Tree Growth, Crop Yields, and Estimated Returns for an Agroforestry Trial in Goldsboro, North Carolina

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Agroforestry and Silvopasture

- Expanding throughout world
- Possible advantages
  - Good returns, with crop/tree diversification
  - Less risk than monoculture crops – failure, fire, pests, diseases, weather
  - Shade for livestock
- Disadvantages
  - May earn less than crops, especially good sites
  - More difficult to manage than monocultures
  - Uncommon, little research/extension

Outline

- Agroforestry systems
- Methods
  - Project establishment
  - Timber growth, yield, and financial analyses
- Results
  - Tree growth
  - Crop yields
  - Growth, yield, and financial returns
- Conclusions

Project Objectives

1) NC agroforestry demonstration for landowners, farmers, professionals, and researchers
2) Long-term research of alley cropping and eventually silvopasture systems
3) Measure production tradeoffs of trees and crops / silvopasture
4) Research site for graduate students and professors with interests in agroforestry systems

Project Site

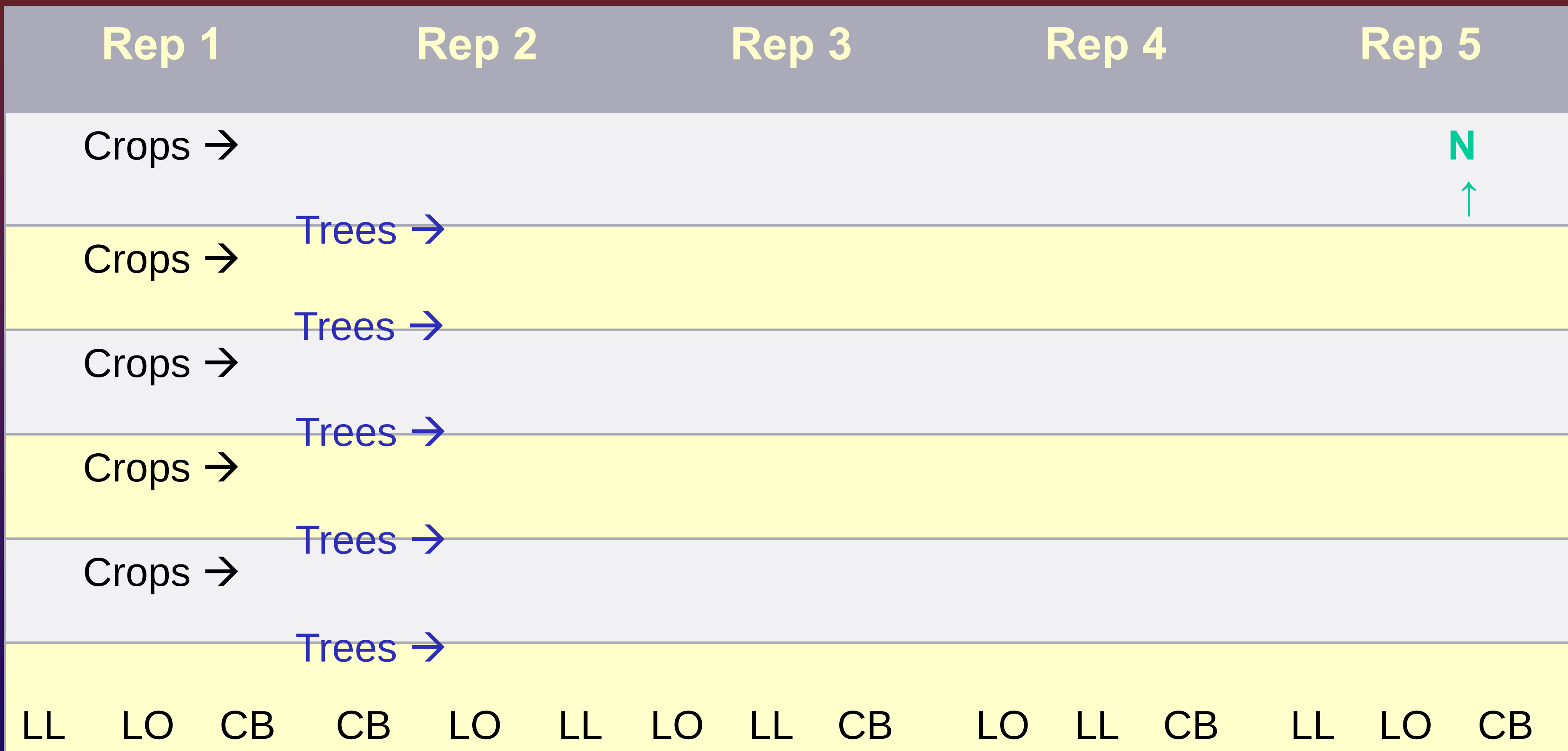
- NC State University / NC Department of Agriculture
  - Center for Environmental Farming System (CEFS)
  - Cherry Research Farm / Prison / Goldsboro, NC
- Site characteristics
  - 17 ac demo and research alley cropping system
  - Old field, Neuse River bottom, flood/droughts
  - Mixture of soil types – sandy (W) to organic (E)
  - Tree rows planted ~E/W; maximize sun on crops
- Three tree species
  - Loblolly pine, longleaf pine, cherrybark oak
  - Planted in 3 row sets, 5’ x 5’ diamond spacing


N
Image U.S. Geological Survey
Google
Imagery Date: 12/31/2007
1993
35°22'12.44" N 78°02'42.48" W elev 71 ft
Eye alt 1929 ft

Experimental Design

- Randomized block alley crop system
  - 5 replications, with 4-5 rows of trees
  - Three lines of trees per row
  - Each set of tree species in each replication
  - 40’ or 80’ crop alleys randomly established between trees
- Check plots at wet, eastern end in square blocks
- Site establishment, January 2007
  - Compass, string to line up rows
  - Pins 1st, then paint to mark seedling spots

Field Experimental Layout



Tree species: LL – longleaf pine; LO – loblolly pine; CB – cherrybark oak
410’ rows per Rep; 140’ rows per each tree species per Rep; check plots at east end

Planting & Establishment

- Tree planting
  - Drop tube – pottapookie for longleaf in sandy soils, or dibble in organic soil
  - Dibble for loblolly
  - Modified KBC 6” bar for cherrybark oak
- Weed control
  - Oust, March 2007, March 2008 before bud break
  - Hand hoe to remove morning glory and sicklepod, August 2007
- Crops – soybeans / corn rotation

Timber Growth, Yield, Costs, Prices

- Trees measured in January 2011 at 4 years old
- Longleaf, Cherrybark projected yields
  - NATYIELD - Smith and Hafley 1986,
  - Validity checks with several others
- Loblolly projected yields
  - Siry et al., 2001, TAUYIELD
- NC DFR tree planting costs statistics
- Timber Mart-South Eastern NC prices 2010
- Capital Budgeting (CB) models, timber analysis only
- 4% real discount rate

Tree Survival and Growth

- Excellent tree survival rates
  - Longleaf least, but good, and out of grass stage
- Tree growth varied across field
  - Worst on drier, sandier soils on west end
  - Best on wet organic soils, rep 5, and check plots
- Relative ranking
  - Loblolly, longleaf, cherrybark oak
  - Longleaf closer to loblolly on sandy soils
  - Cherrybark much better on wet Rep 5, check plots

Tree Survival and Growth, January 2011

Fourth Year Metric	Loblolly Pine	Longleaf Pine	Cherrybark Oak
Survival rate	97%	88%	93%
Base diameter (in)			
All Reps	3.2	2.1	1.0
Rep 5	4.6	2.3	1.4
Height (ft)			
All Reps	10.4	5.2	4.6
Rep 5	15.7	6.3	6.6

All differences between species for base diameters and heights were statistically significant at alpha = 0.01

Timber Yields, Costs, Prices by Species

	Loblolly pine	Longleaf pine	Cherrybark oak
Rotation Age	25	40	80
Harvest ages (yr): volumes (cu ft /ac)	17: 475 cu ft 25: 2,225 cu ft	25: 265 cu ft 40: 1,460 cu ft	55: 868 cu ft 80: 3,978 cu ft
Planting costs ($/ac)	$400	$400	$375
Timber prices ($/ton)	Pulp: $8.45 Chip n saw: $16.89 Small saw: $29.82 Large saw: $61.92	Pulp: $8.45 Chip n saw: $16.89 Small saw: $29.82 Large saw: $61.92	Pulp: $ 4.29 Sawtimber: $31.41

Timber Capital Budgeting Returns, 2010

Capital Budgeting Criterion	Loblolly Pine	Longleaf Pine Timber Only No Pine Straw	Longleaf Pine Timber With Pine Straw	Cherrybark Oak
Net Present Value ($/ac)	493	-49	274	-360
Land Expectation Value ($/ac)	789	-61	346	-376
Annual Equivalent Value ($/ac)	32	-2	11	-15
Internal Rate of Return (%)	7.2	3.7	5.5	1.9

4% discount rate; timber investment returns only, stand level model; Agroforestry returns will vary with more effects of crop interactions


6 year old pruned loblolly, March 2013


6 year old longleaf, March 2013

Check plots in best organic soils – 8+ ft cherrybark oak, 2010

Results – Weather and Crops

Year / Crop Planted	2007 Soybeans	2008 Corn	2009 Soybeans	2010 Corn
Growing Season Rainfall (in.)	15	22	19	14
Crop Yield, All Reps (bushel/ac)	12	51	12	20
Crop Yield, Rep 5 (bushel/ac)	30	112	30	52

Reps 1-4 on west end were drier and sandier; Rep 5 was wetter, more organic matter

Crop Yields and Returns

Year	Crop	Yield (Bu/ac)	Cost ($/ac)	Price ($/bushel)	Sale Price ($/ac)	Net Returns ($/ac)
2007	Soybeans	12	228	10.10	121	-107
2008	Corn	51	299	3.5	179	-120
2009	Soybeans	12	228	9.59	115	-113
2010	Corn	20	411	4.35	87	-324
2011	Soybeans	31	273	12.00	370	97
2012	Corn	49	453	7.64	375	-79
2013	Flooded	Grass/ Hay	Beans Corn	~14.00 ~7.00	NA	NA

Yields based on field data; costs and prices on NCSU crop budgets; average loss=$110/ac/yr

Agroforestry practice – CEFS August 2011

Corn, June 2012, Best Site


Corn, June 2012, Poor Site


Agroforestry practice after hurricane
CEFS September, 2011

Field of Dreams, Dyersville, Iowa


Corn, Dyersville, July 20


Silvopasture potential – Burgaw, NC 2011

Conclusions - Timber Returns

- Returns track projected and observed growth rates
  - Loblolly pine (7.2% IRR)
  - Longleaf pine (3.7%), cherrybark oak (1.9%)
  - Loblolly same to establish, has similar prices
  - Planting costs should be less on bare fields; thus returns greater
- Other possible benefits than timber
  - Nontimber benefits
  - Nonmarket values
- Longleaf/oak may be better in hurricanes, droughts
- Interaction with crops/livestock matters

Conclusions - Crop Returns

- Droughts and floods were common
- Crop yields on sandy soils were poor; better on wet, end of field with more clay
- Low yields
  - generated crop losses in years observed
  - -$100 to -$300 per acre
- Best end of field
  - perhaps more typical of better farm land
  - would generate returns of about $80 per acre

Conclusions – Agroforestry Alley Cropping

- Successful tree establishment at CEFS
- Trees performed well, including oaks and longleaf, after 4 years of floods and droughts
  - In poor, sandy soils
  - Perhaps with increasing climate variability
- Crops did not, especially in dry, sandy soil
- Better crops in more clay, wet soils
- But even that part of the field was flooded often
- Potential for trees and crops→ to trees and livestock
- Agroforestry and silvopasture opportunity?

Conclusions – Tree Species Selection

- Loblolly grows fastest
  - but is bushy, shades crops
  - more root interference?
- Oaks start slow
  - may catch up, but not known
- Longleaf grows slow, but
  - pine straw and intermediate income
  - but fire a risk; chemicals may be better
  - hurricane resistant when old, but may be damaged when young

Conclusions – Financial Modeling

- Tree survival not used directly in growth models
- But indicated that general stand models acceptable
- Confirmed by check plots with similar growth to rows
- Timber production returns – stand level models
  - Clearly favor loblolly pine
  - Supported by field results to date
- Differences between tree species returns indicate incentives, cost-share rates, nonmarket benefits required to favor longleaf or cherrybark
- Crop modeling will follow in future

Conservation Planning Groups, Agroforestry Workshop, Goldsboro, December 2011

Outreach and Extension: Field Discussion Feedback

- Tree selection
  - Longleaf may be best on dry sites; cherrybark wet
  - But forester noted more weed control could lead to fast longleaf growth on wet end
  - But more intervention requires more management time and costs
- Planting of more rows may be good for longleaf straw
- Mixed tree species may be good for hunting
- Wider crop rows
  - May be best for crops growth
  - Decrease browsing
- Move toward silvopasture may be best long run mix

Agroforestry Field Meeting, Goldsboro, December 2011

Future Field Monitoring and Modeling

- Interactions of trees and crops
  - Root, shade, nutrient competition - Adam Brown
  - Tradeoffs may favor longleaf or oaks
  - Silvopasture benefits may differ by tree species
- Possible nontimber tree benefits
  - Loblolly – more carbon, but not much else
  - Longleaf – straw, biodiversity, woodpeckers
  - Cherrybark – biodiversity, mast
- Could offer opportunities for payments for environmental services

Prospects & Acknowledgements

- Successful demonstration project
  - Opportunity for long term monitoring, modeling, and extension
  - Stay tuned for future developments

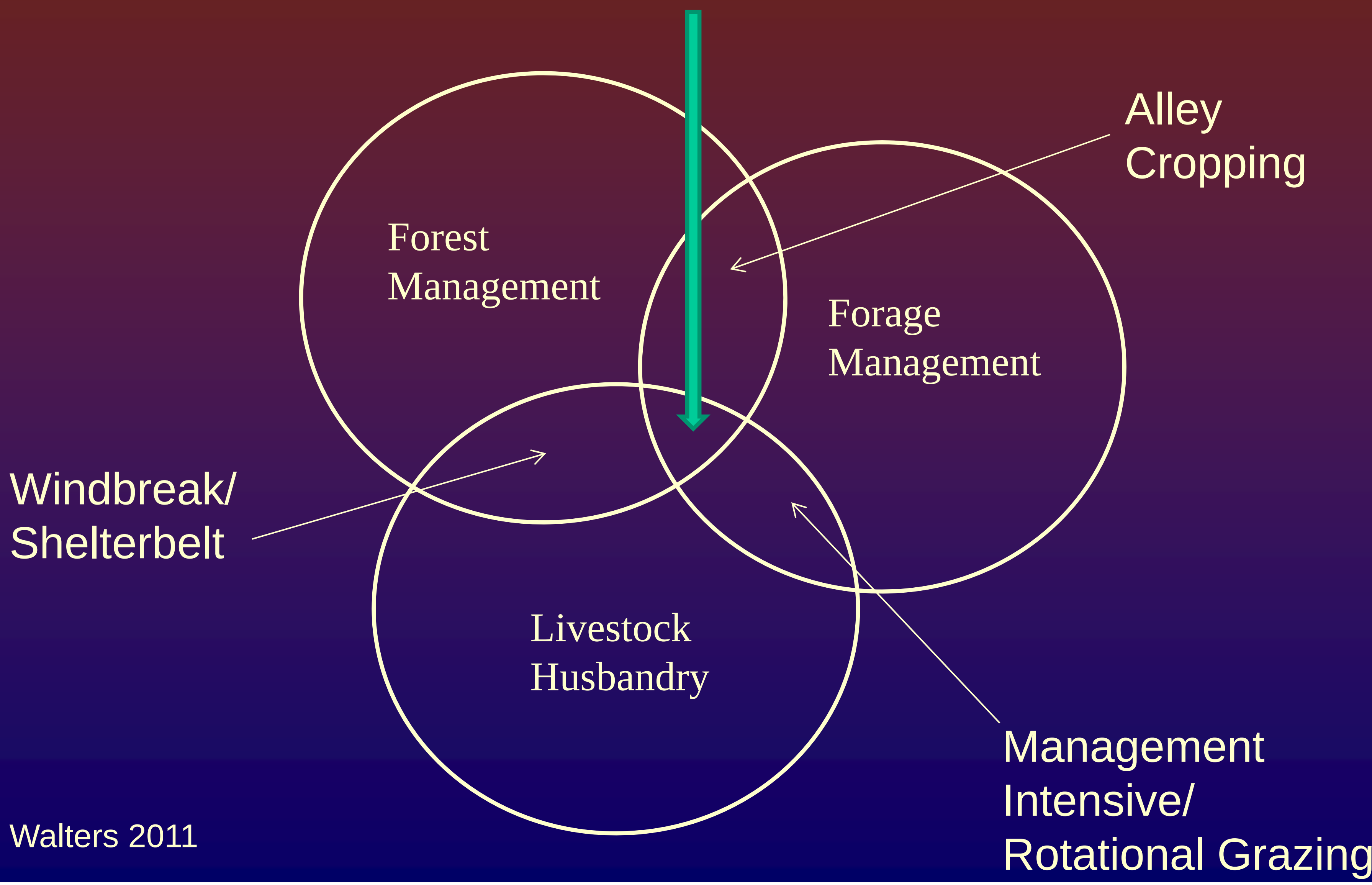
- Acknowledgements:
  - NC Department Agriculture
  - CEFS management and staff
  - Natural Resource Conservation Service grant
  - Selected graduate students, NCSU

Reference Article:

- Cubbage, Frederick, Viola Glenn, J. Paul Mueller, Daniel Robison, Russell Myers, Jean-Marie Luginbuhl, and Ron Myers. 2012. Early tree growth, crop yields, and estimated returns for an agroforestry trial in Goldsboro, North Carolina. Agroforestry Systems 86(3):323-334. Agroforest Syst DOI 10.1007/s10457-012-9481-0.

Extra Relevant Slides

The triple crown of agroforestry: Silvopasture



Walters 2011

Shade – When Needed for Livestock

- 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.

NO STRESS — MILD STRESS — MEDIUM STRESS — SEVERE STRESS

DEG	RELATIVE HUMIDITY																				
F	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													

Walters 2011

[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.

Shade Benefits - Cattle and Goats

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

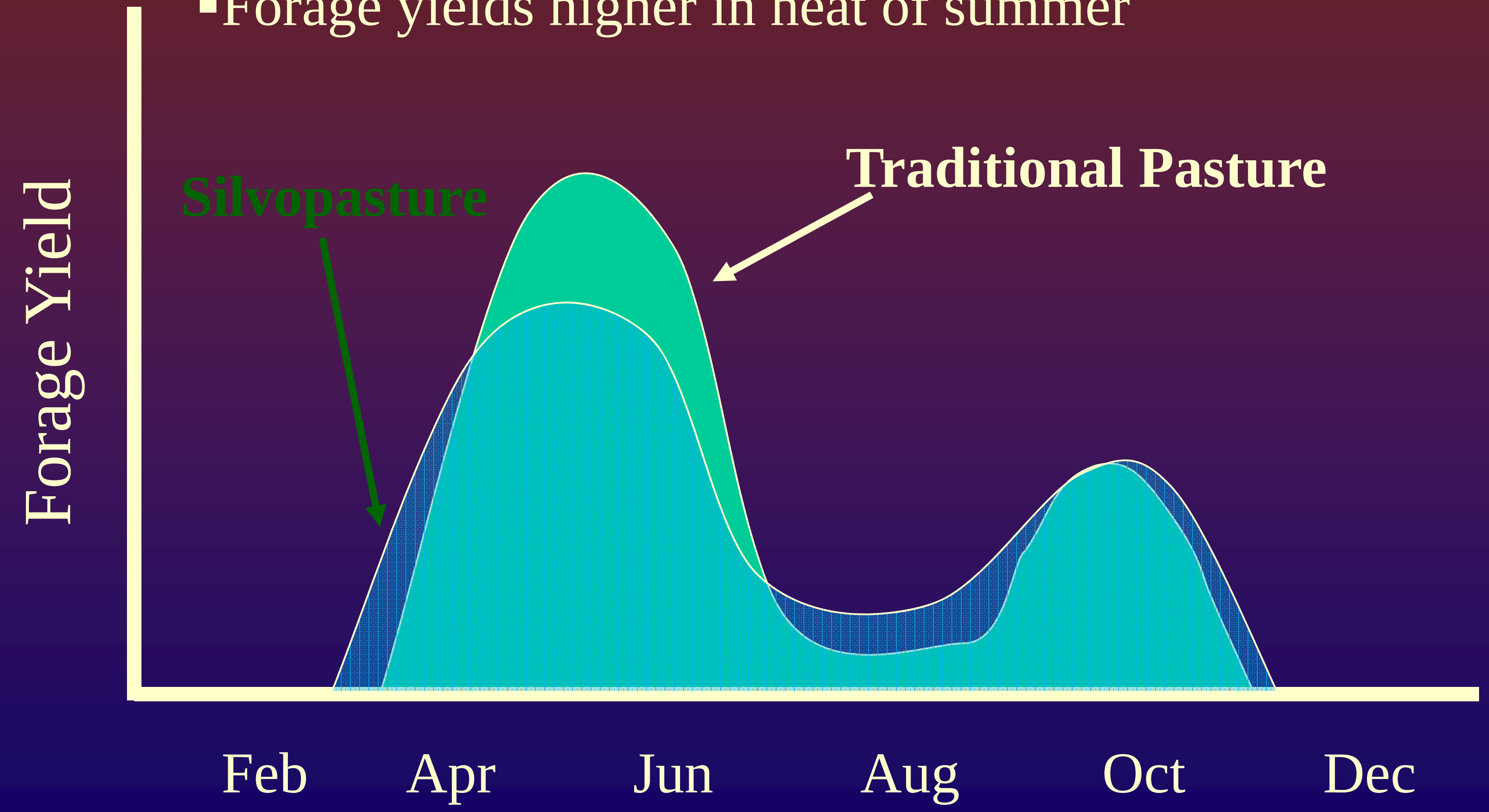
But – it does depend:

- Animal selection
- Temp.-Humidity Index above 72
- Endophyte infected fescue
- Rotational Grazing

Walters 2011

Silvopasture Forage Growth Differences

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



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