Assessing the Effect of Prescribed Fire Frequency and Mechanical Treatment on the Sustainability of Southern Florida Rangelands

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Outline
- RCREC- Long-Term Agroecosystem Research (LTAR) team
- Overview of LTAR
- Archbold Biological Station – Range Cattle Research and Education Center
- Native flatwood rangeland
  - Why is this ecosystem important?
  - Why fire and mechanical control?
- The RCREC-LTAR experiment
  - Treatments
  - Measurements
  - Temperature during fire
  - Ashes and ash-derived nutrient deposition
  - Effect of treatments on vegetation
  - Effect of treatments on soil C, N, P, and K
- Ongoing research efforts

RCREC LTAR team
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- Raoul Boughton
- Brent Sellers
- João Vendramini
- Philippe Moriel
- Students:
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- Former research assistants:
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  - Britt Smith
  - Kacey Aukema
  - Lucas Zanini
  - Igor Machado

Ona Long-Term Agroecosystem Research (LTAR) Highlight

Temperate climate, sand, heat
- Create a good condition for growing tropical grass
- Sparse vegetation
- Decomposition of the grasses
- Without intervention, the soil will remain barren
- Provide adequate water
- Maintenance should be done every two years

Soil management
- Mechanical treatment
  - Pruning
  - Plowing
  - Burning
- Fire frequency
  - 1 year
  - 2 years
  - 3 years

Research objectives
- To study the effect of prescribed fire frequency and mechanical treatment on the sustainability of Southern Florida rangelands
- To determine the optimal fire frequency and mechanical treatment for maintaining the ecosystem

Methods
- Experimental design
  - Randomized complete block design
  - Replication
  - Treatments
    - Fire frequency
      - Annual
      - Biennial
      - Triennial
    - Mechanical treatment
      - None
      - Light
      - Moderate
      - Heavy
  - Measurements
    - Vegetation
      - Species diversity
      - Biomass
    - Soil properties
      - Carbon
      - Nitrogen
      - Phosphorus
      - Potassium

Results
- Vegetation
  - Species diversity increases with annual fire
  - Biomass decreases with biennial fire
- Soil properties
  - Carbon and nitrogen increase with mechanical treatment
  - Phosphorus and potassium decrease with mechanical treatment

Discussion
- Annual fire frequency is optimal for maintaining vegetation diversity
- Light mechanical treatment is recommended for soil fertility

Conclusion
- Prescribed fire frequency and mechanical treatment are effective in maintaining the sustainability of Southern Florida rangelands
- Annual fire frequency and light mechanical treatment are recommended for maintaining the ecosystem

References
**USDA Long-Term Agroecosystem Research (LTAR)**

**Mission:** to develop long-term, transdisciplinary research to better understand and forecast the Nation's capacity to provide agricultural commodities and other ecosystem goods and services under changing environmental and resource-use conditions.

**Source:** USDA, 2019.

**Working Groups**
- Soils
- Soil Health
- Grazing lands
- Livestock tracking
- Manureshed
- Stocks and Flows
- CO₂ emissions
- Non-CO₂ emissions
- Weather and Climate

**Archbold Biological Station & University of Florida**

**Joint location**

**Beef cattle industry:**
- Cow-calf operations
- Utilizes both cultivated pastures (~5 million acres bahiagrass, bermudagrass, limpograss, ...) and native rangeland (~2.5 million acres)
- Extensive production systems (low inputs)

**Archbold Biological Station**
- Range Cattle Research and Education Center - UF
- Archbold Biological Station

**Native Pine Flatwood Rangeland**
- ~300 plant species
- ~300 plant species
- Saw-palmetto:
  - ~300 species of insects visit the flowers to collect pollen
  - Part of diet of black bears, gopher tortoises, raccoons, white-tail deer
  - Dens for the Florida panther
- However...
  - Least protected ecosystems
  - 64% loss, mostly due to conversion to urban and suburban areas

**Source:** Florida Department of Agriculture, 2018.
Native Pine Flatwood Rangeland

- Used for dry pregnant beef cows during winter
- High biomass production
- High incidence of lightning
- Fire occurs naturally every 3 - 4 years
- Land managers use prescribed burning every 4 years
- ↓ saw-palmetto plants, ↑ forage production
- ↓ occurrence of uncontrolled fire
- Chopping also used to reduce presence of palmetto

Fire every 2 yr - Aspirational
Fire every 4 yr - Business as usual (BAU)
Fire every 4 yr + mechanical control (chopping)
Unburned

Range Cattle Research and Education Center (UF)

- Experimental area:
  - 16 plots
  - 40 to 60 acres per experimental unit
  - Total of 980 acres
  - In each plot, 5 transects (150 ft) where sampling is concentrated
Unburned
Burned
Burned and chopped

- Fire every 2 yr - Aspirational
- Fire every 4 yr - Business as usual (BAU)
- Fire every 4 yr + mechanical control (chopping)

- Fire: February through May 2019
- Chopping: May through June 2019
Important to determine losses of soil C and nutrients
Impact on soil microorganisms
Average temperature during peak: 507°F
Peak temperature range (per thermocouple): 123 to 1112°F
↑variable (weather, vegetation)

Temperature peak is short (minutes)
### Temperature during fire

- **Temperature peak is short (minutes)**
- **Thermocouple Transect A**
- **Thermocouple Transect C**

<table>
<thead>
<tr>
<th>Time</th>
<th>Temperature (F)</th>
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<tr>
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<tr>
<td>9:21</td>
<td>200</td>
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<tr>
<td>11:45</td>
<td>300</td>
</tr>
<tr>
<td>14:09</td>
<td>400</td>
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</tbody>
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### Ashes

- **Ashes** – material on the ground
- **Source of C and of nutrients to the ecosystem**
- **Two measurements:**
  - Wet collection: ashes deposited during fire at soil surface
  - Dry collection: remaining ashes at soil surface after fire
  - Wet collection: 430 lb/acre
  - Dry collection: 1720 lb/acre

**Wet collection**

**Dry collection**

13 lb N/acre, 2.7 lb P/acre, and 3.3 lb K/acre
510 lb C/acre

### Vegetation

- **Land managers use prescribed burning every 4 years**
- **↓ saw-palmetto plants, ↑ forage production**
- **How will burning and burning + chopping affect vegetation composition?**
- **Samples: 21 ft² per transect (September 2019)**
  - Total biomass
  - Functional groups:
    - Saw-palmetto
    - Desirable grasses
    - Undesirable grasses
    - Forbs
    - Shrubs
Vegetation
Saw-palmetto

Vegetation
Desirable grasses
Classification based on animal preference, persistence to unfavorable management (overgrazing, etc.)

Vegetation
Undesirable grasses
Classification based on animal preference, persistence to unfavorable management (overgrazing, etc.)
Vegetation

- Forbs
  - Wax myrtle
  - Caesar weed
  - Dogfennel
  - Golden rod
  - Wild sausage root
- Shrubs
  - Blueberry
  - Blackberry
  - Virginia creeper
  - Queen's delight
  - Milk pea
  - Golden aster
  - Sludge
  - Paw-paw
  - Galberry

Total biomass was similar between Unburned and Burned treatments.

Associating chopping and burning reduced biomass in ~45%.

How about distribution among functional groups?
Total biomass was similar between Unburned and Burned treatments.

Associating chopping and burning reduced biomass in ~45%.

How about distribution among functional groups?

Unburned: ↑ saw-palmetto, ↓ desirable grasses.
Saw-palmetto Desirable grasses Forbs Shrubs Undesirable grasses

Unburned: ↑ saw-palmetto, ↓ desirable grasses
Burned: ↓ saw-palmetto, ↑ desirable grasses

Burned: ↓ saw-palmetto, ↑ desirable grasses
Burned + chopped: ↓ saw-palmetto, ↑ forbs
Burned + chopped
• ↓ Saw-palmetto
• ↑ Forbs

Soil Chemical Characteristics

- Others have found short-term increase in soil extractable N
- Probably due to inputs from ashes
  - 13 lb N/acre
  - 2.7 lb P/acre
- Reduction in ext. P: Effect on solubility

Ongoing studies
- Above-ground litter decomposition
- Evaluating Unburned and Burned x botanical composition x N application
- Soil responses
  - Soil C stocks and stability
  - Natural abundance of 13C isotope
  - Impacts of pyrogenic C on soil C stocks and long-term stability – Shanna Stingu (M.Sc.)
  - Soil microbial community responses to fire (diversity and activity), soil enzymes, and RNA – Dipti Rai (Ph.D.)
- GHG emissions
  - Evaluating Unburned, BAU, and Burned + Chopping treatments

Pasture x native rangeland comparisons
- Above- and below-ground litter decomposition
- GHG emissions
Ongoing studies

- Eddy covariance tower:
  - CO₂ fluxes
  - Temperature
  - Wind speed and direction
  - Precipitation
  - PAR
  - Solar radiation
  - Atmospheric pressure
- PhenoCam
  - Measurement of canopy greenness every 30 min in several locations across the globe

Thank you!