Maintaining soil fertility in biomass for bioenergy production systems

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Outline

- Central role of soils in ecosystem function
- How biomass production systems can negatively impact on soil fertility
- The need for active management to protect soil values, and a few examples
- Conclusions

Linkages between forest management, soils, and other forest values

Forest Management Activities

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Changed physical, chemical and biological properties of soils

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Changed Soil Functional Process

(nutrient and water supply, aeration, root growth, biological activities, carbon cycling and storage)

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Ecosystem Functional Responses

(regeneration, species composition and N fixation, habitat and fauna, water quality, productivity, C storage, wood production)

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Socio-Economic Consequences

(e.g. forest industry, biodiversity, recreation, water)

Management can degrade soil fertility

- **Accelerated erosion**
- **Disturbance/compaction**
- **Nutrient depletion**
- **Acidification**
- **Biological changes**

Bioenergy creates extra challenges

- More frequent harvest
  - greater soil disturbance
  - increase rate of nutrient removal

- Sometimes more complete (foliage and stems) removal of biomass (C and nutrients). How to judiciously manage fertilizer inputs?

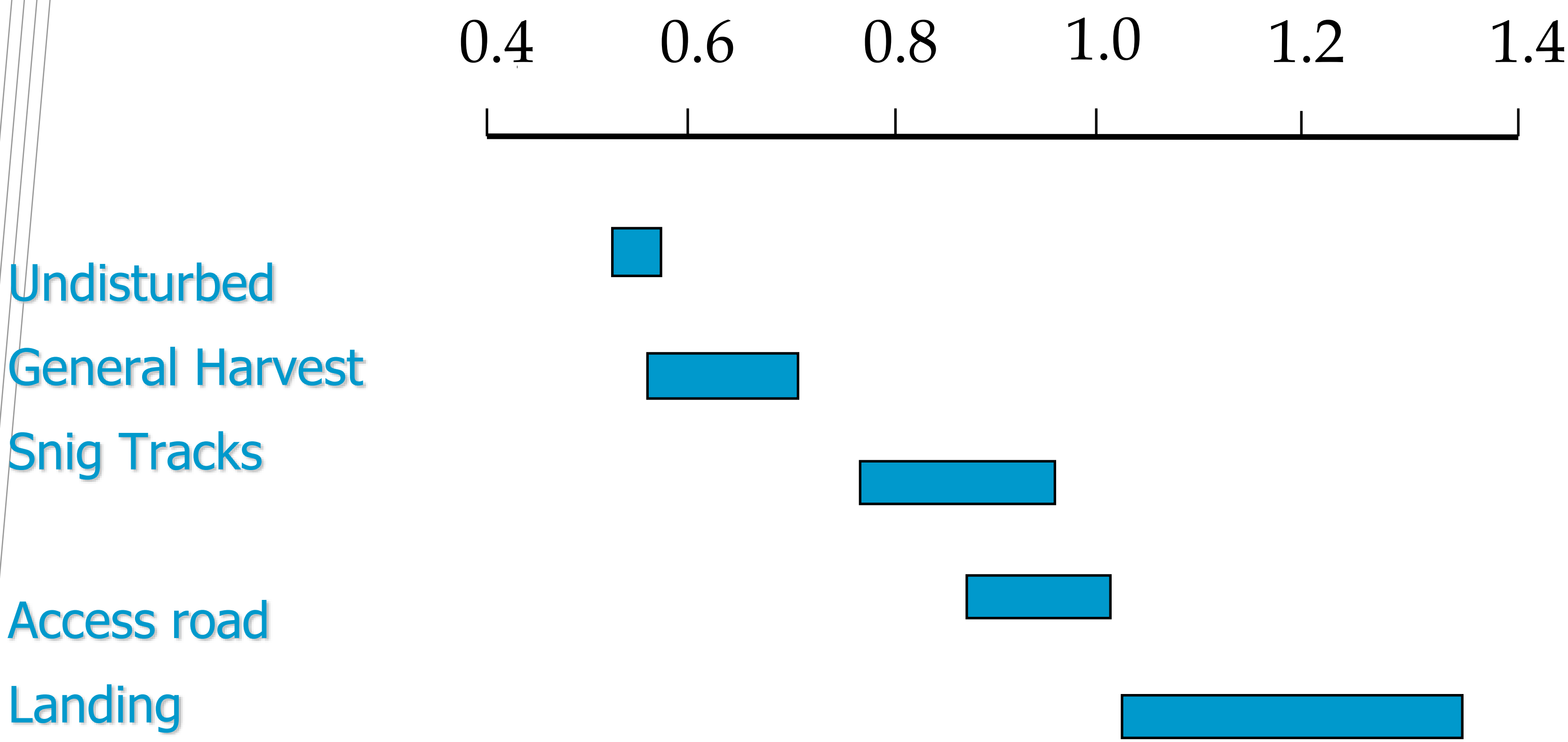
- Sometimes new fast growing species

Monitoring changes in soil fertility

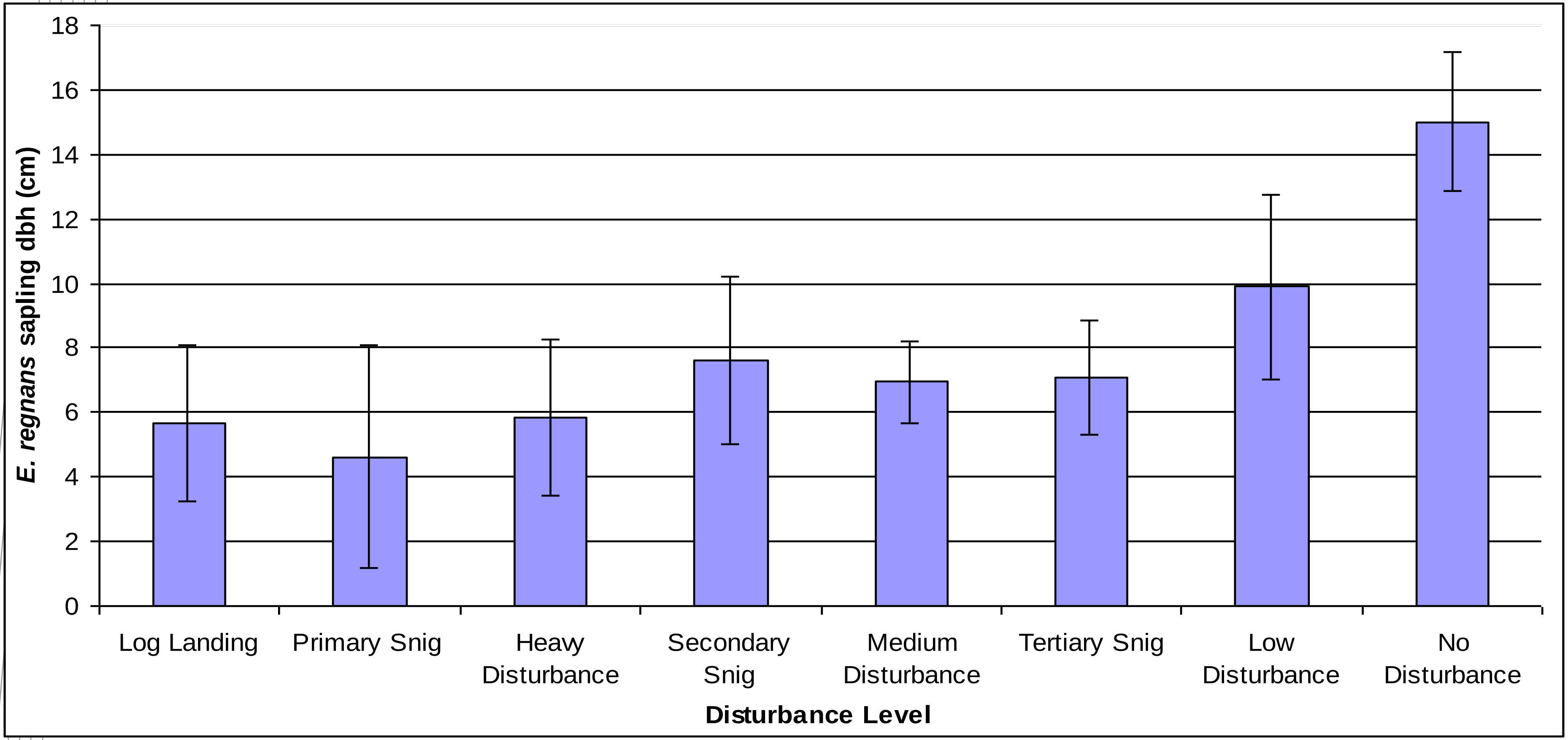
Broad Soil Indicator	*Key Functions*	*Field Measure*
Physical change	root growth	bulk density/soil strength
	aeration	macro-porosity
	water movement	hydraulic conductivity
Chemical change	nutrient supply acidification	SOM, N&P availability pH, base exchange
Erosion risk	many	disturbed soil, cover, infiltration
Pollution	soil biology, toxicity	accumulation of chemicals

Soil physical disturbance

Surface (0-10cm) Soil Bulk Density (Mg m^{-3})

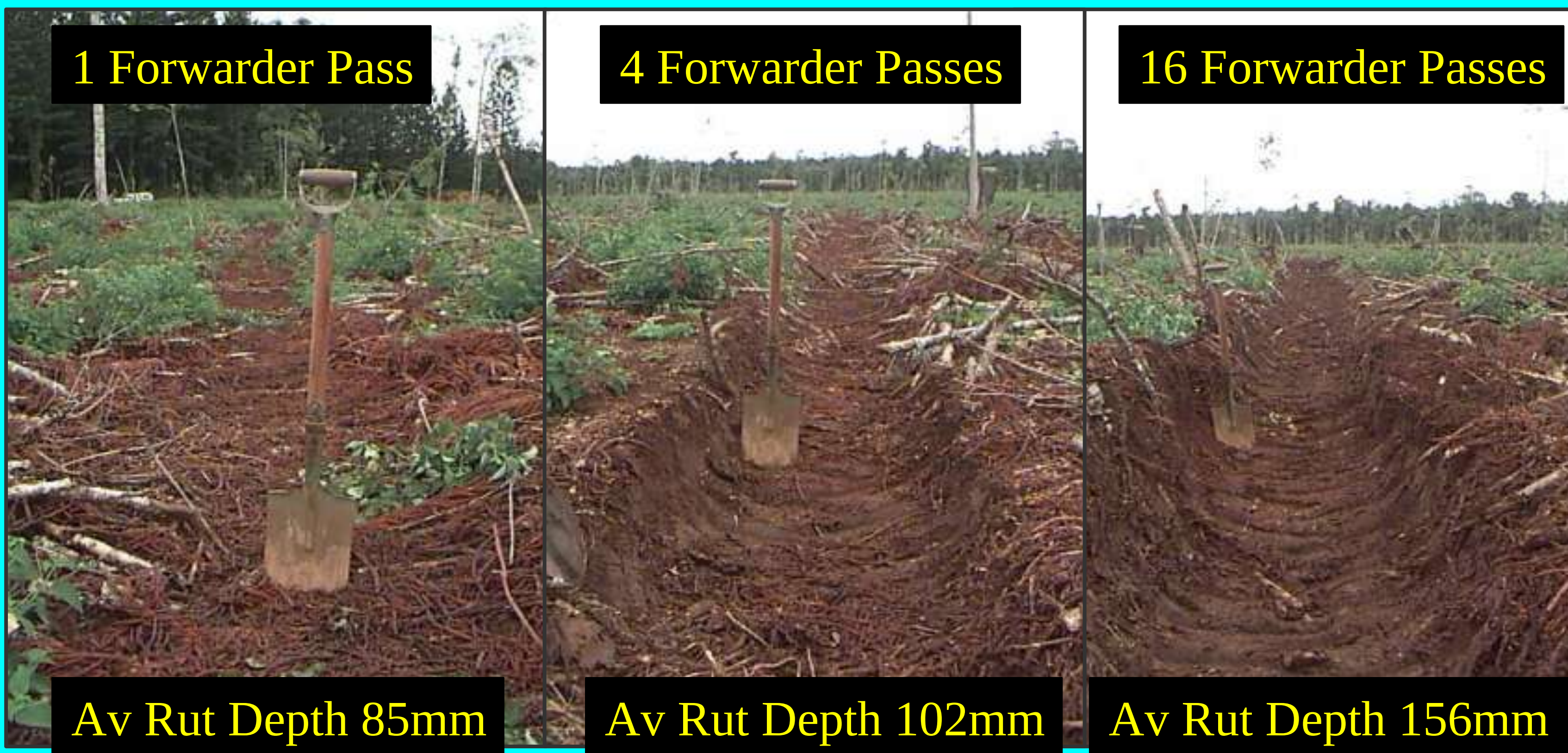


Soil disturbance can lower growth of the regenerating forest



Soil rutting

Rutting depth

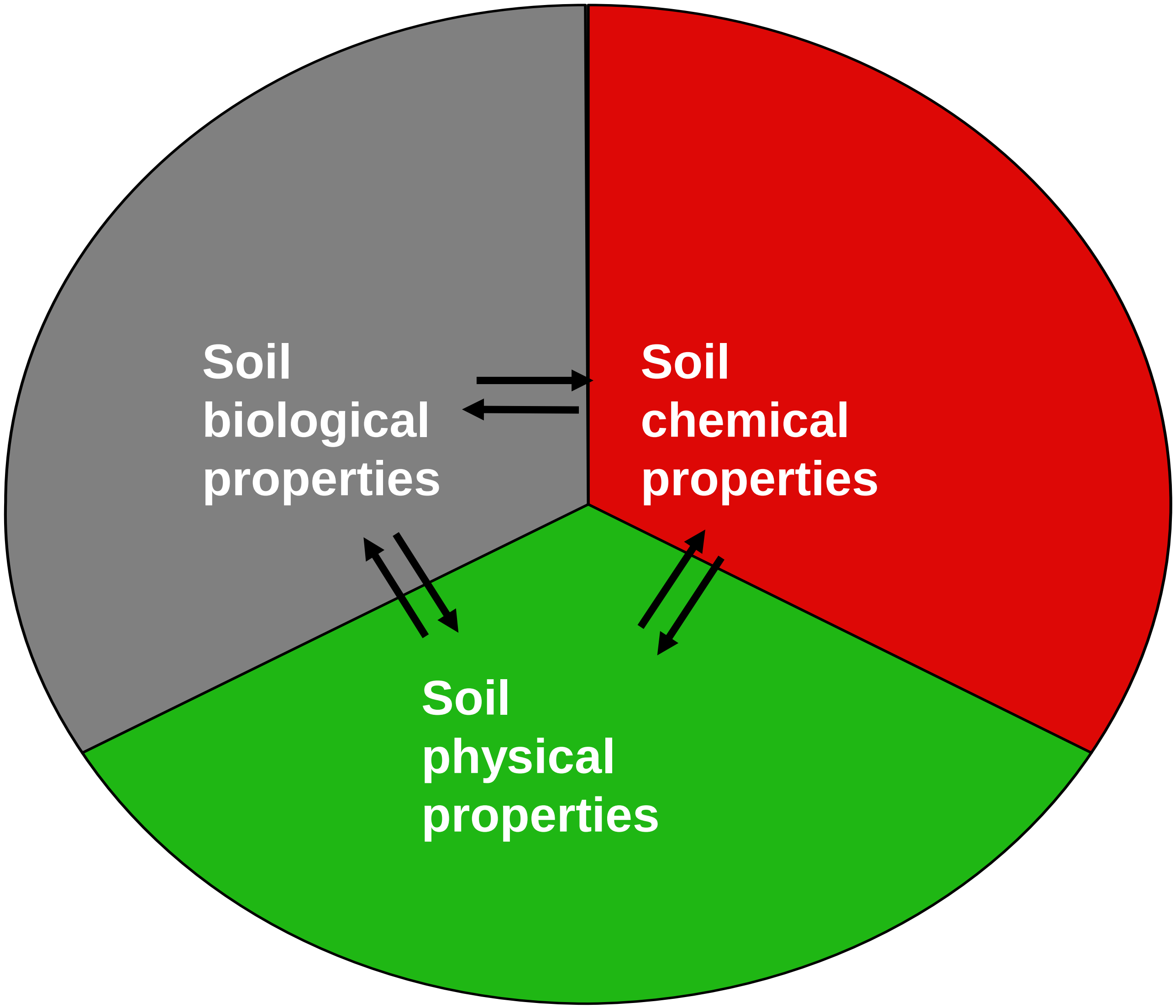


Average Soil Moisture: 38.5% w/w

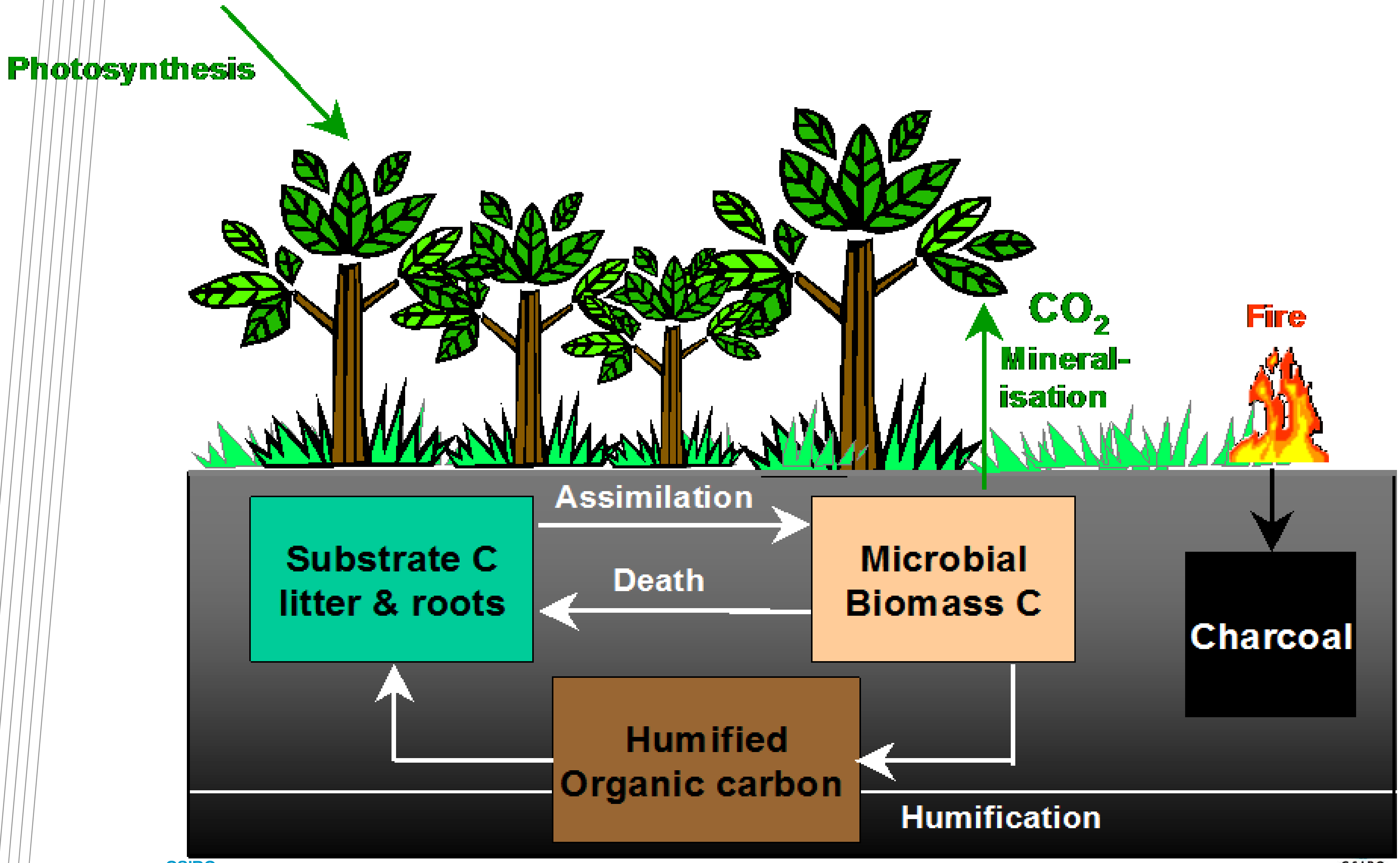
Minimizing soil physical damage

- Using harvesting residues to protect the soil from ‘traffic’
- Ceasing harvest on wet soils
- Machines with low ground pressure
- Harvest when soils frozen

Soil organic matter is important

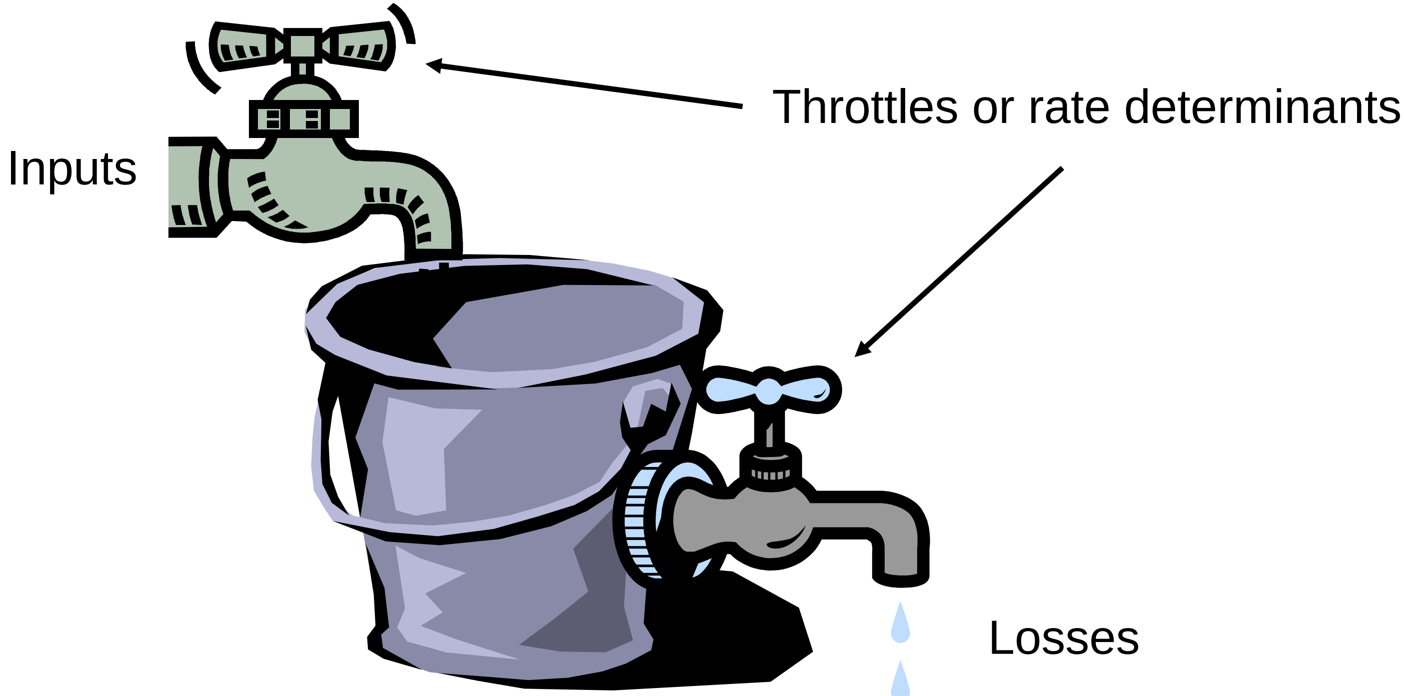


Soil Organic Carbon Cycle

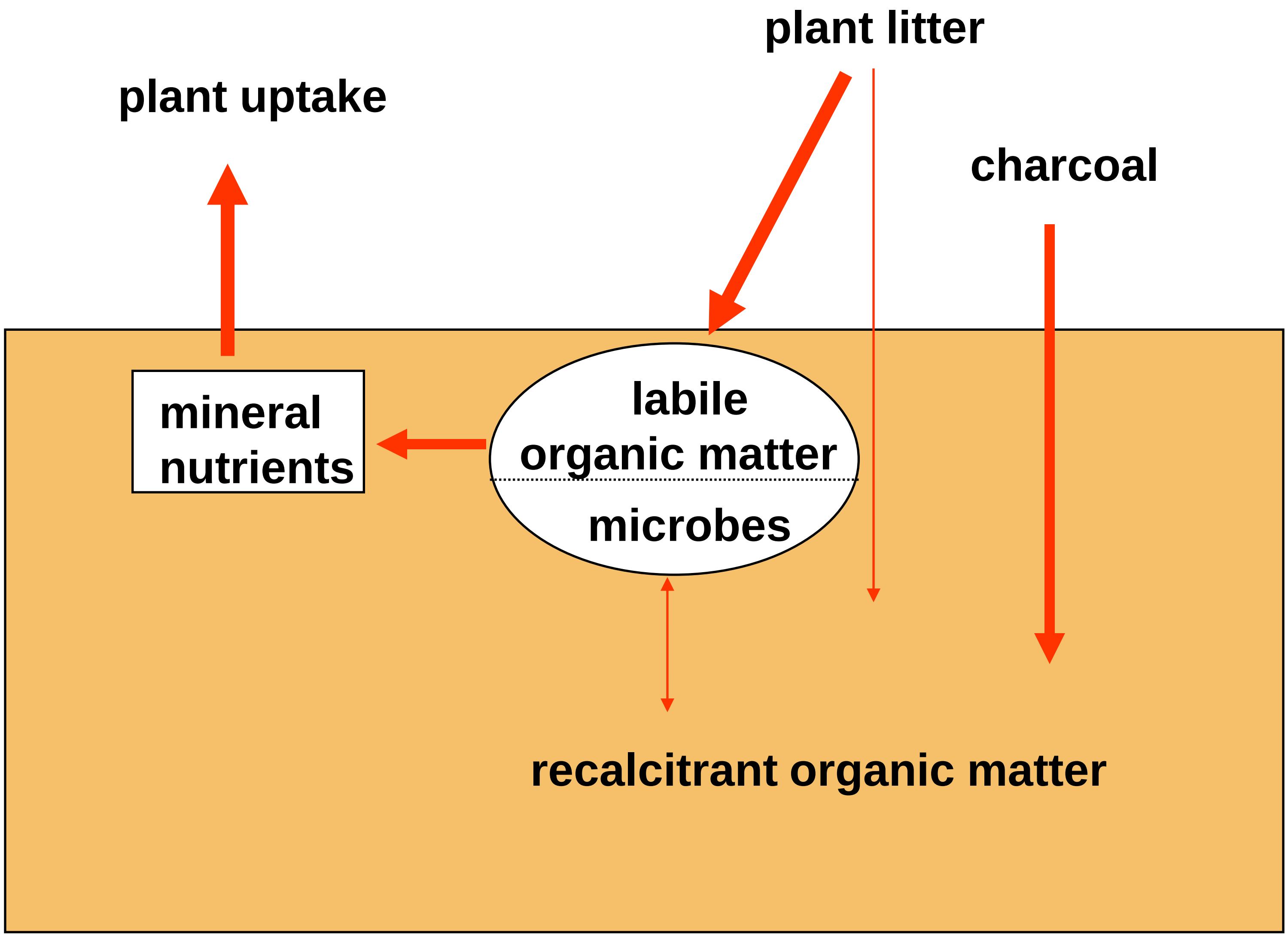


What determines SOC change?

Organic C content = *f* (Inputs of organic C , Losses of organic C)



Labile soil C controls rates of nutrient cycling



Mallee eucalypt production system

Mallee eucalypts in WA - annual biomass and nutrient export under 3 - 4 year harvest regimes.

- **Biomass** 5.9 - 7.5 t/ha
- **Nitrogen** 46.7 - 50.1 kg/ha
- **Phosphorus** 3.9 - 4.7 kg/ha
- **Calcium** 32.2 - 46.6 kg/ha

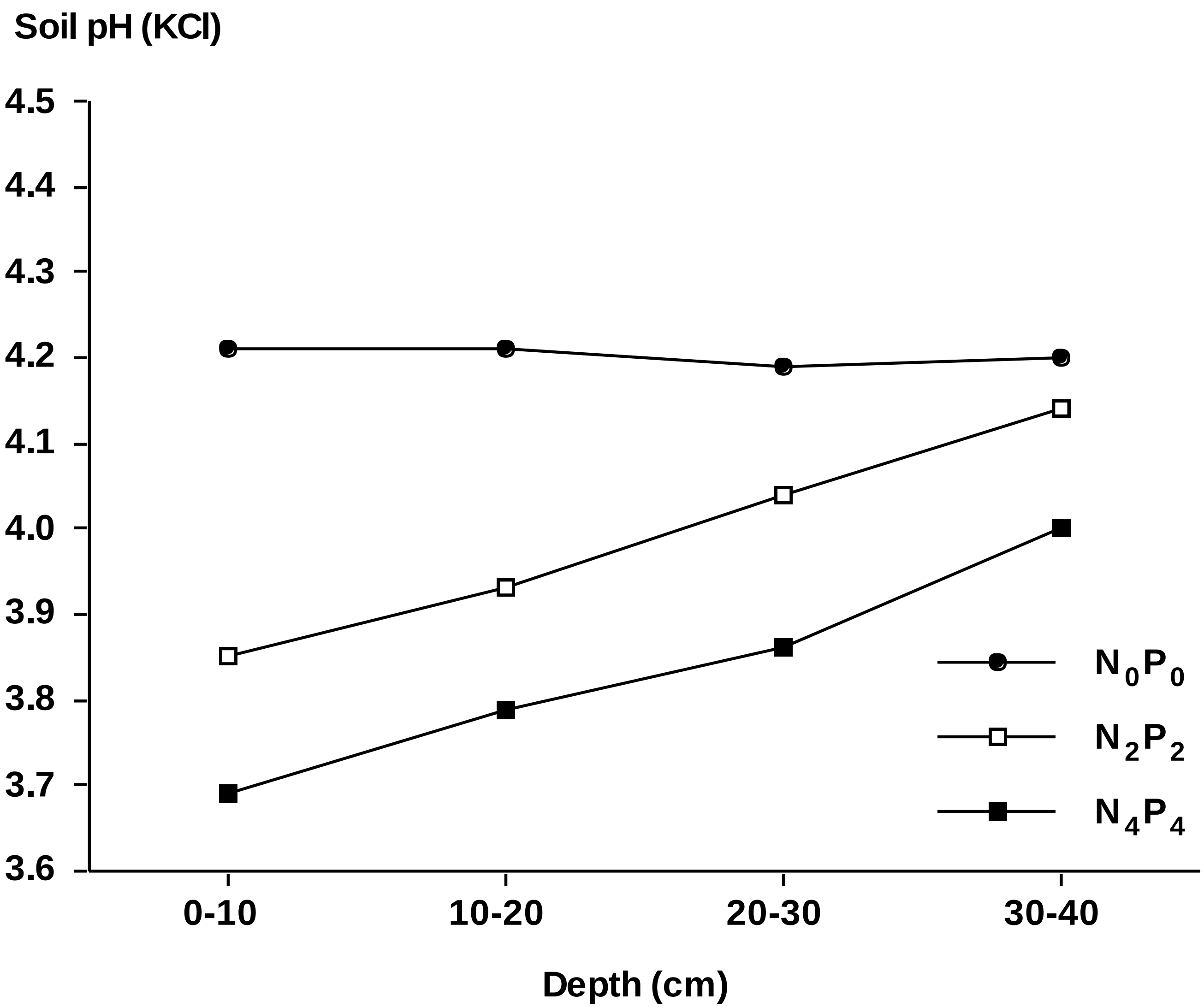
Amounts exceed those in wheat cropping

Recovery of nutrients added in Fertilizer is often very low

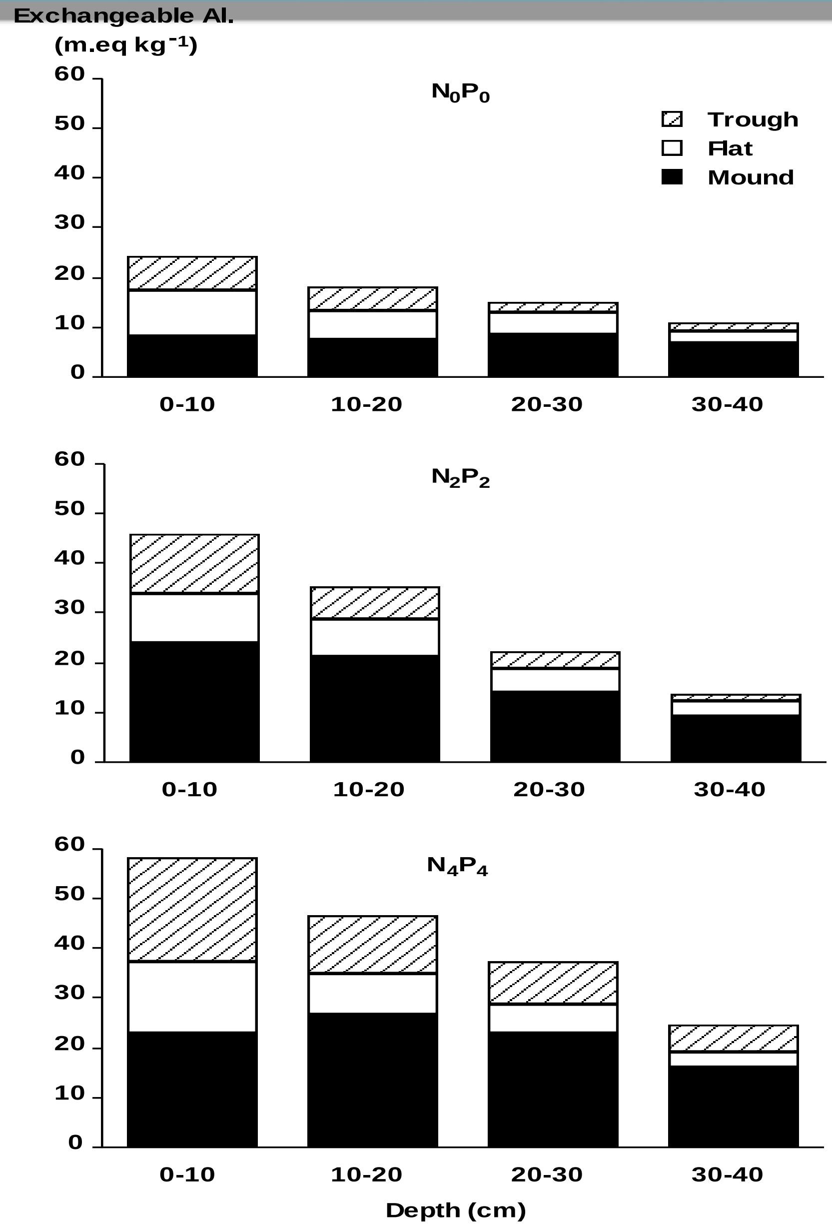
- Nitrogen – often < 50%

- Phosphorus - low, but high soil retention

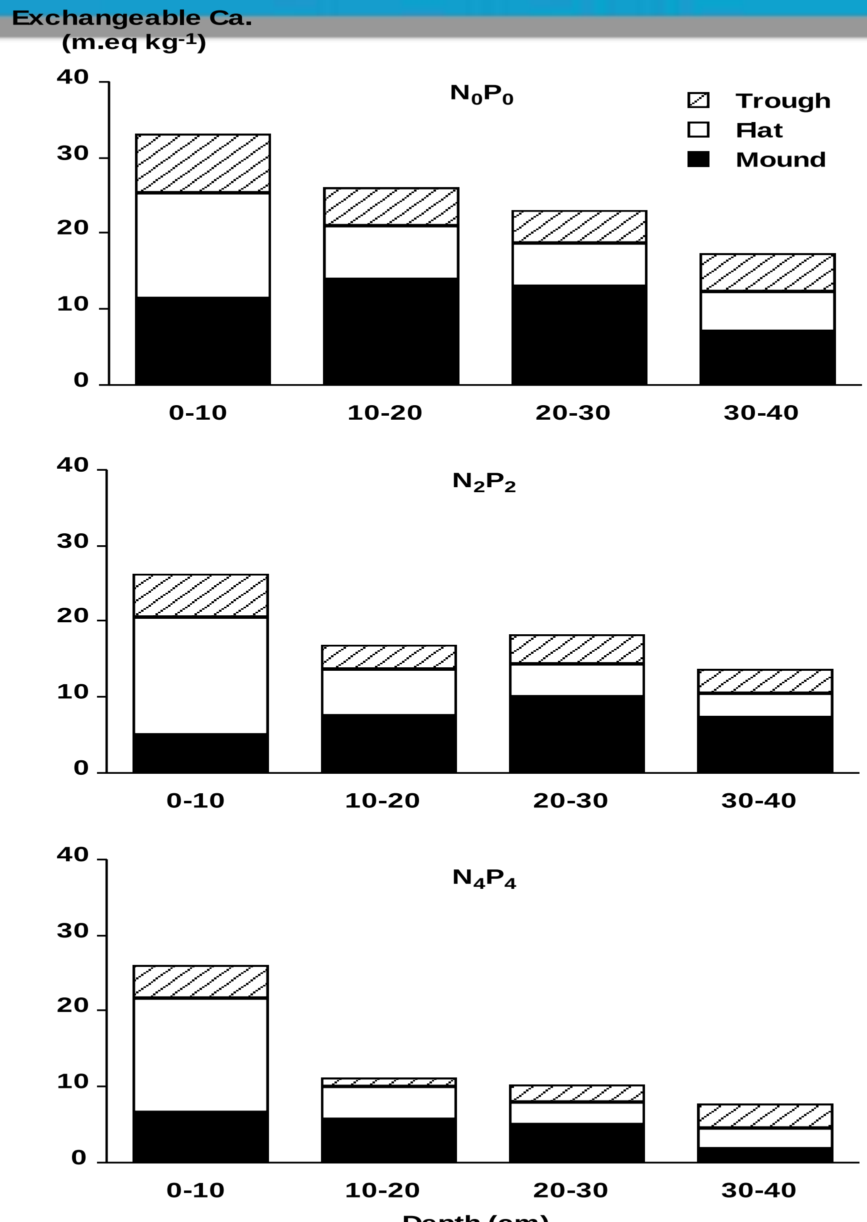
Soil acidification after N fertilization



Acidification increases exchangeable soil Aluminium



Depletion of exchangeable soil Calcium



Cation (Ca, Mg) replacement by ash recycling

Soil Protection is critical

- Soil influences most forest values (biological, social, economic). Off-site effects can be significant (eg. on water)

- Difficult to generalize about the risks created by specific management practices

- Need site-level assessments of risks and impacts, and management guidelines. Reflected in manag. plans

How can we protect soils?

- Undertake 'local' assessments of the risks to soil fertility imposed by biomass production systems
- Develop and apply management prescriptions that mitigate risks of erosion and soil compaction
- Retain nutrient-rich biomass, avoid burning of in-field residues
- Lengthen rotations to reduce [nutrient] in harvested biomass
- Incorporate a legume in the production system if possible
- Judicious use of fertilizers, return ash to site
- Drainage and disturbance of peat will lead to massive C losses!

Adaptive production systems 'Framework'

Plans

(stakeholders set goals, indicators and targets)

Operational guidelines
(implementation)

Monitored Outcomes
(use of indicators)

Evaluation processes
(comparison with goals, targets)

Agreed Responses (adaptation of plans or guidelines)

Reports to stakeholders

Tiered Approach to Soil Protection

AIM is to avoid the need for expensive rehabilitation practices.

1. **Broadscale auditing for compliance with Codes of Practice (good practice rules/guidelines).**
2. **Monitoring of soil disturbance classes on selected sites based on risk.**
3. **R&D on representative important forest types/management systems to calibrate disturbance classes or other simple monitoring methods, and to provide a basis for evaluation of change.**
4. **Review and improvement ethic.**

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Thank you

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