# biochar

## AN ELEGANT SOLUTION FOR COMPLEX PROBLEMS

# biomass to biochar

**Zero-Waste and Carbon Negative…**

**Can it be done?**

# What is Biochar?

*"Biochar is a **fine-grained charcoal** high in organic carbon and largely **resistant to decomposition**. It is produced from pyrolysis of plant and waste feedstocks. As a **soil amendmen**t, biochar creates a recalcitrant soil carbon pool that is carbon-negative, serving as a **net withdrawal of atmospheric carbon dioxide** stored in highly recalcitrant soil carbon stocks. The **enhanced nutrient and moisture retention** capacity of biochar-amended soil not only reduces the total fertilizer requirements, but also the climate and environmental impact of croplands."*

*(International Biochar Initiative Scientific Advisory Committee)*

# Translation:

*Biochar is a fine-grained charcoal high in organic carbon and largely resistant to decomposition. It is produced from pyrolysis of plant and waste feedstocks…*

Charcoal made from plant material or waste in high-temperature ovens with limited oxygen.

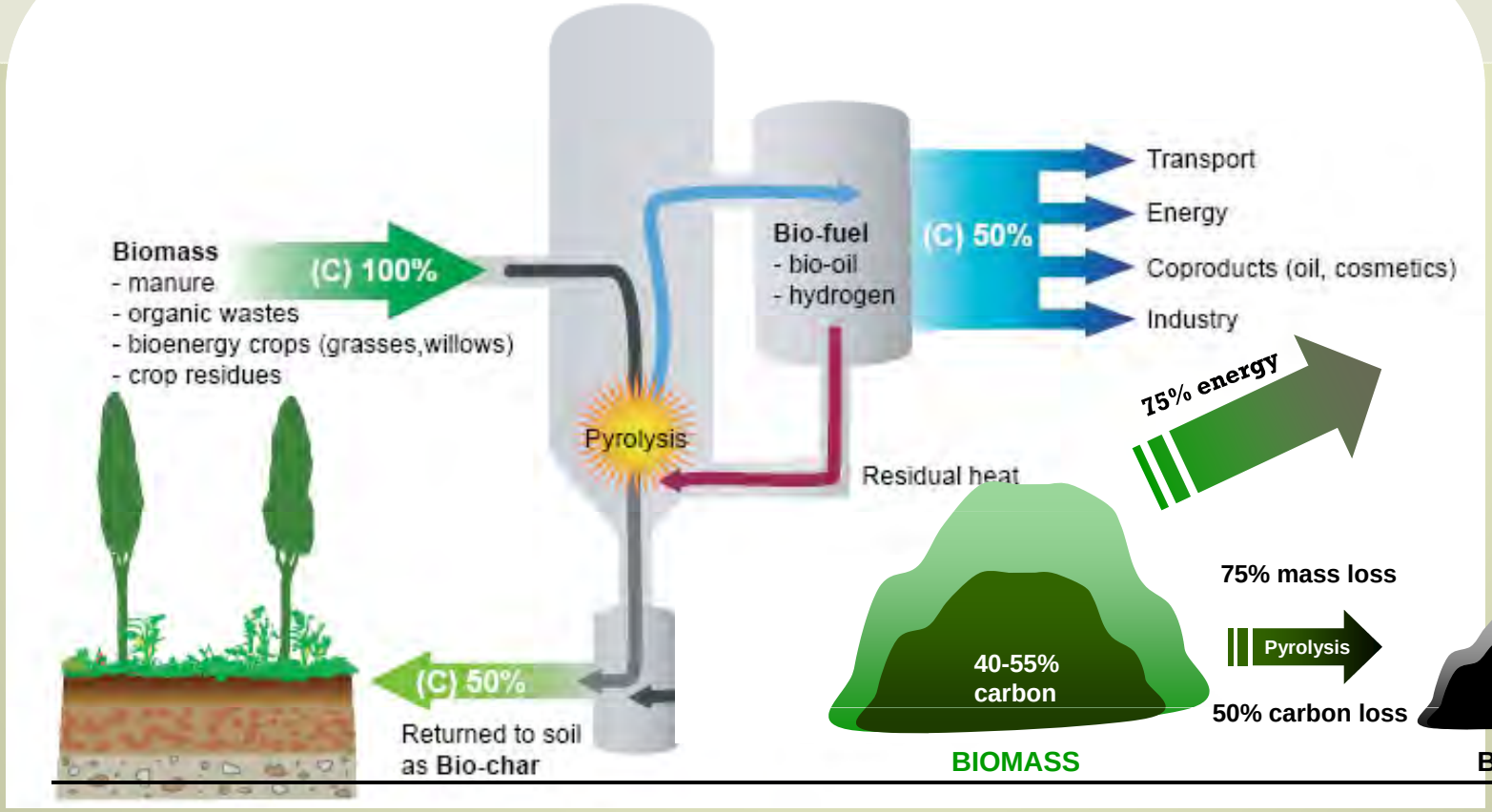
# Translation:

*…As a soil amendment, biochar creates a recalcitrant soil carbon pool that is carbon-negative, serving as a net withdrawal of atmospheric carbon dioxide stored in highly recalcitrant soil carbon stocks…*

When put in soil, biochar sequesters carbon for 1000's of years. It's carbon-negative because it holds carbon from that would otherwise remain in the active carbon cycle.

International Biochar Initiative

# Biochar = carbon-rich residue of heating biomass without oxygen




Lehmann, 2007, *Frontiers in Ecology and the Environment* 7, 381-387

# Products of Pyrolysis

- Syngas
- Bio-oil
- Biochar
- Heat
- Low emissions

# Zero-Waste and Carbon-Negative?

**Biomass**, now a waste product, becomes:

- ***Energy***—process heat, bio-oil and gases (steam, volatile hydrocarbons convert to energy)
- ***Soil Amendment***—holds water and nutrients persistently, raises pH, reduces fertilizer needs, reduces $N_2O$ emissions by 50-80%
- ***Water Quality Enhancer-*** mitigates N run-off, holds heavy metals, raises pH
- ***Climate Change Mitigation***—sequesters carbon for 1000's of years, minimizes $CO_2$, $N_2O$ and $CH_4$ emissions, creates carbon neutral energy, increased net primary productivity (plant growth & absorption of $CO_2$)

# BIOMASS

# Biomass-to-Energy Concerns

- Use of food or animal-feed as feedstock
- Conversion of cropland to grow biomass
- Conversion of CRP lands
- Industrial-scale production and/or collection of biomass
- Transportation carbon footprint & costs
- Ecologically unsustainable amount of biomass from cropland & forests removed
- Effects on visual quality and wildlife habitat

# Suitable Biochar Feedstocks

- Pulpwood (insect-killed trees)
- Forest Slash and Thinned Material
- Yard and Urban Forest Trimming
- Manure
- Agriculture Crop Waste
- Bluegrass Straw – Spoiled Hay or Straw
- Bagasse (residue from sugar production)
- Methane Digester Residue
- Offal (requires testing)

*~intercepting the waste stream~*

# USFS Biomass Estimates

Fuels Reduction Tons Burned 2008

*~100+ Million (USA)*

Fuels Reduction Tons /Acre

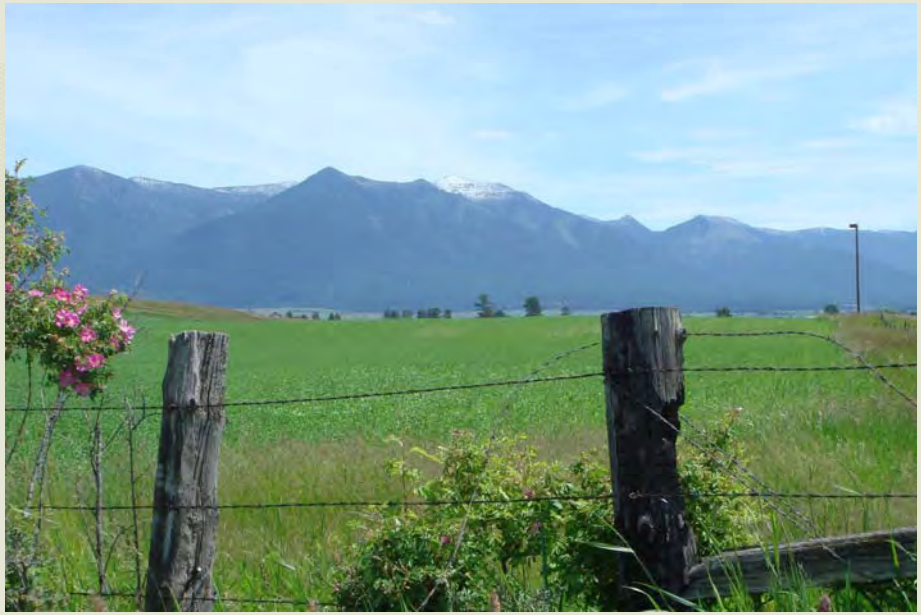
*10 to 40 Tons Typical*

Tons burned In Wildfires

*~1.5 Gt/yr Burned*

# Social Implications of Biomass or Why We Live in the West

Desire rural lifestyles, and/or access to open space…



Want to see abundant wildlife, agricultural lands, and wildlands …

# Resistance to Change

….and typically, we want those lands to stay "in character," meeting our visual expectations.

And that means people tend not to happy about change, especially change they can see.

# ECONOMICS

# USFS Bio-oil Project

Diamond Lake RD, Umpqua National Forest

Sustainable forest bioenergy production using in-woods fast-pyrolysis conversion for bio-oil production and biochar incorporation

# Bio-Oil Uses

- Bio-Oil Product is comparable to Bunker Fuel
  - 1 Ton of Slash = 120 Gallons of BioOil
- Bio-oil - refinement possible to #2 Diesel
  - Fischer-Tropsch Process or Blending
- Bio-oil is heavier than water
  - Spill clean up may be an issue in water

# Pyrolsis Product Values

**1 ton Forest Biomass = ~$211 of Products**

Syngas (fuel for Fast Pyrolysis) = ? lbs of gas

- Value not included in estimate
- May be used for Electrical Generation
  - *(Popular Mechanics, Dec, 2008)*

BioOil (or Bunker Fuel) = 120 gal of BioOil

- ~ $0.89/gal Houston TX
  - *(Bunkerworld.com)*

BioChar (or Horticultural Char) = 500 lbs

- ~$500 - $600.00/ton
  - *(TIME, Dec. 2008)*

# Timber Sale Implications

- D-Bug Timber Sale Example – Umpqua NF
  - Non Timber Sale Acres in project = 2213
  - 18 Green Ton Slash/ac = 9 Dry ton/ac
  - Est. value of products = $211/ton
  - Potential value increase for D-Bug Timber Sale
    - +$4,202,487
      - In addition to Saw Log Value

# Carbon Sequestration Values

1 ton of Biochar is worth about 3 tons $CO_2$

@ \$15/ton for $CO_2$ => \$50/ton Biochar

@ \$30/ton for $CO_2$ => \$100/ton Biochar

@ \$60/ton for $CO_2$ => \$200/ton Biochar

@ \$90/ton for $CO_2$ => \$300/ton Biochar

# Thank you

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# Product Output Comparison Values

- Soil Fertility from Biochar: $100/t to $500/t
- Carbon Credits from Biochar: $50/t to $300/t
- Gas for Heat: substitutes @ $10/MBTU for Natural Gas, $20-30/MBTU for Propane, So: $150/t biomass for Gas, $300-450 Propane
- Gas-to-Liquid Fuel: 50 gal per ton (w/o char) @ $2 to $4 /gal Diesel = $100 to $200
- Gas to Electricity: 1MWhr per ton (w/o char) @ $0.04 to $0.12 per kWhr = $40 to $120

# Product Output Comparison Values

| Biochar Value $/tonne: | $0 | $50 | $100 | $250 | $500 | $750 |
|---|---|---|---|---|---|---|
| **Value derived from 1 metric tonne of Biomass:** | | | | | | |
| Biochar Alone (25% yield) | - | $13 | $25 | $63 | $125 | $188 |
| Capital Cost per tonne Biomass per year ~ $100 to $700 | | | | | | |
| $.10/kWh Electric & Char | $100 | $79 | $91 | $129 | $191 | $254 |
| $.25/kWh Electric & Char | $250 | $178 | $190 | $228 | $290 | $353 |
| $3/gal Diesel & Biochar | $150 | $113 | $125 | $163 | $225 | $288 |
| $4/gal Diesel & Biochar | $200 | $145 | $157 | $195 | $257 | $321 |
| Capital Cost per tonne Biomass per year ~ $2,000 to $10,000 | | | | | | |

# Biochar vs. Energy Tradeoff

25% Biochar Production = 60-70% of max energy

1 mton biomass => 1MWhr (max) = $100 (max)
1 mton biomass => ¼ ton Biochar + 700kWhr

1 mton biomass => 200 liters Diesel (50 gal)
1 mton biomass => ¼ ton Biochar + 140 liters

¼ mton biochar => $25 to $125 for Soil Fertility
+ $12 for Carbon = $37 to $137
+ $60-70 max for Energy, or + $100 Heat (Natural Gas), or + $200-250 (Propane)