



United States Department of Agriculture

# Limiting factors to restore abandoned mine lands with woody biochar

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Forest Service

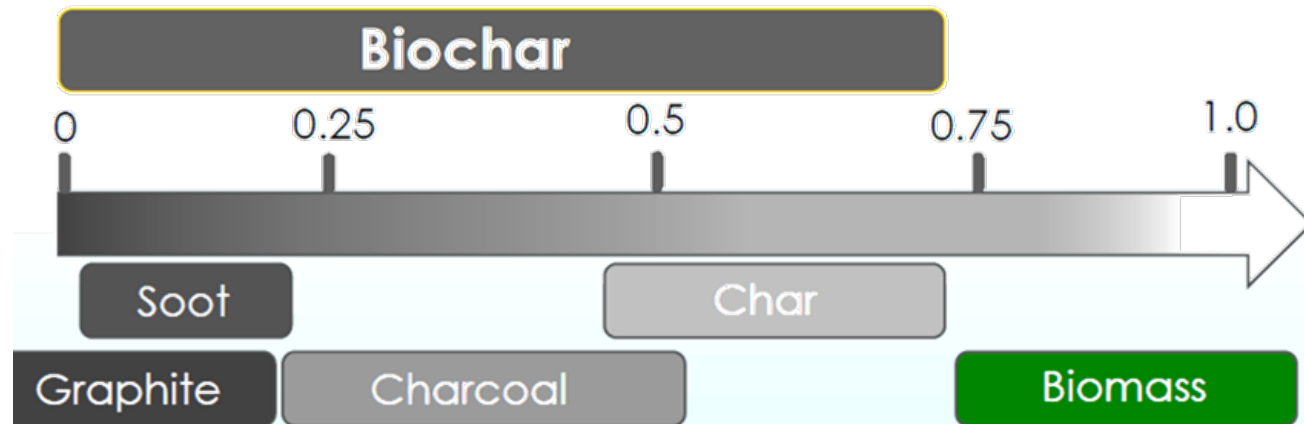
Research and Development

# Black carbon and biochar

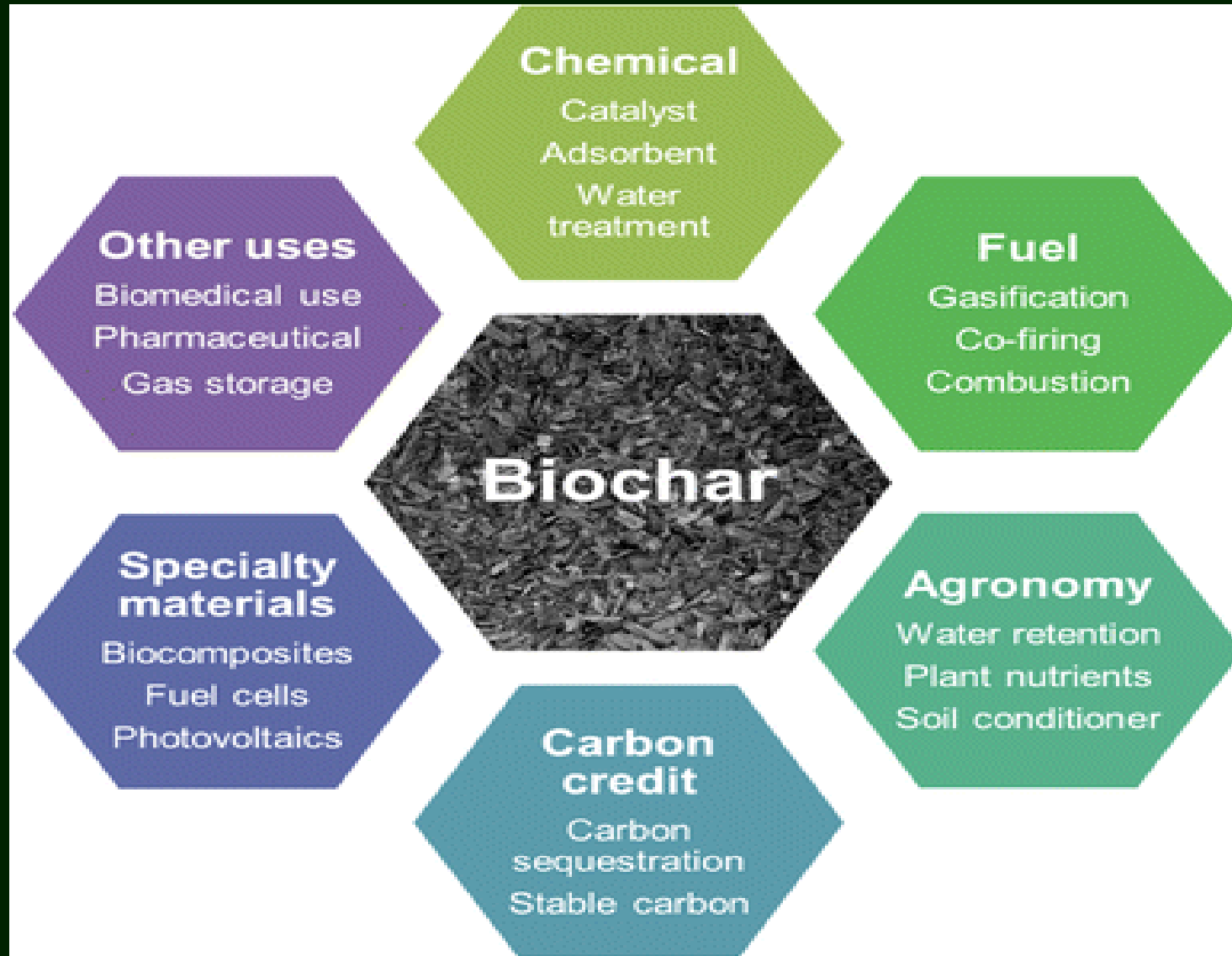
Black carbon is a range of solids resulting from thermal conversion of any carbon containing materials

Biochar is NOT a new division or material

Oxygen to carbon (O:C) molar ratio



Source: Heather Nobert. Biochar 101. Nebraska Forest Service. <https://nfs.unl.edu/documents/TCW2017/TCW%20Biochar%20101.pdf>



Source: Nanda, S., Dalai, A.K., Berruti, F. *et al.* Biochar as an Exceptional Bioresource for Energy, Agronomy, Carbon Sequestration, Activated Carbon and Specialty Materials. *Waste Biomass Valor* 7, 201–235 (2016). <https://doi.org/10.1007/s12649-015-9459-z>



# ArcGIS National Mines and FIA aboveground forest biomass

Details Basemap

Share Print Measure Find address or place

About Content Legend

**Legend**

**NMMR Mine Points**

- 

**Administrative Forest Boundaries**

Administrative Forest Boundaries - National Extent

- 

**CONUS Aboveground Forest Biomass**

pounds per acre

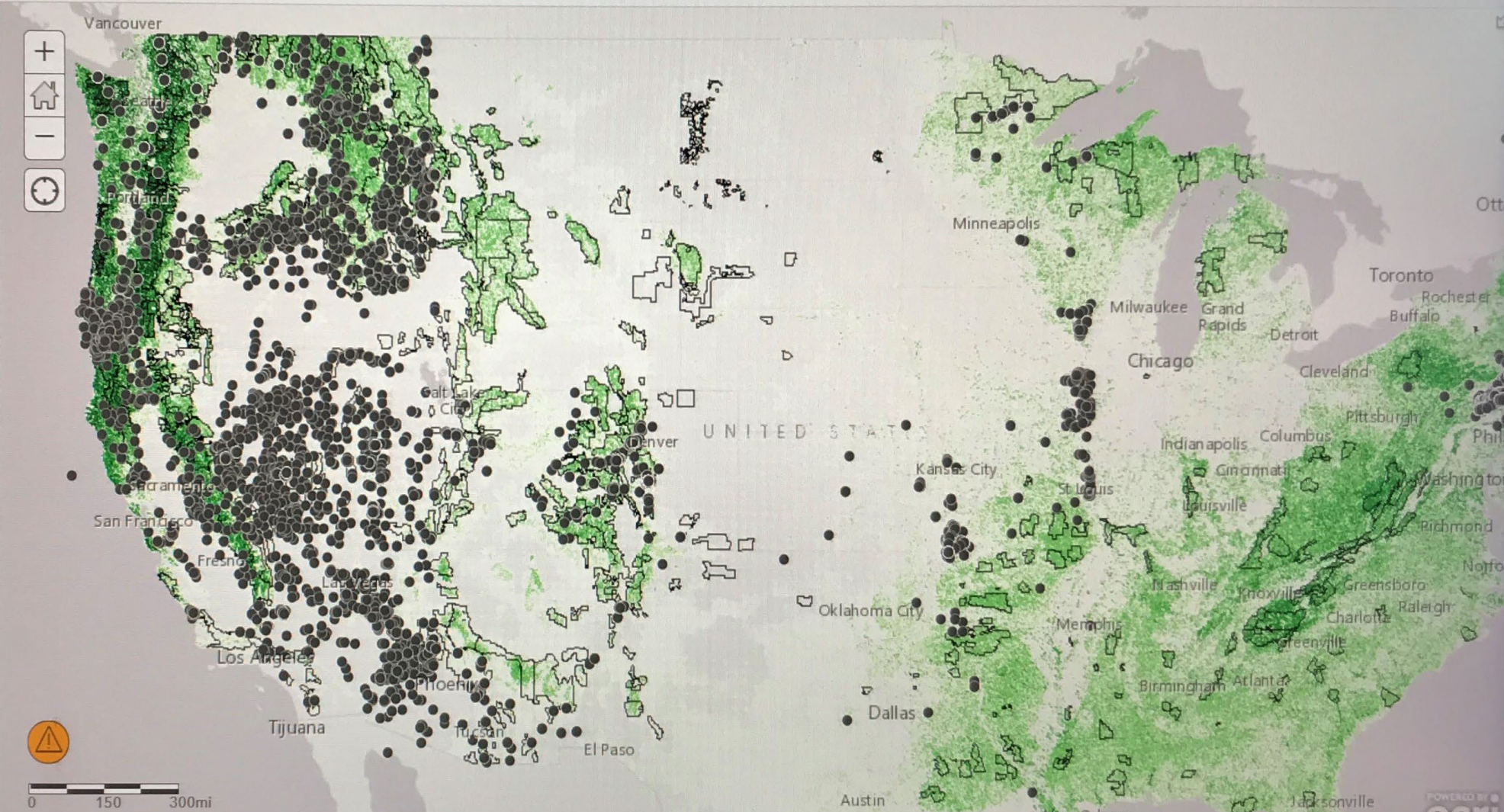
- > 240,000
- 120,000 - 240,000
- 60,000 - 120,000
- 30,000 - 60,000

**Land, water, and watersheds contaminated or scarred by extraction of ores and minerals (not coal) that are inactive**

**>150,000 abandoned hard rock mine sites in the 12 western states and Alaska**

**Degraded water quality, erosion (wind and water), and human health concerns**

**Barren of soil and plants**





# Biochar Opportunities for Public Lands

- ❖ Increase forest management in Public Forests for energy supply and bioproducts from renewable biomass sources;
- ❖ Decrease the impacts of climate change; decrease the risk of catastrophic fires, and improve environmental conditions
- ❖ Promote economic development in rural, forest-dependent communities
- ❖ Creating innovation



# Climate Change and Disturbances

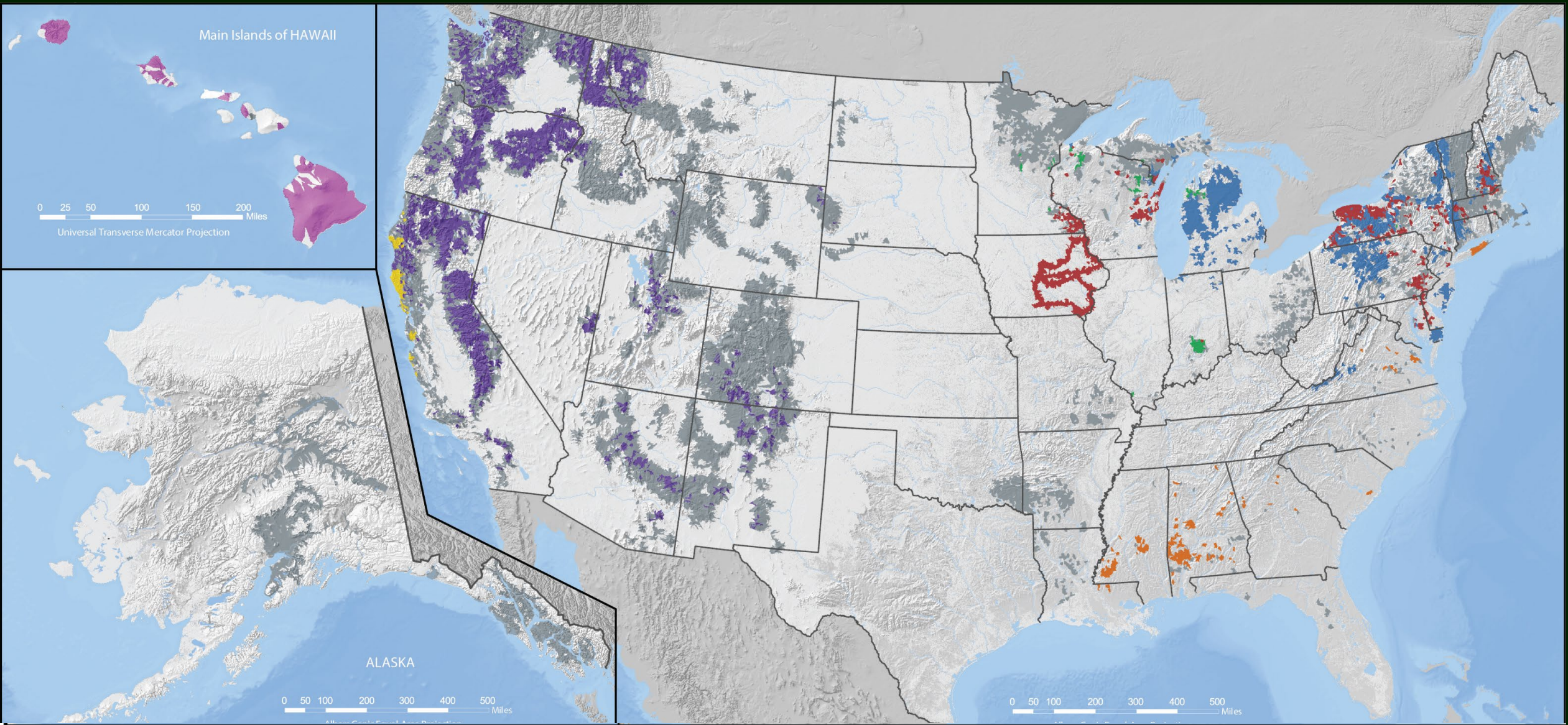


- Fire regimes
  - Increased severity
  - Possible changes in size, seasonality
- Drought
  - Increase in frequency
- Insects and diseases
  - Changes in distributions
- Hurricanes, landslides, ice storms, windstorms
  - Alterations are possible





# 2021 INSECT AND DISEASE SURVEY—WATERSHEDS WITH TREE DAMAGE



Sudden oak death

Southern pine beetle

Emerald ash borer

Rapid 'ōhi'a death

Fir engraver

Spongy moth

Oak wilt

\*\* Other damage

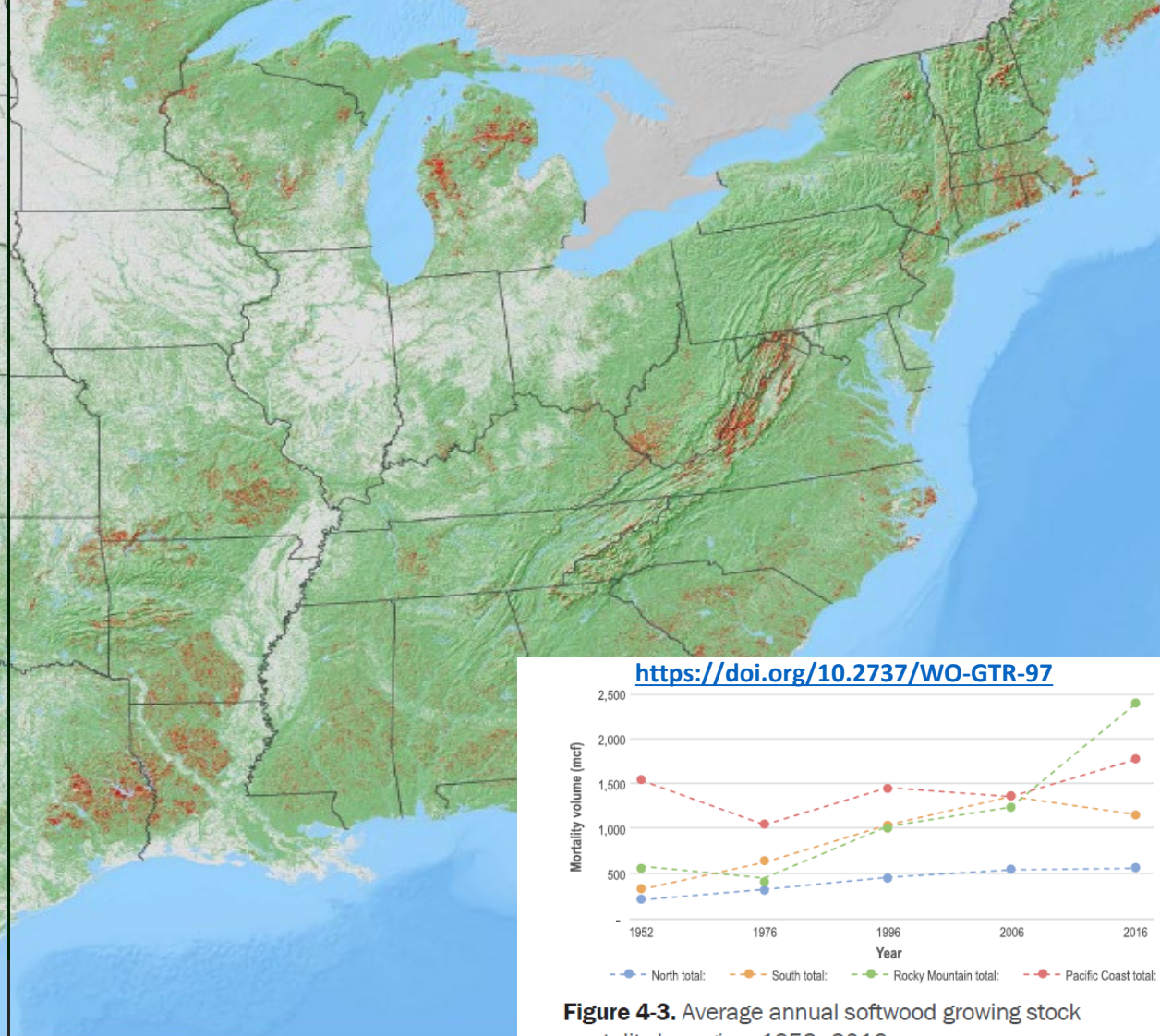
Source: <https://www.fs.usda.gov/foresthealth>

\*\*Includes damage from spruce budworm, western blackheaded budworm, spruce beetle and other western bark beetles, eastern larch beetle, hemlock sawfly, browntail moth, beech leaf disease, and many other less significant pests.





Total number of live trees of all species = 320 billion  
 The number of standing dead trees exceeds 7 billion nationwide ([https://www.nrs.fs.usda.gov/pubs/gtr/gtr\\_wo079/gtr\\_wo079\\_191.pdf](https://www.nrs.fs.usda.gov/pubs/gtr/gtr_wo079/gtr_wo079_191.pdf))



**Figure 4-3.** Average annual softwood growing stock mortality by region, 1952–2016.



# Forest Industry Supply Chains

Treatment is needed.  
Treatment is costly.  
Revenues offset costs.

- Sawlogs
- Pulpwood
- Biomass
- “Other”



Source: Nate Anderson. Presentation:  
Evolving Forest Industry Supply Chains:  
Navigating Emerging Markets and  
Opportunities



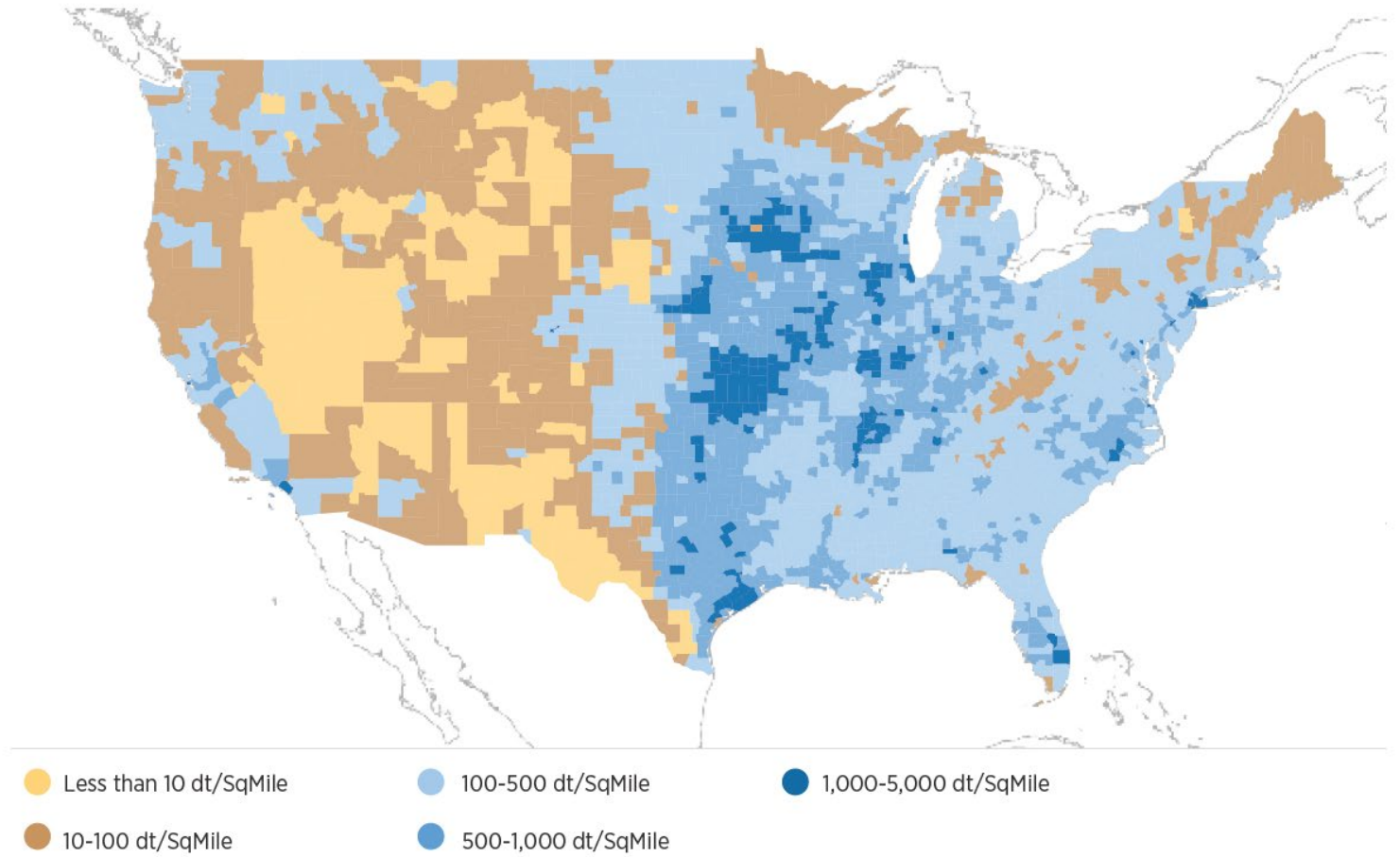


# U.S. woody biomass potential production from federal and private lands



The One Billion Ton report (U.S. Department of Energy, 2016) indicates a high-yield potential scenario of having 483 million dry metric tons in 2022 and up to 1.15 billion dry tons in 2040 of forest wastes and residues that could be sustainably produced each year in the U.S

Figure ES.4 | Combined potential supplies from forestry, wastes, and agricultural resources, base case, 2040<sup>10</sup>



Source: U.S. Department of Energy. 2016. 2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy, Volume 1: Economic Availability of Feedstocks. M. H. Langholtz, B. J. Stokes, and L. M. Eaton (Leads), ORNL/TM-2016/160. Oak Ridge National Laboratory, Oak Ridge, TN. 448p. <https://info.ornl.gov/sites/publications/Files/Pub62368.pdf>

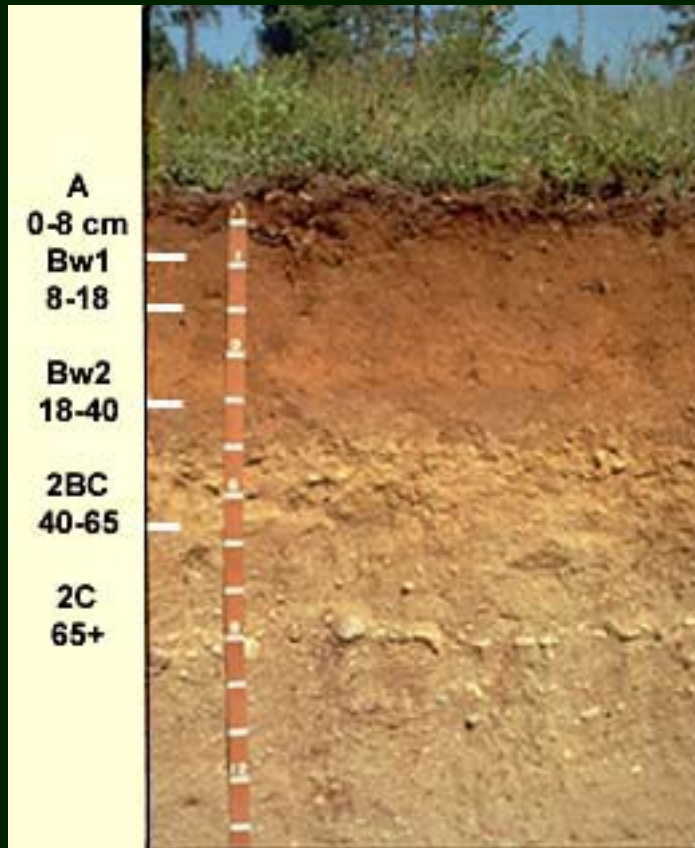


# Biochar production and use on public lands

- Many abandoned mines are located near or in national forests
- Many national forests are increasing thinning operations
- Ready source of feedstock
- Moderate-scale, mobile biochar production units can create biochar near-site
- Currently most activities are small-scale



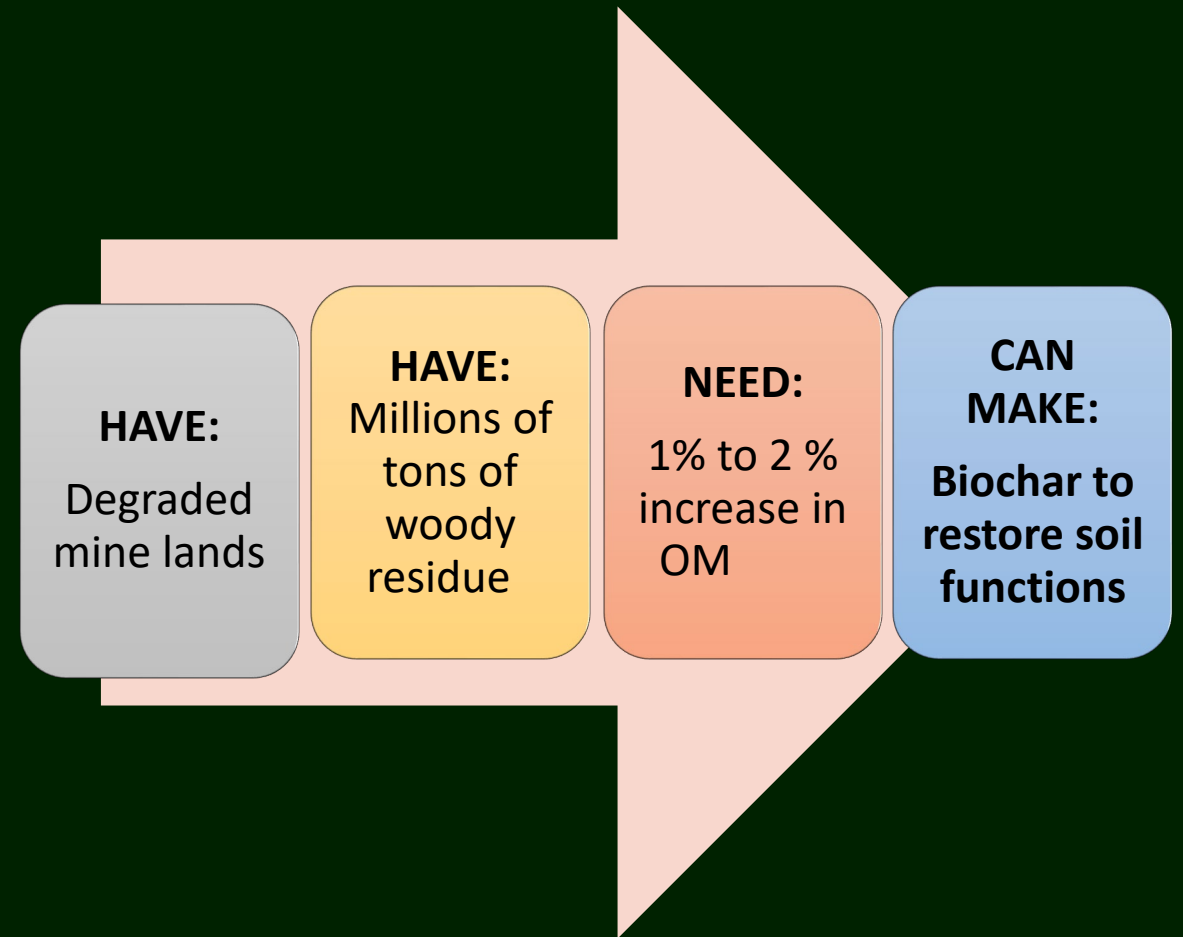
# Addressing multiple ecosystem threats with biochar



- Build soil resilience
- Contribute to sustainability
- Address long-term productivity
- Increase resistance and resilience to changing climate

# Moving ahead

- Mining operations decrease ecosystem services
- Local low value residues or invasive woody shrubs are effective as a liming agent or to sequester heavy metals
- Biochar can increase soil cover and be used alone or mixed with other amendments







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# Abandoned Mine Land (AMLs) Restoration using Biochar

“Terraforming” – Umatilla National Forest

- Biochar can be made near AMLs on public lands
- Production methods vary
- Benefits
  - Reduce wood volume
  - Increase soil quality to provide vegetative cover
  - Reduce wind and water erosion
  - Reduce organic and inorganic contaminants
  - Local feedstocks to create biochar for local mine land reclamation
  - Solves local excess biomass issues



## Upper Animas Basin, CO

Biochar created from dead trees and converted to biochar in a pyrolysis unit

- Increased water retention
- Iron and Aluminum in soil solution decreased
- Bulk density decreased
- Increased soil cover
- Increased grass biomass
- Raised soil pH

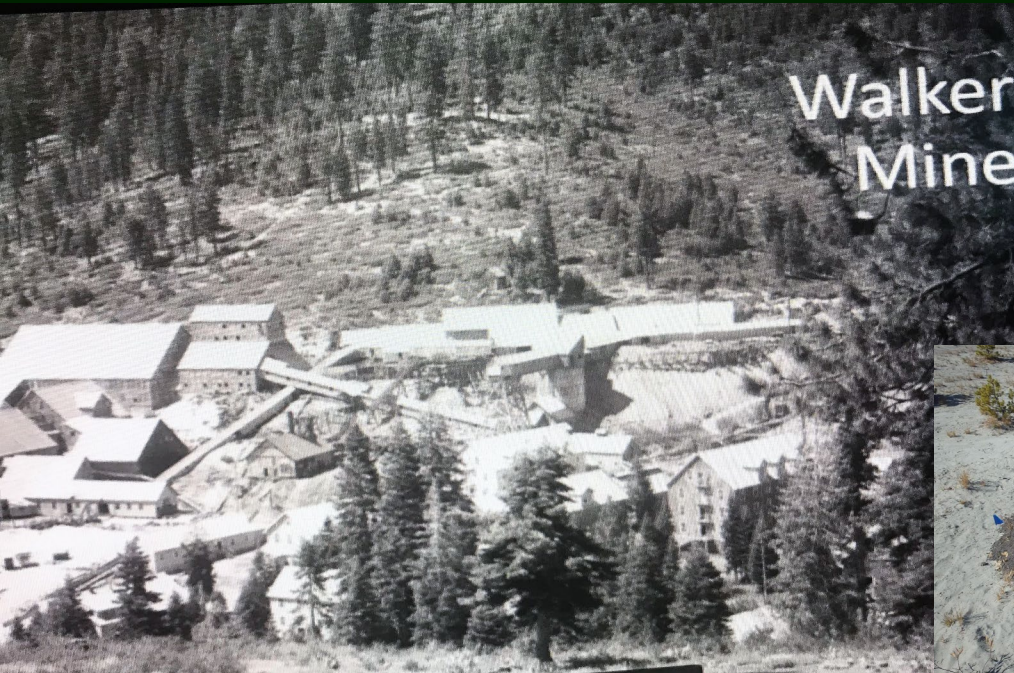




- ❖ Limiting factor – aridity
- ❖ Spreading sterile soil with biochar incorporated
- ❖ Juniper and pinyon used to make biochar in a pyrolyzer
- ❖ Established a perennial plant community



## Ruby Hill – open pit gold mine



## Walker Mine Plumas National Forest

- 100 acres covered in fine-grained sand, silt, clay-like tailing material
- Tested biochar with compost, soil, clay, fertilizer, lime, and wood chips
- Biochar adsorbed metals and buffered pH
- **BEST BENEFIT:** Increased water holding capacity





# Methods for local biochar-mine site restoration

## Kilns

### Slash Piles



Low cost, limited biochar



- Low cost, employ a local workforce
- Low volume of biochar
- Larger Kilns need a loader, water to quench coals

- ❖ Equipment cost: ~\$600,000
- ❖ Grappler to load
- ❖ Forwarder
- ❖ Water to quench coals



**Tigercat, Inc: CARBONATOR**



- ❖ Continuously makes biochar
- ❖ Equipment estimated cost ~\$120,000
- ❖ Needs equipment to load
- ❖ Quenching pan – limited water required

**•NEW Air Burner, Inc: CHARBOSS**



# How much biochar would be needed?

**GOAL: - increase soil C from 0 to near normal (~2% to a depth of 25 cm)**

- Conversion rate from biomass to biochar is 15-50% (depending on method)
- Need 40+ tons of biochar/acre
- Rates around 10-15 tons biochar/acre are ideal
- Incremental annual additions
- Targeted applications (biological islands)
- Part of engineered soil stabilization





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# Limiting factors for using biochar for AMLs Reclamation



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**“Spoil Soil” Formosa Mine**

## **Abandoned mine high restoration costs**

- **Cleanup could exceed \$20 billion**
- **Superfund sites (50 in 2015) cost >\$500,000,000/site**
- **What is the cost of lost ecosystem services?**
- **What is the cost of lost forage or tree productivity?**



# National Laws and Regulations

- ❖ There are some main national (federal) laws relevant to harvesting that must be complied with regardless of the landownership type, these include:
  - **The US Lacey Act.** makes it unlawful for any person the trade of any plant or plant product (including timber or wood product) that is taken, possessed, transported, or sold in violation of any law, treaty, or regulation of the United States, a US State, a US Indian Tribe, or the law of a foreign country that protects plants or regulates certain plant related offenses.
  - **The Clean Water Act.** It is the primary federal law governing discharge of pollutants into waters and quality standards for surface waters.
  - **The Clean Air Act.** Regulates air quality levels and regulates sources of pollution.
  - **The Endangered Species Act** is a program for conservation of threatened & endangered plants and animals & habitats.

# Technical definition for mobile pyrolizers

The EPA placed the mobile biochar production units into the incinerator category.

**This has caused many misunderstandings and over-regulations and regulations that do not apply or miss the real live practical usefulness of the machines.**

An incinerator by definition requires an external fuel source, such as natural gas or coal that by using flames and heat incinerates the waste materials, burns it to ashes.

Incineration is the process of burning hazardous materials at temperatures high enough to destroy contaminants.

Incineration is conducted in an “incinerator,” which is a type of furnace designed for burning hazardous materials in a combustion chamber. This chamber uses oxygen and sometimes it has to be pumped.

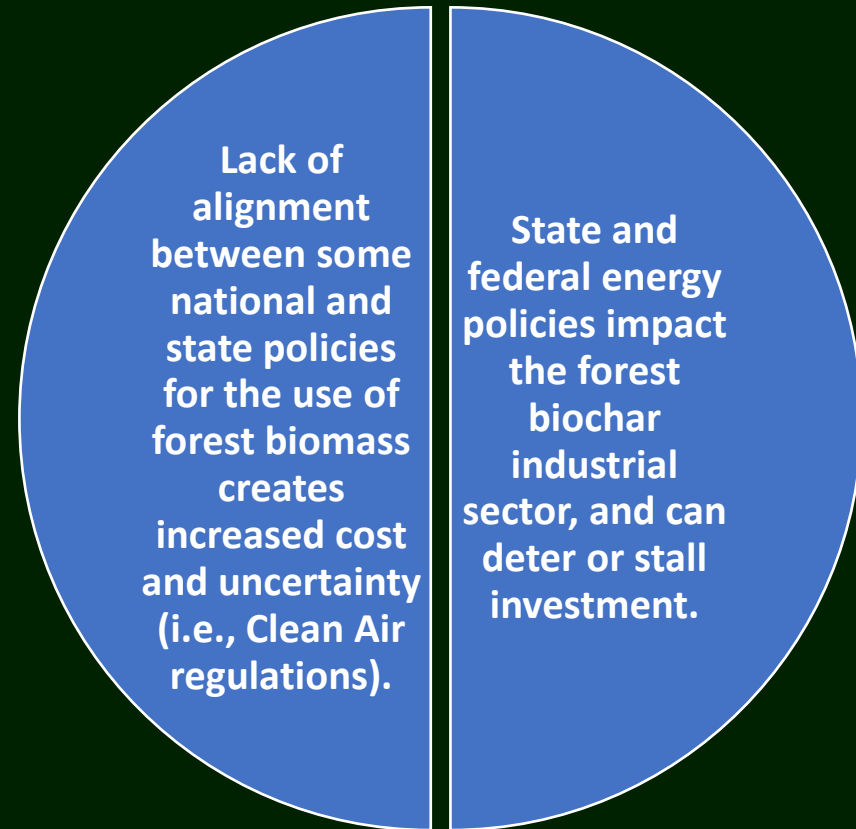
**Biochar is produced in absence of oxygen, and the production process is not designed to process waste or hazardous materials, because the raw material is woody biomass coming from forest management operations.**



# Implications

## Barriers to increase the use of woody biomass in the U.S.

- ❖ There are several high-influence policies that create an unbalance between the support for the use of forest biomass and the limits on its deployment because of high standard regulations. Examples are:
  - ❖ **The Clean Air Act,**
  - ❖ **The Endangered Species Act, and**
  - ❖ **Policies regulating FS National Forest System management.**



# Associated problems in the supply chain

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- ❖ High Transportation Costs, and tonnage limits in roads.
- ❖ Certification paper is too much administration work
- ❖ Initial investment to start a logging business for young people with no credit history is too high (\$3M).
- ❖ Insurance cost too high for same reason (starting business have no safety records), Cost \$28k.





# The Operational Issue

- ❖ Organizations in the American forestry industry are suffering operational dysfunction linked to staffing shortages.
- ❖ **The logging workforce is declining at an accelerated rate, according to the Bureau of Labor Statistics, which estimates that the industry will be short of some 7,000 loggers by 2026 (<https://www.bls.gov/ooh/farming-fishing-and-forestry/logging-workers.htm>)**

## Employment by Occupation In Forestry and Logging

Data series	Employment, 2021
Fallers	2,700
First-line supervisors/managers of farming, fishing, and forestry workers	2,270
Logging equipment operators	19,290
Sawing machine setters, operators, and tenders, wood	730
Truck drivers, heavy and tractor-trailer	8,070

# Main Issues facing the Logging Industry

- Young engineers do not want to join this industry because the mills tend to be located in smaller towns and there is a belief that forestry is not “high tech.”
- According to the Forest Resource Association. People who might be interested in working in the forestry industry struggle to get the education and practical instruction they need to find success out in the field.
- Companies are having difficulty replacing tradesmen as they retire and, in turn, are losing all that knowledge and expertise.





# Social Issues



- **Environmental community concerns about:**
- **Environmental Justice on topics related to**
  - **noise and traffic around processing mills,**
  - **human health,**
  - **location of the mills in/or close to underserved communities.**
- **Climate change**
  - **major topics are carbon neutrality and carbon debt.**
- **Sustainability**
  - **wetlands impacts**
  - **biodiversity**
  - **soil erosion, and**
  - **water pollution**



# National Environmental Justice Advisory Council

**The National Environmental Justice Advisory Council. It is a federal advisory committee to EPA established in 1993.**

**Provides advice and recommendations to EPA on broad, cross-cutting issues related to EJ.**

- ❖ **Integrate environmental justice considerations into Agency programs, policies and activities.**
- ❖ **Improve the environment or public health in communities disproportionately burdened by environmental harms and risks.**
- ❖ **Address environmental justice by ensuring meaningful involvement in EPA decision-making, building capacity in disproportionately burdened communities, and promoting collaborative problem-solving for issues involving environmental justice.**
- ❖ **Strengthen its partnerships with other governmental agencies, such as other Federal agencies and State, Tribal, or local governments, regarding environmental justice issues.**
- ❖ **Enhance research and assessment approaches related to environmental justice.**





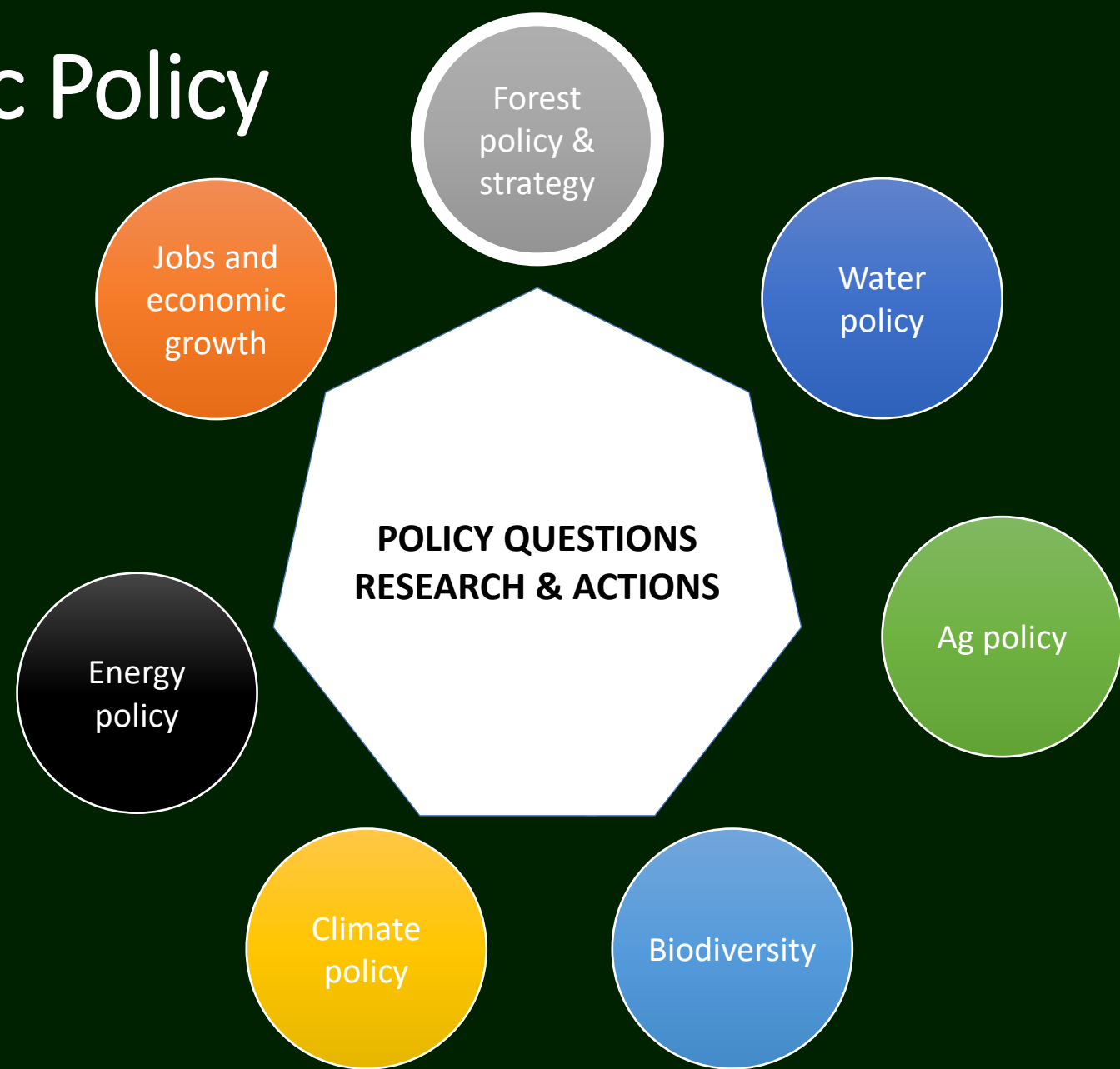
# Public Policy

## How do we incentivize clusters?

- Direct incentives: tax credits, subsidies, carbon offsets, etc.
- Grants, loan guarantees, public-private co-investment, partnerships
- Feed-in tariffs, long-term contracts, supply and offtake agreements
- Research, development and Extension

## Other considerations to be taken:

- Federal and State incentives using the Development Opportunities Zones certified by the U.S. Treasury Department, in which certain types of investments may be eligible for preferential tax treatment, Transportation incentives
- State Departments of Transportation as well as the State Department of Economic Development and the Federal Department of Commerce



# Recommendations

The FS in implementing the 10-year strategy to confront the wildfire crisis increasing restoration work and decreasing of hazardous fuels materials, could consider:



- ❖ Amendments of CFR title 36, subpart 223 to change contracting mechanisms to promote the utilization of biomass over pile burning.
  - Provide incentives in timber sale and stewardship contracts to use woody biomass for bioenergy and biobased products rather than paying for purchasers/contractors to create slash piles for burning on-site without the benefit of producing useful biobased products that benefit society.
- ❖ The principle of using Air curtain incinerators (ACIs) technologies (fix biochar mills in the States) to reduce overall particulate matter (PM) emissions from open burning of forest biomass is a good solution to the slash piles burning.
- ❖ Supporting the use of an ACIs and biochar kilns provide land managers with the opportunity to continuously treat biomass year-round to help make consistent progress in land management objectives to reduce the threat of wildfire smoke impacts to communities



# 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

## Moving the Needle

Year 1



Year 10

### Technology

Development of mobile biochar production units (e.g., the Charboss) presents promising opportunities to increase in-woods biochar production and dispose of slash piles outside of winter months.

### Policy Change

Incorporate slash-based biochar production into state and federal land management strategies, including targets for biochar production and the necessary funding investments in equipment and personnel.

### Science

By leveraging and synthesizing existing biochar research, additional print and online resources and communication materials can be made available for land managers of specific soils, landscapes and interests.

### Markets

The formation of stable biochar markets depends on increasing biochar production, better information about soil benefits, and connecting biochar suppliers with land managers.

### Biomass Utilization Campuses

With stabilized slash supply and demand for biochar, biomass utilization campuses become increasingly viable, creating opportunities for additional slash-based products and generation of biofuel.

### Communication

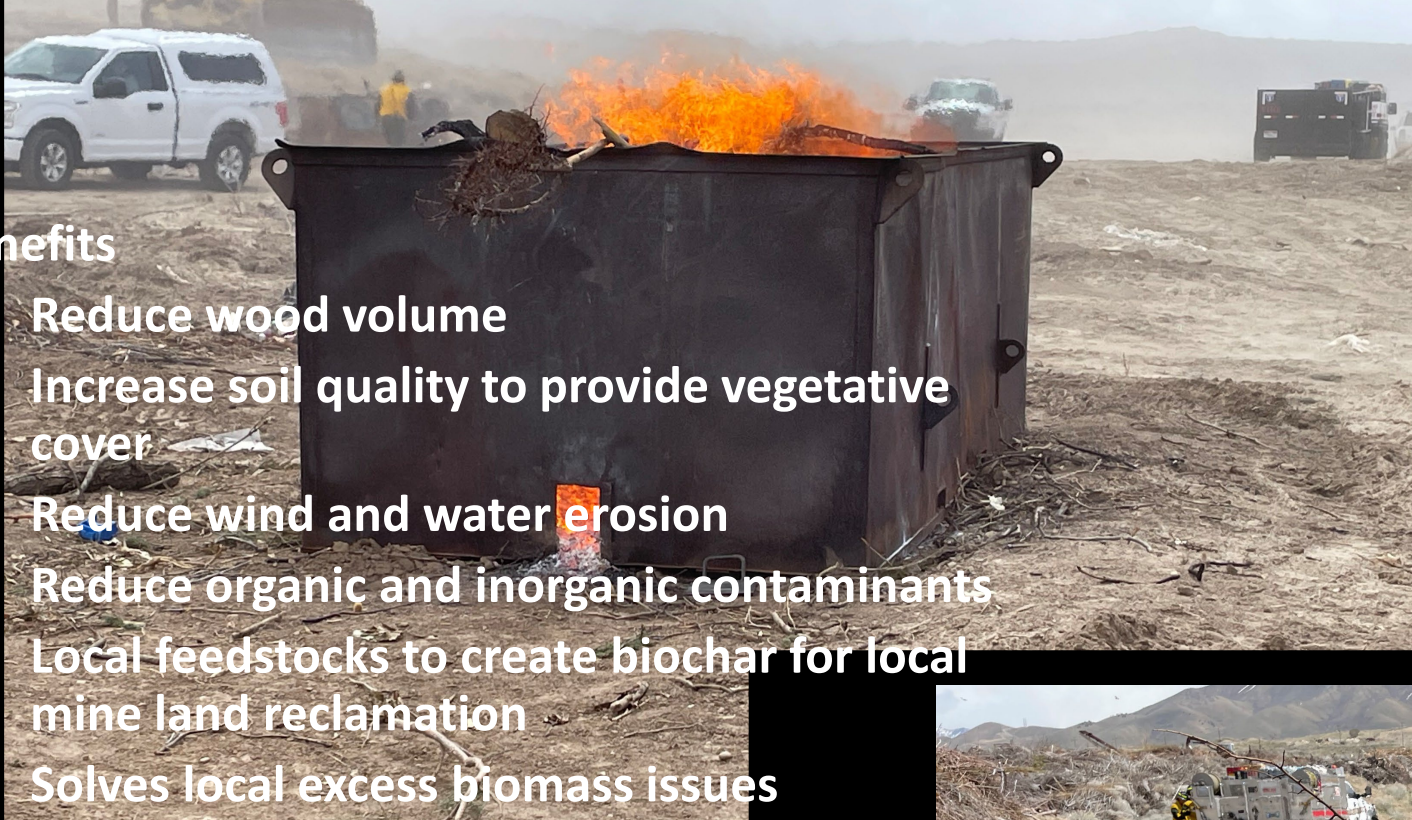
### Permits

Update state air quality and federal National Forest biomass use permitting to reduce costs and speed project development with respect to slash-based biochar production.

### Case Studies

Research will continue to improve biochar production pathways and application opportunities. Sharing knowledge from these studies is vital.





- **Benefits**

- Reduce wood volume
- Increase soil quality to provide vegetative cover
- Reduce wind and water erosion
- Reduce organic and inorganic contaminants
- Local feedstocks to create biochar for local mine land reclamation
- Solves local excess biomass issues

# Summary

- ❖ Biochar can be made near AMLs on public lands
- ❖ Production methods vary







# POTENTIAL BENEFITS FROM INCREASING ORGANIC CARBON IN SOIL



INCREASED WATER RETENTION

**+37**  
billion m<sup>3</sup>

**+0.4%**

ANNUAL INCREASE  
IN SOIL CARBON  
CONTENT

CLIMATE BENEFITS

**-10%**

HUMAN-INDUCED  
CARBON EMISSIONS

SAVING

**\$600 billion**  
IN CARBON  
MITIGATION  
FOR THE NEXT **30**  
YEARS

INCREASED CROP PRODUCTION

WHEAT

**+22.9%**

MAIZE

**+23.4%**

RICE

**+41.9%**



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# Thank you!



## Contacts

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