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

NRES 417: AGROFORESTRY (3 Credits)

SPRING MINI-SESSION 2023

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

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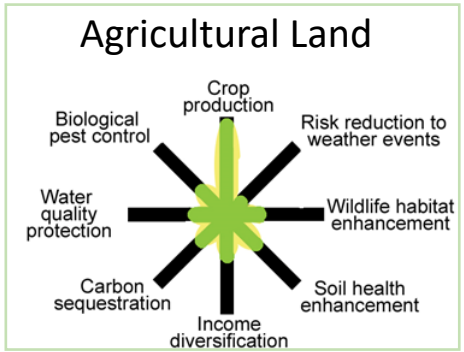
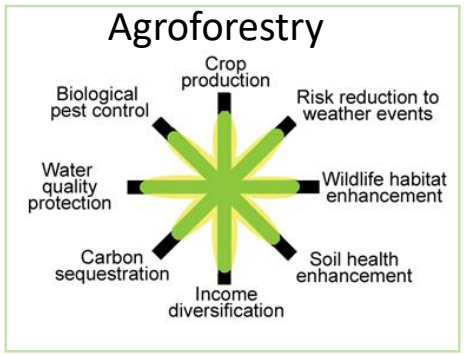
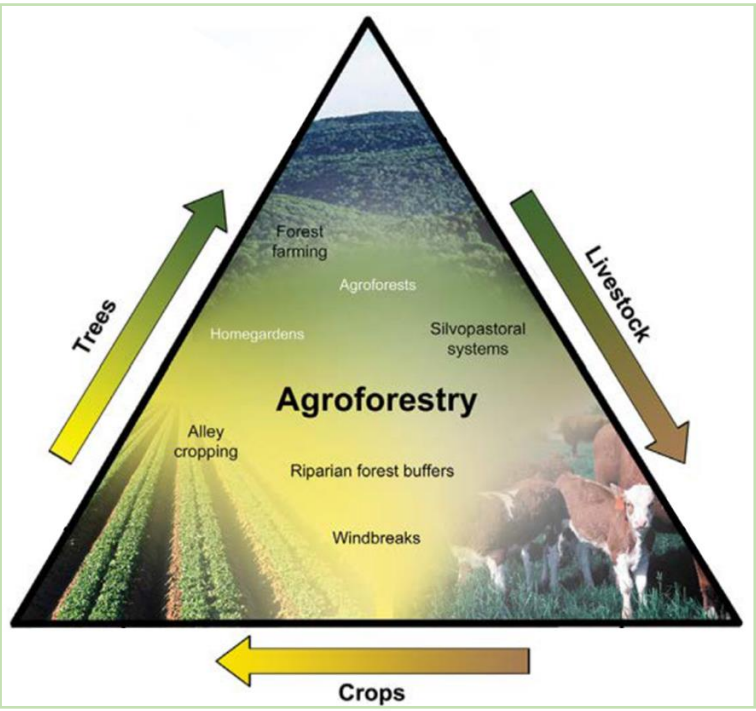
Phone // 402-472-6697

OFFICE HOURS

9am – 11am W/F or by appointment.







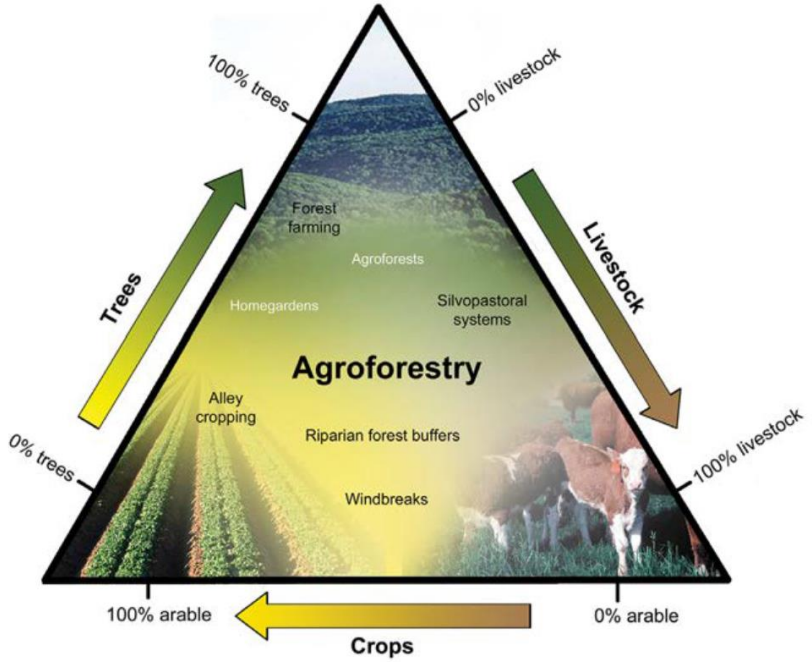
Decreasing effect *Increasing effect*

Forest Farming ***Windbreaks*** ***Silvopasture*** ***Alleycropping*** ***Riparian Forest Buffers***

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.



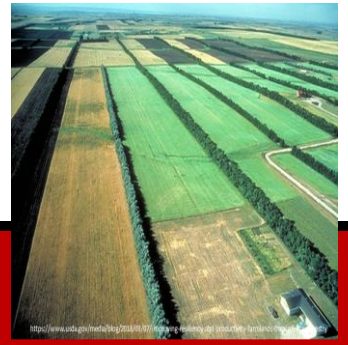
USDA, 2017 (Adapted from den Herder et al. 2015)

Intentional

Intensive

Interactive

Integrated

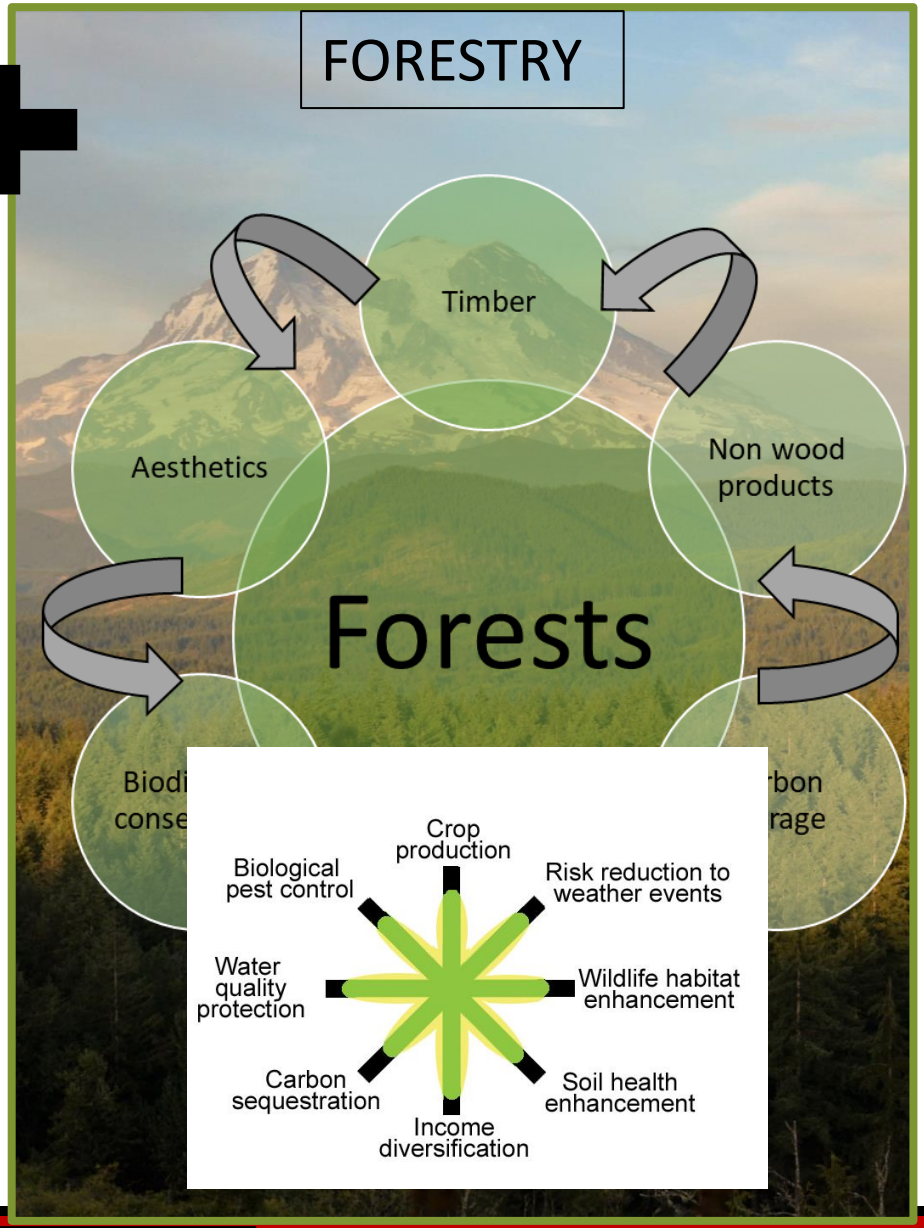


Agric and Forestry?

AGRO

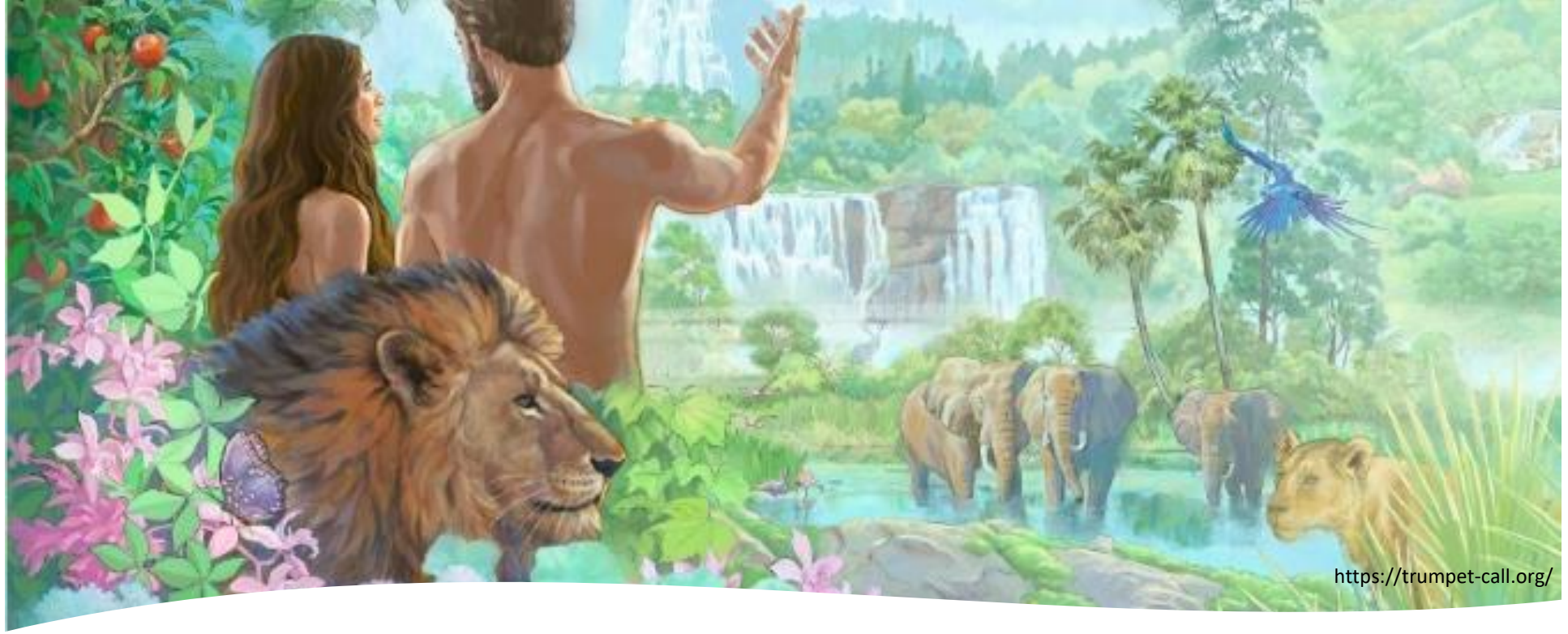
Risk management is difficult in simple monoculture systems.

FORESTRY



AGROFORESTRY

Misconception:
Agroforestry is here to save the day!



History of Agroforestry

Genesis 2: 8 – 9

8

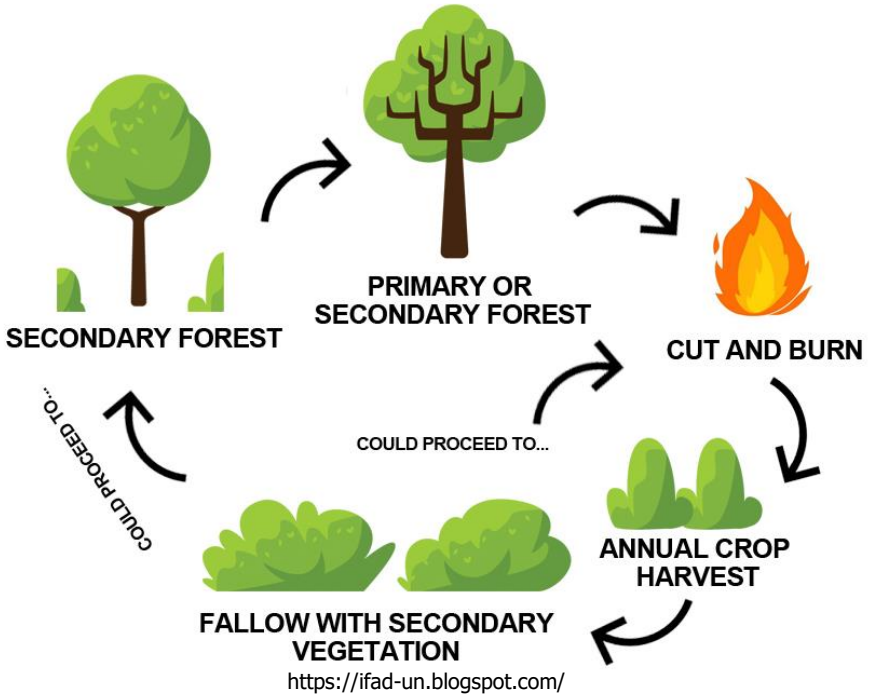
Now the LORD God had planted a garden in the east, in Eden; and there he put the man he had formed.

9

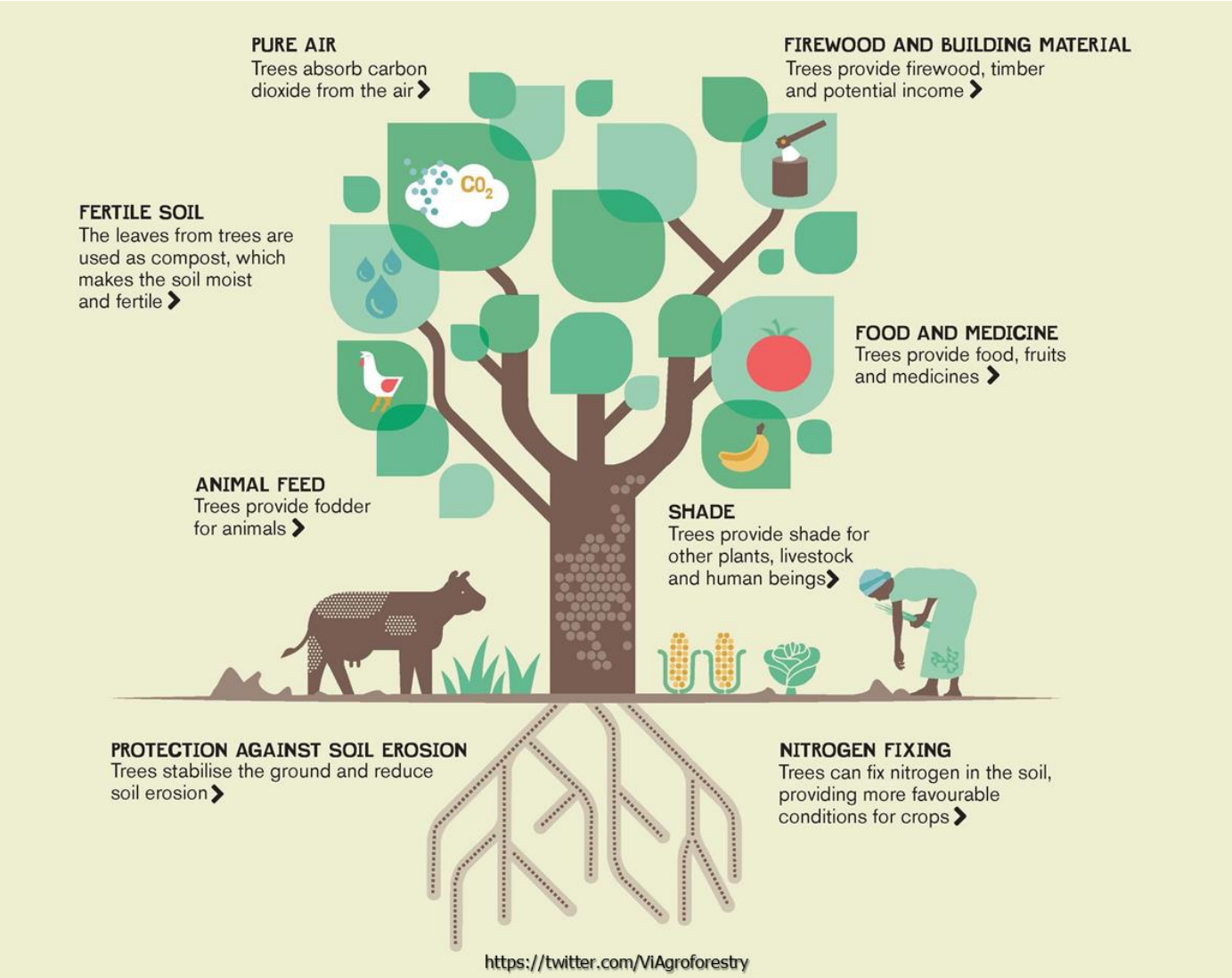
And the LORD God made all kinds of trees grow out of the ground--trees that were pleasing to the eye and good for food. In the middle of the garden were the tree of life and the tree of the knowledge of good and evil.

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



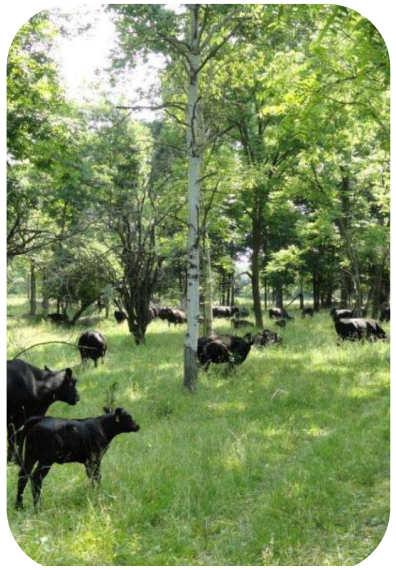
Misconception: Agroforestry means ag land changing to forestland.

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

USFS and USDA-NRCS

Most Common Temperate Agroforestry Systems

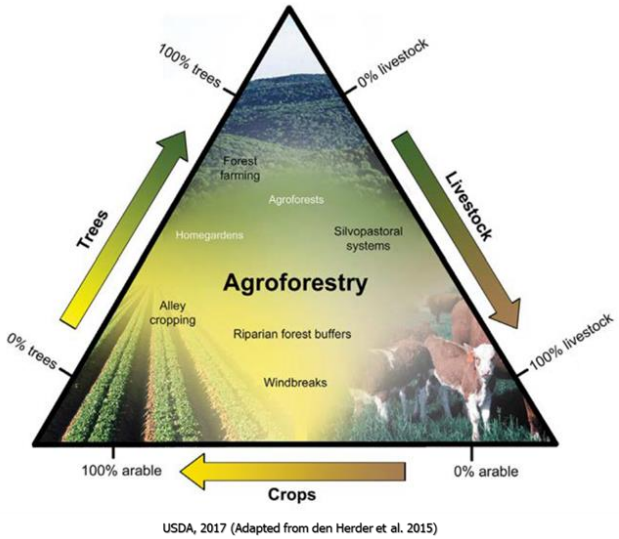


Silvopasture

Windbreaks

Riparian buffers

Alley cropping



USDA, 2017 (Adapted from den Herder et al. 2015)

Forest farming

... putting the right trees, in the right location, for the right reason.

Alley Cropping

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?

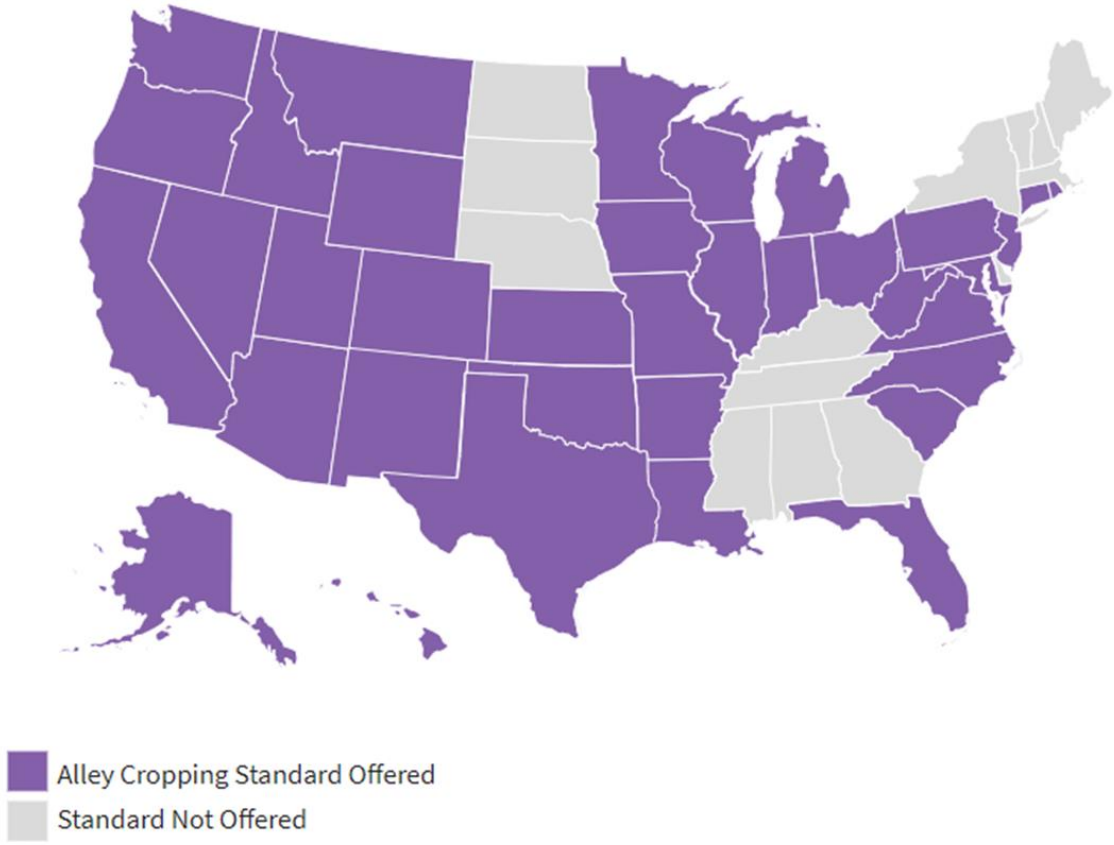
Alley Cropping (311)

Multistory Cropping (379)

Riparian Forest Buffers (391)

Silvopasture Establishment (381)

Windbreak Establishment (380)



Alley Cropping Standard Offered

Standard Not Offered

What practice is used and where in the US?

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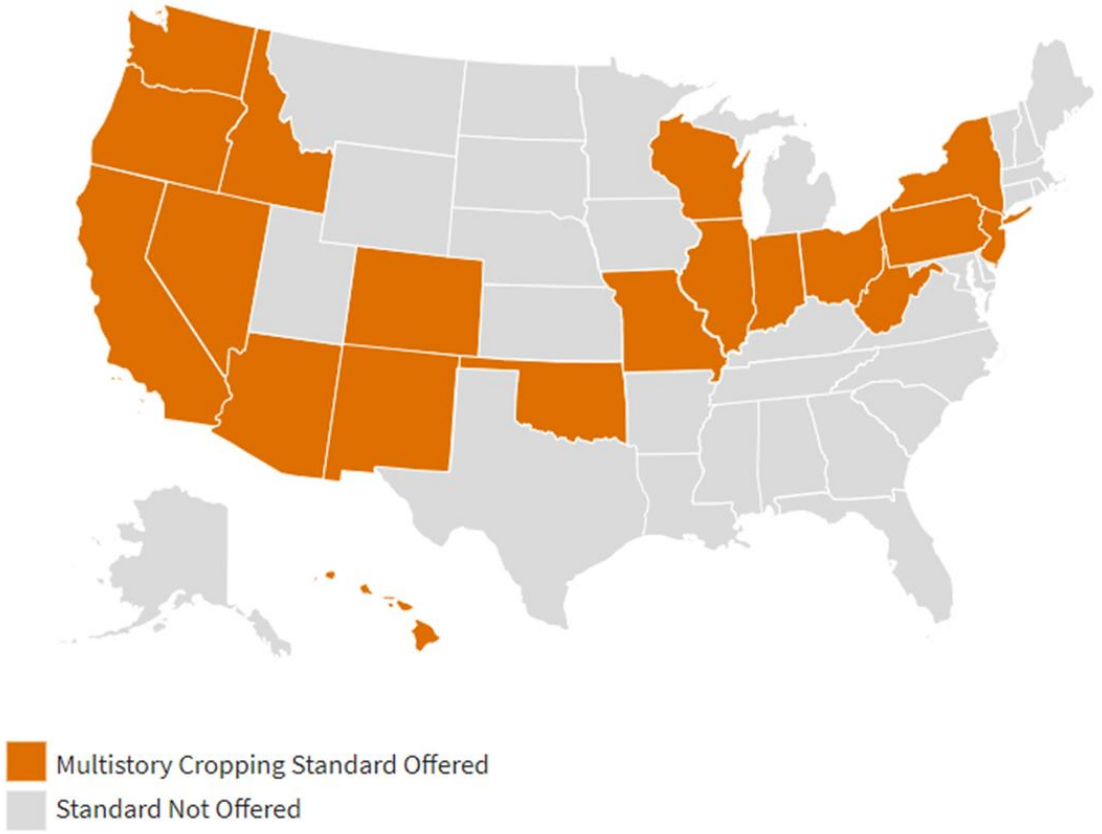
Windbreak Establishment (380)



Multistory Cropping Standard Offered

Standard Not Offered

What practice is used and where in the US?

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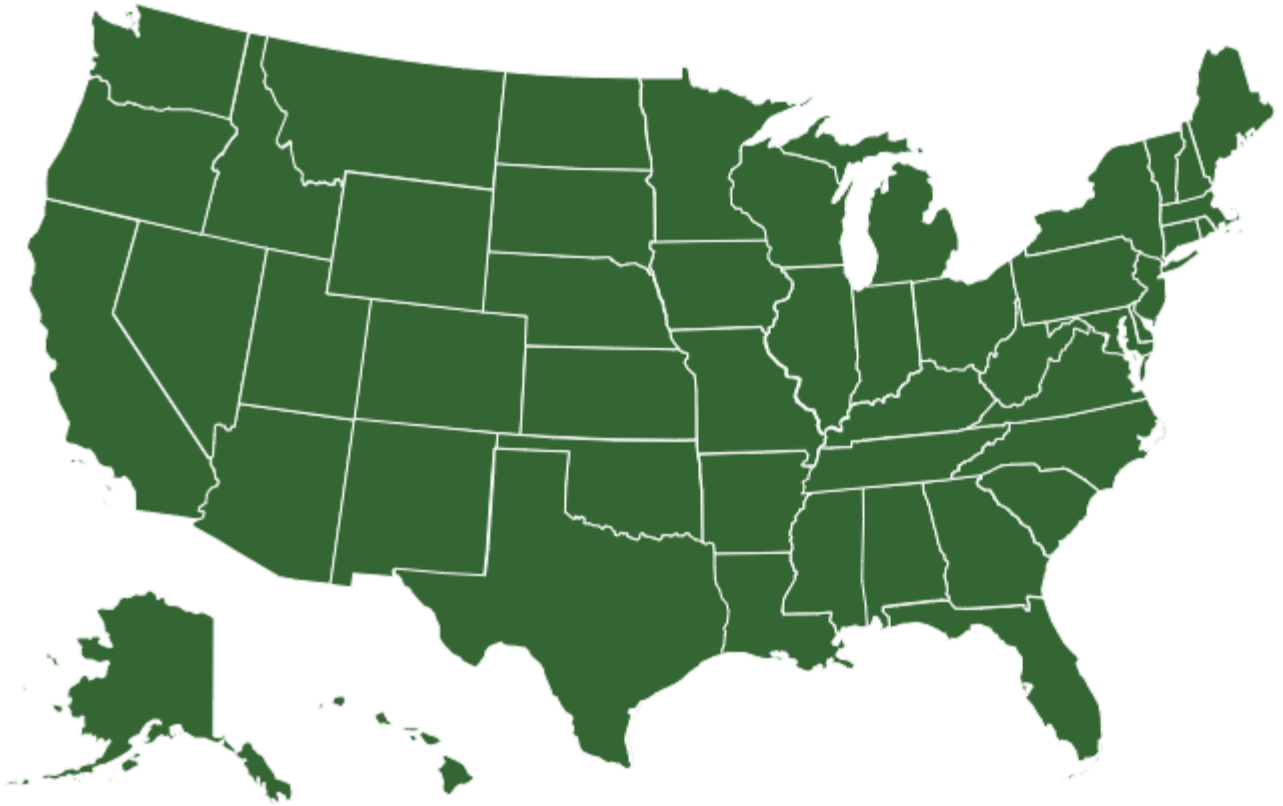
Multistory Cropping (379)

Riparian Forest Buffers (391)

Silvopasture Establishment (381)

Windbreak Establishment (380)



Riparian Forest Buffer Standard Offered

Standard Not Offered

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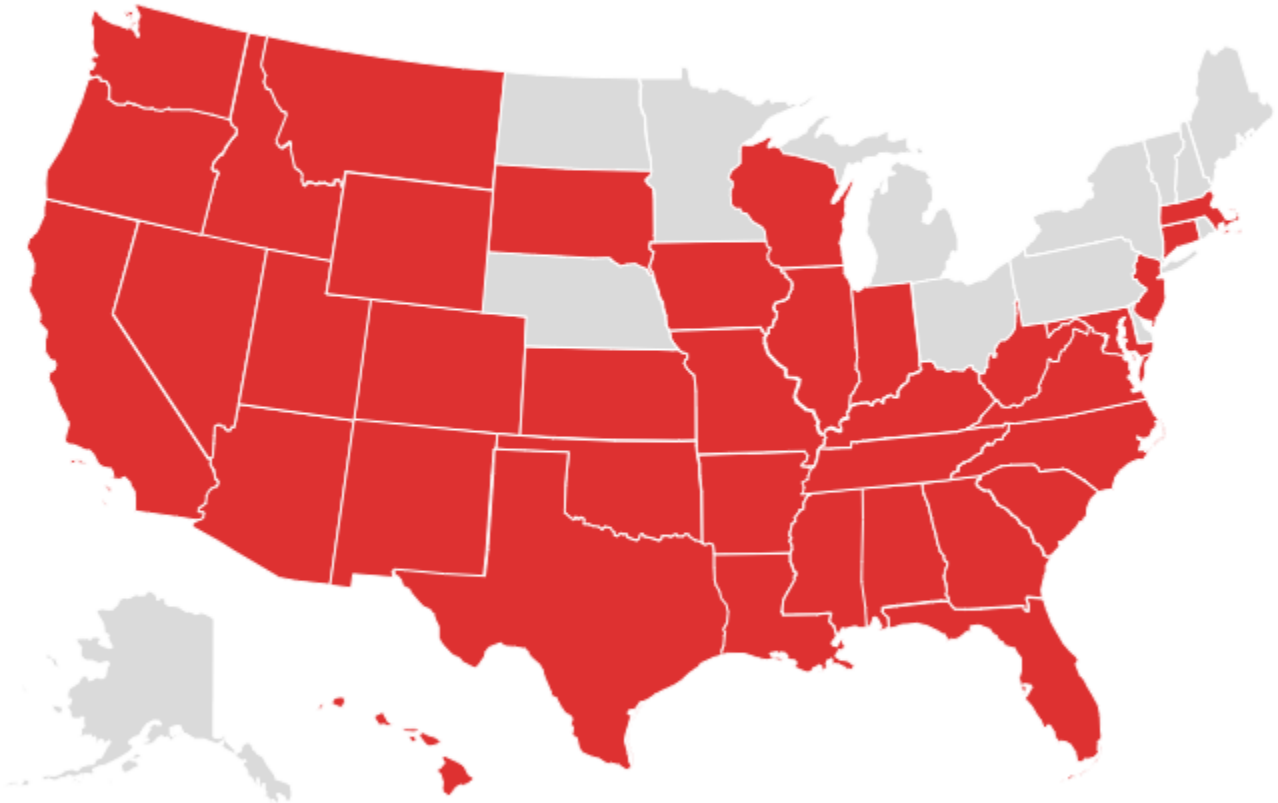

Silvopasture Establishment Standard Offered

Standard Not Offered

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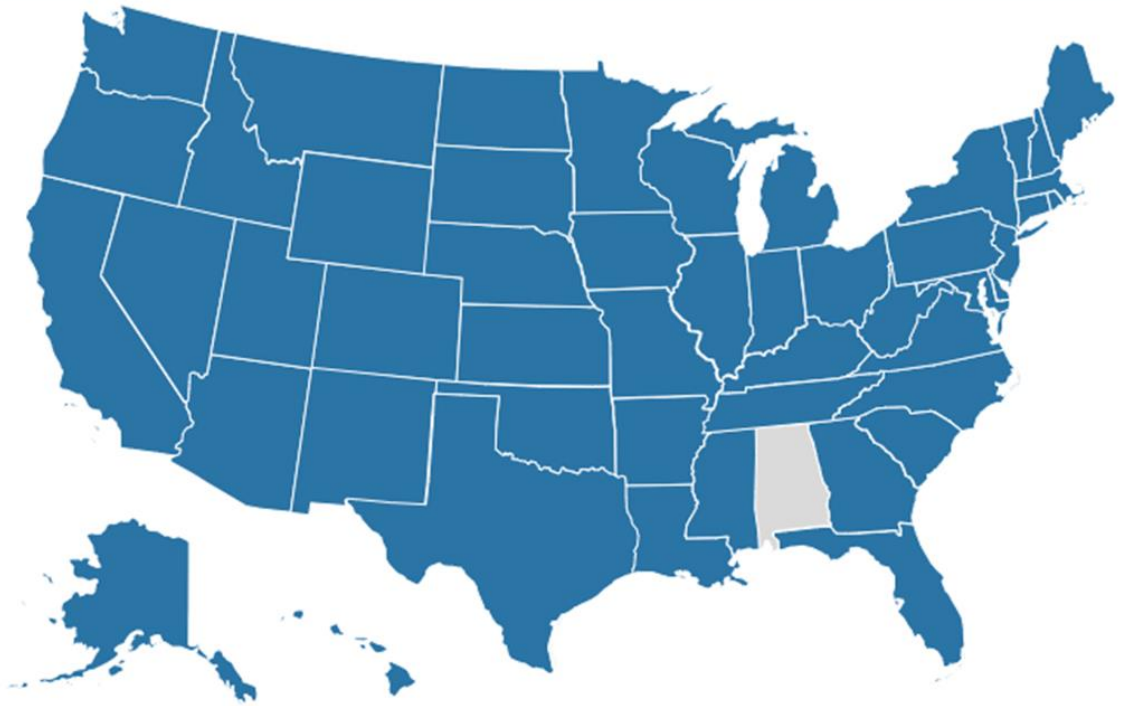
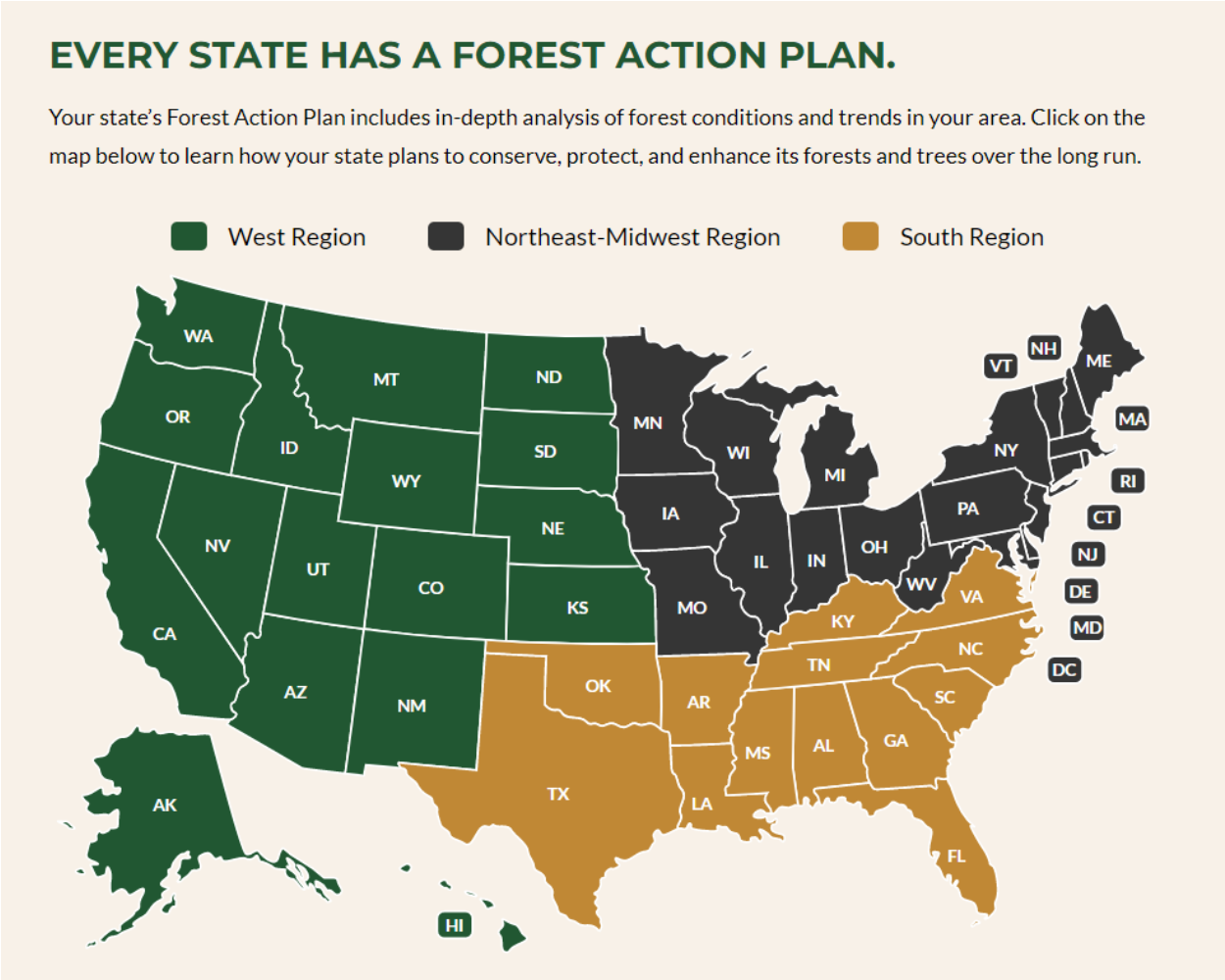


Windbreak Establishment Standard Offered

Standard Not Offered

Project 1 – Agro … what …?



Objectives:

1. Streamline the use of agroforestry terminology to foster consistency and easier determination of agroforestry practice

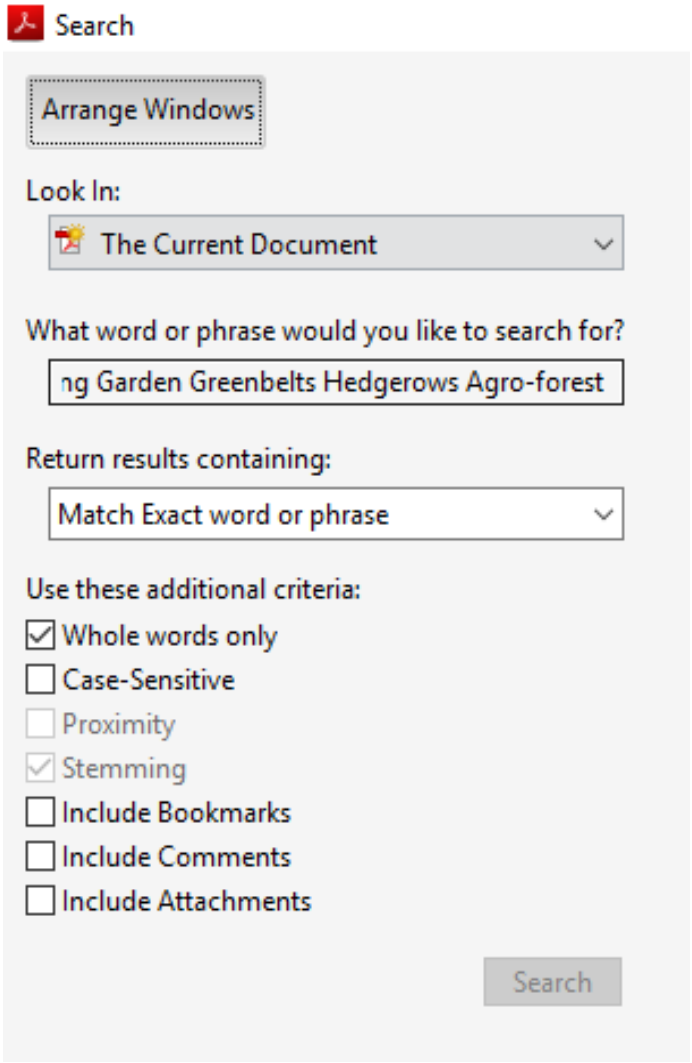
2. Solicit conversations on the inclusion of agroforestry sections in statewide FAPs

3. Make recommendations on the utilization of agroforestry using applicable scenarios determined by FAPs

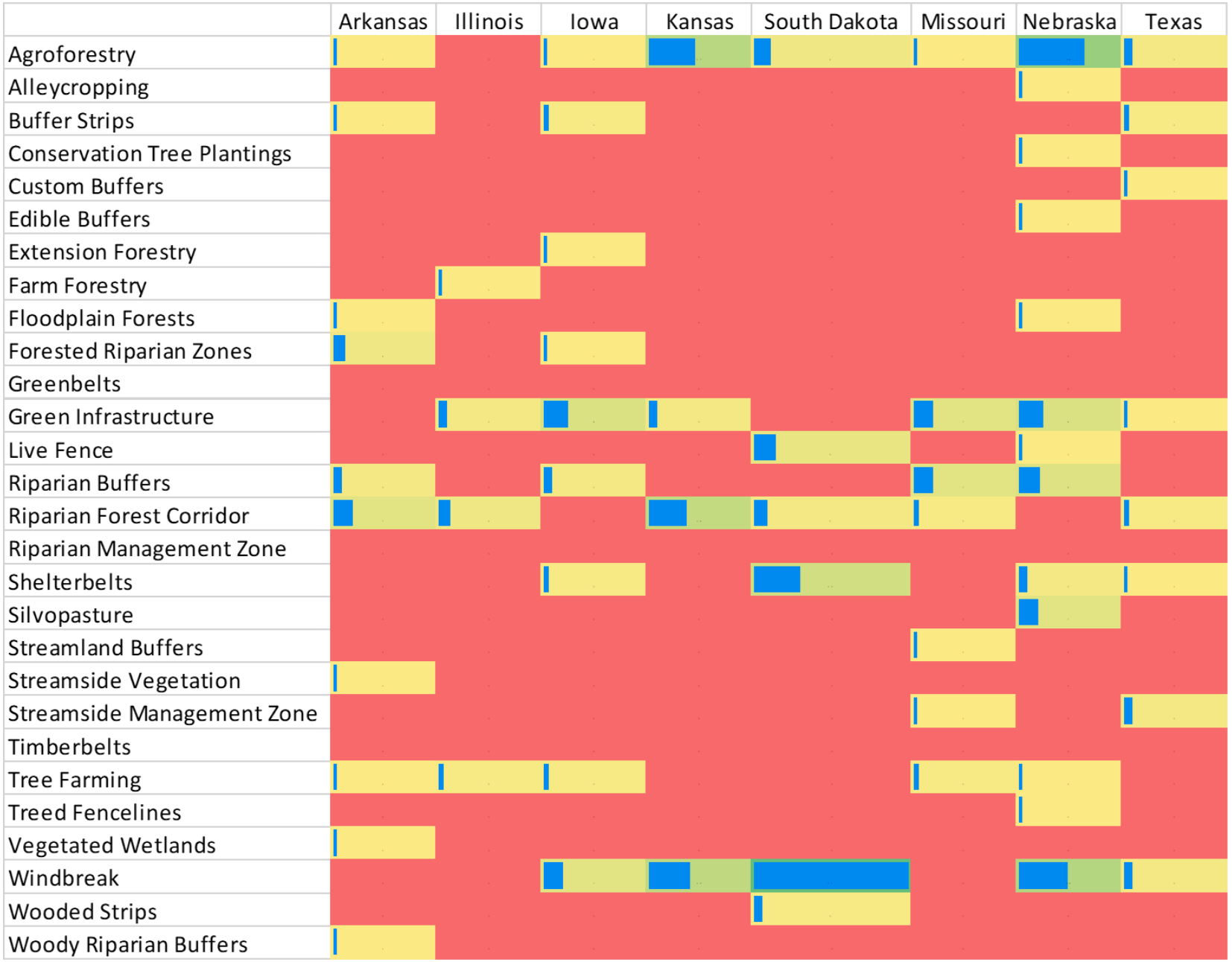
Keywords

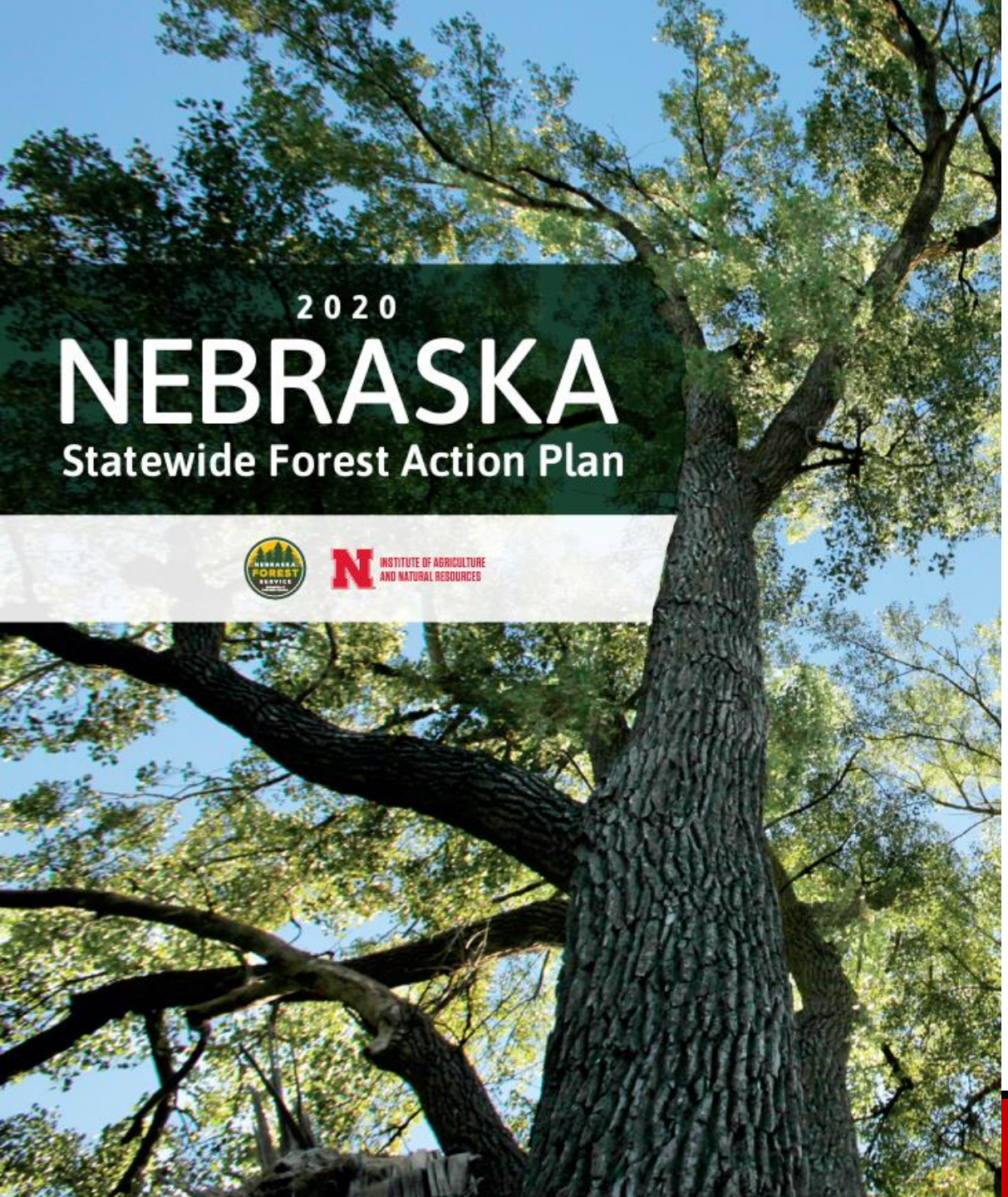
- Agroforestry
- Agro-forestry
- Agriforestry
- Agrisilviculture
- Buffer Strips
- Contour Strips
- Farm Forestry
- Forest Farming
- Forest Garden
- Greenbelts
- Hedgerows
- Linear Strips
- Live Fence
- Mixed Forestry
- Multi-story Cropping
- Dooryard Gardens
- Permaculture
- Riparian Forest Buffers
- Shelterbelts
- Silvopasture
- Strip cropping
- Tree Farming
- Timberbelts
- Vegetated Buffer Strips
- Windbreaks
- Woody Riparian Buffers
- Vegetated Wetlands

Method



Project 1 – Agro … what …?





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.

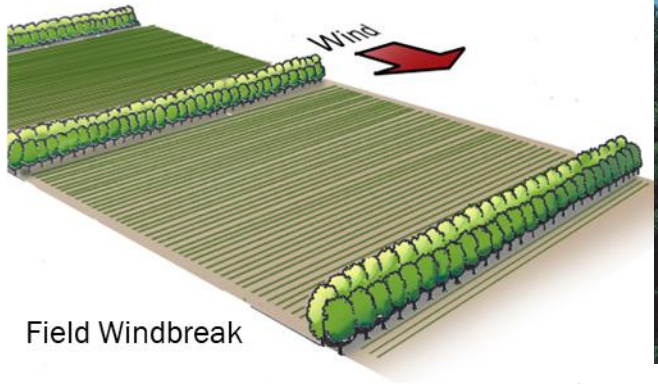
Project 2:

Agricultural Systems
Volume 187, February 2021, 103032

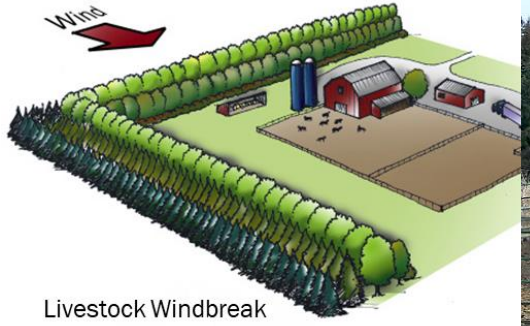
Review

Windbreaks in the United States: A systematic review of producer-reported benefits, challenges, management activities and drivers of adoption

Matthew M. Smith [a], Gary Bentrup [a], Todd Kellerman [a], Katherine MacFarland [a], Richard Straight [a], Lord Ameyaw [b]

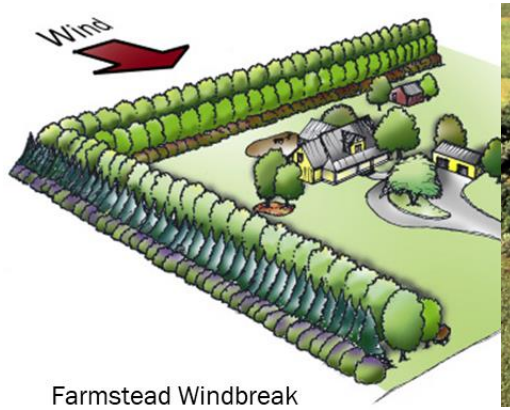


Field Windbreak



Livestock Windbreak

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?



Farmstead Windbreak

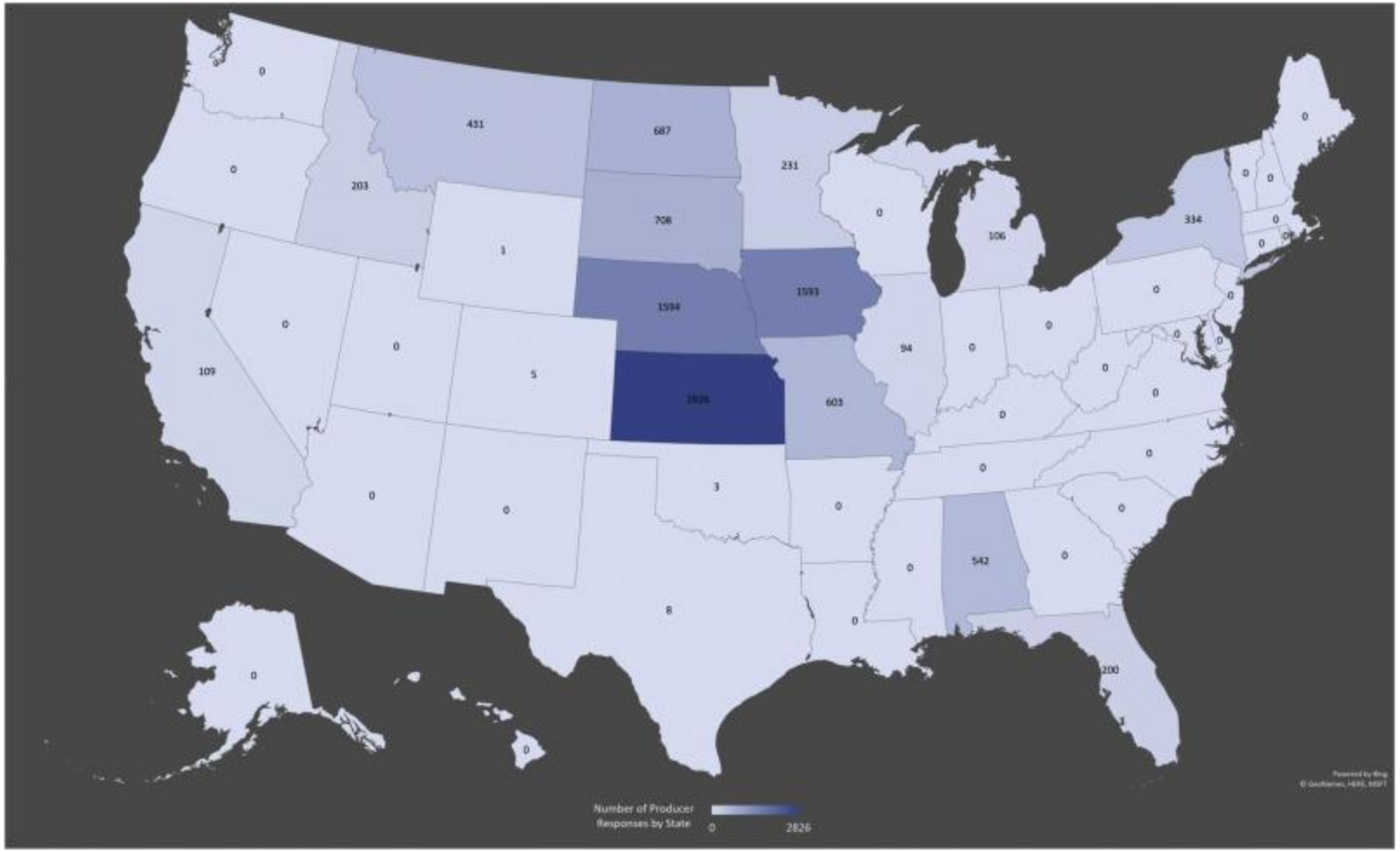
Methods for the Systematic Review

- 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

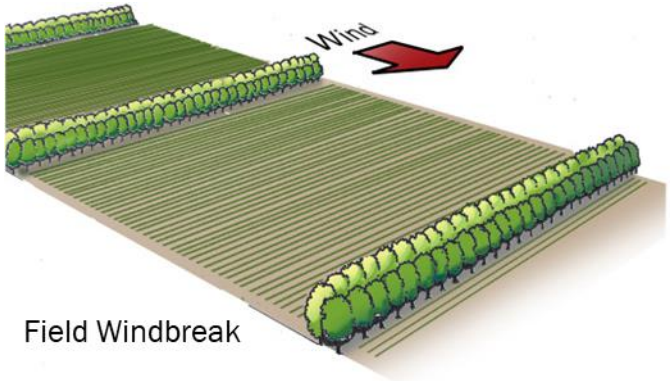
Summary of Included Studies (Surveys)



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

		Importance Ranking										
Authors	Type of Windbreak	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th
Laughlin 1989	Field	Soil Erosion Control	Wind Protection	Snow Control	Crop Protection	Wildlife Habitat	Aesthetics	Increase Crop Yield	Livestock Protection	Increase Property Value	Improve Water-Use Efficiency	Wood Products
Dearmont et al. 1983	Field	Soil Erosion Control	Livestock Protection	Snow Control	Increase Crop Yield	Aesthetics	Wildlife Habitat	Wood Products				
Tomczak 2009(b)	Field	Soil Erosion Control	Livestock Protection	Snow Control	Other	Wildlife Habitat	Increase Property Value	Wood Products	Increase Crop Yield	Aesthetics		
Laughlin 1989	Farmstead	Aesthetics	Wind Protection	Snow Control	Energy Savings	Increases property Value	Livestock Protection	Wildlife Habitat	Soil Erosion Control	Noise Control	Improves Water-Use Efficiency	Wood Products
Tyndall 2009	Livestock	Odor Reduction	Visual Screening	Aesthetics	Energy Savings							
Hand et al. 2019(b)	Farmstead Field Livestock	Wind Protection	Livestock & Crop Protection	Aesthetics	Privacy	Hunting, Fishing, Recreation	Enhance Water Quality	Enhance Soil Quality	Carbon Storage	Wood Products	Non-Timber Forest Products	
Workman et al. 2003 (b)	Farmstead Field Livestock	Soil Erosion Control	Aesthetics	Long-Term Return	Wildlife Habitat	Shade	Enhance Water Quality	Increase Biodiversity	Increase Property Value	Improves Farm Interest	Increase Financial Security	Enhance Water Quantity
Cable and Cook 1997	Farmstead Field Livestock	Livestock Protection	Crop Protection	Soil Erosion Control	Wildlife Habitat							

Producer-Reported Reasons for Windbreak Removal

	Rank							
Authors	1st	2nd	3rd	4th	5th	6th	7th	8th
Dearmont et al. 1983	Conflict with Irrigation	Age and Poor Condition	Conflict with Farming Practices	Crop Competition	Field Consolidation	Snow Drift Issues	Preparing Site for New Windbreaks	No Value in Windbreaks
Laughlin 1989	Poor Condition	Age	Conflict with Equipment	Gain Acreage	Crop Competition	Snow Drift Issues	Field Consolidation	Conflict with Irrigation
Cable and Cook 1997	Gain Acreage	Crop Competition	Conflict with Irrigation	Conflict with Equipment				
Tomczak 2009(b)	Conflict with Farming Practices	Age and Condition	Conflict with Irrigation	Crop Competition	No Value in Windbreaks	Field Consolidation	Preparing Site for New Windbreaks	Other

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)

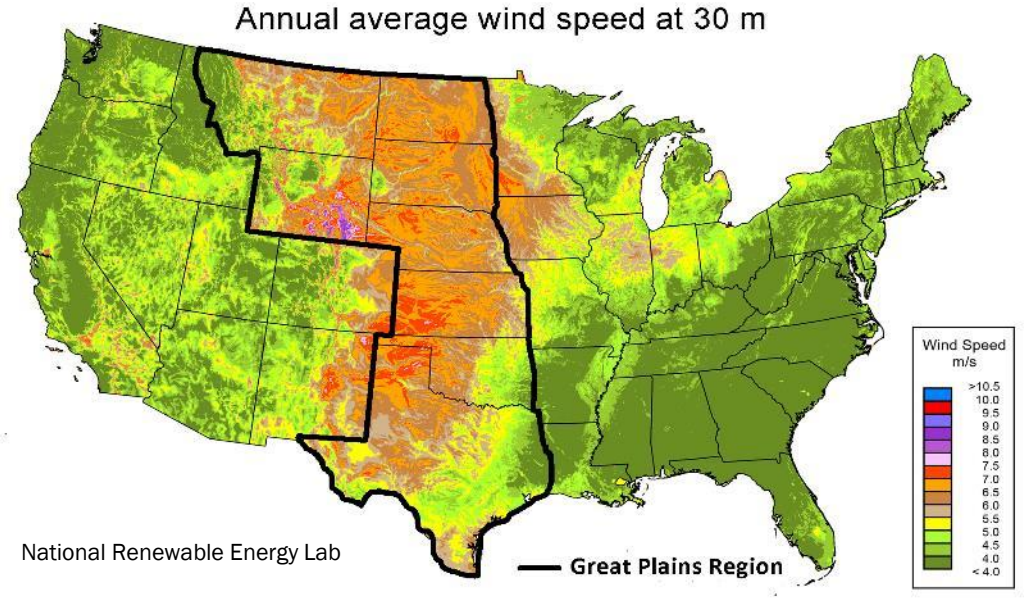
Conservation, Profit, or Both?

- 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

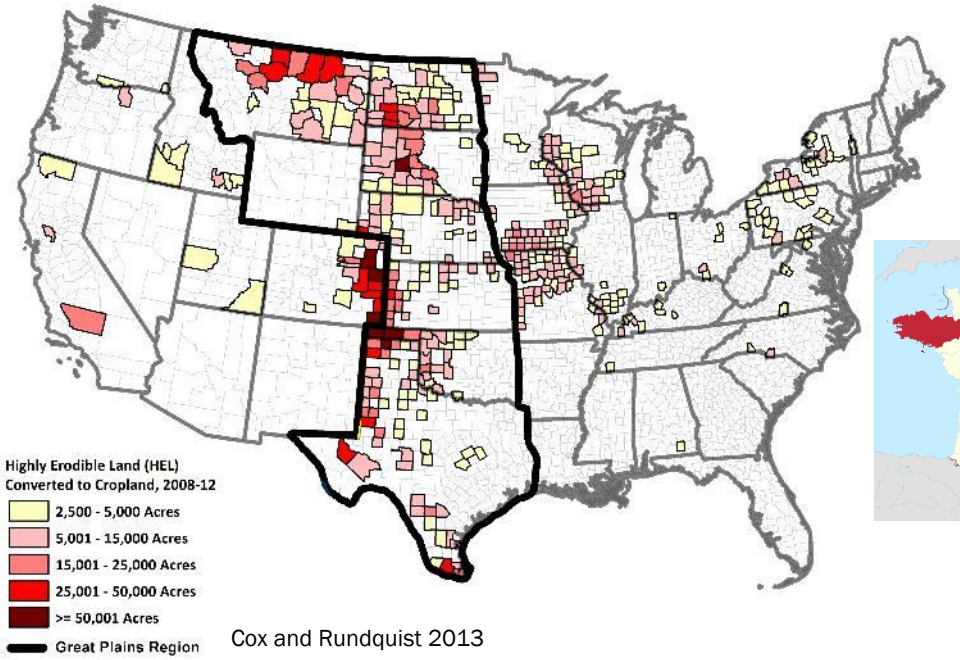
I-80 Pile Up - Omaha World Herald April 29, 2018

2^{o} C increase could increase wind erosion by 15-18% Lee et al. 1996

USDA Natural Resources Conservation Service



National Renewable Energy Lab



Cox and Rundquist 2013

Project 3:

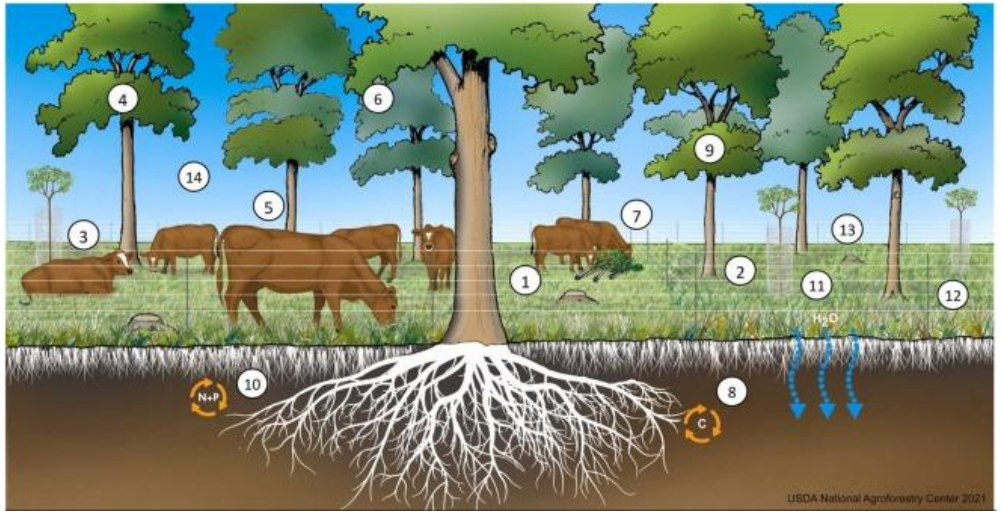
Agriculture, Ecosystems & Environment
Volume 326, 1 March 2022, 107818

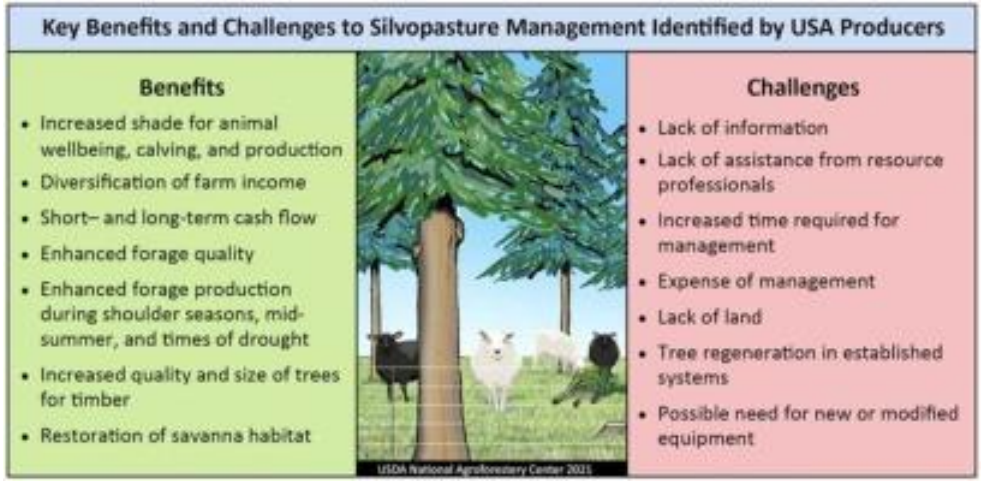
Silvopasture in the USA: A systematic review of natural resource professional and producer-reported benefits, challenges, and management activities

Matthew M. Smith [a], Gary Bentrup [a], Todd Kellerman [a], Katherine MacFarland [b], Richard Straight [a], Lord Ameyaw [c], Susan Stein [d]

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	Component	Summarized primary effects	Key references
1	Forage	Microclimate modification can maintain or enhance forage yield and quality compared to open pasture depending on species and management.	Buergler et al. (2006), Ford et al. (2019b), Fannon et al. (2019), Orefice 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 McDougald (1989), Feldhake (2002), Kallenbach et al. (2006), Coble et al. (2020)
3	Livestock	Shade reduces solar radiation and heat stress which can enhance animal productivity.	Karki and Goodman (2010), Schütz et al. (2014), Van laer et al. (2014), Pent et al. (2020b, 2021)
4	Livestock	Shelter from trees can offer thermal protection for livestock during winter by reducing wind and precipitation reaching sheltering animals.	Van laer et al. (2014, 2015), He et al. (2017)
5	Livestock	Livestock weight gain in silvopastures can be comparable to that of livestock grazed in open pastures depending on species and management.	Kallenbach et al. (2006), Ford et al. (2019b), Pent et al. (2020a)
6	Tree	Trees in silvopasture can produce products to increase enterprise diversification. Tree growth can benefit from nutrient input but may be negatively impacted by livestock if not adequately managed.	Ares et al. (2006), Broughton et al. (2012), Bruck et al. (2019), Pent 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), Vandermeulen et al. (2018), Pent and Fike (2019), Hassan et al. (2020), Seidavi et al. (2020)
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.	Haile et al. (2008, 2010), Baah-Acheamfour et al. (2014, 2015), 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), Lal 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), Bambo et al. (2009), Boyer and Neel (2010), Nyakatawa et al. (2012)
11	Ecosystem service	Infiltration rates are similar or slightly higher in silvopasture than open pasture 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 (1999), Mcadam et al. (2007) Torralba et al. (2016), Moreno et al. (2018)
13	Ecosystem service	Grazing and woodland management in silvopasture systems may reduce fuel load and wildlife risk.	Ruiz-Mirazo and Robles et al. (2012), Palaiologou et al. (2020), Damianidis et al. (2021)
14	Ecosystem service	Silvopasture may provide cultural ecosystem services including sense of place, aesthetic value, recreation and ecotourism, and cultural heritage value.	Fagerholm et al. (2016), Moreno et al. (2018)

Questions/Comments ...??