.00
Minimum		63.00
Maximum		876.00

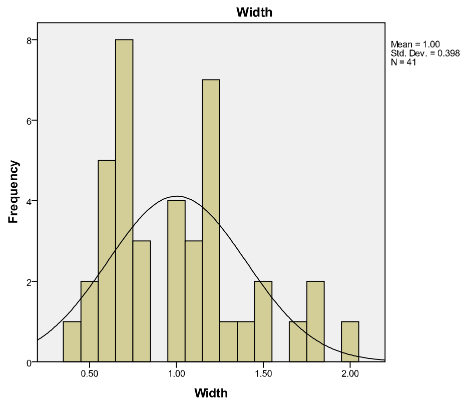
150 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 4)

Figure A 21.15: *Mentha aquatica* Histogram and Data of Stem Heights with Increasing Nutrients for Microcosms 1-5 with Full Root Competition



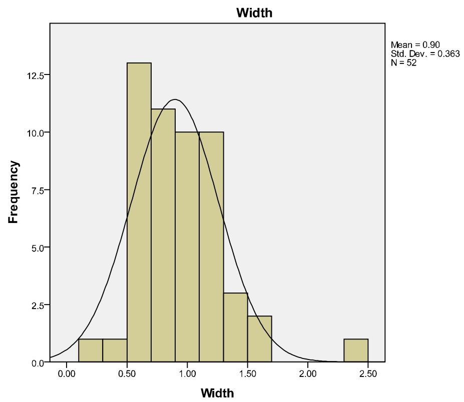
N	Valid	369
	Missing	0
Mean		1.1634
Std. Error of Mean		.03244
Median		1.0000
Std. Deviation		.62318
Variance		.388
Range		3.60
Minimum		.20
Maximum		3.80

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 1 and 5)



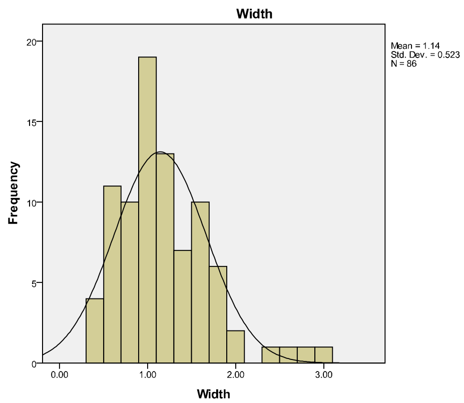
N	Valid	41
	Missing	0
Mean		1.0024
Std. Error of Mean		.06213
Median		1.0000
Std. Deviation		.39780
Variance		.158
Range		1.60
Minimum		.40
Maximum		2.00

50 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 2)



N	Valid	52
	Missing	0
Mean		.8981
Std. Error of Mean		.05037
Median		.8500
Std. Deviation		.36326
Variance		.132
Range		2.20
Minimum		.20
Maximum		2.40

100 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 3)



N	Valid	86
	Missing	0
Mean		1.1419
Std. Error of Mean		.05642
Median		1.0000
Std. Deviation		.52322
Variance		.274
Range		2.60
Minimum		.40
Maximum		3.00

150 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 4)

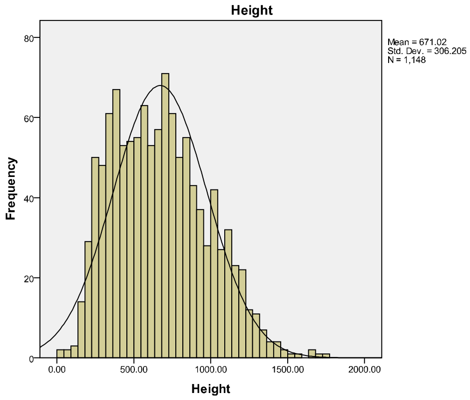
Figure A 21.16: *Mentha aquatica* Histogram and Data of Stem Widths with Increasing Nutrients for Microcosms 1-5 with Full Root Competition

Stem Heights of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	28.094	3	9.365	70.663	.000
	Within Groups	600.468	4531	.133		
	Total	628.561	4534			
Phragmites australis	Between Groups	14.225	3	4.742	70.003	.000
	Within Groups	141.500	2089	.068		
	Total	155.725	2092			
Lythrum salicaria	Between Groups	1.411	3	.470	6.607	.000
	Within Groups	70.097	985	.071		
	Total	71.507	988			
Filipendula ulmaria	Between Groups	1.277	3	.426	5.028	.002
	Within Groups	76.311	901	.085		
	Total	77.588	904			
Mentha aquatica	Between Groups	.404	3	.135	1.729	.160
	Within Groups	42.383	544	.078		
	Total	42.787	547			

Table A 21.3: One Way ANOVA Results for Effects of Different Nutrient Ratios on Stem Harvest Heights (Log10) for Microcosms 1-5 with Full Root Competition

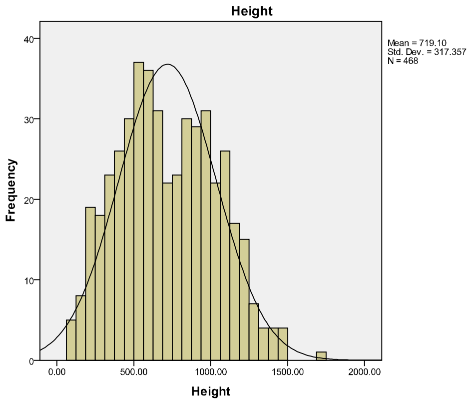
Stem Widths of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	20.703	3	6.901	83.679	.000
	Within Groups	373.679	4531	.082		
	Total	394.382	4534			
Phragmites australis	Between Groups	8.265	3	2.755	190.716	.000
	Within Groups	30.177	2089	.014		
	Total	38.442	2092			
Lythrum salicaria	Between Groups	2.610	3	.870	18.532	.000
	Within Groups	46.236	985	.047		
	Total	48.846	988			
Filipendula ulmaria	Between Groups	.332	3	.111	1.238	.295
	Within Groups	80.482	901	.089		
	Total	80.813	904			
Mentha aquatica	Between Groups	.435	3	.145	3.201	.023
	Within Groups	24.620	544	.045		
	Total	25.055	547			

Table A 21.4: One Way ANOVA Results for Effects of Different Nutrient Ratios on Stem Harvest Widths (Log10) for Microcosms 1-5 with Full Root Competition



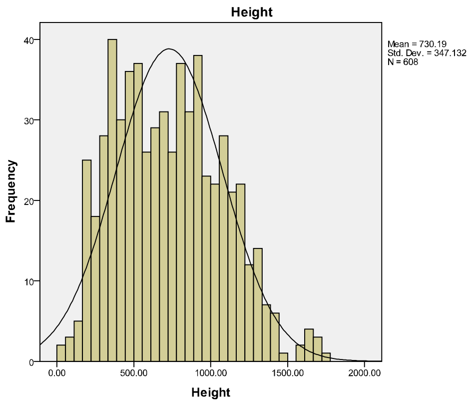
N	Valid	1148
	Missing	0
Mean		671.0183
Std. Error of Mean		9.03736
Median		646.0000
Std. Deviation		306.20503
Variance		93761.519
Range		1730.00
Minimum		10.00
Maximum		1740.00

10 mg/L Nitrogen and <0.05 ‰ Salinity



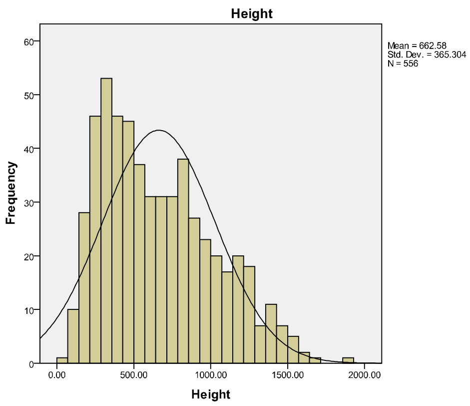
N	Valid	468
	Missing	0
Mean		719.0983
Std. Error of Mean		14.66983
Median		690.5000
Std. Deviation		317.35687
Variance		100715.382
Range		1627.00
Minimum		85.00
Maximum		1712.00

10 mg/L Nitrogen and 5 ‰ Salinity



N	Valid	608
	Missing	0
Mean		730.1924
Std. Error of Mean		14.07805
Median		706.5000
Std. Deviation		347.13174
Variance		120500.446
Range		1744.00
Minimum		30.00
Maximum		1774.00

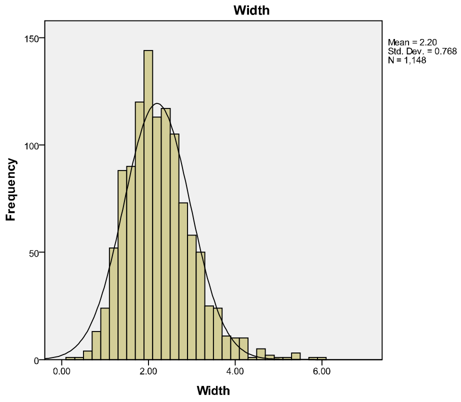
10 mg/L Nitrogen and 10 ‰ Salinity



N	Valid	556
	Missing	0
Mean		662.5755
Std. Error of Mean		15.49235
Median		590.5000
Std. Deviation		365.30431
Variance		133447.239
Range		1822.00
Minimum		70.00
Maximum		1892.00

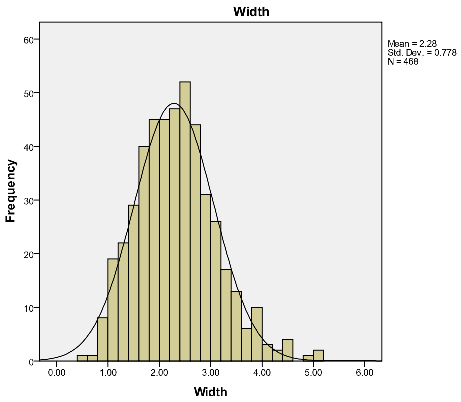
10 mg/L Nitrogen and 15 ‰ Salinity

Figure A 21.17: *Phragmites australis* Histogram and Data of Stem Heights with Increasing Salinity



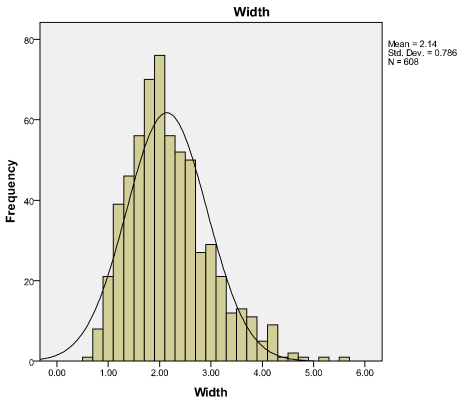
N	Valid	1148
	Missing	0
Mean		2.2012
Std. Error of Mean		.02266
Median		2.1000
Std. Deviation		.76768
Variance		.589
Range		5.80
Minimum		.20
Maximum		6.00

10 mg/L Nitrogen and <0.05 ‰ Salinity



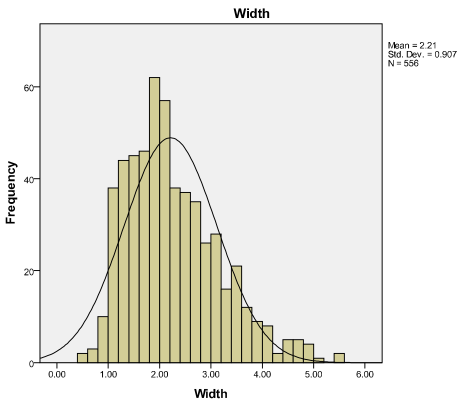
N	Valid	468
	Missing	0
Mean		2.2846
Std. Error of Mean		.03596
Median		2.2000
Std. Deviation		.77792
Variance		.605
Range		4.60
Minimum		.50
Maximum		5.10

10 mg/L Nitrogen and 5 ‰ Salinity



N	Valid	608
	Missing	0
Mean		2.1408
Std. Error of Mean		.03187
Median		2.0000
Std. Deviation		.78584
Variance		.618
Range		5.00
Minimum		.60
Maximum		5.60

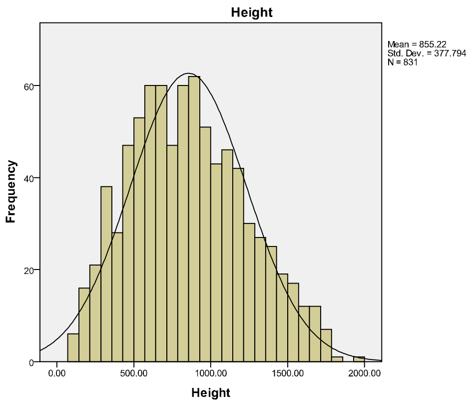
10 mg/L Nitrogen and 10 ‰ Salinity



N	Valid	556
	Missing	0
Mean		2.2124
Std. Error of Mean		.03847
Median		2.0000
Std. Deviation		.90717
Variance		.823
Range		4.90
Minimum		.50
Maximum		5.40

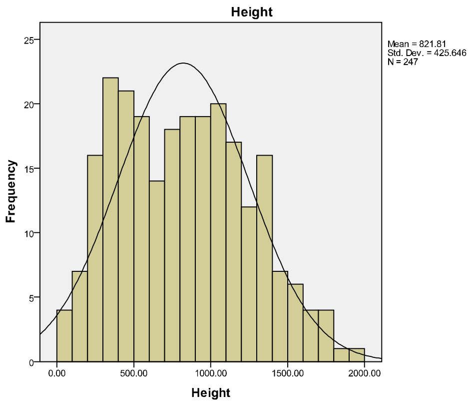
10 mg/L Nitrogen and 15 ‰ Salinity

Figure A 21.18: *Phragmites australis* Histogram and Data of Stem Widths with Increasing Salinity



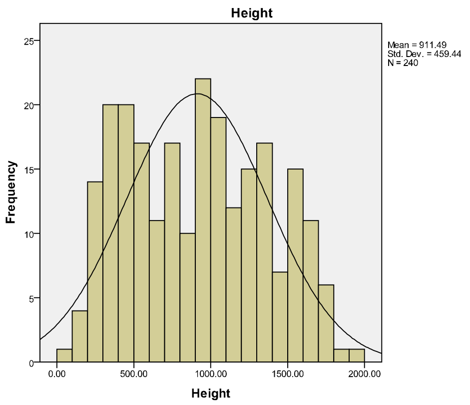
N	Valid	831
	Missing	0
Mean		855.2190
Std. Error of Mean		13.10552
Median		833.0000
Std. Deviation		377.79381
Variance		142728.162
Range		1815.00
Minimum		122.00
Maximum		1937.00

10 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	247
	Missing	0
Mean		821.8057
Std. Error of Mean		27.08319
Median		830.0000
Std. Deviation		425.64578
Variance		181174.328
Range		1912.00
Minimum		43.00
Maximum		1955.00

10 mg/L Nitrogen and 5 ‰ Salinity



N	Valid	240
	Missing	0
Mean		911.4875
Std. Error of Mean		29.65673
Median		919.0000
Std. Deviation		459.44014
Variance		211085.247
Range		1853.00
Minimum		73.00
Maximum		1926.00

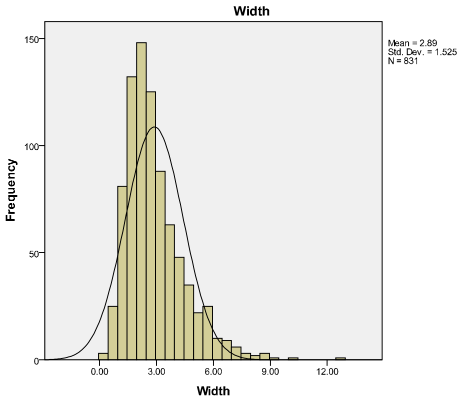
10 mg/L Nitrogen and 10 ‰ Salinity

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

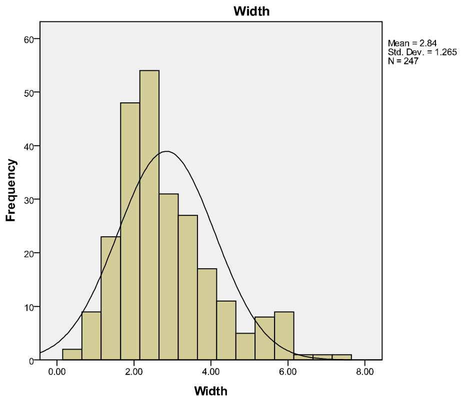
10 mg/L Nitrogen and 15 ‰ Salinity

Figure A 21.19: *Lythrum salicaria* Histogram and Data of Stem Heights with Increasing Salinity



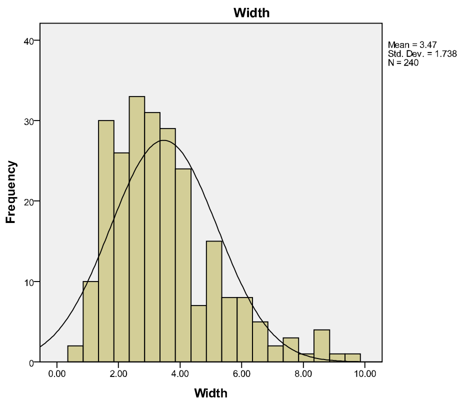
N	Valid	831
	Missing	0
Mean		2.8857
Std. Error of Mean		.05290
Median		2.5000
Std. Deviation		1.52494
Variance		2.325
Range		12.30
Minimum		.20
Maximum		12.50

10 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	247
	Missing	0
Mean		2.8417
Std. Error of Mean		.08050
Median		2.6000
Std. Deviation		1.26520
Variance		1.601
Range		7.00
Minimum		.40
Maximum		7.40

10 mg/L Nitrogen and 5 ‰ Salinity



N	Valid	240
	Missing	0
Mean		3.4733
Std. Error of Mean		.11219
Median		3.1500
Std. Deviation		1.73797
Variance		3.021
Range		8.90
Minimum		.60
Maximum		9.50

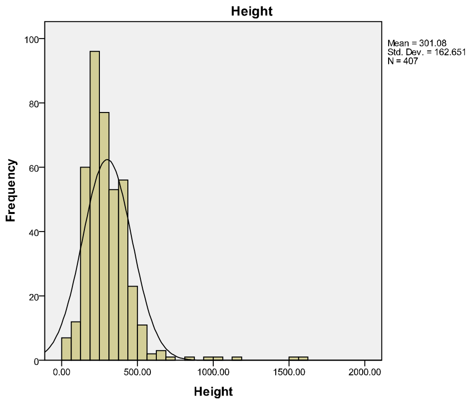
10 mg/L Nitrogen and 10 ‰ Salinity

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

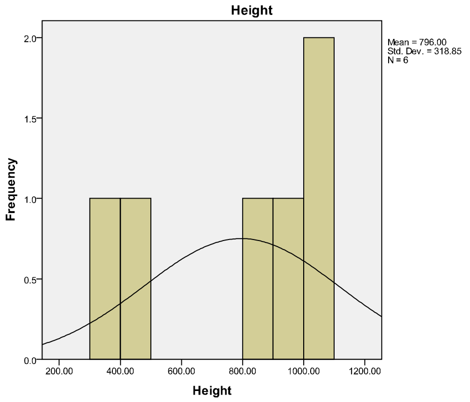
10 mg/L Nitrogen and 15 ‰ Salinity

Figure A 21.20: *Lythrum salicaria* Histogram and Data of Stem Widths with Increasing Salinity



N	Valid	407
	Missing	0
Mean		301.0786
Std. Error of Mean		8.06232
Median		277.0000
Std. Deviation		162.65112
Variance		26455.388
Range		1564.00
Minimum		20.00
Maximum		1584.00

10 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	6
	Missing	0
Mean		796.0000
Std. Error of Mean		130.17015
Median		938.0000
Std. Deviation		318.85044
Variance		101665.600
Range		693.00
Minimum		381.00
Maximum		1074.00

10 mg/L Nitrogen and 5 ‰ Salinity

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

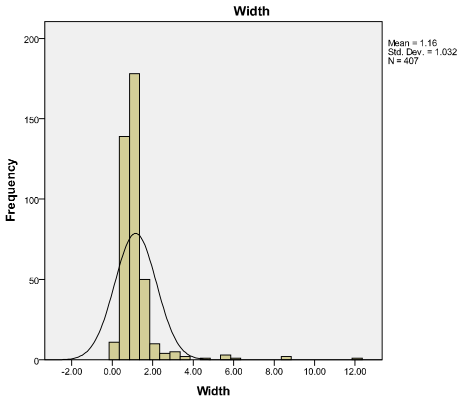
10 mg/L Nitrogen and 10 ‰ Salinity

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

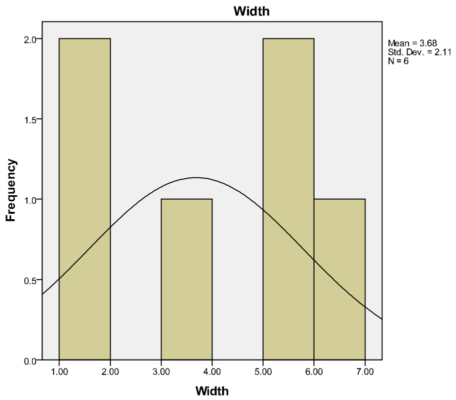
10 mg/L Nitrogen and 15 ‰ Salinity

Figure A 21.21: *Filipendula ulmaria* Histogram and Data of Stem Heights with Increasing Salinity



N	Valid	407
	Missing	0
Mean		1.1553
Std. Error of Mean		.05115
Median		1.0000
Std. Deviation		1.03201
Variance		1.065
Range		11.90
Minimum		.10
Maximum		12.00

10 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	6
	Missing	0
Mean		3.6833
Std. Error of Mean		.86156
Median		4.1500
Std. Deviation		2.11037
Variance		4.454
Range		5.00
Minimum		1.10
Maximum		6.10

10 mg/L Nitrogen and 5 ‰ Salinity

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

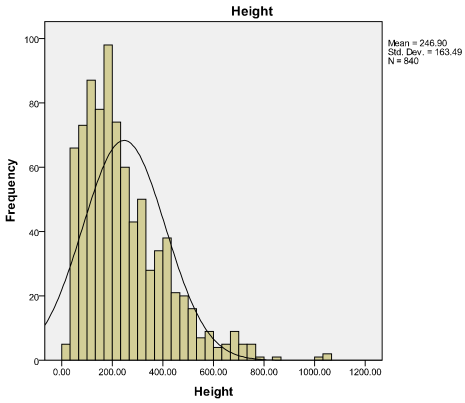
10 mg/L Nitrogen and 10 ‰ Salinity

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

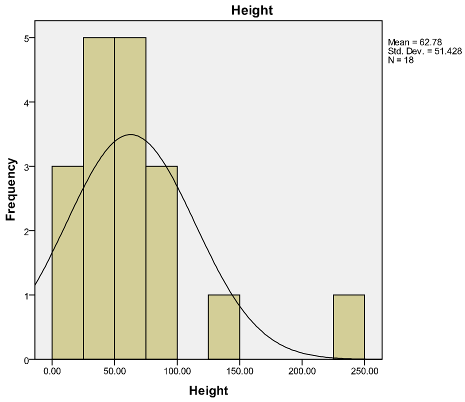
10 mg/L Nitrogen and 15 ‰ Salinity

Figure A 21.22: *Filipendula ulmaria* Histogram and Data of Stem Widths with Increasing Salinity



N	Valid	840
	Missing	0
Mean		246.9024
Std. Error of Mean		5.64096
Median		205.0000
Std. Deviation		163.49049
Variance		26729.142
Range		1045.00
Minimum		14.00
Maximum		1059.00

10 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	18
	Missing	0
Mean		62.7778
Std. Error of Mean		12.12181
Median		51.0000
Std. Deviation		51.42848
Variance		2644.889
Range		220.00
Minimum		9.00
Maximum		229.00

10 mg/L Nitrogen and 5 ‰ Salinity

No Surviving Plants.

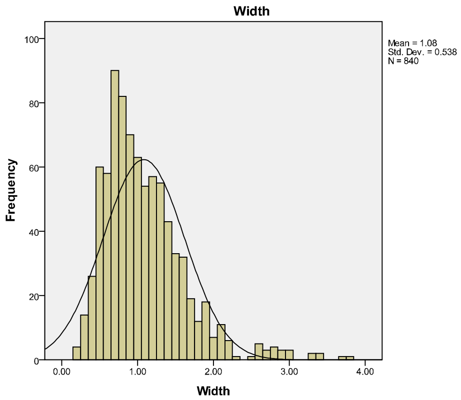
N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

10 mg/L Nitrogen and 10 ‰ Salinity

No Surviving Plants.

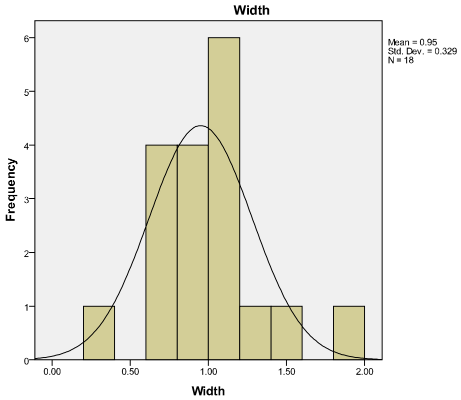
N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

Figure A 21.23: *Mentha aquatica* Histogram and Data of Stem Heights with Increasing Salinity



N	Valid	840
	Missing	0
Mean		1.0823
Std. Error of Mean		.01856
Median		1.0000
Std. Deviation		.53798
Variance		.289
Range		3.60
Minimum		.20
Maximum		3.80

10 mg/L Nitrogen and <0.05 ‰ Salinity



N	Valid	18
	Missing	0
Mean		.9500
Std. Error of Mean		.07765
Median		.9500
Std. Deviation		.32944
Variance		.109
Range		1.50
Minimum		.30
Maximum		1.80

10 mg/L Nitrogen and 5 ‰ Salinity

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

10 mg/L Nitrogen and 10 ‰ Salinity

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

10 mg/L Nitrogen and 15 ‰ Salinity

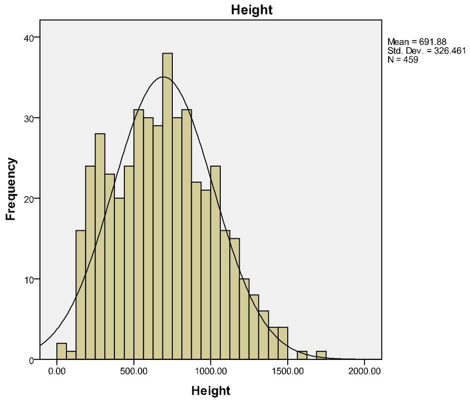
Figure A 21.24: *Mentha aquatica* Histogram and Data of Stem Widths with Increasing Salinity

Stem Heights of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	34.982	3	11.661	112.185	.000
	Within Groups	557.642	5365	.104		
	Total	592.624	5368			
Phragmites australis	Between Groups	1.243	3	.414	6.942	.000
	Within Groups	165.640	2776	.060		
	Total	166.883	2779			
Lythrum salicaria	Between Groups	.423	2	.212	3.417	.033
	Within Groups	81.410	1315	.062		
	Total	81.833	1317			
Filipendula ulmaria	Between Groups	1.126	1	1.126	23.073	.000
	Within Groups	20.055	411	.049		
	Total	21.181	412			
Mentha aquatica	Between Groups	6.526	1	6.526	69.985	.000
	Within Groups	79.815	856	.093		
	Total	86.341	857			

Table A 21.5: One Way ANOVA results for effects of different salinity ratios on surviving stem harvest heights

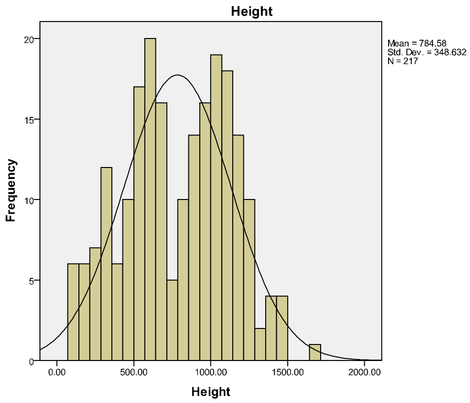
Stem Widths of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	22.824	3	7.608	129.266	.000
	Within Groups	315.752	5365	.059		
	Total	338.576	5368			
Phragmites australis	Between Groups	.264	3	.088	3.297	.020
	Within Groups	74.196	2776	.027		
	Total	74.460	2779			
Lythrum salicaria	Between Groups	1.347	2	.673	13.961	.000
	Within Groups	63.432	1315	.048		
	Total	64.779	1317			
Filipendula ulmaria	Between Groups	1.469	1	1.469	25.404	.000
	Within Groups	23.775	411	.058		
	Total	25.244	412			
Mentha aquatica	Between Groups	.021	1	.021	.473	.492
	Within Groups	37.246	856	.044		
	Total	37.266	857			

Table A 21.6: One Way ANOVA results for effects of different salinity ratios on surviving stem harvest widths



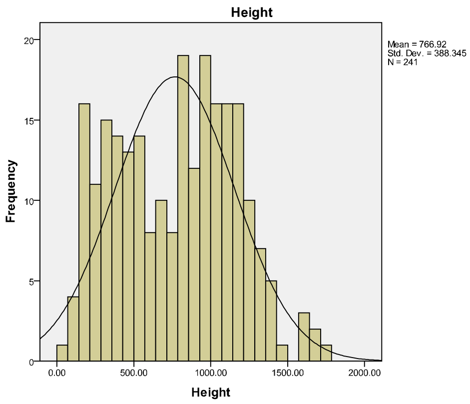
N	Valid	459
	Missing	0
Mean		691.8845
Std. Error of Mean		15.23788
Median		694.0000
Std. Deviation		326.46064
Variance		106576.552
Range		1711.00
Minimum		10.00
Maximum		1721.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 1 and 5)



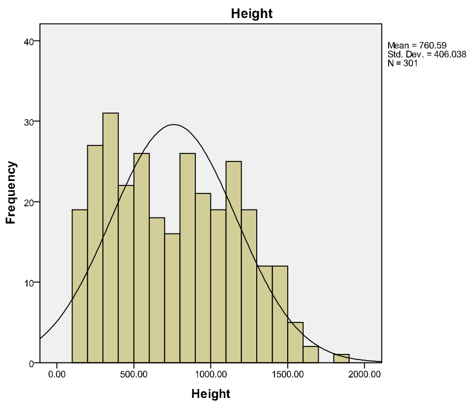
N	Valid	217
	Missing	0
Mean		784.5806
Std. Error of Mean		23.66669
Median		814.0000
Std. Deviation		348.63208
Variance		121544.328
Range		1627.00
Minimum		85.00
Maximum		1712.00

10 mg/L Nitrogen and 5 ‰ Salinity (Microcosm 6)



N	Valid	241
	Missing	0
Mean		766.9170
Std. Error of Mean		25.01553
Median		812.0000
Std. Deviation		388.34540
Variance		150812.151
Range		1730.00
Minimum		44.00
Maximum		1774.00

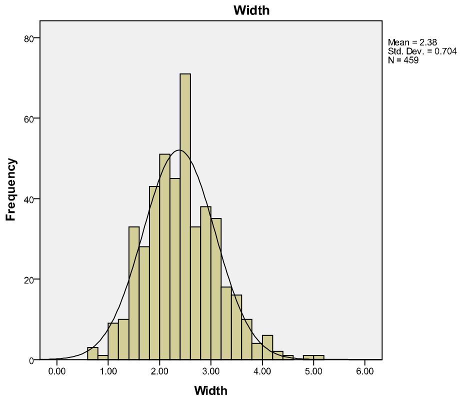
10 mg/L Nitrogen and 10 ‰ Salinity (Microcosm 7)



N	Valid	301
	Missing	0
Mean		760.5947
Std. Error of Mean		23.40363
Median		756.0000
Std. Deviation		406.03779
Variance		164866.689
Range		1776.00
Minimum		116.00
Maximum		1892.00

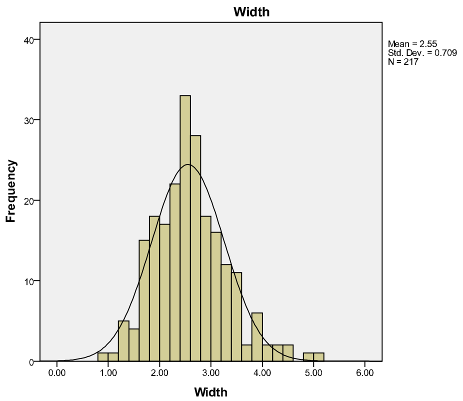
10 mg/L Nitrogen and 15 ‰ Salinity (Microcosm 8)

Figure A 21.25: *Phragmites australis* Histogram and Data of Stem Heights with Increasing Salinity for Microcosms 1, 5-8 with Full Root Competition



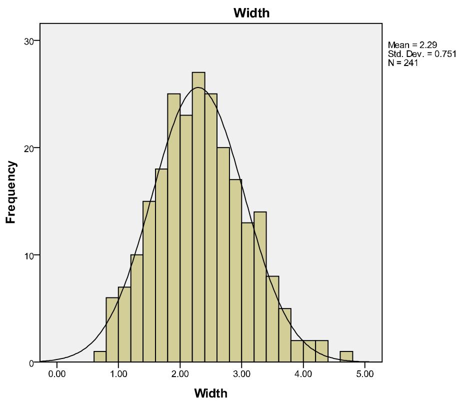
N	Valid	459
	Missing	0
Mean		2.3791
Std. Error of Mean		.03284
Median		2.4000
Std. Deviation		.70358
Variance		.495
Range		4.30
Minimum		.70
Maximum		5.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 1 and 5)



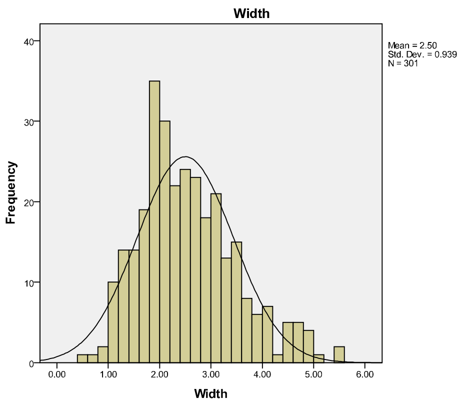
N	Valid	217
	Missing	0
Mean		2.5535
Std. Error of Mean		.04811
Median		2.5000
Std. Deviation		.70868
Variance		.502
Range		4.10
Minimum		.90
Maximum		5.00

10 mg/L Nitrogen and 5 ‰ Salinity (Microcosm 6)



N	Valid	241
	Missing	0
Mean		2.2942
Std. Error of Mean		.04839
Median		2.2000
Std. Deviation		.75114
Variance		.564
Range		4.00
Minimum		.70
Maximum		4.70

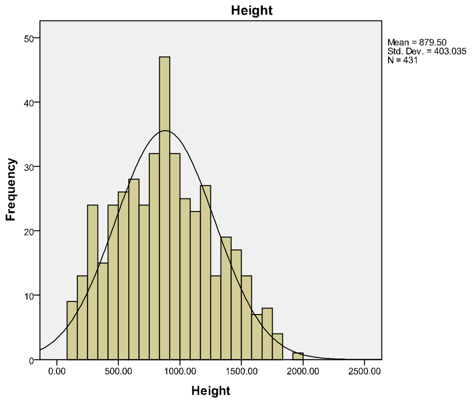
10 mg/L Nitrogen and 10 ‰ Salinity (Microcosm 7)



N	Valid	301
	Missing	0
Mean		2.5000
Std. Error of Mean		.05410
Median		2.4000
Std. Deviation		.93858
Variance		.881
Range		4.90
Minimum		.50
Maximum		5.40

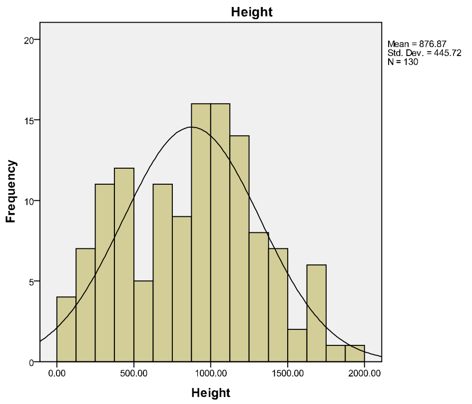
10 mg/L Nitrogen and 15 ‰ Salinity (Microcosm 8)

Figure A 21.26: *Phragmites australis* Histogram and Data of Stem Widths with Increasing Salinity for Microcosms 1, 5-8 with Full Root Competition



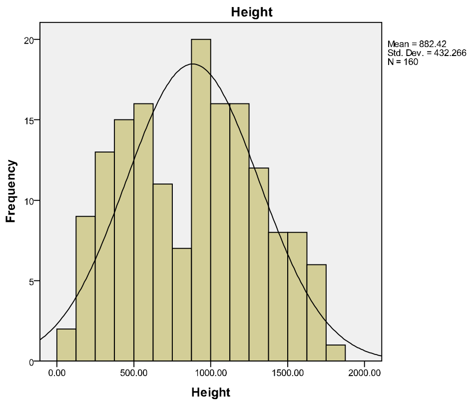
N	Valid	431
	Missing	0
Mean		879.4988
Std. Error of Mean		19.41353
Median		872.0000
Std. Deviation		403.03533
Variance		162437.478
Range		1815.00
Minimum		122.00
Maximum		1937.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 1 and 5)



N	Valid	130
	Missing	0
Mean		876.8692
Std. Error of Mean		39.09225
Median		914.5000
Std. Deviation		445.72022
Variance		198666.518
Range		1912.00
Minimum		43.00
Maximum		1955.00

10 mg/L Nitrogen and 5 ‰ Salinity (Microcosm 6)



N	Valid	160
	Missing	0
Mean		882.4188
Std. Error of Mean		34.17361
Median		919.0000
Std. Deviation		432.26572
Variance		186853.654
Range		1751.00
Minimum		73.00
Maximum		1824.00

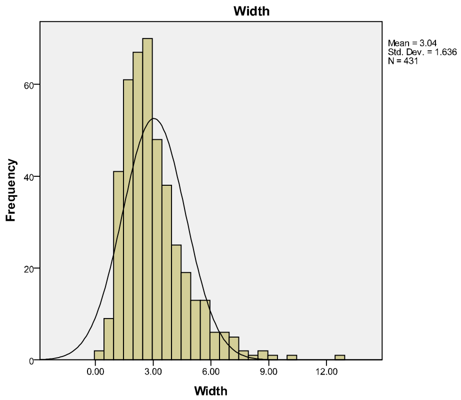
10 mg/L Nitrogen and 10 ‰ Salinity (Microcosm 7)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

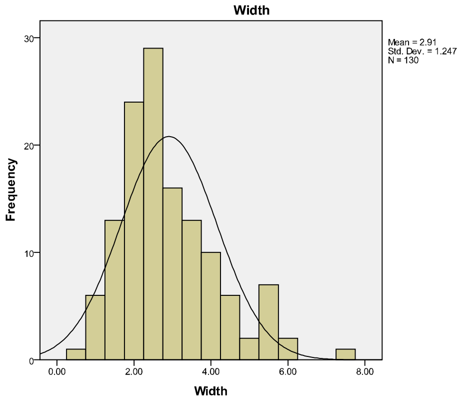
10 mg/L Nitrogen and 15 ‰ Salinity (Microcosm 8)

Figure A 21.27: *Lythrum salicaria* Histogram and Data of Stem Heights with Increasing Salinity for Microcosms 1, 5-8 with Full Root Competition



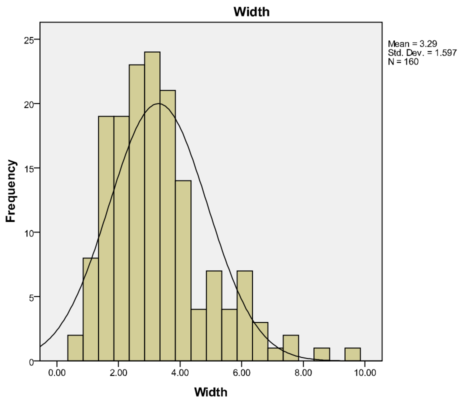
N	Valid	431
	Missing	0
Mean		3.0445
Std. Error of Mean		.07880
Median		2.7000
Std. Deviation		1.63587
Variance		2.676
Range		12.30
Minimum		.20
Maximum		12.50

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 1 and 5)



N	Valid	130
	Missing	0
Mean		2.9092
Std. Error of Mean		.10939
Median		2.6000
Std. Deviation		1.24723
Variance		1.556
Range		6.90
Minimum		.50
Maximum		7.40

10 mg/L Nitrogen and 5 ‰ Salinity (Microcosm 6)



N	Valid	160
	Missing	0
Mean		3.2913
Std. Error of Mean		.12623
Median		3.0000
Std. Deviation		1.59675
Variance		2.550
Range		8.90
Minimum		.60
Maximum		9.50

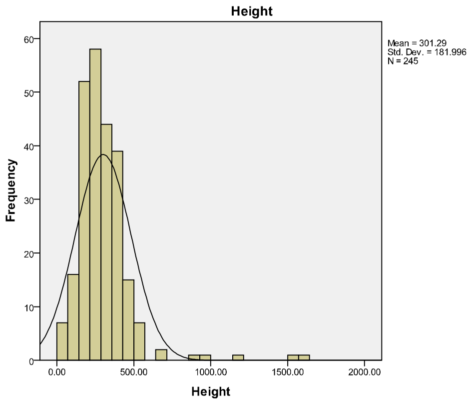
10 mg/L Nitrogen and 10 ‰ Salinity (Microcosm 7)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

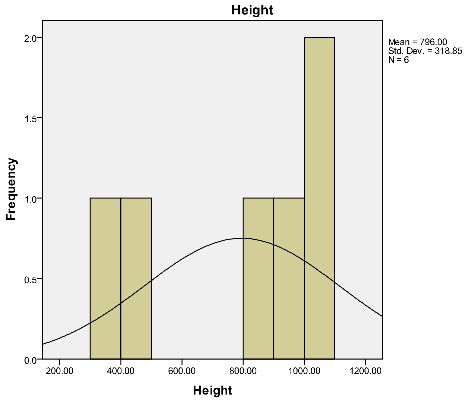
10 mg/L Nitrogen and 15 ‰ Salinity (Microcosm 8)

Figure A 21.28: *Lythrum salicaria* Histogram and Data of Stem Widths with Increasing Salinity for Microcosms 1, 5-8 with Full Root Competition



N	Valid	245
	Missing	0
Mean		301.2857
Std. Error of Mean		11.62728
Median		276.0000
Std. Deviation		181.99572
Variance		33122.443
Range		1556.00
Minimum		28.00
Maximum		1584.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 1 and 5)



N	Valid	6
	Missing	0
Mean		796.0000
Std. Error of Mean		130.17015
Median		938.0000
Std. Deviation		318.85044
Variance		101665.600
Range		693.00
Minimum		381.00
Maximum		1074.00

10 mg/L Nitrogen and 5 ‰ Salinity (Microcosm 6)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

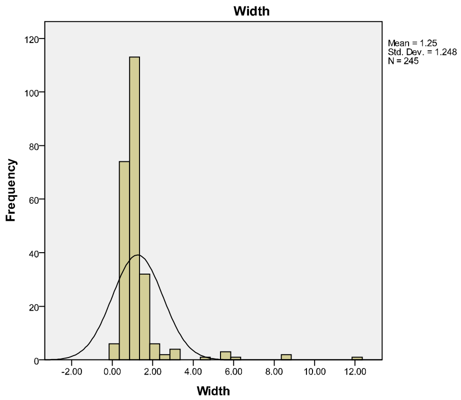
10 mg/L Nitrogen and 10 ‰ Salinity (Microcosm 7)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

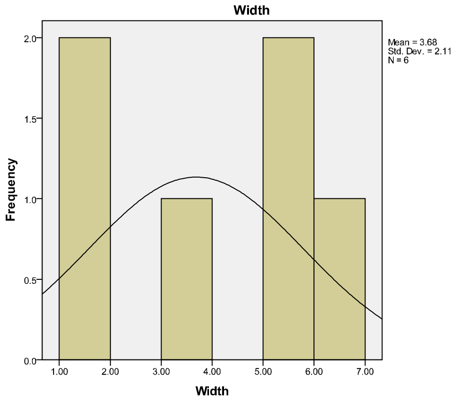
10 mg/L Nitrogen and 15 ‰ Salinity (Microcosm 8)

Figure A 21.29: *Filipendula ulmaria* Histogram and Data of Stem Heights with Increasing Salinity for Microcosms 1, 5-8 with Full Root Competition



N	Valid	245
	Missing	0
Mean		1.2535
Std. Error of Mean		.07973
Median		1.0000
Std. Deviation		1.24790
Variance		1.557
Range		11.90
Minimum		.10
Maximum		12.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 1 and 5)



N	Valid	6
	Missing	0
Mean		3.6833
Std. Error of Mean		.86156
Median		4.1500
Std. Deviation		2.11037
Variance		4.454
Range		5.00
Minimum		1.10
Maximum		6.10

10 mg/L Nitrogen and 5 ‰ Salinity (Microcosm 6)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

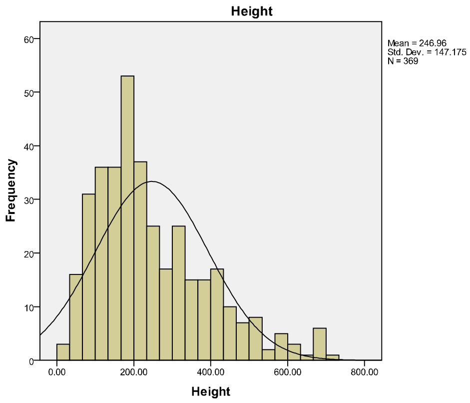
10 mg/L Nitrogen and 10 ‰ Salinity (Microcosm 7)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

10 mg/L Nitrogen and 15 ‰ Salinity (Microcosm 8)

Figure A 21.30: *Filipendula ulmaria* Histogram and Data of Stem Widths with Increasing Salinity for Microcosms 1, 5-8 with Full Root Competition



N	Valid	369
	Missing	0
Mean		246.9621
Std. Error of Mean		7.66165
Median		207.0000
Std. Deviation		147.17547
Variance		21660.618
Range		709.00
Minimum		14.00
Maximum		723.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 1 and 5)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

10 mg/L Nitrogen and 5 ‰ Salinity (Microcosm 6)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

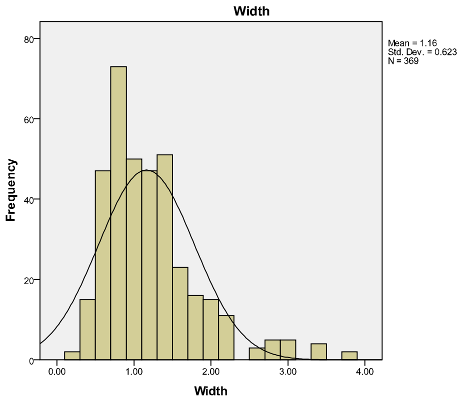
10 mg/L Nitrogen and 10 ‰ Salinity (Microcosm 7)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

10 mg/L Nitrogen and 15 ‰ Salinity (Microcosm 8)

Figure A 21.31: *Mentha aquatica* Histogram and Data of Stem Heights with Increasing Salinity for Microcosms 1, 5-8 with Full Root Competition



N	Valid	369
	Missing	0
Mean		1.1634
Std. Error of Mean		.03244
Median		1.0000
Std. Deviation		.62318
Variance		.388
Range		3.60
Minimum		.20
Maximum		3.80

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 1 and 5)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

10 mg/L Nitrogen and 5 ‰ Salinity (Microcosm 6)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

10 mg/L Nitrogen and 10 ‰ Salinity (Microcosm 7)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

10 mg/L Nitrogen and 15 ‰ Salinity (Microcosm 8)

Figure A 21.32: *Mentha aquatica* Histogram and Data of Stem Widths with Increasing Salinity for Microcosms 1, 5-8 with Full Root Competition

Stem Heights of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	23.369	3	7.790	72.758	.000
	Within Groups	273.550	2555	.107		
	Total	296.919	2558			
Phragmites australis	Between Groups	.514	3	.171	2.290	.077
	Within Groups	90.926	1214	.075		
	Total	91.440	1217			
Lythrum salicaria	Between Groups	.086	2	.043	.592	.553
	Within Groups	52.061	718	.073		
	Total	52.147	720			
Filipendula ulmaria	Between Groups	1.159	1	1.159	20.622	.000
	Within Groups	13.998	249	.056		
	Total	15.157	250			
Mentha aquatica*	Between Groups	N/A	N/A	N/A	N/A	N/A
	Within Groups	N/A	N/A	N/A	N/A	N/A
	Total	N/A	N/A	N/A	N/A	N/A

Notes: *** Only surviving in a single microcosm therefore one-way ANOVA is not feasible.

Table A 21.7: One Way ANOVA Results for Effects of Different Salinity Ratios on Stem Harvest Heights (Log10) for Microcosms 1, 5-8 with Full Root Competition

Stem Widths of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	14.792	3	4.931	83.008	.000
	Within Groups	151.763	2555	.059		
	Total	166.555	2558			
Phragmites australis	Between Groups	.364	3	.121	5.599	.001
	Within Groups	26.332	1214	.022		
	Total	26.696	1217			
Lythrum salicaria	Between Groups	.220	2	.110	2.277	.103
	Within Groups	34.686	718	.048		
	Total	34.906	720			
Filipendula ulmaria	Between Groups	1.333	1	1.333	20.154	.000
	Within Groups	16.464	249	.066		
	Total	17.796	250			
Mentha aquatica*	Between Groups	N/A	N/A	N/A	N/A	N/A
	Within Groups	N/A	N/A	N/A	N/A	N/A
	Total	N/A	N/A	N/A	N/A	N/A

Notes: *** Only surviving in a single microcosm therefore one-way ANOVA is not feasible.

Table A 21.8: One Way ANOVA Results for Effects of Different Salinity Ratios on Stem Harvest Widths (Log10) for Microcosms 1, 5-8 with Full Root Competition

Appendix 22 One Way ANOVA Results for All Microcosms and Full Competition Microcosms

Stem Heights of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	76.432	3	25.477	217.991	.000
	Within Groups	1048.699	8973	.117		
	Total	1125.130	8976			
Phragmites australis	Between Groups	22.053	3	7.351	114.853	.000
	Within Groups	283.790	4434	.064		
	Total	305.842	4437			
Lythrum salicaria	Between Groups	1.891	3	.630	11.042	.000
	Within Groups	113.579	1990	.057		
	Total	115.470	1993			
Filipendula ulmaria	Between Groups	1.069	3	.356	4.638	.003
	Within Groups	97.672	1272	.077		
	Total	98.741	1275			
Mentha aquatica	Between Groups	2.395	3	.798	8.644	.000
	Within Groups	116.855	1265	.092		
	Total	119.251	1268			

Table A 22.1: One Way ANOVA results for effects of different nutrient ratios on stem harvest heights (Log10) for all microcosms not subject to increased salinity levels

Stem widths of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	53.491	3	17.830	249.840	.000
	Within Groups	640.382	8973	.071		
	Total	693.873	8976			
Phragmites australis	Between Groups	16.351	3	5.450	267.701	.000
	Within Groups	90.273	4434	.020		
	Total	106.623	4437			
Lythrum salicaria	Between Groups	3.211	3	1.070	21.265	.000
	Within Groups	100.173	1990	.050		
	Total	103.384	1993			
Filipendula ulmaria	Between Groups	1.162	3	.387	4.513	.004
	Within Groups	109.159	1272	.086		
	Total	110.321	1275			
Mentha aquatica	Between Groups	1.444	3	.481	11.125	.000
	Within Groups	54.743	1265	.043		
	Total	56.188	1268			

Table A 22.2: One Way ANOVA results for effects of different nutrient ratios on stem harvest widths (Log10) for all microcosms not subject to increased salinity levels

Stem Heights of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	28.094	3	9.365	70.663	.000
	Within Groups	600.468	4531	.133		
	Total	628.561	4534			
Phragmites australis	Between Groups	14.225	3	4.742	70.003	.000
	Within Groups	141.500	2089	.068		
	Total	155.725	2092			
Lythrum salicaria	Between Groups	1.411	3	.470	6.607	.000
	Within Groups	70.097	985	.071		
	Total	71.507	988			
Filipendula ulmaria	Between Groups	1.277	3	.426	5.028	.002
	Within Groups	76.311	901	.085		
	Total	77.588	904			
Mentha aquatica	Between Groups	.404	3	.135	1.729	.160
	Within Groups	42.383	544	.078		
	Total	42.787	547			

Table A 22.3: One Way ANOVA Results for Effects of Different Nutrient Ratios on Stem Harvest Heights (Log10) for Microcosms 1-5 with Full Root Competition

Stem Widths of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	20.703	3	6.901	83.679	.000
	Within Groups	373.679	4531	.082		
	Total	394.382	4534			
Phragmites australis	Between Groups	8.265	3	2.755	190.716	.000
	Within Groups	30.177	2089	.014		
	Total	38.442	2092			
Lythrum salicaria	Between Groups	2.610	3	.870	18.532	.000
	Within Groups	46.236	985	.047		
	Total	48.846	988			
Filipendula ulmaria	Between Groups	.332	3	.111	1.238	.295
	Within Groups	80.482	901	.089		
	Total	80.813	904			
Mentha aquatica	Between Groups	.435	3	.145	3.201	.023
	Within Groups	24.620	544	.045		
	Total	25.055	547			

Table A 22.4: One Way ANOVA Results for Effects of Different Nutrient Ratios on Stem Harvest Widths (Log10) for Microcosms 1-5 with Full Root Competition

Stem Heights of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	34.982	3	11.661	112.185	.000
	Within Groups	557.642	5365	.104		
	Total	592.624	5368			
Phragmites australis	Between Groups	1.243	3	.414	6.942	.000
	Within Groups	165.640	2776	.060		
	Total	166.883	2779			
Lythrum salicaria	Between Groups	.423	2	.212	3.417	.033
	Within Groups	81.410	1315	.062		
	Total	81.833	1317			
Filipendula ulmaria	Between Groups	1.126	1	1.126	23.073	.000
	Within Groups	20.055	411	.049		
	Total	21.181	412			
Mentha aquatica	Between Groups	6.526	1	6.526	69.985	.000
	Within Groups	79.815	856	.093		
	Total	86.341	857			

Table A 22.5: One Way ANOVA results for effects of different salinity ratios on surviving stem harvest heights

Stem Widths of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	22.824	3	7.608	129.266	.000
	Within Groups	315.752	5365	.059		
	Total	338.576	5368			
Phragmites australis	Between Groups	.264	3	.088	3.297	.020
	Within Groups	74.196	2776	.027		
	Total	74.460	2779			
Lythrum salicaria	Between Groups	1.347	2	.673	13.961	.000
	Within Groups	63.432	1315	.048		
	Total	64.779	1317			
Filipendula ulmaria	Between Groups	1.469	1	1.469	25.404	.000
	Within Groups	23.775	411	.058		
	Total	25.244	412			
Mentha aquatica	Between Groups	.021	1	.021	.473	.492
	Within Groups	37.246	856	.044		
	Total	37.266	857			

Table A 22.6: One Way ANOVA results for effects of different salinity ratios on surviving stem harvest widths

Stem Heights of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	23.369	3	7.790	72.758	.000
	Within Groups	273.550	2555	.107		
	Total	296.919	2558			
Phragmites australis	Between Groups	.514	3	.171	2.290	.077
	Within Groups	90.926	1214	.075		
	Total	91.440	1217			
Lythrum salicaria	Between Groups	.086	2	.043	.592	.553
	Within Groups	52.061	718	.073		
	Total	52.147	720			
Filipendula ulmaria	Between Groups	1.159	1	1.159	20.622	.000
	Within Groups	13.998	249	.056		
	Total	15.157	250			
Mentha aquatica*	Between Groups	N/A	N/A	N/A	N/A	N/A
	Within Groups	N/A	N/A	N/A	N/A	N/A
	Total	N/A	N/A	N/A	N/A	N/A

Notes: *** Only surviving in a single microcosm therefore one-way ANOVA is not feasible.

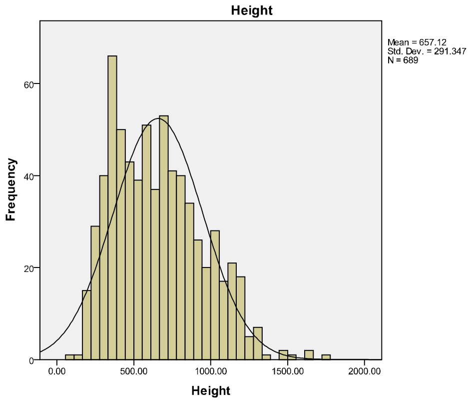
Table A 22.7: One Way ANOVA Results for Effects of Different Salinity Ratios on Stem Harvest Heights (Log10) for Microcosms 1, 5-8 with Full Root Competition

Stem Widths of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	14.792	3	4.931	83.008	.000
	Within Groups	151.763	2555	.059		
	Total	166.555	2558			
Phragmites australis	Between Groups	.364	3	.121	5.599	.001
	Within Groups	26.332	1214	.022		
	Total	26.696	1217			
Lythrum salicaria	Between Groups	.220	2	.110	2.277	.103
	Within Groups	34.686	718	.048		
	Total	34.906	720			
Filipendula ulmaria	Between Groups	1.333	1	1.333	20.154	.000
	Within Groups	16.464	249	.066		
	Total	17.796	250			
Mentha aquatica*	Between Groups	N/A	N/A	N/A	N/A	N/A
	Within Groups	N/A	N/A	N/A	N/A	N/A
	Total	N/A	N/A	N/A	N/A	N/A

Notes: *** Only surviving in a single microcosm therefore one-way ANOVA is not feasible.

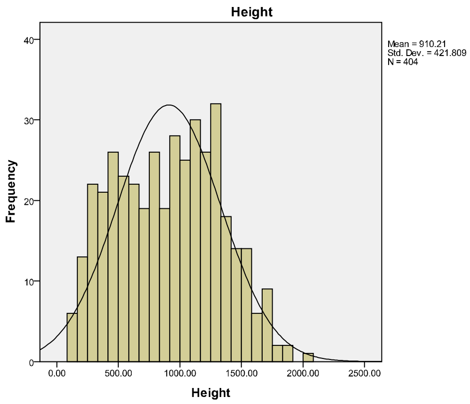
Table A 22.8: One Way ANOVA Results for Effects of Different Salinity Ratios on Stem Harvest Widths (Log10) for Microcosms 1, 5-8 with Full Root Competition

Appendix 23 Histogram and Data Heights for Restricted Competition Microcosms



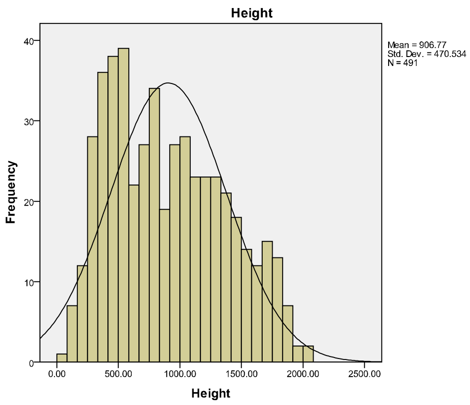
N	Valid	689
	Missing	0
Mean		657.1176
Std. Error of Mean		11.09942
Median		628.0000
Std. Deviation		291.34666
Variance		84882.874
Range		1669.00
Minimum		71.00
Maximum		1740.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 9 and 13)



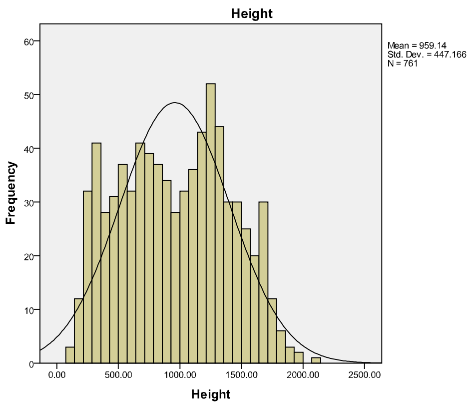
N	Valid	404
	Missing	0
Mean		910.2054
Std. Error of Mean		20.98579
Median		936.5000
Std. Deviation		421.80922
Variance		177923.017
Range		1911.00
Minimum		105.00
Maximum		2016.00

50 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 10)



N	Valid	491
	Missing	0
Mean		906.7678
Std. Error of Mean		21.23490
Median		837.0000
Std. Deviation		470.53406
Variance		221402.301
Range		1979.00
Minimum		58.00
Maximum		2037.00

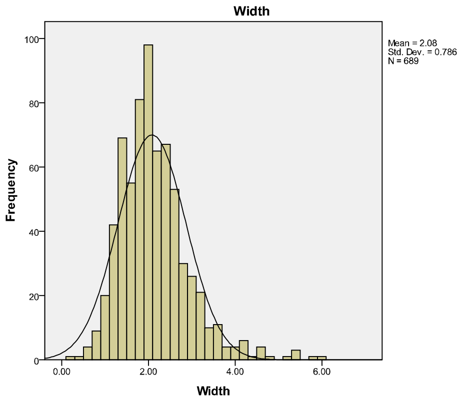
100 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 11)



N	Valid	761
	Missing	0
Mean		959.1419
Std. Error of Mean		16.20976
Median		971.0000
Std. Deviation		447.16601
Variance		199957.443
Range		2006.00
Minimum		121.00
Maximum		2127.00

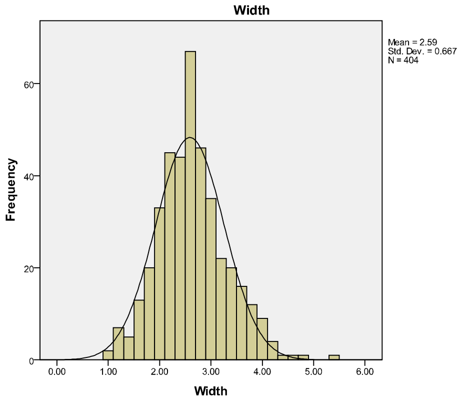
150 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 12)

Figure A 23.1: *Phragmites australis* Histogram and Data of Stem Heights with Increasing Nutrients for Microcosms 9-13 with Restricted Root Competition



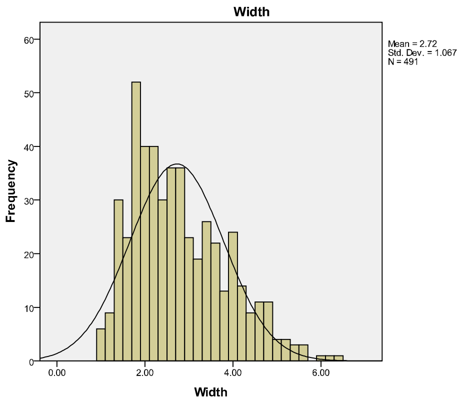
N	Valid	689
	Missing	0
Mean		2.0827
Std. Error of Mean		.02994
Median		2.0000
Std. Deviation		.78600
Variance		.618
Range		5.80
Minimum		.20
Maximum		6.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 9 and 13)



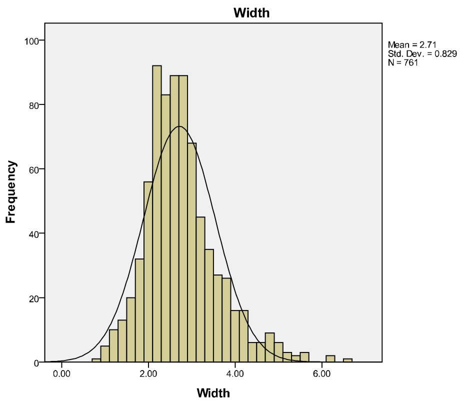
N	Valid	404
	Missing	0
Mean		2.5901
Std. Error of Mean		.03321
Median		2.5000
Std. Deviation		.66743
Variance		.445
Range		4.40
Minimum		1.00
Maximum		5.40

50 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 10)



N	Valid	491
	Missing	0
Mean		2.7236
Std. Error of Mean		.04814
Median		2.5000
Std. Deviation		1.06674
Variance		1.138
Range		5.30
Minimum		1.00
Maximum		6.30

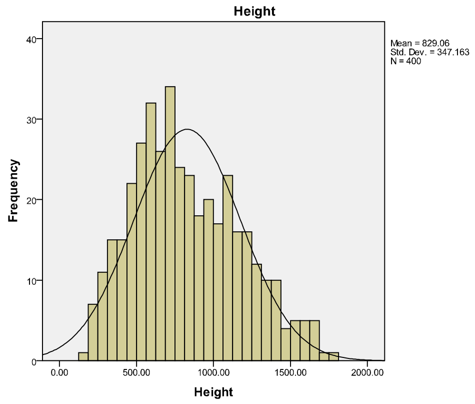
100 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 11)



N	Valid	761
	Missing	0
Mean		2.7143
Std. Error of Mean		.03007
Median		2.6000
Std. Deviation		.82939
Variance		.688
Range		5.70
Minimum		.80
Maximum		6.50

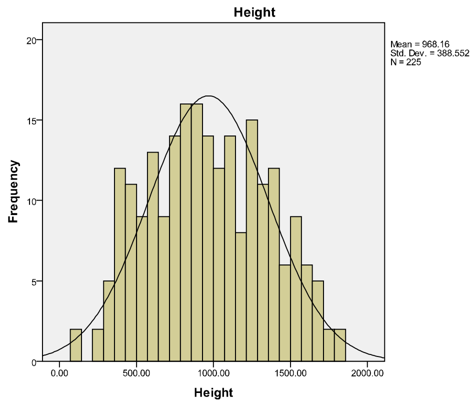
150 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 12)

Figure A 23.2: *Phragmites australis* Histogram and Data of Stem Widths with Increasing Nutrients for Microcosms 9-13 with Restricted Root Competition



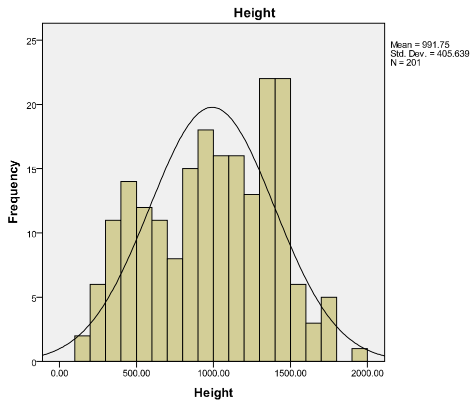
N	Valid	400
	Missing	0
Mean		829.0575
Std. Error of Mean		17.35816
Median		778.0000
Std. Deviation		347.16326
Variance		120522.330
Range		1608.00
Minimum		170.00
Maximum		1778.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 9 and 13)



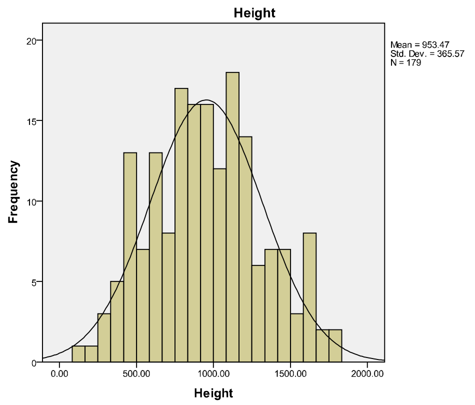
N	Valid	225
	Missing	0
Mean		968.1644
Std. Error of Mean		25.90347
Median		934.0000
Std. Deviation		388.55202
Variance		150972.674
Range		1728.00
Minimum		101.00
Maximum		1829.00

50 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 10)



N	Valid	201
	Missing	0
Mean		991.7463
Std. Error of Mean		28.61160
Median		1012.0000
Std. Deviation		405.63942
Variance		164543.340
Range		1755.00
Minimum		153.00
Maximum		1908.00

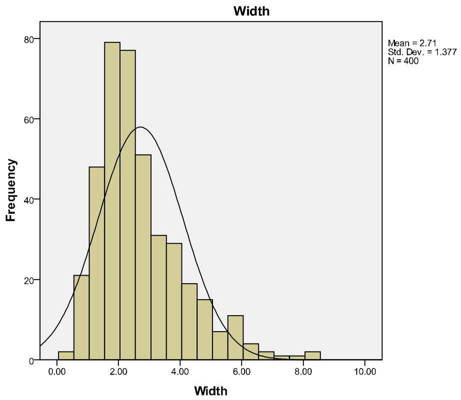
100 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 11)



N	Valid	179
	Missing	0
Mean		953.4749
Std. Error of Mean		27.32400
Median		935.0000
Std. Deviation		365.57025
Variance		133641.610
Range		1705.00
Minimum		111.00
Maximum		1816.00

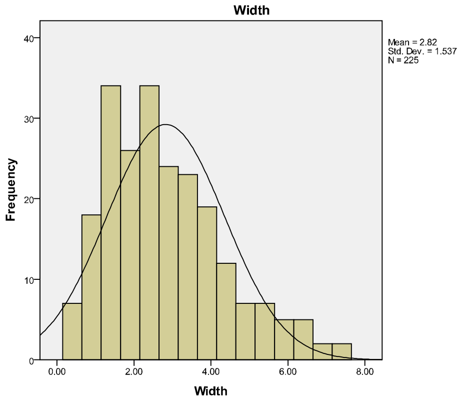
150 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 12)

Figure A 23.3: *Lythrum salicaria* Histogram and Data of Stem Heights with Increasing Nutrients for Microcosms 9-13 with Restricted Root Competition



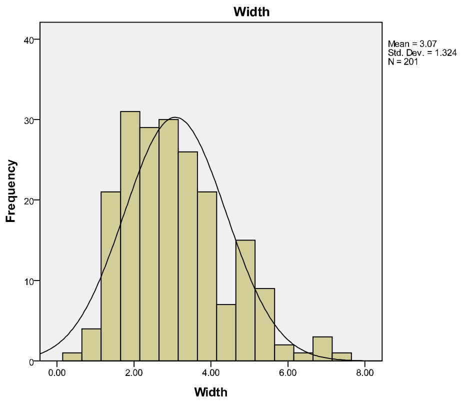
N	Valid	400
	Missing	0
Mean		2.7145
Std. Error of Mean		.06886
Median		2.4000
Std. Deviation		1.37724
Variance		1.897
Range		8.20
Minimum		.30
Maximum		8.50

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 9 and 13)



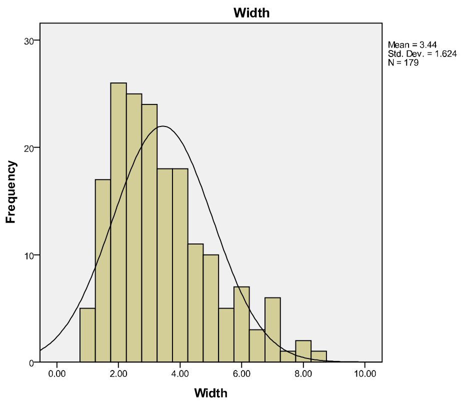
N	Valid	225
	Missing	0
Mean		2.8249
Std. Error of Mean		.10243
Median		2.6000
Std. Deviation		1.53652
Variance		2.361
Range		7.20
Minimum		.40
Maximum		7.60

50 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 10)



N	Valid	201
	Missing	0
Mean		3.0746
Std. Error of Mean		.09339
Median		2.8000
Std. Deviation		1.32409
Variance		1.753
Range		7.00
Minimum		.40
Maximum		7.40

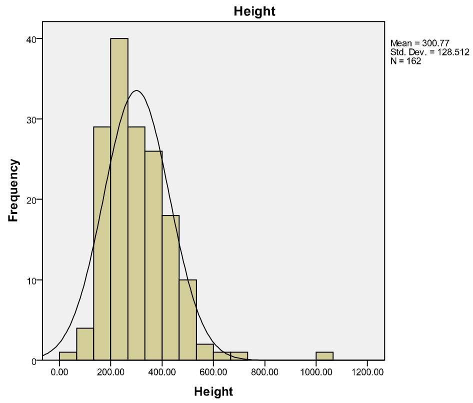
100 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 11)



N	Valid	179
	Missing	0
Mean		3.4374
Std. Error of Mean		.12137
Median		3.1000
Std. Deviation		1.62387
Variance		2.637
Range		7.70
Minimum		1.00
Maximum		8.70

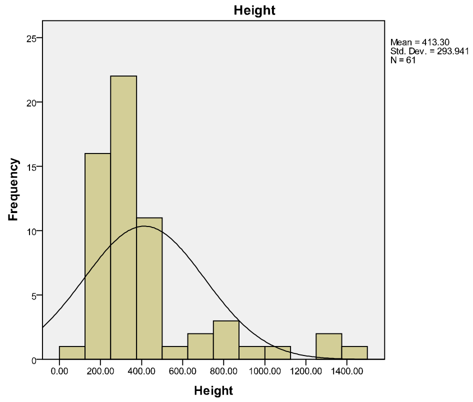
150 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 12)

Figure A 23.4: *Lythrum salicaria* with Restricted Root Competition Histogram and Data of Stem Widths with Increasing Nutrients for Microcosms 9-13



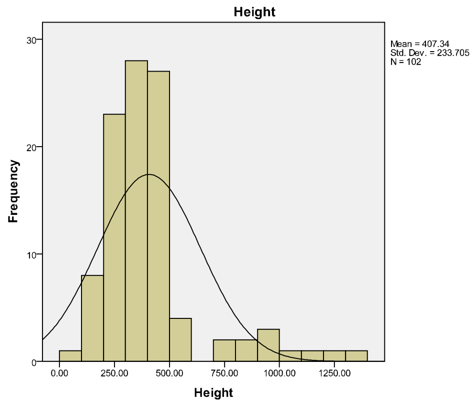
N	Valid	162
	Missing	0
Mean		300.7654
Std. Error of Mean		10.09689
Median		279.5000
Std. Deviation		128.51239
Variance		16515.435
Range		1029.00
Minimum		20.00
Maximum		1049.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 9 and 13)



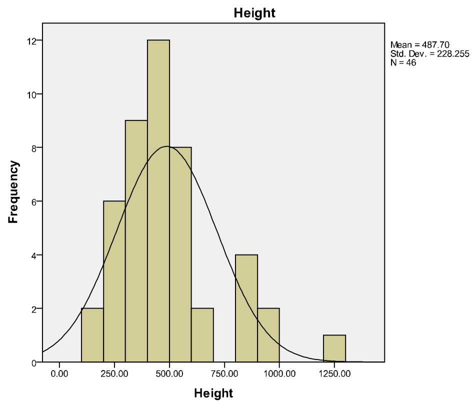
N	Valid	61
	Missing	0
Mean		413.2951
Std. Error of Mean		37.63528
Median		329.0000
Std. Deviation		293.94094
Variance		86401.278
Range		1375.00
Minimum		28.00
Maximum		1403.00

50 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 10)



N	Valid	102
	Missing	0
Mean		407.3431
Std. Error of Mean		23.14021
Median		366.5000
Std. Deviation		233.70462
Variance		54617.851
Range		1230.00
Minimum		86.00
Maximum		1316.00

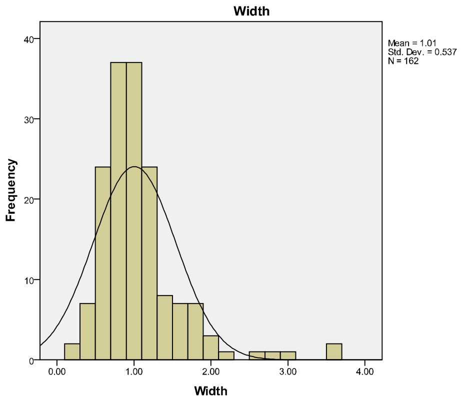
100 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 11)



N	Valid	46
	Missing	0
Mean		487.6957
Std. Error of Mean		33.65442
Median		455.0000
Std. Deviation		228.25540
Variance		52100.528
Range		1070.00
Minimum		190.00
Maximum		1260.00

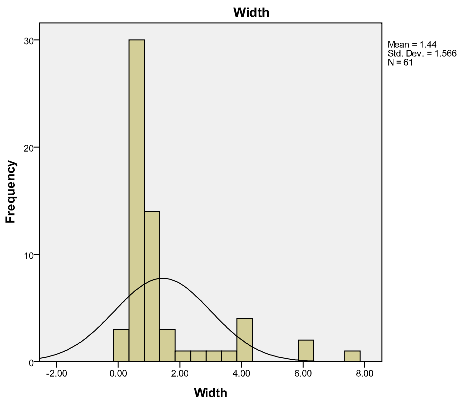
150 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 12)

Figure A 23.5: *Filipendula ulmaria* Histogram and Data of Stem Heights with Increasing Nutrients for Microcosms 9-13 with Restricted Root Competition



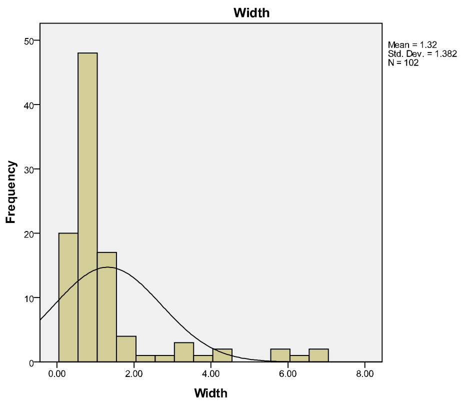
N	Valid	162
	Missing	0
Mean		1.0068
Std. Error of Mean		.04222
Median		.9000
Std. Deviation		.53743
Variance		.289
Range		3.40
Minimum		.20
Maximum		3.60

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 9 and 13)



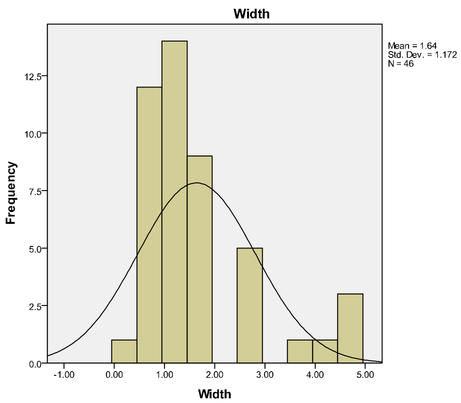
N	Valid	61
	Missing	0
Mean		1.4393
Std. Error of Mean		.20045
Median		.8000
Std. Deviation		1.56560
Variance		2.451
Range		7.60
Minimum		.10
Maximum		7.70

50 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 10)



N	Valid	102
	Missing	0
Mean		1.3216
Std. Error of Mean		.13685
Median		.9000
Std. Deviation		1.38211
Variance		1.910
Range		6.50
Minimum		.30
Maximum		6.80

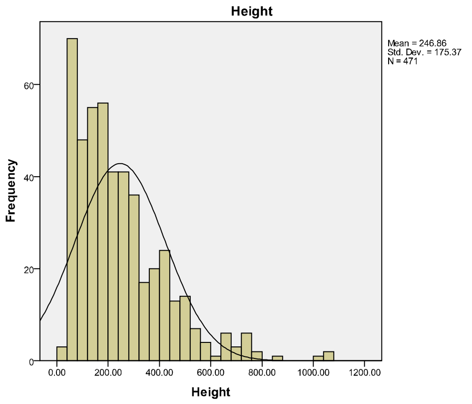
100 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 11)



N	Valid	46
	Missing	0
Mean		1.6391
Std. Error of Mean		.17274
Median		1.2000
Std. Deviation		1.17160
Variance		1.373
Range		4.50
Minimum		.20
Maximum		4.70

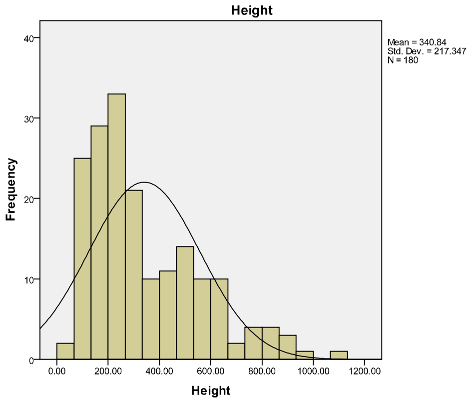
150 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 12)

Figure A 23.6: *Filipendula ulmaria* Histogram and Data of Stem Widths with Increasing Nutrients for Microcosms 9-13 with Restricted Root Competition



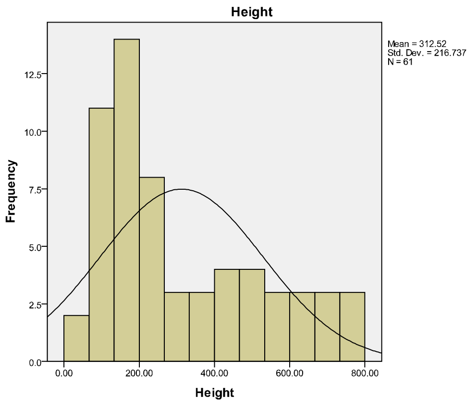
N	Valid	471
	Missing	0
Mean		246.8556
Std. Error of Mean		8.08061
Median		205.0000
Std. Deviation		175.36976
Variance		30754.554
Range		1044.00
Minimum		15.00
Maximum		1059.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 9 and 13)



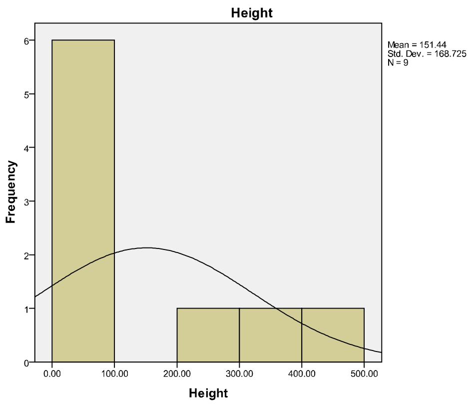
N	Valid	180
	Missing	0
Mean		340.8444
Std. Error of Mean		16.20009
Median		268.5000
Std. Deviation		217.34700
Variance		47239.719
Range		1027.00
Minimum		54.00
Maximum		1081.00

50 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 10)



N	Valid	61
	Missing	0
Mean		312.5246
Std. Error of Mean		27.75033
Median		228.0000
Std. Deviation		216.73698
Variance		46974.920
Range		726.00
Minimum		40.00
Maximum		766.00

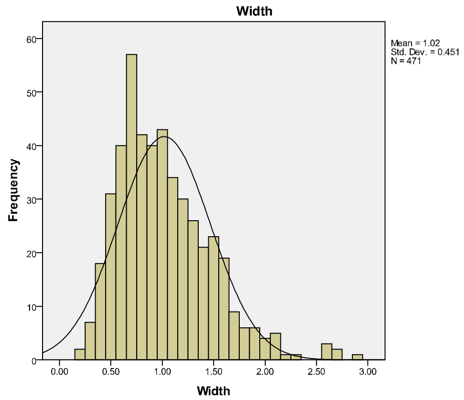
100 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 11)



N	Valid	9
	Missing	0
Mean		151.4444
Std. Error of Mean		56.24182
Median		51.0000
Std. Deviation		168.72545
Variance		28468.278
Range		413.00
Minimum		25.00
Maximum		438.00

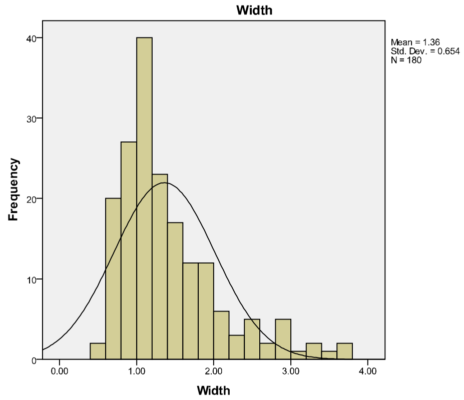
150 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 12)

Figure A 23.7: *Mentha aquatica* Histogram and Data of Stem Heights with Increasing Nutrients for Microcosms 9-13 with Restricted Root Competition



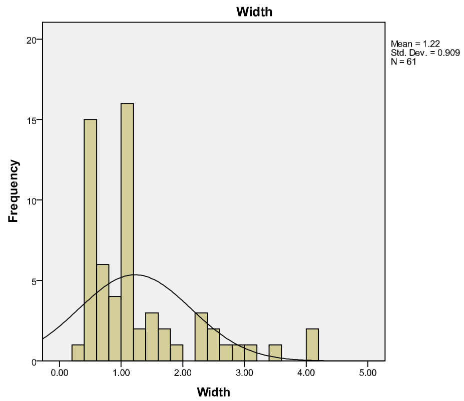
N	Valid	471
	Missing	0
Mean		1.0187
Std. Error of Mean		.02078
Median		.9000
Std. Deviation		.45095
Variance		.203
Range		2.70
Minimum		.20
Maximum		2.90

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 9 and 13)



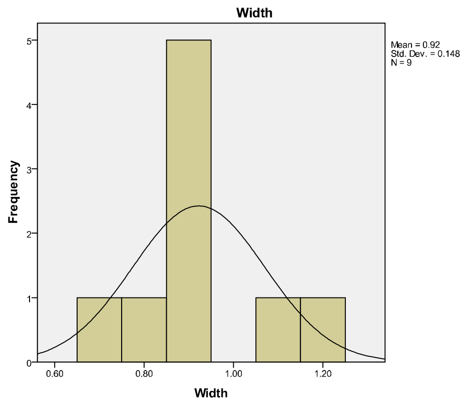
N	Valid	180
	Missing	0
Mean		1.3606
Std. Error of Mean		.04876
Median		1.2000
Std. Deviation		.65421
Variance		.428
Range		3.20
Minimum		.50
Maximum		3.70

50 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 10)



N	Valid	61
	Missing	0
Mean		1.2246
Std. Error of Mean		.11633
Median		1.0000
Std. Deviation		.90860
Variance		.826
Range		3.80
Minimum		.30
Maximum		4.10

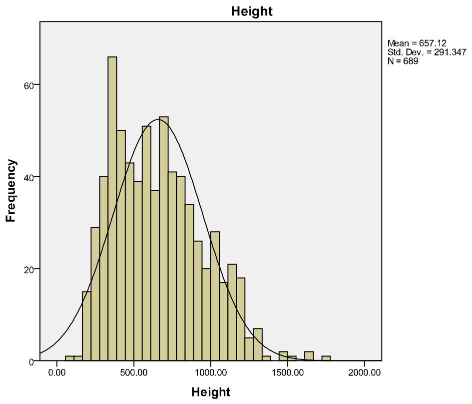
100 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 11)



N	Valid	9
	Missing	0
Mean		.9222
Std. Error of Mean		.04938
Median		.9000
Std. Deviation		.14814
Variance		.022
Range		.50
Minimum		.70
Maximum		1.20

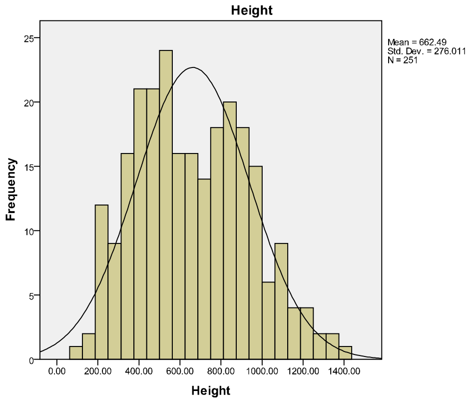
150 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 12)

Figure A 23.8: *Mentha aquatica* Histogram and Data of Stem Widths with Increasing Nutrients for Microcosms 9-13 with Restricted Root Competition



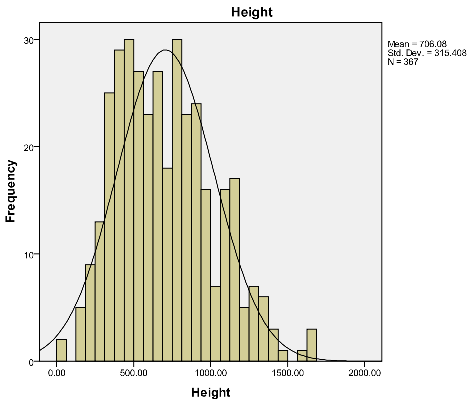
N	Valid	689
	Missing	0
Mean		657.1176
Std. Error of Mean		11.09942
Median		628.0000
Std. Deviation		291.34666
Variance		84882.874
Range		1669.00
Minimum		71.00
Maximum		1740.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 9 and 13)



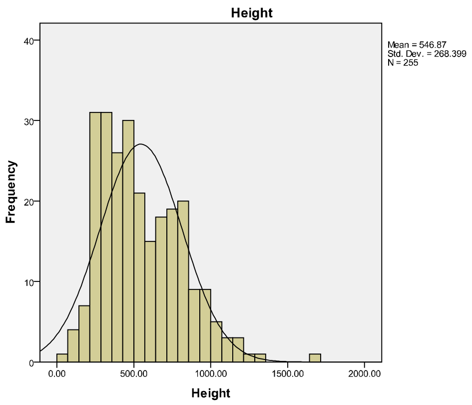
N	Valid	251
	Missing	0
Mean		662.4861
Std. Error of Mean		17.42169
Median		634.0000
Std. Deviation		276.01148
Variance		76182.339
Range		1303.00
Minimum		110.00
Maximum		1413.00

10 mg/L Nitrogen and 5 ‰ Salinity (Microcosm 14)



N	Valid	367
	Missing	0
Mean		706.0763
Std. Error of Mean		16.46414
Median		672.0000
Std. Deviation		315.40752
Variance		99481.901
Range		1645.00
Minimum		30.00
Maximum		1675.00

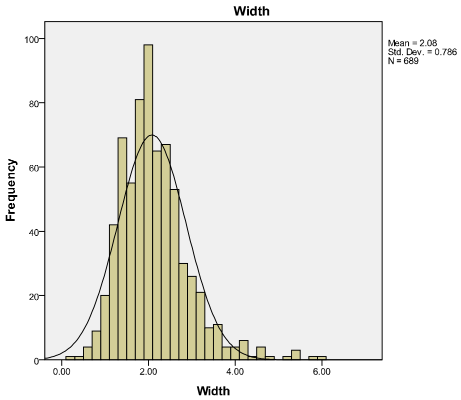
10 mg/L Nitrogen and 10 ‰ Salinity (Microcosm 15)



N	Valid	255
	Missing	0
Mean		546.8745
Std. Error of Mean		16.80780
Median		495.0000
Std. Deviation		268.39903
Variance		72038.039
Range		1617.00
Minimum		70.00
Maximum		1687.00

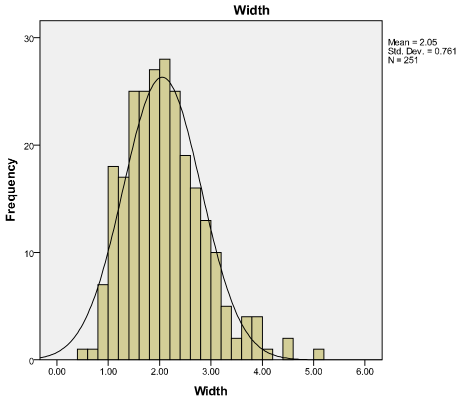
10 mg/L Nitrogen and 15 ‰ Salinity (Microcosm 16)

Figure A 23.9: *Phragmites australis* Histogram and Data of Stem Heights with Increasing Salinity for Microcosms 9, 13-16 with Restricted Root Competition



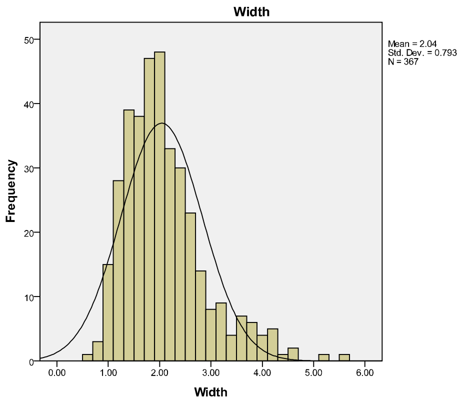
N	Valid	689
	Missing	0
Mean		2.0827
Std. Error of Mean		.02994
Median		2.0000
Std. Deviation		.78600
Variance		.618
Range		5.80
Minimum		.20
Maximum		6.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 9 and 13)



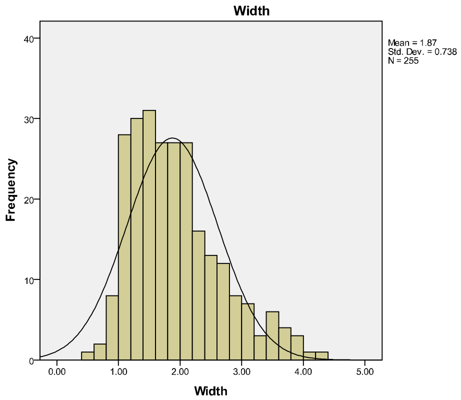
N	Valid	251
	Missing	0
Mean		2.0522
Std. Error of Mean		.04805
Median		2.0000
Std. Deviation		.76128
Variance		.580
Range		4.60
Minimum		.50
Maximum		5.10

10 mg/L Nitrogen and 5 ‰ Salinity (Microcosm 14)



N	Valid	367
	Missing	0
Mean		2.0401
Std. Error of Mean		.04138
Median		1.9000
Std. Deviation		.79280
Variance		.629
Range		5.00
Minimum		.60
Maximum		5.60

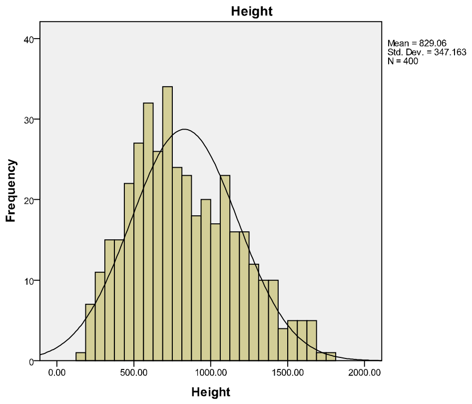
10 mg/L Nitrogen and 10 ‰ Salinity (Microcosm 15)



N	Valid	255
	Missing	0
Mean		1.8729
Std. Error of Mean		.04619
Median		1.8000
Std. Deviation		.73758
Variance		.544
Range		3.70
Minimum		.50
Maximum		4.20

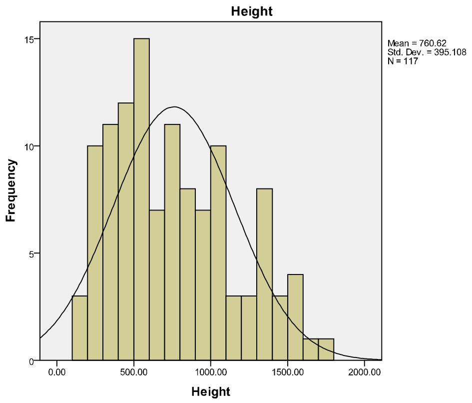
10 mg/L Nitrogen and 15 ‰ Salinity (Microcosm 16)

Figure A 23.10: *Phragmites australis* Histogram and Data of Stem Widths with Increasing Salinity for Microcosms 9, 13-16 with Restricted Root Competition



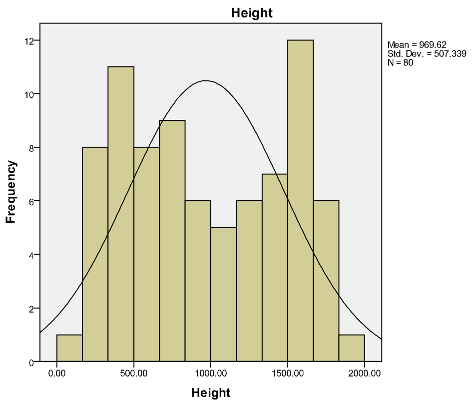
N	Valid	400
	Missing	0
Mean		829.0575
Std. Error of Mean		17.35816
Median		778.0000
Std. Deviation		347.16326
Variance		120522.330
Range		1608.00
Minimum		170.00
Maximum		1778.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 9 and 13)



N	Valid	117
	Missing	0
Mean		760.6239
Std. Error of Mean		36.52774
Median		700.0000
Std. Deviation		395.10790
Variance		156110.254
Range		1605.00
Minimum		148.00
Maximum		1753.00

10 mg/L Nitrogen and 5 ‰ Salinity (Microcosm 14)



N	Valid	80
	Missing	0
Mean		969.6250
Std. Error of Mean		56.72224
Median		918.5000
Std. Deviation		507.33913
Variance		257392.997
Range		1766.00
Minimum		160.00
Maximum		1926.00

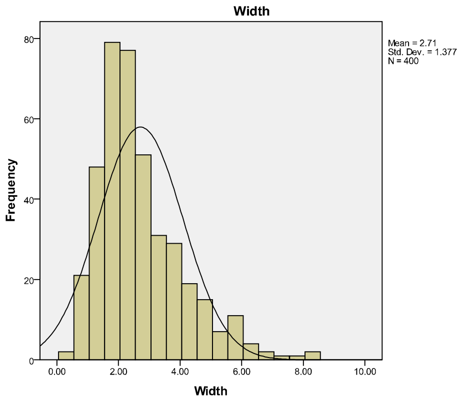
10 mg/L Nitrogen and 10 ‰ Salinity (Microcosm 15)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

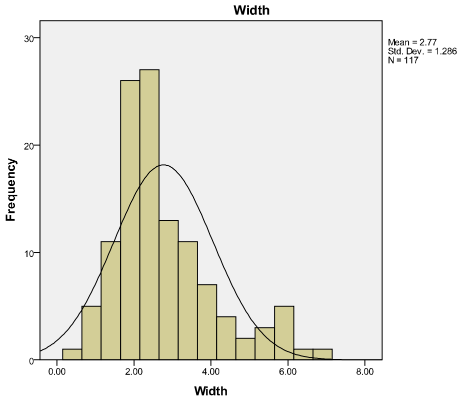
10 mg/L Nitrogen and 15 ‰ Salinity (Microcosm 16)

Figure A 23.11: *Lythrum salicaria* Histogram and Data of Stem Heights with Increasing Salinity for Microcosms 9, 13-16 with Restricted Root Competition



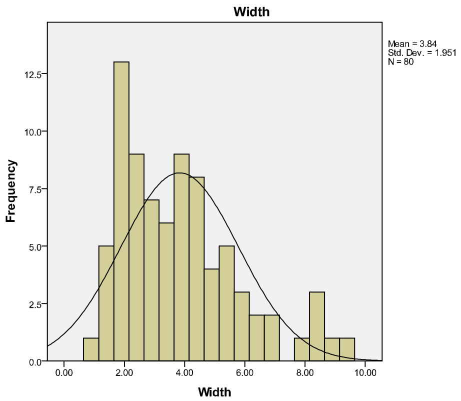
N	Valid	400
	Missing	0
Mean		2.7145
Std. Error of Mean		.06886
Median		2.4000
Std. Deviation		1.37724
Variance		1.897
Range		8.20
Minimum		.30
Maximum		8.50

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 9 and 13)



N	Valid	117
	Missing	0
Mean		2.7667
Std. Error of Mean		.11890
Median		2.5000
Std. Deviation		1.28607
Variance		1.654
Range		6.40
Minimum		.40
Maximum		6.80

10 mg/L Nitrogen and 5 ‰ Salinity (Microcosm 14)



N	Valid	80
	Missing	0
Mean		3.8375
Std. Error of Mean		.21809
Median		3.6000
Std. Deviation		1.95068
Variance		3.805
Range		8.30
Minimum		.90
Maximum		9.20

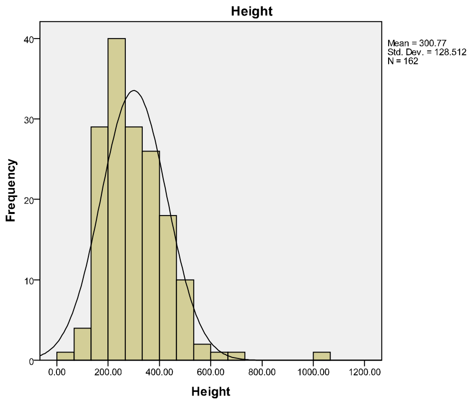
10 mg/L Nitrogen and 10 ‰ Salinity (Microcosm 15)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

10 mg/L Nitrogen and 15 ‰ Salinity (Microcosm 16)

Figure A 23.12: *Lythrum salicaria* Histogram and Data of Stem Widths with Increasing Salinity for Microcosms 9, 13-16 with Restricted Root Competition



N	Valid	162
	Missing	0
Mean		300.7654
Std. Error of Mean		10.09689
Median		279.5000
Std. Deviation		128.51239
Variance		16515.435
Range		1029.00
Minimum		20.00
Maximum		1049.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 9 and 13)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

10 mg/L Nitrogen and 5 ‰ Salinity (Microcosm 14)

No Surviving Plants.

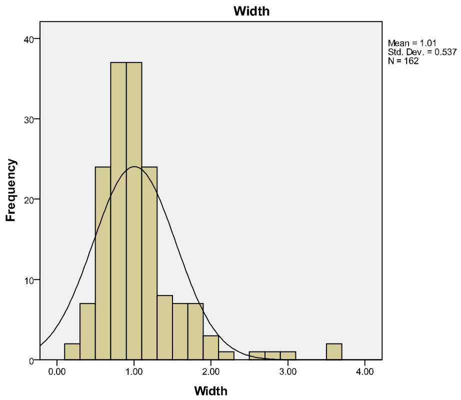
N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

10 mg/L Nitrogen and 10 ‰ Salinity (Microcosm 15)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

Figure A 23.13: *Filipendula ulmaria* Histogram and Data of Stem Heights with Increasing Salinity for Microcosms 9, 13-16 with Restricted Root Competition



N	Valid	162
	Missing	0
Mean		1.0068
Std. Error of Mean		.04222
Median		.9000
Std. Deviation		.53743
Variance		.289
Range		3.40
Minimum		.20
Maximum		3.60

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 9 and 13)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

10 mg/L Nitrogen and 5 ‰ Salinity (Microcosm 14)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

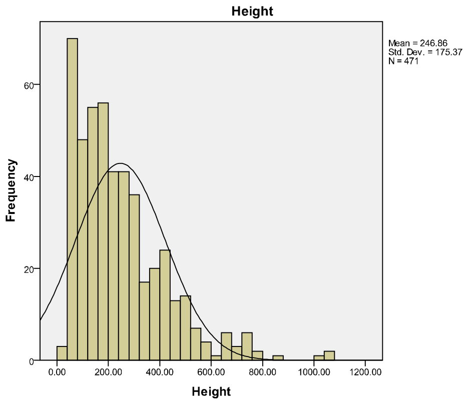
10 mg/L Nitrogen and 10 ‰ Salinity (Microcosm 15)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

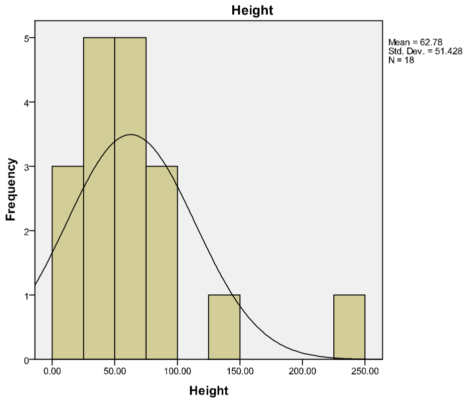
10 mg/L Nitrogen and 15 ‰ Salinity (Microcosm 16)

Figure A 23.14: *Filipendula ulmaria* Histogram and Data of Stem Widths with Increasing Salinity for Microcosms 9, 13-16 with Restricted Root Competition



N	Valid	471
	Missing	0
Mean		246.8556
Std. Error of Mean		8.08061
Median		205.0000
Std. Deviation		175.36976
Variance		30754.554
Range		1044.00
Minimum		15.00
Maximum		1059.00

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 9 and 13)



N	Valid	18
	Missing	0
Mean		62.7778
Std. Error of Mean		12.12181
Median		51.0000
Std. Deviation		51.42848
Variance		2644.889
Range		220.00
Minimum		9.00
Maximum		229.00

10 mg/L Nitrogen and 5 ‰ Salinity (Microcosm 14)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

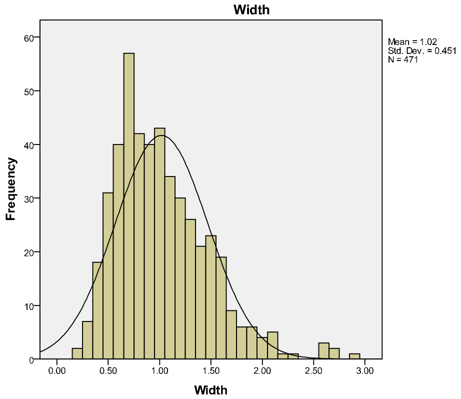
10 mg/L Nitrogen and 10 ‰ Salinity (Microcosm 15)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

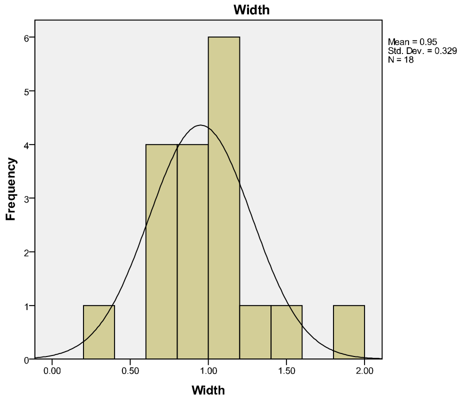
10 mg/L Nitrogen and 15 ‰ Salinity (Microcosm 16)

Figure A 23.15: *Mentha aquatica* Histogram and Data of Stem Heights with Increasing Salinity for Microcosms 9, 13-16 with Restricted Root Competition



N	Valid	471
	Missing	0
Mean		1.0187
Std. Error of Mean		.02078
Median		.9000
Std. Deviation		.45095
Variance		.203
Range		2.70
Minimum		.20
Maximum		2.90

10 mg/L Nitrogen and <0.05 ‰ Salinity (Microcosm 9 and 13)



N	Valid	18
	Missing	0
Mean		.9500
Std. Error of Mean		.07765
Median		.9500
Std. Deviation		.32944
Variance		.109
Range		1.50
Minimum		.30
Maximum		1.80

10 mg/L Nitrogen and 5 ‰ Salinity (Microcosm 14)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

10 mg/L Nitrogen and 10 ‰ Salinity (Microcosm 15)

No Surviving Plants.

N	Valid	N/A
	Missing	N/A
Mean		N/A
Std. Error of Mean		N/A
Median		N/A
Std. Deviation		N/A
Variance		N/A
Range		N/A
Minimum		N/A
Maximum		N/A

10 mg/L Nitrogen and 15 ‰ Salinity (Microcosm 16)

Figure A 23.16: *Mentha aquatica* Histogram and Data of Stem Widths with Increasing Salinity for Microcosms 9, 13-16 with Restricted Root Competition

Appendix 24 One Way ANOVA Results for Restricted Competition Microcosms

Stem Heights of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	53.187	3	17.729	177.790	.000
	Within Groups	442.551	4438	.100		
	Total	495.738	4441			
Phragmites australis	Between Groups	9.033	3	3.011	50.880	.000
	Within Groups	138.534	2341	.059		
	Total	147.567	2344			
Lythrum salicaria	Between Groups	1.116	3	.372	8.705	.000
	Within Groups	42.771	1001	.043		
	Total	43.887	1004			
Filipendula ulmaria	Between Groups	1.872	3	.624	13.383	.000
	Within Groups	17.113	367	.047		
	Total	18.985	370			
Mentha aquatica	Between Groups	4.981	3	1.660	16.664	.000
	Within Groups	71.440	717	.100		
	Total	76.421	720			

Table A 24.1: One Way ANOVA Results for Effects Of Different Nutrient Ratios on Stem Harvest Heights (Log10) for Microcosms 9-13 with Restricted Root Competition

Stem Widths of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	33.247	3	11.082	186.802	.000
	Within Groups	263.288	4438	.059		
	Total	296.535	4441			
Phragmites australis	Between Groups	6.890	3	2.297	103.244	.000
	Within Groups	52.075	2341	.022		
	Total	58.965	2344			
Lythrum salicaria	Between Groups	1.930	3	.643	12.835	.000
	Within Groups	50.172	1001	.050		
	Total	52.102	1004			
Filipendula ulmaria	Between Groups	.948	3	.316	4.127	.007
	Within Groups	28.104	367	.077		
	Total	29.052	370			
Mentha aquatica	Between Groups	2.076	3	.692	17.074	.000
	Within Groups	29.057	717	.041		
	Total	31.132	720			

Table A 24.2: One Way ANOVA Results for Effects of Different Nutrient Ratios on Stem Harvest Widths (Log10) for Microcosms 9-13 with Restricted Root Competition

Stem Heights of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	14.085	3	4.695	47.041	.000
	Within Groups	280.050	2806	.100		
	Total	294.135	2809			
Phragmites australis	Between Groups	2.256	3	.752	16.193	.000
	Within Groups	72.348	1558	.046		
	Total	74.604	1561			
Lythrum salicaria	Between Groups	.498	2	.249	5.074	.007
	Within Groups	29.164	594	.049		
	Total	29.662	596			
Filipendula ulmaria***	Between Groups	N/A	N/A	N/A	N/A	N/A
	Within Groups	N/A	N/A	N/A	N/A	N/A
	Total	N/A	N/A	N/A	N/A	N/A
Mentha aquatica	Between Groups	6.171	1	6.171	59.886	.000
	Within Groups	50.186	487	.103		
	Total	56.357	488			

Notes: *** Only surviving in a single microcosm therefore one-way ANOVA is not feasible.

Table A 24.3: One Way ANOVA Results for Effects of Different Salinity Ratios on Stem Harvest Heights (Log10) for Microcosms 9, 13-16 with Restricted Root Competition

Stem Widths of		Sum of Squares	df	Mean Square	F	Sig.
All Stems	Between Groups	8.759	3	2.920	52.038	.000
	Within Groups	157.434	2806	.056		
	Total	166.193	2809			
Phragmites australis	Between Groups	.444	3	.148	5.411	.001
	Within Groups	42.590	1558	.027		
	Total	43.034	1561			
Lythrum salicaria	Between Groups	1.490	2	.745	15.766	.000
	Within Groups	28.067	594	.047		
	Total	29.557	596			
Filipendula ulmaria***	Between Groups	N/A	N/A	N/A	N/A	N/A
	Within Groups	N/A	N/A	N/A	N/A	N/A
	Total	N/A	N/A	N/A	N/A	N/A
Mentha aquatica	Between Groups	.004	1	.004	.106	.745
	Within Groups	18.391	487	.038		
	Total	18.395	488			

Notes: *** Only surviving in a single microcosm therefore one-way ANOVA is not feasible.

Table A 24.4: One Way ANOVA Results for Effects of Different Salinity Ratios on Stem Harvest Widths (Log10) for Microcosms 9, 13-16 with Restricted Root Competition