SILVOPASTURE
An Agroforestry Practice
–benefits to integrating farm and forest management –

Dusty Walter

Special Thanks:  Mark Kennedy (Missouri NRCS)
Rob Kallenbach (University of Missouri)
Outline

- Silvopasture Defined
- Historical Context
- Components of Success
  - Livestock husbandry
  - Pasture management
  - Forest management
- Integrating the Components
- Planning and Monitoring
Combinations of trees, forages, and grazing principles which are integrated and managed to promote broader resource utilization and enhanced farm productivity.
Grazing unmanaged woodlands is **NOT** a silvopasture practice!

One or two trees in a pasture ... **NOT** a silvopasture practice.
Silvopasture

A. Silvo – from the word “Silviculture”
-- the art and science of tending and producing a forest

B. Pasture – plants grown for grazing
-- selective production of quality forage for grazing by livestock

*Integrates Forestry, Forage, Livestock practices and management*
Silvopasture: The triple crown of agroforestry

- Forest Management
- Forage Management
- Livestock Husbandry
- Alley Cropping
- Windbreak/Shelterbelt
- Management Intensive/Rotational Grazing
Historical Successes

Southern Silvopasture has successfully integrated pine production and grazed forage

http://www.unl.edu/nac/
Midwest Silvopasture has demonstrated short-term success associated with rotationally grazed cool-season forages grown in intensively managed upland oak forests.
The Shieling System

A Scottish practice persisting from the 11th century to the mid 1800’s.

a term that reflects movement of livestock to summer woodland pastures in the mountains.


The dehesa system has persisted for millennia, and exists today, because of its versatility (diversity); because it has been, and it is now, the most efficient system to satisfy the changing demands of the human society within that difficult natural environment.
Outline

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- Historical Context
- Components of Success
  - Livestock husbandry
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Components of Success

- Tree/Shade Management
- Livestock Husbandry
- Forage Management
Do cattle need shade?

- It depends!
  - Are cattle grazing endophyte infected fescue?
  - Is the Temperature–Humidity Index (THI) over 72?
  - Have the cattle been selected for short hair coats and heat tolerance?
  - Is plenty of good quality water present?
  - What is the overall condition of the animals?
  - What are the animals accustomed to?
Shade – When it is probably needed

- Shade is probably beneficial any time Temperature–Humidity Index (THI) is above 72.
- Especially if livestock are grazing endophyte infected fescue

Figure 1. Temperature Humidity Index (THI)\(^1\) for Dairy Cows. Modified from Dr. Frank Wierama (1990), Department of Agricultural Engineering, The University of Arizona, Tucson, Arizona.

| DEG F  | 0  | 5  | 10 | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 | 85 | 90 | 95 | 100 |
|--------|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
|        | 72 | 72 | 72 | 73 | 73 | 74 | 74 | 75 | 76 | 76 | 77 | 78 | 79 | 80 | 81 | 81 | 82 | 83 | 84 | 84 | 85 |
| 72     | 72 | 73 | 73 | 74 | 74 | 75 | 75 | 76 | 76 | 77 | 78 | 79 | 80 | 81 | 81 | 82 | 83 | 84 | 85 | 86 | 86 |
| 73     | 74 | 74 | 75 | 75 | 76 | 76 | 77 | 77 | 78 | 78 | 79 | 79 | 80 | 81 | 81 | 82 | 83 | 84 | 85 | 86 | 87 |
| 75     | 75 | 76 | 76 | 77 | 77 | 78 | 78 | 79 | 79 | 80 | 80 | 81 | 81 | 82 | 82 | 83 | 84 | 85 | 86 | 87 | 88 |
| 90     | 72 | 73 | 74 | 74 | 75 | 75 | 76 | 77 | 77 | 78 | 78 | 79 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 89 |
| 95     | 73 | 74 | 74 | 75 | 76 | 76 | 77 | 77 | 78 | 78 | 79 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 89 |
| 100    | 77 | 78 | 79 | 80 | 80 | 81 | 82 | 82 | 83 | 83 | 84 | 84 | 85 | 86 | 86 | 87 | 88 | 89 | 90 | 91 | 92 |
| 105    | 79 | 80 | 82 | 83 | 83 | 84 | 84 | 85 | 86 | 87 | 88 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 |
| 110    | 81 | 83 | 84 | 86 | 87 | 88 | 89 | 90 | 91 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100| 100|
| 115    | 84 | 85 | 87 | 88 | 90 | 91 | 91 | 93 | 94 | 95 | 96 | 97 | 98 | 100| 100| 100| 100| 100| 100| 100|
| 120    | 86 | 88 | 89 | 91 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100| 100| 100| 100| 100| 100| 100| 100| 100| 100|

\(^1\)THI = (Dry-Bulb Temp. °C) + (0.36 dew point Temp., °C) + 41.2

If more than two cows out of 10 have respiratory rates exceeding 100 breaths per minute, then immediate action should be taken to reduce heat stress.
Effects of endophyte and shade
Cow/calf – MU Southwest Center 2000

- Cows were bred AI/cleanup bull prior to study
- Preg check at start of study confirmed 85–90% bred at the start of study
- Evidently heat stress with no shade caused cows to slip calves
- Studies elsewhere have shown heat stress with no shade reduced bull fertility/cow cycling.
Providing Shade – portable
# Effects of endophyte and shade

**Cow/calf – MU Southwest Center 2000**

(E+ fescue with endophyte, E– fescue without endophyte, S+ paddock with shade, S– paddock without shade)

<table>
<thead>
<tr>
<th></th>
<th>E+S-</th>
<th>E+S+</th>
<th>E-S-</th>
<th>E-S+</th>
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<tr>
<td><strong>Cows</strong></td>
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<tr>
<td>ADG</td>
<td>-0.45</td>
<td>0.27</td>
<td>0.61</td>
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<tr>
<td>∆BCS</td>
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<tr>
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<td>-0.3</td>
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<tr>
<td>%Preg</td>
<td>37.5</td>
<td>87.5</td>
<td>62.5</td>
<td>87.5</td>
</tr>
<tr>
<td><strong>Calves</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ADG</td>
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<td>1.87</td>
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<td>0.8</td>
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### Effects of endophyte and shade

**Steers – MU Southwest Center 2001**

<table>
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<th>E+S+</th>
<th>E-S-</th>
<th>E-S+</th>
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<tr>
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<td>1.46</td>
<td>1.46</td>
<td>1.53</td>
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<tr>
<td>δHS</td>
<td>-0.2</td>
<td>-0.3</td>
<td>-0.1</td>
<td>-0.9</td>
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</table>
Shade – good and bad?

- When shade is isolated in only a few areas of a paddock there is nutrient transfer from the grazing area to the shade, eventually killing the trees and lowering productivity of the paddock.
Shade – good and bad?

- Cattle tend to congregate under shade even when they don’t need it
  - Time spent under shade reduces time spent grazing
  - Less grazing time results in less intake and reduced performance
Shade effects on Manure Distribution

One paddock of 3–pasture rotation

One paddock of 24–pasture rotation

Piles per 500 ft²
Shade Benefits –– Cattle and Goats

- Improved animal condition
- Improved milk production
- Improved breeding efficiency
- Improved feed intake
- Improved weight gain
- & Improved nutrient distribution?

But – it does depend:

- Animal selection
- Temp.–Humidity Index above 72
- Endophyte infected fescue
- Rotational Grazing
Components of Success

- Forest/Shade Management
- Livestock Husbandry
- Forage Management
Select appropriate forages:
1. Available light (percent shade)
2. Timing of grazing
Insight from New Research

HARC Shade Structure Layout

Each structure is:
- 16 feet wide
- 32 feet long
- 8 feet high

LEGEND
- 0% shade
- 30% shade
- 55% shade
- 60% shade
- 80% shade

- Water Tank and Pump
- Fence

2008 shade layout

0% shade
30% shade
55% shade
60% shade
80% shade

Each structure is:
- 16 feet wide
- 32 feet long
- 8 feet high
Insight from New Research

The Effect of Light / Shade

Under 50% shade Cool Season Grasses and Forbs

1. Increase or maintain yield;

2. Improve quality –
   - Reduced lignin and improved digestibility
   - Increased, or no change, in ADF, NDF, CP
   - Improved N content
Designing Silvopastoral Systems

Cool-Season Grasses and Legumes

- Reed canarygrass
- Orchardgrass
- Smooth brome
- Kentucky bluegrass
- Tall fescue
- Perennial ryegrass
- Timothy
- Annual ryegrass
- Redtop
- Crownvetch
- Kura clover
- Strawberry clover
- Crimson clover
- Subclover
- Red clover
- White clover
- Alfalfa
- Birdsfoot trefoil
- Alsike clover

Shade Tolerance Percentile
Designing Silvopastoral Systems

Native Warm-Season Grasses and Legumes

Shade Tolerance Percentile

Eastern gama
Bermuda
Bahia grass
Big bluestem
Indian grass
Switchgrass
Prairie cordgrass
Prairie dropseed

Hog peanut
Hoary tickclover
Eastern gama
Cluster fescue
Paniculated tickclover
Illinois bundleflower
Big bluestem
Switchgrass
Prairie cordgrass
Prairie dropseed

0 20 40 60 80 100

0 20 40 60 80 100
Balance Livestock Numbers with Forage Supply

- **Stocking rate**: The number of animals or animal liveweight assigned to a grazing unit on a seasonal basis.

- **Carrying capacity**: The stocking rate that provides a target level of performance while maintaining the integrity of the resource base.

  - Stocking rate has an effect on intake and availability.
Carrying capacity of pasture is determined by four factors

\[
\text{Carrying Capacity} = \frac{\text{Forage Production} \times \text{Seasonal Utilization Rate} \times \text{Daily Intake} \times \text{Length of the Grazing Season}}{} 
\]
Effect of Forage Availability on Relative Forage Intake
Optimize Forage Quantity & Quality

- Protein/energy
- Fiber/lignin
- Availability
- Optimum grazing

Available Forage (lb/acre)
IVDMD (%)

Days of Rest
Grazing Period Length Affects Utilization
Figure 1. Impact of distance from water on temporal utilization rate in rectangular 10 acre paddocks.

Clean, well placed water is critical to a silvopasture system.
Rotational Grazing is Essential !!!

- The amount of residual left in a pasture after each grazing affects:
  - Root system
  - Health and vigor of plants
  - Photosynthesis/rate of plant regrowth

<table>
<thead>
<tr>
<th>% Leaf Removed</th>
<th>% Root Growth Stopped</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</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 to 4</td>
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<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>
</tr>
</tbody>
</table>
Erosion and Runoff

3 inches of rainfall in 90 minutes, 10% slope, silt loam soil

*University of Nebraska & USDA-SCS, 1937*

- **Excellent pasture**: 95% ground cover
- **Fair pasture**: 75% ground cover
- **Poor pasture**: 50% ground cover

Soil loss (tons/A) vs. Percent runoff

| Soil loss (tons/A) | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 |
|-------------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|
| Percent runoff    |   |   |   |   |   |   |   |   |   | 0% | 10%| 20%| 30%| 40%| 50%| 60%| 70%| 80%|
Designing Silvopastoral Systems

1. Grazing Periods less than 5 days
2. Rest periods 20 – 45 days or longer depending on grass growth rates
3. Grazing Heights:
   - Cool Season:
     In @ 8 – 10"
     Out @ 3 – 4"
   - Warm Season:
     In @ 12 – 18"
     Out @ 6 – 8"
4. Monitor and Evaluate – soils, forage, trees, animals
5. Make adjustments as needed
Designing Silvopastoral Systems

--Forage Management--

- Browse
  - Goats
  - Llamas
- Forbs
  - Sheep
  - Elk
- Grass
  - Bison
  - Horses
  - Cattle
Components of Success

- Livestock Husbandry
- Forest/Shade Management
- Forage Management
Silvopasture – Shaded Naturally

Establishment and Maintenance

- Trees into Pastures
- Pastures into the Forest
Establishment and Design of a Silvopasture Practice

Existing Pasture

1. Primary difficulty is tree establishment.
Silvopasture – Shaded Naturally

Trees into Pastures

1) Select species appropriate for the site.
   a. Soils Units (local NRCS or Extension)
   b. What is growing on or adjacent to the planting area.
   c. Dig a hole – texture and depth

What are the landowners’ interests?
Species Selection

1. Trees matched to site conditions
2. Produce a light shade
3. Produce desired products
   -- Nuts, Timber, Syrup ...
4. High value
   -- grafted vs. nursery seedlings
   -- Black Walnut vs. White Oak
5. Deep rooted
Silvopasture – Shaded Naturally

Trees into Pastures

1) Select Species appropriate for the site.

2) Weed Control –
   a. Mechanical
   b. Herbicide
   c. Mulch
      i. Vegetation – living or dead
      ii. Fabric
Mowing is not Weed Control !!!
Trees into Pastures
1) Select Species appropriate for the site.
2) Weed Control.
3) Protection from Grazing.
Got Deer?
Benefits of Establishing Trees in an Existing Pasture

1. You Choose the Species

2. You Choose the Spacing

** Proper configuration and species selection will influence both the available light for forage production with an added benefit of reduced likelihood of tree damage from mowing **
Spacing Considerations

Within the Row

Between the Row
Row Orientation
Planting Configurations

Considerations:

1. Shade Management
2. Mowing
3. Fencing
4. Product growth and harvest
Are there additional Maintenance Considerations when putting trees in the Pasture?
If the landowners’ objectives include high value timber – – planted trees will need pruning.
Corrective Pruning
Pruning for quality
Prune at least 9 feet high, but if possible, prune up to 17 feet in two or more stages. Stem forks, crooks, or large branches may restrict pruning height. Do not remove more than 25 percent of the live crown or prune higher than 50 –60 percent of total tree height.
Silvopasture – Shaded Naturally

**Establishment and Maintenance**

- Trees into Pastures
- Pastures into the Forest
Existing Forest Managed for the Silvopasture Practice

Considerations

1. Select the highest quality trees to remain as crop trees
2. Manage for appropriate light levels
3. Select appropriate sites
4. Rotationally graze to minimize adverse effects
Wurdack Farm & Silvopasture Area
Wurdack Farm & Silvopasture Area
MU Wurdack Farm Silvopasture Research

**Thinned Treatment Summary**

- Overstory Tree count per ha reduced by ~60% to 67 tpa
- Residual basal area reduced from 112 to 45 ft²/ac
- Stocking approximately 40%
- White oak 70% of residual
- Black oak 20% of residual
Use Tree Selection methods similar to Crop Tree Thinning

1. Identify “best” trees
   i. Site appropriate
   ii. Quality related to objectives

2. Thin around “best” trees to open the crown
   i. 50–60% open across the site

3. Identify next “best” tree
Thinning

Before

After
Thin for light

Thin for quality
Study Design

Five Forest Treatments (Replicated 5 times)

1. Control (1ac)
2. Thin with no Forage (1ac)
3. Thin with Forage (1ac)
4. Thin with Forage and Grazed (2.5ac)
5. Thin without Forage and Grazed (1ac) – created in 2005

2002

2003
Plan Logging Access Carefully
Other Activities
1. Soil testing
2. Soil amendment
   i. Lime
   ii. Fertilizer
   iii. ????
3. Grass seeding
4. Regeneration
5. Future thinnings
MU Wurdack Farm Silvopasture Research

Soil Fertility Adjusted

1. 5 tons ENM pelletized lime/ac (initial pH 4.3)
2. 450 lbs 0-150-75 NPK / ac

Forages Established in the Spring 2003

1. Kentucky 31 tall fescue (34 lb/ac)
2. Red clover (2 lb/ac)
3. Marion lespedeza (7 lb/ac)
6 months after planting
Pasture in the Woods

Possible Concerns

Log quality impacts – –
epicormic branch development?

Site impact/degradation – –
growth rates of residual trees

Regeneration – –
what about the next generation tree
MU Wurdack Farm Silvopasture Research

Epicormic response of white and black oak overstory trees when converting hardwood forests to a silvopasture

*Purpose:* to identify whether residual tree densities resulted in an increased probability of epicormic branch development.
Each tree was measured for epicormic bole sprouts immediately following completion of the thin process (March 2003).

Branches existing on the first 8-foot log and the second 8-foot log were tallied for 2 years periods, through 2007.

Hypotheses:

1. There are no significant differences in epicormic response of overstory trees between the thinned treatments and unthinned control from 2003 – 2005;
2. There are no significant differences in epicormic response of overstory trees between the thinned treatments and unthinned (TGz) from 2003 – 2007.
Released Crop Trees were no more likely to develop epicormic sprouts than unthinned trees.
MU Wurdack Farm Silvopasture Research

Basal area increment growth response of black and white oak overstory trees in a silvopasture practice

*Purpose:* to quantify and separate the influences of a silvopasture practice on tree growth (basal area increment) of intensively managed upland oak overstory trees.
Ten trees from the center of each treatment had increment cores extracted (sample size 50 tree cores per treatment). Radial growth increment was converted into tree diameter, and then basal area. Year-to-year growth differences were expressed as Basal Area Increment (BAI).

Black and white oak account for 241 of the 250 trees sampled.

Using GLM Procedure in SAS, LSMeans were tested to identify differences among treatments for black and white oak, and between black and white oak within treatments.

Data reflects 6-years prior to and 6-years post treatment for all but treatment TGz (implemented after the 2005 growing season). TGz means reflect 3-years pre- and 3-years post-treatment.

Tree ring growth analysis by: University of Missouri Tree-Ring Lab.
## MU Wurdack Farm Silvopasture Research

**Table 3.3** -- Comparison of basal area increment six years prior (1997-2002) to and six years post- (2003-2008) treatment between black and white oaks within a treatment.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Treatment Description</th>
<th>Treatment Description</th>
<th>Treatment Description</th>
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<tbody>
<tr>
<td>C</td>
<td>Control</td>
<td>Forest Thin Only</td>
<td>Forest Thin, Grass Established, Grazed</td>
</tr>
<tr>
<td>T</td>
<td>Forest Thin Only</td>
<td>Forest Thin, Grass Established, Grazed</td>
<td></td>
</tr>
<tr>
<td>TG</td>
<td>Forest Thin, Grass Established</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TGGz</td>
<td>Forest Thin, Grass Established, Grazed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TGz³</td>
<td>Forest Thinned, No Grass, Grazed</td>
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### White Oak BAI (LSMean Values)

<table>
<thead>
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<th>Treatment</th>
<th>pre (in²)</th>
<th>post (in²)</th>
<th>Percent Change</th>
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<tbody>
<tr>
<td>C</td>
<td>11.8</td>
<td>13.9</td>
<td>13.5 d</td>
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<tr>
<td>T</td>
<td>11.6</td>
<td>23.7</td>
<td>157.8 d</td>
</tr>
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<td>TG</td>
<td>10.6</td>
<td>21.2</td>
<td>140.7 d</td>
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<tr>
<td>TGGz</td>
<td>9.3</td>
<td>18.3</td>
<td>121.9 d</td>
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<td>TGz³</td>
<td>4.3</td>
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### Black Oak BAI (LSMean values)

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<td>16.2</td>
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<td>-5.4 d</td>
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<tr>
<td>T</td>
<td>18.9</td>
<td>25.2</td>
<td>37.8 e</td>
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<tr>
<td>TG</td>
<td>19.3</td>
<td>22.4</td>
<td>23.5 e</td>
</tr>
<tr>
<td>TGGz</td>
<td>16.6</td>
<td>25.4</td>
<td>45.9 e</td>
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<tr>
<td>TGz³</td>
<td>9.9</td>
<td>12.9</td>
<td>34.3 e</td>
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1 C=Control; T=Forest Thin Only; TG=Forest Thin, Grass Established; TGGz=Forest Thin, Grass established, Grazed; TGz=Forest Thinned, No Grass, Grazed
Response of underplanted white oak regeneration to an upland silvopasture practice

Purpose: to report on the response of containerized RPM® white oak seedlings to grass and cattle grazing, and to test differences in seedling survival and growth in response to the applied treatments.
80 RPM® seedlings were established per treatment in November 2004 using an auger. All seedlings were caged.

Annual Measurements:

Survival – seedling was either alive or dead.
Caliper (c) was measured at approx. 1-inch above ground line.
Height (h) was measured from ground line to tip of the tallest living bud.
Volume (V) was calculated as $c^2 \times h$

Hypotheses:

1. There are no significant differences in survival of underplanted seedlings among treatments.
2. There are no significant differences in annual volumes of underplanted seedlings among treatments.
3. There is no significant difference in seedling volume growth among treatments.
Table 4.3 -- Comparison of percentage survival for underplanted RPM® white oak seedlings by treatment.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>n</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
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<td>C³</td>
<td>80</td>
<td>100(^1) a(^2)</td>
<td>98.8 a</td>
<td>85.0 a</td>
<td>72.5 b</td>
<td>68.8 b</td>
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<tr>
<td>T</td>
<td>80</td>
<td>100 a</td>
<td>100 a</td>
<td>95.0 a</td>
<td>91.3 a</td>
<td>88.8 a</td>
</tr>
<tr>
<td>TG</td>
<td>80</td>
<td>100 a</td>
<td>97.5 a</td>
<td>95.0 a</td>
<td>90.0 a</td>
<td>83.8 a</td>
</tr>
<tr>
<td>TGGz</td>
<td>80</td>
<td>100 a</td>
<td>96.9 a</td>
<td>93.8 a</td>
<td>88.8 a</td>
<td>88.8 a</td>
</tr>
<tr>
<td>TGz</td>
<td>80</td>
<td>100 a</td>
<td>97.5 a</td>
<td>95.0 a</td>
<td>87.5 a</td>
<td>86.3 a</td>
</tr>
</tbody>
</table>

\(^1\) Percentage computed based on the annual number of surviving RPM® seedlings out of 80 planted per treatment.

\(^2\) Treatments within a column with the same letters are not significantly different at alpha = 0.05.

\(^3\) C=Control; T=Forest Thin Only; TG=Forest Thin, Grass Established; TGGz=Forest Thin, Grass established, Grazed; TGz=Forest Thinned, No Grass, Grazed
## Table 4.4 -- Comparison of LSMean volume (in³) of RPM® white oak seedlings by treatment and year.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>n</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>C²</td>
<td>80</td>
<td>6.5 ad¹</td>
<td>9.4 be</td>
<td>8.9 ae</td>
<td>8.3 ae</td>
<td>8.7 ae</td>
</tr>
<tr>
<td>T</td>
<td>80</td>
<td>7.3 d</td>
<td>12.5 b</td>
<td>15.6 f</td>
<td>19.5 h</td>
<td>25.5 i</td>
</tr>
<tr>
<td>TG</td>
<td>80</td>
<td>7.2 d</td>
<td>11.8 b</td>
<td>15.1 fg</td>
<td>18.8 h</td>
<td>22.9 i</td>
</tr>
<tr>
<td>TGGz</td>
<td>80</td>
<td>6.8 ad</td>
<td>10.7 b</td>
<td>12.4 befg</td>
<td>12.9 b</td>
<td>15.9 c</td>
</tr>
<tr>
<td>TGz</td>
<td>80</td>
<td>6.7 ad</td>
<td>10.4 b</td>
<td>11.4 beg</td>
<td>12.8 bc</td>
<td>15.2 c</td>
</tr>
</tbody>
</table>

¹ Treatments within a row or within a column with the same letters are not significantly different at alpha = 0.5

² C=Control; T=Forest Thin Only; TG=Forest Thin, Grass Established; TGGz=Forest Thin, Grass established, Grazed; TGz=Forest Thinned, No Grass, Grazed
Regeneration

1. Seed

2. Seedlings (existing or planted)

3. Stump Sprouts

The key will be protection & weed control !!!
Outline

- Silvopasture Defined
- Historical Context
- Components of Success
  - Livestock husbandry
  - Pasture management
  - Forest management
- Integrating the Components
- Planning and Monitoring
- Overall Potential for Adoption
Applied Silvopasture research conducted at HARC
Ran side-by-side test for 2 years to determine the feasibility of introducing silvopasture as part of a whole-farm forage-livestock system.

Two Treatments:
1. *Traditional* “open” pastures with limited shade
2. *Integrated* silvopasture x open pasture where 25% of the pasture area is silvopasture and 75% of the pasture area is a traditional open pasture
Insight from New Research

Summary of Findings (Dr. R.L. Kallenbach, University of Missouri)

• Cows in the Integrated (silvopasture and open paddocks) system
  Lost approximately 10% less weight over winter
  Had less stress at calving
  Weaned heavier calves

• Overall returns in the Integrated system were about $42.63 per pair greater than in the Traditional (no silvopasture paddocks)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Cow BW loss over winter (lbs)</th>
<th>Calving Difficulty %</th>
<th>Calf Weaning Weight (lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional</td>
<td>231</td>
<td>17</td>
<td>595</td>
</tr>
<tr>
<td>Integrated</td>
<td>205</td>
<td>4</td>
<td>650</td>
</tr>
<tr>
<td>p value</td>
<td>0.02</td>
<td>0.04</td>
<td>0.01</td>
</tr>
<tr>
<td>$ value</td>
<td>$16.89</td>
<td>-</td>
<td>$25.74</td>
</tr>
</tbody>
</table>
Silvopasture:
- Forages start growth earlier in spring, continue later in fall
- Forage yields higher in heat of summer
Develop “silvopasture systems” that landowners can easily implement and profitably use to produce livestock products and high-quality forest products simultaneously.
The Grazing Systems Program: why?

Benefits of rotational grazing

- Improved *legume persistence*
- Reduced *N fertilizer* requirement
- Better *manure distribution*
- Reduced *P & K fertilizer* requirement
- Increased *forage quality*
- Increased *carrying capacity*
- Other benefits
  - Feed budgeting
  - Checking cattle

<table>
<thead>
<tr>
<th>Grazing period</th>
<th>Rest Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 day</td>
<td>22 day</td>
</tr>
<tr>
<td>3 day</td>
<td>33 day</td>
</tr>
<tr>
<td>4 day</td>
<td>44 day</td>
</tr>
<tr>
<td>5 day</td>
<td>55 day</td>
</tr>
</tbody>
</table>

Flexibility!
Outline

- Silvopasture Defined
- Historical Context
- Components of Success
  - Livestock husbandry
  - Pasture management
  - Forest management
- Integrating the Components
- Planning and Monitoring
Proper forage selection based on grazing plan and light

Proper tree spacing – light management

Proper livestock rotation – grazing plan

Planning leads to success and sustainability!
Understanding and Taking Advantage of – Interactions

Livestock

Tree

Forage
Designing Silvopastoral Systems

In most cases, plan to create and maintain:
- 50% light for cool-season forages
- 50–70% light for warm-season forages.
Planning and Monitoring

Tree Management

**Block Plantings**
- Thin to reduce canopy or plant 200–400 T/ac
- Prune crop trees if needed
- Manage canopy 25–45% WS (40–60% CS)
- Thin every ~5–7 years
- Manage understory for desired composition

**Linear Plantings**
- Plant 200 to 400 T/ac
- Begin pruning 5–7 yrs
- 1st Thinning ~age 10
- Thin ~ every 5 yrs
- Thin ~30–50% trees based on tree canopy competition.
Crown Cover and Light

To better understand how oaks, and their size, canopy and density, influence silvopasture light.

All measurements taken from the center of each treatment, including:

- DBH
- Basal Area
- Hemispherical Photographs & GLA
- Crown measurements

** 6 growing seasons after thinning, canopy has gone from about 50% to close to 70% coverage**
Silvopasture Pitfalls

3 Potential Problem Areas

Forage:
  i. Wrong forage for the light and/or site
  ii. Too much shade

Livestock
  i. Lack of a rotational grazing plan – Overgrazing
  ii. Distance to water (paddock size – water system)

Trees
  i. Wrong tree for the site
  ii. No plan for regeneration
## Importance and Potential

<table>
<thead>
<tr>
<th>State</th>
<th>Forest Land¹</th>
<th>Farm Woodland²</th>
<th>Woodland Pastured²</th>
<th>Percent of Farm Woodland Pastured²</th>
</tr>
</thead>
<tbody>
<tr>
<td>New York</td>
<td>18,432,000</td>
<td>1,559,522</td>
<td>1,649,585</td>
<td>165,855</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>16,905,000</td>
<td>1,717,791</td>
<td>1,579,829</td>
<td>150,184</td>
</tr>
<tr>
<td>Missouri</td>
<td>13,992,000</td>
<td>4,414,396</td>
<td>4,852,574</td>
<td>1,866,337</td>
</tr>
</tbody>
</table>


Final Comments

Long-term viability of all of our agricultural practices (including forestry) hinges on productivity and the enhanced utilization of resources without their degradation.

Through appropriate combinations of trees, forages, and grazing principles, productivity and resource utilization can be enhanced.

This is Silvopasture.
Questions?

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www.centerforagroforestry.org