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Forest Carbon Dynamics & The Role for Biochar

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Forests “piling up” with low-value wood stock

- From harvest, fuel treatments, rehabilitation, construction projects etc.
- ~375 million dry tons of forest slash produced each year in the US



Common Practice: Pile Burning

Slash piles are burned for disposal

Negatives:

- Release CO₂ to the atmosphere
- Air quality
- Fire risk
- Nutrient volatilization
- Legacy of burn scars
- Invasive species
- Loss of soil organic matter



Photo Credit: C. Rhoades, L. Asherin; USFS-RMRS

BIOCHAR PRODUCTION

Turning waste biomass into
a climate smart product



Photo credit
Nathanael Johnson





**Burning piles sends most of
the biomass C into the
atmosphere**



**Turning slash into biochar
reduces C emissions by
~20-40%**

**Kilns process 1-2
ton of forest
slash per hour**

**Return 15-25%
as biochar**

**Sequesters
~35%
of the carbon
in biochar**

SOIL CARBON SEQUESTRATION → Where does biochar stand?

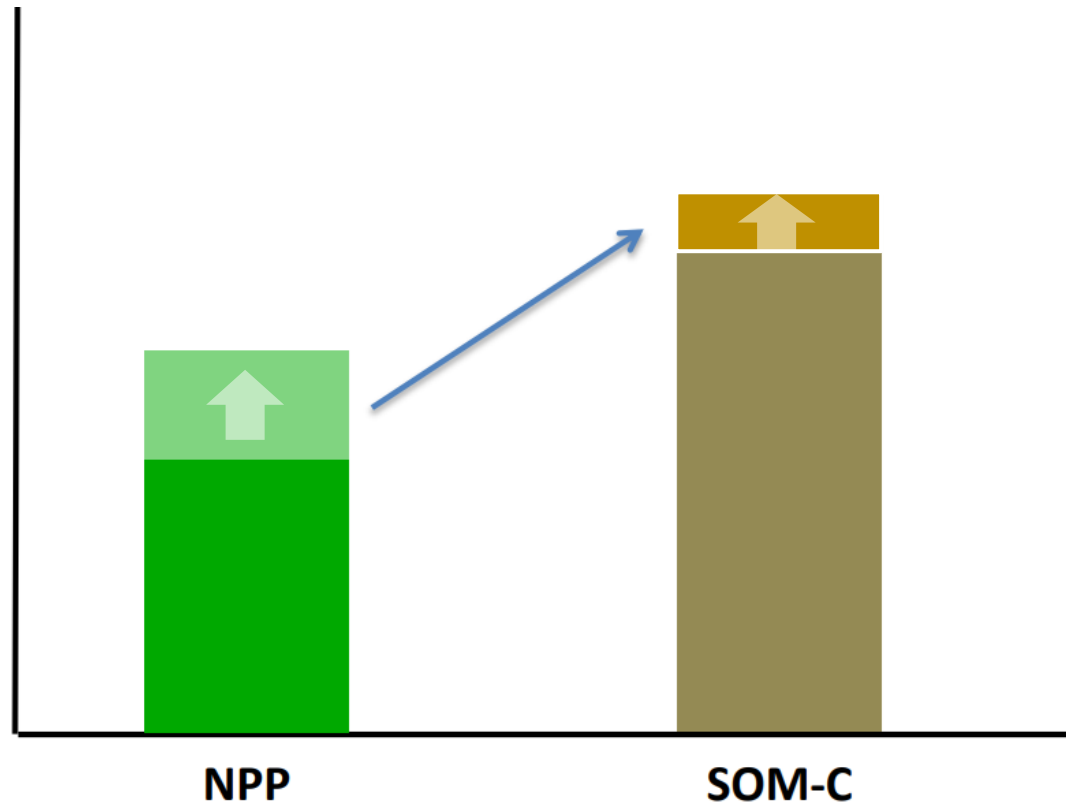




The DIRT Network

DIRT = Detrital Input and Removal Treatment

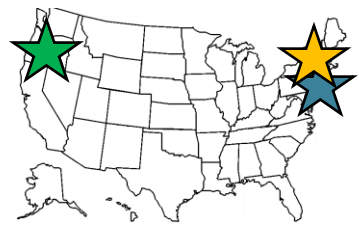
“Often expected” soil organic matter (~carbon) response to additional plant detrital inputs:



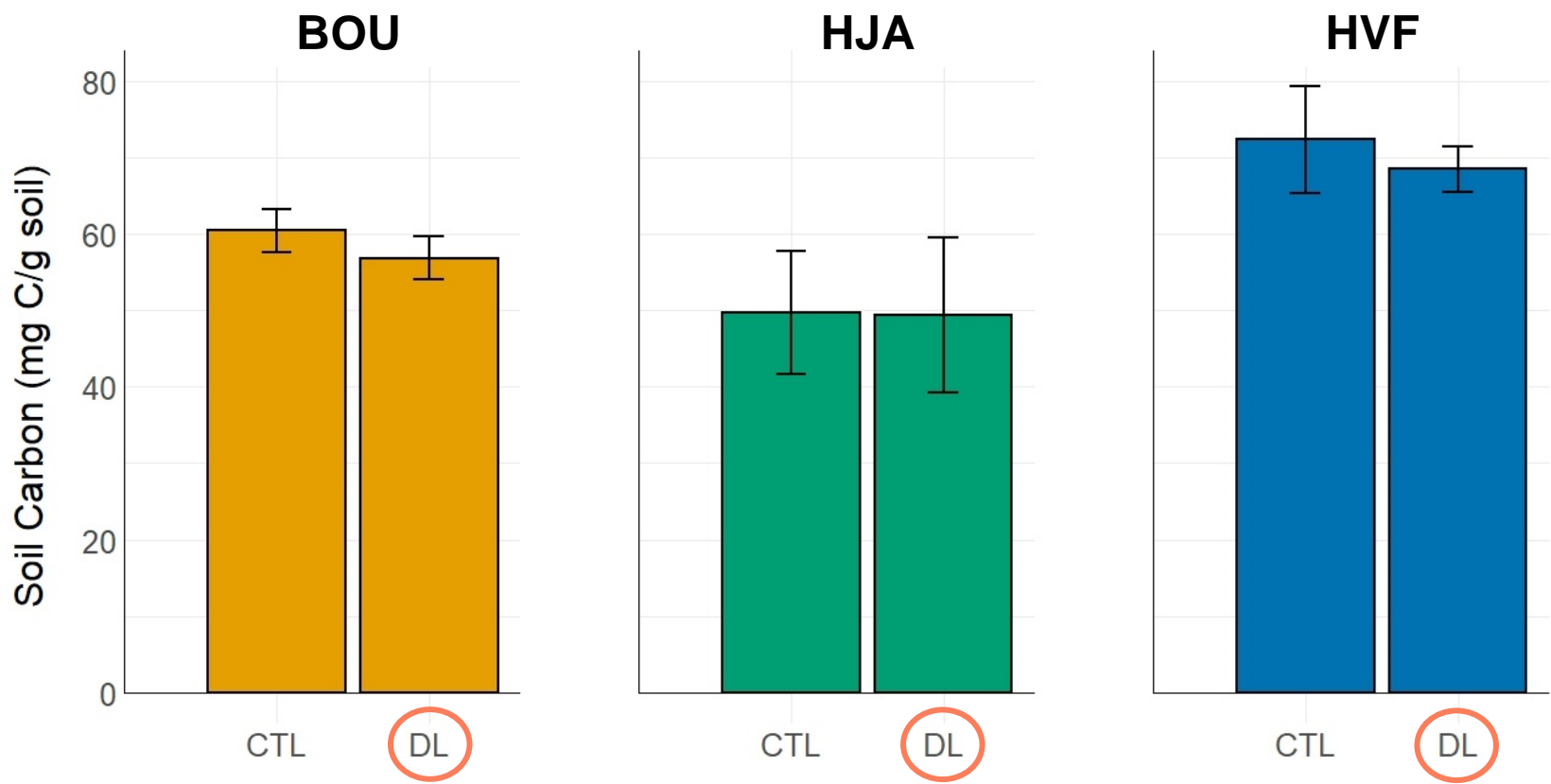
Increased soil C storage with increased NPP and plant inputs to soils

DIRT Network: Add OM \neq More SOC

After 20 years of doubling litter inputs...



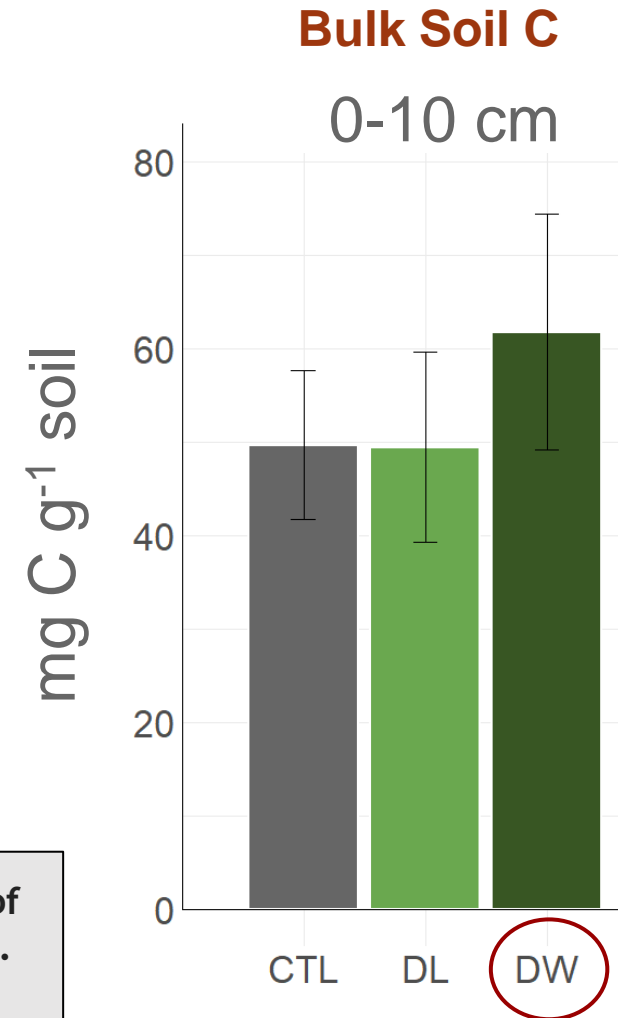
0-10 cm



Differences in Δ SOC by detrital input quality

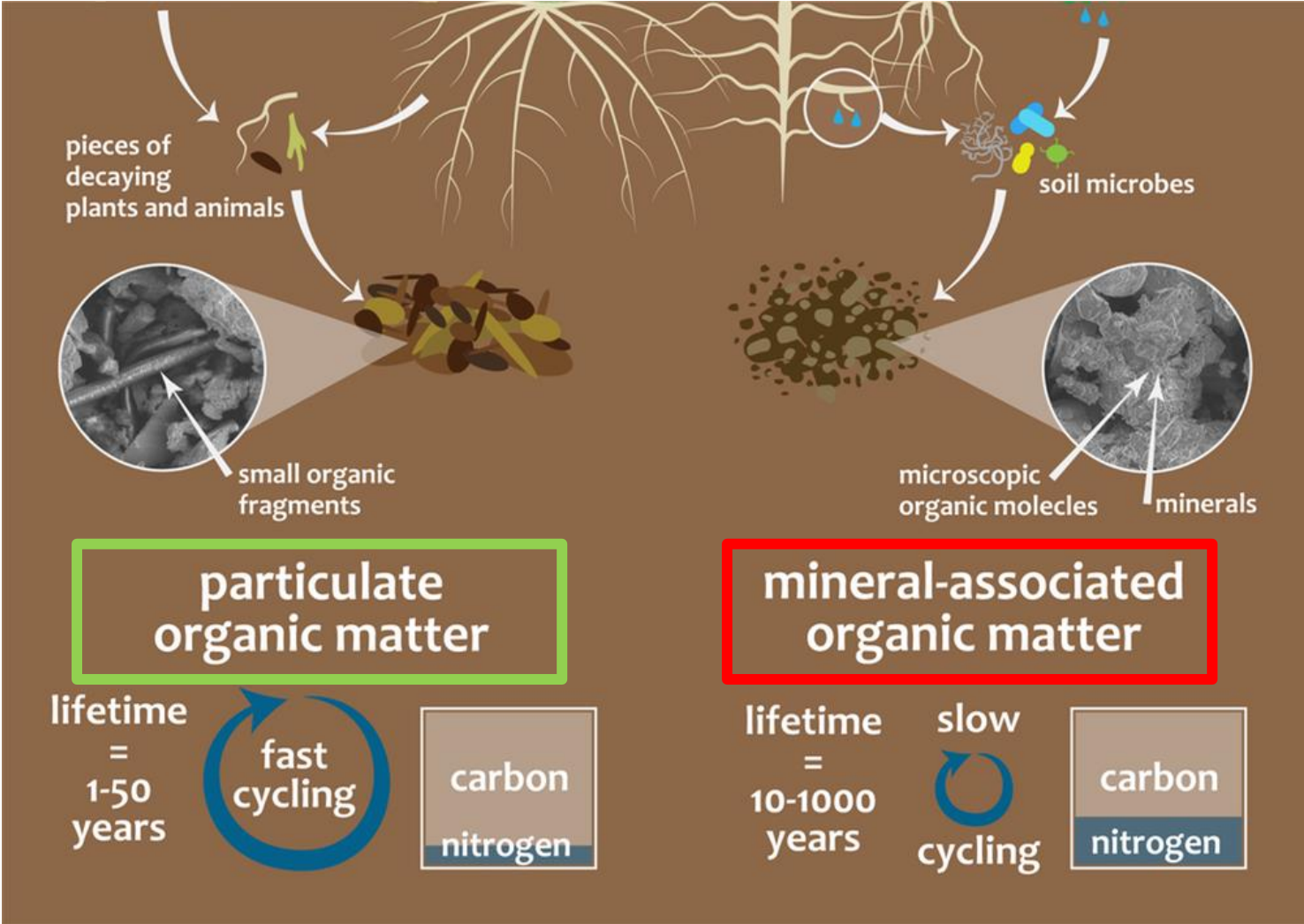
Wood chip additions increase soil carbon from 0-10+ cm.

HJ Andrews EF



Competing Processes Drive the Resistance of Soil Carbon to Alterations in Organic Inputs.
Pierson et al. Frontiers in Environmental Science. 2021 Apr

SOC Pools



POM

MAOM

Short-term
(~Plant origin)

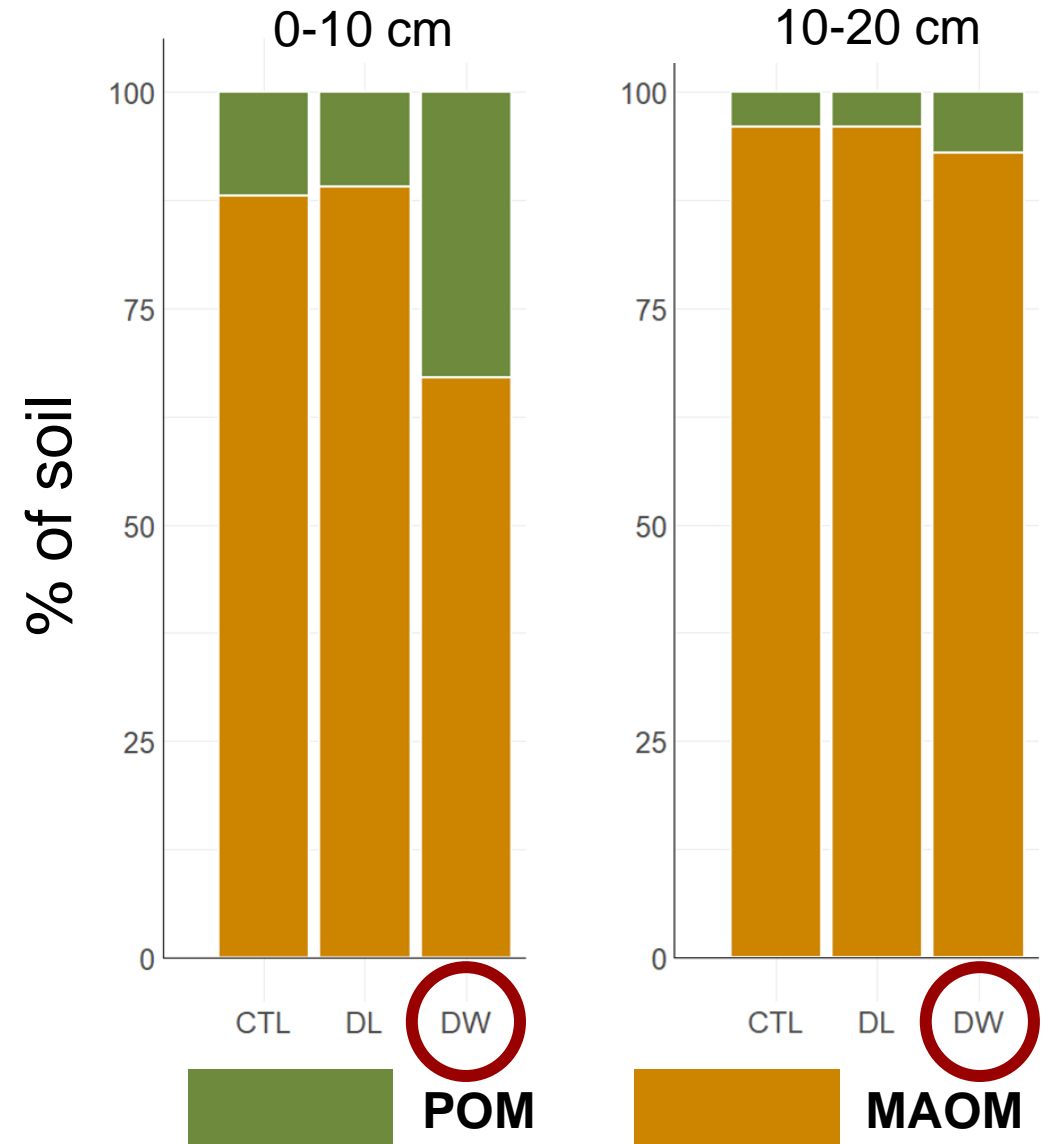
Long-term
(~Microbial origin)

Where did the wood go?

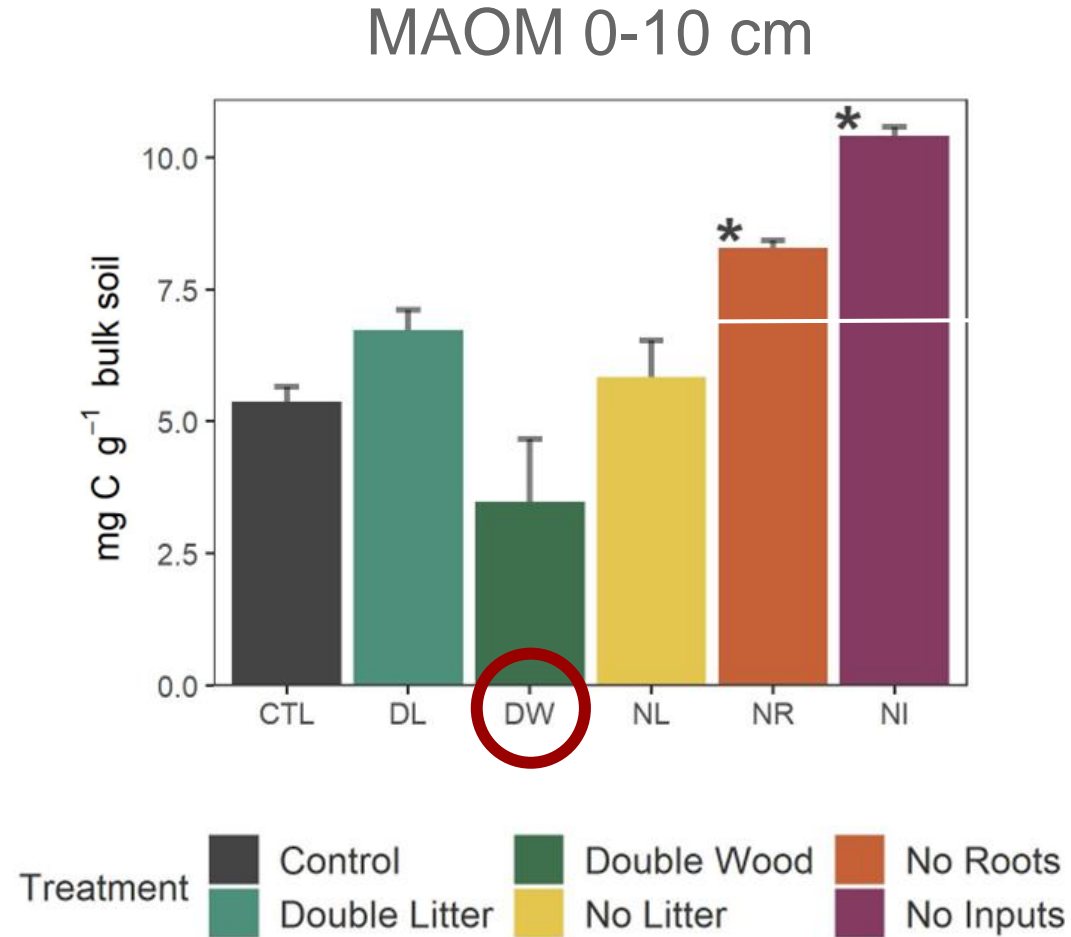
- Double wood addition led to soil C gains in particulate OM
POM = fast cycling, not stabilized

Utilizing Soil Density Fractionation to Separate Distinct Soil Carbon Pools. Journal of Visualized Experiments: Jove. 2022 Dec 16(190).

Soil Density Fractions



Wood addition caused losses of MAOM C stocks @ HJ Andrews LTER



Mineral stabilization of soil carbon is suppressed by live roots, outweighing influences from litter quality or quantity.
Pierson et al. Biogeochemistry
2021 Jul

Biochar is distinct with >turnover time



~ 1 year



10-100 yr



75-200 yr

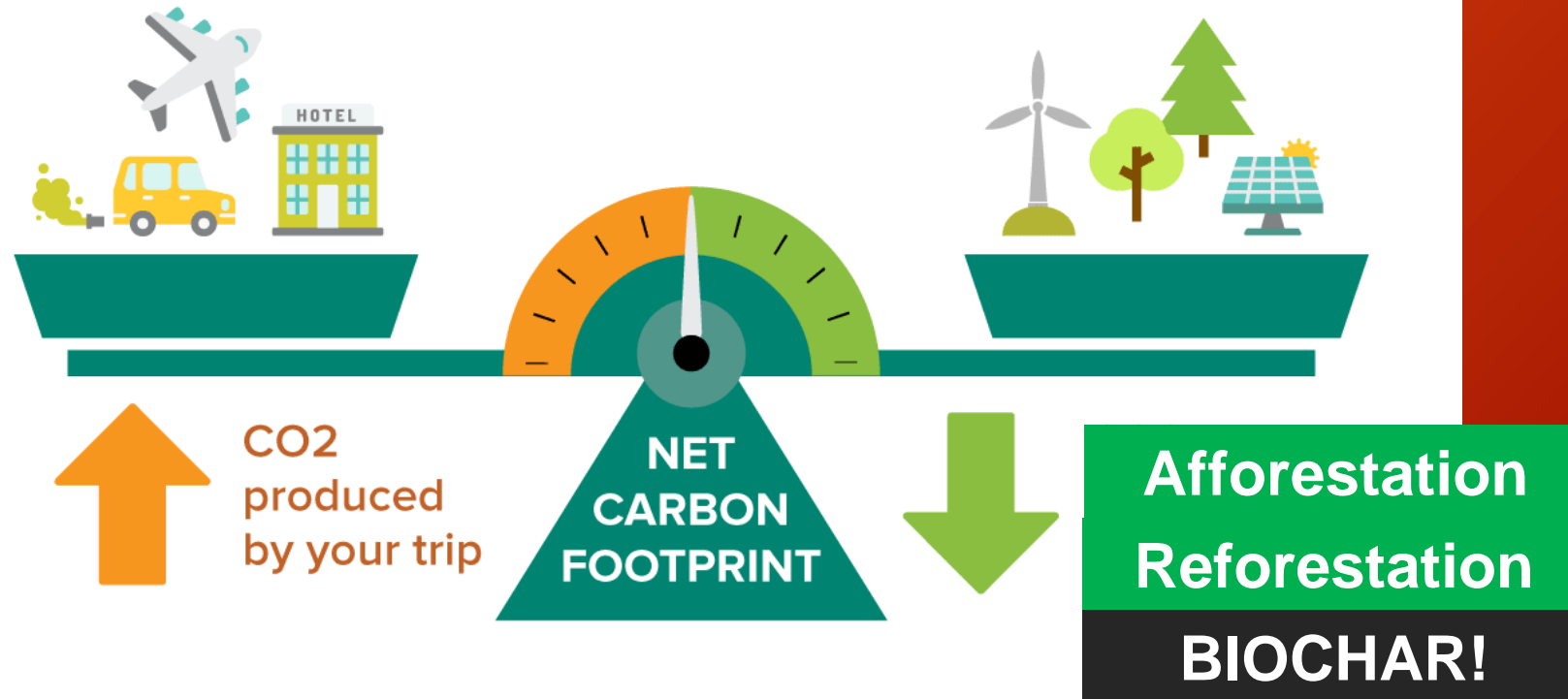


>300 yr

¹⁴C mean residence time

The Search for Forest Carbon Offsets

CARBON OFFSETS ALLOW YOU TO BALANCE OUT
YOUR EMISSIONS



Sustainable biochar to mitigate global climate change

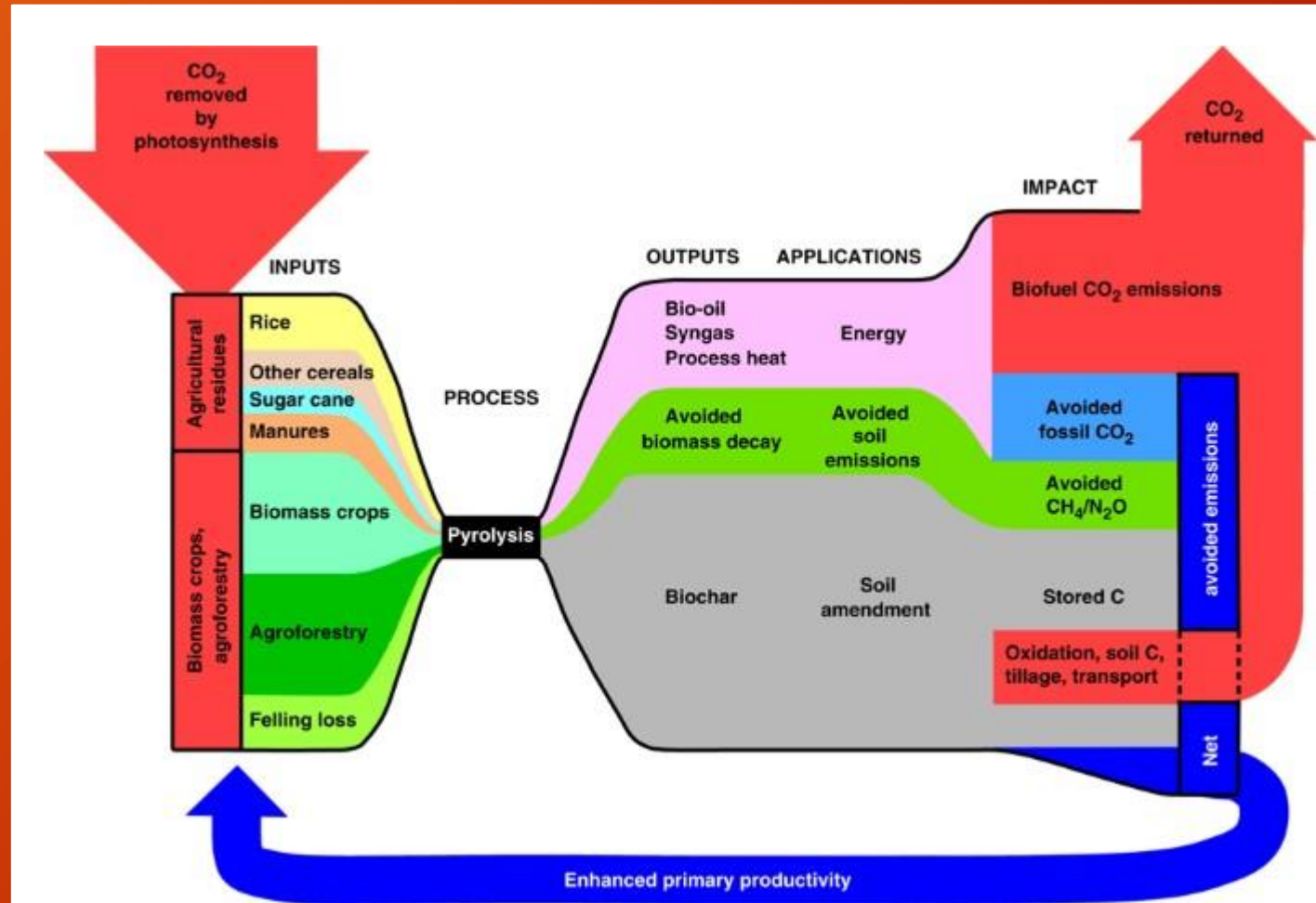
Woolf et al. 2010. Nature communications

Potential C for Sequestration

“~12% of anthropogenic C can be reduced with a biochar-based economy”

“Biochar can be produced sustainably or unsustainably.”

...Scaling up biochar production remains a challenge



Example: Slash piles in Northern CO

140,000 piles in
northern CO

CO₂ from 1 pile = 150
gallons of combusted
gasoline

Let's imagine we make
biochar out ½ of the
piles instead of burning
them...

~~~ Offsets the annual  
CO<sub>2</sub> emissions for  
~7,000 vehicles

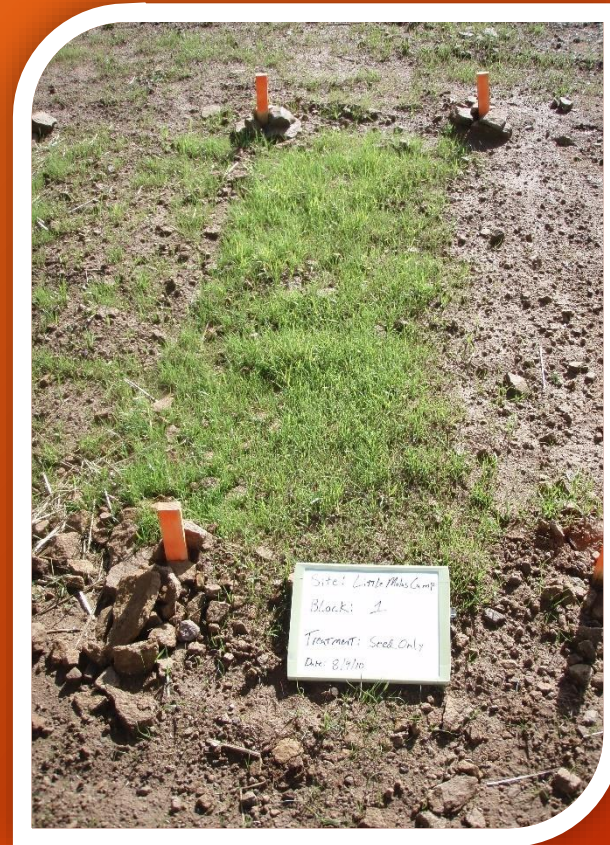


Pile burn scars in northern Colorado. Rhoades et al. 2015

# Biochar has many useful applications



Forest Soils



Mine Lands



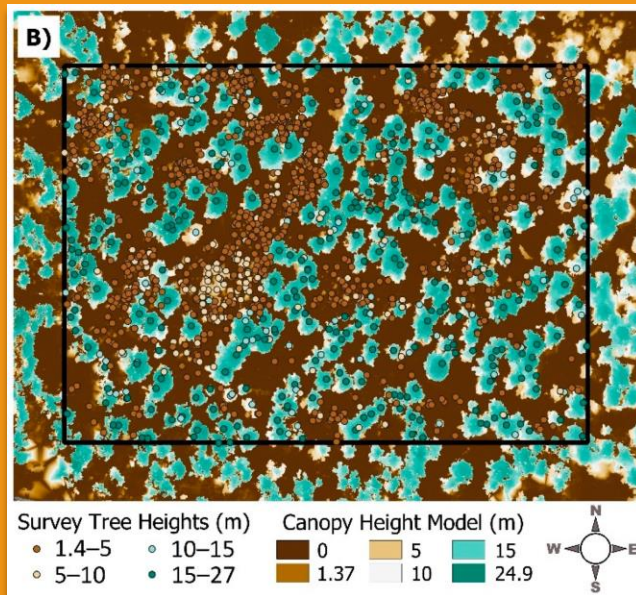
Agriculture

*“Forest  
To  
Farm”*

# High resolution mapping of forest stands & soil

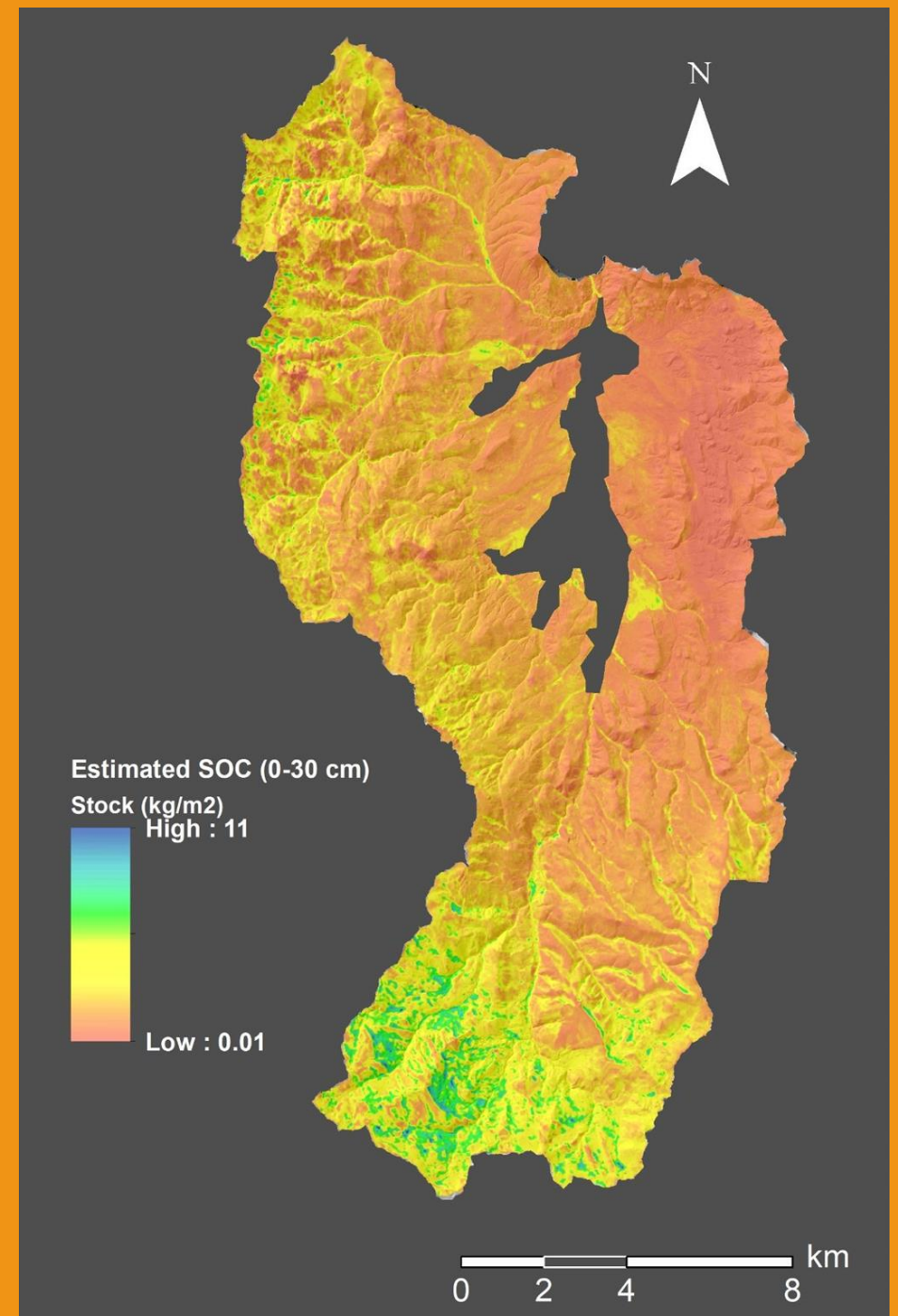
## Moving to management scales:

- Where can we make biochar?
- Where should we add biochar?



← Stand mapping  
Wade Tinkham, USFS-RMRS

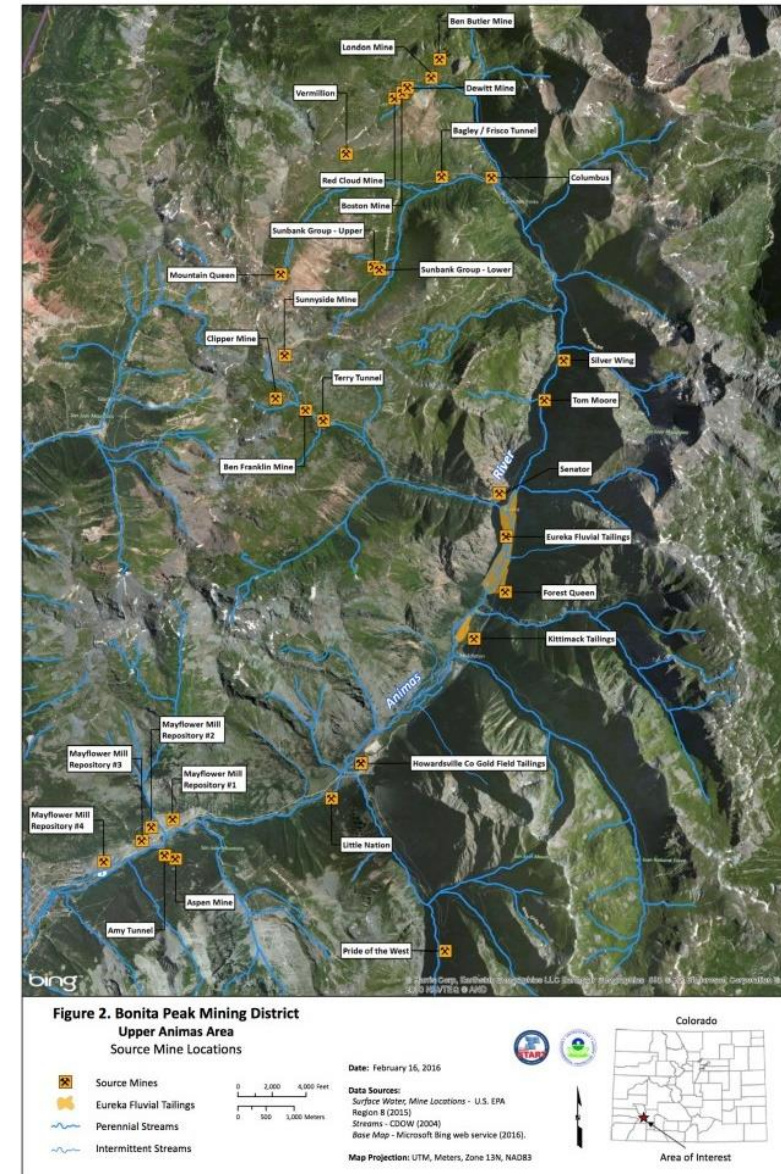
Soil carbon mapping →  
Derek Pierson, USFS-RMRS



# Abandoned Mine Lands (AMLs)

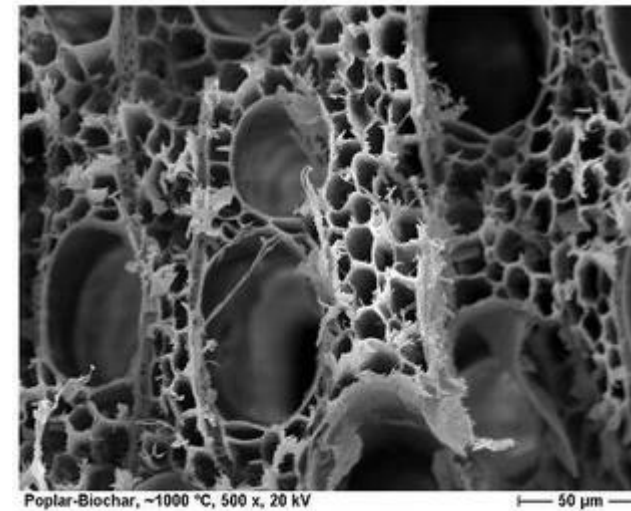


- Sparse vegetation
- Poor soil structure
- Acidic soils
- Heavy metal contamination



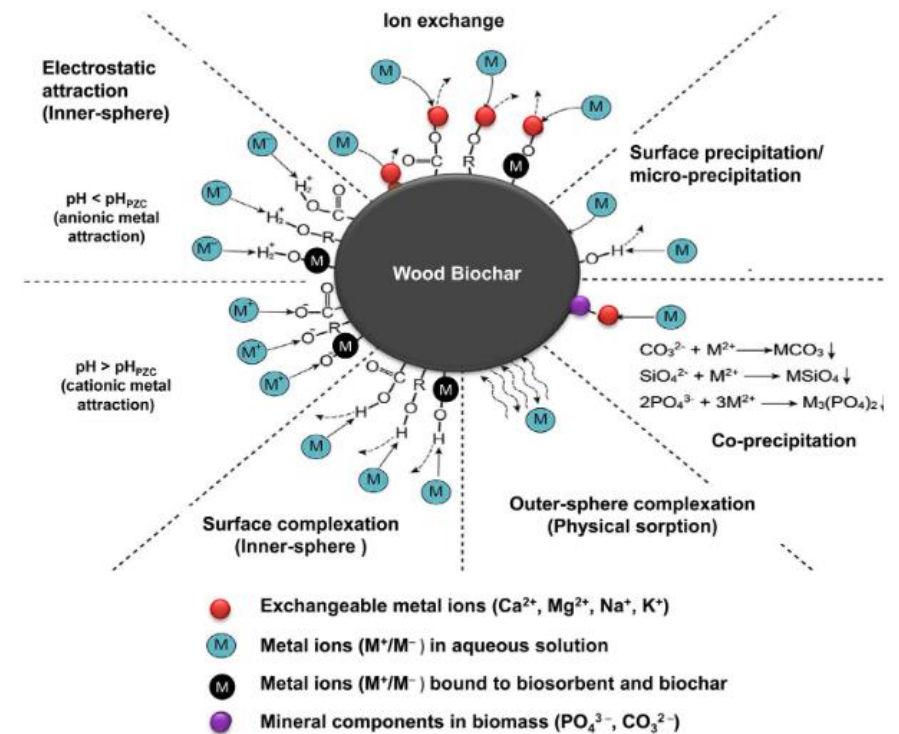
# Biochar Properties

- 1) Biochar is porous... extremely high surface area, >4000 ha per cubic meter
- 2) Forged in fire → Non-specific binding capacity
- 3) Adsorption mechanisms:
  - Surface sorption
  - Electrostatic interaction
  - Cation/ion exchange capacity
  - Precipitation
  - Complexation



Microscopic structure of biochar made from poplar wood chips

Biochar-Fungi Interactions in Soils  
Katja Wiedner & Bruno Glaser  
*Biochar and Soil Biota* (2013)



Schematic diagram of various sorption mechanisms of heavy metals by biochar in water  
(Shaheen et al 2019)

# BARRIERS

Roadblocks for  
biochar  
production  
and use



Applications



Policy



Production

Photo credit: Oakland Zoo

# *Beyond biochar basics:* *Scaling up and moving the needle*

Durango, CO  
September  
2022



Dillon, MT  
October  
2022



Discussions with public &  
private stakeholders

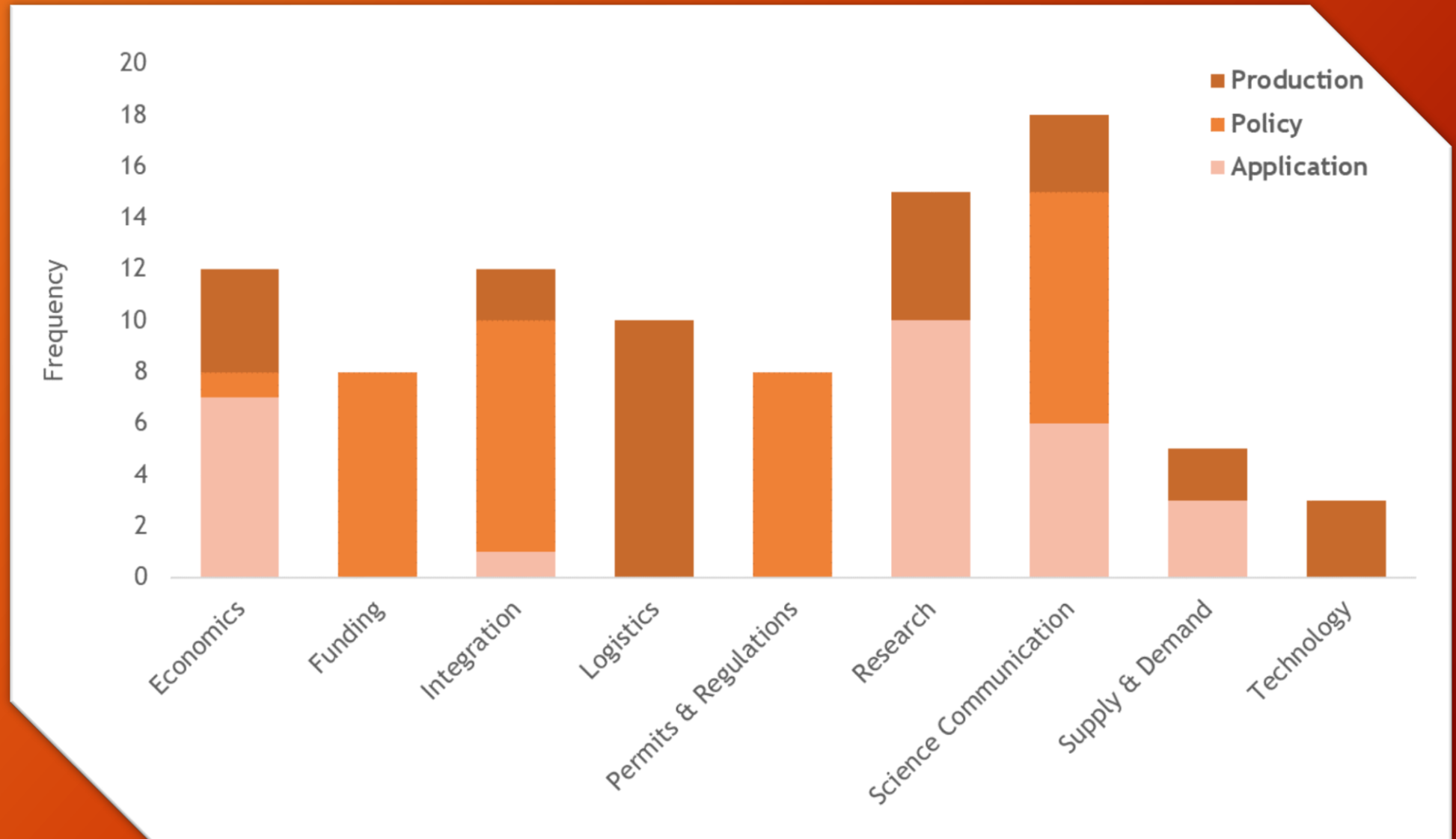
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1. Share barriers for biochar production from wood slash.
2. Identify biochar production and application opportunities.
3. Determine specific, actionable pathways to reduce barriers and “move the needle.”



# Land managers face many, diverse barriers

Categorizing the barriers shared during the workshop series...



# Synthesis Paper

## Biochar Barriers

### POLICY

The use of National Forest slash for biochar production requires improvements in policy and operational support for private contracting, air quality, environmental and land use permitting, commercial markets, and incentives for biochar applications.



Administration and Permitting



Funding and Initiatives



Land Management Decisions



Public Support and Science Communication

These policy-related factors present overarching challenges for biochar production and applications.

### PROCESS

#### On-site Production

On-site production of biochar reduces transportation and handling costs. However, generating biochar from forest slash requires additional funding and support for project planning, technology, transportation, safety and personnel.



#### Off-site Production

Provides the best opportunity to produce slash-based wood products, biochar and energy. Requires a stable supply of biomass and consistent demand to cover production costs. Transportation decreases profit margin and net carbon benefits.



### APPLICATIONS

Biochar has many useful applications for soil remediation and agriculture.

Yet, widespread use remains limited by knowledge gaps, prohibitive cost and insufficient supply of biochar.



Post-wildfire rehabilitation

Cropland soil amendment



Mine land soil remediation



Skid trail/log landing remediation

Vegetation diversity



Carbon sequestration



Animal bedding



Wetland rehabilitation



Home > Biochar > Article

## Beyond the basics: a perspective on barriers and opportunities for scaling up biochar production from forest slash

Perspective | Open access | Published: 02 January 2024  
Volume 6, article number 1, (2024) | Cite this article

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Biochar

Aims and scope →

Submit manuscript →

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1002 Accesses | 1 Altmetric | Explore all metrics →

### Abstract

Biochar production from woody biomass generated during forest management (slash) offers significant benefits for soil health and carbon emissions, yet its adoption remains limited in the western United States

Use our pre-submission checklist →

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Sections

Figures

References

Abstract

Highlights

Introduction

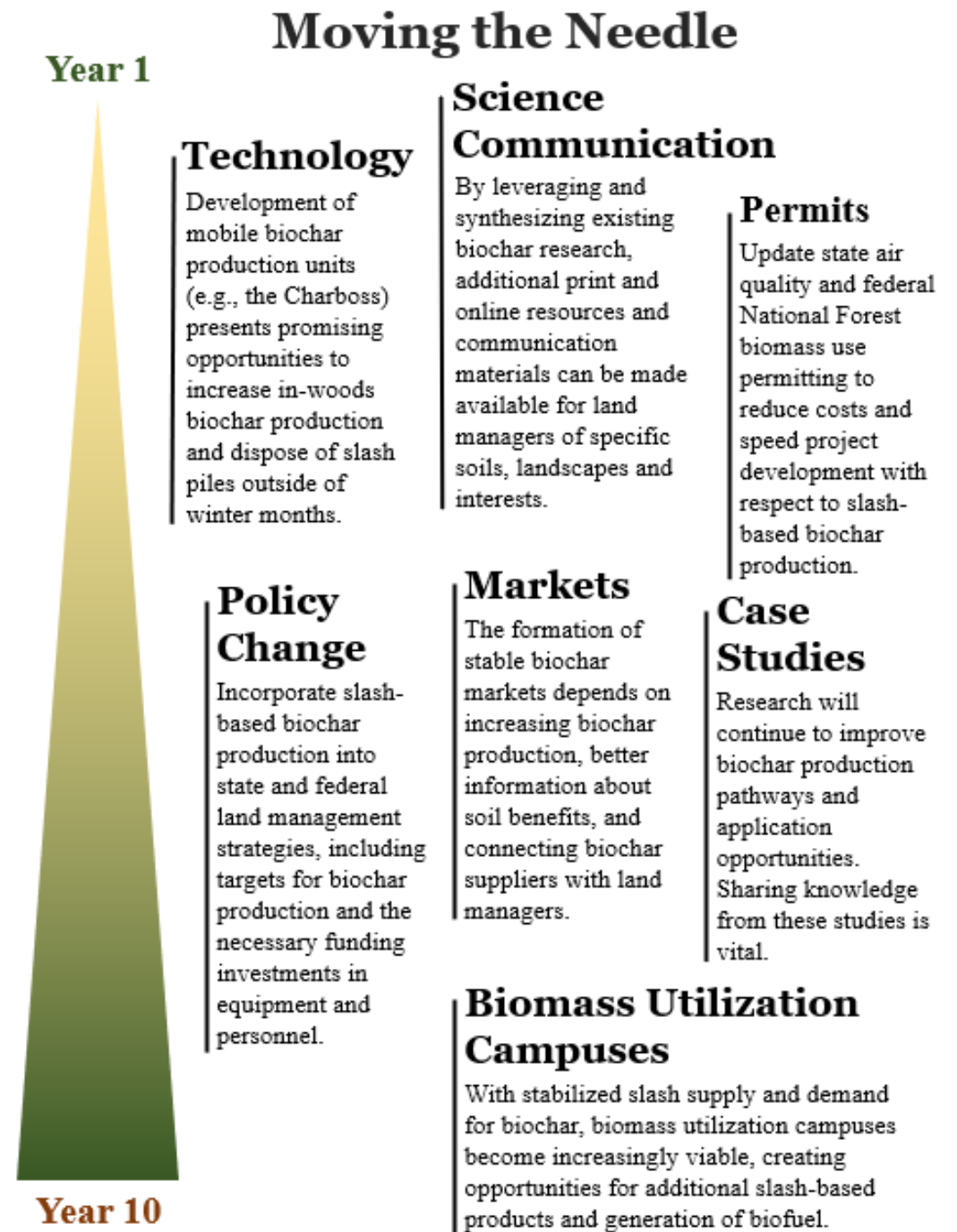
Barriers to biochar-based practice

# Pathways Forward

## “No Targets, No Progress”

- Scott Snelson, USFS

- Creating goals and initiatives
- Improving technology and training
- Simplified, lower cost permitting
- Adjustments to biomass utilization contracting
- Building towards stable markets, infrastructure
- More science communication
- More research and case study examples



# Thank You

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**Questions welcome after the last presentation, also anytime via email**

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