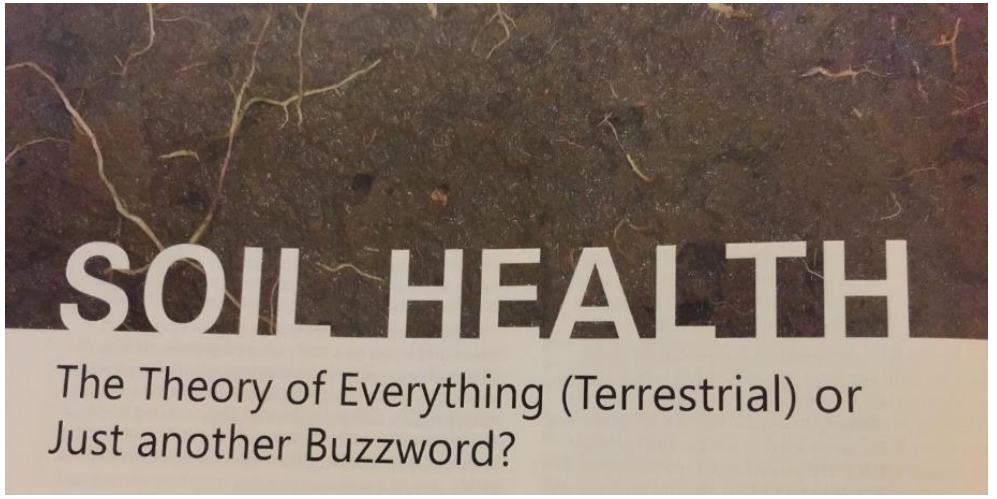
Vegetation Control:
Minimizing Risks to Non-target Soil Resources

Topics

- Shout out to soils: embracing uncertainty
- Minimizing risks? What risks?
- Direct chemical effects of herbicides on soil organisms
- Indirect effects of vegetation control on soil properties

2015
International
Year of Soils

World
Soil Day



What about soil effects from low to moderate severity forest practices?

“it will always be valuable to approach soil management with some degree of uncertainty, and some humility”

Binkley 2018

- Sierra Nevada
- Extreme soil heating during pile burning
- Severe disturbance?

- 2018
  (8 years later)

Compaction Treatment

No effect on 20-year root growth

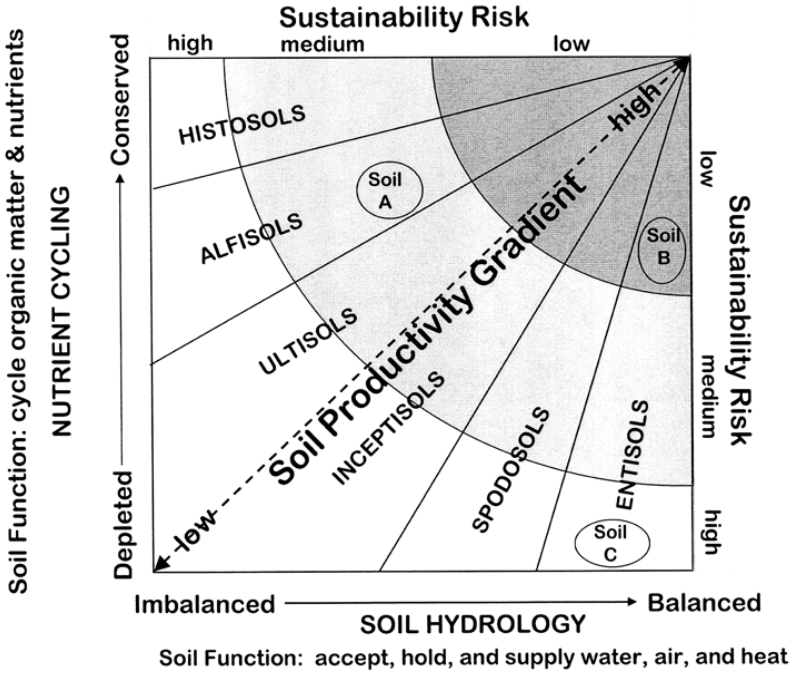
Compacted

Not compacted

The most defensible conclusion about forest soils is that the evidence is too variable to support strong inferences of simple, overall patterns

Embrace uncertainty

- Understand your soil's strengths and weaknesses
- What is the desired function of your soil?
- Rely on science and experiential knowledge as guides, but seek local expertise
- Factor in trade-offs – economic, environmental, social – when considering soil management



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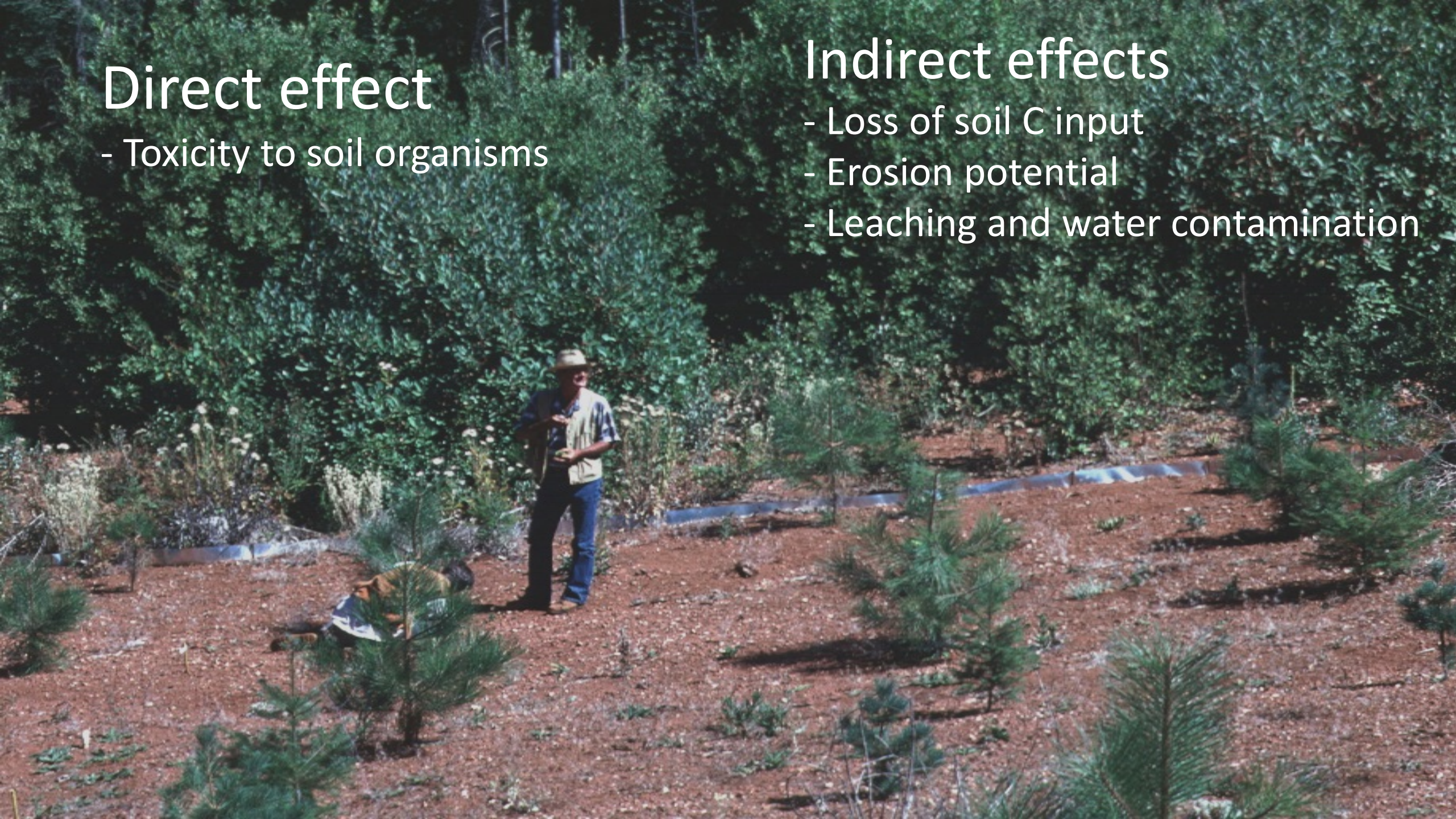
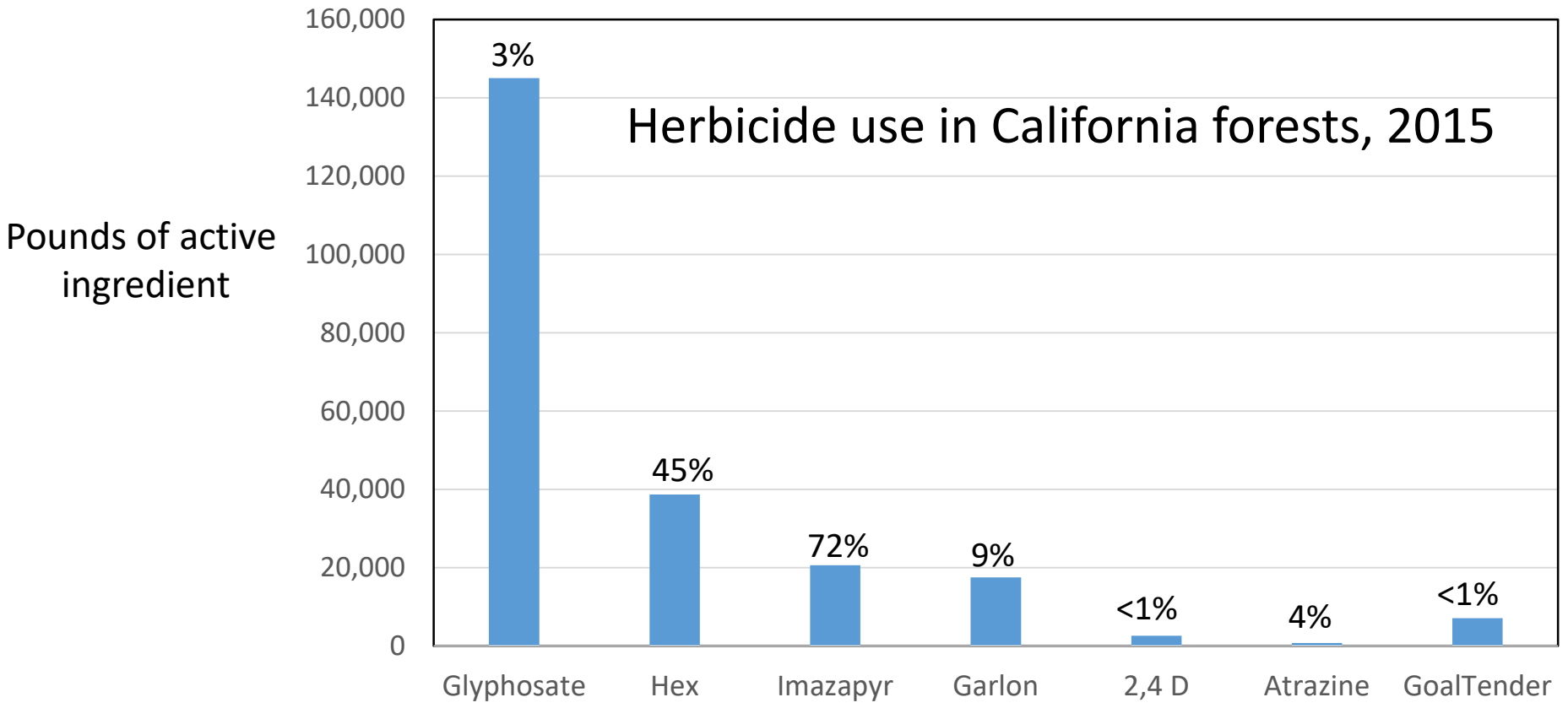

Direct effect
- Toxicity to soil organisms
Indirect effects
- Loss of soil C input
- Erosion potential
- Leaching and water contamination

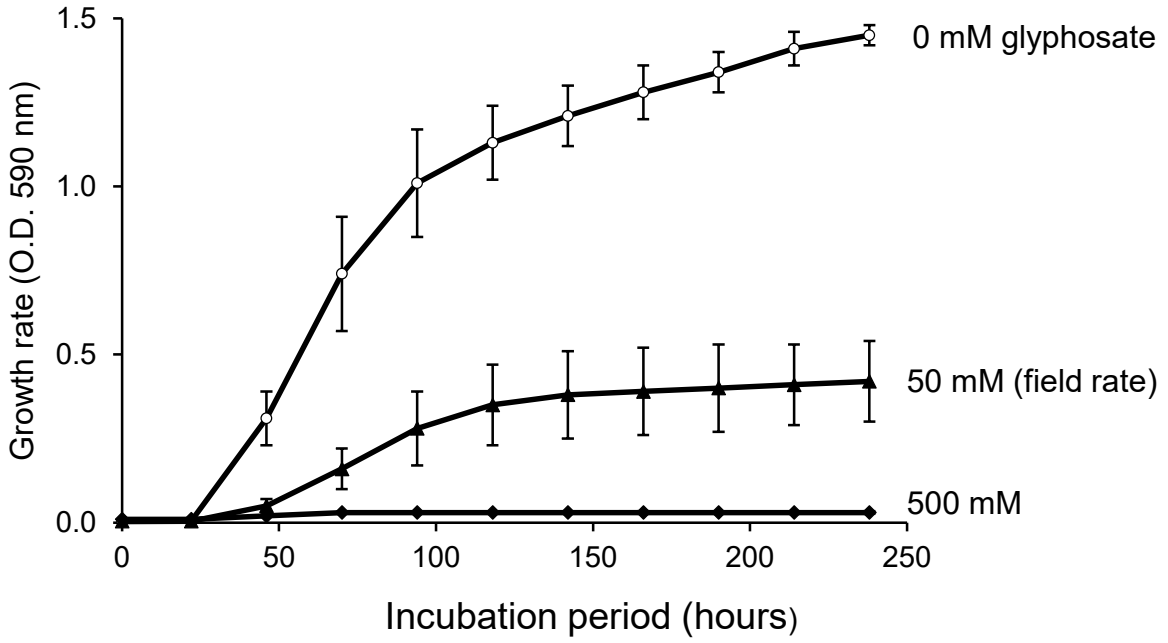
Let’s start with Glyphosate



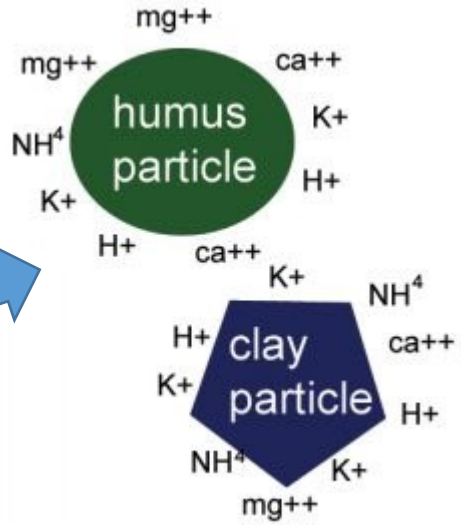
Source: California Dept. of Pesticide Regulation, 2017

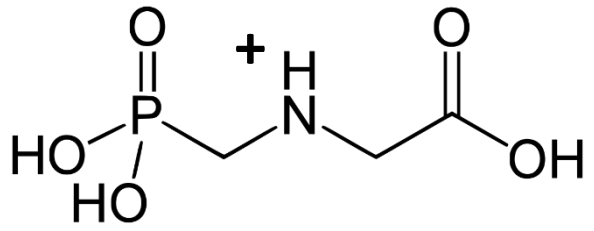
Glyphosate is toxic to soil organisms when grown in pure culture

- Inhibits amino acid synthesis via the Shikimic Acid pathway
- Essential for protein production in plants and soil microorganisms



But….. glyphosate binds strongly to soil

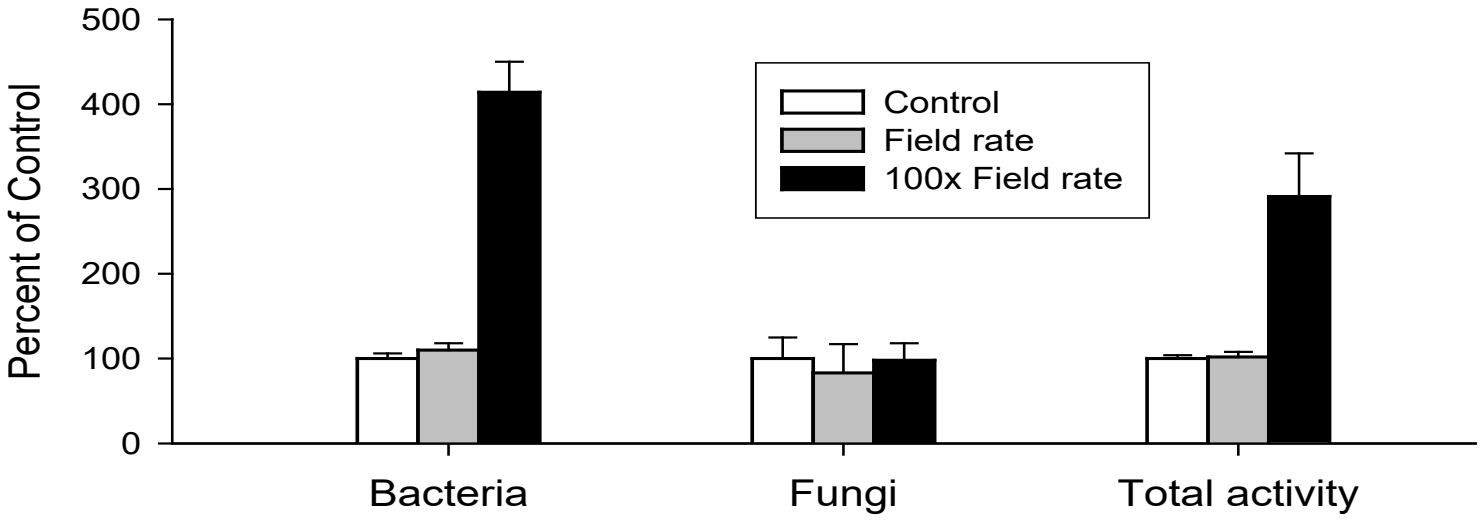


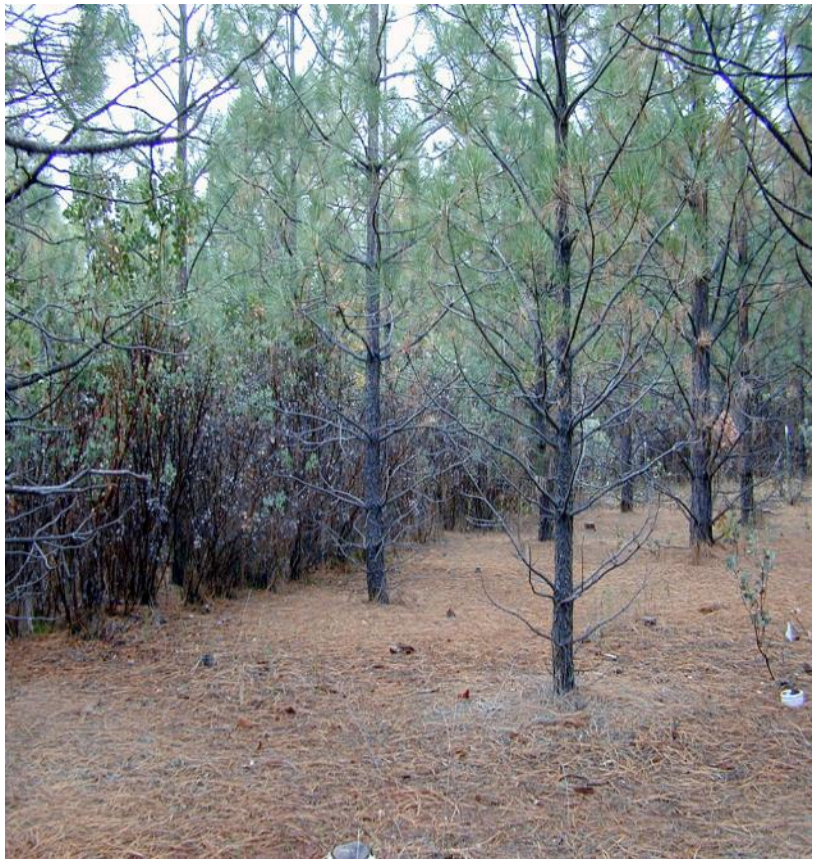


Glyphosate

Positively charged – strong affinity for binding to soil

Glyphosate Stimulates Microbial Activity when applied to plantation soils

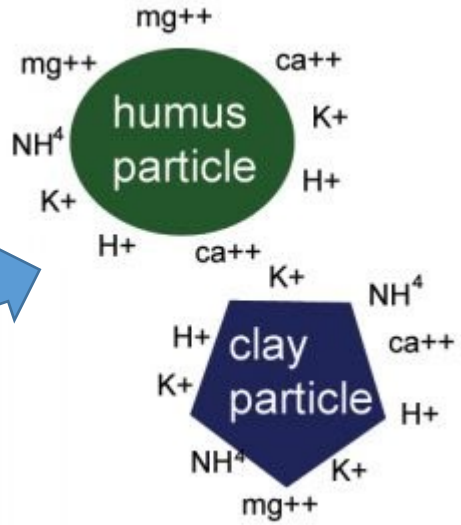


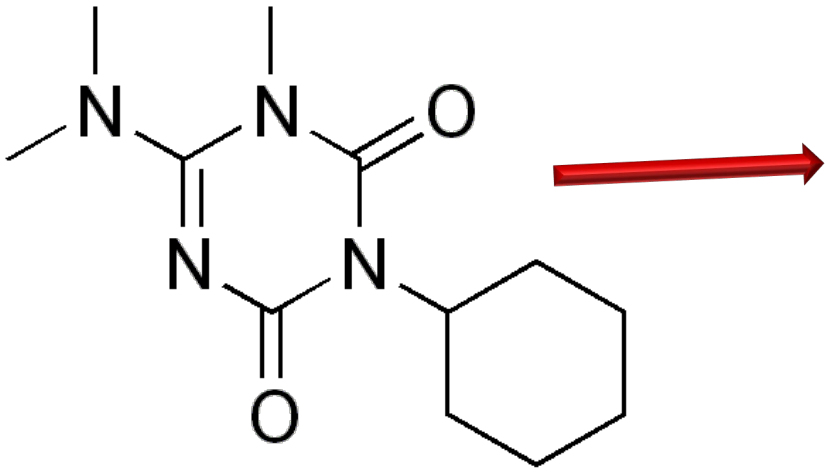


Glyphosate conclusion: no toxicity found in northern California forest soils

	Field rate	100x Field rate
• Viable bacteria	No change	Increase
• Total bacteria	No change	Increase
• Fungal hyphae	No change	No change
• Metabolic diversity	No change	No change
• Soil respiration	No change	Increase
• Microbial biomass	No change	Increase
• Mycorrhizae	No change	No change

What about hexazinone?

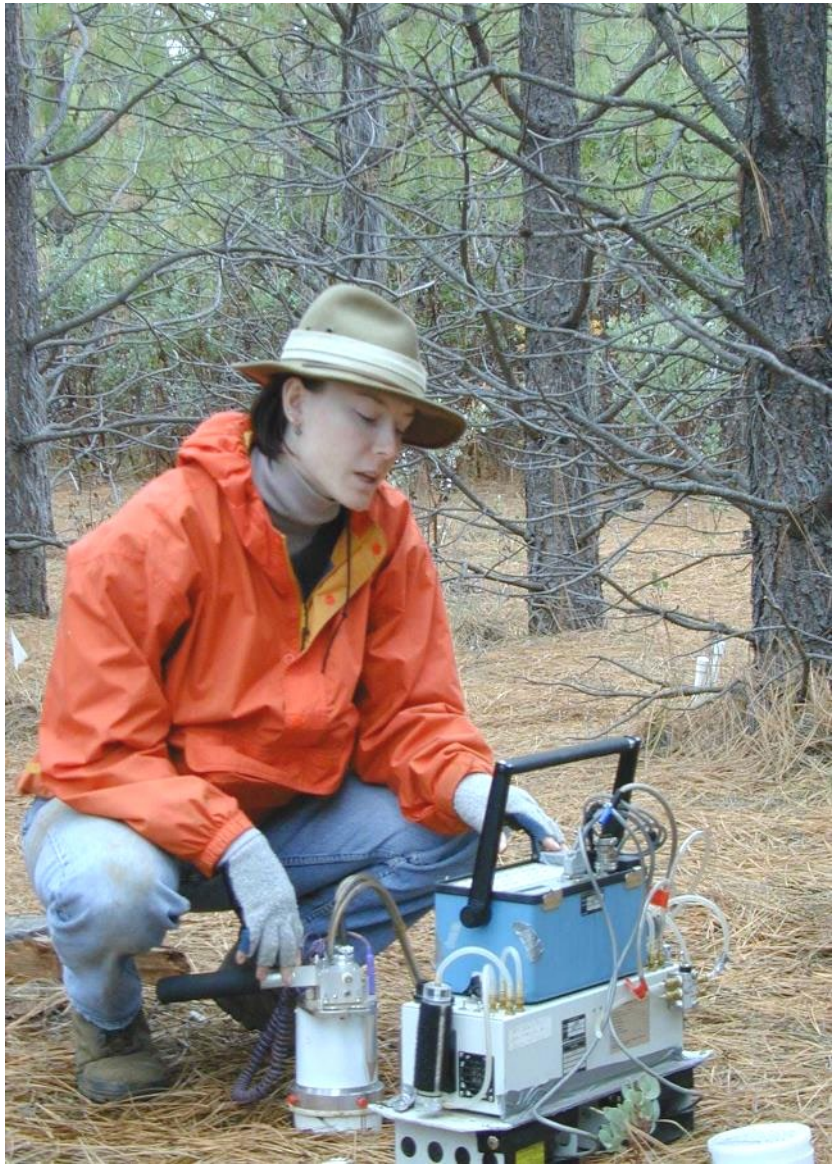




Hexazinone

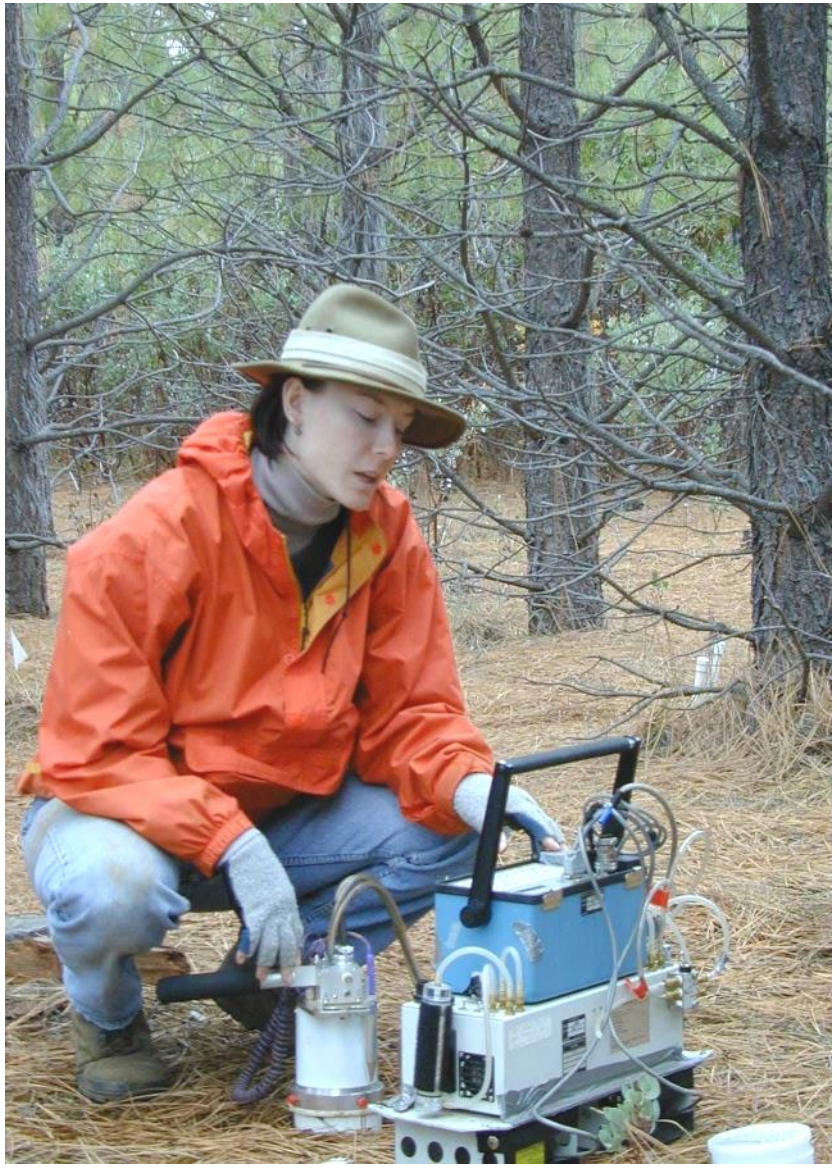
HEXAZINONE field trials

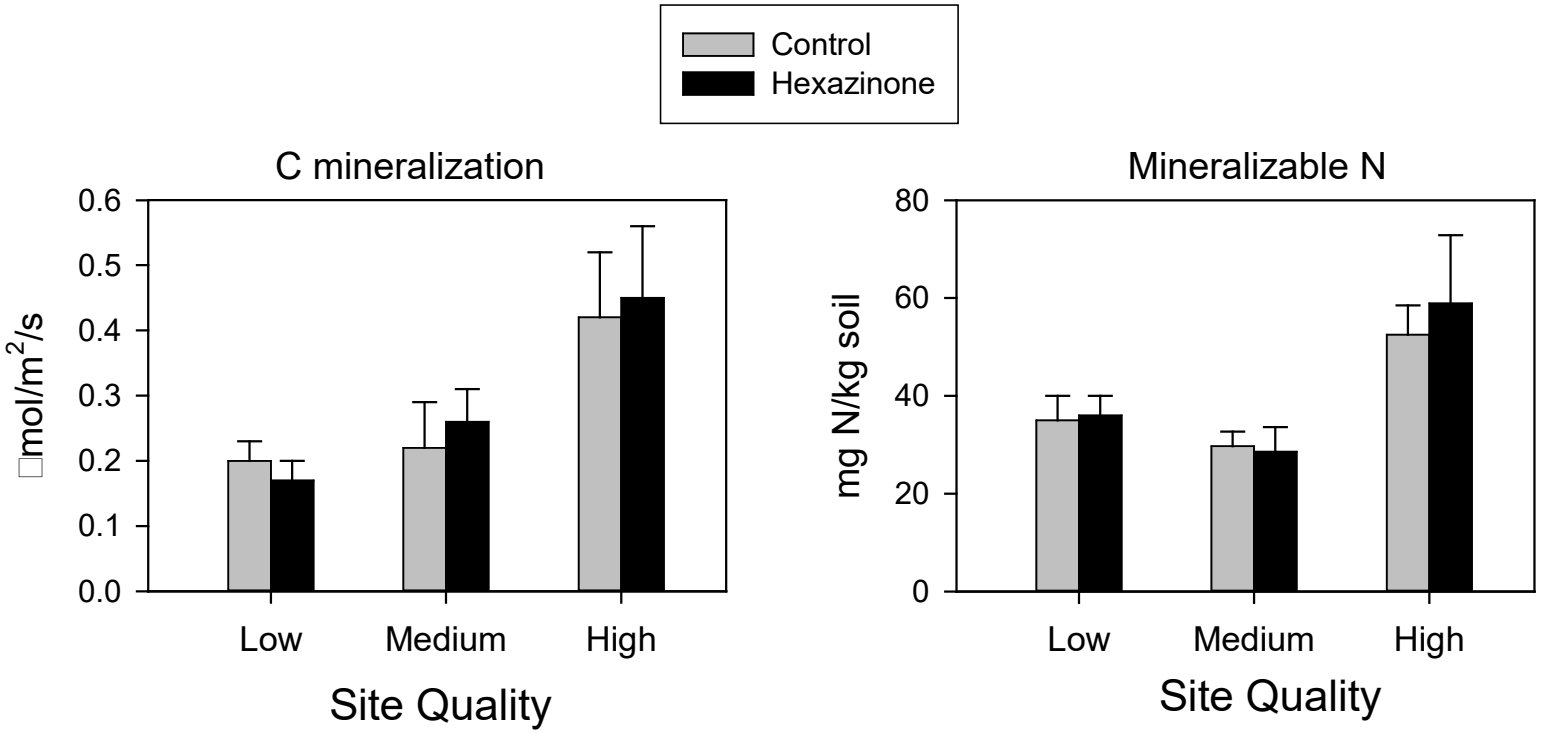
- Paired plots (hex vs control)
- Field rate application
- Replicated at 3 sites in northern CA

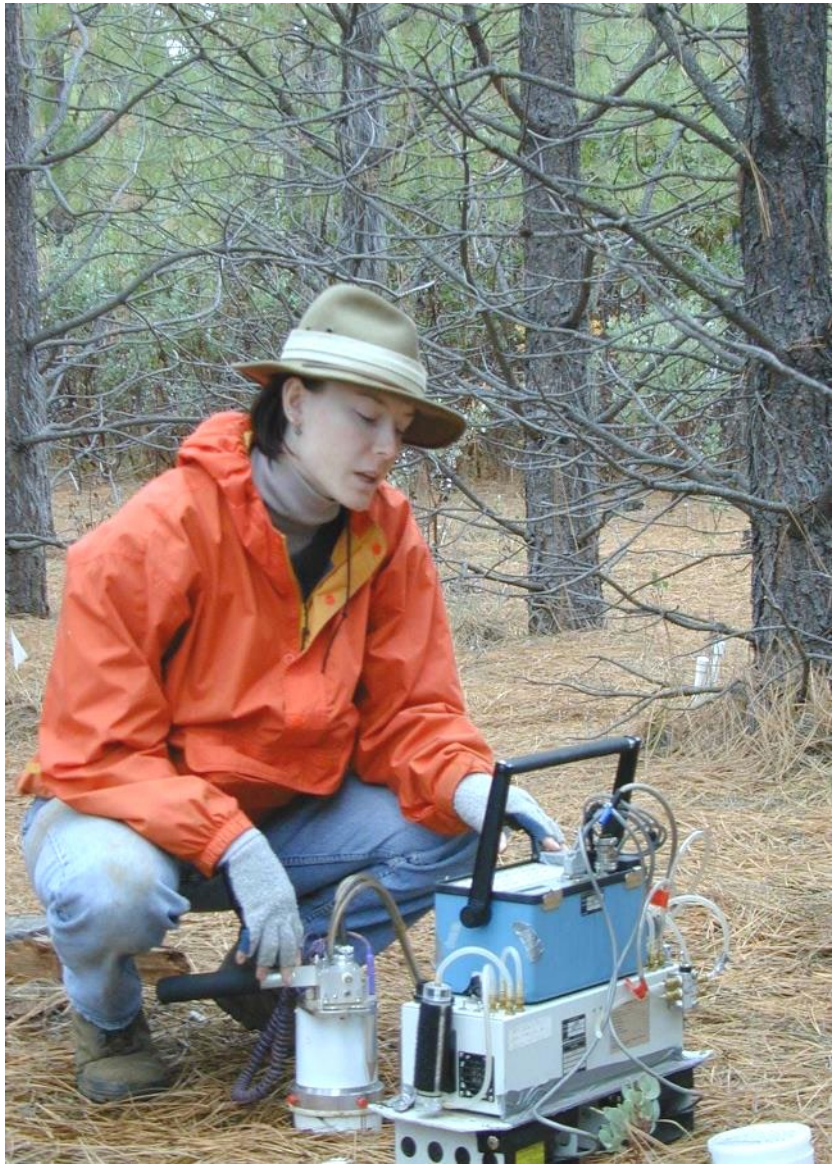


MEASUREMENTS

- Arthropod numbers and diversity
- Protozoa
- Microbial biomass
- Carbon mineralization
- Nitrogen mineralization
- Bacterial diversity




Control
Hexazinone
C mineralization
□mol/m2/s
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Low
Medium
High
Site Quality
Mineralizable N
mg N/kg soil
80
60
40
20
0
Low
Medium
High
Site Quality



HERBICIDE	Benign or Positive effects	Negative effects
Glyphosate	Microbial biomass Total bacteria Fungal hyphae Respiration Diversity Carbon utilization Arthropods	None
Hexazinone	Microbial biomass Respiration Carbon utilization Nitrogen mineralization Protozoa Arthropods	None

Are ectomycorrhizal fungi inhibited by herbicides?

ECTOMYCORRHIZAE

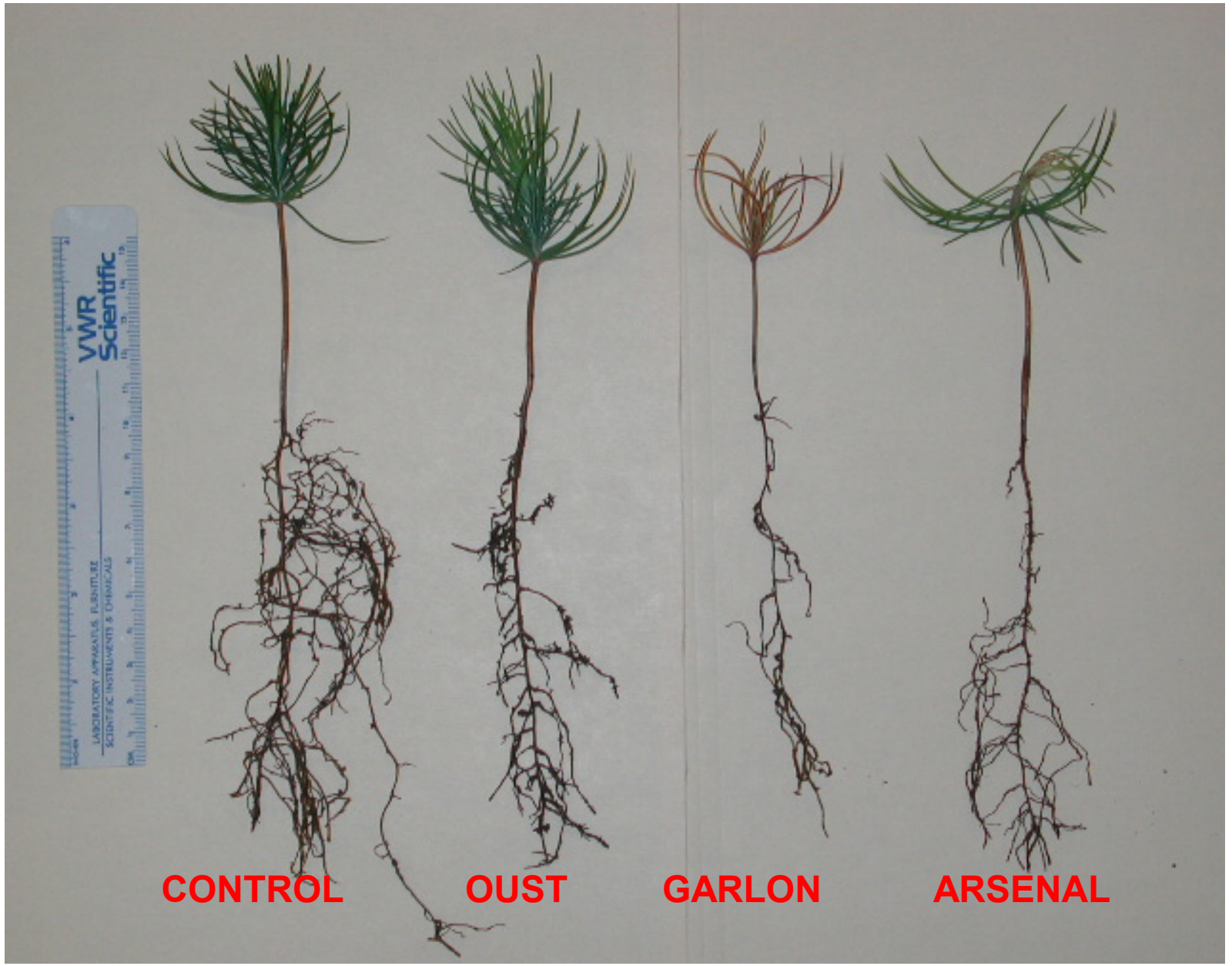
- Fungus-root symbiosis
- Ubiquitous in conifer forests
- Improve conifer nutrition
- Source of edible mushrooms

GREENHOUSE STUDY

- oust, arsenal, garlon, control
- 1x, 2x field rate
- ponderosa pine, white fir, Douglas-fir
- 4 Calif. forest soils

FIELD STUDY

- arsenal (3 rates plus control)
- 3 sites on climatic gradient
- in progress


VWR Scientific
CONTROL
OUST
GARLON
ARSENAL

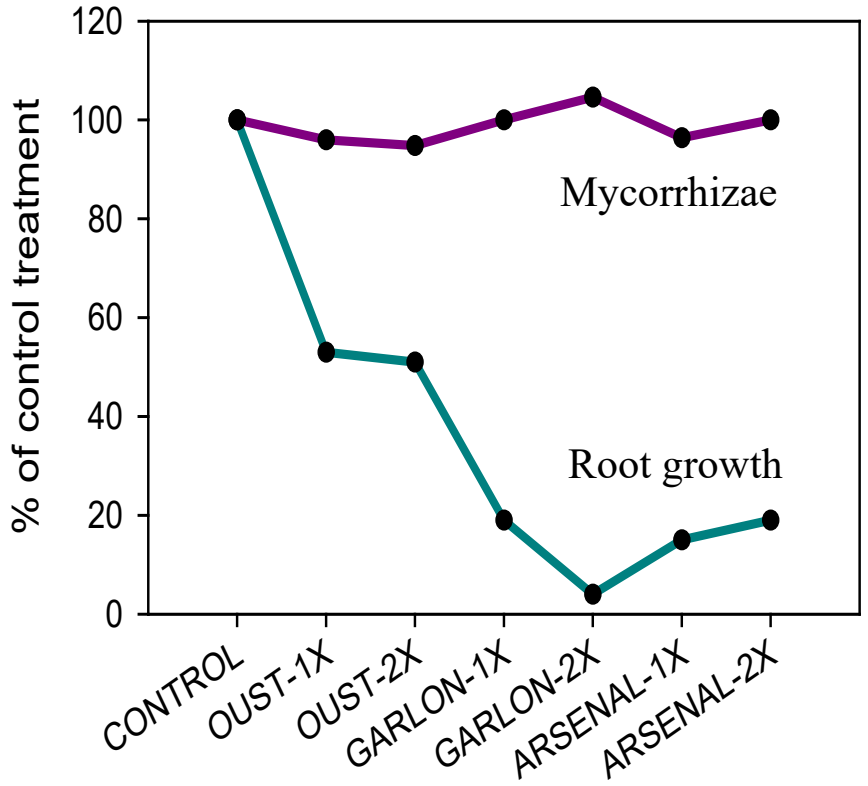
No herbicide: 93% mycorrhizal

Oust: 89% mycorrhizal

Arsenal: 92% mycorrhizal

Garlon: 96% mycorrhizal

ROOT GROWTH AND MYCORRHIZAL FORMATION



- Detrimental root growth
- Herbicides did not alter capability of mycorrhizae to infect surviving roots
- Results consistent across conifer species and soils

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Long-term vegetation control studies

La Pine, Oregon
Pringle Falls Initial Spacing study
Continuous vegetation control since 1959
Minor differences in soil properties

Wildfire in the Sierras

Treatments

- Low-severity wildfire
- High severity wildfire
  - do nothing
  - salvage
  - salvage + mastication
  - intensive forestry (private land)
  - pile burn


Low-severity wildfire


High-severity wildfire
Do nothing


Wildfire + Salvage log

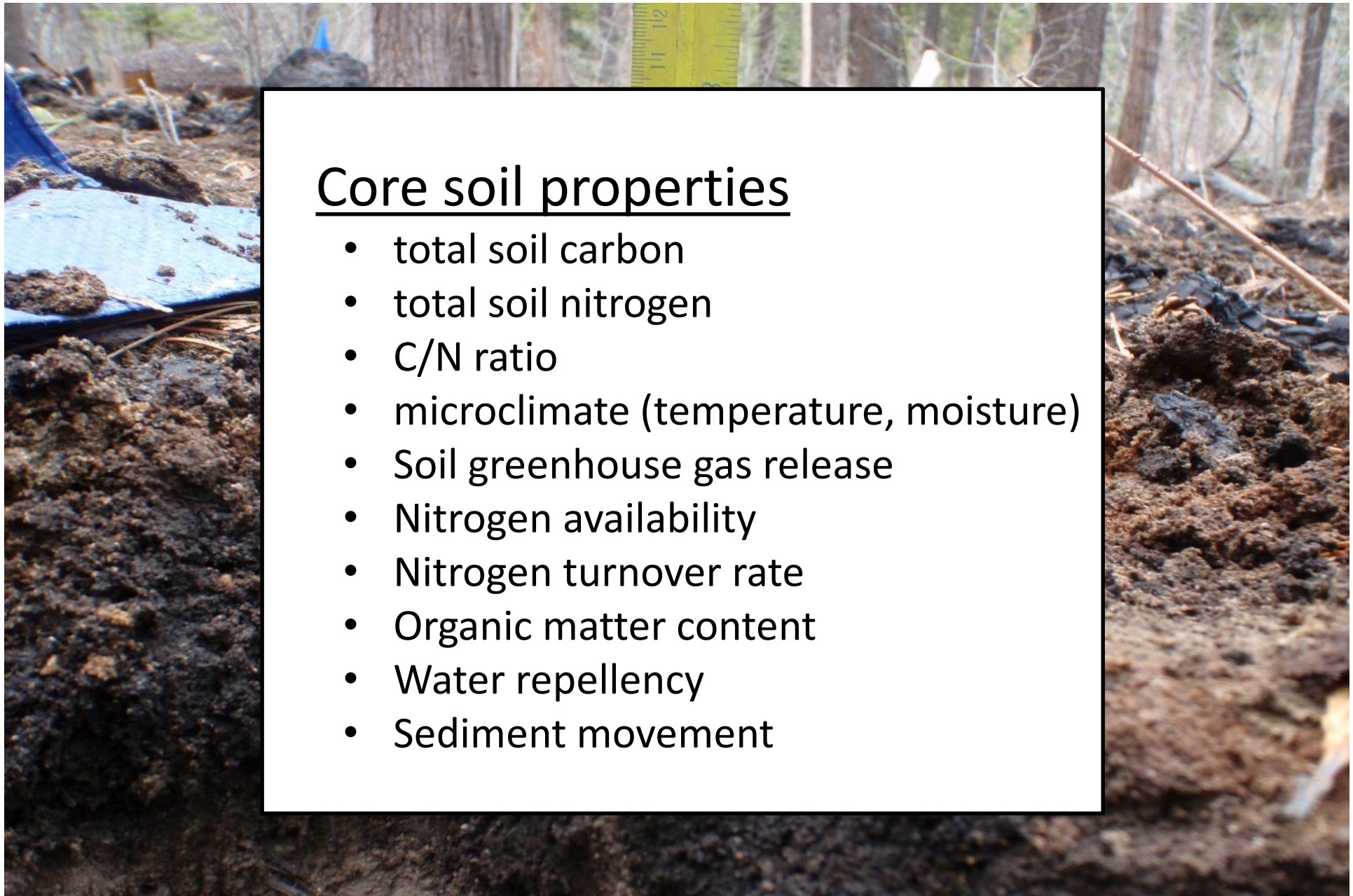

Wildfire + Salvage log + Masticate


Wildfire + intensive forestry


Pile burn


Pile burn

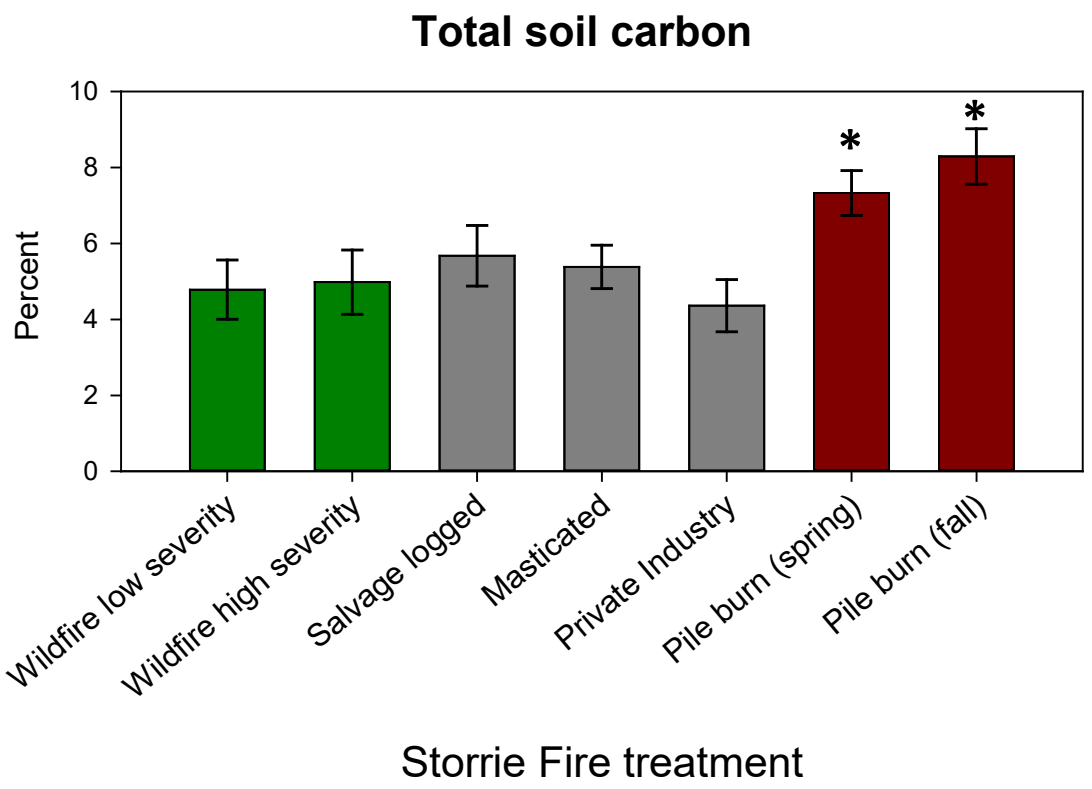
Post-treatment results



Core soil properties

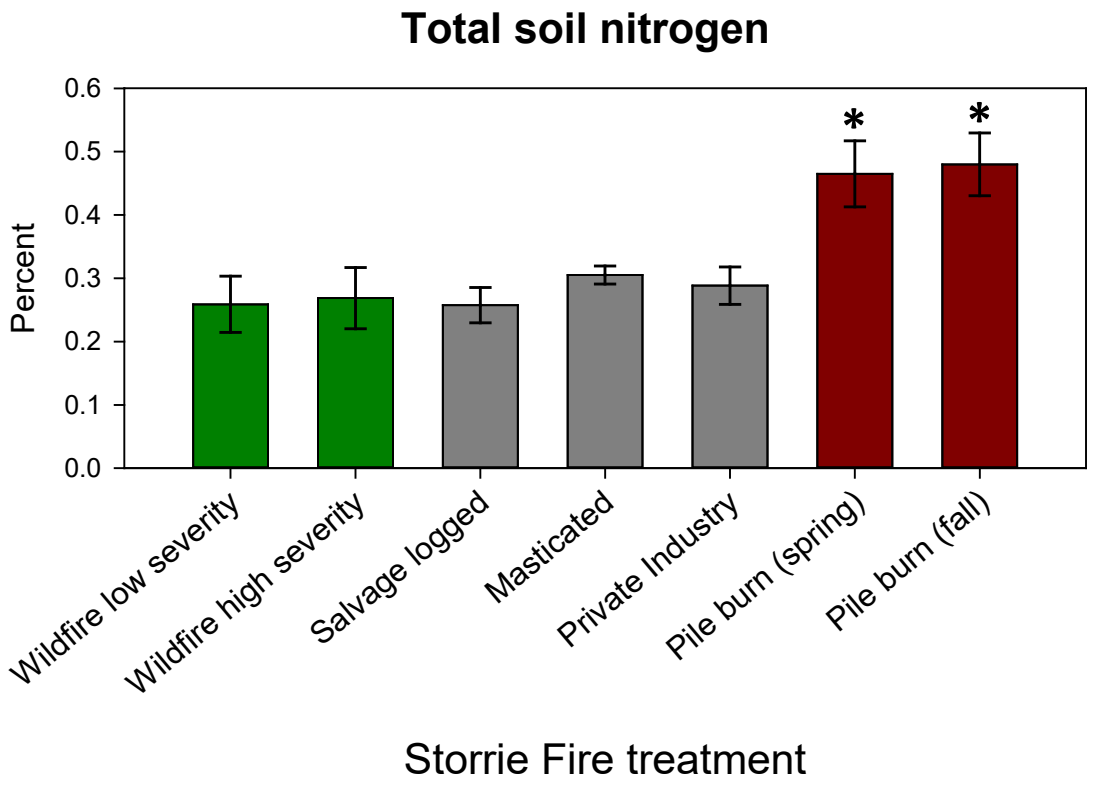
- total soil carbon
- total soil nitrogen
- C/N ratio
- microclimate (temperature, moisture)
- Soil greenhouse gas release
- Nitrogen availability
- Nitrogen turnover rate
- Organic matter content
- Water repellency
- Sediment movement

CORE SOIL PROPERTIES - 11 years post fire



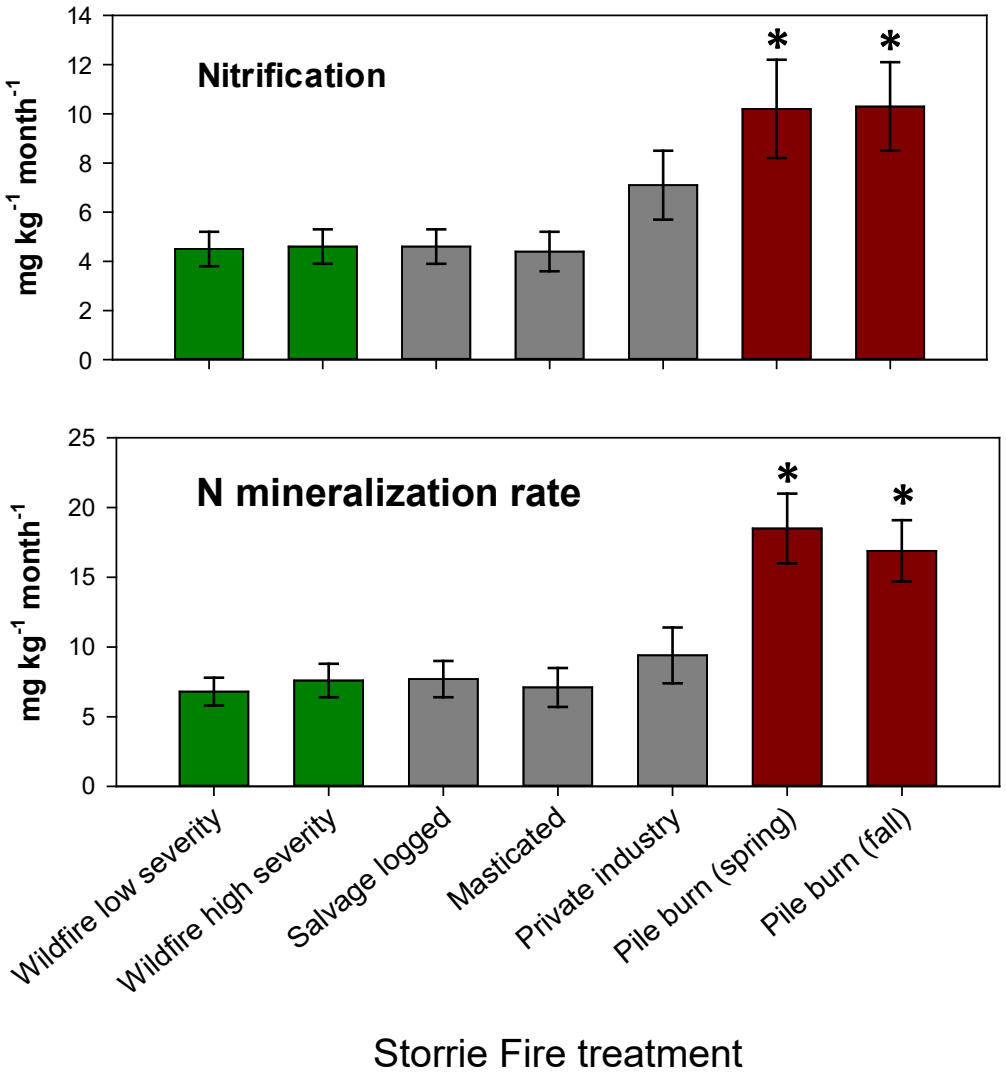
- High soil C regardless of treatment
- No effect of wildfire severity, logging, mastication, or 'intensive forestry'
- Considerable increase due to pile burning. Why??
- No red flags

CORE SOIL PROPERTIES - 11 years post fire

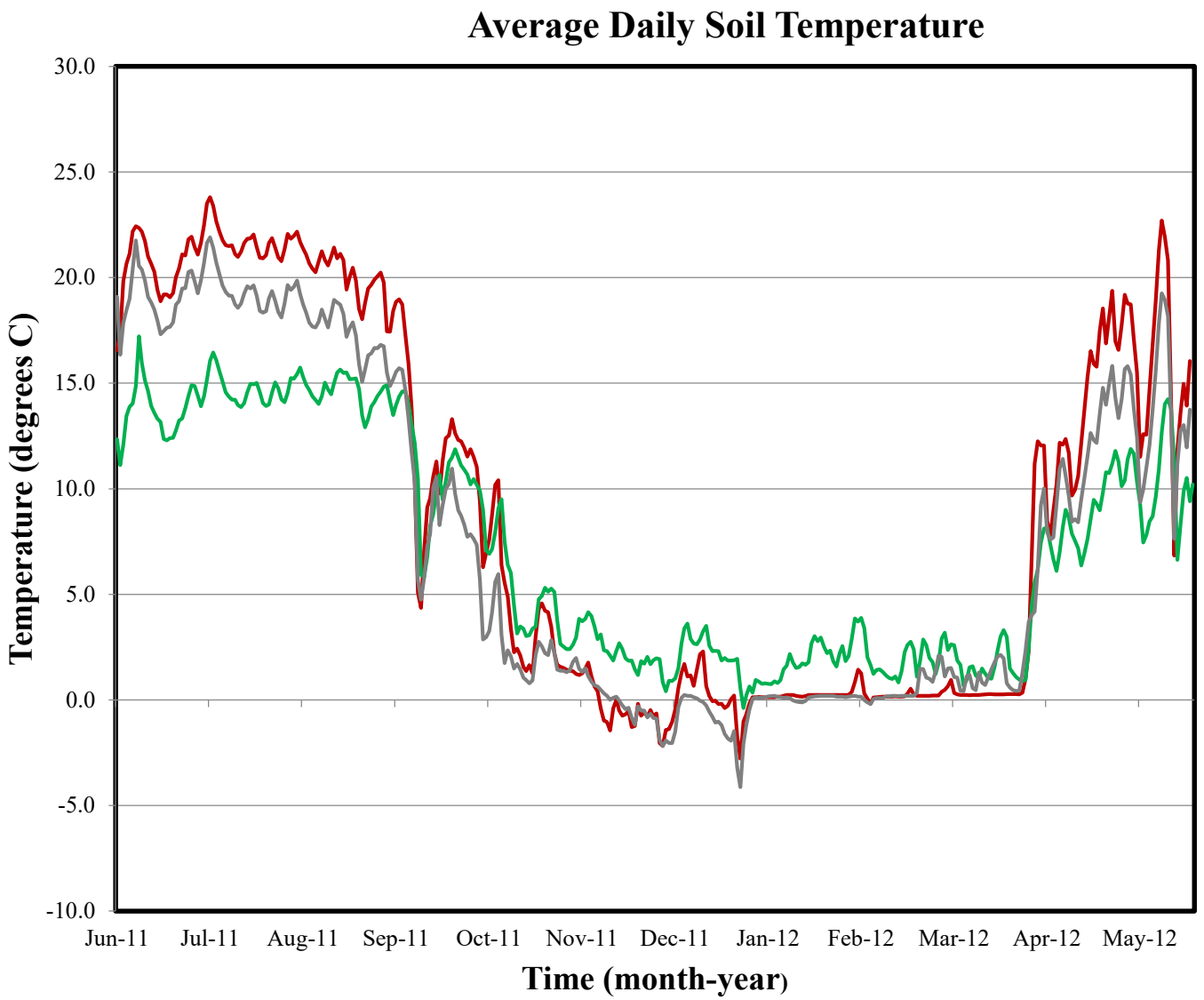


- High soil N regardless of treatment
- No effect of wildfire severity, logging, mastication, intensive forestry
- No red flags

Available N turnover



- Active N turnover in all treatments
- Pile burn results likely reflect the lack of plant N uptake
- No red flags



Pile burn

Private industry

Low-intensity fire

- What about post-fire soil erosion?

SUMMARY:
Vegetation control

- Low risk to most soils
- But, understand your soil's strengths and weaknesses
- Embrace uncertainty in managing your soils