Desert Research Institute Eureka County Biochar Trial Field Day

Friday, April 8, 2016

The Learning Center
Eureka County Administrative Facility
701 S. Main Street
Eureka, NV 89316

University Center for Economic Development
http://www.unr.edu/business/research-and-outreach/uced

University Center for Economic Development – Nevada Leadership Program
http://www.unr.edu/business/research-and-outreach/nevada-leadership
Desert Research Institute
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Friday, April 8, 2016; 9:30am – 2:15pm

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You are invited to attend a Biochar Trial Field Day hosted by the Desert Research Institute and co-sponsored by the University of Nevada, Reno Center for Economic Development. On Friday, April 8, 2016, faculty from the Desert Research Institute will discuss and present the results of a year-long research initiative into the production and use of biochar as a soil amendment in agricultural purposes and soil reclamation in Eureka County.

The Field Day will include a series of presentations by faculty from the Desert Research Institute as well as a tour of various sites at both Ruby Hill and in Diamond Valley used in the Eureka County biochar field trial and demonstration project.

Desert Research Institute faculty who were involved in the Eureka County biochar field trial and demonstration project will provide an overview of DRI’s current work regarding biochar research and application. Other related production-oriented research will also be discussed and presented.

**When?** Friday, April 8, 2016

**Where?** The Learning Center, Eureka County Administrative Facility; 701 S. Main Street, Eureka, NV

**How Long is the Field Day?** The field day will be a one day event beginning at 9:30am and ending at 2:15pm. Morning coffee, snacks and a lunch will be provided.

**What is the Cost?** Registration is **free**.

Please contact Frederick Steinmann, University Center for Economic Development, via phone (775.784.1655) or by email (fred@unr.edu) to RSVP. Space is limited and we can only accommodate those that register in advance of the field day. Please RSVP no later than **Monday, April 4, 2016**.

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Friday, April 8, 2016

9:30am – 10:00am:  Registration and Networking (Coffee and Morning Pastries Provided)

10:00am – 10:15am:  Welcome and Introductions

10:15am – 11:00am:  The Eureka County Biochar Field Trial and Demonstration Project

11:00am – 12:00pm:  Overview of the DRI Assessment for the Eureka County Biochar Experiments

- The Eureka County Biochar Field Trial and Demonstration Project (Diamond Valley and Ruby Hill)
- Task 1: Independent Assessment of Amaron Energy’s Pyrolysis Process and Products (Curtis Robbins, Desert Research Institute)
- Task 2: Soil and Plant Growth Studies (Richard Jasoni, Desert Research Institute)

12:00pm – 1:00pm:  Working Lunch

- Ongoing Biochar Research (Casey Schmidt, Desert Research Institute)
- Biomass Pellet Presentation (Amber Brock, S. Kent Hoekman, Desert Research Institute)

1:00pm – 2:00pm:  Field Tour of the Eureka County Biochar Project Sites (*Weather Permitting – if weather does permit a tour of the project sites, an additional discussion with Desert Research Institute faculty will be provided at this time)

- Pinyon-Juniper Harvesting and Biochar Production Site
- Ruby Hill Mesocosm Site
- Pivots and Corner Pivots in Diamond Valley

2:00pm – 2:15pm:  Wrap-Up and Thank You; Return to Eureka

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Welcome!

Desert Research Institute
Eureka County Biochar Trial Field Day
April 8, 2016

Eureka County Biochar Trial Field Day

Today’s Agenda:

– Discussion and Presentations:
  • The Eureka County Biochar Field Trial and Demonstration Project
  • Overview of the DRI Assessment for the Eureka County Biochar Experiments (Task 1 and Task 2)
  • Ongoing Biochar Research at DRI
– Field Tour of the Eureka County Biochar Project Sites

Eureka County Biochar Trial Field Day

The Eureka County Biochar Field Trial and Demonstration Project – DRI and UNR Involvement:

– To determine whether or not biochar (and the byproducts of bio-oil and biogas) could be effectively produced using pinyon and juniper harvested in Eureka County.
– To test whether or not biochar, used as a soil amendment in agricultural purposes, could improve soil moisture retention rates.
– To test whether or not biochar, used as a soil amendment in sterile soils, could improve microbial activity.
– To explore the economic feasibility and economic development potentials of biochar production.
Desert Research Institute
Eureka County Biochar Trial Field Day
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Eureka County Biochar Projects

• All have a nexus with wildlife habitat and rangeland improvement projects.

• Pinyon-Juniper expansion and encroachment into sagebrush habitat and out of the proper ecological state has been recognized as a major threat to sage grouse as well as other wildlife species. This is in addition to disruption of watershed health and water availability and forage reduction for ranching operations.
PJ Cutting

- In 2013, 2014, and 2015, 4,175 total acres of pinyon-juniper selectively removed – 3,495 on Diamond Range, 600 acres on Roberts Mountain, and 80 acres on the Monitor Range.
  - Up to 1,140 acres more work to be completed in 2016 on Diamond Range ($90K left in grant funds).
  - Over $262,658 spent so far. Mostly grants funded. All contract work with contractors buying materials in Eureka and one crew staying in Eureka hotel, multiple rooms, for many weeks.
1918 and 2004; Pastorino Canyon, Diamond Mountains. The hillside on the right of the photo is one of the areas treated under this project which had downed fuels removed and where the chip pile currently sits.
1900 and 2004; Italian Ranch (now Simpson Creek Ranch), Diamond Mountains.
Biochar for revegetation of mine waste rock piles, Eureka, NV
Good reclamation
Second summer, # of plant stems

May 6, 2015
Other Angles to Test Feasibility

• NRCS Conservation Innovation Grant (CIG)
  • ARS and NV PJ Partnership
  • Diamond Valley alfalfa pivots and pivot corners.
    ➢ Decrease water needs? Increase production on non-irrigated lands?

• US Forest Service Wood Innovations Grant (WIG)
  • ENLC, NVPJP, NDF
  • Goal of grant is to “prove concept” for establishment of PJ utilization industries
  • Components include:
    ➢ Expanding biochar application in Diamond Valley (based on DRI, CIG, ARS results)
    ➢ Biochar amended PJ compost
    ➢ Only PJ compost
Biochar, Pores, and Soil Moisture

**Soil moisture contents obtained after 1st water leaching of soil treated with 2% high temp (HT) and low temp (LT) switchgrass (SW) biochar**

- **Declo soil**
  - Control
  - LSW
  - HTSW

- **Warden soil**
  - Control
  - LSW
  - HTSW

**LT SW** = low temperature (250 C) biochar made from switchgrass

**HT SW** = high temperature (500 C) biochar made from switchgrass

Both added at 2% by weight (equivalent to 20 tons/acre tilled into the top 6-8" of soil)

The Eureka County Biochar Field Trail and Demonstration Project

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University Center for Economic Development
University of Nevada, Reno

Involvement of the University Center for Economic Development (The College of Business, UNR):

- August 2013 through August 2014.
- Hiring of two UNR PhD students to explore the potential uses of biochar production and the economics of biochar production.

Potential Uses and Benefits of Biochar

- Properties of Biochar:
  - High stability of biochar against decay.
  - Strong ability to retain nutrients compared to other types of organic matter.
  - Allows for a reduction in fertilizer use and other soil inputs resulting in decreased nitrous oxide emissions in fertilized fields.

- Ideal for potential use in:
  - Improvement in soils (rehabilitation and agricultural production).
  - Use in climate mitigation strategies.
Potential Uses of and Benefits of Biochar

Soil Reclamation of Sterile or Impaired Soils; Fellet, Marchiol, Vedove, and Peressotti (2011):

- Use of biochar (orchard biomass) to treat mine tailing piles in Italy.
- Found that the treated soil’s pH nutrient retention, and water holding capacity increased.
- Bioavailability of Cadmium, Lead, Thallium, and Zinc all decreased as biochar content increased.
- Concluded “…changes promoted by the biochar seem to be in favor of its use on mine wastes to help the establishment of a green cover in a phytostabilization process.”

Potential Uses of and Benefits of Biochar

Water Benefits and Crop Productivity:

- Asai, et. al (2009); Clark (2014); Laird, et al (2010): each found that biochar application improves soil’s water permeability levels and provides better water capacity.
- Baum and Weitner (2006), Chan, et al (2008), Steiner, et al (2007): found increased crop productivity when biochar is added with both fertilizer(s) and without fertilizer(s).

Carbon Sequestration

- Two Scenarios to Consider:
  - When there is a carbon market that recognizes the avoided emissions and carbon sequestration due to the application of biochar in agricultural soils.
  - When the market price of biochar itself is low enough to allow farmers to earn a profit after applying the amendment to their soil.

- Field, Keske, Birch, Defoort, and Cotrufo (2012):
  - Breakeven point for biochar production and use when a carbon market exists is approximately $50.00 per metric ton of CO₂.
  - Biochar production and application can be profitable when it is possible to capitalize on the impacts of carbon sequestration.
**Production and Pricing**

When it Makes Economic Sense – Existence of a Carbon Market and the Market Price of Biochar:

- Galinato, Yoder, and Granatstein (2011): **NO Carbon Market**
  - Price of Biochar: $9.19 per metric ton in order for a farmer to break even.
  - Price of Biochar: $4.82 per metric ton in order for a farmer to earn a profit (excluding the costs of transportation and application).

- Galinato, Yoder, and Granatstein (2011): **Carbon Market**
  - Market is at $31.00 per metric ton of CO₂ or higher, the cost of biochar can be as high as $100.73 per metric ton and a farmer will still break even.
  - If the market is as low as $1.00 per metric ton of CO₂, there is no price scenario in which a farmer does not lose revenue.

**Production and Transportation**

- Profitability of other byproducts...Bio-Oil and Biogas
- Take into consideration the feedstock...chemical composition, availability, access.
- Transportation:
  - A major factor that significantly influences the economics of biochar production.
  - In mobile pyrolysis: (1) movement of the pyrolysis reactor to the biomass or (2) movement of the biomass to the pyrolysis reactor; Palma, et al. (2011): found that the net present value of production improves as the number of times the mobile pyrolysis devise is moved decreases.

**Regulation and the Regulatory Environment**

- United States:
  - No national regulatory protocols in place specific to the production, storage, transportation, application, and use of biochar.
  - State regulation(s) are fragmented and mostly not biochar-specific.
  - No consideration of regulating the additional byproducts...namely bio-oil and biogas.
- Europe and The European Union:
  - Switzerland has been the first country in Europe to explicitly approve the use of biochar in agricultural processes.
- Japan:
  - Approved the use of biochar for soil conditioning in 1984.
In Conclusion…

Economic Feasibility of Biochar Production is dependent on:

- The end use of biochar once it is produced.
- The existence of a carbon market and prevailing market prices for CO₂ and biochar.
- The use of the other pyrolysis byproducts including bio-oil and biogas.
- Costs associated with production, storage, application and even transportation of biochar.
- Impact of biochar on crop productivity which is impacted by the type of feedstock used in biochar production.
A Biochar Field Trial and Demonstration Project in Eureka, Nevada

- Desert Research Institute hired by University of Nevada Cooperative Extension Eureka County ($90,000) to complete two independent assessments of biochar in Eureka, Nevada.
- Task 1: Engineering Assessment of Pyrolysis Process and Productions (Curt Robbins).

Task 1

  - Biochar
  - Biogas
  - Bio Oil
- Life Cycle Analysis: assessment of the environmental assessments of the process.
Task 1

Results from Task 1:

- **Biochar**: Use of the Amaron Pyrolysis unit proved to be 'sufficient in the production of biochar'; chemical analysis of Amaron produced biochar 'consistent with the standards and specifications for biochar around the world'.
- **Bio Oil**: Oil was 'not of sufficient quality' to be accepted in the market.
- '...a revenue generating oil is necessary in order to economically produce biochar through pyrolysis.'
- Improvements to the pyrolysis process needed (uniform particle size, improved chipping process).
- Consideration of transportation as well as environmental considerations.
Task 2: Soil and Plant Growth Studies

April 8, 2016

Presentation Outline

• Objectives
• Plant culture
• Biomass treatments
• Plant biomass
• Plant tissue nutrient content
• Water holding capacity (volumetric and weight)
• Water use efficiency

Objectives

• To determine the effect of biochar on:
  1. Plant biomass production
  2. Plant tissue nutrient content
  3. Soil water holding capacity
  4. Water use efficiency (WUE)
Alfalfa
- WL377-Roundup Ready
- Soil: Pivot corner
- Pot: 3.5 gallon
- Time-domain reflectometry (TDR) probes in each pot
- Irrigated daily

Center pivot seed mix
- Crested wheatgrass
- Bottlebrush squirreltail
- Intermediate wheatgrass
- Basin wildrye
- Utah northern sweetvetch
- Blue flax
- Scarlet globemallow
- Palmet penstemon
- Soil: Pivot corner
- Pot: 3.5 gallon
- Irrigated daily

Reclamation seed mix:
- Anatone bluebunch wheatgrass
- Arriba western wheatgrass
- Delar small burnet
- Rimrock Indian ricegrass
- Penstemon Rocky Mtn. wildflower
- Cicer milkvetch
- Yellow blossom sweet clover
- Appar lewis blue flax
- Critana thickspike wheatgrass
- Common sandberg bluegrass
- Magnar great basin wildrye
- Canbar canby bluegrass
- Soil: Ruby mine
- Pot: 3.5 gallon
- Irrigated daily
Biochar Treatments

1. 0 g of biochar/kg of soil
2. 5 g of biochar/kg of soil
3. 10 g of biochar/kg of soil
4. 20 g of biochar/kg of soil

Plant Biomass

- Alfalfa plants were harvested two times during the study
- Center pivot plants were harvested two during the study
- Reclamation plants were harvested two times during the study

Plant Biomass

- All plants were harvested 10 cm (4 inches) above the soil surface
- The fresh biomass was weighed and then placed in paper bags
• Paper bags were placed in an oven at 80°C for seven days and then plant biomass weighed to obtain plant dry weight

• Dry plant biomass was ground to a fine powder and then sent for nutrient analysis
Plant Biomass

**Plant tissue nutrient content**

- Biochar did not significantly change any of the plant nutrients for the alfalfa and corner seed mix plant species that were used in this study.

- However, there were a few instances where some plant nutrients (Mn and Fe) were different between biochar treatments for the reclamation seed mix plant species.

**Volumetric Soil Water Holding Capacity**

30 cm TDR probe

30 cm TDR probe in a pot with alfalfa
Volumetric Soil Water Holding Capacity

Water Holding Capacity

- One gallon pots were filled with mine soil
- Biochar was added to the pots based on the same treatment levels as the plant growth study and replicated three times
- Pots were weighed ("dry weight") and then the exact amount of water was added to each pot and then reweighed

Water Holding Capacity

- The pots were weighed everyday, and weights recorded, until the weight of the pots returned to the original weight ("dry weight")
Water Use Efficiency

- Water use efficiency (WUE) was calculated by dividing the dry weight (g) of biomass harvested by the amount of water applied (kg) to produce the harvested biomass.
Water Use Efficiency

Water use efficiency (g dry biomass/kg irrigation water)

0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4

Biochar treatment

0 g biochar 5 g biochar 10 g biochar 20 g biochar

Corner seed mix

Water Use Efficiency

Water use efficiency (g dry biomass/kg irrigation water)

0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4

Biochar treatment

0 g biochar 5 g biochar 10 g biochar 20 g biochar

Reclamation seed mix

Future studies

• Using biochar of different particle sizes

• Specific placement of biochar in the soil rather than completely mixing the biochar in the soil

• Different watering treatments
Pinyon Juniper Plant Nursery and Urban Street Tree Applications

Casey Schmidt, Ph.D – Faculty at DRI
David Howlett, Ph.D – Urban & Community Forestry, Nevada Division of Forestry
Vimala Nair, Biswanath Dari, Nilovna Chatterjee – University of Florida

NDF Biochar
- Pinyon-Juniper forest management
- Biochar produced onsite in a transportable metal kiln (Eric Rousel)
- Develop a market for an underutilized forest resource
  - Plant Nurseries
  - Urban & Community Forestry

Transportable Metal Kiln
Chimneys and Inlets

Packing the Wood

Lighting the Fire
Biochar Production

- Kiln can take 10 cubic yards of relatively tightly packed wood.
- Produce 860 lbs (399 kg) of biochar, and 142 lbs (64 kg) of Carbon produced in a two-day burn.
- Wood volume reduced by ~65%, mass reduction 71%.
- How to process?
Street Tree Benefits

• Street tree canopy can increase individual housing price by $7,000 (Donovan & Butry, 2004)
• Tree canopy in Las Vegas Valley stores nearly 1,010,055 tons of carbon, provides an annual air pollution removal value of $8.5M and a total stormwater runoff mitigation value of approximately $208M.

Source: Las Vegas Valley Urban Canopy Analysis, 2012 Nevada Division of Forestry [http://forestry.nv.gov/content/uploads/2012/05/LasVegasValley_Canopy_2012.pdf]

Street Tree Mortality

Roman and Scatena, 2011 - Street tree survival rates: Meta-analysis of previous studies and application to a field survey in Philadelphia, PA, USA

NDF Nursery Application

• **Initial hazard assessment:** Is it harmful/beneficial to plants, soil organisms
• What application rates/How much to add?
• Do production conditions matter: **Temperature**, transportable metal kiln vs. carefully controlled production conditions
• Guide future biochar applications and projects applicable to urban forestry
Kiln Production Temp

![Graph showing temperature over time](image)

Methods

- Is Feedstock Important, Temperature?

![Diagram showing pyrolysis and biochar methods](image)

NDF Biochar Methods

- How does NDF biochar compare?
Pyrolysis Temp. vs. Soil Properties

- pH increases with pyrolysis temperature; C-N ratio decreases
- NDF Biochar has desirable CEC, C-N Ratio, albeit high pH

Alkalinity and N immobilization of Biochar Mixtures

- What affect will high pH have on alkaline NV soils, urban soils
- Soil-Biochar mixtures tailored to soil type

Cation Exchange Capacity

- Moderate CEC increase for mineral soils
- NDF Biochar
- Non-volatile nutrients increase with temp (e.g. Ca, Mg, K), volatile nutrients stabilize (e.g. P).
- NDF Biochar has high K, P, low Ca.

**Phosphorus Retention**

Vimala Nair, Nilovna Chatterjee and Biswanath Dari.
Biochar in Urban Restoration & Stormwater Remediation

- Biochar as stormwater retention media (Tahoe License Plate)
- Biochar in Rain Garden, stormwater detention system
- Floodplain/Riparian restoration in Stateline, NV
Biochar Amended Rain Garden

Fine Sediment/Nutrient Reduction

[Images of construction and workers]
Kahle Park Restoration

Photo Credit: Craig Zager Real Estate

Soil Studies Conclusions

- P-J Biochar is not a fertilizer
- Potential enrichment of P in biochar
- NDF biochar has a high pH, but also high cation exchange capacity, high phosphorus, high Potassium and compares favorably to the other biochar types.

Greenhouse Study

- Sagebrush (Artemisia tridentata) is the indicator species used.
- Germination Study
Plant Growth:

- **Height**
- **Leaf Count**

Germination Inhibition Study

- Nasturtium and Morning Glory
- No significant difference in ‘Time to germinate’ between treatments
Biochar and Drought
- With long-term droughts, our urban street trees, parks, lawns, yards, roadside vegetation, & stormwater detention systems will have to survive with less water.

Plant Available Water – NDF Potting Media
- Evaluate plant available water to tailor nursery irrigation of biochar mixes/street tree growth

NDF Potting Media Components
- 4 Parts Composted Fir Bark
- 4 Parts Old Soil
- 1 Part Peat Moss
- 1 Part Vermiculite
- 1 Part Perlite
- 1 Part Rice Hulls

How to Process Biochar
Analysis Procedure

- Pack soil mixtures consistently
- Saturate soil mixtures
- Simplified Evaporation Method
- Measure moisture content over time.
- Measure water potential at two depths within the soil
- Fit curves with van Genuchten-Mualem model

NDF Potting Media Moisture

![Graph showing moisture content over time for different NDF Potting Media samples.]

Plant Available Water NDF Potting Soil

- Adding Biochar to the NDF Nursery Potting Media more than doubled plant available water in fines (234%) to an increase of over one-third (36%) in coarse.
- Biochar greater than 2 mm had equivalent PAW
**Orovada State Soil**

- Volcanic ash loess, coarse loamy soil, Aridisol
- Agriculturally important

**Orovada Mixes**

- 0.063 - 0.125 mm
- 0.250 - 0.500 mm