Sustaining Site Productivity: Lessons Learned from 25 years of the North American Long-Term Soil Productivity Experiment

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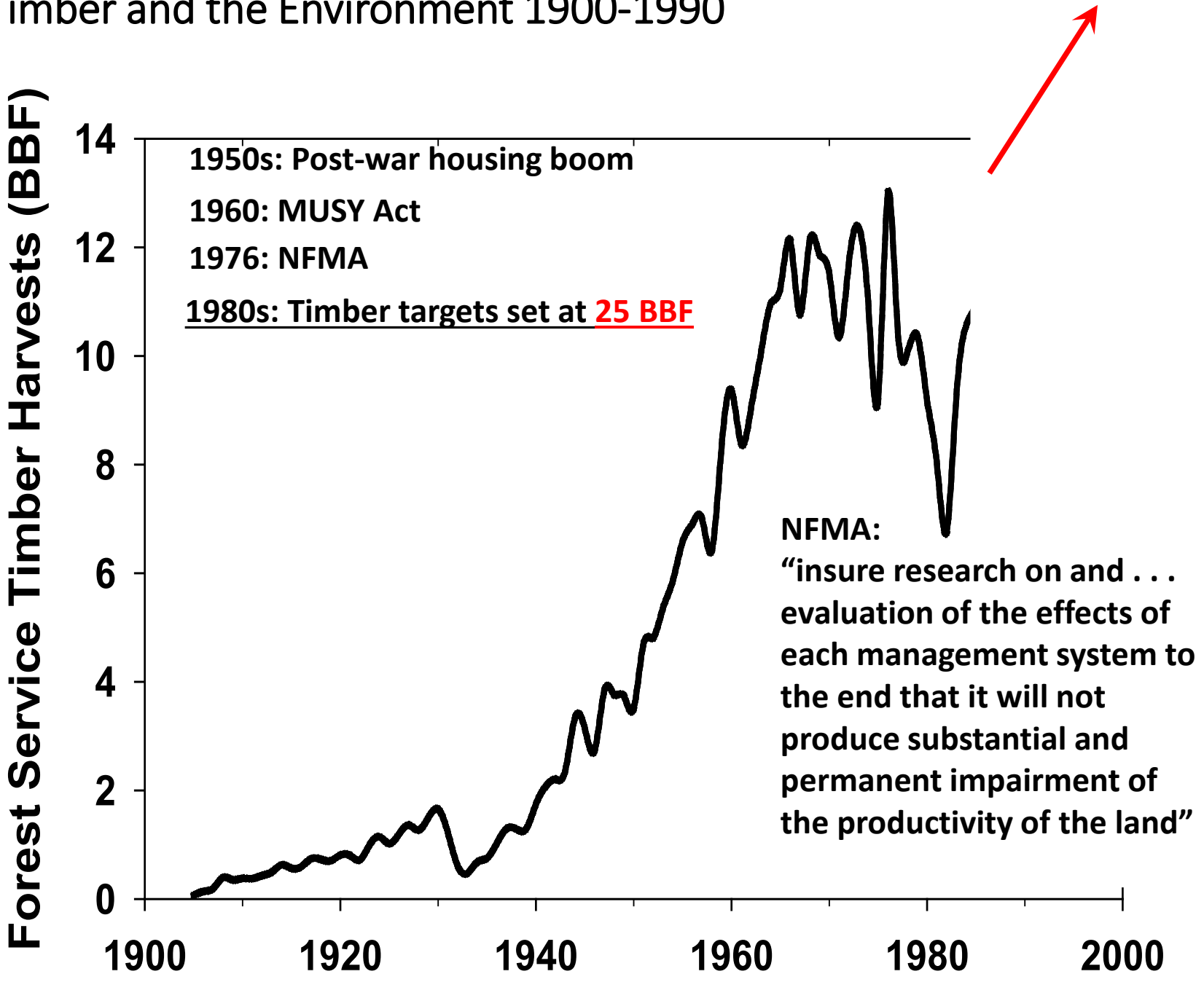
Overview

- A review of how LTSP began
- The LTSP study
- Lessons learned
- Moving forward

Timber and the Environment 1900-1990



Current history of soil and forests in the USA

- Organic Administration Act 1897
  - Forest protection, favorable water flow, continuous supply of timber
- Multiple Use Sustained Yield Act 1960
  - Manage the forests for multiple uses without impairment of the productivity of the land
- National Environmental Policy Act 1969
  - Impacts of proposed actions, relationship of short-term use and enhancement of long-term productivity
- National Forest Management Act 1976
  - Harvest timber only where soil will not be irreversibly damaged

Rough Run Timber Sale 1967 – Monongehela National Forest

Why are these laws such a big deal?

- Soil management underpins sustainable forest management
- Soil disturbance affects on sustainable productivity varies
- NFMA (1976) required research and monitoring to protect the permanent productivity of National Forests.

Soil productivity is …*"the inherent capacity of the soil resource to support plants"*

Measuring growth

- Trying to measure the productive potential of a site with tree or stand data is hard!
  - Growth trends vary with stand age, structure, stocking, treatment history
  - Lack of appropriate reference stands
- Soil-based indices are more objective
  - Measure site capacity for vegetative growth

Soil quality standards in the Forest Service

- FS was the first agency in the world to develop soil standards!
- Evaluate the effects of management
- Meet the direction of NFMA and other legal mandates
- Ensure management of National Forests did not permanently degrade productivity
- Maintain or improve soil quality
- Lack of a ‘standard’ metric for all soils
- Early thresholds were best judgement
  - Not based on science
  - ‘Early warnings’ not absolutes

North American Long-Term Soil Productivity Study

The LTSP Study

- Largest coordinated long-term study on forest management and soil issues in the world
- USFS initiated
  - International and expanding
- Over 100 field sites
- Shared study design and monitoring plots
- Some sites are 25+ years old

Dealing with the issues

- NFMA's call for research on forest management and 'productive capacity of the land'
- Little useable science to validate soil quality standards
- HUGE collaboration

LTSP: collaboration of science and management

USFS R&D

USFS NFS

NR Canada

BC MoE

ON MNR

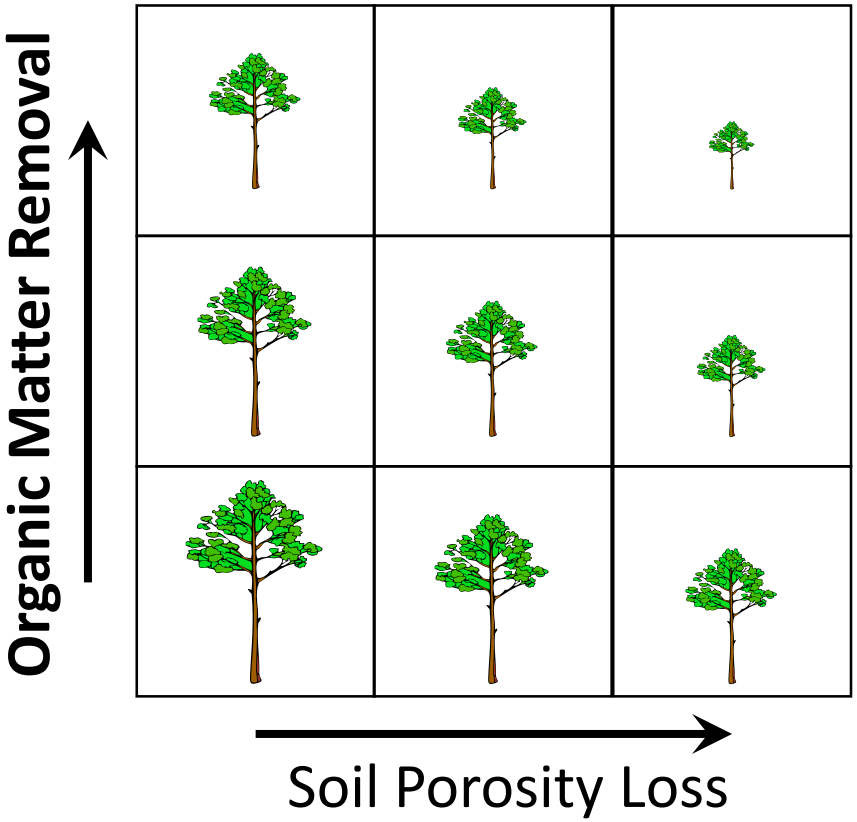
Industry

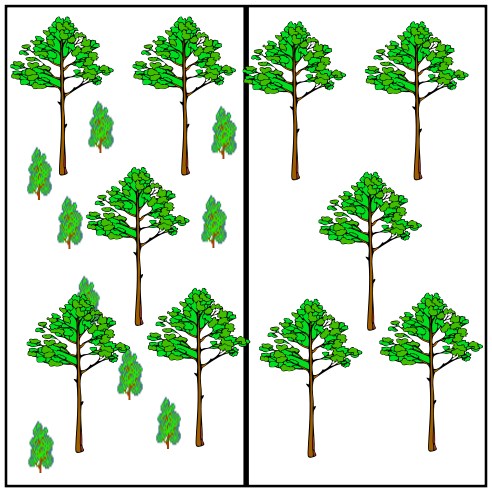
Academia

Core hypotheses

LTSP Hypotheses:

- Pulse changes in site organic matter or soil porosity will not affect a site's long-term productivity.
- If impacts do occur, they are universal.
- If impacts occur, they are irreversible.
- Plant community diversity has no impact on long-term productivity.





1 acre (0.4 ha)

Experiment Locations-Core and Affiliate

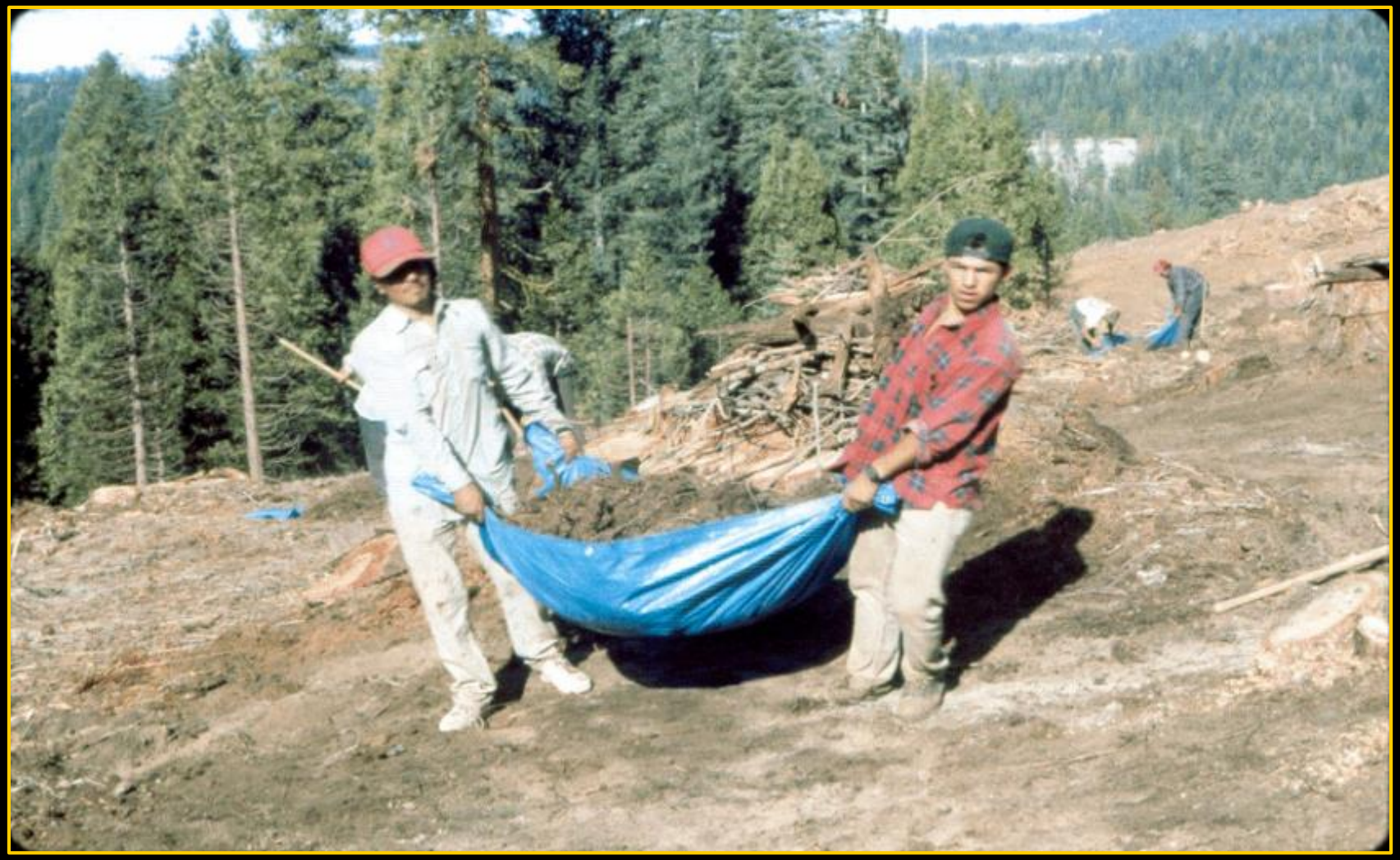
Site installation

Pre-Harvest Conditions

Pre-Harvest Conditions

Logging – Falling

Compaction Preparation



Compaction Treatments (Experimental treatments!)

Compaction Treatment

Experimental Compaction: Severe and ~100% Area

Post-Compaction – Replacing Organic Matter

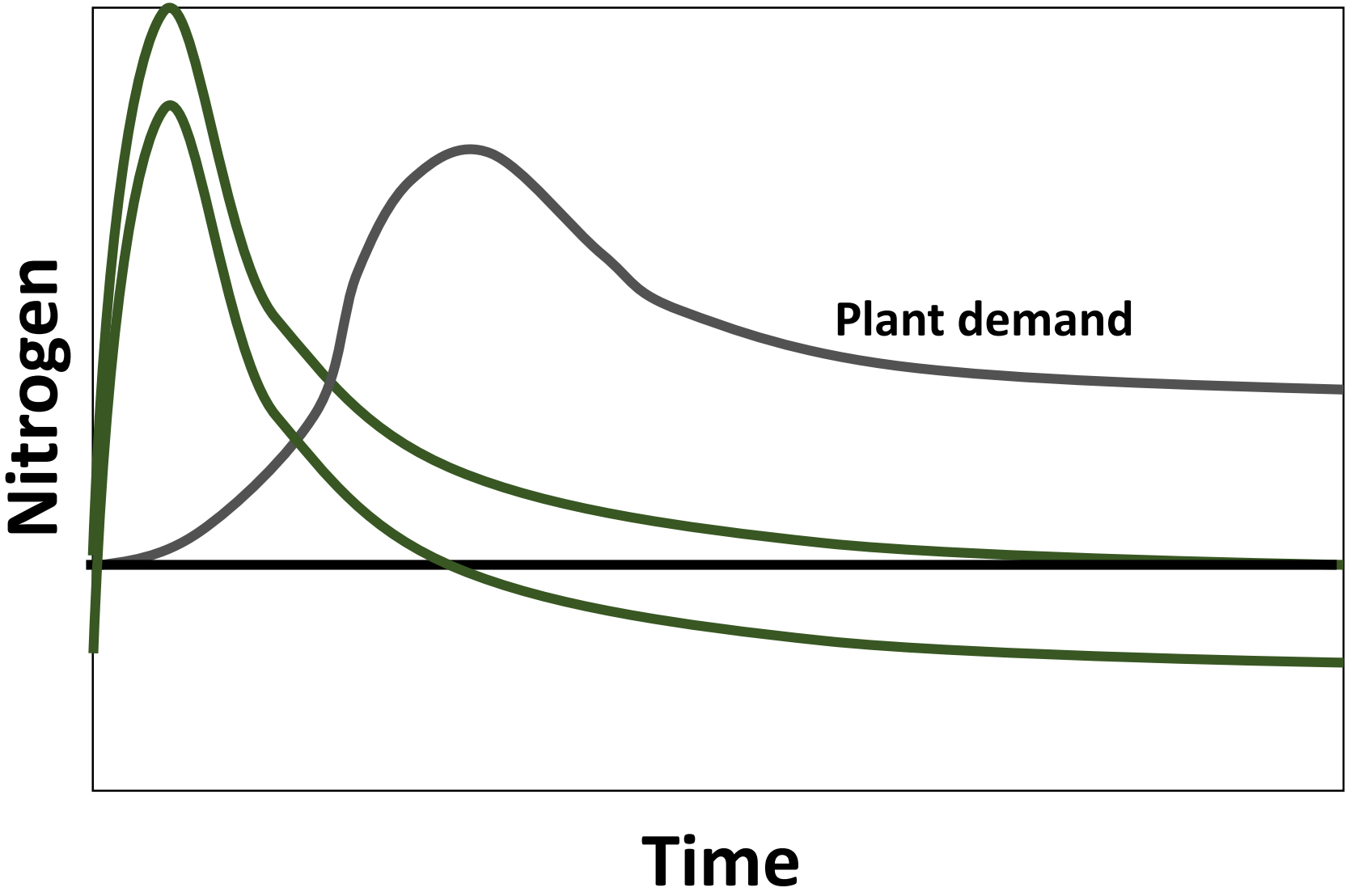
LTSP Study Design -Organic matter removal

Productivity gradients

- **Sites represented “timber” sites**
- **Climate, texture, species**
- **LTSP answers “what’s likely”, <u>not</u> “most susceptible”**

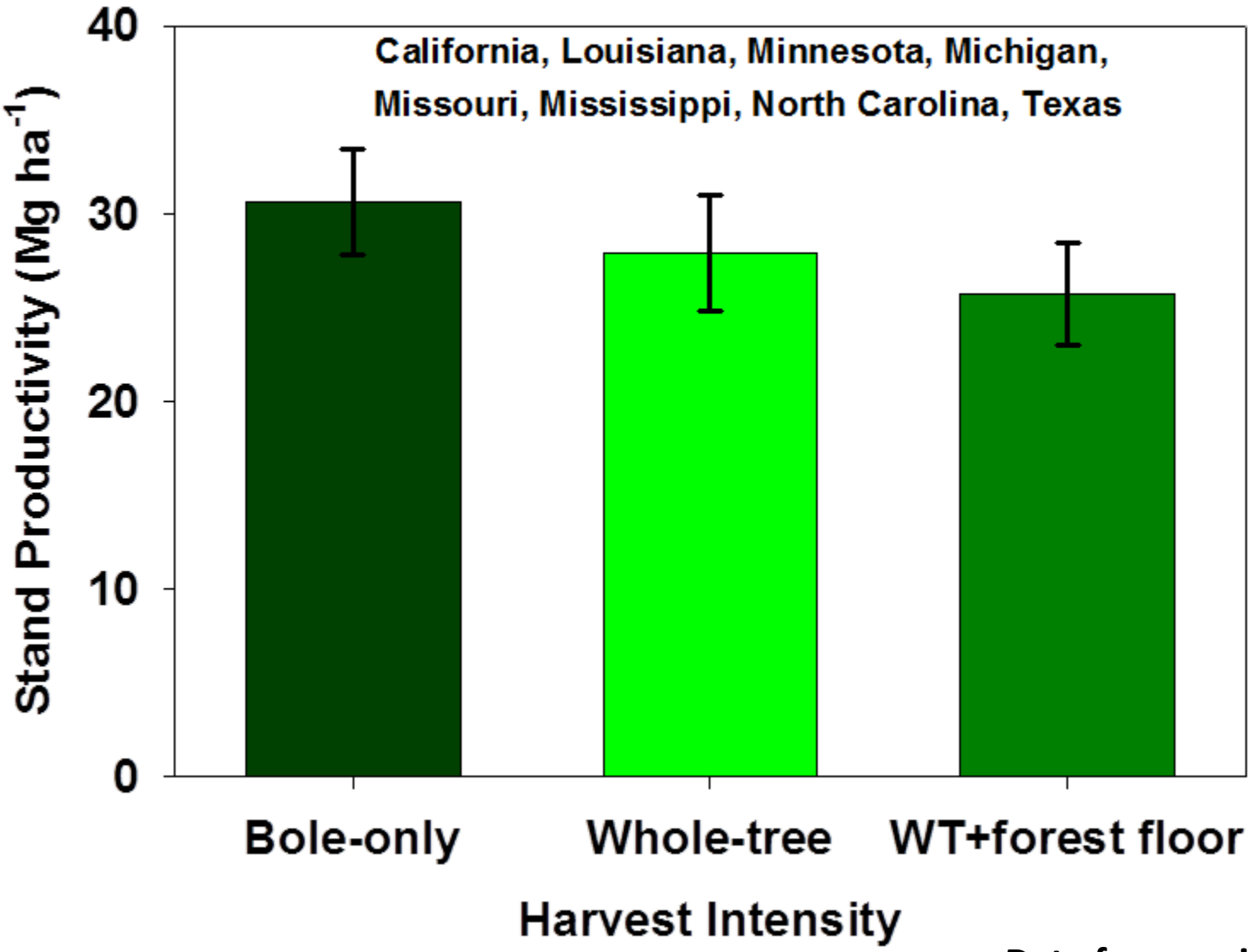
Examples of results from LTSP (and others)

ASYCRONY:— small trees don't demand nutrients and water, but nutrients and water are available right after harvesting



Organic matter and nutrients

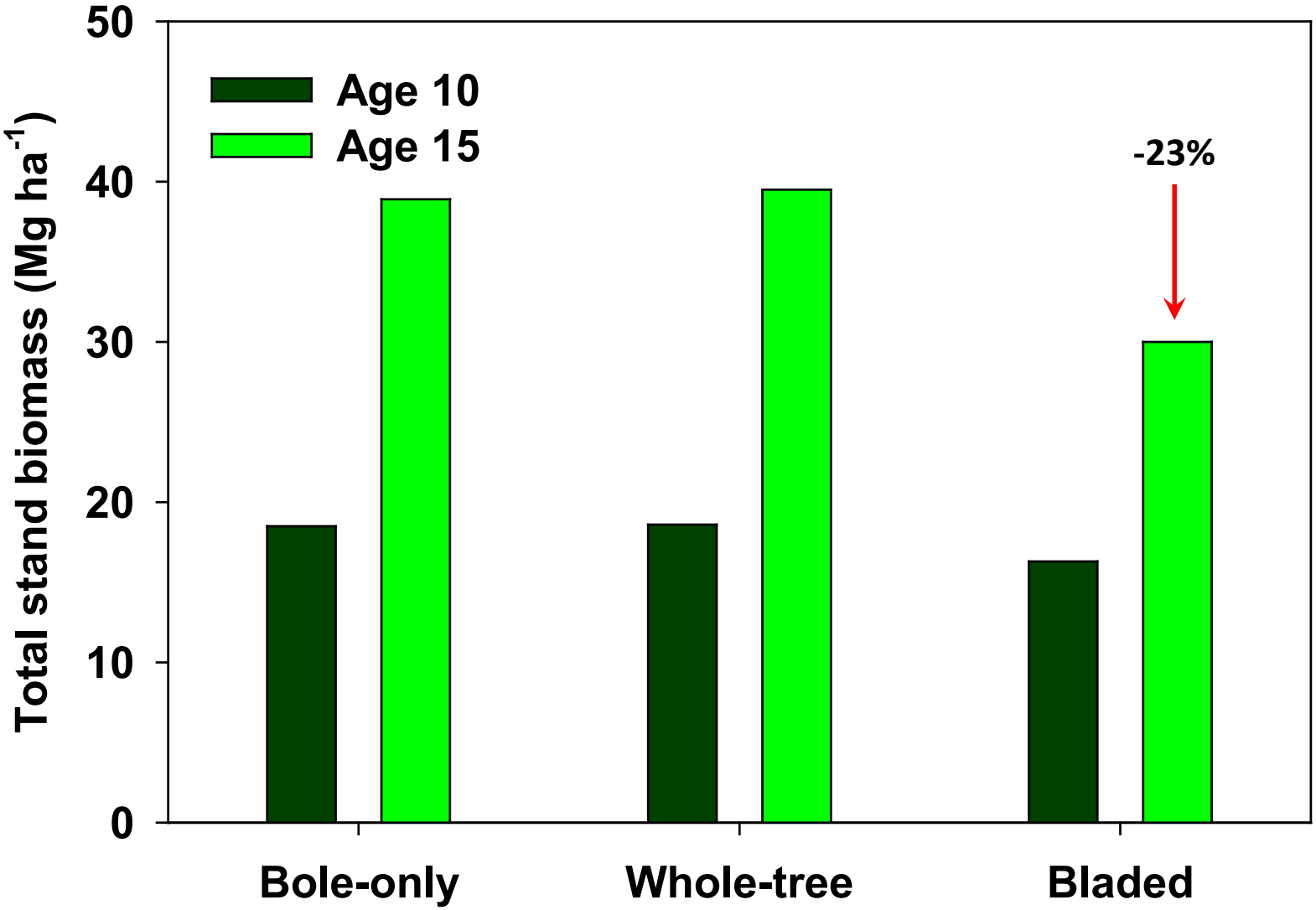
Organic matter removal overall impact on productivity-Age 10



Data from various sources

15-Year Response North-Central Jack Pine (9 sites)

1. By 15 years of age, many sites show a reduction to complete OM removal



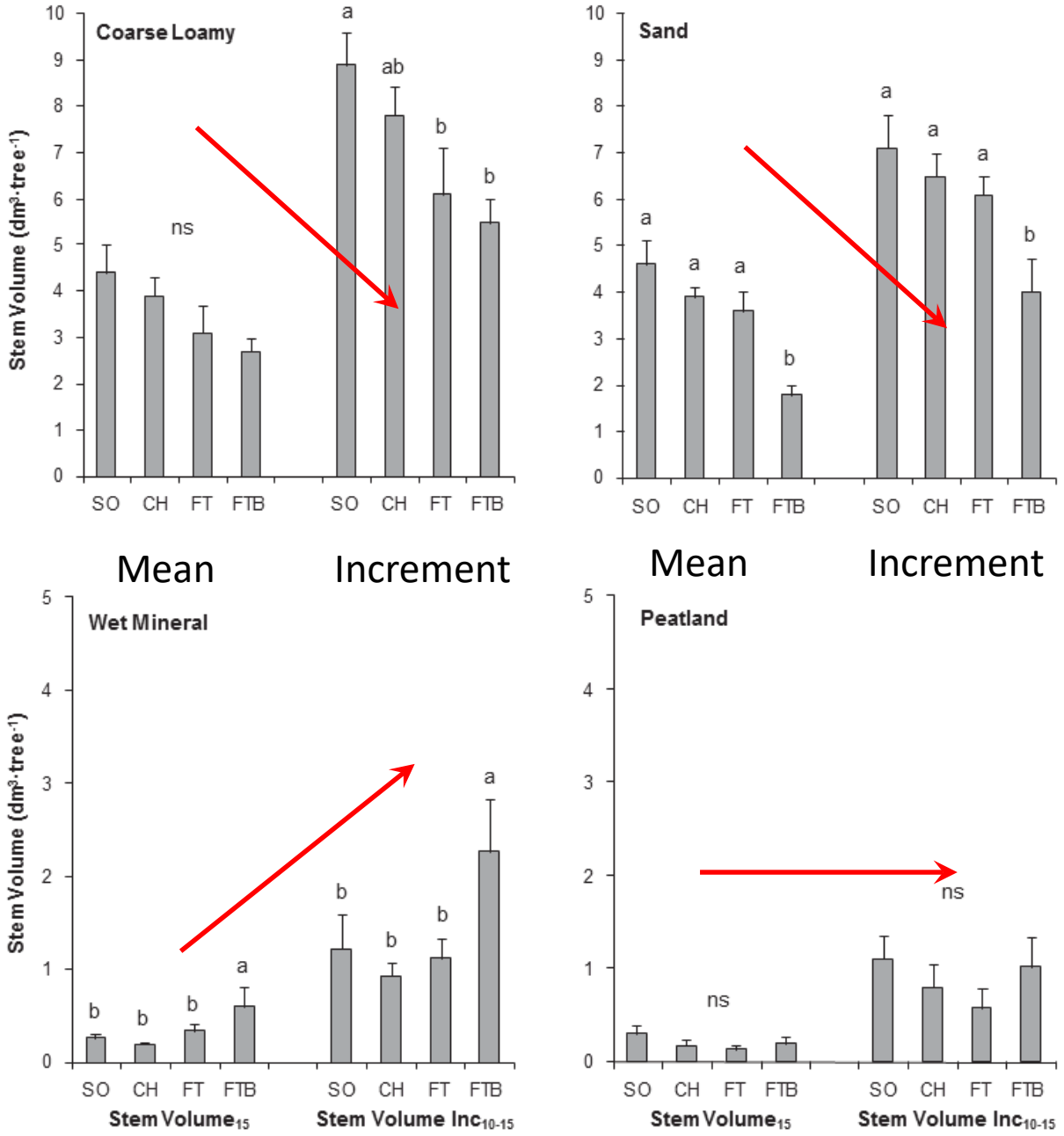
Fleming et al.
CJFR 44:1566-1574

15-Year Response of Douglas-Fir in Washington

1. By 15 years of age, many sites show a reduction to complete OM removal

Unpublished from Holub 2015

Black Spruce-Age 15 Ind. Stem Volume

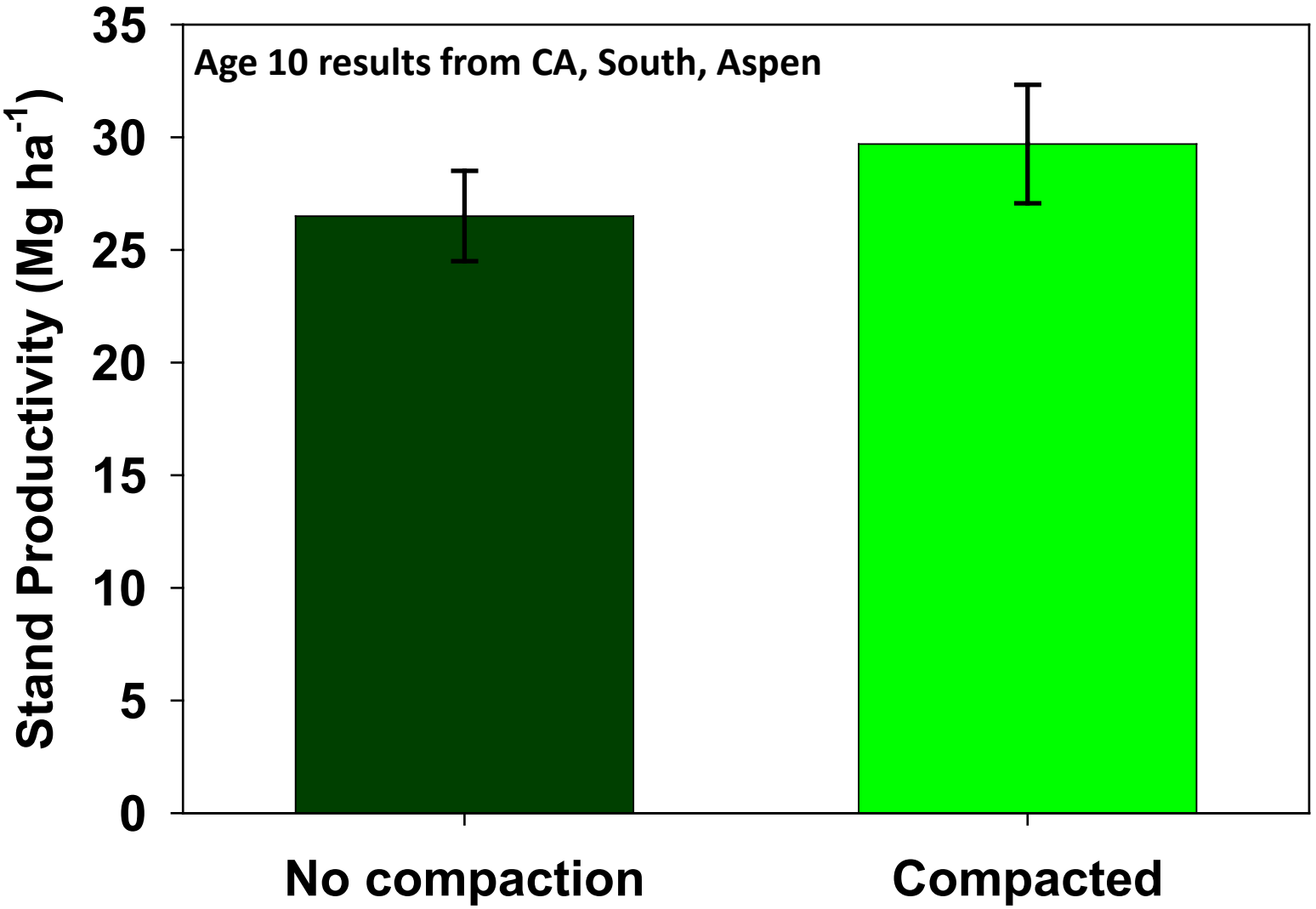


Morris et al. 2014
CJFR 44:313-325

A couple thoughts on compaction

Lessons on compaction

1. Simple compression has had very few negative impacts on the growth of planted trees



Lessons on compaction

1. Simple compression has had very few negative impacts on the growth of planted trees
    1. Different effects based on texture

Young (<10yr) Mixed Conifer in CA

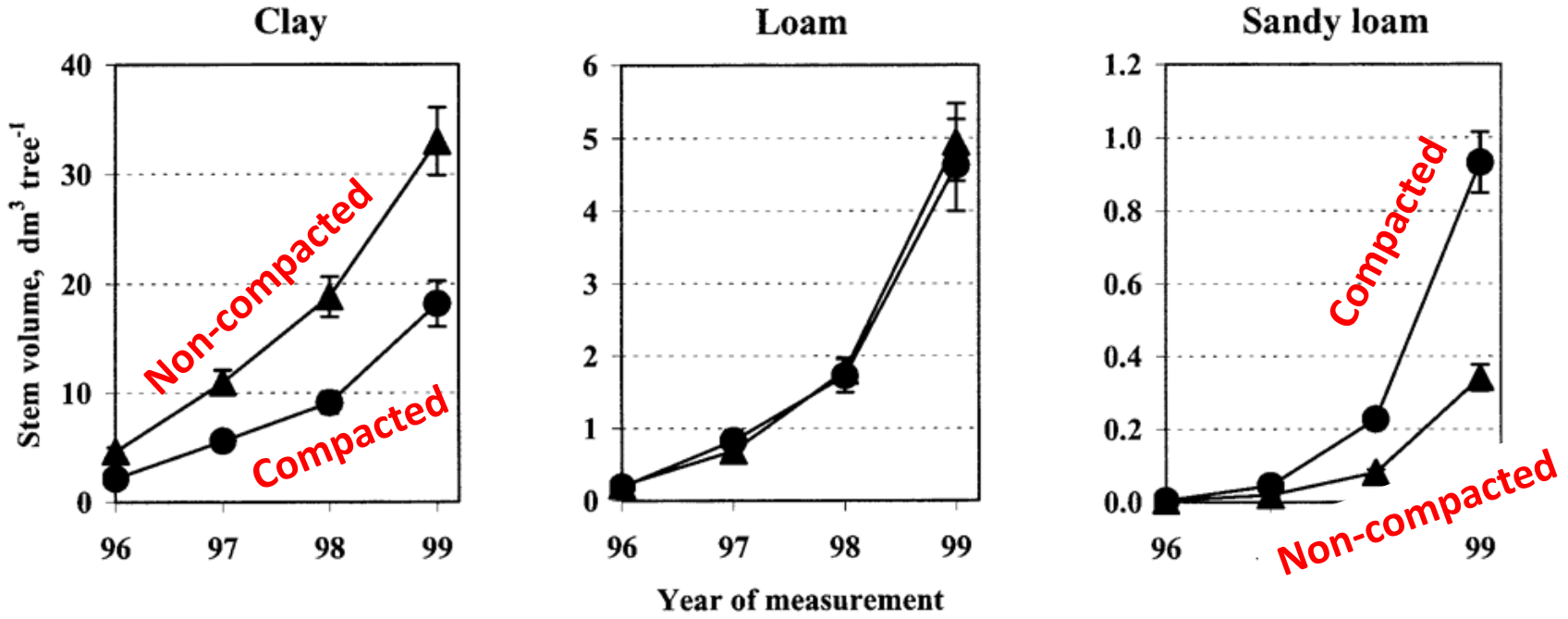
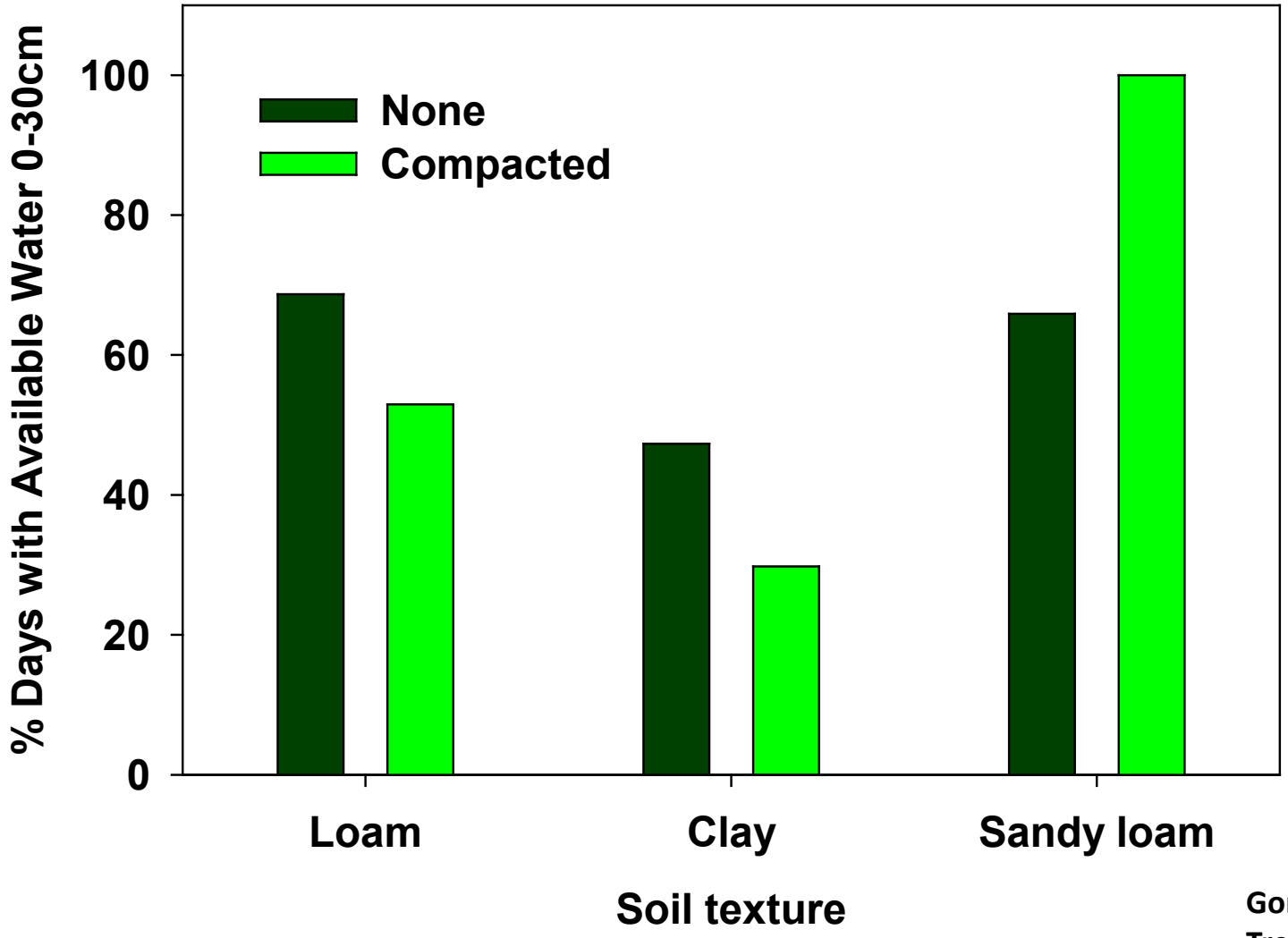


Fig. 2. Cumulative stem volume for ponderosa pine at the three study sites for noncompacted (triangle) and compacted (circle) treatments. All sites are for full forest floor + logging slash removed. Age of plantations in 1999 was 8, 5, and 3 yr, respectively. Vertical bars represent standard errors.

Gomez et al. 2002
SSSAJ 66:1334-1343

Lessons on compaction

2. Sandy soils with very low initial bulk density can increase water holding capacity with compaction



Gomez et al.
Tree Phys 22:459-467

A summary of what have we found in the last 25 years

- Short- and long-term results are highly site specific – few results hold for all sites.
- Surface organic matter removal and soil porosity (intensive harvesting and compaction) have had both NEGATIVE and POSITIVE effects
- **Soil Compaction:**
  - Few negative impacts on planted trees
  - Increased water holding capacity on sandy soils
- **Organic matter removal:**
  - Forest floor removal can lead to nutrient deficiencies
  - Timing of responses is variable

- Intensive harvesting generally HAS NOT DECREASED productivity or soil C sequestration across the network
  - Some clay soils have shown decreases, some sandy soils have shown increases.
  - Soils are recovering from compaction at varying rates, dependent on soil texture and climatic regime

Major findings-What we've learned from LTSP

1. Productivity has a strong positive responses to vegetation control

2. Soil compaction has **increased** planted tree growth **more** than decreased it
   - Changing water relations

3. Whole-tree removal has had little impact on soils or productivity

4. Complete OM removal has reduced productivity on very few sites through age 10 despite 3-5x nutrient removals

Why?

1. Productive sites, choice of efficient species
2. Nutrient supply/demand asynchrony
3. Differential impacts (nutrients, water, vegetation)

What next?

1. Are responses temporary or permanent?
2. What soil indicators are useful?
3. Incorporate new process work

My perspective on two (plus) decades of research

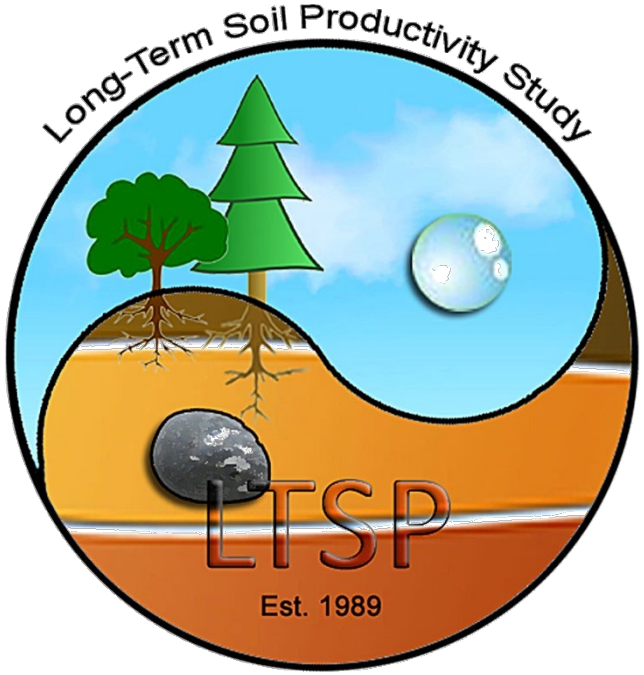
- LTSP was conducted on productive forest sites and planted with genetically superior stock.
- The lack of a definitive ‘this is bad (or good)’ doesn’t mean we can harvest without concern.
- Site condition, ecosystem service, texture, etc. are all important in determining what forest responses mean (not just tree growth)

- Many (80% or more) forest sites are highly productive and resilient
- Know which ones are not and either exclude harvesting those or harvest with additional care

Do we know everything?

- NO!
- Many stands are just approaching crown closure
- Many results may still surprise us as the stands age
- Understanding process level changes may give us different conclusions from tree or stand productivity

Take Home Messages



- At 10-25 years, bioassays have greater relevance
- OM gradient useful for testing responses
- Indicators useful for nutritional responses
- Process-level work helping to understand future ecosystem changes
- Continued monitoring, expansion to fill gaps & synthesizing soil responses necessary

Questions?

How come topsoil isn't dirt cheap?