SILVOPASTURE
An Agroforestry Practice

-benefits to integrating farm and forest management -

Dusty Walter and Gene Garrett

Special thanks to:

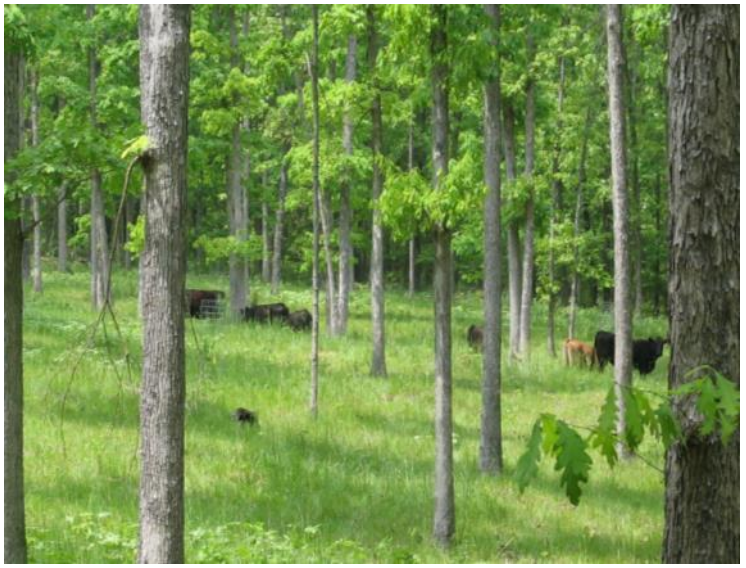
Rob Kallenbach
Mark Kennedy
Larry Godsey
Ranjith Udwata

Outline

- Silvopasture Defined
- Historical Context
- Components of Success
  - *Livestock husbandry*
  - *Pasture management*
  - *Forest management*
- Integrating the Components
- Planning and Monitoring

The Silvopastoral System

Combinations of trees, forages, and grazing principles which are integrated and managed to promote broader resource utilization and enhanced farm productivity.



What Silvopasture is NOT

Grazing unmanaged woodlands is NOT a silvopasture practice!

One or two trees in a pasture … NOT a silvopasture practice.

TWO APPROACHES

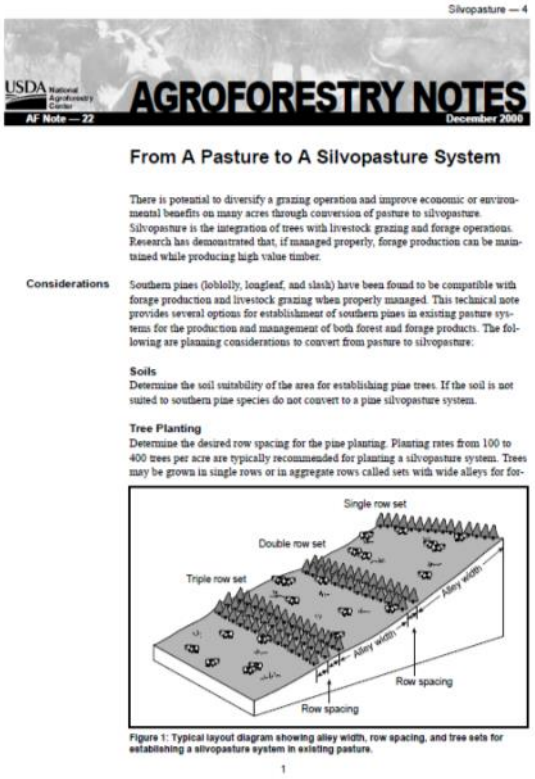
Establish trees in pastures

Establish pastures in trees

Historical Successes

Southern Silvopasture has successfully integrated pine production and grazed forage

http://www.unl.edu/nac/



Silvopasture — 4

USDA National Agroforestry Center

AGROFORESTRY NOTES

AF Note — 22 December 2000

From A Pasture to A Silvopasture System

There is potential to diversify a grazing operation and improve economic or environmental benefits on many acres through conversion of pasture to silvopasture. Silvopasture is the integration of trees with livestock grazing and forage operations. Research has demonstrated that, if managed properly, forage production can be maintained while producing high value timber.

Considerations

Southern pines (loblolly, longleaf, and slash) have been found to be compatible with forage production and livestock grazing when properly managed. This technical note provides several options for establishment of southern pines in existing pasture systems for the production and management of both forest and forage products. The following are planning considerations to convert from pasture to silvopasture:

Soils

Determine the soil suitability of the area for establishing pine trees. If the soil is not suited to southern pine species do not convert to a pine silvopasture system.

Tree Planting

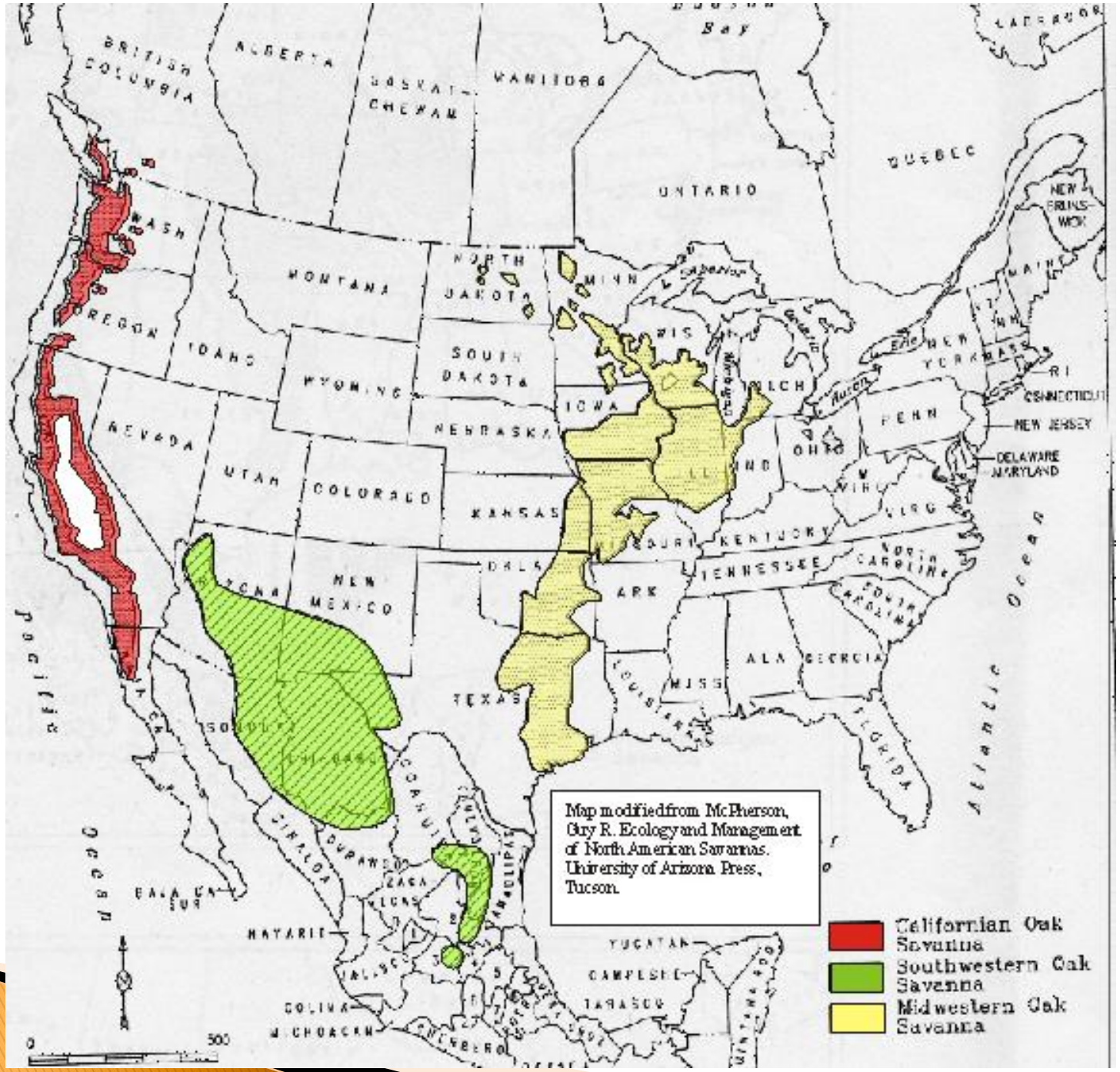
Determine the desired row spacing for the pine planting. Planting rates from 100 to 400 trees per acre are typically recommended for planting a silvopasture system. Trees may be grown in single rows or in aggregate rows called sets with wide alleys for for-

Figure 1: Typical layout diagram showing alley width, row spacing, and tree sets for establishing a silvopasture system in existing pasture.

1

Historical Successes

Midwest Silvopasture has demonstrated short-term success associated with rotationally grazed cool-season forages grown in intensively managed upland oak forests.


Map modified from McPherson, Guy R. Ecology and Management of North American Savannas. University of Arizona Press, Tucson.
Californian Oak Savanna
Southwestern Oak Savanna
Midwestern Oak Savanna
0
500
BRITISH COLUMBIA
ALBERTA
ONTARIO
QUEBEC
MONTANA
OREGON
IDAHO
WYOMING
NEVADA
UTAH
COLORADO
KANSAS
NEBRASKA
TEXAS
NEW MEXICO
OKLAHOMA
MISSOURI
KENTUCKY
TENNESSEE
ILLINOIS
IOWA
OHIO
PENN
NEW YORK
NEW JERSEY
DELAWARE
MARYLAND
CONNECTICUT
RI
FLORIDA
GEORGIA
ALA
MISS
ARK
LOUISIANA
NAYARIT
JALISCO
COLIMA
MICHOACAN
YUCATAN
CAMPECHE
TABASCO
SINALOA
DURANGO
ZACATECAS
COAHUILA
NUEVO LEON
TAMAULIPAS
Pacific Ocean
Atlantic Ocean

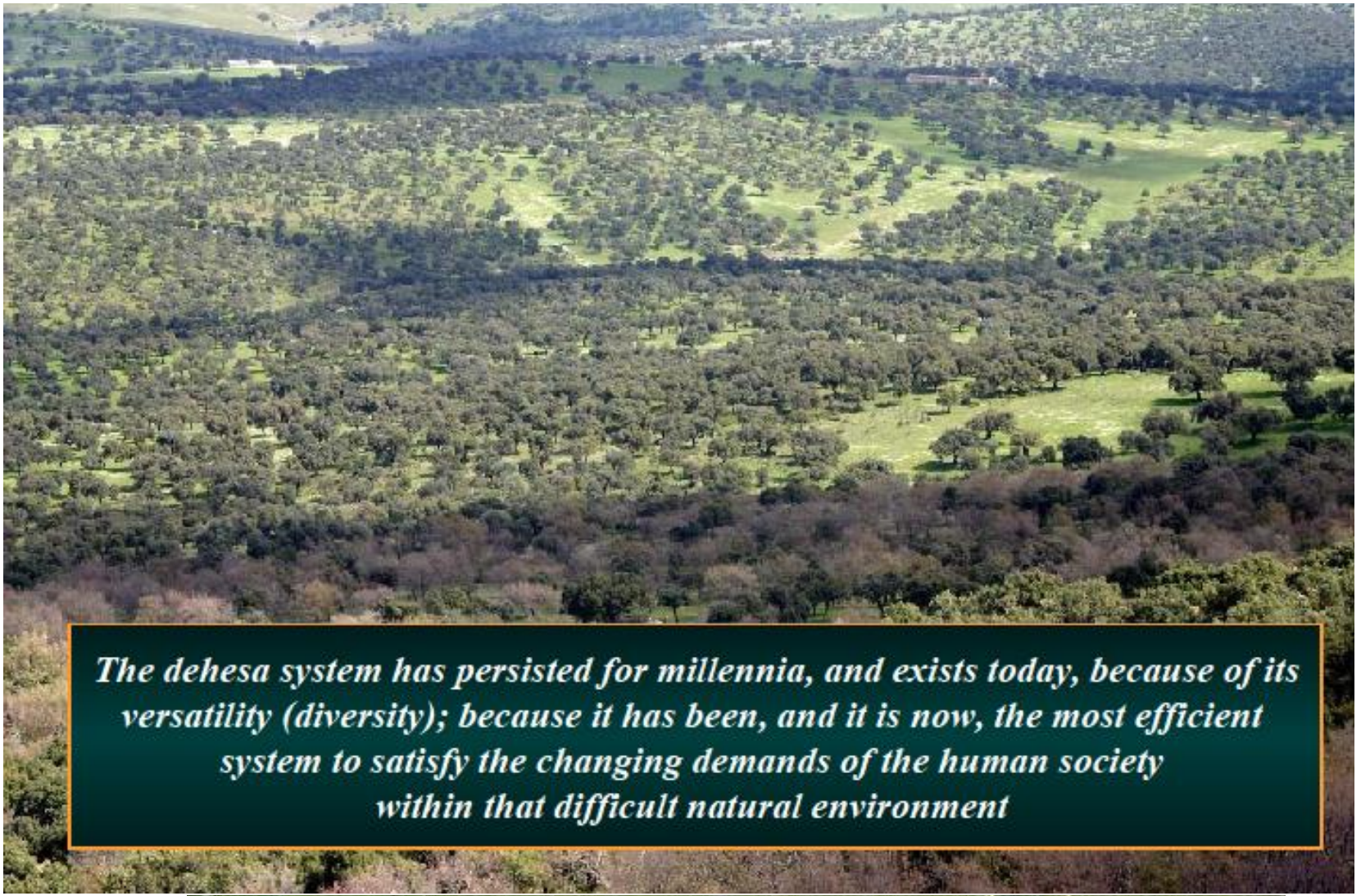
Oak Savannas of the Midwest

Characteristic Species
Black Oak
Hill's Oak
Blackjack Oak
Post Oak

Characteristic Species
Bur Oak
White Oak
Northern Red Oak
Swamp White Oak

- Dry Sites
  - Geographic Gradient
    - Southern Oak Savanna
    - Northern Sands
      - Northern Sand Savanna
    - Eastern Sands
      - Eastern Sand Savanna
- Mesic Sites
  - Poorly Drained
    - Clay-Loam Savanna
  - Moderate to Well Drained
    - Floodplain Sands
      - Floodplains Sand Savanna
    - Loams
      - Mesic Loam Savanna

Historical Successes



Source:

Opening paper. XXIst General Meeting. European Grassland Federation. Badajoz (Spain) April 2006

Prof. Leopoldo Olea-Márquez de Prado. School of Agricultural Sciences. University of Extremadura

Prof. Alfonso San Miguel-Ayanz. School of Forestry. Polytechnic University of Madrid

Components of Success

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 – good and bad

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

NO STRESS

MILD STRESS

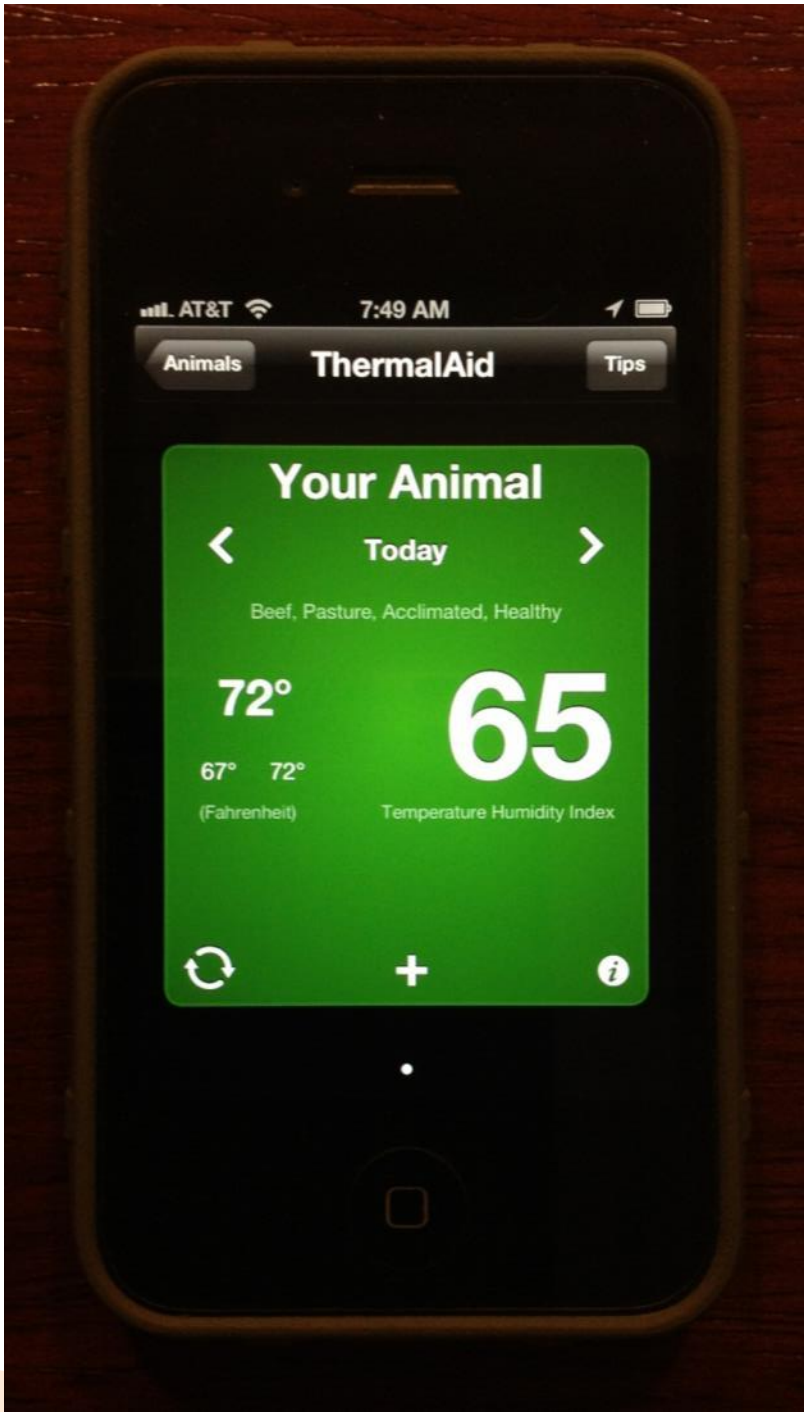
MEDIUM STRESS

SEVERE STRESS

[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.

There's an App for that!



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

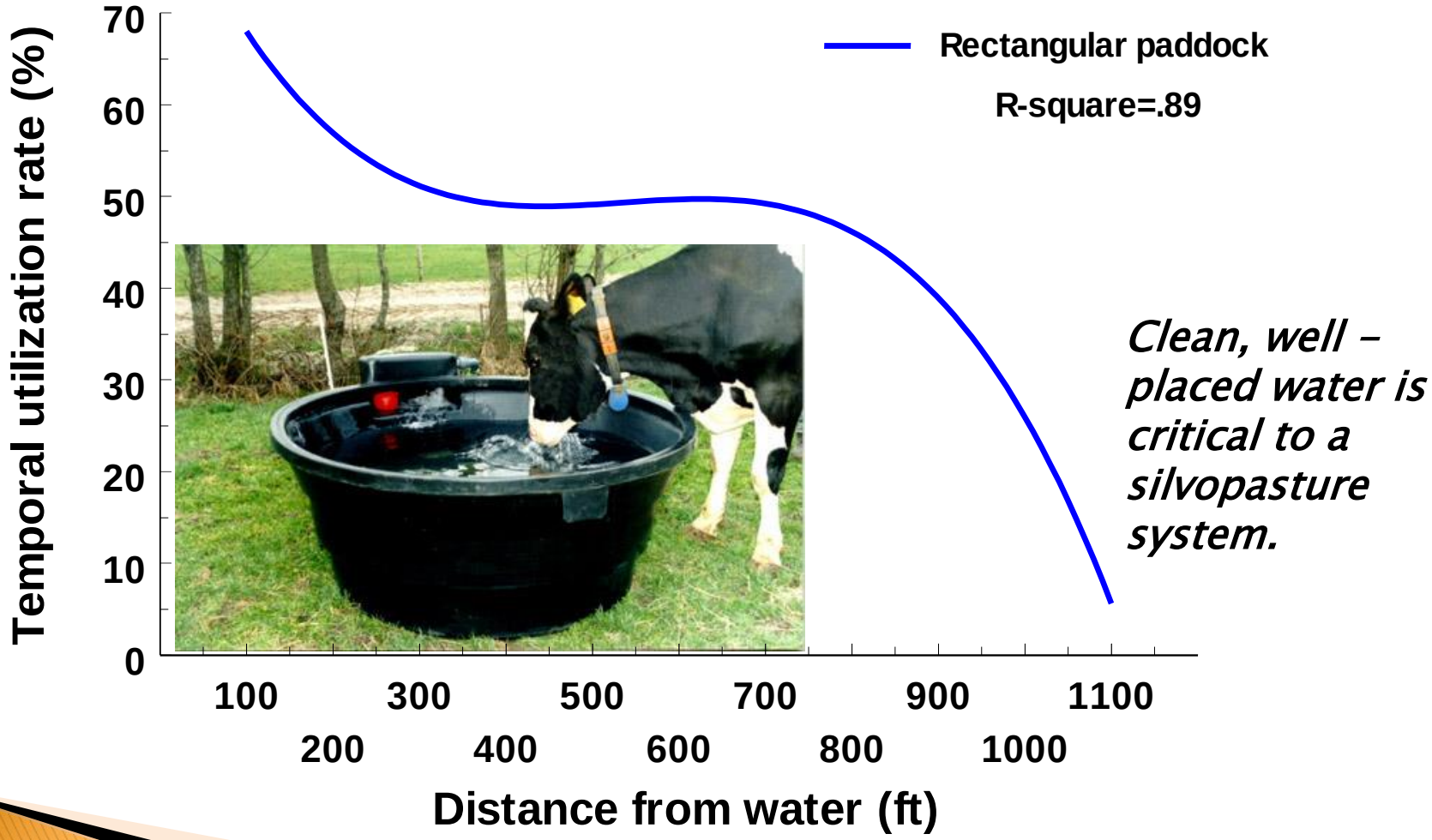
Well Distributed Shade Benefits

- 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

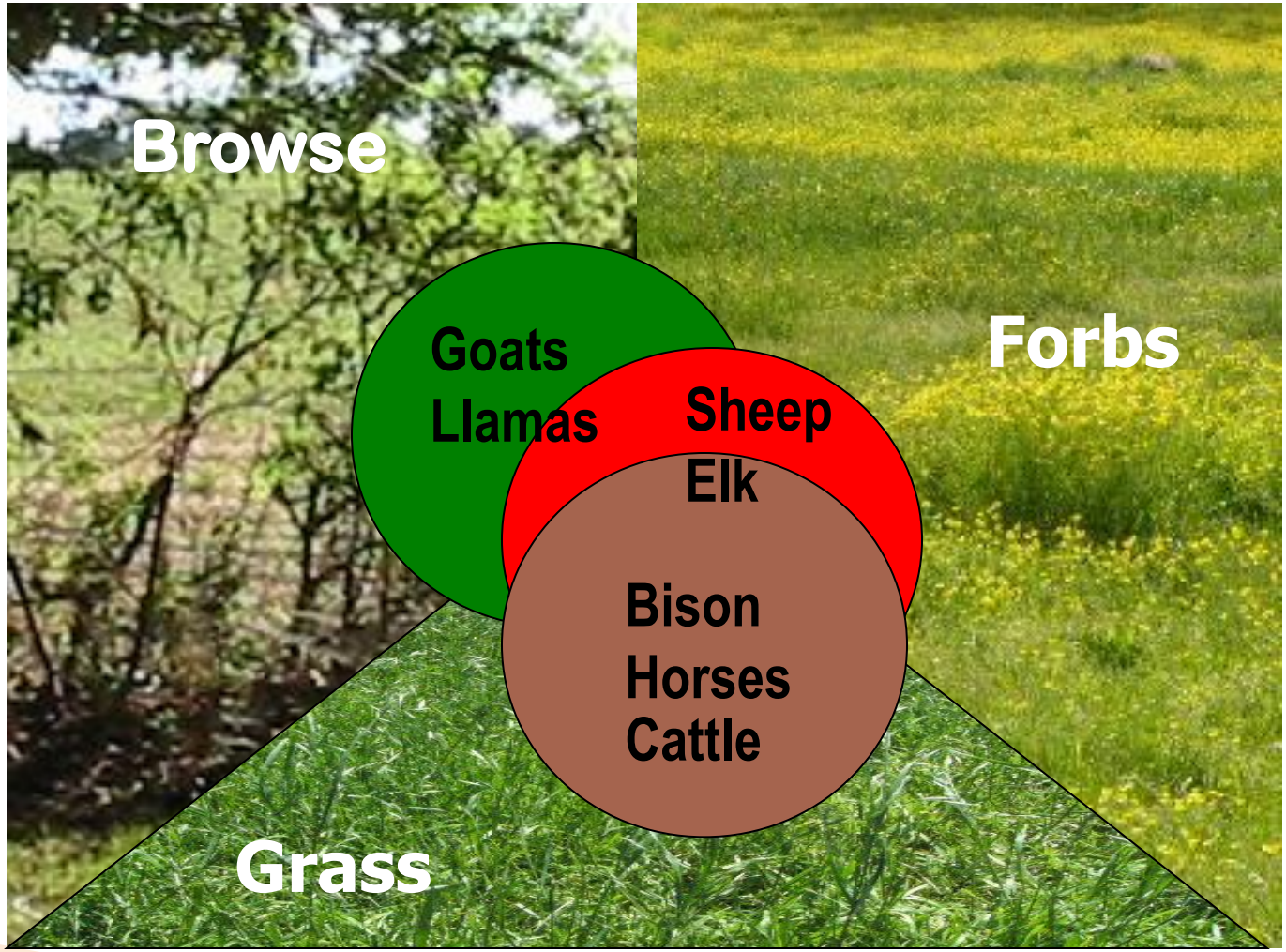
Figure 1. Impact of distance from water on temporal utilization rate in rectangular 10 acre paddocks.



Components of Success

Designing Silvopastoral Systems

--Forage Management --



Forage Response to Light/Shade

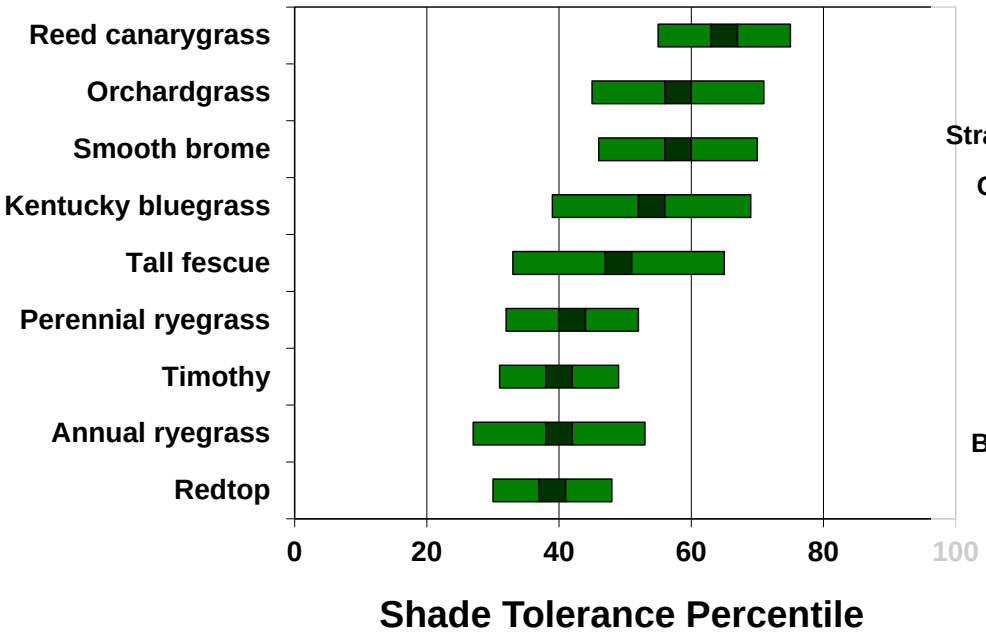
The Effect of Light / Shade

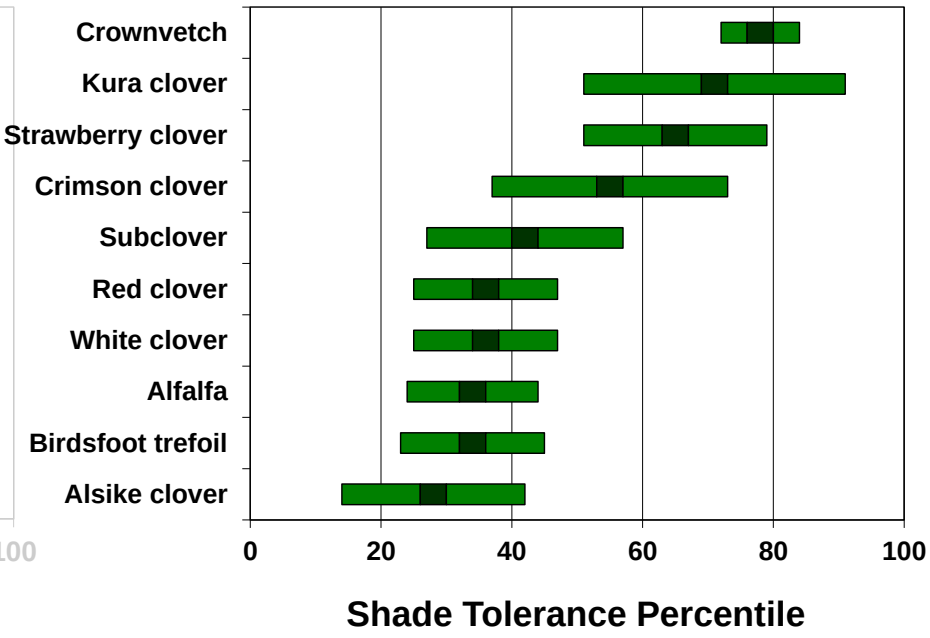
Under 50% shade Cool Season Grasses and Forbs

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

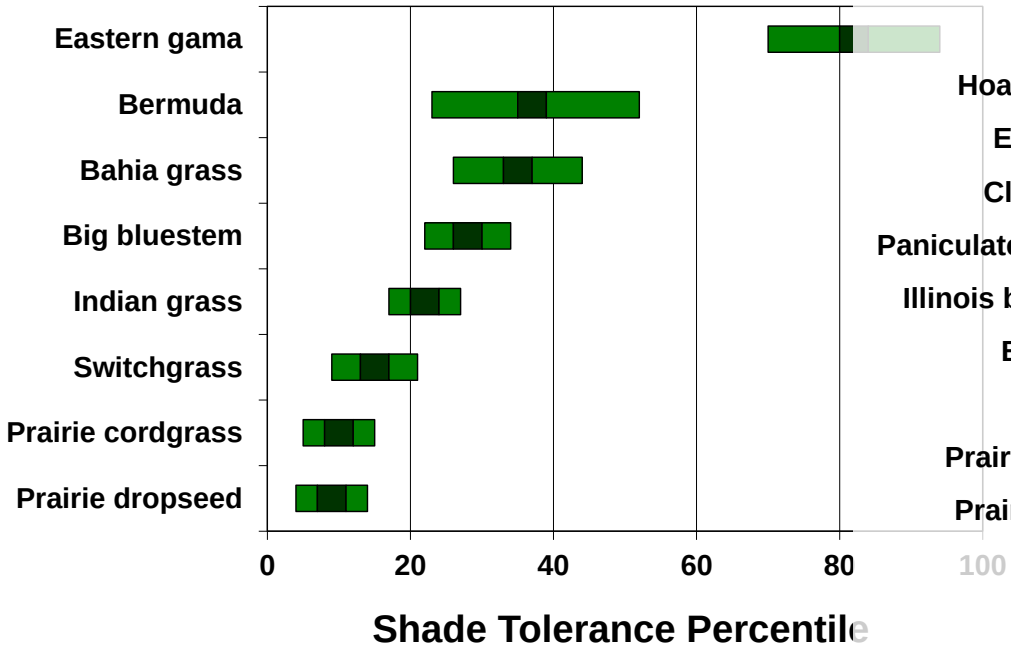
Cool-Season Grasses and Legumes

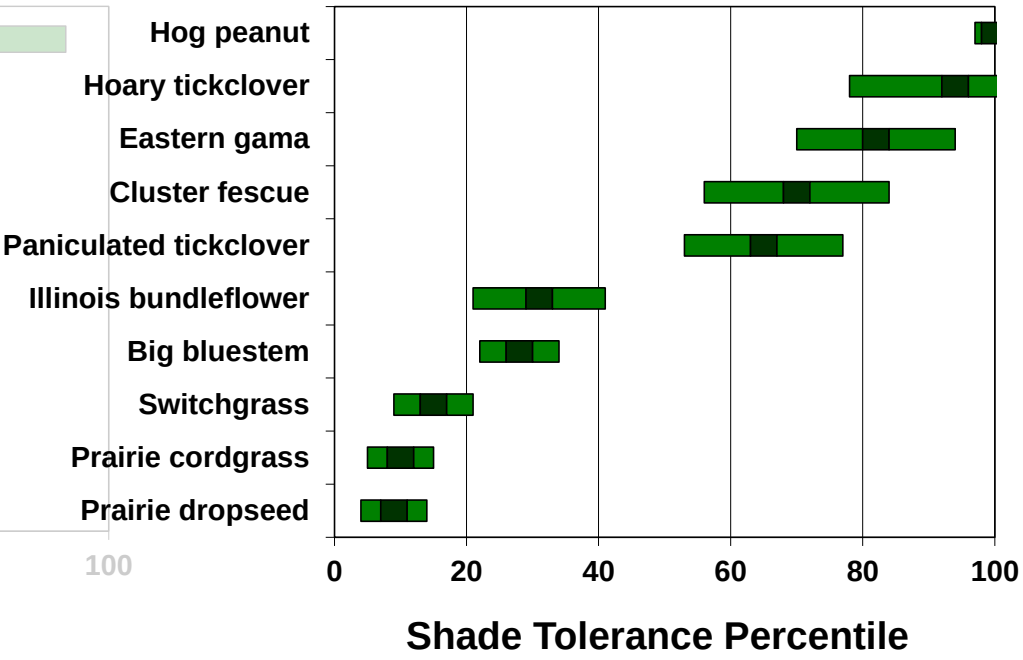




Designing Silvopastoral Systems

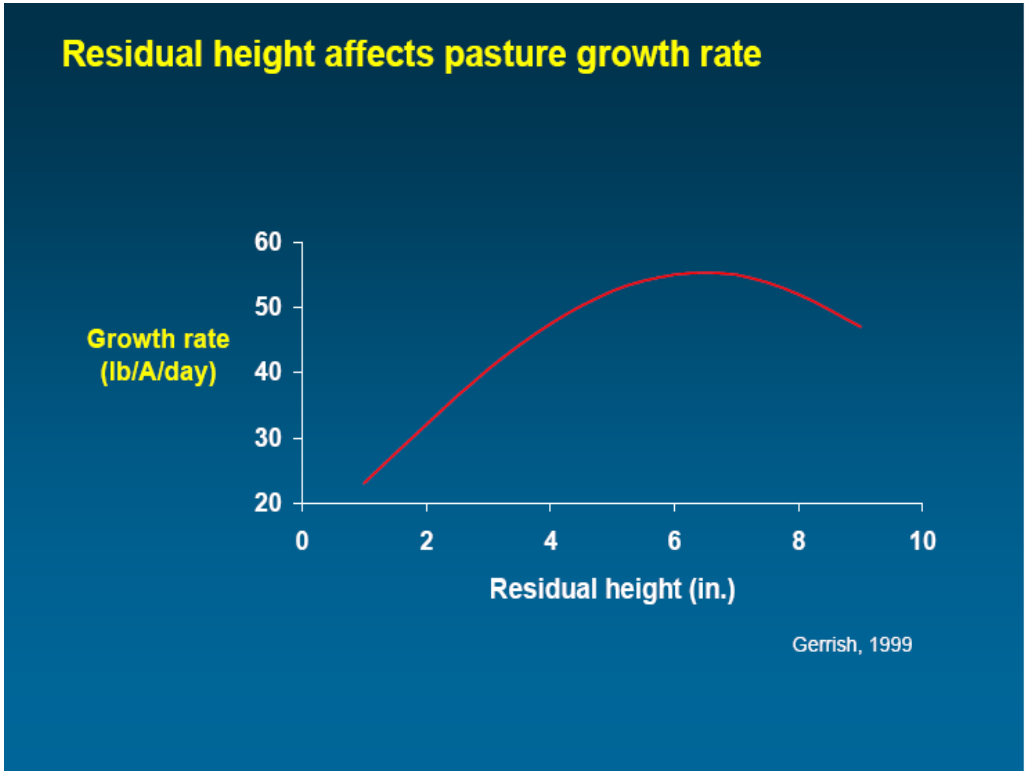
Native Warm-Season Grasses and Legumes



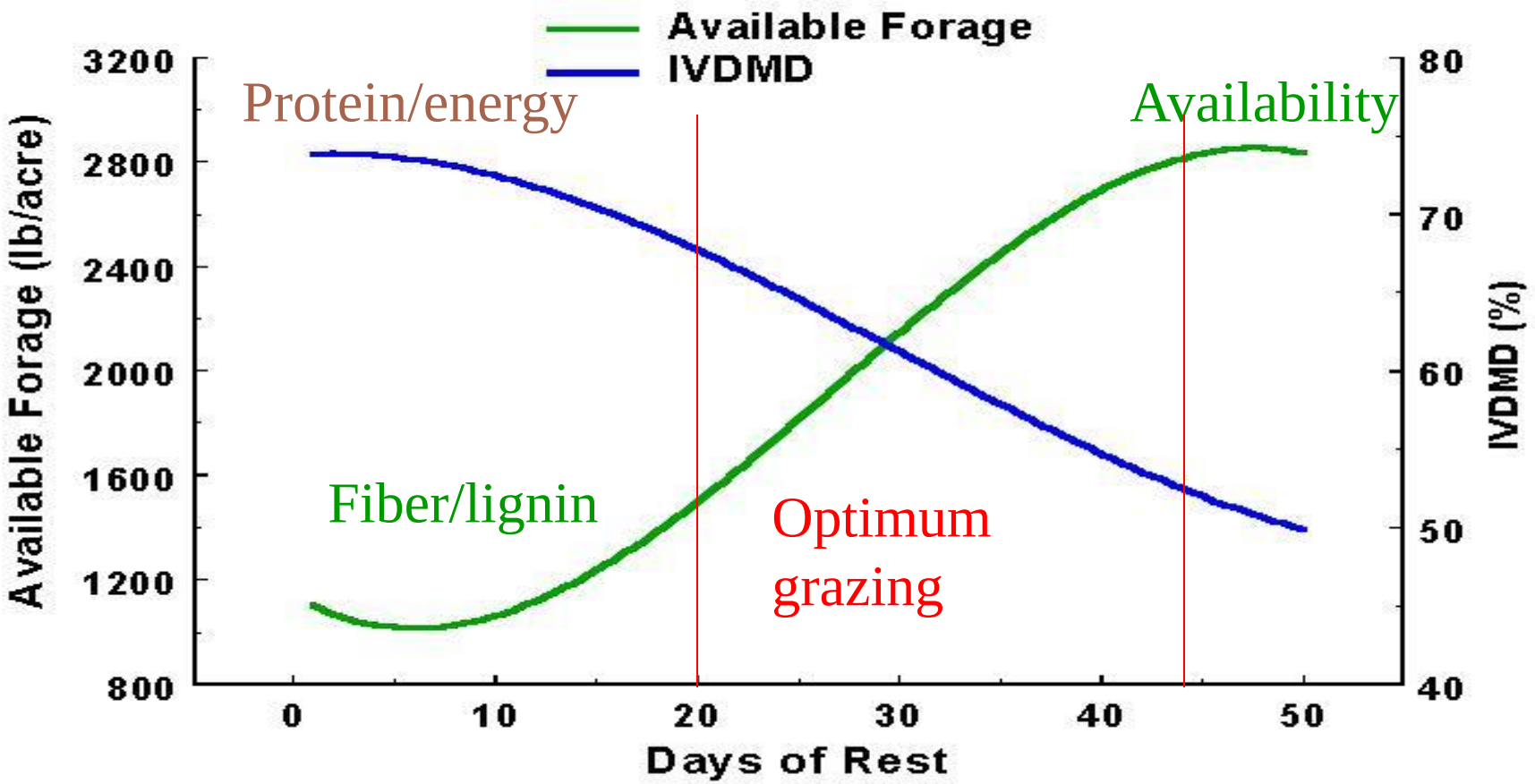


Designing Silvopastoral Systems

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



Optimize Forage Quantity & Quality



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

% Leaf Removed	% Root Growth Stopped
10	0
20	0
30	0
40	0
50	2 to 4
60	50
70	78
80	100
90	100

Components of Success

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.

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.**
   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

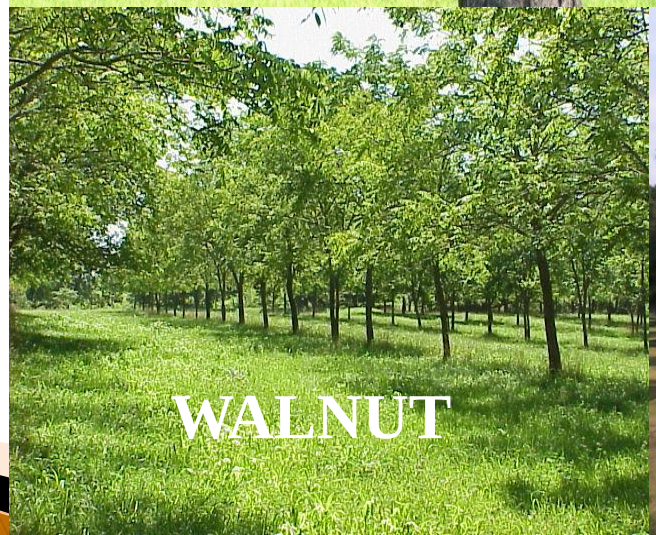
What are the landowners' interests?

Desirable Tree Species

- Loblolly Pine
- Slash Pine
- Longleaf Pine
- Shortleaf Pine
- Black Walnut
- Pecan
- Bur Oak
- Red Oaks
- White Oaks

(Low site oaks)

- Post Oak?
- Hickories?



Silvopasture – Shaded Naturally

Trees into Pastures

1) Select Species appropriate for the site.

2) Weed Control –

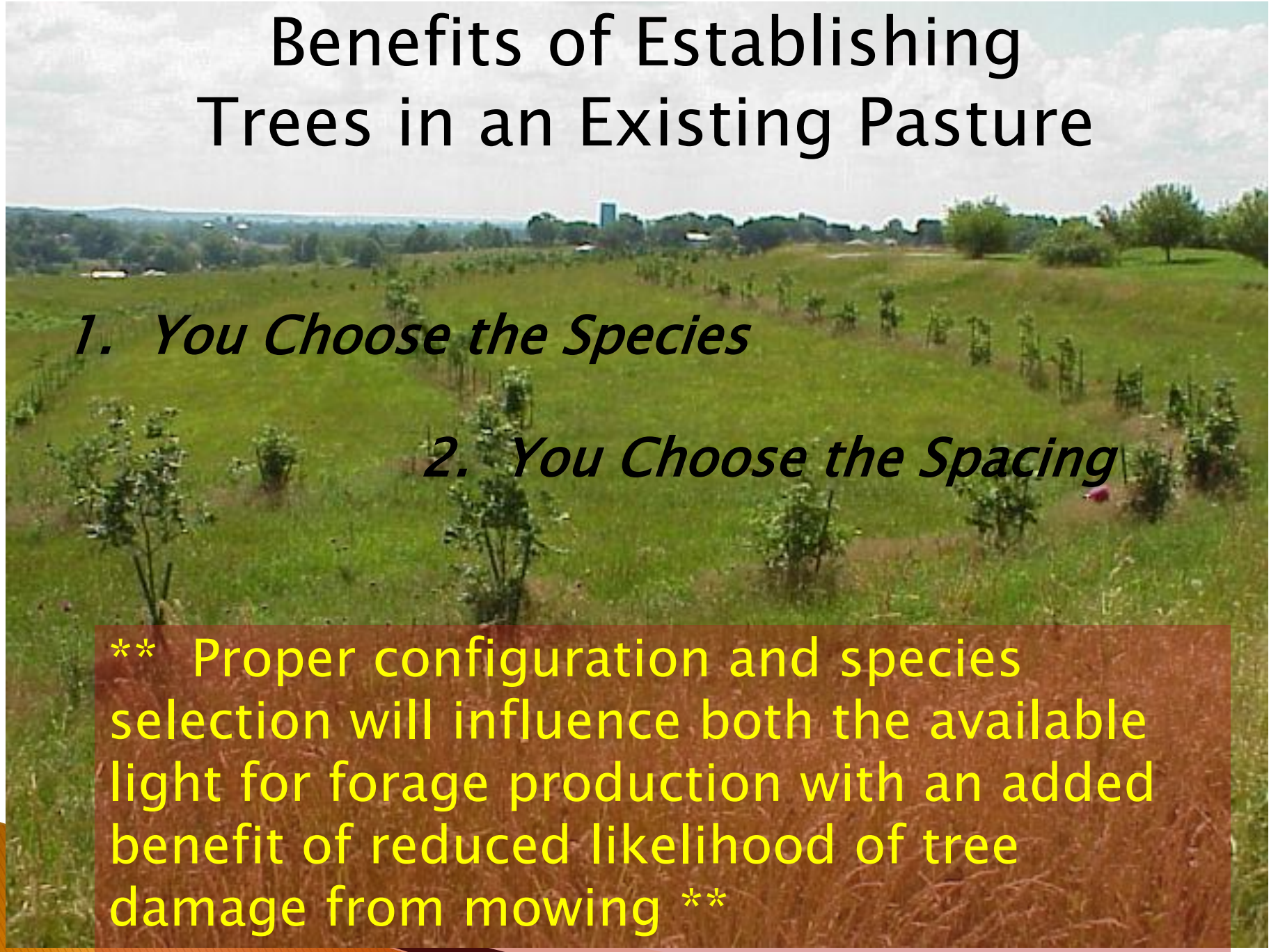
a. Mechanical
b. Herbicide
c. Mulch
   i. Vegetation – living or dead
   ii. Fabric

Silvopasture – Shaded Naturally

Trees into Pastures

1) Select Species appropriate for the site.
2) Weed Control.
3) Protection from Grazing.

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 **

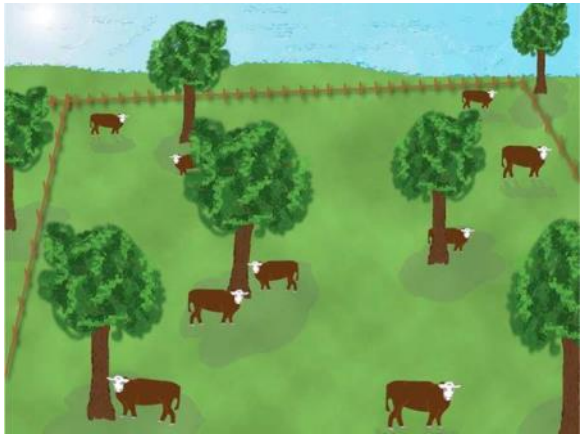
Planting Configurations

Clustered or Grouped Trees

Considerations:

1. Shade Management
2. Mowing
3. Fencing
4. Product growth and harvest

Single Trees



Rows

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

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 ft^2/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

Thin for light

Thin for quality

Other Activities

1. Soil testing
2. Soil amendment
   i. Lime
   ii. Fertilizer
   iii. ?????
3. Grass seeding
4. Regeneration
5. Future thinnings


2003


2005

Percent Increase in White Oak B*asal Area Increment in cm²*

(6-year pre-thin vs. 6-year post-thin)

Treatment	Pre-thin	Post-thin	Percent Increase
Control	76.17	87.14	14.4
Thin With Grass and Grazed	60.13	117.97	**96.2**
Thin With Grass	68.25	137.21	101.0
Thin Only	72.20	153.48	112.6

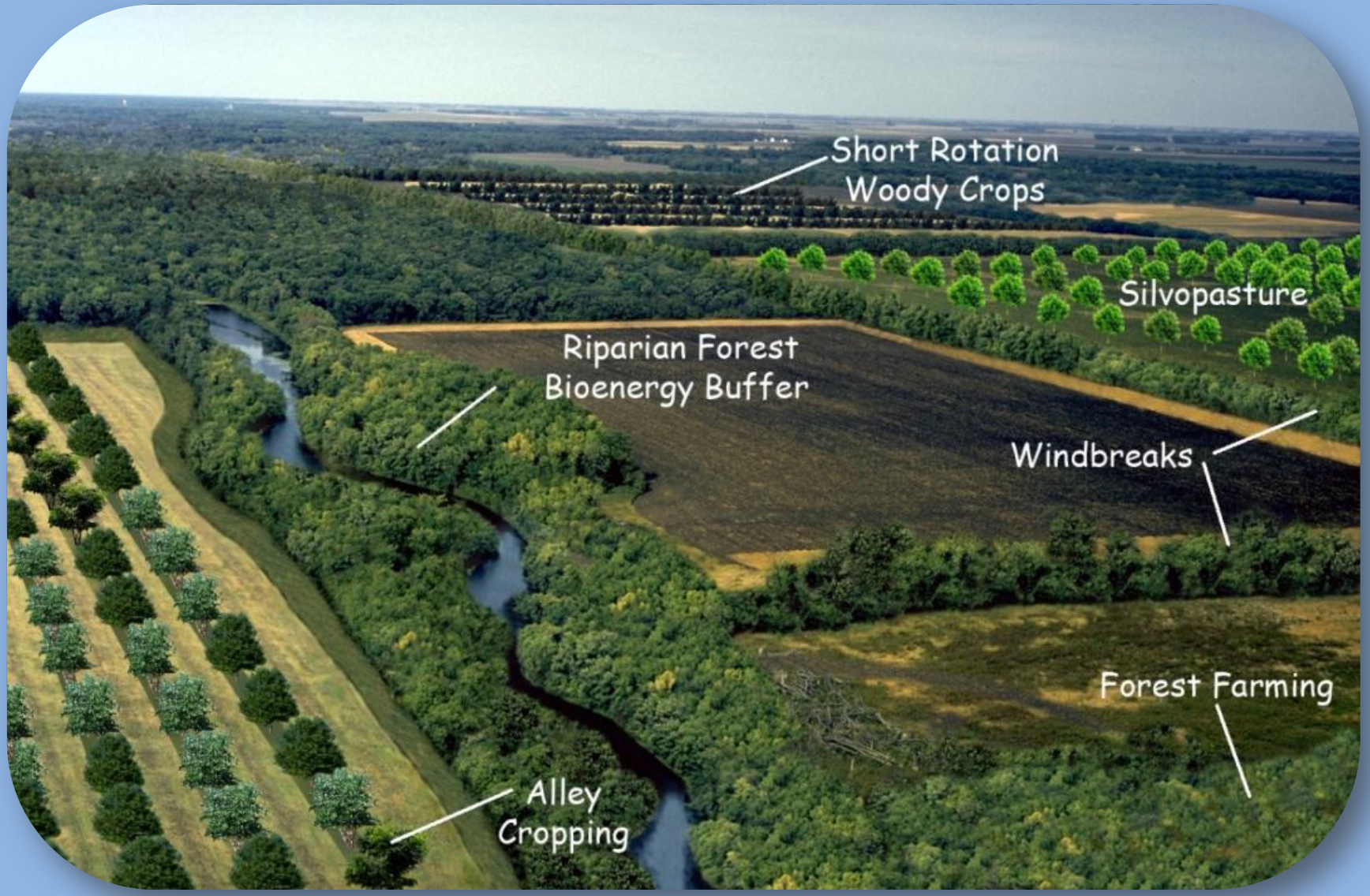
Regeneration

1. Seed
2. Seedlings (existing or planted)
3. Stump Sprouts

Planting Large Containerized Stock Works!

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

Agroforestry as part of a larger agricultural and forested landscape



The Question Is ?

How does silvopasture and buffer management affect:

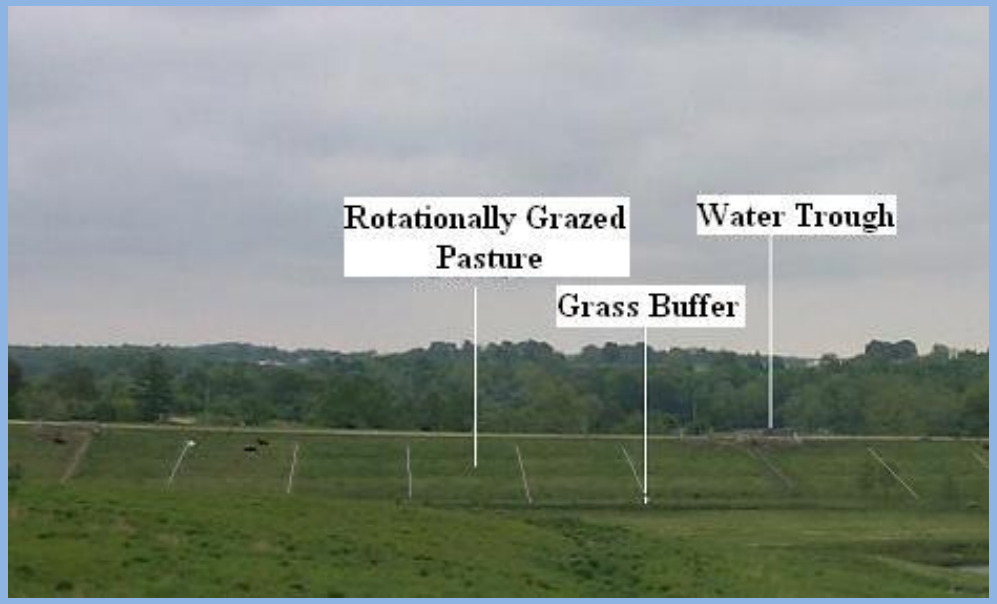
1. Soil features
2. Water quality
3. Air quality

Or Does It ?

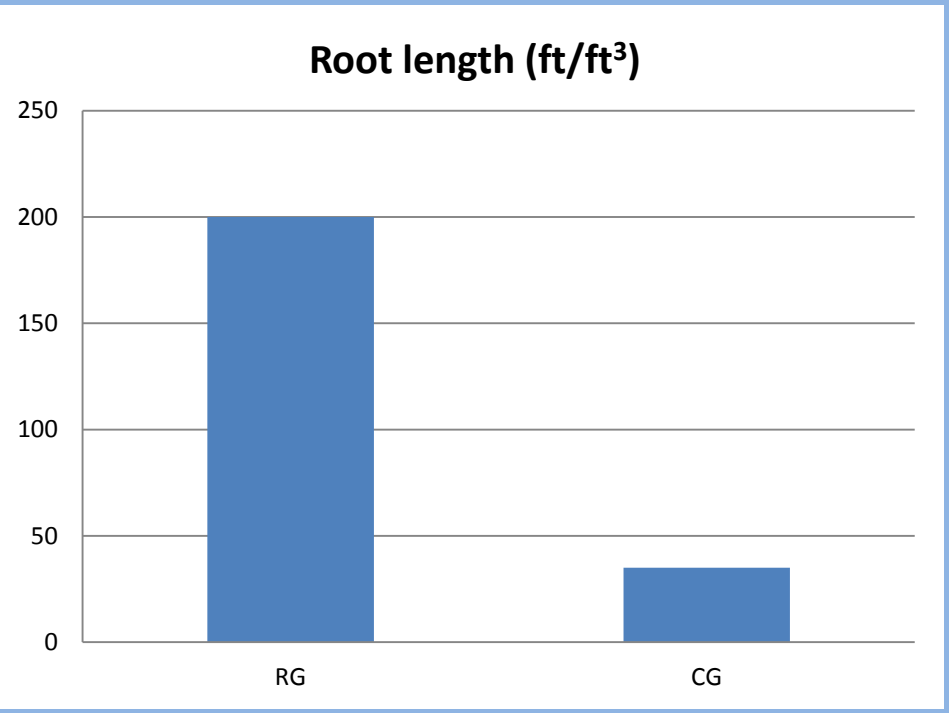
Major Take-home Point

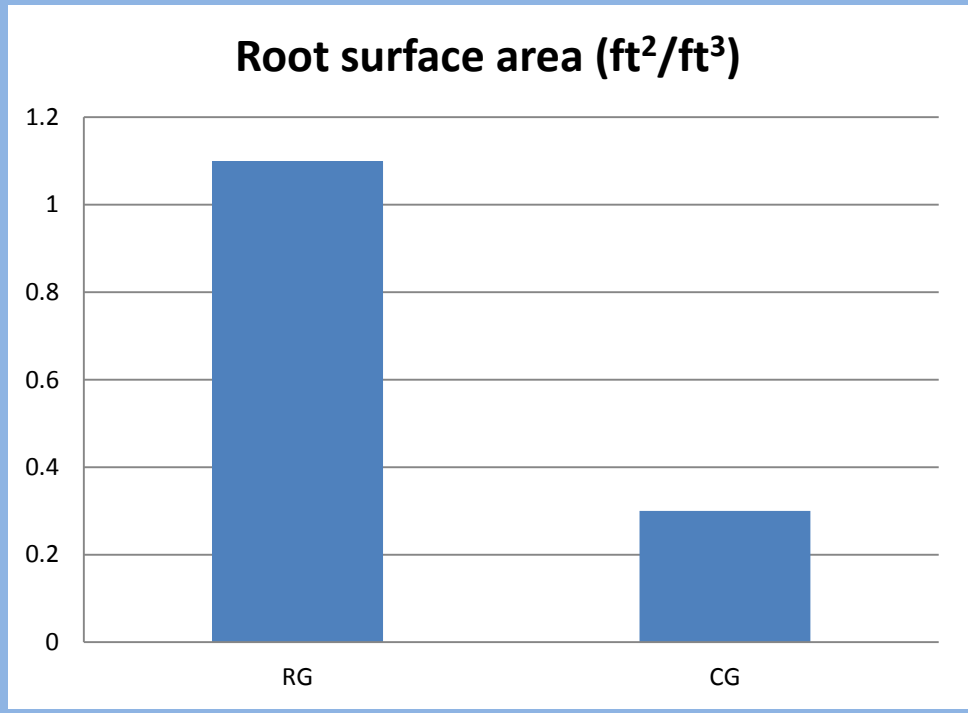
* *Do not* use continuous grazing

Rotational Grazing - - essential for successful Silvopasture Practices!



One consequence of continuous grazing is a reduction in forage root length and surface area

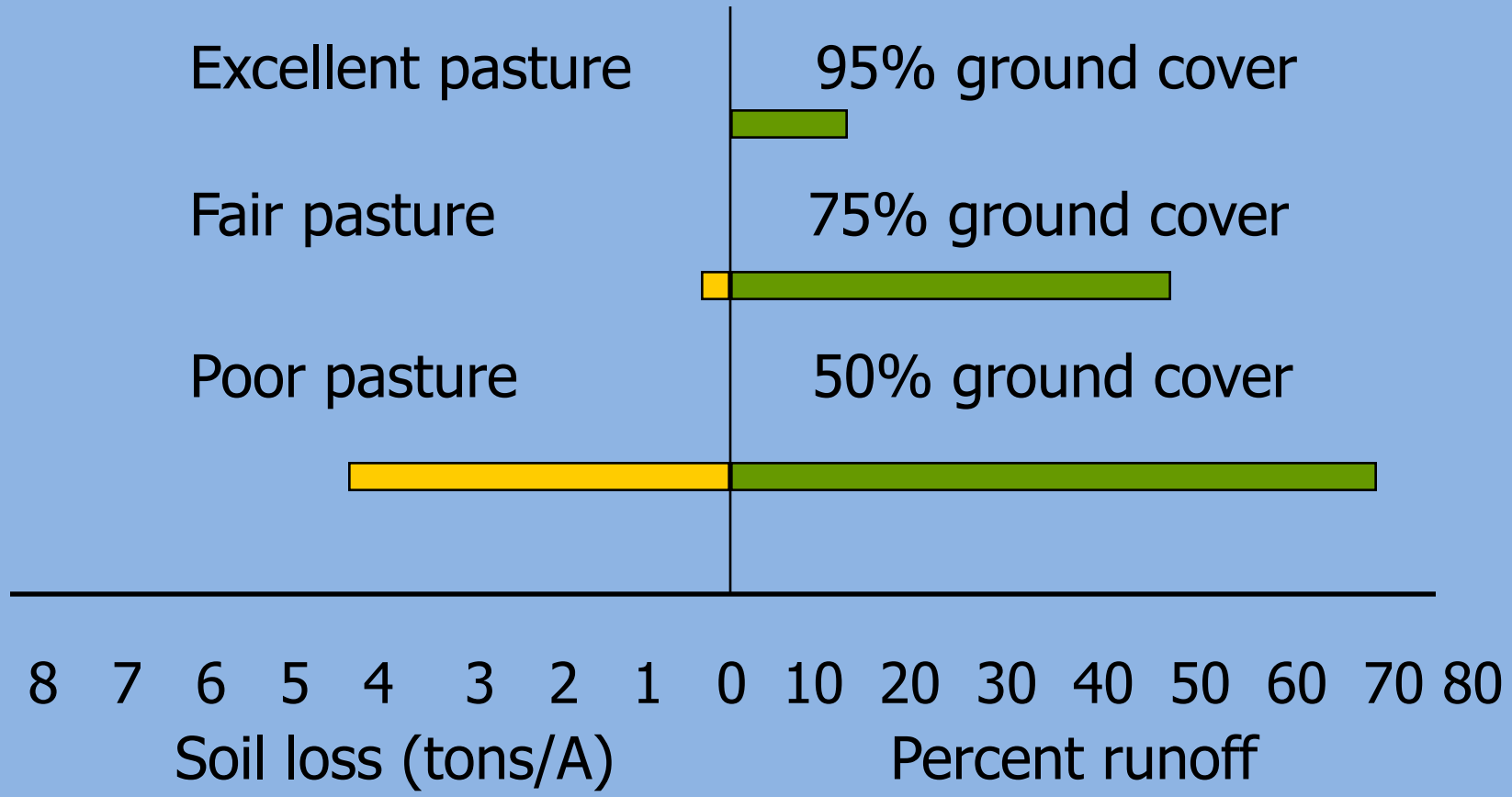




Erosion and Runoff

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

(University of Nebraska & USDA-SCS, 1937)



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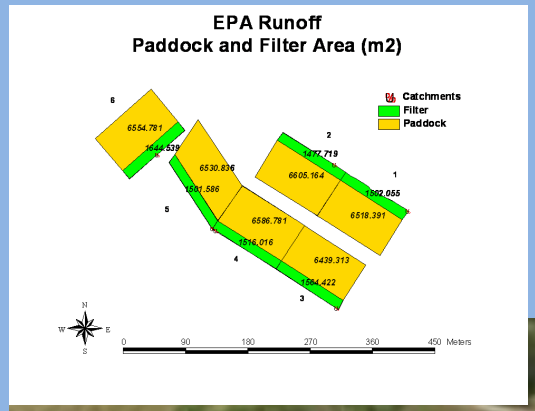


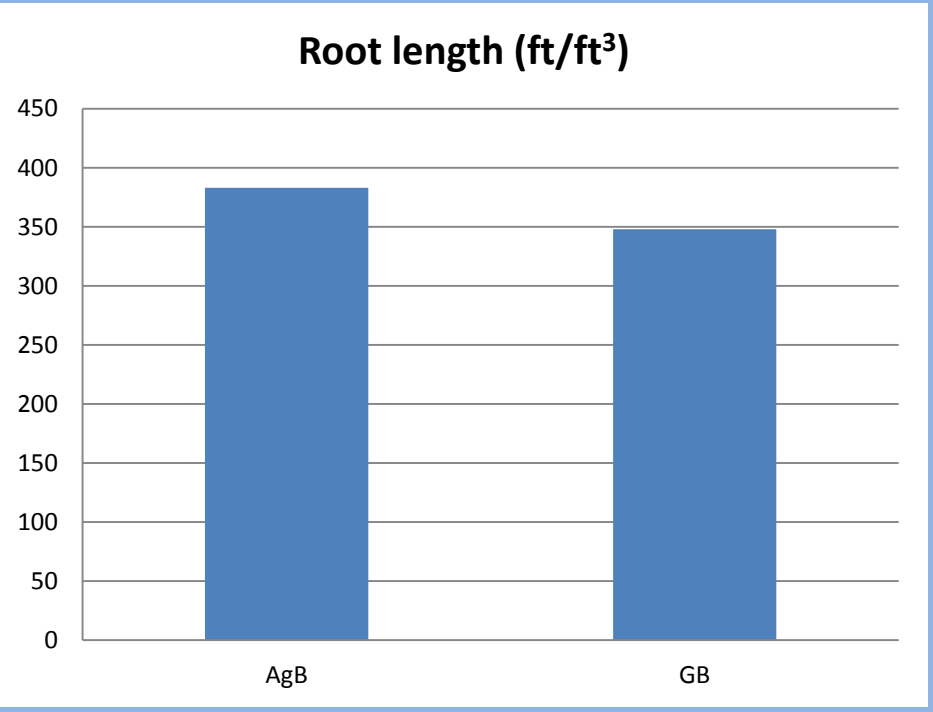
Water Quality and Livestock

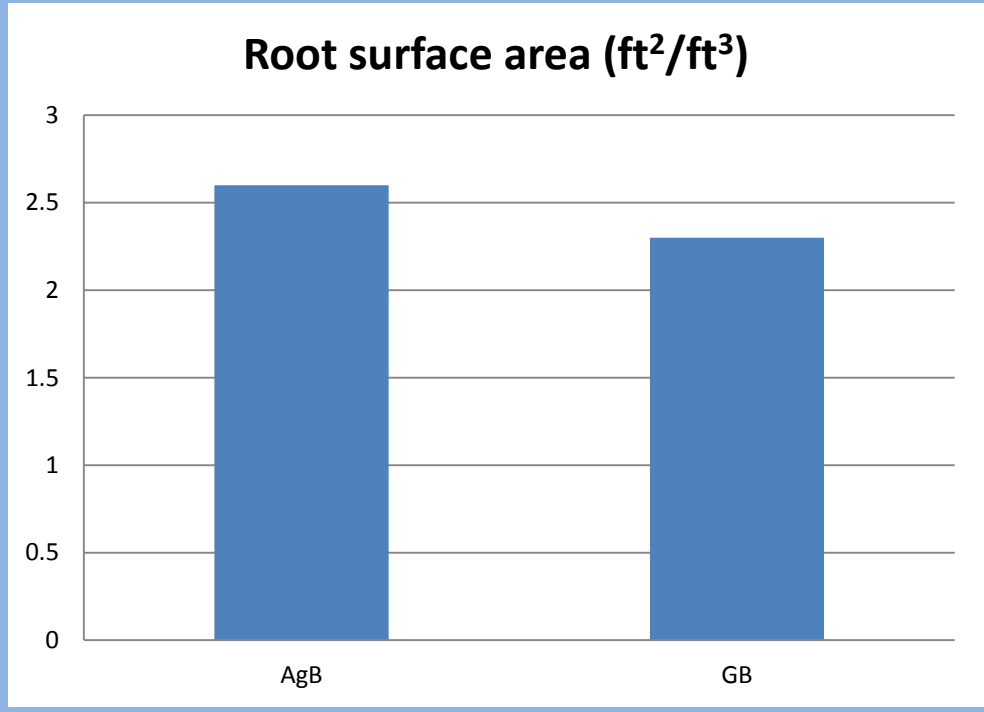
Rhizodegradation of Antibiotics

AgB Treatment

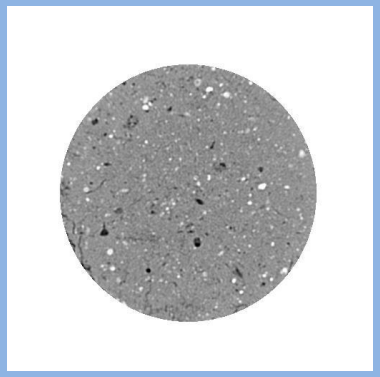
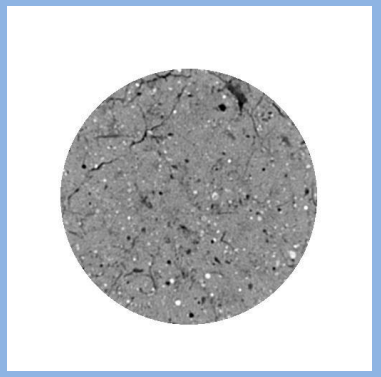
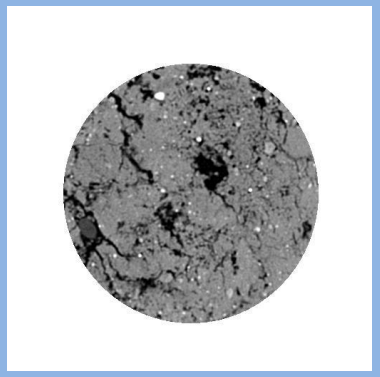
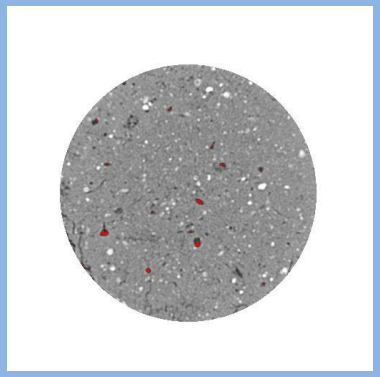
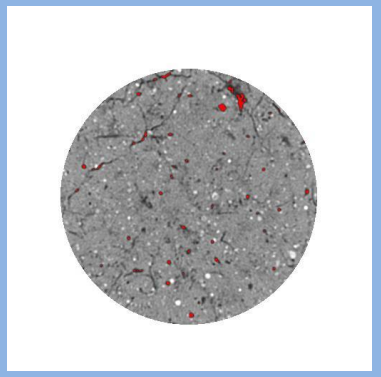
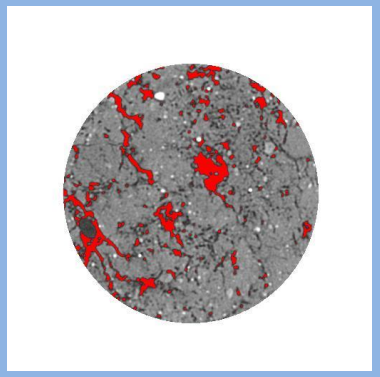
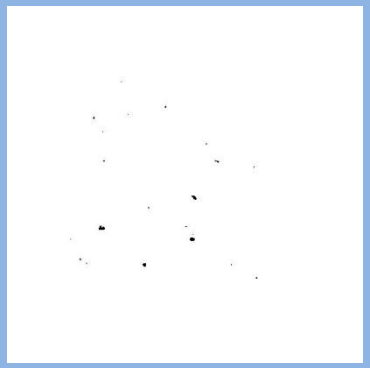
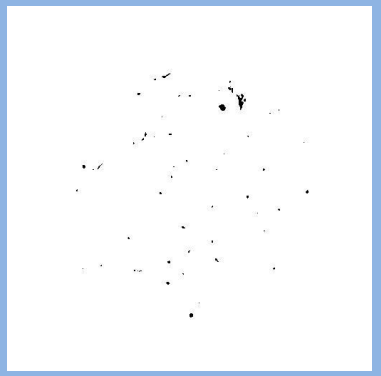
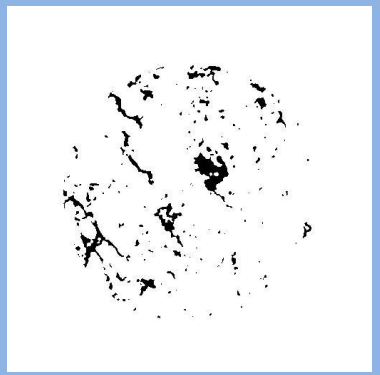

GB
Treatment

A comparison of a tree/grass and a grass buffer root system





Soil Properties and Pore Characteristics as Influenced by Grass and Agroforestry Buffers

	Row crop	Grass buffer	Agroforestry
Typical scan images 2.7 inches diam. area			
After thresholding, air-filled pores are in red			
Isolated pores within the scans			

Udawatta et al., 2006

CONCLUSIONS

Results of this study show that agroforestry and grass buffers improve soil physical properties such as bulk density, hydraulic conductivity, and CT-measured pore parameters.

This relates to a reduction in runoff, nutrient, and sediment loss and improved water quality.

Agroforestry Environmental Services

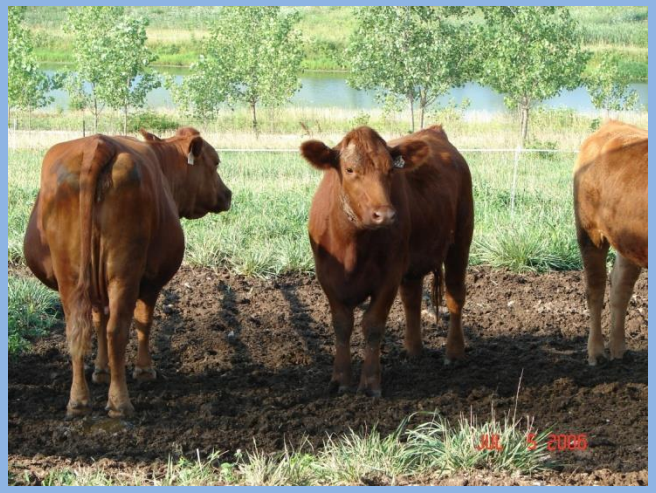
- Agroforestry Buffer Technologies -

Reduction in:	Agroforestry	Grass
Sediment	48%	23%
Total Nitrogen	75%	68%
Total Phosphorous	70%	67%

Agroforestry Buffer

Grass Buffer

Use of Veterinary Antibiotics



- 24 to 35 million lb antibiotics used in US and 70% for non-therapeutic purposes (Levy, 1998; Mellon, 2001)

- 30 – 80% of an antibiotic dose can pass through the GI tract (Elmund, et al., 1971; Levy, 1992)

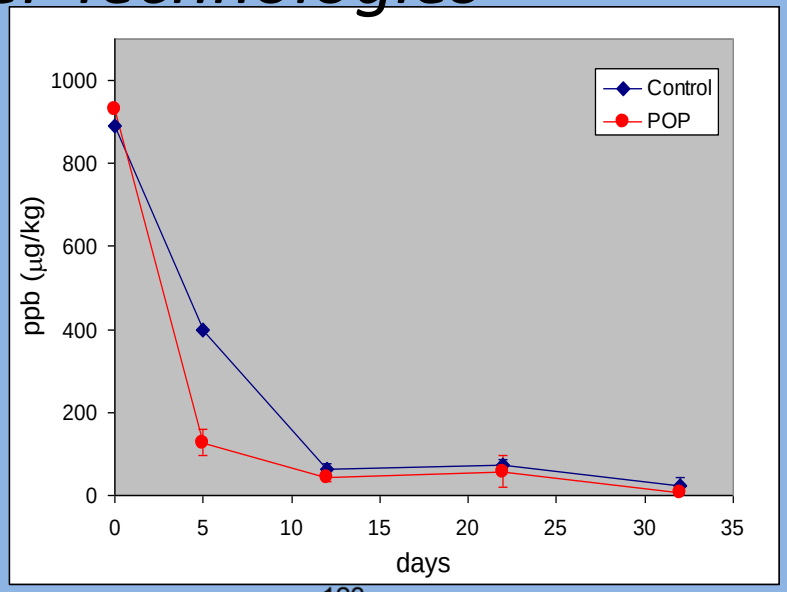
Poplar Buffer

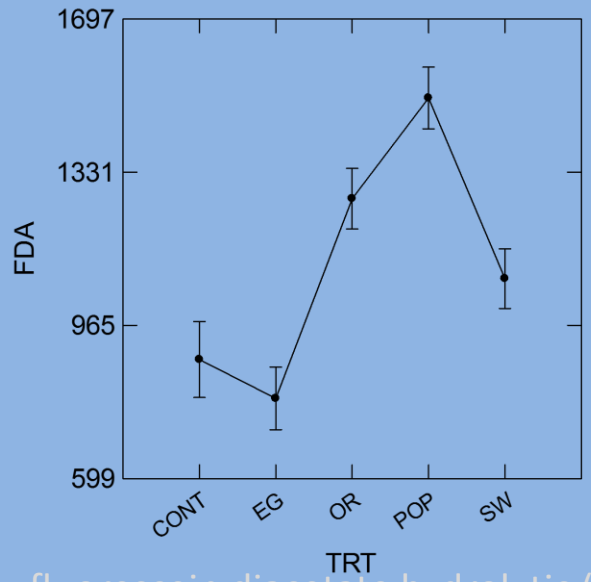
Grass Buffer

Agroforestry Environmental Services

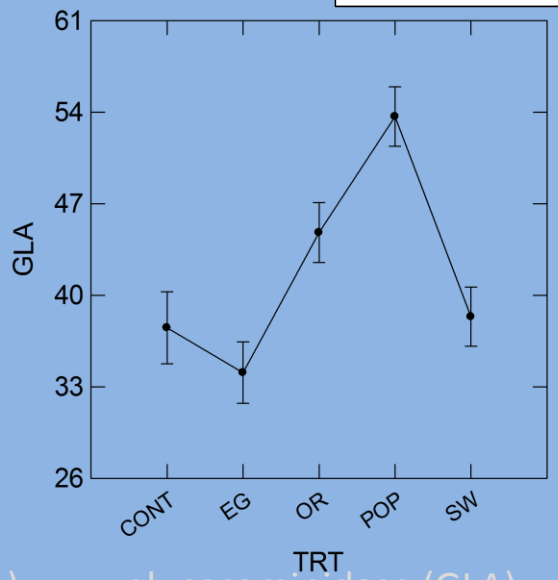
- Agroforestry Buffer Technologies -

Degradation of Veterinary Antibiotics

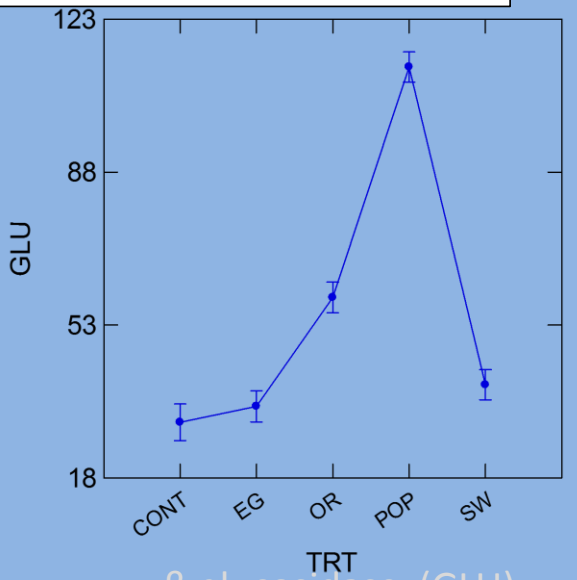




fluorescein diacetate hydrolytic (FDA)



glucosaminidase (GLA)



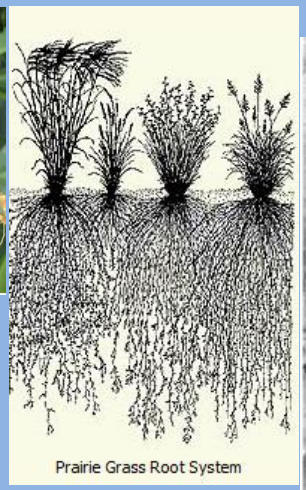
β-glucosidase (GLU)

Carbon Sequestration

Corn

Soybean

Grass



Prairie Grass Root System

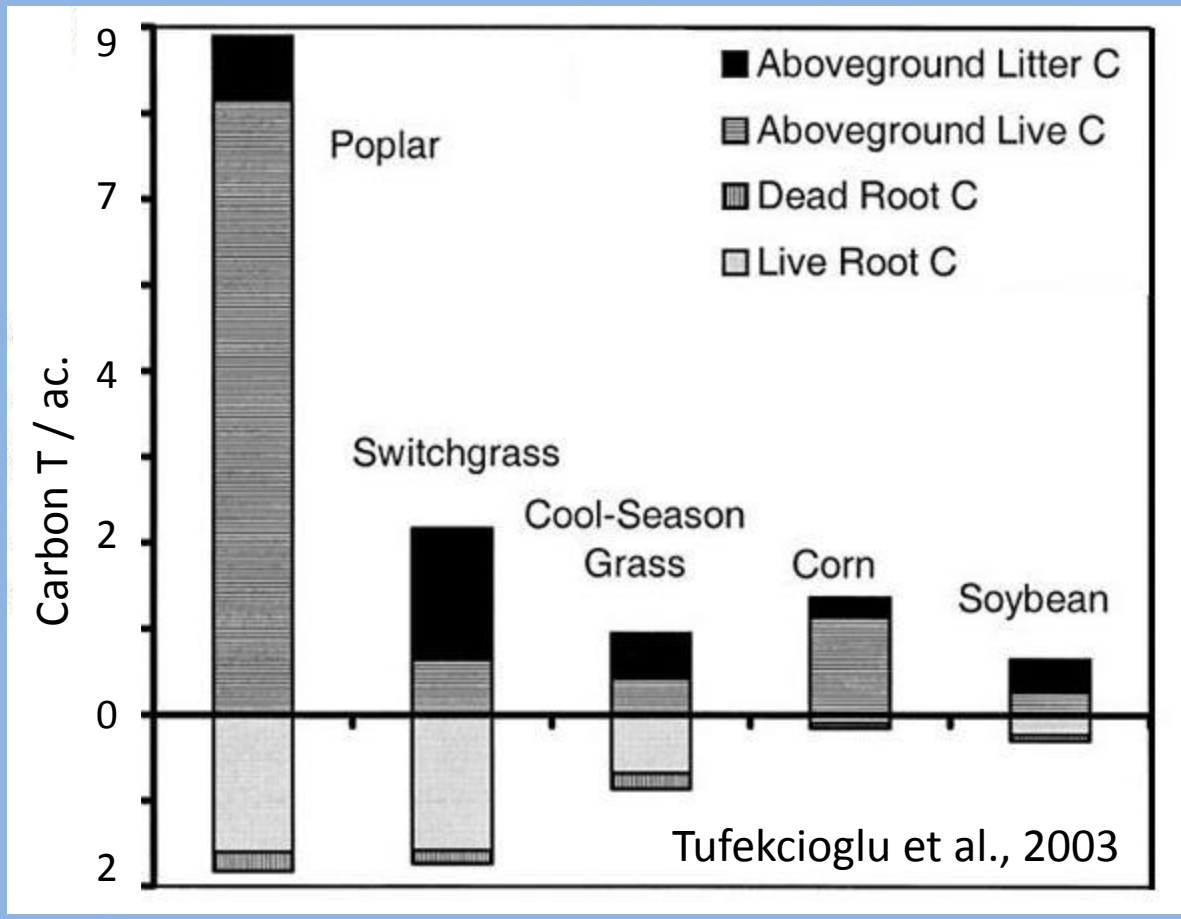
Photo: W.R. Mattoon, 1927

Tree Roots

1. Depth
2. Volume
3. Carbon form (recalcitrant)
4. Root exudates (leaching)
5. Root Turnover (33% NPP fine root)

6. Associated microbial communities
   C, exudates, turnover

Silvopasture for Carbon Sequestration



Is Silvopasture Management a Viable Option for Carbon Sequestration?

Table 2.2 – estimated potential annual carbon sequestration for selected changes in land use and production practices in U.S. agriculture (USDA Tech. Bul. TB-1909).

Land-use change or management practice	Estimated per acre sequestration	Total potential sequestration
	Mt per acre	*MMT*
Grazing land:		
Afforestation of pasture	0.73 - 2.09	8 - 22
Rangeland management	0.05 - 0.15	5 - 16
Pasture management:		
Improved use of fertilizers	0.10 - 0.20	2 - 4
Use of organic manure	0.20 - 0.50	3 - 9
Planting of improved species	0.10 - 0.30	1 - 3
Grazing management	0.30 - 1.30	5 - 20

Outline

- Silvopasture Defined
- Historical Context
- Components of Success
  - *Livestock husbandry*
  - *Pasture management*
  - *Forest management*
- Integrating the Components
- Planning and Monitoring

Insight from New Research

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

Treatment	Cow Body Weight loss over winter (lbs.)		Calf Weaning Weight (lbs.)		Calving Difficulty (%)
	2007	2015 Price (last wk April)	2007	2015 Price (last wk April)	2007
Traditional	231	$370.755	595	$1362.95	17
Integrated	205	$329.025	650	$1429.38	4
p-value	0.02		0.01		0.04
$-value	$16.89	$41.73	$25.74	$66.43	

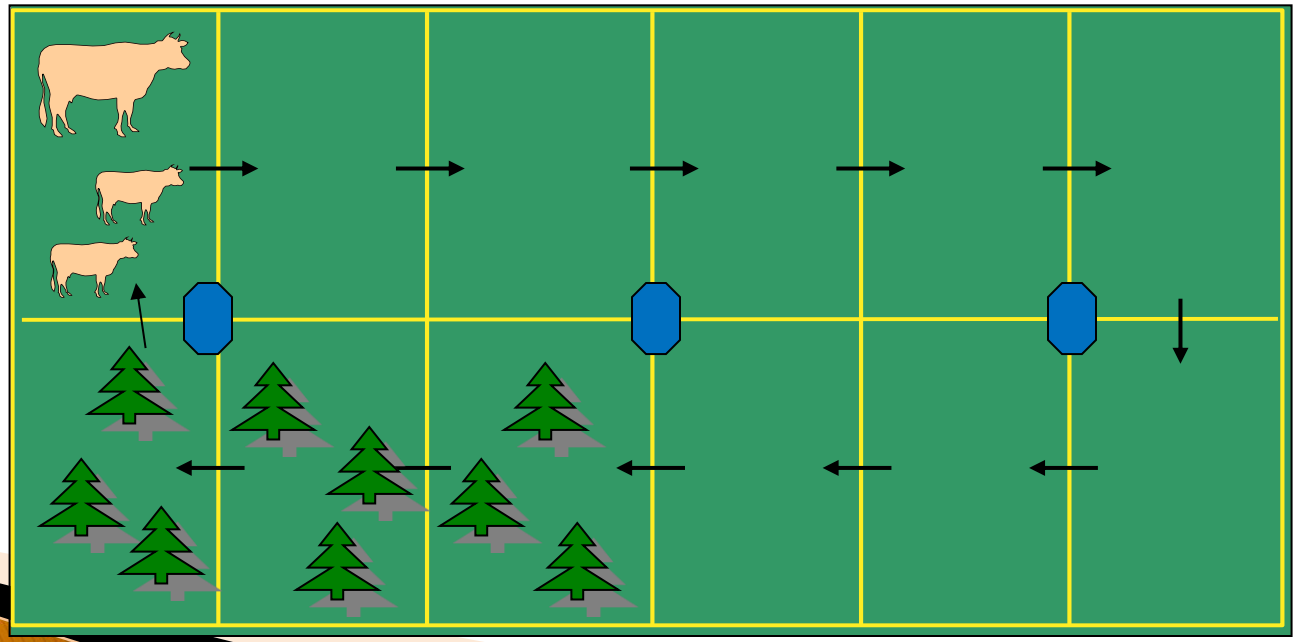
The Grazing Systems Program: why?

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

Grazing period	Rest Period
2 day	22 day
3 day	33 day
4 day	44 day
5 day	55 day

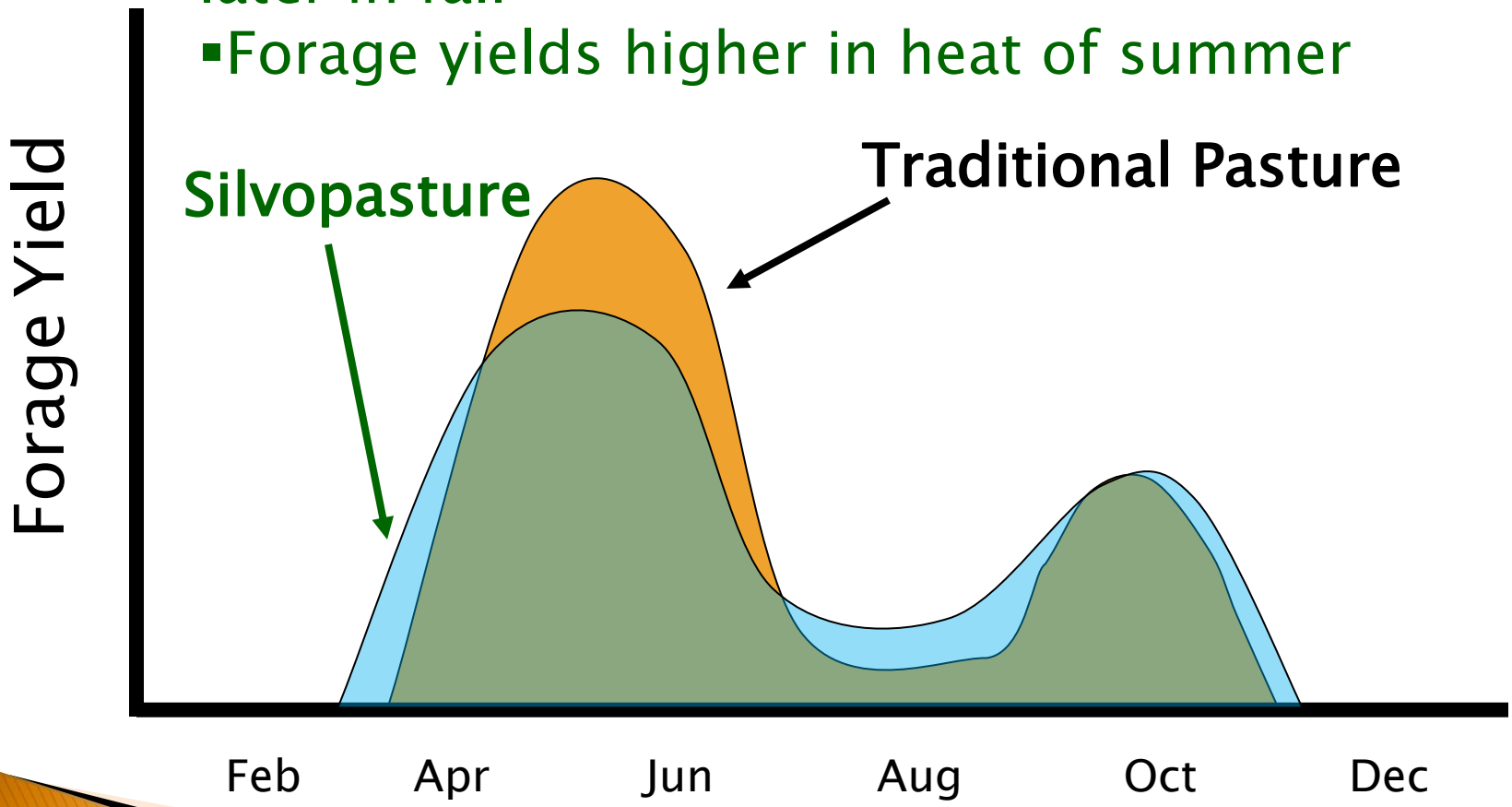
Flexibility!



Forage Growth Differences

Silvopasture:

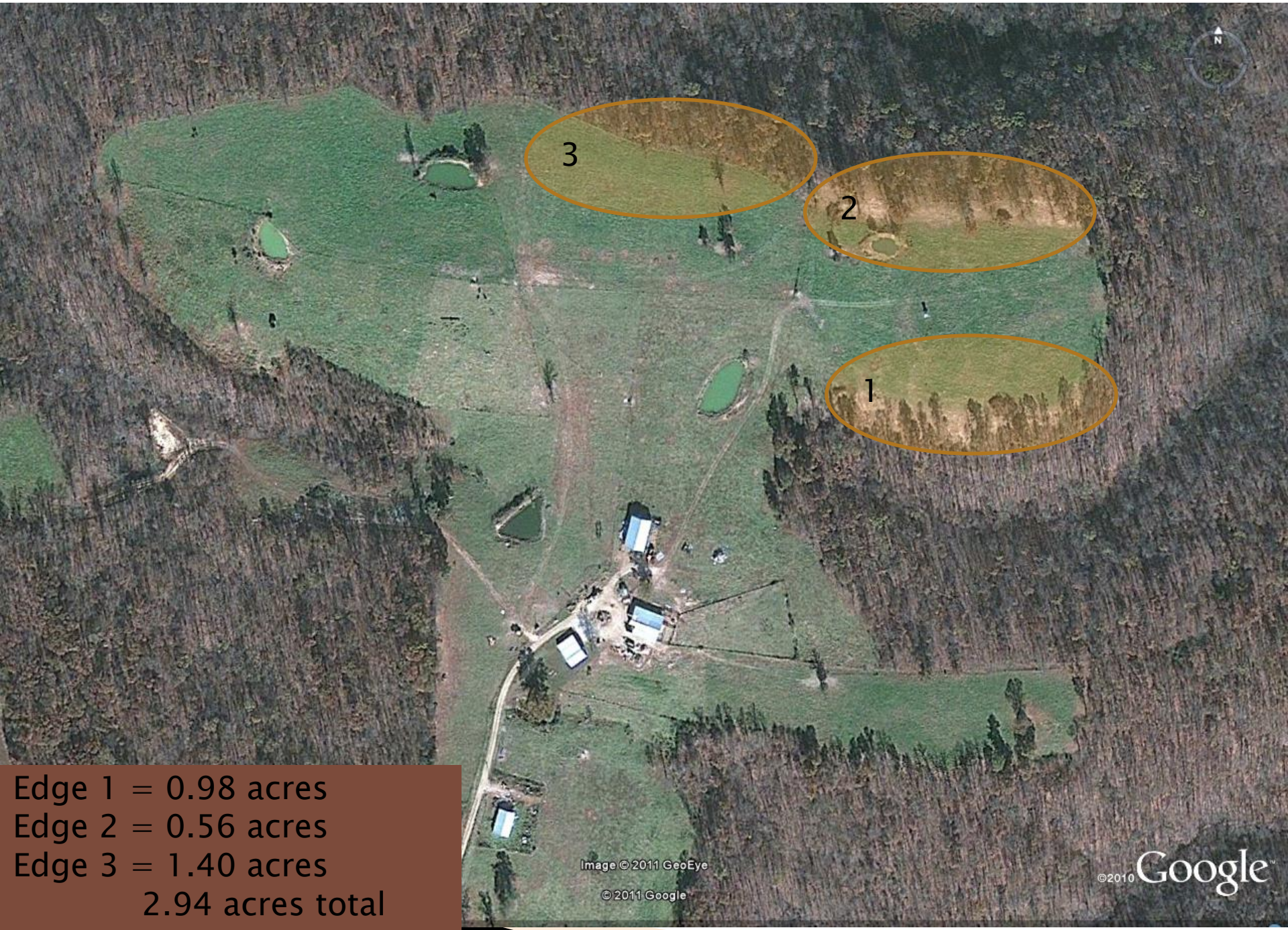
- Forages start growth earlier in spring, continue later in fall
- Forage yields higher in heat of summer



Case Studies

The Tomazi Farm

- 210 acres divided into 31 paddocks
  - 6 – 9 acres each paddock
  - 84 head cow/calf operation
  - Rotational grazing system
- Reason for adopting silvopasture:
  - Improved weight gain in the heat of the summer,
  - Increased grass acreage without purchasing or renting (put non-productive land into production)



Edge 1 = 0.98 acres
Edge 2 = 0.56 acres
Edge 3 = 1.40 acres
2.94 acres total

Edge 1: Established in 2010, area cleared was approximately 85 ft x 500 ft

Edge 2: Established in 2010, area cleared was approximately 60 ft x 407 ft

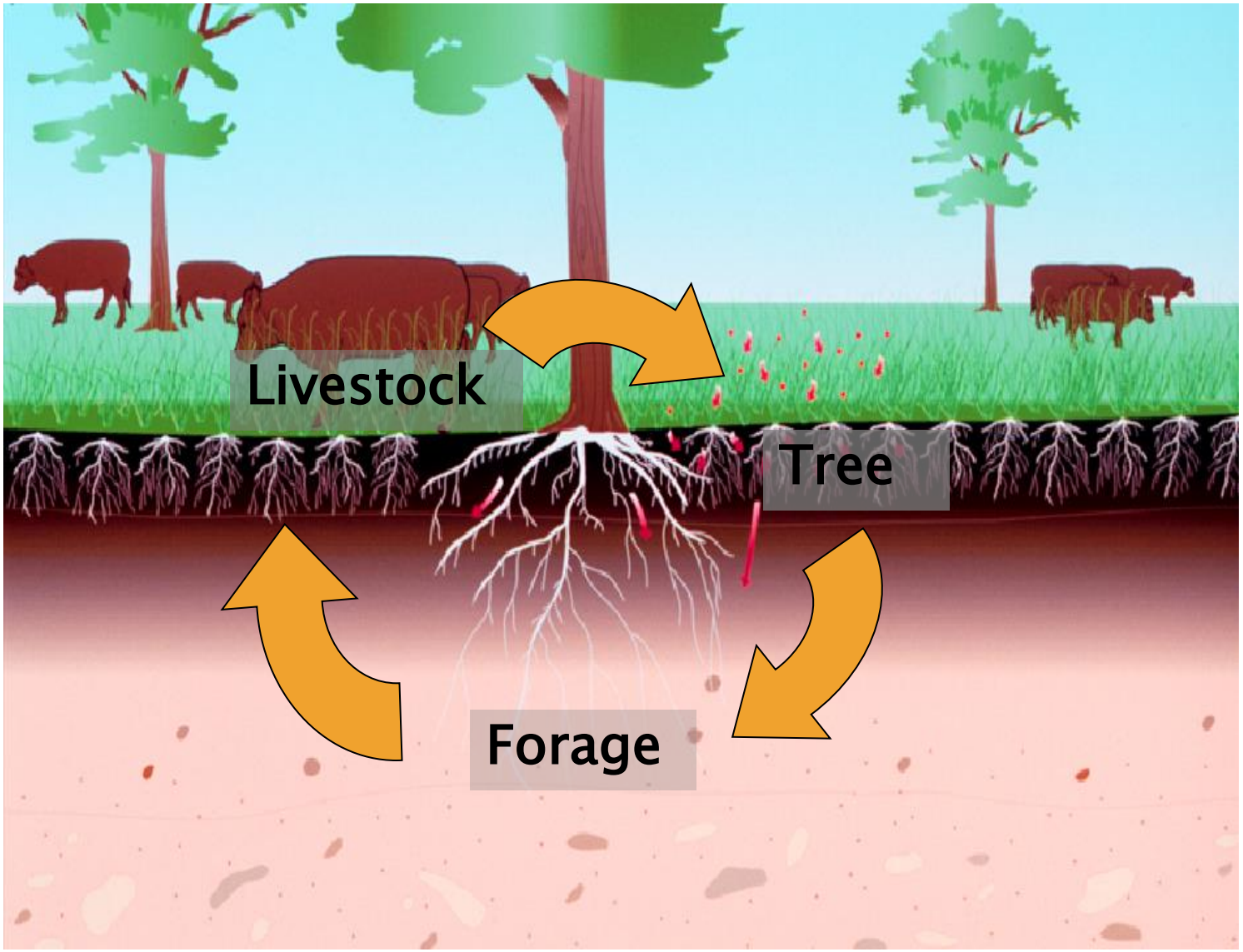
Edge 3: Established in 2011, area cleared was approximately 84 ft x 723 ft

Economic Analysis

- From June 15 – Aug 15, 2010
  - ADG: 1.6 – 2.1 lbs/hd/day
    - (Typical ADG: 0 –(– 1) lb/hd/day)
  - ≅ 96 – 126 lbs/hd
  - $130 – $170/hd
  - $10,920 – $14,280 increase in profit
- The silvopasture edges are estimated to cost about $1200/acre ($3,500 total).
- B/C ratio: 3.12 – 4.08

Designing Silvopasture Systems

Planning leads to success and sustainability!



Understanding and Taking Advantage of – Interactions

Designing Silvopastoral Systems

Thinning the Forest

Planted in the Pasture

In most cases, plan to create and maintain:

- 50% light for cool-season forages
- 50-70% light for warm-season forages.
- Thin every 5-7 years

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

Questions?

Gene Garrett and Dusty Walter