Grassland Ecosystem Function: Uplands

25th September 2015, Fredericksburg

Richard Teague, Texas A&M AgriLife Research, Vernon
Soil health differences due to management

Christine Jones, 2014
Low density grazing

High density grazing

Neil Dennis, 2014
90% of Soil function is mediated by microbes.

Microbes depend on plants.

So how we manage plants is critical.
The Soil Food Web

First trophic level: Photosynthesizers
Second trophic level: Decomposers, Mutualists, Pathogens, Parasites, Root-feeders
Third trophic level: Shredders, Predators, Grazers
Fourth trophic level: Higher level predators
Fifth and higher trophic levels: Higher level predators
Bacteria

Organic matter

Plant
Shoots and roots

C:N = 15:1

C:N = 6:1

Fungi
Mycorrhizal Saprophytic

CO₂ from microbes forms carbonic acid in the soil which makes minerals from parent material available
Infiltration with Vegetation Composition

Thurow 1991

- Canopy Interception: 7.0%
- Grass & Litter Interception: 0.5%
- Grass & Litter Interception: 0.4%
- Interception: 0%

Litter Interception: 12.0%

Interrill Erosion: 0 kg/ha
Surface Runoff: 0%
Infiltration: 81.0%

Oak Motte

Bunchgrass

Sodgrass

Bare Ground

Infiltration: 75.5%

Infiltration: 54.6%

Infiltration: 25.0%

Erosion: 200 kg/ha
Runoff: 24.0%

Erosion: 1400 kg/ha
Runoff: 45.0%

Erosion: > 6000 kg/ha
Runoff: 75.0%
Mean annual precipitation
Patagonia - Fence line contrast with neighbor ranch after 5000 lambing ewes for 50 days (Dec 2011)
Overgrazing

- Overgrazing has little to do with number of animals.
- It has to do with the amount of time plants are exposed to the animals.
- If animals remain for too long in one place, or return to the grazed plants too soon, they overgraaze those plants.
- One cow grazing on 10 acres all season can kill thousands of plants.
- But 1000 cows grazing the same acre for 1 day will not kill a single plant.
We can turn this desertified land......
...into this productive land, with grazing!
What ecological functional differences are there between these?
Managing proactively for best results

<table>
<thead>
<tr>
<th>% Leaf Volume Removed</th>
<th>% Root Growth Stoppage</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>0%</td>
</tr>
<tr>
<td>20%</td>
<td>0%</td>
</tr>
<tr>
<td>30%</td>
<td>0%</td>
</tr>
<tr>
<td>40%</td>
<td>0%</td>
</tr>
<tr>
<td>50%</td>
<td>2-4%</td>
</tr>
<tr>
<td>60%</td>
<td>50%</td>
</tr>
<tr>
<td>70%</td>
<td>78%</td>
</tr>
<tr>
<td>80%</td>
<td>100%</td>
</tr>
<tr>
<td>90%</td>
<td>100%</td>
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</tbody>
</table>

Range Condition

- Excellent
- Good
- Poor

Figure 2. Plants of *Festuca rubra* unclipped and clipped to stubble heights of 5 inches, 3 inches, and 1 inch at 4-week intervals.
Managing to maximize plant recovery

**RELATIONSHIP OF TIME TO VOLUME OF FORAGE**

- Phase 1
- Phase 2
- Phase 3

**VOLUME**

**Time**
OVERGRAZING BECAUSE GRAZING PERIOD IS TOO LONG

Staying Too Long In One Area

GRAZING DAYS

1  5  10  15

DURING FAST DAILY GROWTH
OVERGRAZING DUE TO TOO SHORT A RECOVERY PERIOD

Coming Back Too Quickly

PLANT OVERGRAZED

1 1.0 20 30

RECOVERY DAYS DURING SLOW DAILY GROWTH
To improve Soil Health

Improve soil microbe population by:

- Keeping the 4 ecosystem processes functioning
- Improving plant cover
  - Perennial plants rather than annuals
  - Manage for most productive plants
  - Leave adequate plant residue
- Minimizing bare ground
- Manage for plant growth (green leaves) for as many days each year as possible
Landscape impact of continuous grazing

Edwards Plateau Ranch 3-D View w/ GPS Locations

1. 39% area used
2. 41% GPS points on 9% area
3. SR: 21 ac/cow
4. Effective SR: 9 ac/cow
Continuous grazing at Light stocking
Patch selection and overgrazing
Many Grass farmers use Adaptive Multi-Paddock (AMP) grazing successfully. Most conservation award winners use AMP grazing.
Landscape impact of continuous grazing

Planned multi-paddock grazing

Manager can control:
- How much is grazed
- The period of grazing, and
- The length and time of recovery
- Use livestock to enhance wildlife habitat

Animals:
- Graze more of the whole landscape
- Select a wider variety of plant species
High-density grazing

Light continuous grazing
Overgrazed rangeland
18 paddocks + water point
Managed to IMPROVE plant species
Restoration using Planned grazing

Noble Foundation, Coffey Ranch
Charles Griffith, Hugh Aljoe, Russell Stevens

![Graph showing animal unit days from 1988 to 1997]
Managing for Desired Outcomes

- Flexible stocking to match forage availability and animal numbers
- Spread grazing over whole ranch
- Defoliate moderately in growing season
- Use short grazing periods
- Adequate recovery before regrazing
- Graze again before forage too mature
- Adaptively change with changing conditions
Influence of multi-paddock grazing on soil and vegetation
Influence of multi-paddock grazing on soil and vegetation

Neighbouring ranches in each county:
- Continuous graze @ heavy SR (± 10 ac/AU)
- Continuous graze @ light SR (± 20 ac/AU)
- Planned HM graze @ heavy SR (± 10 ac/AU)

Grazing treatment at least 10 years
Continuous grazing at high SR
Multi-paddock grazing at high SR
Light Continuous

Heavy Multi-paddock
**Bare Ground**

- **Heavy Continuous**: 35% (P = 0.0006)
- **Heavy Multi-camp**: 5% (b)
- **Light Continuous**: 5% (b)

Legend:
- a: Statistically significant
- b: Statistically significant
Tall Grasses

Biomass (kg ha\(^{-1}\))

P = 0.003

Heavy Continuous

Heavy Multi-camp

Light Continuous

\(P = 0.003\)
Mid Grasses

Biomass (kg ha$^{-1}$)

- Heavy Continuous
- Heavy Multi-camp
- Light Continuous

$P = 0.188$

Biomass categories with different letters (a, b) indicate significant differences.

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Texas A&M System
Annual Forbs

Biomass (kg ha\(^{-1}\))

- Heavy Continuous
- Heavy Rotation
- Light Continuous

P = 0.014

AgriLIFE RESEARCH
Texas A&M System
## Soil Microbes

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Grazing Management</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Heavy continuous</td>
</tr>
<tr>
<td>Total bacteria (g m⁻²)</td>
<td>82a</td>
</tr>
<tr>
<td>Total fungi (g m⁻²)</td>
<td>97b</td>
</tr>
<tr>
<td>Fungi to Bacteria ratio</td>
<td>1.2b</td>
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</tbody>
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Importance of Fungi

Fungi provide:
- Access and transport nutrients
- Extend root volume and depth
- Exude glomalin to enhance soil C
- Increase water and nutrient retention
- Increase drought resistance
- Plant growth highest with highest fungal - bacterial ratio

## Soil Carbon, Nutrients and Water

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Heavy Continuous</th>
<th>Light Continuous</th>
<th>Multi-paddock</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Organic Matter</td>
<td>3.1&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>4.86&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Cation Exchange Capacity</td>
<td>24.6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>23.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>27.4&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Water holding (Gal/acre)</td>
<td>55,700</td>
<td>79,059</td>
<td>87,324</td>
</tr>
</tbody>
</table>
Clear Creek Watershed, North Texas

Grazing management scenario

Fraction in total flow

Surface runoff
Groundwater flow

HC
LC
MP
EX

Grazing management scenario
Indicators for Uplands

Energy flow:
- Total canopy
- Plant form and vigour
- Production potential

Water cycle:
- Trails/gullies
- Erosion and pedestalling
- Bare ground and crusting

Mineral cycle:
- Living organisms
- Litter soil contact
- Litter abundance and distribution

Plant community:
- Goal plants
- Germination sites and recruitment
- Species diversity
- Undesirable plants
Conclusions

Adaptive Multi-Paddock grazing can:

- Build SOC levels and soil microbial function
- Enhance water infiltration and retention
- Build soil fertility
- Control erosion more effectively
- Decrease drought impacts
- Improve economic returns while improving the resource base
- Enhances wildlife and biodiversity