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Oak Savanna Restoration and Climate Change Mitigation through Silvopasture in Minnesota

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Abstract
Reducing emissions of world food systems will be critical to combatting climate change. Silvopasture systems, which integrate managed forests with pastureland, have been shown to be a more sustainable alternative to traditional livestock production and have the ancillary benefit of diversifying the sources of income for farmers. Silvopasture may also have the capacity to serve as a mechanism for ecological restoration. This paper combines existing literature with an interview of a farmer who is engaging in silvopasture to evaluate the potential of silvopasture as means to restore Minnesota's disappearing oak savanna ecosystem, while improving the sustainability of food production within the state. **Based on current land usage within the historic oak savanna range, there is significant potential to restore a dwindling habitat while improving Minnesota's food system through silvopasture.**

Background
What is Silvopasture?
The US Department of Agriculture defines silvopasture as "the deliberate integration of trees and grazing livestock operations on the same land." In silvopasture, livestock animals graze on forbs and grasses that grow within forest stands. In silvopasture systems trees must be relatively dispersed to allow light to reach the ground and promote plant growth. The livestock animals graze on a rotational cycle, maintaining optimal levels of undergrowth to allow trees to thrive. In silvopasture, forage types, grazing rotations, and tree planting rotations are all intentionally chosen to work in harmony and maximize production. Existing literature has shown that silvopasture produces less carbon dioxide emissions compared to traditional livestock production with minimal sacrifices to livestock yield. Conversion of land to silvopasture is typically done either by planting trees on existing pastureland or, more quickly, by thinning existing forest stands and planting forage grasses.

Oak Savanna Habitat
Oak savanna habitat is characterized by a dispersed canopy of fire-resistant oak trees, elevated above prairie grasses and forbs. This habitat occurs at the intersection between woodland and prairie. Oak savannas are ideal habitats for many species of animals such as deer, turkeys, and red-headed woodpeckers. This habitat once made up over 10 percent of the states land, but it is now less than half a percent. The main causes for the disappearance of oak savannas in the state have been the clearing of land for agriculture and development, and overgrowth due to a lack of understory management. Traditionally, indigenous people used fire regimes to keep shrubs and forbs under control, allowing for trees to flourish.

Further Reading
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Smith, Matthew M., Gary Bentrup, Todd Kellerman, Katherine MacFarland, Richard Straight, Lord Ameyaw, and Susan Stein. "Silvopasture in the USA: A Systematic Review of Natural Resource Professional and Producer-Reported Benefits, Challenges, and Management Activities." *Agriculture, Ecosystems & Environment* 326 (2022): N.PAG- N.PAG. https://doi.org/10.1016/j.agee.2021.107818.

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Methods
To establish an overview of silvopasture, I synthesized existing literature and constructed a table illustrating the benefits, costs and barriers, best practices, and planning considerations associated with silvopasture systems. The second step of my analysis was to create a geographical overview of viable land for oak savanna restoration within Minnesota. The Minnesota Department of Natural Resources (DNR) uses an Ecological Classification System that divides the state into provinces, sections and subsections based on climate, geology, topography, soils, hydrology, and vegetation. Using 2006 land use surveys from the DNR, I constructed a table that presents information about land ownership, population density, current land use, and the disappearance of oak savanna habitat within the seven Subsections that make up the "Eastern Broadleaf Province." These subsections were chosen because of their significant historic oak savanna presence. I combined the DNR data with the silvopasture literature overview to determine which areas in the state show the greatest potential for oak savanna restoration using silvopasture. Finally, I visited the farm of Tom Hunter who is currently using silvopasture to restore oak savanna habitat on his land in Wabasha. Minnesota.

Table 1. Analysis of the Viability of Silvopasture in Minnesota

Benefits	Costs & Barriers	Best Practices	Planning Considerations
• Reduced economic risk through product diversification • Decreased livestock stress due to shade and shelter provided by trees - may result in reduced upkeep costs • Increased forage quality • More ethical treatment of animals compared to feedstock production • Potential immediate profit from thinning if land is converted from existing forest • Increased carbon sequestration and soil biodiversity if converted from pastureland	• Yearly tree harvest and animal maintenance costs • Reduced carbon sequestration if land is converted from forest to silvopasture • Large initial land base required • More management required than traditional grazing systems • Significant Fencing investment • Ecological interactions within silvopasture systems and ideal practices are not perfectly understood • Substantial waiting period before forest products can first be harvested if starting with pastureland	• Rotational Grazing, 1-6 day grazing period (until forage height is 3-4 inches) with 20-45 days recovery depending on forage species • Evenly dispersed Tree Planting - avoid grazer congregation • Plant Seedlings with well-established root systems • Prune trees do improve light dispersion • Select forage that is well adapted to shade and is compatible with nutritional needs of livestock • Fence around planted trees to prevent damage from livestock trampling or browsing	• Fencing and water infrastructure required for rotational grazing • Soil Moisture Levels - must avoid soil compaction or erosion from trampling • Slope - steep slopes are not compatible with livestock grazing • Water resources on land must be protected • Tree type, forage type and livestock should be compatible and symbiotic • Allow enough space between trees for equipment movement • Tree planting arrangement: single row, double row or blocks • A prescribed burn may be required to initially clear debris

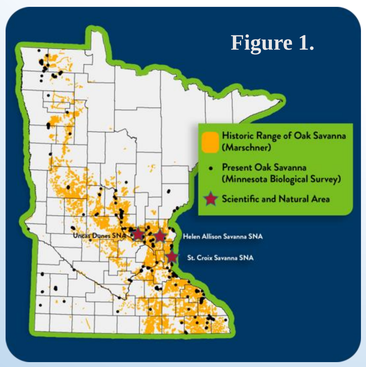

Figure 1 depicts the current and historic range of oak savanna habitat in Minnesota

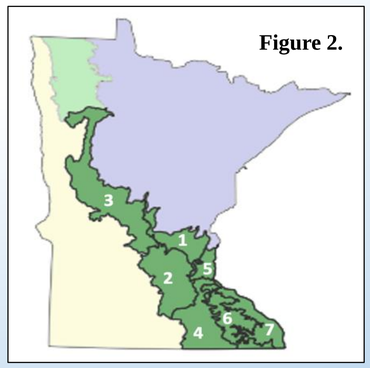

Figure 2 illustrates the seven Subsections that make up the Eastern Broadleaf Province

Results
Discussion
Table 1 describes the benefits, barriers, best practices, and planning considerations for silvopasture adoption in Minnesota. The primary benefits to landowners for adopting silvopasture systems are the diversification of income sources, and the improved quality of life, and subsequently reduced upkeep costs of livestock. For Tom Hunter, the main reason behind pursuing restoration through silvopasture is simply the "romantic notion of aiding in the return of ecological processes that sustain a healthy natural food landscape." The main barriers still preventing landowners from establishing silvopasture systems are a lack of supporting information and resources, and the substantial fencing and land clearing costs. Based on the geographic data, the Blufflands Subsection, Subsection 7, appears to have the most potential for oak savanna restoration through silvopasture. This Subsection contains a high percentage of both forest and pastureland, is sparsely populated, and has also experienced extraordinary losses to oak savanna habitat. Overall, the Eastern Broadleaf Province fell from 31.5 percent oak savanna to 1.5 percent oak savanna from 1890 to 1990 – a decrease of over 3.5 million acres. The province currently contains 2.1 million acres of pastureland and 1.4 million acres of forest which could be converted to silvopasture using planting and thinning processes.

Conclusion
Overall, the potential of oak savanna restoration through silvopasture systems in Minnesota seems high due to the abundance of pasture and forest land contained in the historic range of oak savanna habitat. Particular potential is shown in the Blufflands Subsection of the Eastern Broadleaf Province. If the use of silvopasture was expanded in the state of Minnesota it would improve animal welfare and reduce the carbon footprint of the state food system, particularly if the majority of new silvopasture establishment occurred on existing pastureland through planting. If a portion of these hypothetical silvopasture farms committed to simultaneously restoring oak savanna, it would improve habitat biodiversity within the state of Minnesota and revitalize struggling species.

Figure 3.
Figure 3 is a photo taken at Tom Hunter's farm in Wabasha, Minnesota