Base cation fluxes and budgets under different harvest scenarios for Irish conifer forests

Jim Johnson Thomas Cummins Julian Aherne Pat Neville Ted Farrell…

TRENT UNIVERSITY

UCD DUBLIN

coillte

epa Environmental Protection Agency

jim.johnson@ucd.ie

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Photograph: Randy E Barnett

Biomass harvesting has the potential to limit nutrient availability and acidify soils:

The majority of nutrients in above-ground biomass are contained in branches and needles.

This material is generally left on site after harvesting to contribute to the growth of subsequent rotations.

The use of biomass as a source of renewable energy means that there is interest in removing these residues.



Residue harvesting in Ireland has the potential to reduce nutrient availability and acidify soils:

Plantation forests are primarily confined to shallow acidic or organic soils.

Intensively managed plantations comprise fast growing conifer species with short rotations.

Afforestation is recent – majority are first rotation forests.



Study objectives:

1. To assess the sustainability of base-cation supply (Ca, Mg and K) under three scenarios of biomass removal: stem-only (current practice), stem + branches, above-ground biomass.

2. To assess the potential for soil (soil water) acidification under these scenarios.

Site-specific input-output budgets were used to meet the objectives.

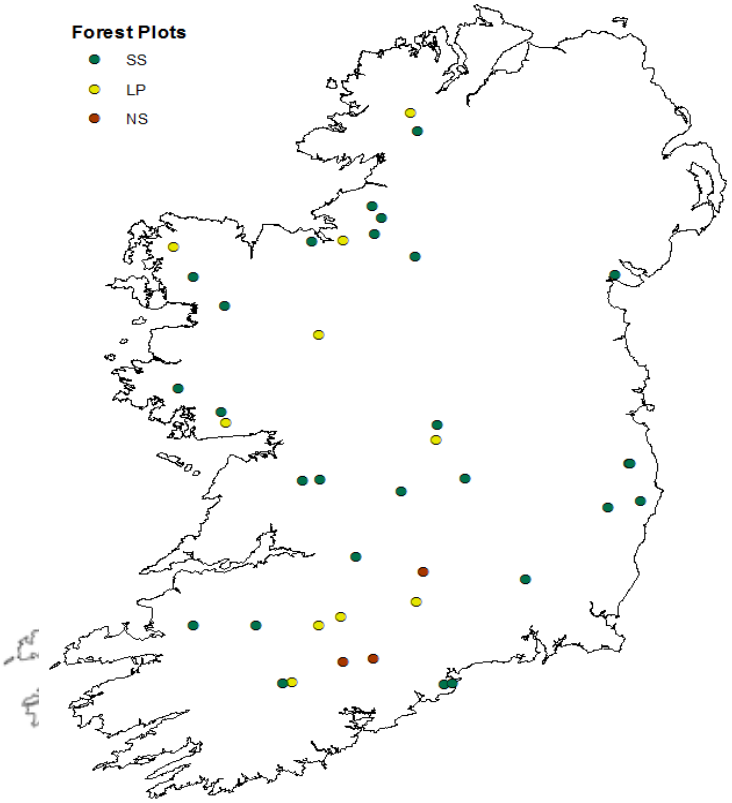
1.Nutrient sustainability (base cation budget):

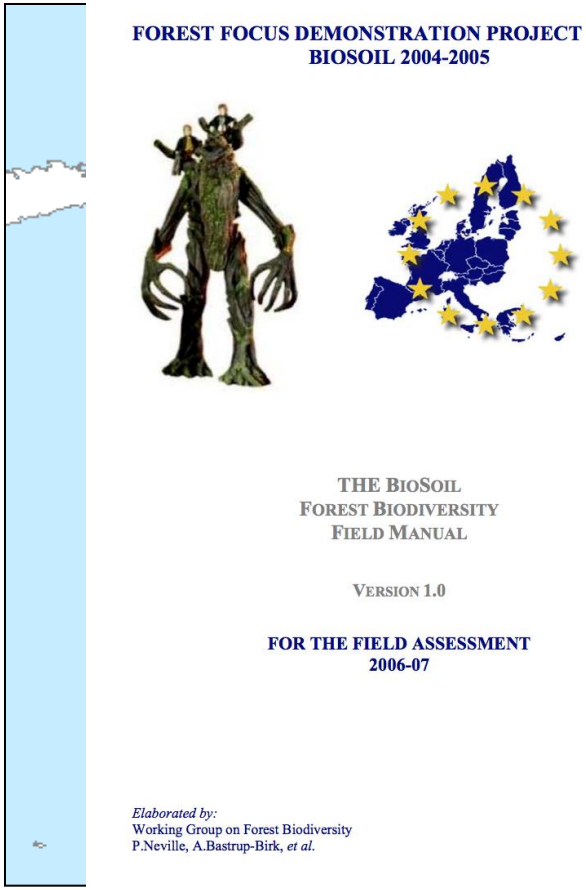
Δ soil pool = Bc deposition + Bc weathering - Bc leaching - Bc harvest

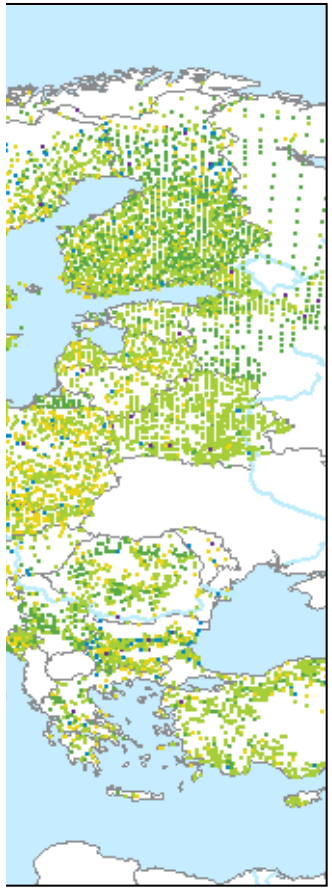
2.Acidification (simplified proton budget):

Δ acidity = Bc weathering – Bc harvest – H^+ deposition

Approach: Site specific base-cation input-output budget (Ca, Mg & K) @ 40 forest (ICP-Forests*) plots

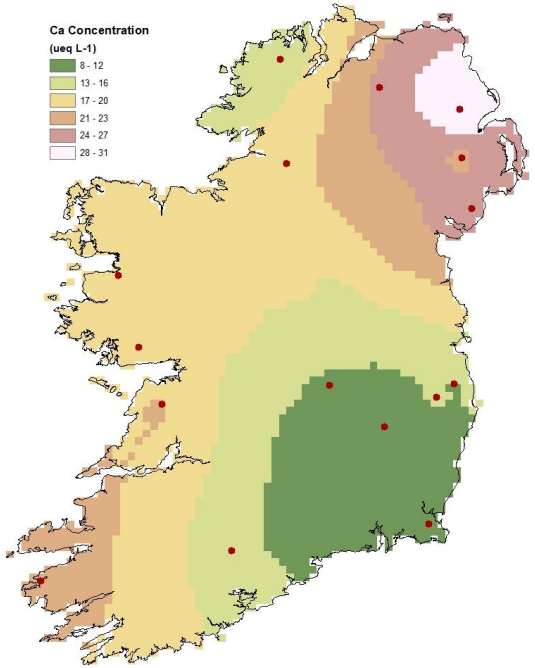


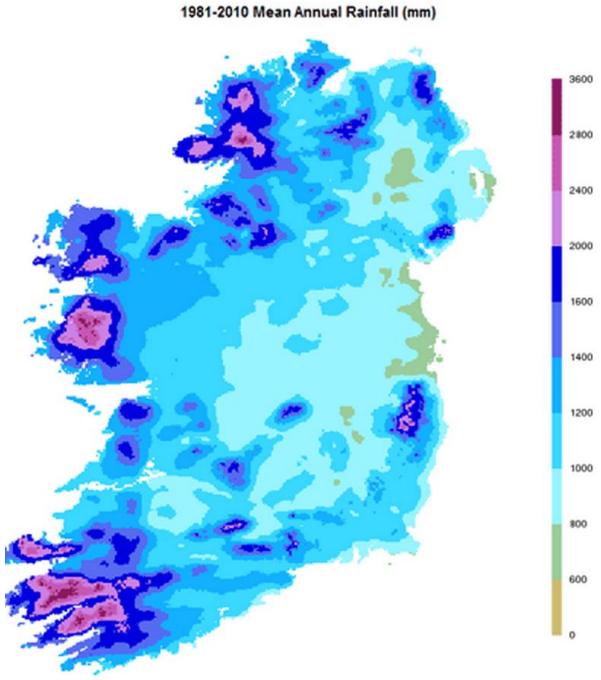


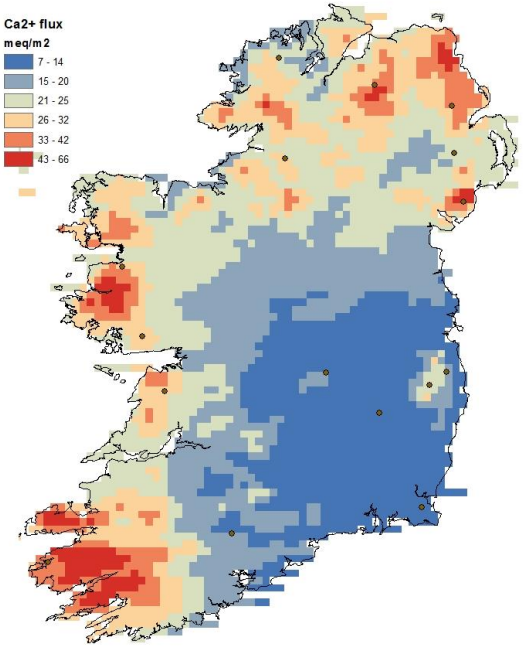


[*International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests operating under the UNECE Convention on Long-range Transboundary Air Pollution; URL:icp-forests.net]

deposition + weathering = leaching + harvest removal







Bulk-precipitation chemistry

Total deposition (wet, dry, stemflow) ≈ 2 x Bulk Deposition

deposition + weathering = leaching + harvest removal

3. Soil data [particle size, bulk density, etc]

1. total oxide analysis
mineral list

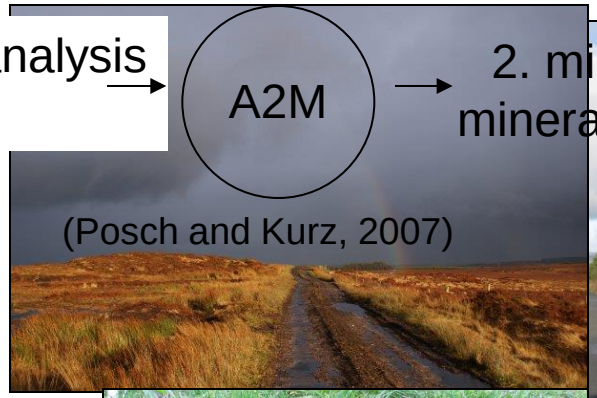
A2M

2. mineral classes
mineral stoichiometry

PROFILE

(Posch and Kurz, 2007)

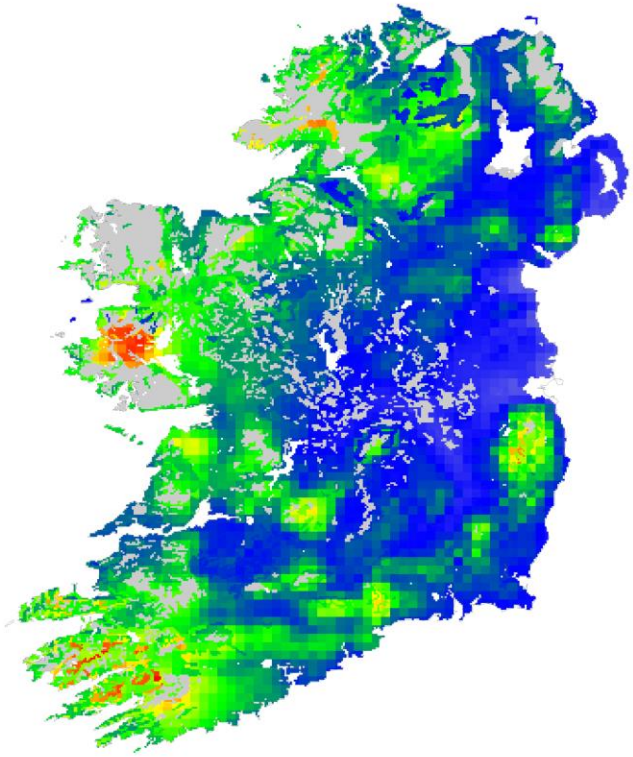
(Warfvinge and Sverdrup, 1992)

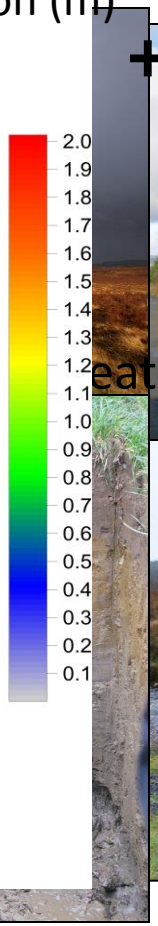


```
                                                    Na2O       TiO2
Oxides (%):                                         67  1.0233  1.3200
Mineral list: qtz kfs                                t
A2M Output : 28.46 0.5                              0.22 0.66 1.6

Mineral Data: K-Feldsp                              rite:7.359
Soil data: bulk densit                              e= 0.241m

PROFILE Output:    Cawe
                   2.4
```

deposition + weathering = leaching + harvest removal

soil percolation (m)





minimum base-cation leaching
0.002 (eq $m^{-3}yr^{-1}$)

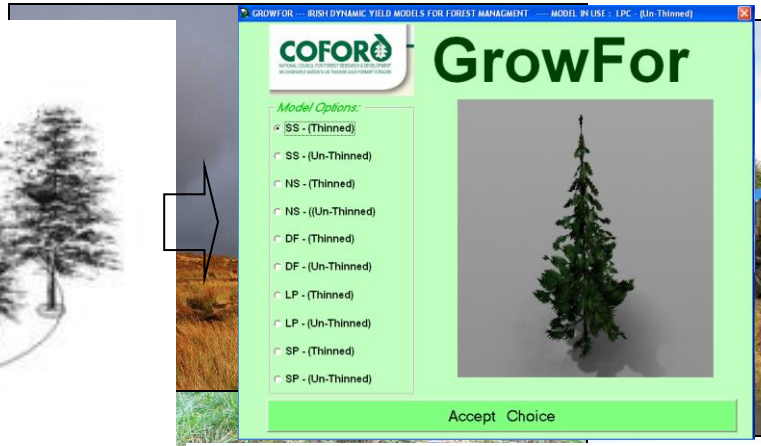
+

eathering – Harvest – Leaching

Methyd (Posch and Reinds 2010)

deposition + weathering = leaching + harvest removal

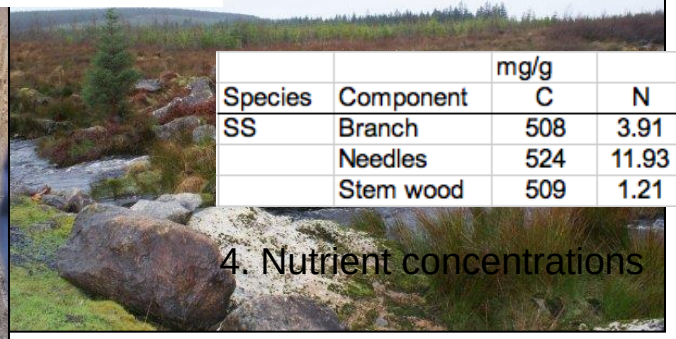
1. Biosoil biodiversity survey



2. Growfor: Irish dynamic yield models for forest management

Component	Eqt No	Source	Equation
Stemwood	1	Irish yield model	biomass = volume ha^{-1}·stemwood basic density
Stembark	2	This study	ln(biomass) = 0.126574·dbh – 0.1065634
Live branch	3	This study	ln(biomass) = 0.1126·dbh – 0.3405
Dead Branch	4	This study	biomass = 1.2771·dbh – 12.378
Needle	5	This study	$\log_{10}$(needle) = 2.73955·$\log_{10}$(dbh) – 2.78585

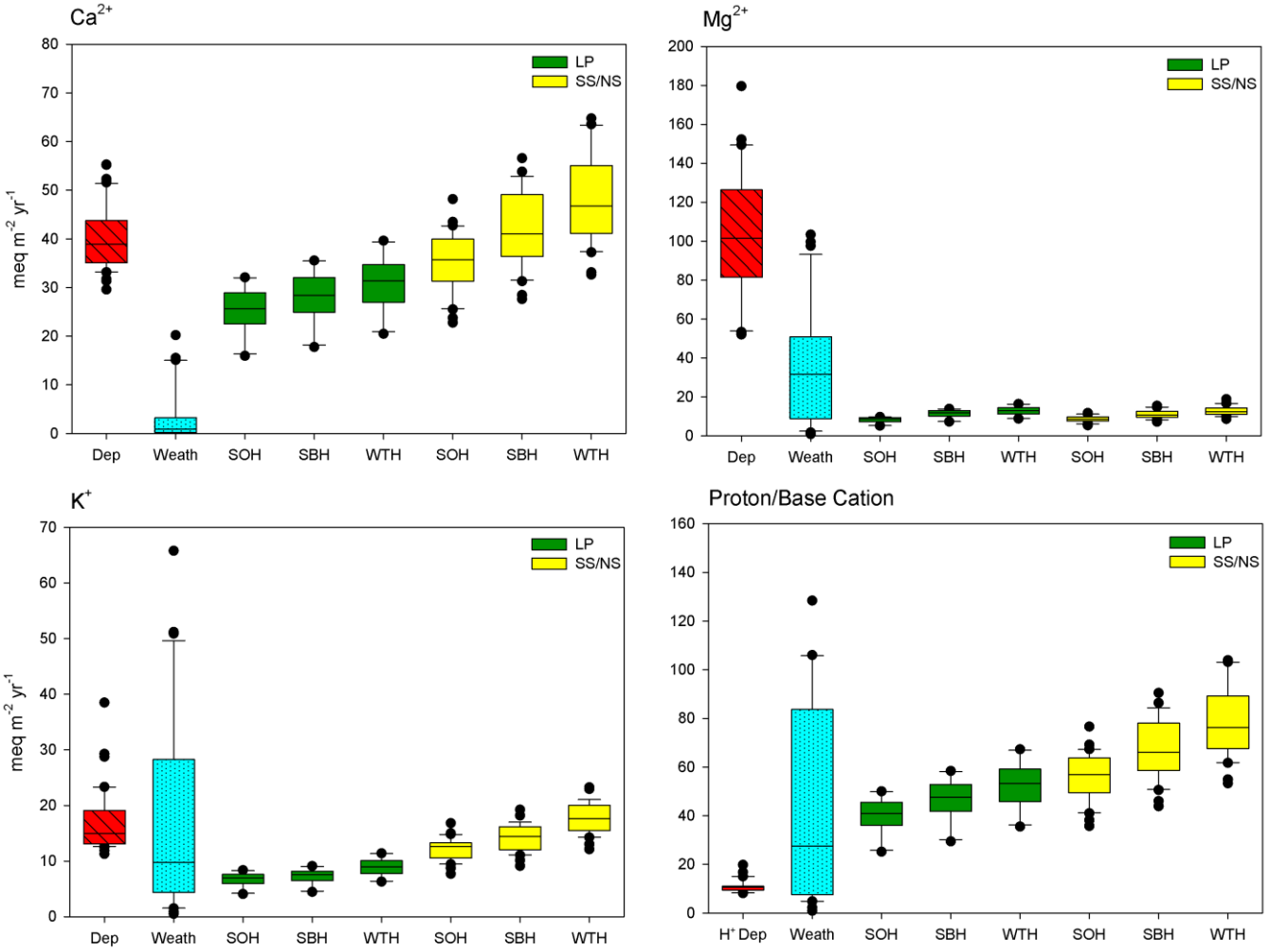
+



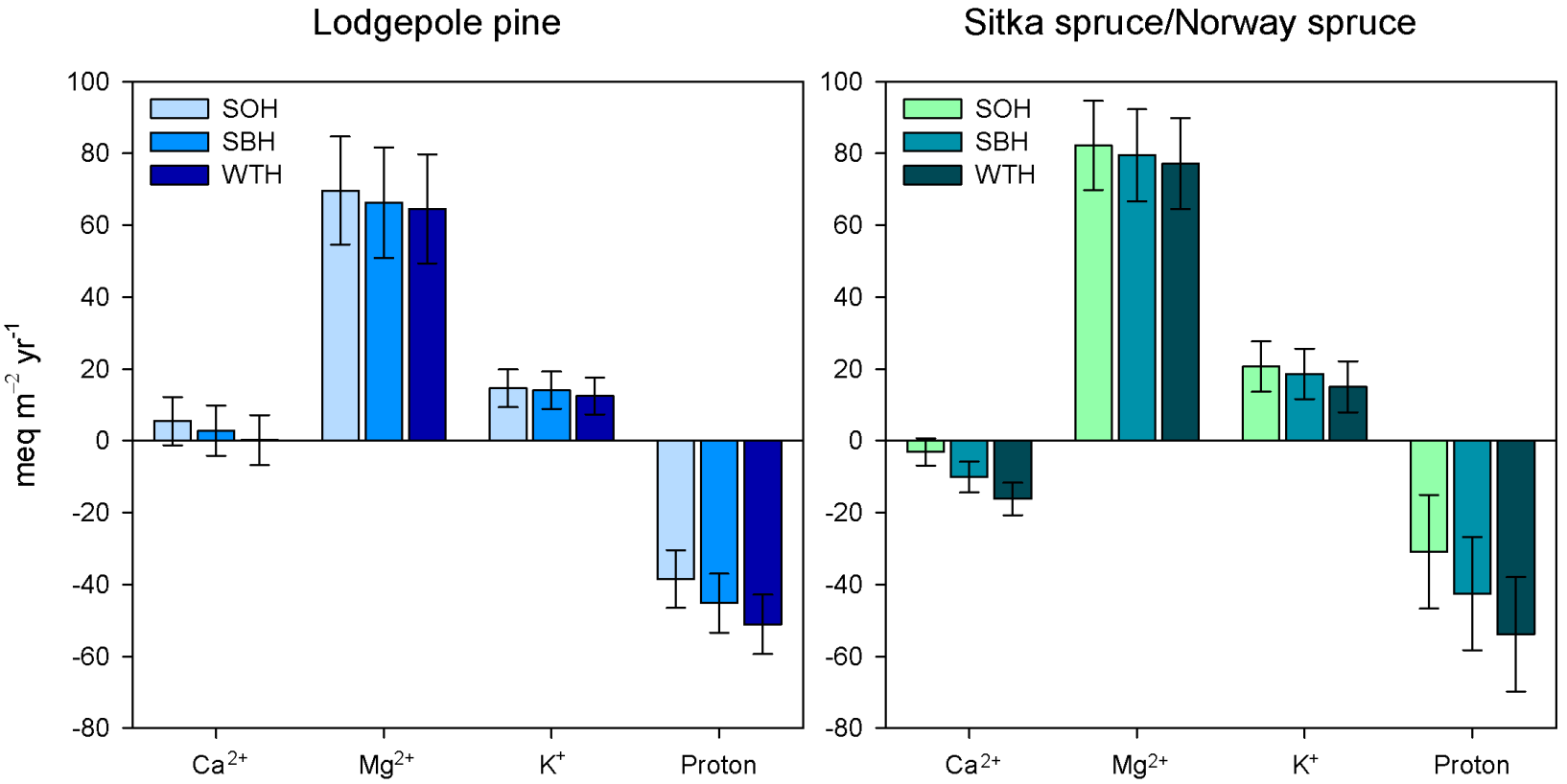
Species	Component	mg/g C	N	P	K	Ca	Mg
SS	Branch	508	3.91	0.40	1.75	2.39	0.46
	Needles	524	11.93	0.98	4.72	3.23	0.68
	Stem wood	509	1.21	0.04	0.33	0.49	0.08

4. Nutrient concentrations

Results 1. Ca^{2+}, Mg^{2+}, K^{+} and Bc fluxes



Results 2. Average input-output budgets

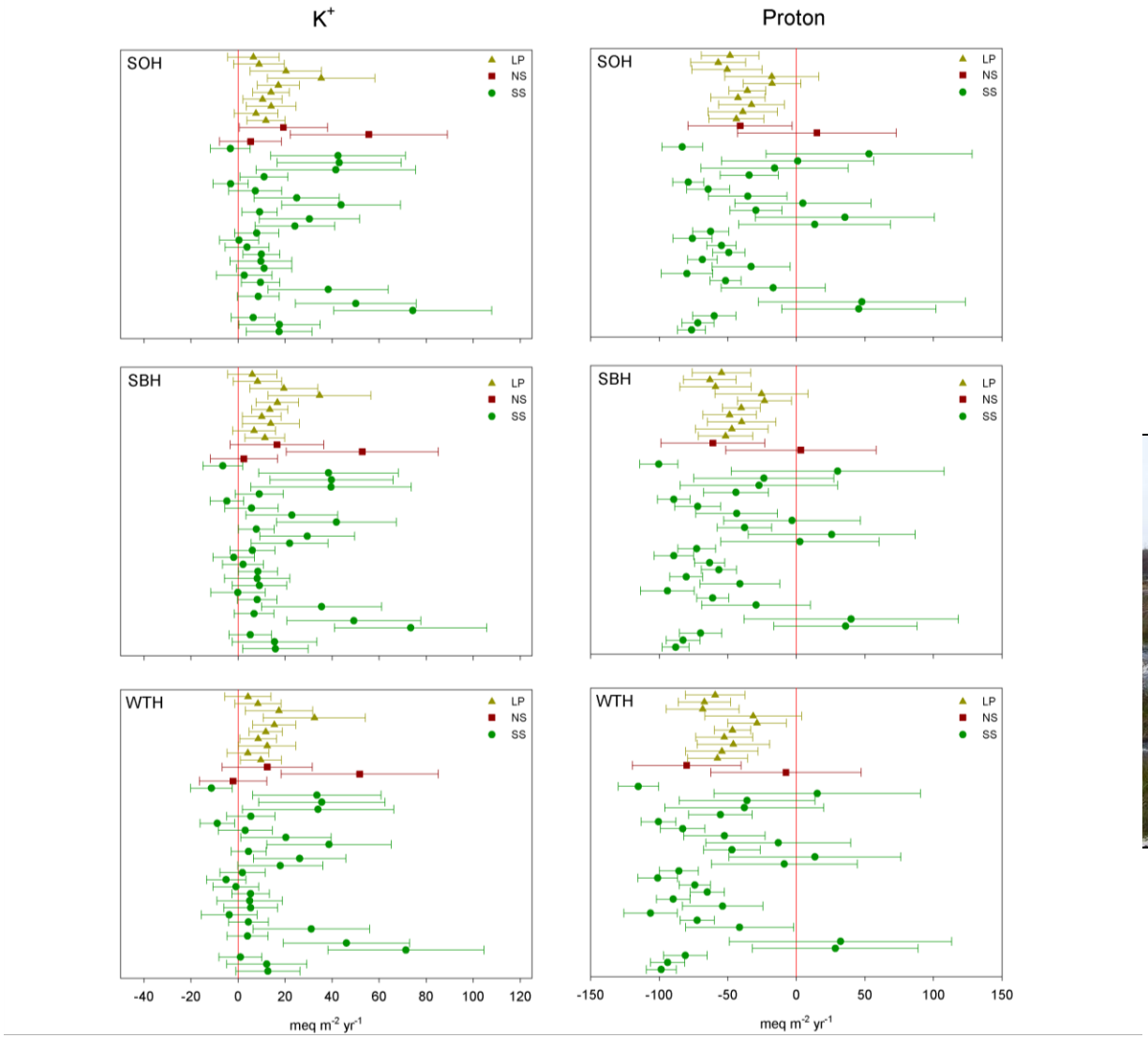


For sites with budget deficits - how many years does it take to deplete exchangeable soil pools?

Table 3.2 Number of sites with budget deficits and the average number of years to deplete the soil exchangeable pool at these sites for Ca^{2+}, Mg^{2+} and K^{+} budgets under stem-only harvest (SOH), stem plus branch harvest (SBH) and whole-tree harvest (WTH).

		Ca^{2+}			Mg^{2+}			K^{+}		
		5th %tile	50th %tile	95th %tile	5th %tile	50th %tile	95th %tile	5th %tile	50th %tile	95th %tile
SOH	n	38	20	2	9	0	0	14	2	0
	years	135	611	1133	227	-	-	48	65	-
SBH	n	38	28	7	14	0	0	18	3	0
	years	94	315	858	215	-	-	49	54	-
WTH	n	38	33	9	15	0	0	22	5	2
	years	83	367	288	216	-	-	41	76	133

Results 3. There was considerable uncertainty around fluxes



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Some uncertainties around base cation fluxes include

estimates of biomass removal using allometric equations
removal of material in thinnings

weathering rates

uncertainty around deposition (Ca, Mg, K) – due to interpolation, dry deposition etc

Not forgetting about:

leaching losses due to acid deposition and harvest disturbance
limitation of other nutrients N,P
changes in soil organic matter, moisture



What can we conclude?

1. These plantation forests receive much of their K^+, Ca^{2+} and Mg^{2+} input from the atmosphere

2. Exchangeable K pools in soil are comparable to above-ground biomass. There is the potential of depletion of soil K pools at a small number of sites.

3. The disparity between weathering and uptake means that while nutrient inputs are mostly sufficient to support removal, there is a net acidifying effect on the soils.



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Thank You


Questions?