Wildland Fire and Soils

Presentation Outline

- Southern Fire Exchange Introduction
- How does fire impact soils?
  - Soil Heating
  - Erosion Concerns
  - BAER
  - Hydrophobic Layer Formation
  - Effects on SOM
  - Effects on Soil N
  - Effects on Soil P
  - Carbon cycling and fire
  - Biochar and *Terra Preta*
  - Hydric Soils and Smoke
- Stuff we don’t know about fire and soils
Introduction to the Southern Fire Exchange
“Increase the availability and application of fire science information for natural resource management and to serve as a conduit for fire managers to share new research needs with the research community.”

-Southern Fire Exchange Mission
Accessible Fire Science for Resource and Fire Managers

- SFE is one of 14 JFSP regional consortia of fire managers and science providers
- Started 2010
- SFE refunded for 2013 - 2015
- Goal: enhance fire science delivery and adoption
Southern Fire Exchange Lead Organizations and Team

Leadership:
Leda Kobziar, Ph.D. (UF) (Project PI)
Alan Long, Ph.D. (UF Emeritus) (Director)
Joe Roise, Ph.D. (NC State)
Kevin Robertson, Ph.D. (Tall Timbers)
Annie Hermansen-Baez (USFS InterfaceSouth)

Staff:
David Godwin, Ph.D. (UF) (Outreach Coordinator)
Annie Oxhrart, MS (UF) (Tech Transfer Specialist)
Chet Buell (NC State) (IT Specialist)
Carol Armstrong (Tall Timbers) (Librarian Specialist)
Programing Based on:

- **Needs assessment survey** (2009, 976 fire managers in SE)
- Biennial **email survey** of managers / researchers
- **Advisory Board** (fire managers / researchers)
- **Steering Committee** (leading regional fire managers)
- Annual feedback from **Southern Group of State Foresters**
- **JFSP Guidance**
- Recommendations from **all end-users**
Southern Fire Exchange Programs
Online Southern Fire Science Resource Center

www.SouthernFireExchange.org

- Current highlights, news / events in Southern fire
- State level info on rxfire / PFCs / permits
- Tools for rxfire planning (weather / models / plans)
- All SFE science briefs and products
- Events calendar (training, webinars, meetings)
- Discussion Board / Forum
- Links to many other fire information resources
Online Prescribed Fire Resources

- Links to NOAA fire weather products
- Fact sheet for getting detailed point weather forecasts
- Links to example burn plans
- Links to individual state burn permit systems
- Links to fire / smoke models and tools

www.SouthernFireExchange.org
Southern Online Events Calendar

- Training Events
- Field Tours
- Webinars
- Prescribed Fire Council Meetings
- Conferences

Updated Weekly!

www.SouthernFireExchange.org
SFE Spotlight Series

- Fire in Wetlands
- Fire and Wildlife
- Prescribed Fire Techniques
- Smoke and Fog
- GIS / Mapping (Now)
- Fuel Treatments (May – June)

Each Spotlight Topic Features:
- Webinars
- Fact Sheets
- Research Briefs
- Research Reviews
- 10 Min Interviews
- Partner Webinars
- Additional Resources
SFE Fire Science Fact Sheets: 23 each 1-3 pgs.

- Cypress Mortality Following Wildfires
- Nests Under Fire: Effect of Season of Burn
- Accessing the Encyclopedia of Southern Fire Science
- Accessing FRAMES and the Southern Fire Portal
- Accessing Joint Fire Science FireScience.gov
- Searching the Tall Timbers Fire Ecology DB
- Economic Impacts of Wildfire
- Effects of Prescribed Fire and Wildfire in NC
- Effects of Prescribed Fire and Wildfire in FL
- Health Effects of Wildland Fire Smoke
- Accessing Detailed Point Weather Forecasts
- Predicting Smoke Movement with Computer Models
- Nighttime Smoke and Fog on Prescribed Fires
- Smoke Prediction with VSMOKE
- Wildfire Ignitions in the Southeast

Most Recent Fact Sheets:
- Science of Superfog
- Basic Smoke Management Practices
- Back Fire Techniques
- Rxfire Ignition Devices
- Fire Intensity & Fire Severity
- Fuel Moisture for Rxfire
- Flame Descriptors
SFE “10 Min Interviews” with Rxfire and Management Experts

Steve “Torch” Miller  
Chief of Land Management  
St. Johns River Water Management District

Mike Carloss  
Biologist and Director  
Louisiana Department of Wildlife and Fisheries

Justin Ellenberger  
Wildlife Biologist and WMA Manager  
Florida Fish and Wildlife Conservation Commission

Margit Bucher  
Fire Manager  
Nature Conservancy North Carolina

Mark Melvin  
Conservation Manager  
Joseph W. Jones Center

Gary Curcio  
Smoke and Weather Expert  
NC Forest Service (Retired)
Webinars (w/ Scientists, Researchers, and Experts)

Many count towards SAF CFE credit

Recent Webinars:
- Monitoring Trends in Burn Severity Applications in the Southeast
- Integrated Smoke Management Training
- Vsmoke-Web Introduction and Applications
- Dale Wade’s Lessons in Smoke Management
- Introduction to LANDFIRE in the Southeast

Past and future webinars archived on YouTube!
- [http://www.youtube.com/user/SouthernFireExch](http://www.youtube.com/user/SouthernFireExch)
“Fire Lines” - Bi-Monthly Digital Newsletter

- Southern Fire Science News
- Research Briefs
- Lessons Learned Reports
- Partner Introductions
- Management Discussions
- Training Dates
- Meeting Dates

Are you getting Fire Lines?
Friday Update: Biweekly Southern Fire E-News

Short. Sweet. To the Point!

- Southern Fire Science News
- Timely Upcoming Events
- New Research
- New SFE Products

Sign up at www.southernfireexchange.org
Fall 2013 SFE Field Workshops

• September 2013, Geneva, GA
• Longleaf Pine Ecosystem Restoration
• TNC / CFLCP Fall Line Project Area
Fall 2013 SFE Field Workshops

- September 2013, Lake Wales, FL
- Sand Hill / Scrub Restoration
- TNC Tiger Creek Preserve
Fall 2013 SFE Field Workshops

- October 2013, Jacksonville, FL
- WUI Sand Hill / Flatwoods Restoration
- SJRWMD Julington Durbin Preserve
We want your input:

- Do you have recommendations for possible research/field demo sites?

- What topics would you like to see covered in future fact sheets, webinars, or field tours?
Connect with us!

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@SEFireScience

facebook.com/sefirescience

www.linkedin.com/company/southern-fire-exchange
Soil Heating

Fire impacts soils by transferring heat downward into soils.

- Heat flux to soils is MUCH LESS than heat released aboveground.
- 8-10% (maximum of 25%) of heat is transmitted downward to the soil

Heat transfer processes to soils:

- **Radiation** and **convection**: responsible for most heat transfer from light fuels to soil.

- **Conduction** important in heavy fuels (duff, organic soils, and slash piles)

- **Vaporization** and **condensation**: water moves much faster through soil pores as a vapor and releases heat when it condenses.
The degree of soil heating is highly variable and depends on:

- **Fuel characteristics**: loading, size, arrangement, moisture content
- **Fire behavior**: rate of spread, flame length, intensity, duration
- **Litter layer**: thickness, packing, moisture content, and
- **Soil properties**: texture, organic content, moisture content
Notice the temperature differences between fire types and litter / soil depths!

DeBano et. al 1998
How do you think these fuel characteristics will influence soil heating?
How do you think these fuel characteristics will influence soil heating?
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How do you think these fuel characteristics will influence soil heating?
How do you think the fuels and fire behavior influenced soil heating?
Surface layers and upper horizons are most influenced by heating.

As depth increases impacts of soil heating decrease.

Highly spatially variable due to fuels, fire behavior, residence time, and soil conditions (see prev. photos).

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**Figure 2.5** Sample of studies investigating the relationship between peak temperature and depth in the soil. In all cases, peak temperature declines very rapidly with depth.

- **A.** Fires in longleaf pine (*Pinus palustris*) forest in south-eastern USA (from Heyward 1938).
- **B.** Fires in Californian chaparral (from DeBano et al. 1977).
- **C.** Temperatures under heavy slash fuels after logging in forest (from Neal et al. 1965).
- **D.** Fires in eastern Australia eucalypt forest (from Beadle 1940).

From Whelan, 1995
Effects of Soil Heating

Effects of different soil temperatures on soil properties

Elevated soil temperatures can kill soil microbes, plant roots, and seeds; destroy soil organic matter; and alter soil nutrient and water status.

Effects of Soil Heating

- Surface material consumption
  - Increased soil temp. due to insolation
  - Decreased SOM input
  - Increased erosion potential

- Adapted from Kennard, D.
Effects of Soil Heating

- Soil biota mortality / injury
  - Altered soil microbial populations
  - Altered soil fungal populations
  - Possible changes in nutrient / carbon cycling
  - Possible changes in decomposition rates
Soil erosion: transport of soil by water and wind.

Sediment: eroded soil carried to stream channels.

Sedimentation: deposition of sediment.

Susceptibility of soils to erosion is influenced by:
- Soil Properties (course soils more erodible)
- Topography (higher on steep slopes)
- Vegetative cover (protection)
- Land use (large machinery, grazing)
- Climate (high rainfall following burns)
Surface erosion: Fire can increase surface erosion by:
- Removing cover (litter, vegetation)
- Loss of stabilizing root systems
- Consuming SOM
- Creating hydrophobic soils

Soil mass movement: Fire can increase mass soil movement (i.e. landslides, debris flows)
- Often following periods of high rainfall, after a fire and prior to vegetation recovery
- Associated with steep slopes and high severity fires

Would you expect to see fire induced erosion at the ACF?
This erosion of a drainage created an incised channel after the Cerro Grande Fire near Los Alamos, NM. The view is upstream and the blue backpack is about 1 meter tall. The maximum 30-minute rainfall intensity was about 20 mm/h. The incision seen in this photo was after the wildfire and rain storm; prior to the storm this drainage had no definite banks. Photo by John A. Moody
Video of post-fire (Waldo Canyon) flooding in Manitou Springs, Colorado:

http://www.youtube.com/watch?v=Etj1Z4nLeEo
Burned Area Emergency Response

- “Burned Area Emergency Response” Program
- Interagency Organization
- BAER is “first aid” – immediate stabilization that often begins before a fire is fully contained.
BAER objectives are to:

- Alleviate emergency conditions to help stabilize soil; control water, sediment and debris movement; prevent impairment of ecosystems; mitigate significant threats to health, safety, life property and downstream values at risk.
- Monitor emergency treatments.
BAER teams often develop early first-order fire effects maps for soil stabilization response programs.

- 2013 Table Rock Fire, Pisgah NF, North Carolina
- 2013 Hopkins Prairie Fire, Ocala NF, Florida
Burned Area Emergency Response

Aerial Treatments

Carpenter 1 BAER
Spring Mountains NRA
Humboldt-Toiyabe NF

Legend

- Carpenter 1 Fire
- Aerial Mulching
- Wilderness Boundary
Burned Area Emergency Response

- BAER Mulch / Straw Treatments
- Heli-Mulching:
  http://youtu.be/zrjBZ8RM3Ow?t=1m7s
Burned Area Emergency Response

- BAER Video from NPS:
  - http://www.youtube.com/watch?v=BLB8QojgVbw
Hydrophobic Soils

- Can form following soil heating
- Result: Water infiltration is limited (degree varies)

http://geography.swansea.ac.uk/hydrophobicity/soil_hydrophobicity.htm
Hydrophobic Soils

- Influenced by vegetation, litter and duff accumulation, fire intensity and duration of heating
- Believed to be caused by volatilization and condensation of organic compounds
- Depth and thickness of hydrophobic layer varies
- Duration of layer
  - Prescribed Fire < 1yr
  - Wildfire > Several Years
Hydrophobic Soils

Debano 2000
Fire in Organic Soils

- Organic soils are different due to their potential to combust
- High-moisture, low-oxygen, smoldering combustion can release high amounts of carbon, smoke, heat
- Can last for days, months, years!
Fire in Organic Soils

Photo by Adam Watts
Fire in Organic Soils

Photo by Adam Watts
Fire Effects on SOM

- High heating of the soil can result in the alteration or consumption of soil organic matter (SOM).
- SOM destruction begins at 200ºC and is complete at 500ºC;
- SOM content usually highest in upper horizons
Why care about SOM?

- SOM holds sand, silt, and clay particles into aggregates.
- Loss of SOM = Loss of soil structure
- Decreased SOM = Increased soil bulk density and reduced soil porosity
- SOM important for carbon and nutrient cycling = soil quality / health
Fire Effects on Soil N

Nitrogen (N)

- Fire can have significant impacts on soil N.
  - Due to relatively low N volatilization temperatures

- Fire can volatilize available N in the litter, vegetation, and upper horizons resulting in net system losses.

- Ash deposition, incomplete combustion, and post-fire colonization by N fixing early successional legumes can lead to near-term recovery and pulses
Fire Effects on Soil N

Nitrogen Concentration

Nitrogen Pool

Prescribed Fire Impacts on Nitrogen Pool at the Austin Cary Forest

(From Lavoie et al. 2010)
Fire Effects on Soil P

Phosphorous (P)

- Fire tends to have little negative impact on soil P
  - Due to very high P volatilization temp
- Fire can increase soil available P via ash deposition and incomplete combustion residue
Fire Effects on Soil P

Phosphorous Concentration

Prescribed Fire Impacts on Phosphorous Pool at the Austin Cary Forest

(From Lavoie et al. 2010)
In temperate forest ecosystems 50-60% of ecosystem carbon is found within the soil.
Think: Carbon Pools and Fluxes
- Pool = Reservoir
- Flux = Movement

Above Ground Biomass (ACF)
8,084 g C m$^{-2}$
Powell et al. 2008

NEP = 192 g C m$^{-2}$
(2000-2001)

Fire C F$_{\text{dist}}$*
(ACF)
3860 g C m$^{-2}$
Lavoie et al. 2010
*Fire occurred in 2003

GEP
(ACF)
1794 g C m$^{-2}$ yr$^{-1}$
Powell et al. 2008

$R_s = R_a + R_h$
(N Florida)
1,179 g C m$^{-2}$ yr$^{-1}$
Ewell et al. 1987

Forest Floor Biomass
1,780 g C m$^{-2}$
Ewell et al. 1987

SOM / SOC
8,550 g C m$^{-2}$
Ewell et al. 1987

$R_e$
(ACF)
1602 g C m$^{-2}$ yr$^{-1}$
Powell et al. 2008

$F_{\text{lateral}}$
(Unknown)

$R_s = R_a + R_h$
(N Florida)
1,179 g C m$^{-2}$ yr$^{-1}$
Ewell et al. 1987

Forest Floor Biomass
1,780 g C m$^{-2}$
Ewell et al. 1987

SOM / SOC
8,550 g C m$^{-2}$
Ewell et al. 1987

$F_{\text{lateral}}$
(Unknown)
Soil carbon pools are usually unlikely to change in response to individual fires.
Long-term prescribed fire experiments have shown little impact on Southeastern soil carbon pools.

(From K. Robertson Presentation 2009)
Soil Carbon Fluxes

- Soils regularly emit (a flux) CO$_2$ in a process known as soil respiration or soil CO$_2$ efflux.

Image from Woods Hole Research Center
http://www.whrc.org/new_england/forest_ecol.htm
Soil respiration represents 50-60% of total ecosystem carbon budgets.

Globally, soil respiration contributes an estimated 75 Pg C yr\(^{-1}\) to atmosphere (while fossil fuel burning contributes 6 Pg C yr\(^{-1}\)).
Carbon Cycling and Fire

\[ R_s = R_a + R_h \]

- In temperate forests soil respiration is derived primarily from two main sources:
  - Autotrophic sources of CO\(_2\) (\(R_a\))
  - Heterotrophic sources of CO\(_2\) (\(R_h\))
Carbon Cycling and Fire

- Autotrophic sources of CO$_2$ ($R_a$)
  - Plant Roots
  - Rhizosphere Fungi

- Heterotrophic sources of CO$_2$ ($R_h$)
  - Microbial aerobic respiration
Carbon Cycling and Fire

- Factors shown to influence soil respiration
  - Soil Temperature
  - Soil Moisture
  - Soil Physical Properties
  - Surface Vegetation Characteristics
  - Soil Surface Characteristics (duff/litter)

Image from Woods Hole Research Center
http://www.whrc.org/new_england/forest_ecol.htm
Carbon Cycling and Fire

- Factors shown to influence soil respiration
  - Soil Temperature
  - Soil Moisture
  - Soil Physical Properties
  - Surface Vegetation Characteristics
  - Soil Surface Characteristics (duff/litter)

Does fire influence these factors?
Stoddard Plot Prescribed Fire Soil Respiration Study

“One of the last great places”
The Nature Conservancy
Study questions

- How do long-term prescribed fire management regimes influence old-field soil respiration rates?
- How do biotic and abiotic factors including soil temperature, soil moisture, monthly precipitation, and stand characteristics affect soil CO$_2$ efflux?
Stoddard Plot Prescribed Fire Soil Respiration Study

- “Red Hills” of N. FL and S. GA
  - 2,400 km$^2$ region
  - Over 1,220 km$^2$ in private hunting estates
  - Managed with freq. prescribed fire
  - Important as:
    - Critical habitat for Red-cockaded woodpecker, gopher tortoise, and 62 other T/E species
    - Remnant longleaf pine forests and native groundcover
    - Habitat for regionally declining Northern Bobwhite Quail
Stoddard Plot Prescribed Fire Soil Respiration Study

- Tall Timbers Research Station (TTRS)
  - Est. 1958
  - Leon County, Florida
  - Former quail hunting plantation
  - Prior to that it was farmed for cotton
  - 1,600 ha of ‘old field’ pine dominated uplands
  - Site of the historic Herbert Stoddard Sr. Fire Ecology Research Plots (est. in 1960s)

Stoddard Fire Research Plots:
- Annually Burned (1YR)
- Biennially Burned (2YR)
- Fire Excluded Sites (40YR)
Stoddard Plot Prescribed Fire Soil Respiration Study

- **Overstory**
  - Open canopy
  - Loblolly pine (*Pinus taeda*)
  - Shortleaf pine (*Pinus echinata*)

- **Midstory**
  - Open

- **Understory**
  - Dense oaks, grasses, herbs, shrubs
  - Shallow duff/litter layer

- **Fire**
  - Frequent low intensity (March / April)
  - Burns understory veg. and litter
Stoddard Plot Prescribed Fire Soil Respiration Study

- Annual burn interval (1YR)
Stoddard Plot Prescribed Fire Soil Respiration Study

- Play Stoddard Plot 1YR Video:
- [http://www.youtube.com/watch?v=fpPgIDFqoo](http://www.youtube.com/watch?v=fpPgIDFqoo)
Stoddard Plot Prescribed Fire Soil Respiration Study

- Biennial burn interval (2YR)
Stoddard Plot Prescribed Fire Soil Respiration Study

- Fire excluded since 1960s (40YR)
Stoddard Plot Prescribed Fire Soil Respiration Study

Fire Excluded (40YR)
Stoddard Plot Prescribed Fire Soil Respiration Study

Fire Excluded (40YR)

- **Overstory**
  - Closed canopy
  - Loblolly pine (*Pinus taeda*)
  - Shortleaf pine (*Pinus echinata*)
  - Sweet Gum (*Liquidambar styraciflua*)
  - Hickory (*Cary tomentosa*)

- **Midstory / Understory**
  - Sapling hardwoods, herbs, shrubs
  - Deep duff / litter layer

- **Fire**
  - Excluded since 1960s
Study Equipment

- LI-8100, Li-Cor Biosciences, Lincoln NE
  - Infared Gas Analyzer (IRGA) to detect CO2 concentrations.
- 8100-103 Model 20 cm Survey Chamber
- Decagon Systems EC-5 Soil Moisture Probe
- Omega 88311 E T-Handle Soil Temperature Probe
Study Design

- Three prescribed fire treatments
  - 1YR, 2YR, 40YR (Long-unburned)
- Three replicates of each treatment
  - (1YR-a, 1YR-b, 1YR-c)
  - (2YR-a, 2YR-b, 2YR-c)
  - (40YR-a, 40YR-b, 40YR-c)
- Each replicate plot consisted of nine sampling points in a 3 x 3 grid with 5m separation
- Each plot sampled once every four weeks
  - Three times over the course of a day (~0800-2000).
- Plot vegetation sampled (BA, TPH, Litter, Duff)

Measured Variables

- Soil CO$_2$ Efflux Rate ($\mu$mol CO$_2$ m$^{-2}$ s$^{-1}$)
- Soil Temperature (°C)
- Soil Moisture (m$^3$/m$^3$)
Why repeated measurements?

13,925 soil respiration measurements....
Stoddard Plot Prescribed Fire Soil Respiration Study

Monthly Mean Soil Respiration Rate by Fire Return Interval

$R_s$ (μmol CO$_2$ m$^{-2}$ sec$^{-1}$)

- 1YR
- 2YR
- 40YR

Month:
- Aug
- Sep
- Oct
- Nov
- Dec
- Jan
- Feb
- Mar
- Apr
- May
- Jun
- Jul
- Aug
- Sep
- Oct
- Nov
- Dec
- Jan
- Feb
- Mar
- Apr

Year:
- 2009
- 2010
- 2011
Stoddard Plot Prescribed Fire Soil Respiration Study

Monthly Mean Soil Respiration Rate by Fire Return Interval

- **1YR**
- **2YR**
- **40YR**

![Graph showing monthly mean soil respiration rate by fire return interval](image)
Stoddard Plot Prescribed Fire Soil Respiration Study

Monthly Mean Soil Moisture Content by Fire Return Interval

Soil moisture content (m^3/m^3)

1YR

40YR
Stoddard Plot Prescribed Fire Soil Respiration Study

Soil moisture content (m³/m³)

1YR  2YR  40YR

1YR  40YR
Stoddard Plot Prescribed Fire Soil Respiration Study

Monthly Mean Soil Temperature by Fire Return Interval

- **1YR**
- **40YR**
Stoddard Plot Prescribed Fire Soil Respiration Study

Monthly Mean Soil Temperature by Fire Return Interval

- **1YR**
- **40YR**
Monthly total C flux calculated using treatment specific lin reg models of $R_s$ response to air temperature (following Samuelson et al. (2004))

Hourly air temperature from Aug 2009 – Jul 2010 from Quincy FAWNS station used as input

Annual 40YR soil C efflux was 37% and 25% higher than 1YR and 2YR

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Est. Annual Soil C Efflux</th>
</tr>
</thead>
<tbody>
<tr>
<td>1YR</td>
<td>1069 g m$^{-2}$ yr$^{-1}$</td>
</tr>
<tr>
<td>2YR</td>
<td>1268 g m$^{-2}$ yr$^{-1}$</td>
</tr>
<tr>
<td>40YR</td>
<td>1688 g m$^{-2}$ yr$^{-1}$</td>
</tr>
</tbody>
</table>
Supporting evidence in freq. burned Stoddard Plots shows prescribed fire reducing carbon cycling and increasing C turnover time.

### Tall Timbers Fire Plots soil C turnover

<table>
<thead>
<tr>
<th>Fire Interval (yr)</th>
<th>%M $^{14}$C</th>
<th>Res. T (yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>113.5</td>
<td>11</td>
</tr>
<tr>
<td>40</td>
<td>108.4</td>
<td>5.5</td>
</tr>
</tbody>
</table>

*Ping Hsieh, Florida A&M University*

(From K. Robertson Presentation 2009)
In loblolly-shortleaf pine old-field forests of North Florida:

- A management regime of frequent prescribed fire (annual and biennial burning) results in lower soil respiration rates /annual soil C emissions than one of fire exclusion.

- A prescribed fire management regime appears to slow carbon cycling in old-field sites, while the absence of fire leads to increased soil carbon decomposition and carbon cycling.
Biochar or “Terra Preta”

- A stable form of carbon (think charcoal)
- Created from incomplete organic matter combustion (low oxygen environment)
- Biochar molecular structure facilitates nutrient retention (i.e. increased soil CEC)
Biochar and Terra Preta

- *Terra Preta* (trans: black earth) famous in the Brazilian Amazon region

- Believed to be evidence of large past civilization / agriculture in region now dominated by tropical forest

- *Terra Preta* believed to be an intentional soil amendment to increase soil nutrient retention (increased CEC) in a region with poor soils.

- Why? Increased CEC = Better Plant Growth = More Food

Photo by Michael Palace
Recent research demonstrates significant increase in soil/plant productivity following biochar amendments.

(Biederman and Harpole, 2012)


Techniques developed to identify critical temperature/O2 thresholds for the formation of biochar.

Issues remain for “scaling-up” biochar production at the industrial level.
Why Biochar Today?

- Increased cost of industrial fertilizers
- Demand for food production given global population growth
- Stable and low-cost / possibly profitable carbon sequestration technique
What we don’t know

“Isn’t fire like growing cows or corn? Don’t we have it figured out by now?”

– North Florida Prescribed Fire Council Attendee
What we don’t know

- Increased use of fuels mastication treatments
  - Reduce wildfire behavior
  - Prepare long-unburned sites for prescribed fire
What we don’t know

Osceola Treatments

- Control
- Mow
- Burn
- Mow+Burn
Osceola Monthly Mean Soil Respiration Rates by Treatment

What we don’t know

What happens in three to ten years?
What we don’t know

- How well do prefire treatments and fire “surrogates” maintain ecosystem / soil processes over time?

- Can we “masticate” our way out of WUI fire problems while maintaining functioning fire dependent ecosystems?
What we don’t know

- What are the best strategies for ecosystem / soil carbon retention?
  - Mature tree retention via forest “restoration” projects?
  - Stoddard-Neel forestry practices?
What we don’t know

- How will soil carbon and nutrient cycles respond to changes in climate and changes in disturbances (ie fire)?
- Example: Changes in NPP following Duke Forest FACE (Free-Air CO$_2$ Enrichment) experiment
What we don’t know

- How will change in fire regimes (fire frequency and severity) alter soil carbon pools and fluxes in boreal forests and subarctic regions?
- What about fire mediated methane (CH₄) fluxes in these regions?
Resources for more information

- “Wildland Fire in Ecosystems: Effects on Soil and Water” (JFSP/USFS GTR)
- Whelan, 1995 “The Ecology of Fire”
- DeBano, 2000 “The Role of Fire and Soil Heating on Water Repellency”
- Certini 2005 “Effects of Fire on Properties of Forest Soils: A Review”
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