Envisioning a TREED Trajectory for AGRICULTURE: Findings from Agroforestry Research

SNR Seminar Series
October 19, 2021

Lord Ameyaw
Assistant Professor - Forestry

SCHOOL OF NATURAL RESOURCES
Outline

- Agroforestry 101
- Recent research
- Way forward
COURSE DESCRIPTION
Do you love nature? Are you interested in knowing the benefits of integrating forests and trees on public and private agricultural lands? Learn about the environmental, social and economic attributes and opportunities associated with incorporating trees into agricultural and other land use decisions (aka Agroforestry).

PREREQUISITE
None for this course.

INSTRUCTOR
Dr. Lord Kwakye Ameyaw
Address // 416 Hardin Hall
Email // lameyaw2@uw.edu
Phone // 402-472-6697

OFFICE HOURS
9am – 11am W/F or by appointment.
Definition of Agroforestry

An intensive land management system that optimizes the benefits from the biological interactions created when trees and/or shrubs are deliberately combined with crops and/or livestock.

Agroforestry is the intentional integration of trees or shrubs with crop and/or animal production to create environmental, economic, and social benefits.

Intentional
Intensive
Interactive
Integrated
Agric and Forestry?

Risk management is difficult in simple monoculture systems.
Misconception:
Agroforestry is here to save the day!
Genesis 2: 8 – 9
8
Now the LORD God had planted a garden in the east, in Eden; and there he put the man he had formed.

9
And the LORD God made all kinds of trees grow out of the ground--trees that were pleasing to the eye and good for food. In the middle of the garden were the tree of life and the tree of the knowledge of good and evil.
History of Agroforestry

• Trees have always been used in agricultural systems
• 7000 BC (Neolithic Age – Agricultural Revolution) where people started permanent settlements – Home Gardens
• Middle ages - Shifting cultivation (slash and burn)
Benefits of Agroforestry

Misconception: Agroforestry means ag land changing to forestland.
History of Agroforestry (in the United States)

- Many Indigenous/Tribal communities have long histories of managing crops under forest canopies.
- Traditional agricultural practices incorporating trees were/are prevalent in the tropics, Hawaii, and the Pacific Islands.
- Agroforestry gained interest during the dust bowl era (1930’s) - Prairie States Forestry Project.

220,000 million tree seedlings

~18,600 miles of windbreaks
Most Common Temperate Agroforestry Systems

- Windbreaks
- Riparian buffers
- Alley cropping
- Silvopasture
- Forest farming

... putting the right trees, in the right location, for the right reason.
Trees or shrubs are planted in sets of single or multiple rows with agronomic, horticultural crops or forages produced in the alleys between the sets of woody plants that produce additional products.
Forest Farming

Existing or planted stands of trees or shrubs that are managed as an overstory with an understory of woody and/or non-woody plants that are grown for a variety of products.
Riparian Forest Buffer

An area predominantly trees and/or shrubs located adjacent to and up-gradient from watercourses or water bodies.
Silvopasture

Establishment and/or management of desired trees, forages and livestock on the same land unit.

Photos: Brett Chedzoy, silvopasture.ning.com
Windbreaks

Windbreaks or shelterbelts are single or multiple rows of trees or shrubs in linear configurations.
What practice is used and where in the US?
What practice is used and where in the US?
What practice is used and where in the US?

- Alley Cropping (311)
- Multistory Cropping (379)
- Riparian Forest Buffers (391)
- Silvopasture Establishment (381)
- Windbreak Establishment (380)
What practice is used and where in the US?
What practice is used and where in the US?

- Alley Cropping (311)
- Multistory Cropping (379)
- Riparian Forest Buffers (391)
- Silvopasture Establishment (381)
- Windbreak Establishment (380)
Objectives:
1. Streamline the use of agroforestry terminology to foster consistency and easier determination of agroforestry practice
2. Solicit conversations on the inclusion of agroforestry sections in statewide FAPs
3. Make recommendations on the utilization of agroforestry using applicable scenarios determined by FAPs
Keywords

- Agroforestry
- Agro-forestry
- Agriforestry
- Agrisilviculture
- Buffer Strips
- Contour Strips
- Farm Forestry
- Forest Farming
- Forest Garden
- Greenbelts

- Hedgerows
- Linear Strips
- Live Fence
- Mixed Forestry
- Multi-story Cropping
- Dooryard Gardens
- Permaculture
- Riparian Forest Buffers
- Shelterbelts

- Silvopasture
- Strip cropping
- Tree Farming
- Timberbelts
- Vegetated Buffer Strips
- Windbreaks
- Woody Riparian Buffers
- Vegetated Wetlands

Method

Project 1 – Agro ... what ...

Search

Look In:

The Current Document

What word or phrase would you like to search for?

Search

Use these additional criteria:

- Whole words only
- Case-Sensitive
- Proximity
- Stemming
- Include Bookmarks
- Include Comments
- Include Attachments
<table>
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<th>Project 1 – Agro ... what ...?</th>
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<td><strong>Conservation Tree Plantings</strong></td>
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<td><strong>Custom Buffers</strong></td>
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<td><strong>Floodplain Forests</strong></td>
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<td><strong>Forested Riparian Zones</strong></td>
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<td><strong>Greenbelts</strong></td>
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<td><strong>Green Infrastructure</strong></td>
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<td><strong>Live Fence</strong></td>
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<td><strong>Riparian Buffers</strong></td>
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<td><strong>Riparian Forest Corridor</strong></td>
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<td><strong>Riparian Management Zone</strong></td>
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<td><strong>Shelterbelts</strong></td>
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<td><strong>Silvopasture</strong></td>
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<td><strong>Streamland Buffers</strong></td>
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<td><strong>Streamside Vegetation</strong></td>
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<td><strong>Streamside Management Zone</strong></td>
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<td><strong>Tree Farming</strong></td>
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<td><strong>Vegetated Wetlands</strong></td>
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<td><strong>Windbreak</strong></td>
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<td><strong>Wooded Strips</strong></td>
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<td><strong>Woody Riparian Buffers</strong></td>
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Agroforestry

Overview
Agroforestry provides a unique opportunity to integrate trees and shrubs into crop and animal production systems. The interaction of these components creates practical and viable opportunities for landowners to foster environmental protection and, concurrently, access the economic and social benefits associated with agroforestry.

As the seat of the USDA’s National Agroforestry Center (NAC)—a partnership between the United States Forest Service and the Natural Resources Conservation Service)—the state of Nebraska is opportunistically placed as a leader for agroforestry practice in the United States. The goal is to advance the health, diversity, and productivity of working lands, waters, and communities through the incorporation of agroforestry practices.
Project 2:

1. Primary benefits and challenges being reported by U.S. producers using windbreaks?

2. Are producers satisfied with their windbreak plantings and are they retaining them?

3. What windbreak maintenance and management activities are producers reporting?

4. Primary drivers affecting willingness or intent to adopt windbreaks in the U.S and how do these drivers vary by windbreak type?
Project 2:

Methods for the Systematic Review

- **Keywords used in search:**
  - Windbreak, shelterbelt, hedgerow, vegetative environmental buffer, timberbelt, living snow fence and agroforestry

- **Databases searched:**
  - Web of Science, Scopus, AGRIS, CAB Direct, ProQuest and first 100 results from Google Scholar per search term. Also searched NAC non-digital archive
  - Database filters used to retrieve only U.S. studies
  - No time range or other exclusionary filters used

- Included peer reviewed and grey literature
Project 2:

- Nebraska farmers reported 62% yield increases due to windbreak presence (Tomczak 2009b)
  - No effect = 9%
  - Yield decrease = 28%

- Biophysical studies have reported crop yield increases due to windbreaks
  - Combined data from NE and KS found that winter wheat and soybean had average yield gains of 10% and 16% respectively when protected by windbreaks (Osoroi et al. 2018)
  - Kort (1988) reported yield gains of 6-56% when crops were protected by windbreaks
### Top Ranked Producer-Reported Benefits of Windbreaks

<table>
<thead>
<tr>
<th>Authors</th>
<th>Type of Windbreak</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
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<tbody>
<tr>
<td>Laughlin 1989</td>
<td>Field</td>
<td>Soil Erosion Control</td>
<td>Wind Protection</td>
<td>Snow Control</td>
<td>Crop Protection</td>
<td>Wildlife Habitat</td>
<td>Aesthetics</td>
<td>Increase Crop Yield</td>
<td>Livestock Protection</td>
<td>Increase Property Value</td>
<td>Improve Water-Use Efficiency</td>
<td>Wood Products</td>
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<td>Dearmont et al. 1983</td>
<td>Field</td>
<td>Soil Erosion Control</td>
<td>Livestock Protection</td>
<td>Snow Control</td>
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<td>Tomczak 2009(b)</td>
<td>Field</td>
<td>Soil Erosion Control</td>
<td>Livestock Protection</td>
<td>Snow Control</td>
<td>Other</td>
<td>Wildlife Habitat</td>
<td>Increase Property Value</td>
<td>Wood Products</td>
<td>Increase Crop Yield</td>
<td>Aesthetics</td>
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<tr>
<td>Laughlin 1989</td>
<td>Farmstead</td>
<td>Aesthetics</td>
<td>Wind Protection</td>
<td>Snow Control</td>
<td>Energy Savings</td>
<td>Increases property Value</td>
<td>Livestock Protection</td>
<td>Wildlife Habitat</td>
<td>Soil Erosion Control</td>
<td>Noise Control</td>
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<td>Tyndall 2009</td>
<td>Livestock</td>
<td>Odor Reduction</td>
<td>Visual Screening</td>
<td>Aesthetics</td>
<td>Energy Savings</td>
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<td>Hand et al. 2019(b)</td>
<td>Farmstead Field</td>
<td>Wind Protection</td>
<td>Livestock &amp; Crop Protection</td>
<td>Aesthetics</td>
<td>Privacy</td>
<td>Hunting, Fishing, Recreation</td>
<td>Enhance Water Quality</td>
<td>Enhance Soil Quality</td>
<td>Carbon Storage</td>
<td>Wood Products</td>
<td>Non-Timber Forest Products</td>
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<td>Workman et al. 2003(b)</td>
<td>Farmstead Field</td>
<td>Soil Erosion Control</td>
<td>Aesthetics</td>
<td>Long-Term Return</td>
<td>Wildlife Habitat</td>
<td>Shade</td>
<td>Enhance Water Quality</td>
<td>Increase Biodiversity</td>
<td>Increase Property Value</td>
<td>Improves Farm Interest</td>
<td>Increase Financial Security</td>
<td>Enhance Water Quantity</td>
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<td>Cable and Cook 1997</td>
<td>Farmstead Field</td>
<td>Livestock Protection</td>
<td>Crop Protection</td>
<td>Soil Erosion Control</td>
<td>Wildlife Habitat</td>
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## Producer-Reported Reasons for Windbreak Removal

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<tbody>
<tr>
<td>Dearmont et al. 1983</td>
<td>Conflict with Irrigation</td>
<td>Age and Poor Condition</td>
<td>Conflict with Farming Practices</td>
<td>Crop Competition</td>
<td>Field Consolidation</td>
<td>Snow Drift Issues</td>
<td>Preparing Site for New Windbreaks</td>
<td>No Value in Windbreaks</td>
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<tr>
<td>Laughlin 1989</td>
<td>Poor Condition</td>
<td>Age</td>
<td>Conflict with Equipment</td>
<td>Gain Acreage</td>
<td>Crop Competition</td>
<td>Snow Drift Issues</td>
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</table>

Windbreak removal associated with the installation of center pivot irrigation. Highlighted green indicates tree cover from the High-Resolution Land Cover of Nebraska (2014) dataset (Kellerman et al. 2019)
Conservation, Profit, or Both?

• Producers most value windbreaks for indirect economic benefits from agriculture, followed by direct agricultural benefits and intrinsic values
• Windbreak benefits are variable and dependent on system type (field, farmstead or livestock)
• Windbreak removal is primarily driven by 1) poor condition of the trees, 2) windbreak age, 3) conflict with irrigation and farm machinery, and 4) crop competition
• Producer satisfaction of windbreaks is high in the U.S. (72-99%)
• Windbreak adoption is inhibited most by lack of land and concerns over maintenance
2° C increase could increase wind erosion by 15-18%  
Lee et al. 1996

Annual average wind speed at 30 m

National Renewable Energy Lab

Cox and Rundquist 2013
Project 3:

Silvopasture in the USA: A systematic review of natural resource professional and producer-reported benefits, challenges, and management activities

Matthew M. Smith \^A, ^B, Gary Bentrup \^A, Todd Kellerman \^A, Katherine MacFarland \^A, Richard Straight \^A, Lord Ameyaw \^A, Susan Stein \^A

1. What are the primary benefits and challenges being reported by agricultural producers using silvopasture in the USA and how do those compare to producers from other countries?
2. What silvopasture establishment and management activities are producers reporting?
3. Are producers in the USA satisfied with their silvopasture systems?
4. What are the primary drivers affecting willingness or intent to adopt silvopasture in the USA?
5. What level of knowledge and support do NRPs have for silvopasture management?
Project 3:

Key Benefits and Challenges to Silvopasture Management Identified by USA Producers

**Benefits**
- Increased shade for animal wellbeing, calving, and production
- Diversification of farm income
- Short- and long-term cash flow
- Enhanced forage quality
- Enhanced forage production during shoulder seasons, midsummer, and times of drought
- Increased quality and size of trees for timber
- Restoration of savanna habitat

**Challenges**
- Lack of information
- Lack of assistance from resource professionals
- Increased time required for management
- Expense of management
- Lack of land
- Tree regeneration in established systems
- Possible need for new or modified equipment

Key Component | Summarized primary effects | Key references
--- | --- | ---
1. Forage | Microclimate modification can exaggerate or enhance forage yield and quality compared to open pasture depending on species and management. | Buergler et al. (2006), Ford et al. (2019b), Fannin et al. (2019), Cirecco et al. (2019), Pang et al. (2019a, 2019b)
2. Forage | Potential for extending forage growing season and yields, due to microclimatic modification in droughty summer months and reducing radiation frosts in early and late season. | Frost and McDougall (1989), Feldhaaker (2000), Kollenbach et al. (2008), Cible et al. (2020)
4. Livestock | Shelter from trees can offer enhanced protection for livestock during winter by reducing wind and precipitation reaching sheltering animals. | Van Laer et al. (2014), He et al. (2017)
5. Livestock | Livestock weight gain in silvopasture can be comparable to that of livestock grazed in open pastures depending on species and management. | Kollenbach et al. (2006), Ford et al. (2019b), Peni et al. (2020)
6. Tree | Trees in silvopasture can produce products to increase enterprise diversification. | Anez et al. (2006), Broughton et al. (2012), Bruck et al. (2019), Peni 2020
7. Tree | Leaf fodder and mast (e.g., acorns, honey locust pods, apples) can augment livestock diets and offer nutritional value depending on species. | Moreno et al. (2018), Vanier et al. (2018), Peni and File (2019), Hassan et al. (2020), Seidavi et al. (2019)
8. Ecosystem service | Soil carbon storage is increased at various soil horizons and depths when converting from open pasture to silvopasture but may decrease when converting from forest. | Halde et al. (2008, 2012), Baard-Aasheim et al. (2018, 2019), De Stefano and Jacobson (2018)
9. Ecosystem service | Soil and biomass carbon sequestration is generally higher in silvopasture than open pasture but may be lower than forests. | De Stefano and Jacobson (2018), Lai et al. (2018)
10. Ecosystem service | Silvopasture can enhance nutrient recycling and reduce phosphorus loss and nitrate leaching when compared to open pasture. | Michel et al. (2007), Bambito et al. (2009), Boyer and Neel (2010), Nyakatawa et al. (2012)
11. Ecosystem service | Utilization rates are similar or slightly higher in silvopasture than open pastures but lower than forests. | Sharrow (2007), Moreno et al. (2018), Stewart et al. (2020)
12. Ecosystem service | Silvopasture can increase biodiversity compared to open pastures but may be less than diverse natural forests. | Burgess (1995), Mcadam et al. (2007), Torralba et al. (2016), Moreno et al. (2018)
14. Ecosystem service | Silvopasture may provide cultural ecosystem services including sense of place, aesthetic value, recreation and ecotourism, and cultural heritage value. | Feggerlin et al. (2016), Moreno et al. (2018)