Impacts of short rotation forestry species on hydrology and nutrient cycles.

Mark O'Connor
Liwen Xiao

Department of Civil, Structural and Environmental Engineering
TCD

Microcosm setup for SRF species nutrient and hydrological demand comparison

BNM standard nursery mix

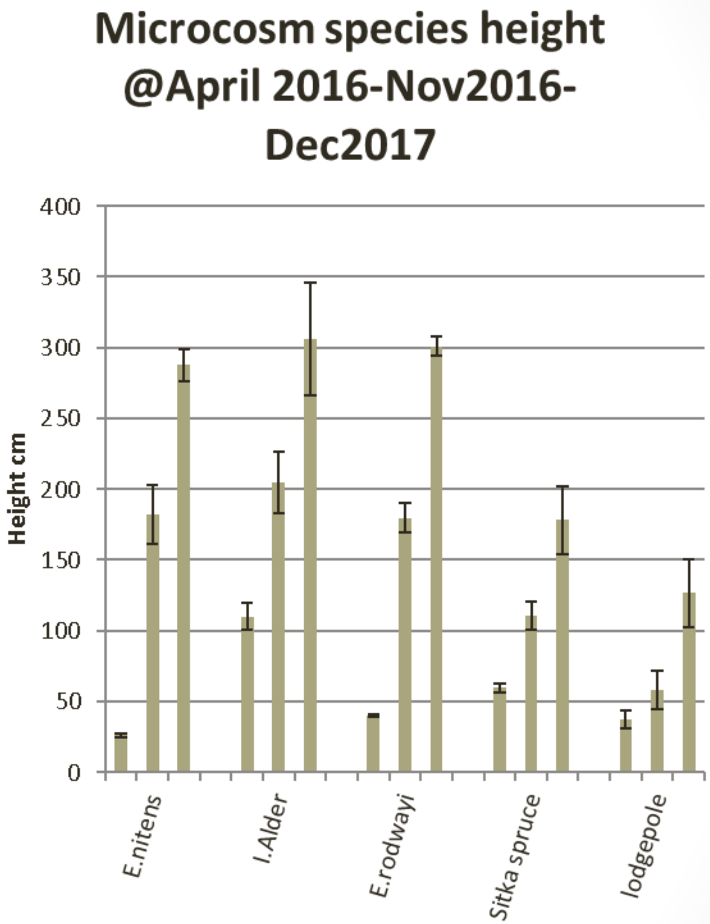
7 x Italian alder, E.nitens, E.rodwayi, Sitka spruce, lodgepole pine.
5 x Control/peat only

Raised platform, secure enclosure and rain gauge, PAR and soil temp onsite

39L pots filled with 42L of compost

Leachate collection in HDPE canisters under pots

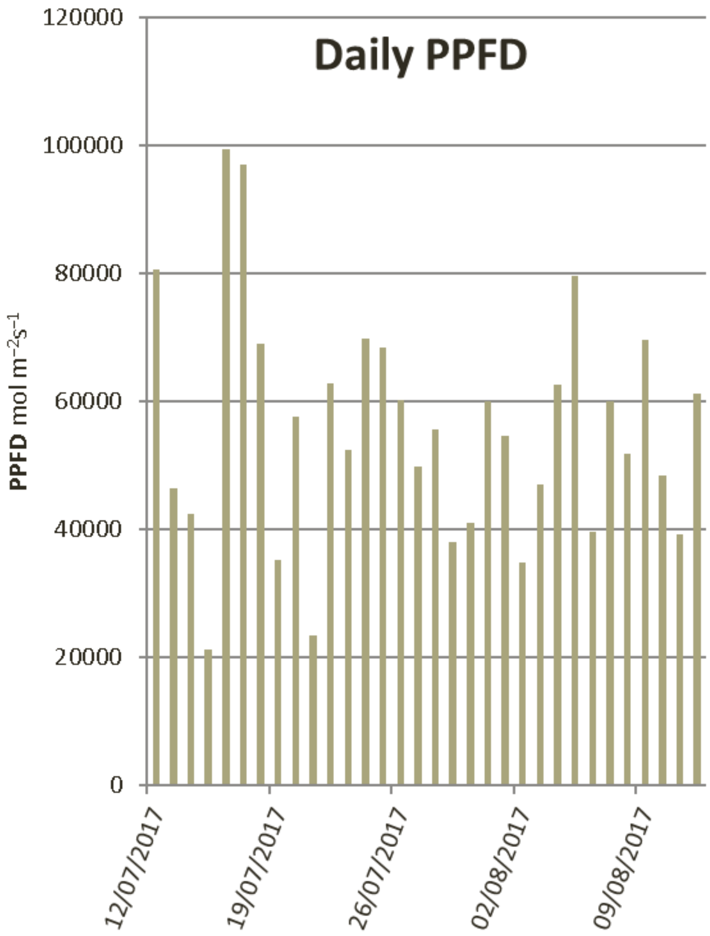
2017 season



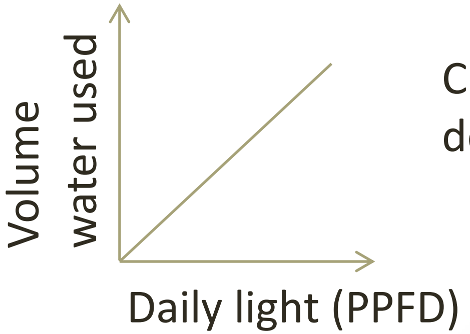
2017 Main Objectives:

- Estimate peak season water demands per species
- Compare species impact on leachate water quality parameters

Modelling water use by species



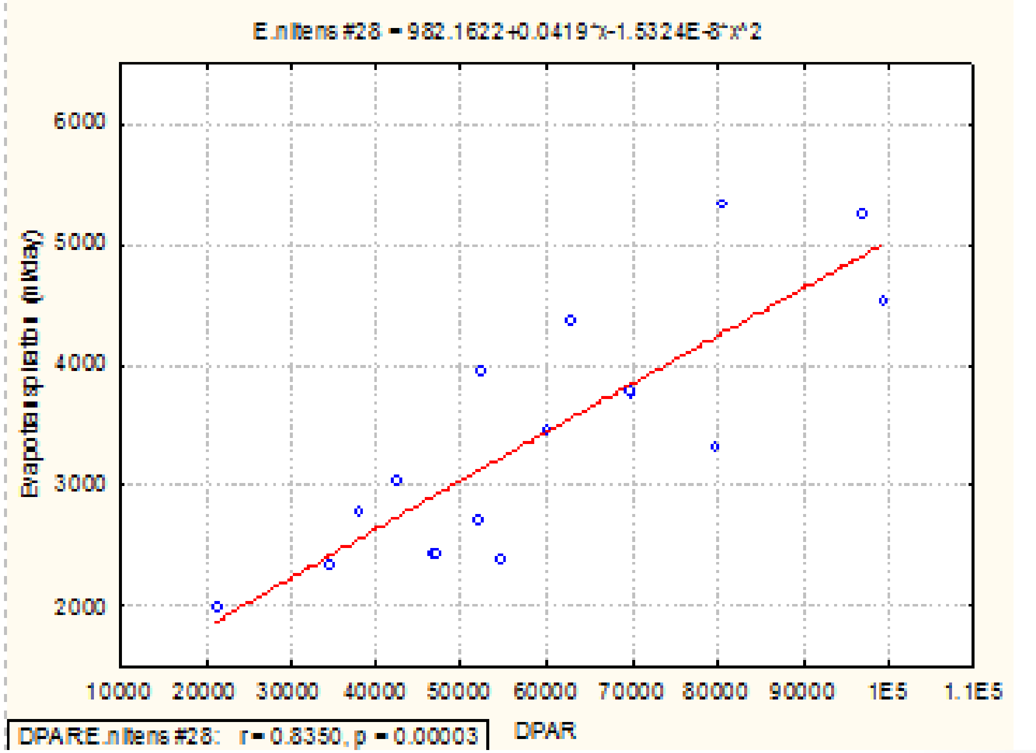
- Several approaches attempted
- Soil water content method unreliable as rain only wetted the soil surface (where probe recorded)
- Mass balance approach difficult and labour intensive
- Water balance approach with rain gauge unreliable as rainfall was diverted outside pot via canopy cover
- Water balance approach with vapour pressure deficit a poor fit to data (met station 14km from site)
- Best fit was a water balance approach from saturated field capacity with daily PPFD recorded onsite (volume of water required to return to field capacity).



Chosen model design

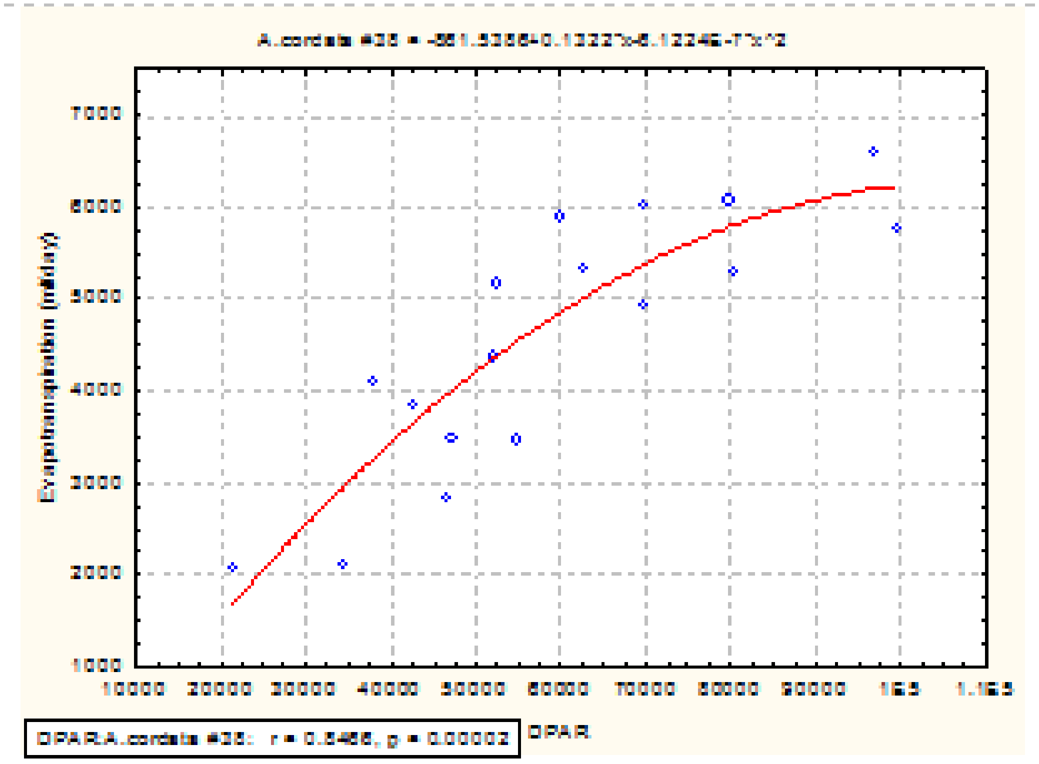
E.nitens: Daily light-evapotranspiration relationship

Tree #	Height (mm)	Est.Max Transpiration (ml/day)*
28	2750	5000
39	2750	4800
4	2560	4750
16	2900	6100
average	**2740**	**5162.5**



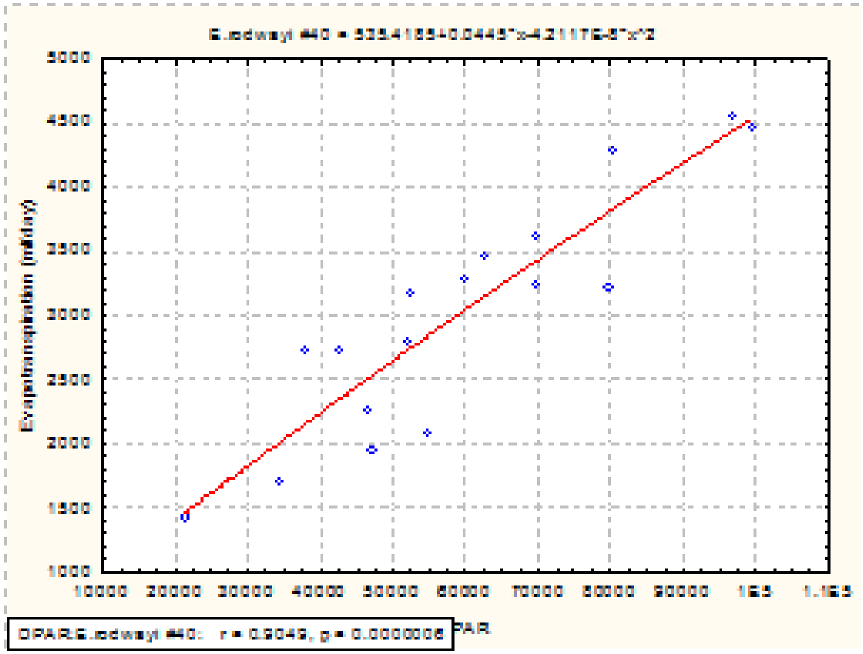
Alder: Daily light-evapotranspiration relationship

Tree #	Height (mm)	Est.Max Transpiration (ml/day)*
31	2620	4800
38	2500	6400
19	3070	6600
25	2780	5800
average	**2742.5**	**5900**



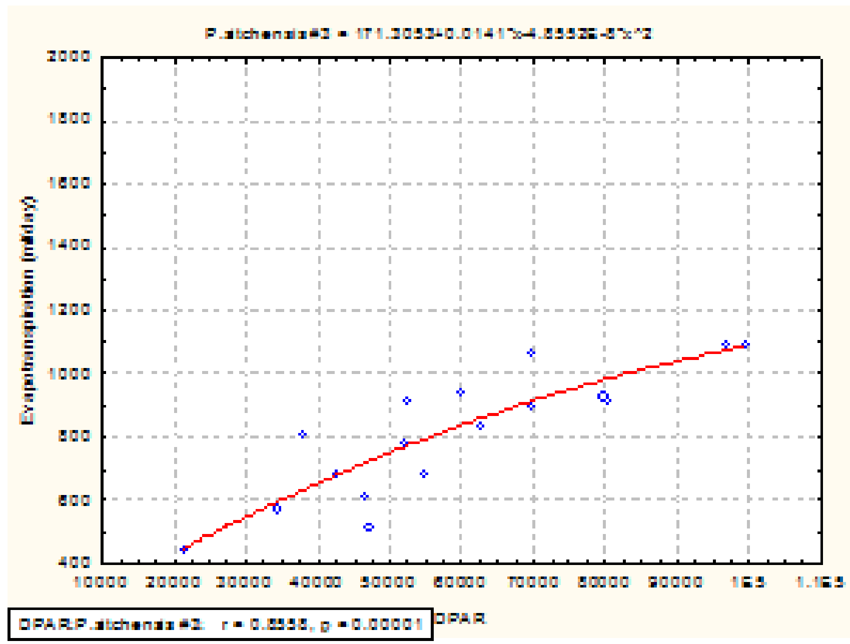
E.rodwayi: Daily light-evapotranspiration relationship

Tree #	Height (mm)	Est.Max Transpiration (ml/day)*
40	2550	4600
29	3480	3800
5	2770	3600
17	2820	4100
average	**2905**	**4025**



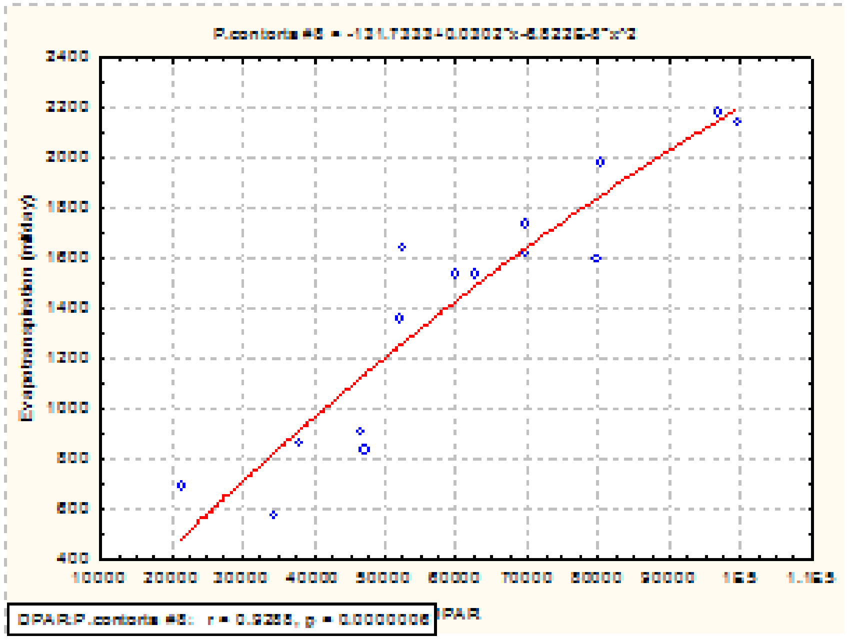
P. Sitchensis (SS): Daily light-evapotranspiration relationshi

Tree #	Height (mm)	Est.Max Transpiration (ml/day)*
3	1750	1250
36	1940	1800
33	1680	1300
14	1500	1440
average	**1717.5**	**1447.5**

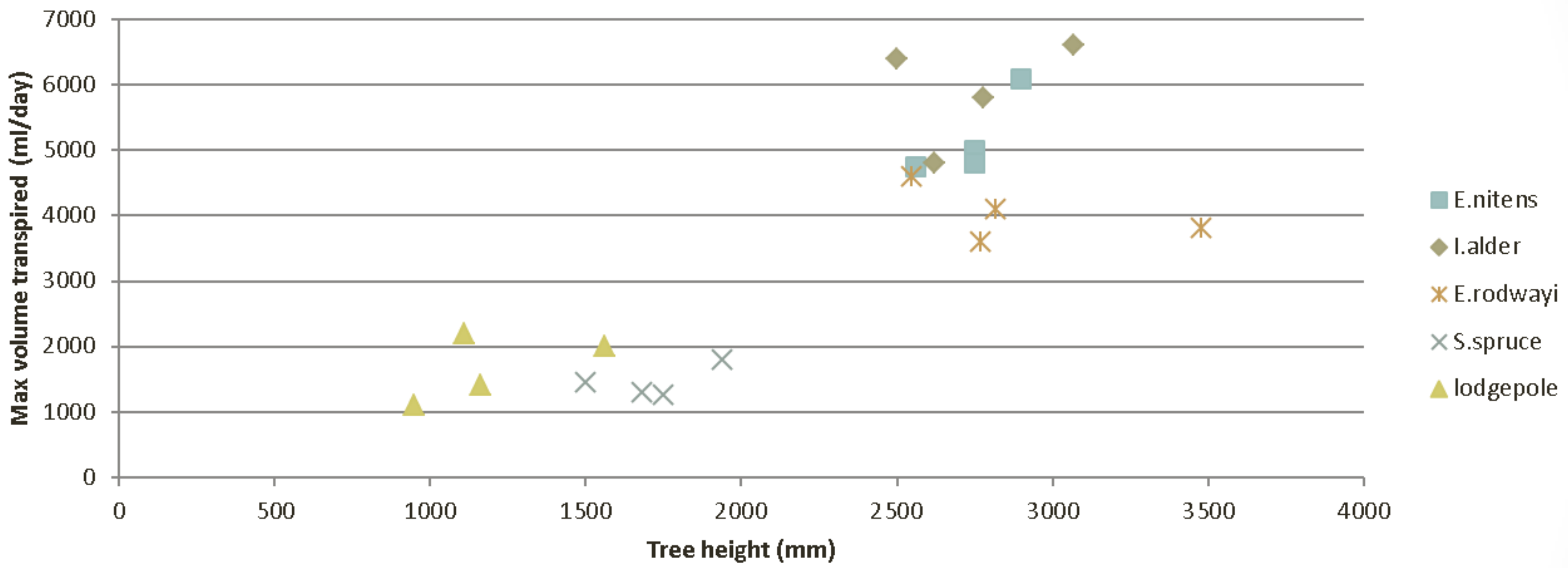


P. contorta: Daily light-evapotranspiration relationship

Tree #	Height (mm)	Est.Max Transpiration (ml/day)
8	1110	2200
13	950	1100
32	1160	1400
2	1560	2000
average	**1195**	**1675**

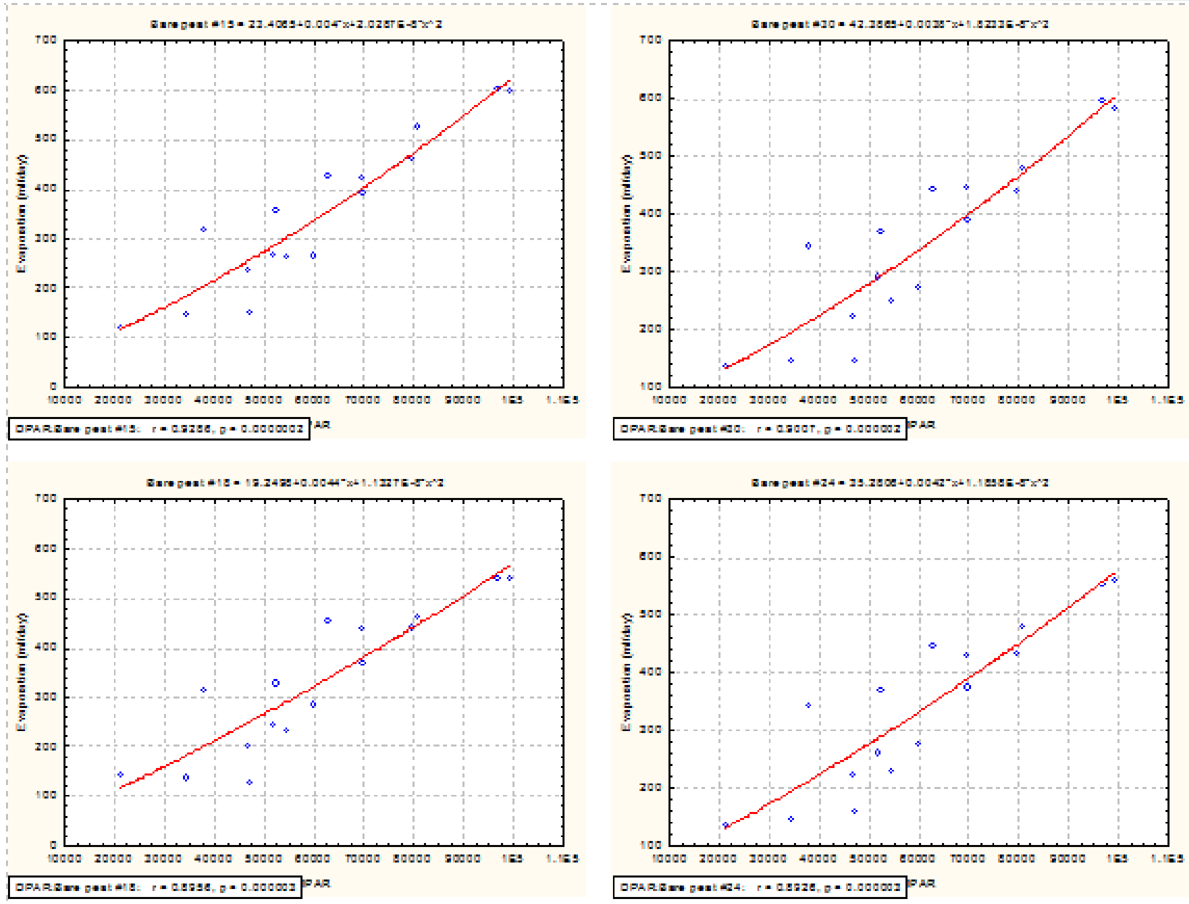


Daily light-evapotranspiration relationship

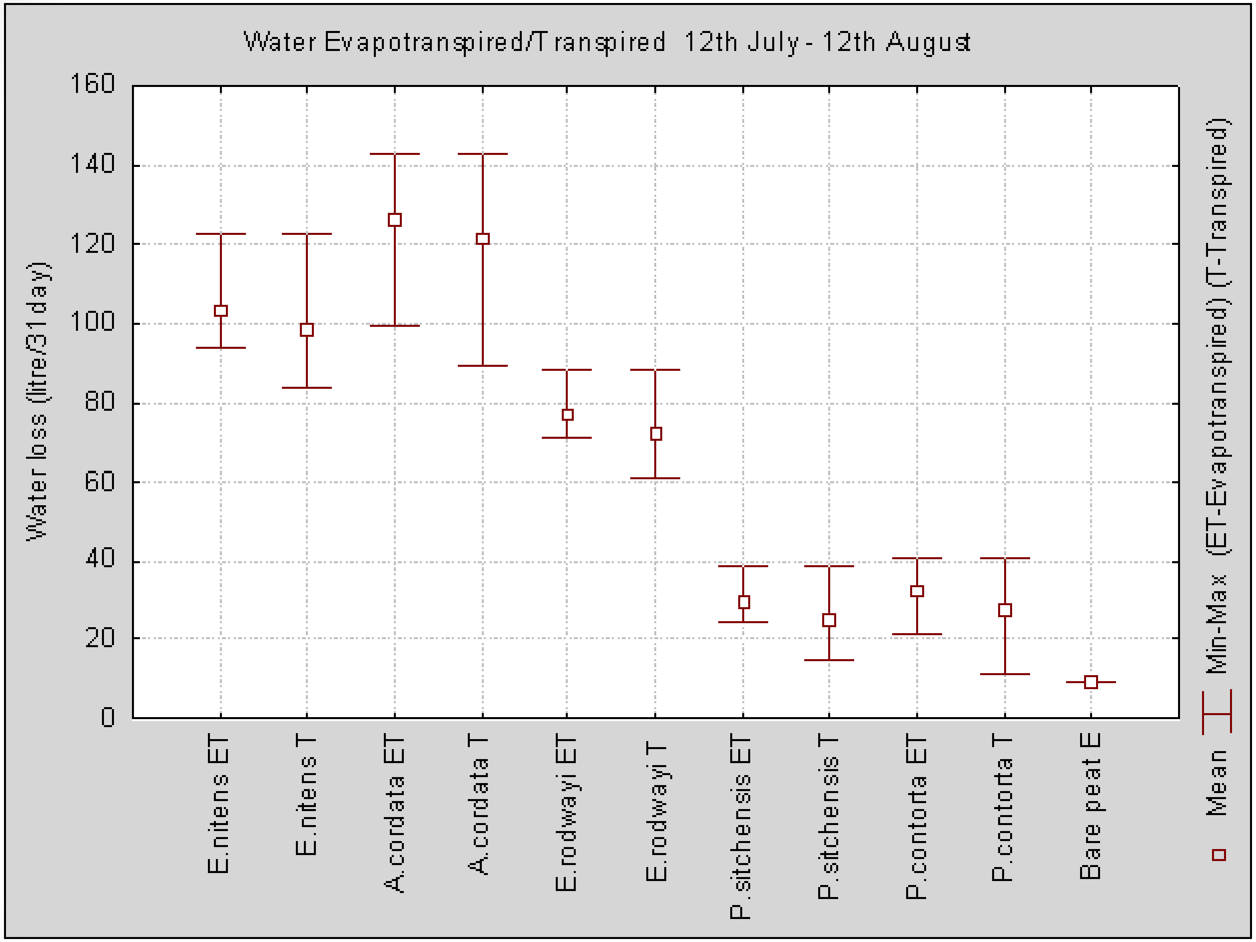


Bare peat: Daily light-evaporation relationship

Pot #	Height (mm)	Est.Max Evapotation (ml/day)
15	N/A	640
30	N/A	620
18	N/A	580
24	N/A	580
average	N/A	605



Water demands of species in second growing season following transplant based on models generated (12th July – 12th August 2017)

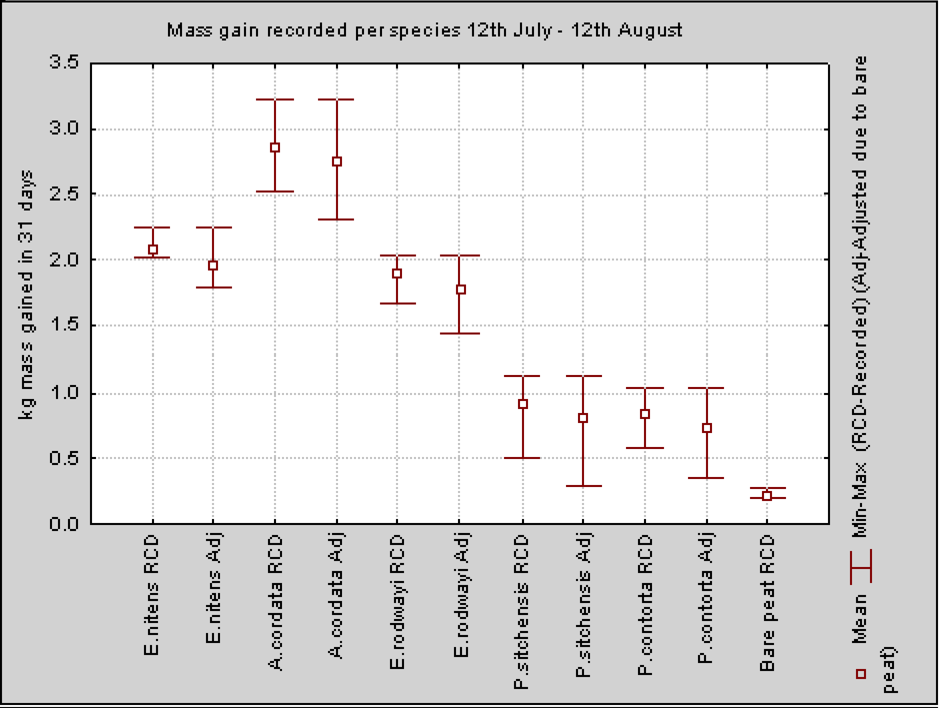


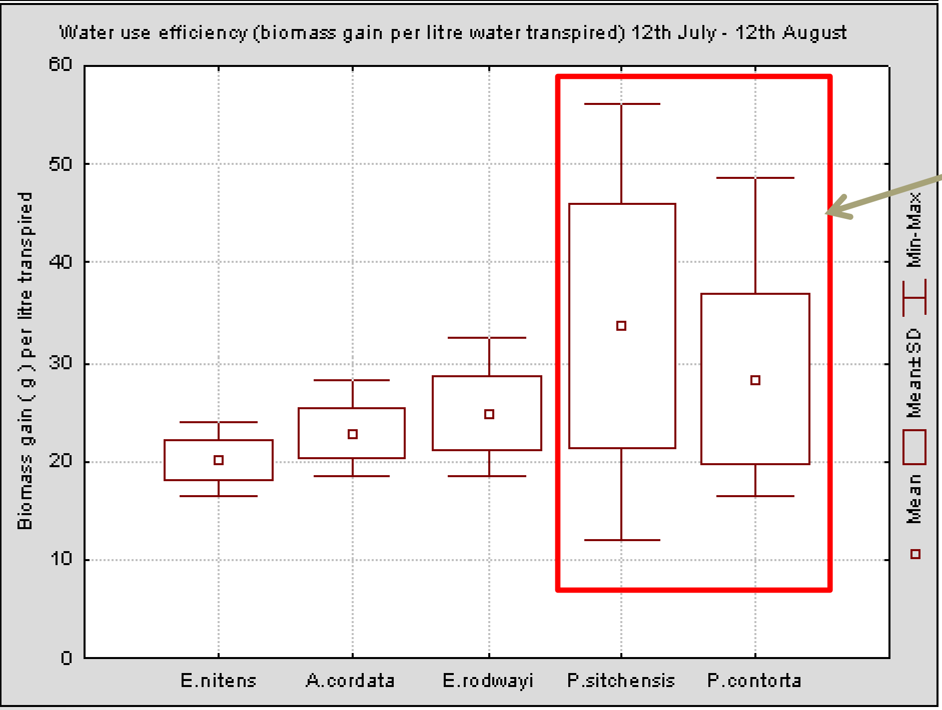
Species	average tree height (mm)	Est.max daily loss (ml)
Nitens	2740	5162.5
Alder	2742.5	5900
Rodwayi	2905	4025
Sitka	1717.5	1447.5
Lodgepole	1195	1675

ET = Evapotranspiration = mean of modelled measurements

E = Soil surface evaporation = mean of modelled measurements

T = Mean of the Transpiration range from ET to ET-E





Water Use Efficiency (WUE)

WUE=Biomass gain/volume water transpired

High level of uncertainty for pine and spruce due to small mass gains, small water volumes transpired and proportion of soil surface evaporation to transpiration rates.

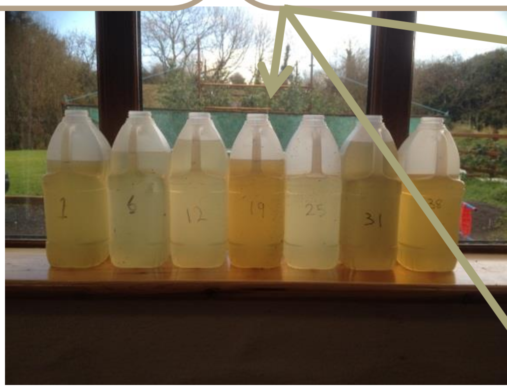
Leachate example Nov 2016

Indications of higher DOC from increased wet/dry soil cycling.

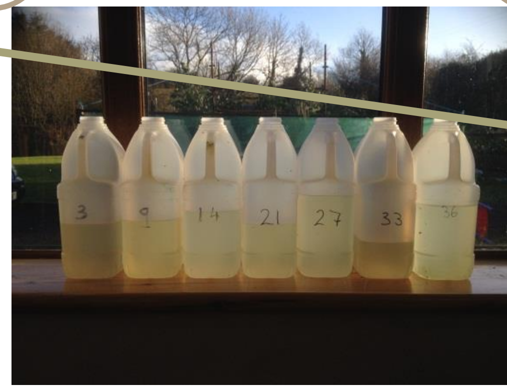
Forestry intensification: potentially non-point source for DOC on soils with high organic content.

Problems downstream include drinking water treatment

Colour
Odour
Trihalometanes
Haloacetic acid



Italian alder



Sitka Spruce

E.rodwayi

lodgepole pine

E.nitens

Control/peat only

Leachate example from 09/2017

High DOC from alder and nitens perhaps due to aerobic decomposition/ wet dry cycling

Increase in DOC from 2016 as spruce and lodgepole have greater impact on soil hydrology

E.rodwayi relatively low in DOC despite aerobic conditions.

Italian alder

Sitka Spruce

E.rodwayi

lodgepole pine

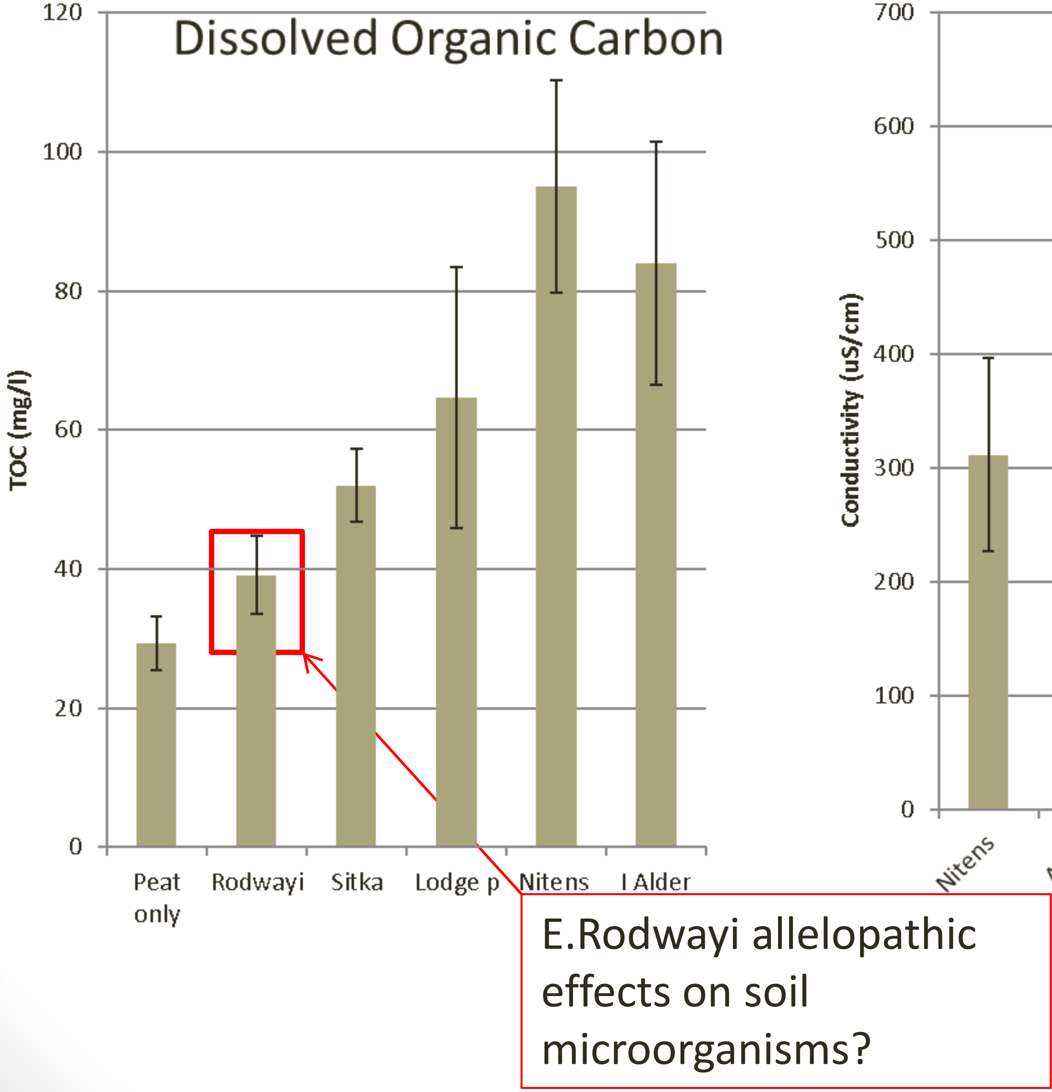
E.nitens

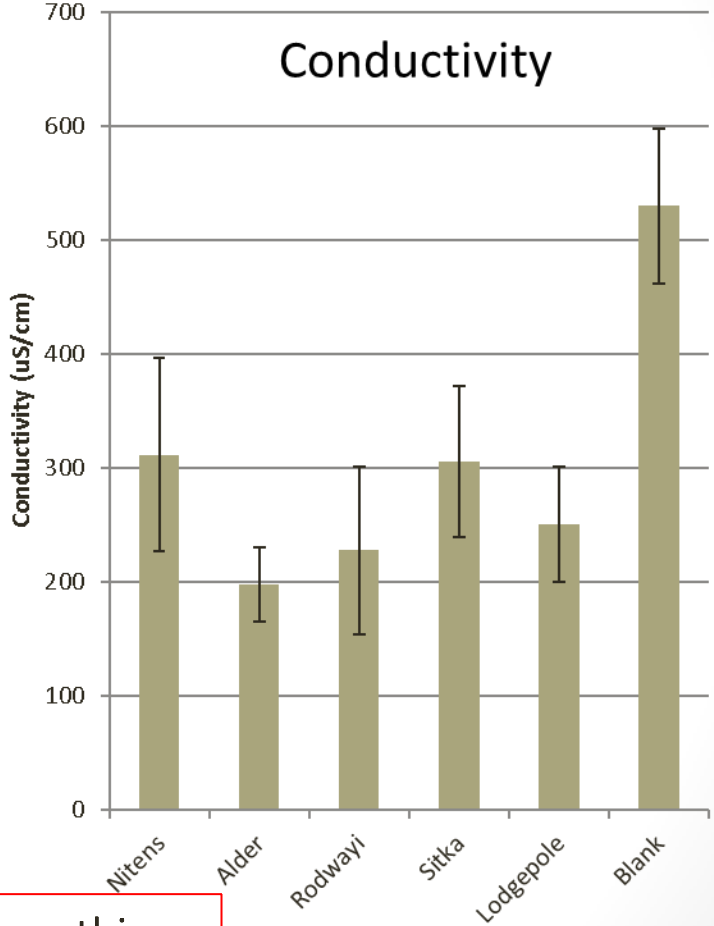
Control/peat only

Leachate properties

Combined results of 4 replicates from four leachate sampling occasions July-Sept 2017

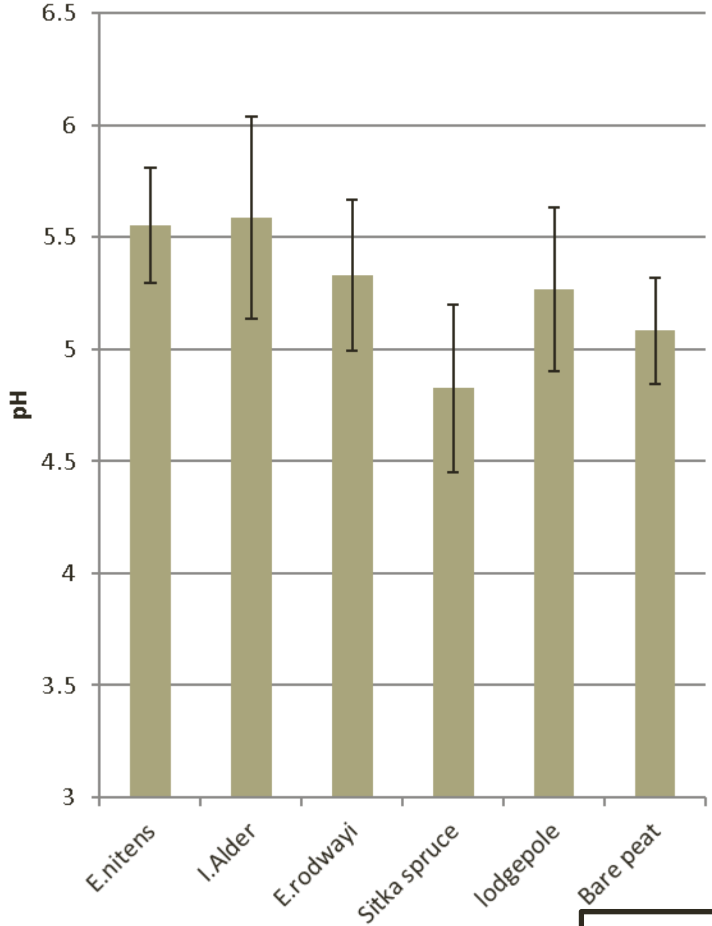
Combined results of 4 replicates from 13 leachate sampling occasions July-Sept 2017



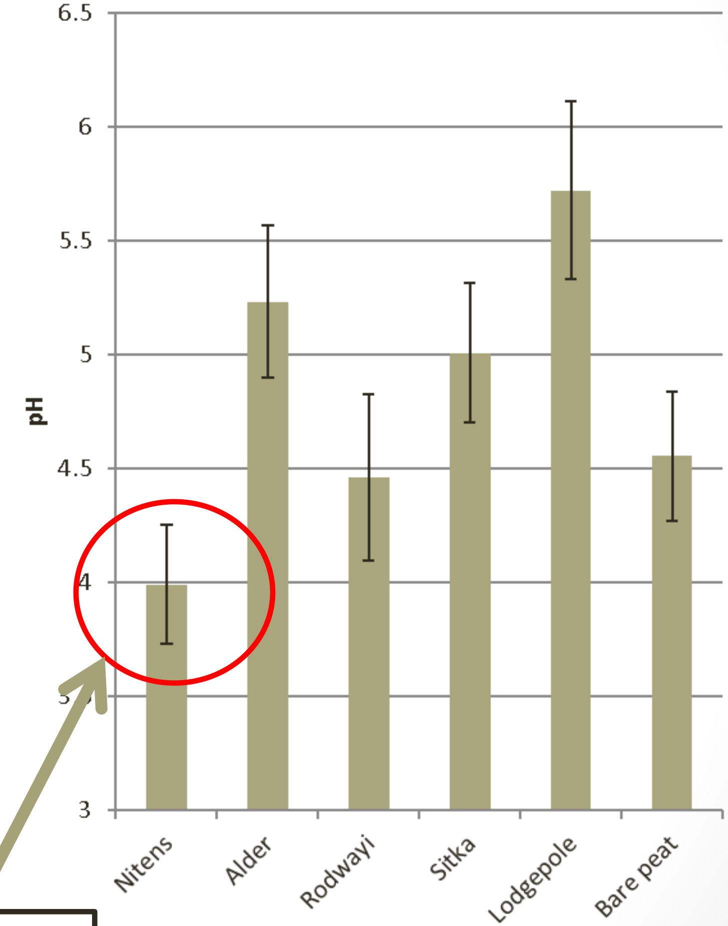


Leachate properties

Combined results of 7 replicates from four leachate sampling occasions 2016.



Combined results of 4 replicates from 13 leachate sampling occasions July-Sept 2017



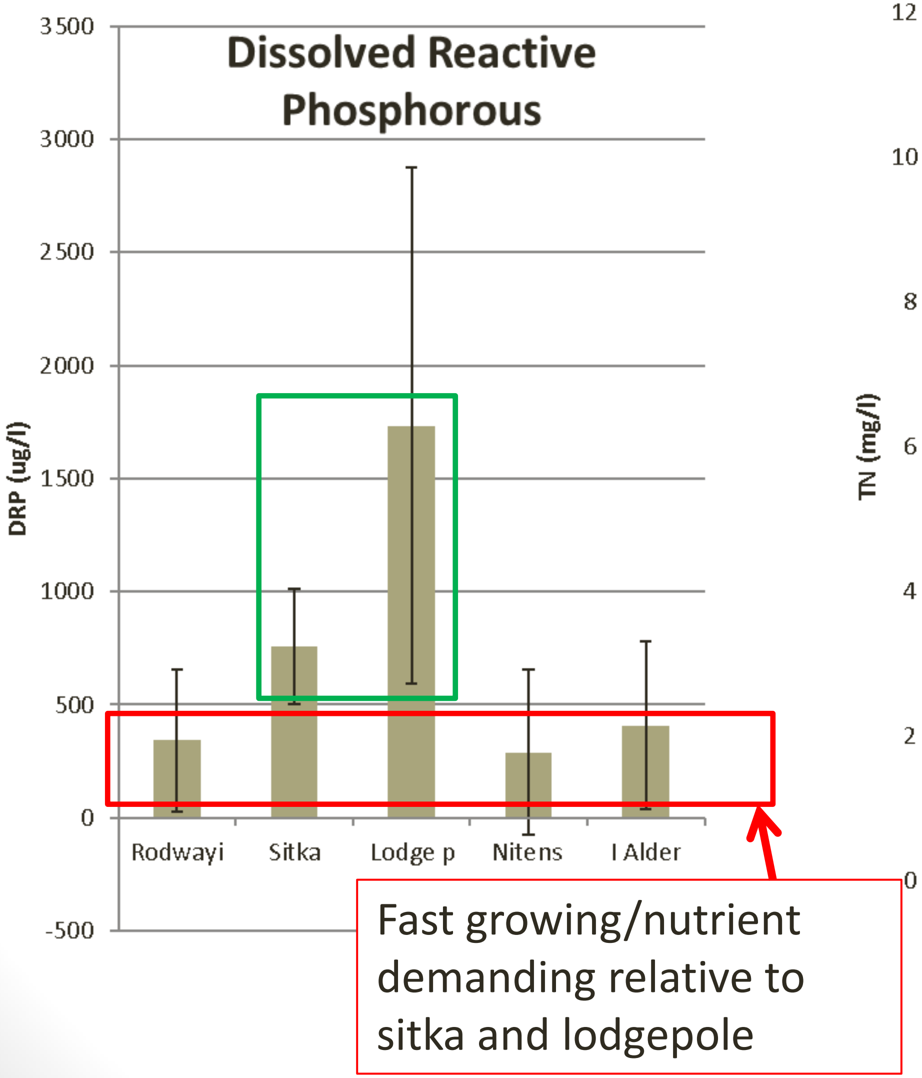
I.Alder only a slight drop despite growth rate

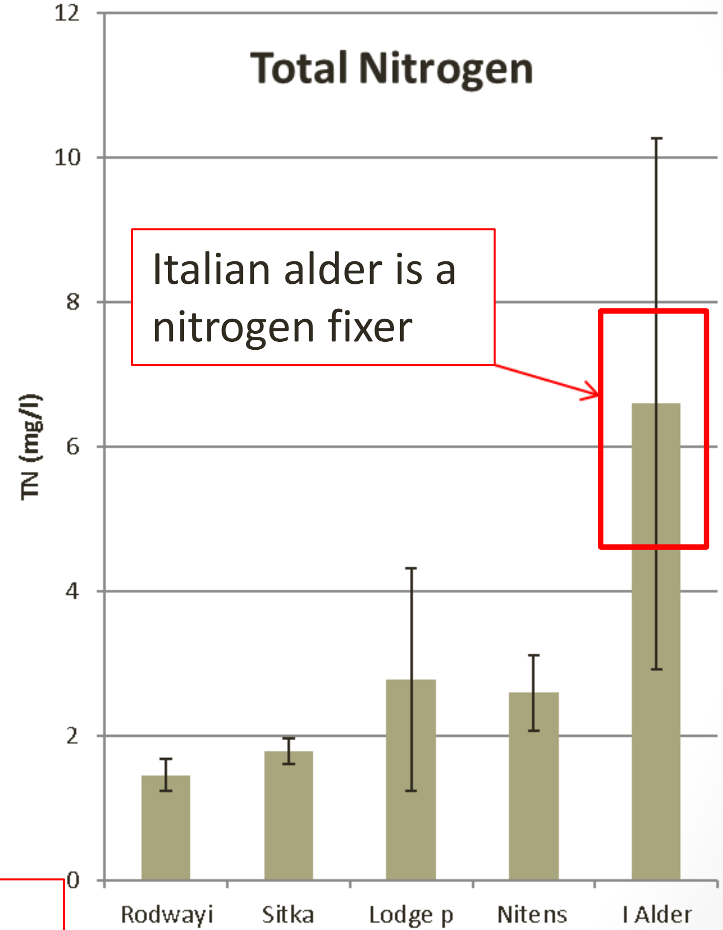
Big drop in pH from 2016

Leachate properties

Combined results of 4 replicates from 5 leachate sampling occasions July-Sept 2017

Combined results of 4 replicates from 4 leachate sampling occasions July-Sept 2017





Site setup: long-term peatland SRF species environmental impact study

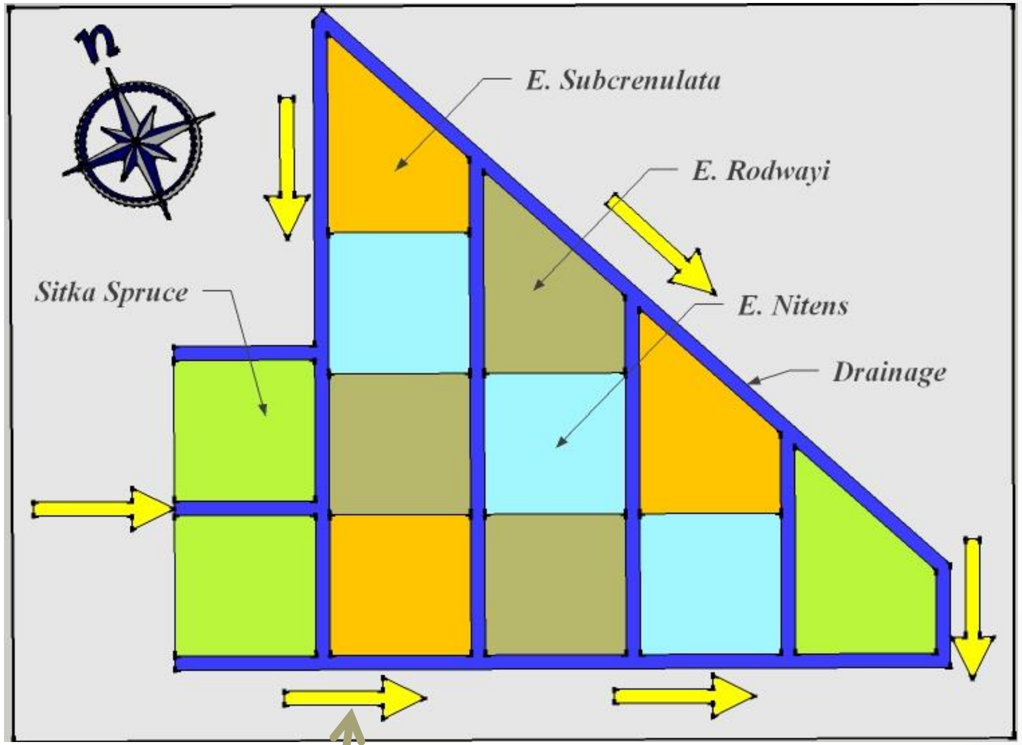
- Exposed south facing site
- 150masl
- Second rotation from SS/LP mix
- Peat depth generally 1m+
- Site left 3-4 years prior to restocking

Objectives:

- Determine the survival and growth rates of Eucalyptus SRF species on peatlands, relative to Sitka spruce with minimal land/nutrient management
- Explore potential environmental benefits of SRF species as a vegetative bioremediation strategy in nutrient sensitive second rotation sites.
- Explore climate cooling potential relative to conventional practices.
- Create peatland study site for the long monitoring of alternative Eucalyptus species.

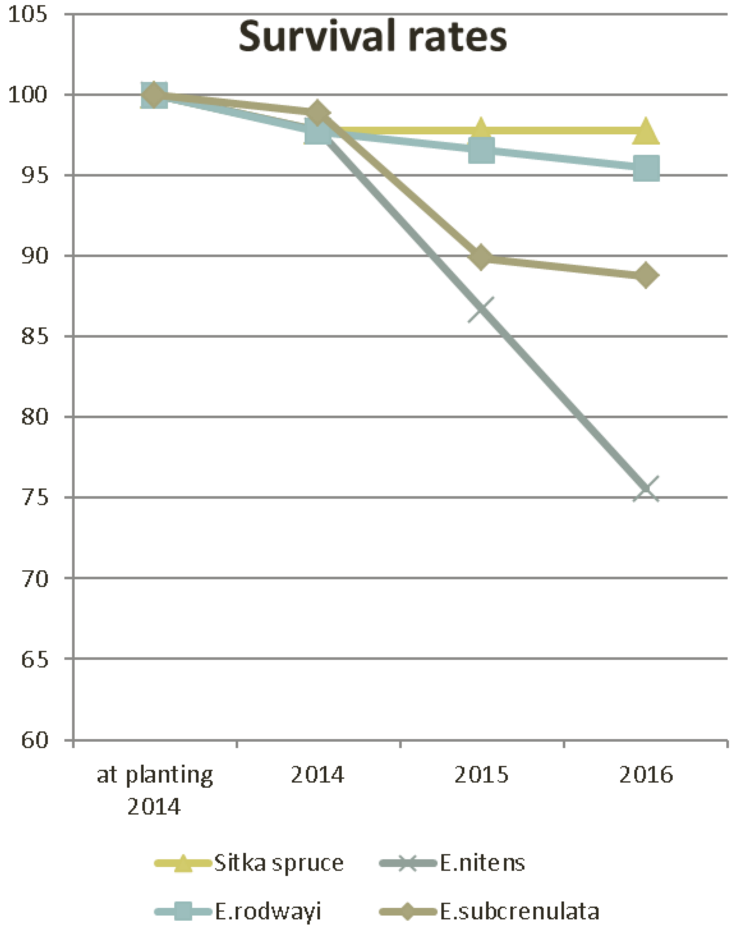
Site layout

- Mounded and drained at 8-10m intervals
- Restocked with SS March/April 2014 (Coillte)
- Restocked with Eucalyptus June 2014 (source D-plant)
- No fertiliser/fisheries area
- 30 per plot/90 per species
- Species selected for cold hardiness, swamp affiliation, popularity and availability.



Drainage direction and slope

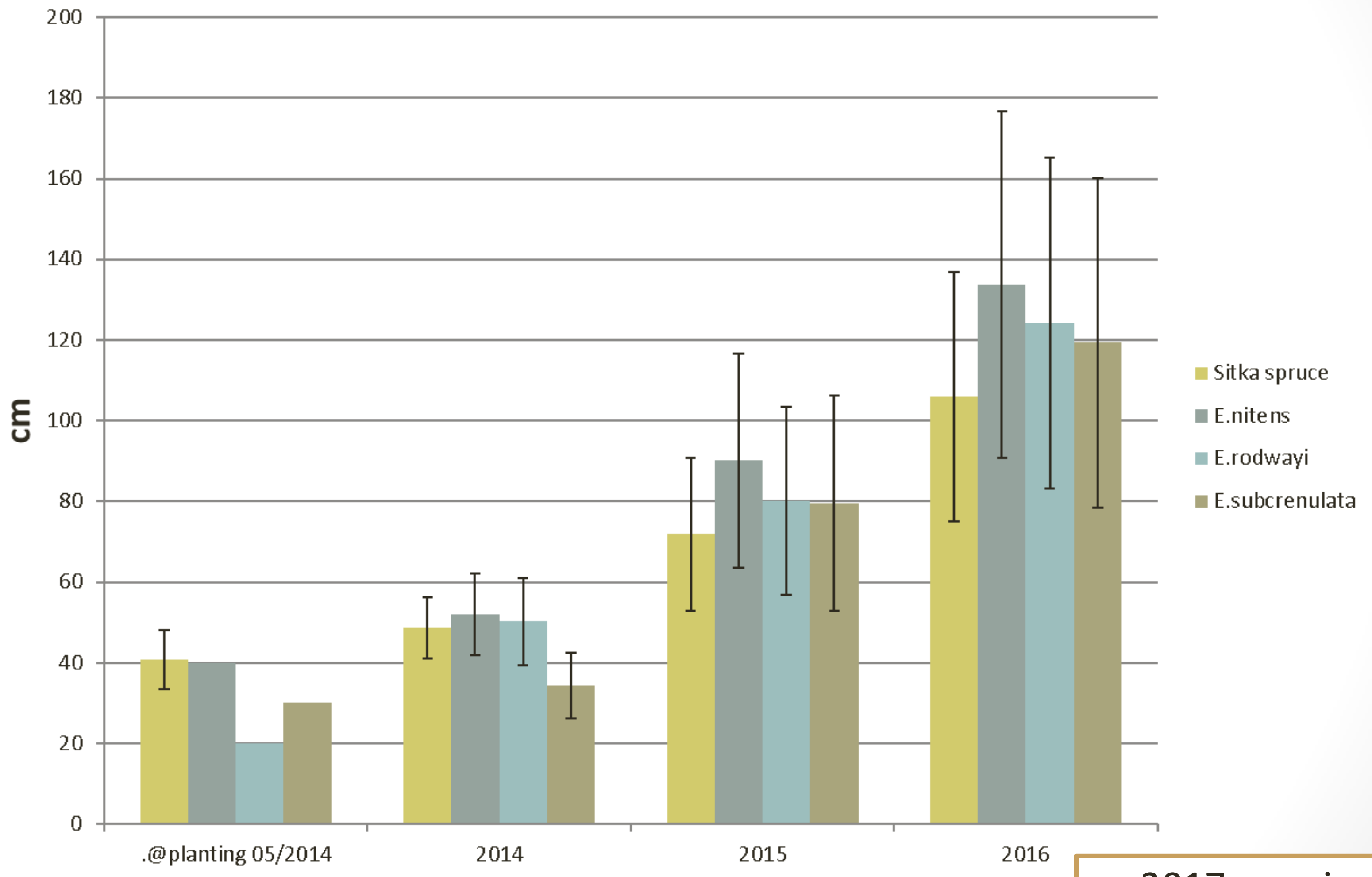
Survival rates per season



- Primary cause of mortality in eucalyptus species is deer damage (bark stripping, thrashing and grazed)
- E.rodwayi and E.subcrenulata visual appearance indicates relative tolerance to the wet and nutrient poor conditions.

2017 growing season remains to be measured

Species height per season with STDEV



2017 growing season remains to be measured

Conclusions:

- Peak seasonal water use in juvenile SRF species: Italian alder>E.nitens>E.rodwayi>lodgepole pine≥sitka spruce>bare soil
- Initial results indicate an opportunity to increase the climate cooling potential of second rotation forested peatlands using SRF species
- Vegetative bioremediation and watercourse protection opportunities.
- Risks include acidification of low buffering capacity waters, and altering the carbon retention capacity of the soil.
- Species risk from Italian Alder near nitrogen sensitive water courses
- Trends indicate juvenile eucalyptus and Italian alder species have similar water use efficiencies.

Thanks for your attention.