Report and Recommendations
NORTHEAST MULTISTATE ACTIVITIES COMMITTEE
September 8, 2026 (virtual)

Members: Puneet Srivastava (Maryland-Chair), Beth Gugino (Pennsylvania), Chris Smart (NY-Geneva), Lee Hecker (Maine), Bill Miller (MA/NEED), Ali Dunigan (NEED)

Non-voting, ex officio: Rick Rhodes (agInnovation NE), David Leibovitz (agInnovation NE)

<u>Discussion of Peer Reviewed Multistate Activities (MAC to provide recommendations)</u>

- NE_TEMP2605: Eastern White Pine as an Iconic North American Tree: Evolving Dynamics and Future Opportunities, 10/01/2026-09/30/2031 [AA: Lee Hecker, Maine]
  - New project related to Eastern White Pine
  - Outreach plan and methods for tracking modern threats to Eastern White Pine were expanded in response to peer review
  - Objectives 2 and 4 are implicit activities of a multistate research project. Should they be revised or could they be removed?
    - NIMSS project language is crawled by search engines and is discoverable. An explicit call out to the development of research proposals that imply leveraging multistate funds might be worth retaining in the multistate project.
  - Under the header of "Importance of the work"; the MAC recommended drafting a statement that specifically ties this forestry-related proposal to agriculture: e.g., language about interconnected landscapes, working lands, agroecosystems, rural economic development.
  - **The MAC recommends the following revisions be made to the proposal:**
    - **Revise objective 4 to remove "Submit research proposals"**
    - **Draft language under "The importance of the work" that serves as a direct articulation of how this proposal relates to agriculture.**
  - **A motion was introduced to recommend revisions to the proposal as outlined above, and subsequently approval of NE_TEMP2605. The motion was approved unanimously.**
- NE_TEMP2650: *Building a Resilient Equine Economy: Sustainable Pathways for Horses and Communities*, 10/01/2026-09/30/2031 [AA: Lee Hecker, Maine]
  - The proposal covers a broad range of issues related to the equine industry. Revisions have been made to narrow its focus by removing objectives and refining project language.
  - The Northeast has an active equine industry, and this proposal has an appropriate fit into the region's multistate research portfolio.
  - This project would also have a strong outreach component.

- The NE2202 *Equine Microbiome* project is intended to sunset. We should extend the invitation for members of that group to join the new equine project. The microbiome project activities would fit into the larger, more broad new proposal concept. This would provide NE2202 with an opportunity to sunset effective fall 2026 if interested.
- **A motion was introduced to recommend approval of this proposal. The existing NE2202 should be encouraged to join this newly formed equine project and recommended for sunsetting. This motion was approved unanimously.**

Multistate Activities Seeking Administrative Adviser Assignments (for association discussion)

- NE2206: Green Stormwater Infrastructure and Agriculture (formerly Josh Kohut) – ends 9/30/2027
- NE2334: Genetic Bases for Resistance and Immunity to Avian Diseases (formerly Chris Ashwell and Bob Taylor) – ends 9/30/2028
- NECC29: Corn Improvement Conference (formerly Margaret Smith) – ends 9/30/2028
- NECC2202: Formal Structure for the Minor Use Animal Drug Program (formerly Margaret Smith) – ends 9/30/2027
- NRSP13: Artificial Intelligence for Agricultural Autonomy (formerly Josh Kohut) – ends 9/30/2030
- NE2201: Mycobacterial Diseases of Animals (currently Rick Rhodes) – ends 9/30/2027
- NECC2312: Northeast Coordinating Committee on Soil Testing (currently Rick Rhodes) – ends 9/30/2028
- NRSP9: National Animal Nutrition Program (currently Rick Rhodes) – ends 9/30/2030

Multistate Activities Ending 9/30/2026 (For information only)

- NEERA2104: Northeast Region Technical Committee on Integrated Pest Management
- NECC2103: High tunnel specialty crop production
- NE2140: Sustainable Management of Nematodes in Plant and Soil Health Systems
- NE2101: Eastern White Pine Health and Responses to Environmental Changes

Multistate Activities Ending 9/30/2027 (For information only)

- NE1962: Outdoor Recreation, Parks and Other Green Environments: Understanding Human and Community Benefits and Mechanisms (AA: Anton Bekkerman)
- NE2201: Mycobacterial Diseases of Animals (AA: Rick Rhodes)
- NE2202: The Equine Microbiome (AA: Chris Smart)
- NE2203: Legal Issues in Agriculture and Natural Resources (AA: Puneet Srivastava)
- NE2204: A regional network of social, behavioral, and economic food systems research (AA: Ock Chun)
- NE2206: Green Stormwater Infrastructure and Agriculture (AA: to be determined)
- NE2210: Improving Forage and Bioenergy Crops for Better Adaptation, Resilience, and Nutritive Value (AA: Eric Bishop von Wettberg)
- NE2220: Multi-state Coordinated Evaluation of Grape Cultivars and Clones (AA: Anna Katharine Mansfield)

- NE2227: Contribution of Ovarian Function, Uterine Receptivity, and Embryo Quality to Pregnancy Success in Ruminants (AA: Dave Townson)
- NE2231: Collaborative Potato Breeding and Variety Development Activities to Enhance Farm Sustainability in the Eastern US (AA: Anton Bekkerman)
- NE2248: Mastitis Resistance to Enhance Dairy Food Safety, Milk Quality, and Animal Welfare (AA: Ock Chun)
- NE2249: Sustainable and Inclusive Rural Economic Development to Enhance Housing, Health, Entrepreneurship, and Equity (AA: Anton Bekkerman)
- NE2251: Tourism Resilience and Community Sustainability: Adaptation and Recovery of Rural Businesses and Destinations (AA: Anton Bekkerman)
- NECC2202: Formal Structure for the Minor Use Animal Drug Program (AA: to be determined)

USDA Multistate Research Project –Proposal Draft
March 1, 2026

Title: Eastern White Pine as an Iconic North American Tree: Evolving Dynamics and Future Opportunities

Start Date: October 1, 2026 End: September 30, 2031

Overall hypothesis or goal: Characterize the current stand development of eastern white pine (EWP) across its range and how that will likely influence future management and health of the species.

Specific objectives (Long-term underlined, short-term follow)

1. Use FIA data to quantify the range of forest composition and growth of EWP where EWP has significant development. The initial analysis will be on data for Maine followed by data for other members of the Multi-state Project, first being New Hampshire, Vermont, and New York. Next will be analyses for North Carolina and Michigan. Finally, analyses will be completed for other states with significant volume of EWP including Massachusetts, Connecticut, Pennsylvania, Virginia, and Wisconsin.
2. Assess the current status of EWP and future opportunities. The Project members will write a review paper that will provide the basis for guiding future research and management of the species.
3. Revise silvicultural recommendations and forest management to improve EWP productivity, health, and economic return. The first recommendations will be developed for Maine after which recommendations will be developed for use in states of other Project members.
4. Improve our understanding of EWP development and how to manage the species.

The need as indicated by stakeholders.:

Eastern white pine is an iconic species for northeastern North America: Iconic species resonate with the public and can be used to engender broader public support for desired outcomes (Davies and Tippler 2024). Iconic species differ from indicator or keystone species because of the public connection; iconic species are not only biologically and ecologically important but also are part of a community's culture.

Eastern white pine's cultural connection to Indigenous Nations' traditions (Mausel, Waupochick, and Pecore 2017) and the European settler's development (D. R. Foster, Motzkin, and Slater 1998) is probably a partial result of its abundance due to regeneration across multiple environments, ability to grow larger and taller than any other species in the east, and wood that was suitable for lumber (Lancaster and Leak 1978; Wendel and Smith 1990).

White pine has enormous economic value throughout its range. Over the region, the net volume of white pine saw logs is over 186 billion board feet (USDA Forest Service, Forest Inventory and Analysis). With a typical market price of $100/1,000 bd ft, the potential value of standing white pine is $18.6 billion.

From an ecological perspective, white pine has significant impact on the eastern forest (Wendel and Smith 1990). White pine attains the largest dimensions of any eastern tree serving as a critical habitat for many species of wildlife that depend on emergent crowns and large snags and downed woody debris. In many parts of the range, EWP was the primary species that recolonized abandoned fields as farmers moved to more productive lands. This resulted in “old field pine”, stands dominated by EWP (Marshall 2009).

Silviculture and management of EWP has recommended developing stands that are dominated by EWP on sites where hardwoods are not aggressive (Lancaster and Leak 1978). However, after analyzing USDA Forest Service Forest Inventory and Analysis (FIA) plots in Maine (unpublished data), only about 5% of the plots were dominated by EWP (> 75% of the stems) (Maeve). Analysis of FIA data in Maine indicates that 15% of EWP commercial volume is in the spruce/fir (SF) type and another 31% is in the commercial hardwood (CH) types equaling the volume (44%) found in the EWP types. Additional analysis shows EWP volume growth is highest in the SF type and among the highest in the CH types resulting in EWP becoming the dominant species in stands with large diameters (12-18 in). About 30% of the regenerating EWP samplings occur in the SF, 53% in CH, and 19% in the pine type, a regeneration abundance that contradicts earlier impressions of eastern white pine becoming less dominant in mixed stands (Marshall 2009); the future of EWP in Maine will be in mixed species types.

For many decades, white pine health has been adversely affected by the non-native white pine blister rust (*Cronartium ribicola*) and the native white pine weevil (*Pisodes strobi*) (Costanza et al. 2018). More recently a stem canker pathogen, *Caliciopsis pinea*, and the pine bast scale, *Matsucoccus macrocicatrices*, have occurred separately or together in association with EWP decline, dieback, and mortality. Managing EWP stands can be effective in reducing risks and losses due to these fungal pathogens and insect pests (Livingston et al. 2019). A recent study (Noone-Price 2025) indicates that an alternative approach to reduce white pine weevil damage is to manage EWP in mixtures.

More information is needed on EWP dynamics in mixed species stands so that silvicultural and management guidelines can be developed to improve EWP regeneration, growth, health, and economic value.

Evolving dynamics of cultural, biological adaptations, and ecological interactions has made eastern white pine an iconic tree species for the forests of northeastern North America that is 1) culturally relevant, 2) covers a broad geography, 3) highly resilient and productive which 4) could be improved with effective management.

The importance of the work, and what the consequences are if it is not done.

Future supply of EWP is essential in states where there is commercial demand for the wood, and assurance of future availability will make the species more attractive for commercial investment in other states. Efforts are needed immediately to reduce the uncertainty about where and how to manage EWP across its range so that its health, growth, and value can be maintained or improved.

Although the multiple stress agents associated with EWP health issues make it a challenge to grow, strategies aimed at improving white pine health are readily available for stands dominated by EWP (Livingston et al. 2019). White pine has long been successfully regenerated using silvicultural methods, such as shelterwood and seed tree cuts, and responds very well to thinning, and recommended management strategies can reduce health risks (Lancaster and Leak 1978). However, as explained above, about half of the current volume of EWP occurs in stands mixed with other species, and it is not known if current recommendations on EWP health are appropriate for the mixed-species stands. By gaining a better understanding of how EWP is developing in the mixed species stand and how it can be managed along with associated species, we will be able to recommend silvicultural treatments that improve EWP growth and value and reduce the risk of white pine damage due to common stressors.

There are concerns about future development and availability of EWP and uncertainty on how the species will respond to a changing climate with some predicting reduced importance (L. Iverson, Prasad, and Matthews 2008; Prasad et al. 2020), and others are predicting stable habitat amounts (Yang et al. 2015; L. R. Iverson et al. 2019; U.S. Department of Agriculture, Forest Service. 2026). The uncertainty on the future range of EWP needs to be addressed to help with making future management decisions for the species.

The Hatch Act of 1887 funds investigations supporting rural economies by maximizing contribution by agriculture to the welfare of the consumer. As an iconic tree species, EWP is a model system where improved knowledge and understanding can significantly improve the species' economic and ecological contributions to rural communities throughout most of the eastern US. As the following narrative will establish, EWP has proven economic value but is underutilized in much of it's range. Our Multi-state effort will strengthen the confidence of land owners and industry that EWP will thrive in the future and be a source of economic prosperity to the region.

The technical feasibility of the research, the advantages of doing the work as a multistate effort.

The USDA Forest Service FIA program has provided a data resource from which the current status of EWP can be defined for states throughout its range. The length of data collection varies by state. Maine's current FIA data set from the same sample plots begins in 1999, and the entire 3000+ plots were remeasured on a 5-year cycle such that most plots have been measured 5 times by 2023. Other states started to measure plots at a similar time but usually have a 7-year cycle for remeasuring plots. The raw data files can be downloaded from the FIA "Datamart" in comma delimited format such that it can easily provide input to R-studio and Excel for analysis.

Given the complexity and extent of EWP issues across a large range, it is unlikely that major advances will be accomplished by any single state's group working in relative isolation; such advances require collaboration among groups working in parallel. Collectively, potential project members have an enormous amount of expertise in various aspects of tree management and health. Bringing members together in a structured and active arrangement would create a synergism in analyses and interpretation efforts, thereby increasing research efficiency and productivity, with the ultimate goal of improving EWP's management and health throughout the region.

Currently, the potential project members include researchers and outreach professionals from Land Grant Universities in Maine, New Hampshire, Vermont, New York, Michigan, and North Carolina. Many of these participants work directly with stakeholders. Creating the multistate project will allow project members to:

1) Review, synthesize, and share information from analyses of FIA data.
2) Identify critical knowledge gaps that currently hamper efforts to improve EWP management.
3) Avoid unnecessary duplication of research effort.
4) Develop additional multi-institutional research proposals for national-level grants in order to bolster and build upon this initial work.
5) Develop silvicultural prescriptions and other management recommendations to help mitigate potential white pine threats.
6) Ensure that new findings are communicated with land managers.

What the likely impact will be from successfully completing the work.

Bringing together region-wide expertise on EWP issues will allow assessment of the species' responses to a changing environment. The combination of land use changes and climate events may be initiating transformations in white pine's responses to its environment that may dramatically alter the appropriate management prescriptions for the future. The proposed working group will initiate this assessment and develop a range-wide understanding of the future of EWP in the region's forests. Finally, our goal of using this initial project to motivate an additional multi-institutional, national-level grant could lead to much broader impact than that outlined above.

Related, Current, and Previous Work:

Eastern white pine is an iconic species for northeastern North America

Iconic species resonate with the public and can be used to engender broader public support for desired outcomes (Davies and Tippler 2024). Iconic species differ from indicator or keystone species because of the public connection; iconic species are not only biologically and ecologically important but also are part of a community's culture. Eastern white pine's connection to Indigenous Nations' traditions (Mausel, Waupochick, and Pecore 2017) and the European settler's development (D. R. Foster, Motzkin, and Slater 1998) is probably a partial result of its regeneration across multiple environments and ability to grow larger and taller than any other species in the east (Lancaster and Leak 1978). Evolving dynamics of cultural, biological adaptations, and ecological interactions has made eastern white pine an iconic tree species for the forests of northeastern North America that is 1) culturally relevant, 2) covers a broad geography, 3) highly resilient and productive which 4) could be improved with effective management.

Historical Importance: Evolving Dynamics of an Iconic Tree

Cultural relevance

As stated by René H. Germain and colleagues, "the historical importance of eastern white pine (Pinus strobus) is legendary" (Germain, Nowak, and Wagner 2016). For European settlers, EWP was the "King's pine", reserved for use by the English Navy for its ships (Keating 2024). EWP is also considered the "Tree that built America" the species was the primary tree that European colonizers used for building settlements, and the transport of the large logs down the region's rivers (Wilson 2005) was legendary, providing the basis for Paul Bunyan stories that began in Maine and spread westward (Croker 2009).

Eastern white pine has cultural significance to indigenous nations, and is well documented for the Menominee Tribe in Wisconsin (Mausel, Waupochick, and Pecore 2017). "The Tribe calls themselves 'Maeqtekuahkíhkíw Kew Kanaˆhwíhtahquaq,' which translates to "The Forest Keepers," and they recognize that the forest must remain for their unborn children's children, a land ethic integral to Tribal identity."

High resiliency and productivity across a broad range explained by eastern white pine's biology and ecology

Eastern white pine has intermediate shade tolerance such that it can respond to a range of disturbances, such as growing after fires under the light shade of birch and aspen (Peterson and Squiers 1995) and taking advantage of gaps in forest cover due to windthrow or harvesting of large trees (Raymond et al. 2006). Periodic "cone crops" with prolific seed production help ensure establishment of the species across suitable habitats (Wendel and Smith 1990).

The species is fast growing compared to other associated species indicating that it can outcompete most other plants for resources (Wendel and Smith 1990). Growth of EWP does not slow down until after age 90 and will continue to add sawtimber volume at 100 years, allowing the species to become super-dominant in the canopy.

Range of EWP is determined by evapotranspiration: Precipitation must exceed evapotranspiration (Jacobson and Dieffenbacher-Krall 1995) which limits species to moister, cooler climates.

During the last glaciation the species was found in the current regions of North Carolina/Virginia western border, and as glaciers retreated, EWP spread up coast to its current range limit in Canada (Om P. Rajora, Andrew J. Eckert, John W. R. Zinck 2016). The species also spread inland and westward to the Great Lakes Region.

The species competes on a wide range of soils that are generally well drained (Wendel and Smith 1990). Hardwoods, such as the maples (*Acer*), are competitive on more nutrient-rich soils, but EWP is still part of mixture in hardwoods types (Eyre and Society of American Foresters 1980). The species becomes dominant on dryer soils, many times associated with red oak (Pine/Oak type). On drier, sandy soils, EWP is associated with hard pines (red pine, pitch pine).

As a consequence of EWP's ability to compete on a wide range of soils and with many species, EWP's was widely distributed in northern Maine prior to European colonization but at low densities, perhaps averaging about 1 large EWP per acre. However, it's ability to develop into large trees across the range of conditions resulted in a massive amount of available timber for harvesting by European colonists, an amount that was three times more than the amount of standing EWP in the 2001 FIA inventory for that part of the state (Wilson 2005). The contrast in amount of EWP timber present in northern Maine over 200 years ago compared to the amount found today indicates the importance of understanding why these changes have occurred and if the past abundance of EWP is indicative of its future potential.

How EWP has maintained its presence across the landscape is dependent on its regeneration. which is associated with disturbance (Lancaster and Leak 1978; Wendel and Smith 1990). Regeneration of EWP will be successful if:

1. Moderate light, > 20%, is available such as in:
    a. Gap openings associated with windthrow or harvesting.

    b. An overstory allowing light to filter through, e.g., as developing stands of aspen/birch (Peterson and Squiers 1995), red maple (R. W. Foster 1959), and red pine that can develop after stand replacing fires or other disturbances.
2. Soils are disturbed resulting in minimal duff layer and vegetative competition (Lancaster and Leak 1978; Wendel and Smith 1990).
3. A seed source is available (Kromholz, Webster, and Hyslop 2025).

In locations where fire is a rare disturbance such as in northern Maine (Lorimer 1977), EWP regenerated in hardwood stands typically as solitary trees that could out-grow the surrounding vegetation, or as small clumps of trees that could exclude regeneration of other species, or as released saplings when overstory trees died or blew over (Hibbs 1982). Outside of New England, fire likely helped maintain EWP in some forests, but in combination with logging of all seed trees and deer browsing, the disturbance could help reduce EWP abundance (Abrams 2001).

After regeneration, EWP stems must become established in the developing canopy. In hardwood stands, establishment of EWP and maintaining the stems in the canopy can be difficult in young ages when hardwood competitors can grow faster than EWP (Lancaster and Leak 1978; Wendel and Smith 1990; Smith and Ashton 1993; Leak 1995). However, once established in the canopy, EWP can maintain its position or emerge resulting in improved stand productivity ((R. W. Foster 1959; Hibbs 1982; Peterson and Squiers 1995; Raymond et al. 2006; Arseneault et al. 2011; Waskiewicz et al. 2013; Waterman et al. 2020; Clark and D'Amato 2021; Copenheaver, Frye, and Deane 2025; Kromholz, Webster, and Hyslop 2025). Interestingly, one study found EWP growth to increase when growing closer to aspen (*Populus grandidentata* and *P. tremuloides*) than other EWP (Peterson and Squiers 1995) indicating that a EWP tree competing with other EWP stems is more stressful than competing with stems of other species.

In softwood mixtures, EWP probably becomes established with eastern hemlock (*Tsuga canadensis*) and red spruce (*Picea rubens*) in manners similar to hardwood mixtures as described above (Orwig et al. 2022), with a few EWP trees emerging above the other species (Mary Ann Fajvan and Seymour 1993) which can increase overall stand volume (M. A. Fajvan and Seymour 1999). In addition, spruce budworm (*Choristoneura fumiferana*) defoliation can increase EWP regeneration and growth when growing with spruce and fir (*Abies balsamae*) (Lavoie et al. 2026).

Another type of EWP stand development became present after European colonizatonwhen agricultural fields within EWP's range were abandoned in the 1800's and early 1900's. EWP could compete with the grasses better than other tree species (D. R. Foster, Motzkin, and Slater 1998) such that many old fields regenerated to almost pure stands of EWP. When these stands mature, they are frequently replaced by mixtures of other species.

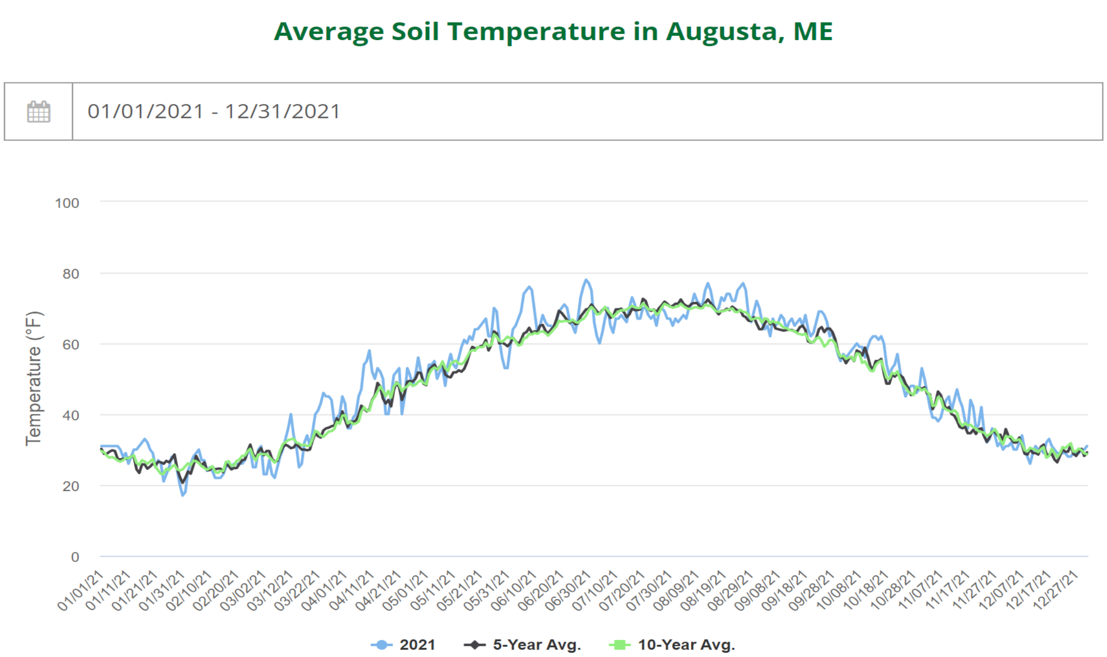
The fastest growth of EWP is found in the southern part of its range. In western North Carolina and adjacent parts of Virginia, EWP reaches merchantable age in 25-50 years (Balmer and Williston 1983) compared to 50-75 years in the Northeast (New York, New England, eastern Canada) (Lancaster and Leak 1978). Volume growth in southern Appalachia (Balmer and Williston 1983) is about 7,000 cubic feet per acre (site index 60, age 35) which is nearly twice the amount found in the Northeast (Lancaster and Leak 1978) at 4,000 cubic feet per acre (site index 60, age 40). Growing season conditions are similar between the two regions (Table 1) but winters are warmer in the south such that roots likely remain active for two additional months each year when compared to the Northeast (Figure 1). With EWP habitat area being stable in the future (L. R. Iverson et al. 2019), there is a potential that EWP productivity will increase as winters become warmer.

Table 1. Climate data for Maine and the Blue Ridge Plateau (VA and NC, National Weather Service data).

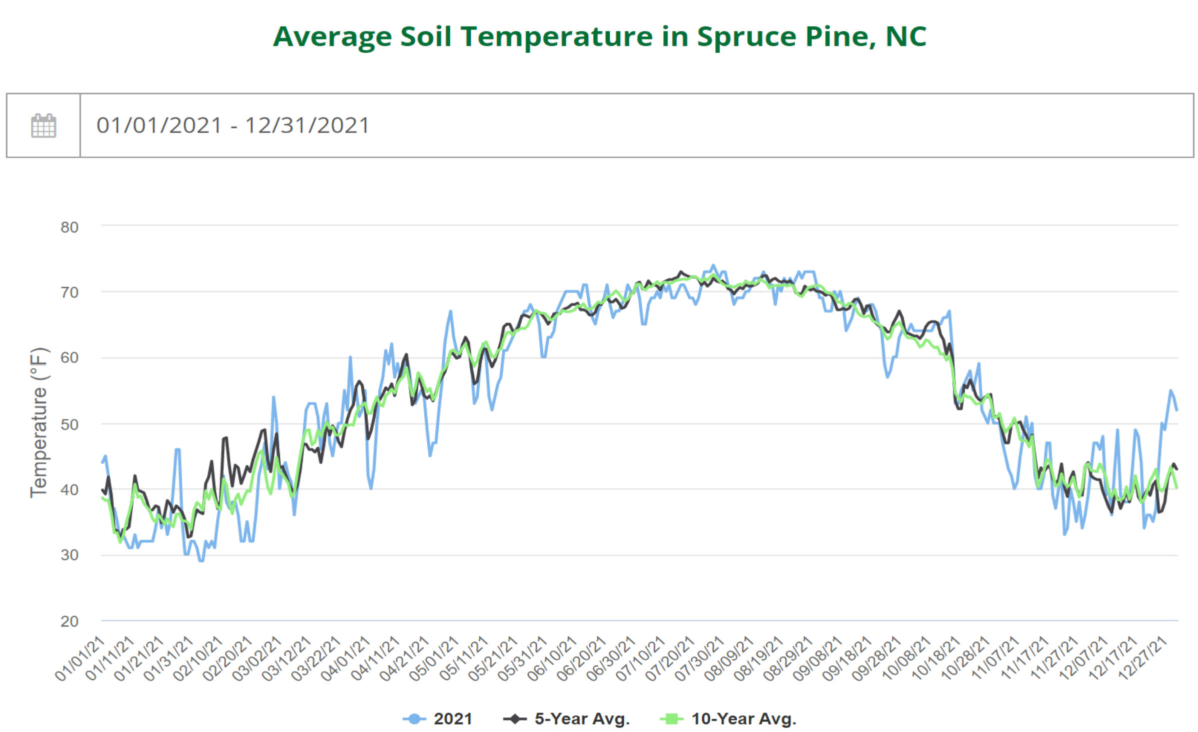
Location	July high avg (°F)	January low avg (°F)	Annual precip. Avg (in)	Total Snow Accum. Avg. (in)	Last spring frost	First fall frost
Augusta, ME	79	8	44	67	May 1	Oct 1
Galax, VA	82	21	43	16	Apr 29	Oct 11
Spruce Pine, NC	81	22	53	13	Apr 29	Oct 11

Figure 1. Soil temperature estimates or (a.) Augusta, ME, and (b.) Spruce Pine, NC. Data from *Open-meteo.com Weather API*. Zenodo. https://doi.org/10.5281/ZENODO.7970649

a.



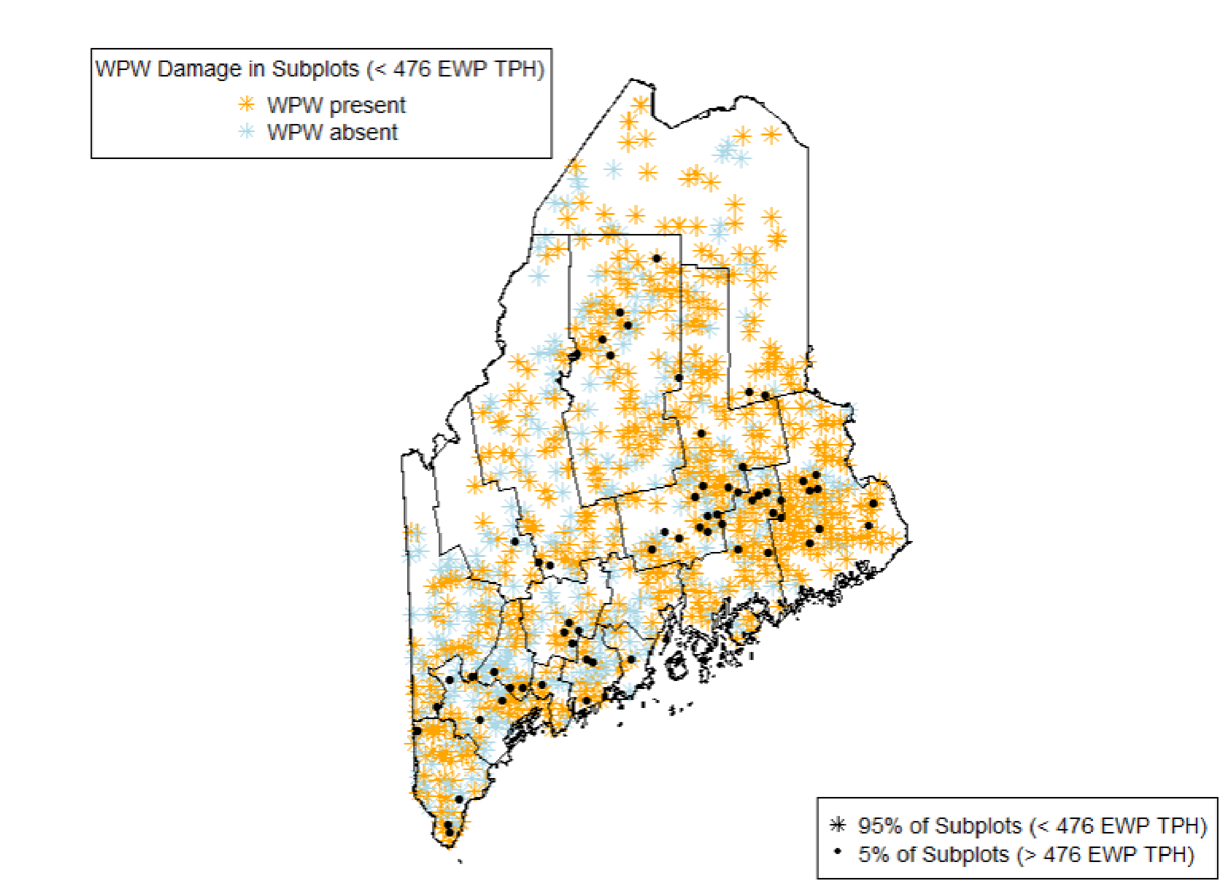
b.



Health Issues

Eastern white pine has experienced a number of health issues that can affect its regeneration, establishment and growth (Costanza et al. 2018). White pine blister rust pathogen, *Cronartium ribicola,* was introduced from Europe on EWP seedlings in the early 1900's, and the fungus is currently found throughout the range but is not considered a limiting factor in EWP regeneration and growth. White pine weevil (*Pisodes strobi*) kills the terminal leaders of developing white pine resulting in deformed stems and loss of economic value. Seventy percent of 1,757 FIA subplots across Maine with at least one EWP had observed white pine weevil damage (Noone-Price 2025). However, if white pine composition was over 75%, all plots had damage (Figure 2). There was a slight spatial association between white pine weevil damage and water surplus index with damage decreasing as the water surplus index increases (Noone-Price 2025).

Figure 2. White pine weevil (WPW) damage across Maine U.S. for subplots with high or low values of EWP TPH. Subplots with > 476 EWP TPH (192 EWP trees per acre (n = 75)) are considered high. Subplots with < 476 EWP TPH (n = 1,682) are considered low. Low EWP TPH values represent the 95th percentile of subplots (Noone-Price 2025).

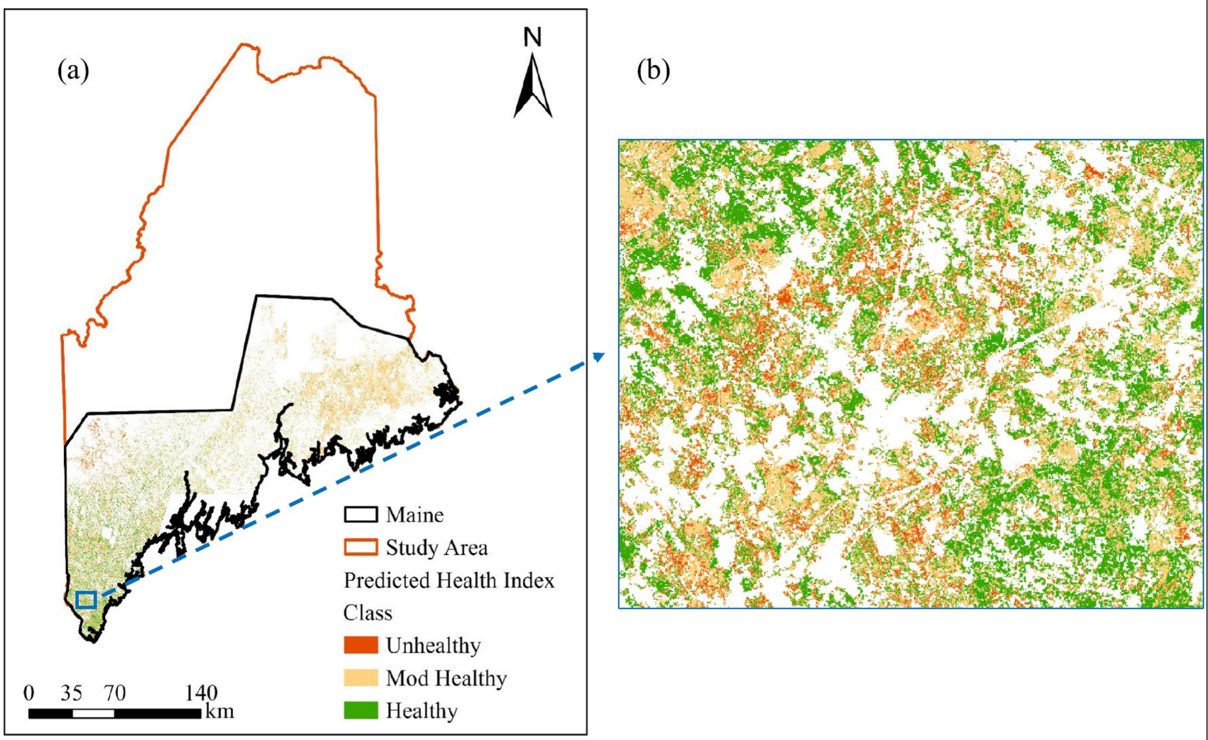


In contrast to the northern part if EWP's range, white pine weevil causes minor damage in the southern part of its range(Katovich and Mielke 1993), possibly associated with shallow duff layer (Noone-Price 2025).

White pine declines, that is, prolonged periods of reduced growth followed associated with diebacks and mortality, occur periodically throughout its range(Costanza et al. 2018). In Maine, a drought incited mortality in EWP stands that were overstocked and on sites with shallow roots(Livingston and Kenefic 2018). Additional stressors associated with EWP declines include *Caliciopsis* pinea canker and pine bast scale (*Matsucoccus*), and needle damage associated with infections by four pathogenic fungi (Costanza et al. 2018).

Use of remote sensing techniques can be used to measure white pine health (Meneghini et al. 2022; Das et al. 2024). Microwave (Sentinel-1) and optical (Sentinel-2) remote sensing data were used to predict leaf area index and live crown ratio. The predictions were integrated with canopy height and stand density to develop a novel health index map for EWP. The resulting health index map successfully delineated patches representing various health categories (Figure 3). The map can indicate trees that are suffering from stresses such as white pine needle damage (Das et al. 2024).

Figure 3. Eastern white pine (EWP) stand health index map for (a) southern Maine, USA, and (b) highlighted over an area.



Forest management can improve EWP resilience, productivity, and wood quality, but the species is mostly underutilized.

The states with the most volume of EWP are in Figure 4. Total volumes, however, do not necessarily equate to the level of management and degree of utilization. For example, North Carolina has the third highest harvest volume of EWP but has the eighth highest total volume

(Figures 4 and 5). Across the New England states of ME, NH and VT the EWP resource is intensively harvested and utilized. These states are harvesting approximately 1.5% of the standing volume on an annual basis, resulting in growth to harvest ratios of less than 2:1 (Figure 5). This indicates an equilibrium between harvesting and growth which allows for a sustained yield of forest products from EWP timberlands.

Most of the remaining states across EWP's range are harvesting less than one percent of the standing volume; the species is underutilized. A case in point is NY, the state with the most EWP of any state in the country has a growth to harvest ratio of 4:1. Wood quality is a problem (Germain, Nowak, and Wagner 2016). As characterized by the USFS, approximately three quarters of the stumpage is classified as low grade (#3 or lower). These stems will generate primarily low-grade logs with a value of roughly $150/mbf which in turn produce low-grade lumber such as standard and industrial grade. Sawmills avoid processing low grade EWP logs because of the poor grade yield. The balance (25%) of the NY EWP stumpage is characterized by stems with a grade 1 or 2 butt log with a value of $200 - $400/mbf which provides a better opportunity to generate better lumber grades of premium, finish and select. But even high quality EWP stems can produce a significant amount of standard and industrial grade lumber due to the high frequency of black knots in the upper logs. Intensive management using low-density thinning at an early age can increase crown ratios and replace degrading black knots with red knots, significantly improving lumber grade yields(Germain, Nowak, and Wagner 2016). There is substantial, unrealized potential for increasing management and utilization of EWP.

Figure 4. Net **merchantable bole volume** of live trees (at least 5 inches d.b.h./d.r.c.), in cubic feet, on forest land.

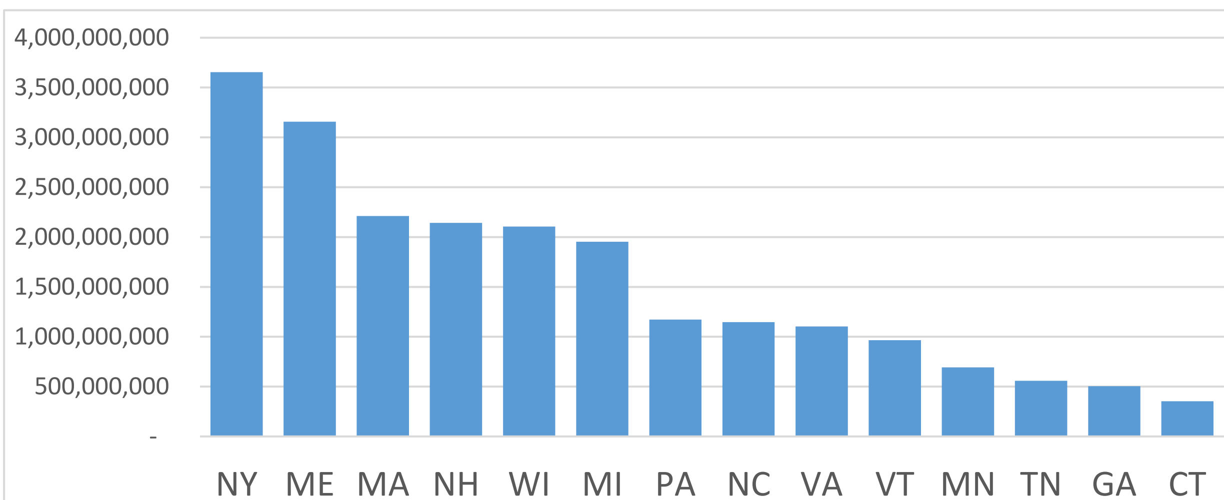
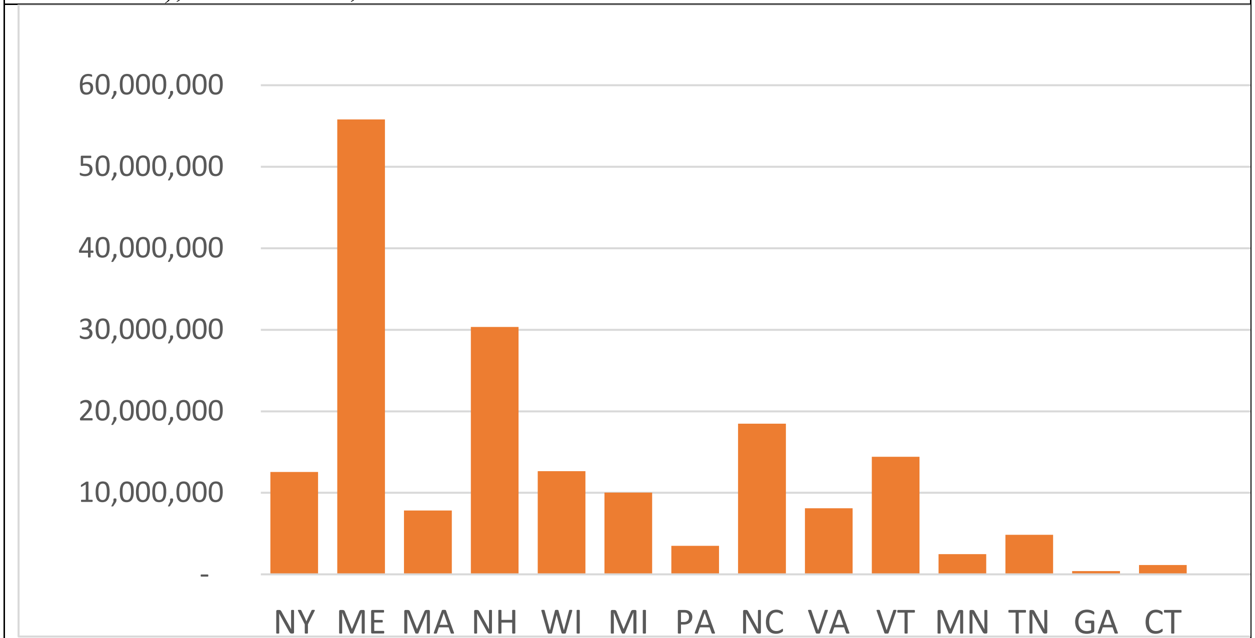


Figure 5. Average annual harvest removals of sound bole volume of trees (at least 5 inches d.b.h./d.r.c.), in cubic feet, on forest land.



Managing tree densities can minimize risks to white pine health and value, and pruning will increase wood quality. Shelterwood cuts can establish high densities of sapling and reduce damage associated with white pine weevil. Afterwards, thinning stands to low densities avoids competition stress and reduces decline risk (Livingston et al. 2019).

Managing EWP in stand mixtures also offers future opportunities. In addition to good productivity as described earlier, wood quality could be improved. Incidence of white pine weevil damage is reduced in Maine in stand mixtures. Weevil damage incidence is 100% of the locations with high EWP densities (> 192 EWP/ac) compared to 70% incidence in locations with lower EWP densities (Noone-Price 2025). Stem quality could also be improved on emergent EWP due to possible self-pruning of branches that are within the canopy.

Eastern white pine plantations are frequently used in North Carolina and Virginia where white pine weevil damage is low. Old fields or harvested sites are prepared for planting, sometimes with prescribed fire, and seedlings are planted at wide spacing, such as 10 ft to 12 ft spacing and harvested after about 50 years (Balmer and Williston 1983).

Menominee Tribal Nation in Wisconsin emphasizes sawlog quality and quantity. Eastern white pine is the primary commercial species, but structural and compositional diversity are part of management plans so that trees are grown to old age and large diameters using uneven-aged management or extended rotations in even-aged management.

Lack of markets for white pine pulpwood limits management options in all regions for removing small diameter stems to reduce stand densities.

The future of eastern white pine as an iconic species

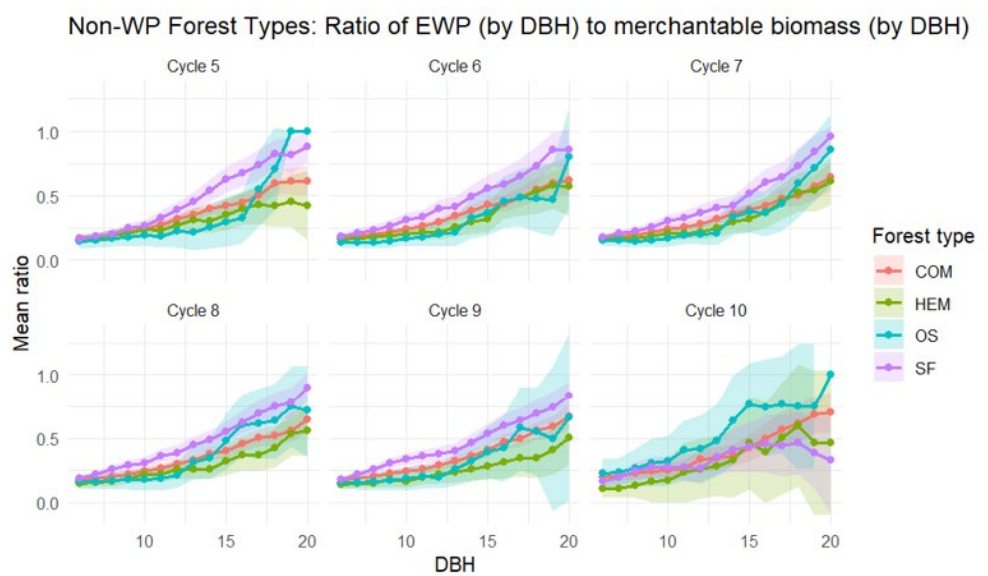
Forest Management and EWP Development

Forest management objectives for EWP will determine its future development across its range. Field abandonment will no longer be a major source of developing stands dominated by EWP. Therefore, future stands with high amount of EWP will depend on plantations and shelterwood management. As indicated by the pre-colonial distribution of EWP, lack of silvicultural intervention will likely result in EWP developing in low densities among other species across a broad range of forests. These stands have fewer EWP per acre, but the area is extensive and a future source of EWP timber. Therefore, forest land managers across much of the EWP range will have the opportunity to manage for EWP over a range of conditions. There are good guidelines for managing EWP dominated stands (Lancaster and Leak 1978, Balmer and Williston 1983, Livingston et al. 2019). For the mixed species stands, there are silvicultural recommendations if the manager wants to increase the presence and development of EWP in hardwoods (Lancaster and Leak 1978). Silvicultural recommendations for EWP growing in conifer mixtures, such as the spruce/fir types in Maine, are lacking, but one study suggests emulating spruce budworm outbreaks by using shelterwood ((Lavoie et al. 2026). In mixed stands, EWP is less likely to be damaged by white pine weevil which should result in better stem quality(Noone-Price 2025).

In general, EWP can be regenerated across different forest types if seed trees are present, partial light (> 20%) is available, and the soil is scarified. Increasing the composition and growth of EWP can be accomplished by removing competitors through managing stand densities (Livingston et al. 2019) and using crop tree management (Raymond et al. 2003) and low densities (R. S. Seymour and Smith 1987; Leak and Lamson 1999; R. S. Seymour 2007).

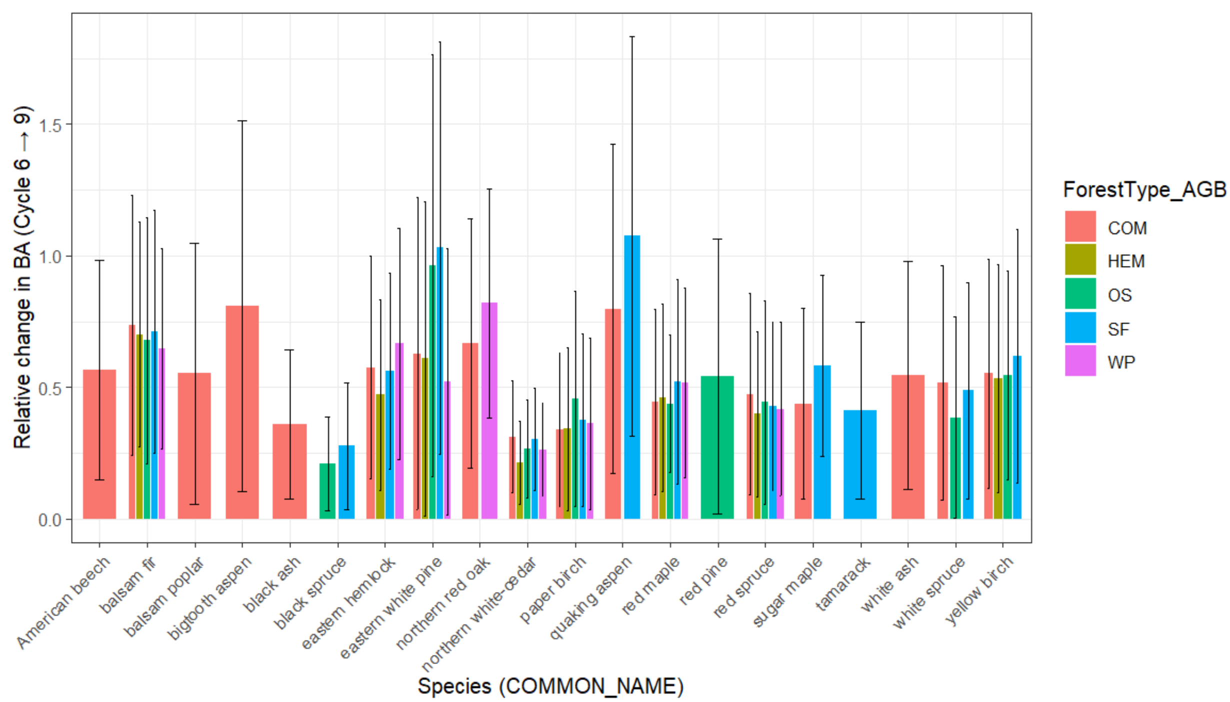
A more detailed analysis of FIA EWP data has begun in Maine across 25 years of FIA data collection in the state (Zhao 2025), and the data confirms EWP's ability to develop across a wide range of conditions and can compete well in many forest types. The data was organized into cycles, a 5-year period during which all inventory plots were measured. The number of plots that had consecutive measurements at 5-year intervals from 1999 to 2023, were less than 140 years old, and contained >= 90% tree coverage totaled 2,980 out of 3,236 plots. The plots were divided into 6 forest types based on the majority of stand composition based on biomass measurements from 2002-2006; white pine (WP), spruce-fir (SF), other softwoods (OS, mostly wet sites), commercial hardwoods (COM), and other hardwoods (OH, mostly wet sites). About half of the EWP stems used in the analysis are in the WP forest type, nearly a third is in the COM type, about 12% in is SF, and 4% in OS. EWP rarely occurs on the OH type and is not included in the analyses. In the SF type, EWP biomass begins to exceed SF biomass when stems are larger than 12 inches DBH (Figure 6). Even in the COM type, EWP biomass begins to exceed the hardwood biomass at 18 inches DBH (Figure 6). Even though EWP on the mixed-species sites is only about 2 to 4% of the stems used in the analysis, EWP can dominate the larger diameter classes.

Figure 6. EWP's relative importance increases with DBH across all non-WP types, indicating that EWP tends to occupy (and persist to) larger size classes. SF shows the earliest and most persistent EWP dominance, while HEM requires the largest sizes for EWP to become dominant. COM and OS are intermediate but differ at small-mid diameters (COM higher than OS). Forest types based on biomass in 2002-2006: COM = commercial hardwoods, HEM = hemlock, OS = other softwoods, SF = spruce/fir. From Cycle 5 = 1999-2003 measurement, Cycle 6 = 2004-2008, Cycle 7 = 2009-2013, Cycle 8 = 2014-2018, Cycle 9=2019-2023, and Cycle 10 = 2024. (Zhao 2025)



Zhao and Livingston (unpublished data) have made preliminary analysis of FIA data to quantify the growth of trees over 5 inventory cycles and compared the trees samples during FIA inventory cycle 5 (1999-2003) with inventory cycle 9 (2019-2023). Basal area (BA) increase per tree is quantified by calculating a relative basal area (Figure 7); $(BA_{Cycle\ 9}--BA_{Cycle5})/BA_{Cycle5}$ such that a double in BA results in a Relative BA =1. The relative basal area increments for EWP had the highest value for conifers in the OS, SF, and WP types, and was among the higher values in the COM type (Figure 7). One major surprise is that EWP basal area increment was the highest in OS and SF types, almost 30% more than in the WP type (Figure 7). Relative BA increment is associated with larger diameters. The DBH of EWP pine was about 13 inches with diameters about a half inch larger in softwood types and about 1.5 inches smaller in the hardwood COM type. These diameter averages are the largest for the species in the softwood stands and among the highest in the COM stands.

Figure 7. Relative change in basal area (BA) as calculated using $(BA_{Cycle\ 9}\text{--}BA_{Cycle5})/BA_{Cycle5}$ such that a double in BA results in a Relative BA =1. Measurements are based individual tree changes over 20 years as completed in FIA Cycle 5 (1999-2003) to Cycle 9 (2019-2013). Forest types based on biomass in 2002-2006: COM = commercial hardwoods, HEM = hemlock, OS = other softwoods, SF = spruce/fir. From Cycle 5 = 1999-2003 measurement, Cycle 6 = 2004-2008, Cycle 7 = 2009-2013, Cycle 8 = 2014-2018, Cycle 9=2019-2023, and Cycle 10 = 2024.



EWP growth in mixed stands is competitive or exceeds the growth of other species. As a plus, there is less weevil damage in the mixed-species stands (Noone-Price 2025). The status of other EWP pests in the mixed-species stands is not known.

Seymour (R. Seymour 2021) summarized the occurrence of 2 in DBH saplings in the FIA dataset and found 18% in the pine types, 30% in the spruce-fir types, and 52% in the hardwood types.

Given the above, EWP will remain present and productive in the Maine forest. A more detailed analysis of EWP status is needed in other states to understand which trends in Maine can be documented elsewhere, and if states are experiencing different trends in EWP development.

In Maine, future development of the majority of the EWP resource will occur outside of stands dominated by EWP. There is a need to understand the economic, ecological, and silvicultural implications of EWP in mixed-species stands.

Future Conditions

In addition, future conditions may be favoring EWP in Maine. EWP in the southern Appalachians has nearly twice the growth rate as in the northeastern US (Lancaster and Leak 1978; Balmer and Williston 1983). When looking at climate data, summer conditions are similar between the two regions (Table 1), but winters are warmer, such that soil activity at > 40 F is probably 2 months longer in the southern region (Figure 1). Therefore, warmer winters could favor EWP growth in the future. Also, the warmer winter temperatures allow more decomposition of the litter layer, a factor associated with less white pine weevil damage (Noone-Price 2025).

USFS Tree Atlas (L. R. Iverson et al. 2019) estimates that eastern white pine will maintain its current importance in the forest by 2100. Increased water use efficiency due to higher CO2 levels could also help eastern white pine remain competitive in parts of its current range (Handler 2014). "Common garden" studies indicate that the population in southern Appalachia will grow faster under warmer conditions compared to northern populations (Chhin et al. 2018).

Eastern white pine is likely to remain available for economic use with the potential to expand into new markets where it is under-utilized.

Future challenges:

The above information provided the basis for future questions requiring additional assessment of current information and research to provide needed information. Such questions include:

1. Most future white pine will be in mixed stands; how should they be managed?
    a. What is likelihood of white pine regeneration with current and future management practices in mixed-species stands?
    b. Is regeneration shifting from where it is currently present?
    c. How well will white pine compete in mixed-species stands? Can EWP in mixed-species stands be managed to make them more valuable economically and ecologically?
2. What are good options for growing EWP dominated stands?
    a. Is shelterwood economically feasible given the need to manage stem densities without markets for small diameter stems?
    b. Can seed sources from southern Appalachia produce trees with higher volume production in northern areas?
    c. Will EWP plantations become feasible if tree improvement and climate changes reduce WPW damage?
3. Can remote sensing be used to quantify geographic distribution of stresses from competition, drought, and pests (e.g., Figures 2 and 3) and used to identify potential strategies to mitigate adverse impacts on EWP?
4. Can new markets for young EWPbe developed, such as pine-tipping, to help improve EWP management and utilization?
5. How can EWP saw-log trees be better utilized across its range?
6.

Related work from CRIS projects

There are no active EWP projects in the CRIS database except for NE 2101 which is ending.

A couple of projects do establish a communications network for developing and improving forest management across states.

S1091: Forest Health and Resilience

Facilitate further integration of the forest health programs at land grant Universities, and provide science-based solutions to land managers and regulators.

WCC1003: Coordination of Western Regional Extension Forestry Activities

Coordinates Extension Foresters in the Western states to enable more efficient and effective use of limited resources available for educating about natural resource management in a collaborative manner.

Objectives:

1. Use FIA data to quantify the range of forest composition and growth of EWP where EWP has significant development. The analysis will be completed for each state represented in the Multi-state project.
2. Assess the current status of EWP and future opportunities. The Project members will write a review paper that will provide the basis for guiding future research and management of the species.
3. Revise silvicultural recommendations and forest management to improve EWP productivity, health, and economic return. The first recommendations will be developed for Maine after which they will be modified for use in states of other Project members.
4. Improve our understanding of EWP development and how to manage the species.

Methods:

1. Use FIA data to quantify the range of forest composition and growth of EWP where EWP has significant development. The initial analysis will be completed using data for Maine followed by data for other members of the Multi-state Project, first being New England (New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island) and New York, Next will be analyses for North Carolina and Michigan. Finally, analyses will be completed for other states with significant volume of EWP including Pennsylvania, Virginia, and Wisconsin. Starting with the first annual meeting and continuing with additional online meetings as needed, the Multi-state members will develop a set of parameters for use in the analysis including forest type definitions, relative measures to compare species over time such as DBH, BA, biomass volume, cut volume, and relative basal area. Figures 4-7 provide examples. Dr. Livingston at the University of Maine will lead the analysis effort, and other committee members will have the opportunity to review results and recommend additional analyses at annual meetings or on a more frequent schedule if desired.
2. Assess the current status of EWP and future opportunities. First, the Project members will write a review paper entitled, "Eastern White Pine as an Iconic North American Tree: Evolving Dynamics and Future Opportunities". The objective of the manuscript is to define the current status of EWP knowledge, indicate how the species will likely develop in the next 100 years, and explore future challenges, opportunities, and research needs to better manage the species. At the first annual meeting, members of the Multi-state project will review a manuscript draft by Dr. Livingston and decide on who will focus on a topic for additional development. Manuscript drafts will be reviewed by all project members until a manuscript is submitted to a national journal, such as the Journal of Forestry. Online tools (Google Docs, Paperpile) to facilitate collaborative work on a manuscript. If

the length of the manuscript is a concern, project members can recommend development of a manuscript series to address the important issues.

3. Revise silvicultural recommendations and forest management to improve EWP productivity, health, and economic return. Outputs from Objectives 1 and 2 will be used to develop silvicultural and management guidelines for EWP. The Project members will need to decide if a single manual is appropriate or if separate manuals are needed for different regions, such as New England, New York, Lake State, and Southern Appalachians.
4. Submit research proposals to improve our understanding of EWP development and how to manage the species. Results from Objectives 1 and 2 will be used to develop research proposals to address the key needs identified in

Measurement of Progress and Results:

Outputs

1. Standardization of FIA analysis among states (Objectives 1):
   - Forest types
   - Measures of growth
   - Relative measures to compare species
2. Publication on the future of EWP (Objective 2).
3. Silvicultural and management recommendations (Objective 3).
   - Presented at professional meetings
   - Documents available for download.
4. Research proposals submitted.

Outcomes or Project Impacts:

Roles of white pine health issues in the forest ecosystem are better understood and help to explain forest responses to land use changes and climate changes. From this understanding, effective management recommendations can be made. Probable impacts are:

1) Review manuscript is accepted for publication in a national journal. New perspectives on EWP management become available to a national audience.
2) New silvicultural and management guidelines become available for use by landowners and forest managers.
3) Research proposals are funded to advance knowledge on EWP growth, health, and management.

Milestones:

- Year 1
  - Basis for FIA analysis and review paper are agreed to by Project members
  - Draft of review paper is submitted
  - FIA analysis completed for New England
- Year 2:
  - Review paper is published
  - Proposal developed for a major program, such as USDA's Sustainable Agriculture Systems.
  - FIA analysis completed for New York, North Carolina, and Michigan.
  - Silvicultural and management recommendations developed for New England.
- Year 3

- FIA analysis completed for Virginia, Pennsylvania, and Wisconsin
  - Silvicultural and management recommendation developed for New York
  - Proposal development continues until funding is achieved.
- Year 4
  - Silvicultural and management recommendations developed for southern Appalachia (NC, VA), Pennsylvania, and Lake States (Michigan, Wisconsin).
  - Proposal development continues until funding is achieved.
- Year 5
  - Proposal development continues until funding is achieved.

Outreach Plan:

The goal of the outreach plan is to provide a two-way communication process so that new information can be shared with external partners and the external partners can share their needs with the research team.

Information developed in the project will be shared with the Northeast Extension Forest Resources Educator Council (NEFREC) and the Northeast Silviculture Institute with the primary contact being Steven Roberge, Extension Forestry Specialist & Professor at the University of New Hampshire Cooperative Extension.

The format for offerings by the Northeast Silviculture Institute for Foresters involves planning a field workshop event at which videos can be made for future use (see https://extension.unh.edu/northeast-silviculture-institute-foresters/about). Each of the workshops includes at least:

- Silvics of individual species & Stand Dynamics including land use history
- Silvicultural Systems and Practices including growth, yield, quality and regeneration
- Economics, utilization & markets
- Forest Health
- Wildlife Considerations specific to forest type
- Soils
- Site Quality and Productivity
- Sample prescriptions
- Legal, landowner objectives & carbon considerations
- Field Trip into forest type

For EWP, the workshop will need to deal with EWP's wide range of stand development, such as EWP dominated stands (plantations, old fields), EWP in hardwood mixtures, and EWP in conifer mixtures.

A workshop on EWP management in mixed species stands is being developed in cooperation with the University of Maine's Cooperative Forest Research Unit which depends on financial support of organizations that own and/or manage forested land in the state. Developing the workshop includes interviewing external partners on their existing plans for managing EWP in mixed stands and what questions and needs they have about the management. The first workshop will be given by June 2027, and the workshop will form the basis of a proposal to add EWP management in mixed species stands as an update to the Northeast Silviculture Institute program.

Project personal will continually provide project information updates at presentations at professional meetings such as the New England Society of American Foresters annual meetings.

A paper that summarizes findings of the FIA analyses will be submitted for publication by the end of 2026. A full review paper on EWP as an iconic species will be submitted for publication in the Journal of Forestry by the end of 2027.

Organization and Governance:

The project will use the standard form of governance. Participating institutions will send at least one representative to an annual meeting, and meeting attendees will be considered the Technical Committee. The Technical Committee will elect officers of chair, chair-elect, and secretary at the annual meeting. The chair-elect normally succeeds to chair the following year. Each officer is eligible for re-election. Sub-committees focused on particular objectives. Meetings will confer as needed by teleconference or in-person to plan and coordinate details of the multi-state project.

Projected Participation:

Include a completed Appendix E

Literature Cited:

Abrams, Marc D. 2001. “Eastern White Pine Versatility in the Presettlement Forest.” *Bioscience* 51 (11): 967.

Arseneault, Justin E., Mike R. Saunders, Robert S. Seymour, and Robert G. Wagner. 2011. “First Decadal Response to Treatment in a Disturbance-Based Silviculture Experiment in Maine.” *Forest Ecology and Management* 262 (3): 404–12.

Balmer, William E., and Hamlin L. Williston. 1983. *Managing Eastern White Pine in the Southeast*. Forestry Report R*-FR 1. U.S. Department of Agriculture, Forest Service, Southern Region.

Chhin, Sophan, Ronald S. Zalesny Jr, William C. Parker, and John Brissette. 2018. “Dendroclimatic Analysis of White Pine (Pinus Strobus L.) Using Long-Term Provenance Test Sites across Eastern North America.” *Forest Ecosystems* 5 (March). https://doi.org/10.1186/s40663-018-0136-0.

Clark, Peter W., and Anthony W. D’Amato. 2021. “Long-Term Development of Transition Hardwood and Pinus Strobus - Quercus Mixedwood Forests with Implications for Future Adaptation and Mitigation Potential.” *Forest Ecology and Management* 501 (119654): 119654.

Copenheaver, Carolyn A., Ethan A. Frye, and Olivia K. Deane. 2025. “Composition and Disturbance History of a Forest Fragment in Virginia, USA.” *Tree-Ring Research* 81 (2): 72–80.

Costanza, Kara K. L., Thomas D. Whitney, Cameron D. McIntire, William H. Livingston, and Kamal J. K. Gandhi. 2018. “A Synthesis of Emerging Health Issues of Eastern White

Pine (Pinus Strobus) in Eastern North America." *Forest Ecology and Management* 423: 3–17.

Croker, M. Ryan. 2009. "The Life and Origins of Paul Bunyan: Volume 1." ProQuest Dissertations & Theses. https://maine.primo.exlibrisgroup.com/discovery/fulldisplay?docid=cdi_proquest_journals_2501896551&context=PC&vid=01MAINE_INST:UM&lang=en&search_scope=MyInst_and_CI&adaptor=Primo%20Central&tab=Everything&query=any,contains,paul%20bunyan%20in%20maine&offset=0.

Das, Pulakesh, Parinaz Rahimzadeh-Bajgiran, William Livingston, Cameron D. McIntire, and Aaron Bergdahl. 2024. "Modeling Forest Canopy Structure and Developing a Stand Health Index Using Satellite Remote Sensing." *Ecological Informatics* 84 (December). https://doi.org/10.1016/j.ecoinf.2024.102864.

Davies, Peter J., and Carl Tippler. 2024. "A Framework for Using Community Determined Iconic Species to Advance Socio-Ecology Connections and Promote Nature-Based Solutions." *Nature-Based Solutions* 6 (100160): 100160.

Eyre, F. H., and Society of American Foresters. 1980. *Forest Cover Types of the United States and Canada*. Vi, 148 pages ; 28 cm. Washington, D.C. (5400 Grosvenor Lane, Washington, D.C. 20014): Society of American Foresters.

Fajvan, M. A., and R. S. Seymour. 1999. "Influence of White Pine on Structure and Yields of Mixed Northern Conifer Forests." *Journal of Sustainable Forestry* 8 (1): 61–74.

Fajvan, Mary Ann, and Robert S. Seymour. 1993. "Canopy Stratification, Age Structure, and Development of Multicohort Stands of Eastern White Pine, Eastern Hemlock, and Red Spruce." *Canadian Journal of Forest Research* 23 (9): 1799–1809.

Foster, David R., Glenn Motzkin, and Benjamin Slater. 1998. "Land-Use History as Long-Term Broad-Scale Disturbance: Regional Forest Dynamics in Central New England." *Ecosystems (New York, N.Y.)* 1 (1): 96–119.

Foster, Ralph W. 1959. "Relation between Site Indexes of Eastern White Pine and Red Maple." *Forest Science* 5 (3): 279–91.

Germain, René H., Chris A. Nowak, and John E. Wagner. 2016. "The Tree That Built America—Not Making the Grade." *Journal of Forestry* 114: 552-561-552–61.

Handler, Stephen Dwight. 2014. *Michigan Forest Ecosystem Vulnerability Assessment and Synthesis a Report from the Northwoods Climate Change Response Framework Project*. 1 online resource (229 pages) : color illustrations, color maps. General Technical Report NRS 129. Newtown Square, PA: U.S. Dept. of Agriculture, Forest Service, Northern Research Station.

Hibbs, David E. 1982. "White Pine in the Transition Hardwood Forest." *Canadian Journal of Botany* 60 (10): 2046–53.

Iverson, Louis, Anantha Prasad, and Stephen Matthews. 2008. "Modeling Potential Climate Change Impacts on the Trees of the Northeastern United States." *Mitigation and Adaptation Strategies for Global Change* 13 (5–6): 487–516.

Iverson, Louis R., Matthew P. Peters, Anantha M. Prasad, and Stephen N. Matthews. 2019. "Analysis of Climate Change Impacts on Tree Species of the Eastern US: Results of DISTRIB-II Modeling." *Forests* 10 (4): 302.

Jacobson, George L., and Ann Dieffenbacher-Krall. 1995. "White Pine and Climate Change: Insights from the Past." *Journal of Forestry* 93 (7): 39–42.

Katovich, S., and M. Mielke. 1993. *How to Manage Eastern White Pine to Minimize Damage from Blister Rust and White Pine Weevil*. USDA-FS, NA-FR-01-93.

Keating, Steve. 2024. "White Pines and the King's Broad Arrow." In *Conifers of the New England–Acadian Forest*, 24–44. University of Massachusetts Press.

Kromholz, David A., Christopher R. Webster, and Michael D. Hyslop. 2025. "Spatial Patterning and Growth of Naturally Regenerated Eastern White Pine in a Northern Hardwood Silviculture Experiment." *Forests* 16 (8): 1235.

Lancaster, Kenneth F., and William B. Leak. 1978. *A Silvicultural Guide for White Pine in the Northeast*. 13 pages : illustrations ; 27 cm. Forest Service General Technical Report NE 41. Broomall, Pa: Dept. of Agriculture, Forest Service, Northeastern Forest Experiment Station.

Lavoie, Janie, Yves Bergeron, Maxence Martin, and Miguel Montoro Girona. 2026. "Spruce Budworm Outbreaks Promote Natural Regeneration of Eastern White Pine." *Forest Ecology and Management* 601 (123320): 123320.

Leak, William B. 1995. *Dynamics of White Pine in New England*. 1 online resource (8 pages) : illustrations. Research Paper NE 699. Radnor, PA: United States Department of Agriculture, Forest Service, Northeastern Forest Experiment Station.

Leak, William B., and Neil I. Lamson. 1999. "Revised White Pine Stocking Guide for Managed Stands."

Livingston, William H., and Laura S. Kenefic. 2018. "Low Densities in White Pine Stands Reduce Risk of Drought-Incited Decline." *Forest Ecology and Management* 423: 84–93.

Livingston, William H., Isabel Munck, Kyle Lombard, Jennifer Weimer, Aaron Bergdahl, Laura S. Kenefic, Barbara Schultz, and Robert S. Seymour. 2019. *MP764: Field Manual for Managing Eastern White Pine Health in New England*. DigitalCommons@UMaine.

Lorimer, Craig G. 1977. "The Presettlement Forest and Natural Disturbance Cycle of Northeastern Maine." *Ecology* 58 (1): 139–48.

Marshall, Philip. 2009. "The Problem of Eastern White Pine (*Pinus Strobus*L.) in Southern New England: Ecophysiology, Site Restriction, and Historical Land-Use Change." *Journal of Sustainable Forestry* 28 (1–2): 108–31.

Mausel, David L., Anthony Waupochick Jr, and Marshall Pecore. 2017. "Menominee Forestry: Past, Present, Future." *Journal of Forestry* 115 (5): 366–69.

Meneghini, Aaron, Parinaz Rahimzadeh-Bajgiran, William Livingston, and Aaron Weiskittel. 2022. "Detecting White Pine Needle Damage through Satellite Remote Sensing." *Canadian Journal of Remote Sensing* 48 (2): 239–57.

Noone-Price, Maeve. 2025. “How White Pine Weevil (Pissodes Strobi [PECK]) Damage to Eastern White Pine (Pinus Strobus [L.]) Varies with Site, Climate and Mechanical Resistance Factors.” Thesis (M.S.) in Forest Resources--University of Maine, 2025. https://maine.primo.exlibrisgroup.com/discovery/fulldisplay?docid=alma991048499934108681&context=L&vid=01MAINE_INST:UM&lang=en&search_scope=MyInst_and_CI&adaptor=Local%20Search%20Engine&tab=Everything&query=any,contains,white%20pine%20silviculture&sortby=date_d&offset=0.

Om P. Rajora, Andrew J. Eckert, John W. R. Zinck. 2016. “Single-Locus versus Multilocus Patterns of Local Adaptation to Climate in Eastern White Pine (Pinus Strobus, Pinaceae).” *PloS One* 11 (7). https://doi.org/10.1371/journal.pone.0158691.

Orwig, David A., Jason A. Aylward, Hannah L. Buckley, Bradley S. Case, and Aaron M. Ellison. 2022. “Land-Use History Impacts Spatial Patterns and Composition of Woody Plant Species across a 35-Hectare Temperate Forest Plot.” *PeerJ* 10 (e12693): e12693.

Peterson, Chris J., and Edwin R. Squiers. 1995. “Competition and Succession in an Aspen-White-Pine Forest.” *The Journal of Ecology* 83 (3): 449.

Prasad, Anantha, John Pedlar, Matt Peters, Dan McKenney, Louis Iverson, Steve Matthews, and Bryce Adams. 2020. “Combining US and Canadian Forest Inventories to Assess Habitat Suitability and Migration Potential of 25 Tree Species under Climate Change.” *Diversity & Distributions* 26 (9): 1142–59.

Raymond, Patricia, Alison D. Munson, Jean-Claude Ruel, and K. David Coates. 2006. “Spatial Patterns of Soil Microclimate, Light, Regeneration, and Growth within Silvicultural Gaps of Mixed Tolerant Hardwood - White Pine Stands.” *Canadian Journal of Forest Research* 36 (3): 639–51.

Raymond, Patricia, Alison D. Munson, Jean-Claude Ruel, and Philippe Nolet. 2003. “Group and Single-Tree Selection Cutting in Mixed Tolerant Hardwood–White Pine Stands: Early Establishment Dynamics of White Pine and Associated Species.” *Forestry Chronicle* 79 (6): 1093–1106.

Seymour, Robert. 2021. *Does Maine Have a White Pine Regeneration Crisis?* DigitalCommons@UMaine.

Seymour, Robert S. 2007. “Low-Density Management of White Pine Crop Trees: A Primer and Early Research Results.” *Northern Journal of Applied Forestry* 24: 301-306-301–6.

Seymour, Robert S., and David M. Smith. 1987. “A New Stocking Guide Formulation Applied to Eastern White Pine.” *Forest Science* 33 (2): 469–84.

Smith, David M., and P. Mark S. Ashton. 1993. “Early Dominance of Pioneer Hardwood after Clearcutting and Removal of Advanced Regeneration.” *Northern Journal of Applied Forestry* 10 (1): 14–19.

U.S. Department of Agriculture, Forest Service. 2026. “Forest Ecosystem Atlas.” Forest Ecosystem Atlas. 2026. https://experience.arcgis.com/experience/fbfad910532e4ae18fa3fe5af6e9260f.

Waskiewicz, Justin, Laura Kenefic, Aaron Weiskittel, and Robert Seymour. 2013. “Species Mixture Effects in Northern Red Oak–Eastern White Pine Stands in Maine, USA.” *Forest Ecology and Management* 298 (June): 71–81.

Waterman, Jamie M., Anthony W. D’Amato, David R. Foster, David A. Orwig, and Neil Pederson. 2020. “Historic Forest Composition and Structure across an Old-Growth Landscape in New Hampshire, USA1.” *The Journal of the Torrey Botanical Society* 147 (4). https://doi.org/10.3159/torrey-d-18-00033.1.

Wendel, G. W., and H. C. Smith. 1990. “Eastern White Pine.” In *Silvics of North America Volume 1: Conifers*, edited by R. M. Burns and B. H. Honkala. Washington, DC.: U.S. Dept Agric, Forest Service, Agric. Handbook 654.

Wilson, Jeremy S. 2005. “Nineteenth Century Lumber Surveys for Bangor, Maine: Implications for Pre-European Settlement Forest Characteristics in Northern and Eastern Maine.” *Journal of Forestry* 103 (5): 218–23.

Yang, Jing, John H. Pedlar, Daniel W. McKenney, and Alfons Weersink. 2015. “The Development of Universal Response Functions to Facilitate Climate-Smart Regeneration of Black Spruce and White Pine in Ontario, Canada.” *Forest Ecology and Management* 339 (March): 34–43.

Zhao, Jianheng. 2025, November 26, 2025.

Appendix G: Peer Review (Submitted)

Status: Complete

Project ID/Title: NE_TEMP2605: Eastern White Pine as an Iconic North American Tree: Evolving Dynamics and Future Opportunities

Rate the technical merit of the project:

1. Sound Scientific approach:
Approve/continue project
2. Achievable goals/objectives:
Excellent
3. Appropriate scope of activity to accomplish objectives:
Excellent
4. Potential for significant outputs(products) and outcomes and/or impacts:
Excellent
5. Overall technical merit:
Excellent
Comments
The proposal presents a clear, well-structured, and scientifically rigorous plan for addressing the evolving dynamics of eastern white pine across its range. The research team articulates a sound scientific approach grounded in extensive FIA data analysis, coupled with a thoughtful integration of silviculture, forest health, and ecological context. The objectives are achievable, logically sequenced, and appropriately scaled for a multistate collaboration.

As a forest pathologist who has worked extensively on health issues affecting eastern white pine, I recognize the importance and timeliness of this coordinated effort. The proposal accurately identifies the major biotic and abiotic stressors influencing EWP productivity and resilience, and it outlines a framework that will meaningfully advance our understanding of how to manage this species in both pure and mixed stands. The emphasis on synthesizing regional expertise, developing updated management recommendations, and generating future research proposals further strengthens the project’s potential impact.

Overall, the project is technically strong, well justified, and positioned to deliver significant outcomes for forest managers, researchers, and stakeholders across the region. I fully support the proposed work.
Your Recommendation:
Approve/continue project

Appendix G: Peer Review (Submitted)

Status: Complete

Project ID/Title: NE_TEMP2605: Eastern White Pine as an Iconic North American Tree: Evolving Dynamics and Future Opportunities

Rate the technical merit of the project:

1. Sound Scientific approach:
Approve/continue project
2. Achievable goals/objectives:
Good
3. Appropriate scope of activity to accomplish objectives:
Excellent
4. Potential for significant outputs(products) and outcomes and/or impacts:
Excellent
5. Overall technical merit:
Good
Comments
Overall, I think this is well written with logical objectives. I see the value in which this research can provide stakeholders who manage for Eastern White Pine. I would like to see more detail on the extension/ outreach regarding how these findings will be disseminated. I would also recommend spatial representations of where trees are being impacted by pests, namely white pine weevil, to see the geographic distribution of this pest and identify potential strategies to mitigate its adverse impacts on health and growth.
Your Recommendation:
Approve/continue project

NE_TEMP2650: Building a Resilient Equine Economy: Sustainable Pathways for Horses and Communities

Status: Submitted As Final

Duration 10/01/2026 to 09/30/2031
Admin Advisors: [Lee Hecker]
NIFA Reps:

Non-Technical Summary

The U.S. equine industry contributes $177 billion in value and supports 2.2 million jobs (American Horse Council, 2023), yet rising costs of keeping horses are threatening the long-term viability of equine owners, businesses, and welfare organizations. Stakeholder surveys across multiple Northeast states identify financial challenges as the top barriers to sustainable horse ownership and management. Without coordinated regional research and educational support, these barriers will continue to limit participation in the equine industry, reduce welfare outcomes, and weaken rural economies.

The goal of this project is to build a more resilient equine economy by generating data-driven solutions that reduce costs, improve horse health, and enhance decision-making among horse owners, professionals, and welfare organizations. Objectives include: (1) conducting a multistate longitudinal survey to assess economic pressures, horse health, and management practices; (2) developing research and outreach on cost-effective pasture, forage, nutrition, and climate-adaptive management; (3) assess horse nutrition practices and develop cost-saving feeding strategies based on survey data**;** (4) development of extension resources.

Target audiences include horse owners, managers, veterinarians, welfare organizations, educators, and industry partners. Stakeholders will benefit through data-driven recommendations, cost-saving decision tools, improved welfare outcomes, and earlier detection of health issues that lead to substantial economic losses.

By integrating research, technology development, and coordinated multistate outreach, this project will generate actionable knowledge and tools that directly reduce the financial burden of horsekeeping and strengthen the economic and social sustainability of equine communities.

Statement of Issues and Justification

Overview: Stakeholders across the U.S. equine industry report rising costs as the top barrier to sustainable horse ownership and operation. Recent needs assessments from Pennsylvania, Kentucky, New Jersey, Maine, Delaware, and other states consistently identify rising expenses, such as feed, veterinary care, and facility maintenance as the top challenges facing owners and equine businesses. These concerns align with national trends: the annual cost of horse ownership has tripled or more since 2003 (American Horse Council, 2023), and general operating expenses now exceed inflation-adjusted 2012 values by 86–128% in some regions (Kentucky Equine Survey, 2022). Without intervention, these challenges will continue to reduce participation in the equine industry, strain welfare organizations, and negatively impact rural economies that depend on equine activity.

The consequences of inaction include declining horse welfare, reduced economic output, and the continued accumulation of preventable expenses associated with poor nutrition and inefficient management. Another factor reducing equine systems profitability is poor pasture management. Improper pasture management (e.g., overgrazing, inadequate nutrient and stocking-rate management, and lack of resting) reduces forage quantity and quality, increases reliance on purchased supplemental feed, such as hay and concentrates, and thereby raises feeding and overall horse-production costs (Macleay and Buckley, 2019; Ringmark et al., 2019).

A multistate approach is essential because economic pressures and management decisions are influenced by climate, forage systems, regional feed costs, facility designs, and state policies. A coordinated effort enables comparative analysis, broader applicability of findings, and collectively developed educational tools that can be disseminated regionally. Successful completion will result in improved cost efficiency, enhanced welfare outcomes, more resilient equine businesses, and better-informed decision-making across diverse equine communities.

1. Rising expenses in horse operations

Justification: Despite the overall industry growth, costs associated with horsekeeping have surged, placing increasing financial pressure on individual owners and operations. According to a report comparing 2003–2016 data from the American Horse Council, the annual cost of owning a horse in the U.S. rose during that period: for show horses, from US$3,186 (2003) to US$24,239 (2016); for recreational horses, from US$2,319 to US$6,710 (datapaddock.com) Even under modest care regimes, the combination of feed, facility maintenance, veterinary care, and other routine expenses places horse ownership far beyond a casual hobby for many.

These rising costs have been confirmed by stakeholder feedback. An unpublished 2024 equine needs assessment conducted at Penn State University identified the top three most important and challenging issues in the equine industry. The most frequently chosen issues were all related to costs of horse-keeping. These responses reflect on-the-ground realities: owners, small operations, and welfare organizations increasingly struggle with escalating feed prices, maintenance, veterinary bills, and facility overhead.

2. Assess horse nutrition practices and develop cost-saving feeding strategies

Justification: Forage access and feeding efficiency are primary cost drivers for nearly all equine operations. Systematic monitoring of hay markets, coupled with research on feeding efficiency and waste reduction, is critical to improving producer financial resilience. These efforts provide producers with reliable benchmarks, predictive insights, and actionable recommendations. In years of drought or supply shortages, timely data help prevent urgent welfare compromises by informing early purchasing, storage, and pasture strategies. Without this objective, financial strain and preventable welfare issues related to forage scarcity will continue to escalate.

3. Grazing land management:

Justification: Pastures represent the most cost-effective and nutritionally valuable feed resources to horse owners, making grazing land a central economic pillar of equine operations. Yet many farms struggle to implement effective grazing practices, leading to wasted forage, higher feeding expenditures, and declining pasture productivity and persistence. Rising feeding prices, high veterinary and care costs, and the limitations of small or suburban acreage make efficient forage use even more critical for horse owners. Challenges such as uneven grazing pressure, poor soil fertility, and lack of management knowledge often translate into preventable financial losses and reduced overall farm resilience.

Feed remains one of the largest recurring expenses in any livestock operation, and poorly managed pastures increase dependence on costly hay and concentrates, particularly during winter or drought periods. Improving grazing-land management through strategies like rotational grazing, integrating warm- and cool-season forages, and optimizing soil fertility can extend the grazing season, improve forage quality, and reduce the need for supplemental feed. Research across forage systems shows that practices enhancing pasture productivity, nitrogen-use efficiency, and plant persistence yield strong economic returns, and these benefits directly apply to equine farms where even modest reductions in supplemental feeding can significantly lower annual operating costs. Together, these points highlight the need for strong, coordinated research, outreach, and education in grazing-land management to help horse farms stay economically viable, reduce their dependence on purchased feeds, and build more resilient equine businesses.

4. Multistate Extension resources

Justification: While academic publications provide essential information and rigor, they are not the primary information source for most horse owners or managers. Rather, this group depends on Extension bulletins, webinars, workshops, podcasts, and short-form digital resources that can be readily applied in daily operations. A multistate dissemination effort will close the gap between research and producer-level application. Additionally, this approach ensures that educational resources reflect diverse management systems and economic realities. The development and dissemination of Extension resources are an essential part of this multistate effort. These materials serve as the primary mechanism through which research findings reach stakeholders, influence management practices, and generate measurable improvements in economic resilience and equine welfare.

Related, Current and Previous Work

This project builds directly on prior multistate collaborations focused on equine nutrition, grazing systems, welfare, and decision-support tools (NE1041, NE1441, NE1941). These projects have generated foundational knowledge on pasture management, forage quality, climate impacts, and the economics of livestock systems. The present proposal extends this work by integrating economic resilience and environmental considerations specifically relevant to the equine sector.

Previous studies demonstrate meaningful economic impacts from management education. Skelly et al. (2011) showed that 31% of participants in Michigan adopted cost-saving practices, while Delaware and Midwest studies reported substantial interest in nutrition, pasture management, biosecurity, and disease prevention- all areas where improved management results in measurable financial benefits (Wickens et al, 2011; Mastellar et al., 2018).

Together, these activities provide a coordinated platform to address the multifaceted drivers of cost and risk in horsekeeping.

Grazing land management:

Implementing thoughtful grazing management strategies is essential not only for maintaining pasture health but also for strengthening the economic sustainability of equine operations. Research has consistently shown that managing the area available for grazing through rotational systems can substantially improve forage production and nutritive value compared with continuous grazing (Williams et al., 2020). Studies across cool-season (Webb et al., 2009; Kenny, 2016), warm-season (Webb et al., 2011), and mixed-species pastures (Daniel et al., 2015) indicate that rotational stocking increases total forage mass and lengthens the grazing period. These improvements reduce the need to purchase hay or concentrate feeds, thereby lowering operating costs. Rotational systems have also been linked with healthier pasture composition, including a greater presence of desirable forage species (Virostek et al., 2015) and improved ground cover (Kenny, 2016), which can decrease the long-term expenses associated with pasture renovation efforts.

Building on these benefits, overseeding can serve as an additional strategy to maintain productive, high-quality stands. Sod-seeding, introducing compatible species into existing pastures, offers a sustainable approach to rejuvenate forage systems and enhance botanical diversity without the cost or soil disturbance associated with complete renovation (Rueda-Ayala and Höglind, 2019). By filling gaps in thinning stands and improving overall forage availability and nutritive value, overseeding helps extend grazing capacity and delay more expensive renovation interventions, supporting both pasture longevity and economic efficiency.

Beyond improving pasture composition and productivity, adjusting the number of hours horses are allowed to graze each day is another strategy that supports forage conservation and economic efficiency. Limiting grazing time helps match feed intake to nutritional requirements, preventing excess energy consumption while slowing pasture depletion. Evidence shows that mature idle light-breed horses grazing between 9 and 12 hours per day typically consume enough to meet maintenance digestible energy needs without exceeding them (Dowler et al., 2012; Siciliano, 2012; Bowman et al., 2017). This reduction in daily intake, estimated at about 5 kg of dry matter for a 500-kg horse when access is restricted to 9–12 hours (Siciliano, 2012), can equate to roughly 20 additional grazing days within a single month. Extending grazing time in this way directly cuts back on supplemental feed purchases, providing clear financial benefits.

Incorporating alternative forage species can also contribute to greater economic resilience. Studies examining annual grasses, including teff, show that these species can effectively lengthen the grazing season in northern regions (DeBoer et al., 2017; Grev et al., 2017). Teff, in particular, has been associated with more favorable glucose and insulin dynamics in horses during the fall and late fall (DeBoer et al., 2018), which may have longer-term health and management advantages. In the Southeast, incorporating rhizoma peanut into bahiagrass pastures enabled a 75% reduction in nitrogen fertilizer use without affecting forage production. This mixed system also improved forage nutritive value and produced similar or more favorable fecal and blood metabolites compared with high-fertilizer bahiagrass monocultures in equine grazing systems (120 kg N ha^{-1}; Vasco et al., 2023; 2025).

Collectively, practices such as rotational stocking, overseeding, controlled grazing duration, and the use of alternative forages enhance forage efficiency, reduce feed costs, and support the economic sustainability of horse operations while maintaining horse and pasture health.

Objectives

1. Conduct a multistate longitudinal survey to identify major social and cost drivers, management practices, welfare concerns, and economic pressures across diverse equine operations.
2. Assess horse nutrition practices and develop cost-saving feeding strategies, including hay price monitoring and decision-support tools.
3. Develop and evaluate cost-effective pasture, forage, climate-adaptive management strategies to reduce feed-related expenses and improve forage utilization.
4. Develop and disseminate multistate Extension resources (webinars, fact sheets, tools) targeted at reducing horsekeeping costs and improving welfare outcomes.

Methods

Objective 1:

Survey Development: Penn State University (PSU), in collaboration with university economics faculty, will lead survey design and IRB development. The survey will include validated question types (Likert items, ranking questions, cost-reporting and management practices fields). Survey topics will include: Top equine operational expenses; Forage, feed, and pasture management practices; Facility management costs; Health-related expenditures; Perceived barriers to implementing cost-saving strategies; Welfare concerns and resource gaps; Climate-related impacts on forage availability and costs. Draft survey tools (e.g. Qualtrics) will undergo review by the multistate technical committee and pilot testing (n=5-10 participants). Revisions will be made based on participant feedback.

Survey Administration: Each participating institution (UMaine, Penn State, Kentucky, Florida, Montana, and partners) will distribute the survey through Extension networks, equine associations, social media, email listservs, and industry events. Multiple dissemination efforts (initial email, 1-week reminder, 3-week reminder) will maximize response rates. Sampling will target a broad cross-section of equine owners, trainers, boarding facilities, welfare organizations, rescues, and industry professionals. Each state will aim for 75 responses, generating a projected dataset of 375 respondents across the project.

Longitudinal Design: The survey will be repeated every two years to track: Changing cost structures; Adoption of cost-saving practices; Emerging welfare and management needs; Economic impacts of feed prices, climate variability, veterinary costs, and facility investments; The effectiveness of educational interventions; and shifts in operational financial resilience.
Unique (non-identifying) participant codes will allow voluntary participation while protecting confidentiality.

Data Analysis: Confidential data will be pooled into a shared multistate repository. Analysis, guided by economic faculty partners, will include: Descriptive statistics of costs and practices; Multivariate regression linking cost outcomes to management decisions; Mixed-effects modeling for longitudinal changes; Correlation of forage and hay pricing with geography and climate indicators; Pre/post comparisons of adoption of recommended best practices. All institutions will participate in data interpretation and multistate synthesis.

Objective 2:

Hay Price Monitoring and Modeling: Participating states will collect annual hay and forage price data from farm surveys, Extension reports, and agricultural market listings. A standardized protocol will capture bale type, weight, forage species, quality grade, and regional availability. These data will be integrated into economic models that estimate feeding costs under varying forage qualities, supply constraints, and seasonal fluctuations.

Feeding-Efficiency Research: Feeding-efficiency studies evaluating storage losses, feeding systems (round-bale feeders, slow-feed nets, rationed vs. free-choice), and supplemental feeding requirements relative to forage quality. Data will include dry-matter intake, waste percentage, time budgets, and cost per unit of nutrition delivered. One specific project is listed below.

Project #1: Investigate the effect of different proportions of alfalfa-bermudagrass hay as single sources of nutrition in diets of mature horses. The objectives of this study are to evaluate the effect of these proportions on diet cost effectiveness, diet digestibility, blood and fecal variables, and feeding behavior of mature horses. This study also aims to identify the optimum proportion of alfalfa-bermudagrass for maximum diet utilization and welfare. **Project #1 methodology:** Dietary treatments will consist of four hay treatments with different proportions of alfalfa (*Medicago sativa* L.) and Bermudagrass [*Cynodon dactylon* (L.) Pers.], with increasing levels of alfalfa as: 0, 34, 66, and 100 % alfalfa. Treatments will be tested in a replicated 4 × 4 Latin square with 20-day experimental periods using eight mature horses and offered at 2% of horses' body weight into three meals. Horses will have free access to fresh water and be provided with vitamin and mineral supplementation daily. Within each experimental period, after a 14-day adaptation phase, a 24-h time-budget behavioral observation (Martin & Bateson, 2007), and bite and chew rates, will be conducted on day 14. On days 15-19, total fecal and urine collection will be conducted for measuring diet digestibility and nitrogen and water balance (Vasco et al., 2021).On day 20, fecal and blood variables pre- and post-feeding responses will be measured in blood samples (insulin, glucose, blood urea nitrogen, total plasma protein and lactate) that will be collected by jugular venipuncture and fecal samples (dry matter, lactate, pH, short-chain fatty acids, and ammonia-nitrogen) that will be collected directly from rectum (Vasco et al, 2026). Diet cost-effectiveness will be measured as cost per unit of nutrient [digestible energy (DE) and crude protein (CP)] supplied, feed cost per day per horse, hay efficiency ratio (DE or CP delivered/cost of hay, estimated cost of health risk reduction - which will be measured based on the pre- and post-feeding responses of the fecal and blood variables, and cost efficiency of nitrogen use and environmental economics (value of reduced economic excretion and water balance), among others. Data will be tested for normal distribution using the Shapiro–Wilk test and submitted to analysis of variance using the GLIMMIX procedure in SAS (SAS Inst. Inc, Cary, NC). Data from the 24-hour time budget assessment will be submitted to ANOVA with repeated measures using the MIXED procedure with the REPEATED statement in SAS (SAS Inst. Inc., Cary, NC). The model will include square, period, treatment, hour, and treatment x hour as fixed effects and horse(square) as random effect when testing the effect of hay and time of day on mean hourly feeding, inactivity, and other activities duration. For hay treatment effect on diurnal, nocturnal, and total daily duration of feeding, inactivity, and other activities, chew rate, bite rate, and frequency of drinking, urination, and defecation, data will be submitted to ANOVA using the MIXED procedure in SAS. Square, period, horse(square), and hay treatment will be included in the model as fixed effects. Nutrient intake and digestibility variables, as well as the economical analysis variables, will be calculated by day, and statistical analysis will be performed on the 5-d average for each collection within a period. The model will include square, period, horse(square), and hay treatment as fixed effects. Data from the fecal and blood variables post-feeding responses, data will be analyzed as a replicated Latin-square design with repeated measures arrangement using the MIXED procedure of SAS (SAS Institute Inc., Cary, NC). Square, horse(square), hay treatment, and period will be considered blocking factors in the replicated Latin-square design. The model for repeated measures analysis will include square, period, hay, hour, and hay x hour as fixed effects, with hour as the repeated measure. Horse(square) will be considered a random effect. A Tukey's post hoc test will be used to determine differences between the means for all significant effects.

Decision-Support Tools and Business Resources: Economic modeling results will be used to develop user-friendly decision-support resources such as ration-cost calculators, hay-price dashboards, and feeding strategy comparison tools. Additional business planning materials (i.e., budget templates, cash-flow tools, and modules for the online Equine Business Course) will be collaboratively authored, piloted by equine managers, and disseminated across states.

Objective 3:

Grazing Research and Field Trials: Plots and large-scale grazing studies will be conducted to evaluate forage species and pasture establishment, or renovation, effects on system economic and overall sustainability. **Project #1:** Determine the effect of sod-seeding aged perennial-warm season grass plots with different legumes on forage productivity, nutritive value, and ecosystem services. Grazing tolerance of these forage systems will also be determined by mob grazing them. **Project #1 methodology:** plots of bromegrass (*Bromus* spp.) alone or sod-seeded with alfalfa (*Medicago sativa* L.), sainfoin (*Onobrychis viciifolia* Scop.), birdsfoot trefoil (*Lotus corniculatus* L.) will be replicated three times in a randomized complete block design and repeated for two years. To allow for measurements of grazing tolerance, each third of the 23 ft x 148 ft plots will be randomly assigned to one of the three grazing treatments: non-grazed (control), cattle grazed, or horse grazed in a split-plot design. Grazed treatments will be mob grazed. Grazing frequency and data collection will be determined by forage phenology. Three to five grazing events/data collection are expected per year. Forage measurements will include herbage mass, botanical composition, NIRS nutrient composition, biological nitrogen fixation, and root mass. In vitro digestibility assay will be conducted using bovine and equine inocula. Soil characteristics will include carbon and nitrogen, using an elemental analyzer, and soil compaction, that will be measured as soil strength. The most successful mixture will be advanced to a large-scale grazing study (Project #2). **Project #2:** Determine the effect of sod-seeding aged perennial-warm season grass pastures with different legumes on forage productivity, nutritive value, animal performance and ecosystem services. **Project #2 methodology:** treatment pastures will include bromegrass alone or sod-seeded with the successful legume from projet #1. Pastures will be replicated three times in a randomized complete block design and repeated for two years. Each pasture will be divided into three paddocks and assigned to one of the grazing treatments: non-grazed (control), cattle grazed, or horse grazed in a split-plot design. Paddocks will be grazed using the rotational stocking method. Animals will be removed from the pastures when recommended post-grazing stubble height is achieved and kept in a dry lot and supplemented with hay while pastures are ready to be grazed again, which will be determined by forage phenology. Forage measurements frequency will be determined by forage phenology and include herbage mass, botanical composition, NIRS nutrient composition, biological nitrogen fixation, and root mass. Soil characteristics will include carbon and nitrogen, using an elemental analyzer, and soil compaction, that will be measured as soil strength. Intake and digestibility will be measured using the dual marker technique. Animal performance will be measured as frequently as forage measurements and determined by body weight and condition score. **Project #3:** Determine the nutritive value and acceptability of limpograss [Hemarthria altissima (Poir.) Stapf & C.E. Hubb.] for horses and compare it to forages commonly used in horse pastures in the Southeast (bermudagrass and bahiagrass). **Project #3 methodology:** Limpograss plots will be established in different horse operations and measured for forage yield, nutritive value, and acceptability/preference. Before the grazing events, forage yield and nutritive value samples will be collected by hand plucking random duplicate 20 x 20 in areas to a height of 10 inches. Samples will be dried at 60°C for 24 hours to determine dry matter and subsequently ground at 2 mm and shipped to a commercial laboratory for nutritional composition. Digestibility will be measured in vitro using equine fecal fluid as the inoculum for incubation. Initiation of the grazing season will be determined based on forage phenology and the grazing duration in hours will be determined based on estimated available forage (Glunk & Siciliano, 2011). Forage acceptability will be determined by visually assessing the percentage of available forage biomass removal on a scale of 0 (no grazing activity) to 100 (100% of the existing vegetation grazed down to 10 cm) as described by Allen et al. (2013).

Economic Analysis of Grazing Strategies: For the plot and grazing projects performed, economic metrics computed will include: establishment cost per acre (seed, sod-seeding labor, fertilizer and herbicide costs), annual maintenance cost per acre (dragging, fertilizer, herbicide, reseeding, and labor), forage yield per acre, grazing days per acre, and hay saved (lb and $/horse/grazing season), cost per unit of ecosystem services ($ per t of CO_2 sequestration, $ per lb of N biologically fixed, and $ saved with avoided fertilizer), ecosystem services per dollar invested, and total feeding cost per animal per day, among others.

Objective 4:

Resource Development and Dissemination: Each institution will develop educational resources tailored to their regional clientele, including fact sheets, webinars, budget tools, pasture tools, and business planning guides. Materials will reference data collected through surveys and applied research, focusing on actionable cost-saving strategies. States will share resources, and each institution will disseminate materials within their geographic region. An annual conference will be held to share results with equine stakeholders.

Measurement of Progress and Results

Outputs

- Analyzed Survey Results Comments: A multistate longitudinal dataset will be developed to capture detailed information on equine management costs and evolving industry needs. These data will be complemented by analyzed survey reports produced every two years, providing ongoing insight into economic and management trends.
- Forage and Hay Price Monitoring Tools Comments: Forage and hay price data from local and regional sources will be collected regularly and will be available in a user-friendly format for equine managers.
- Asynchronous Business Course Comments: An online asynchronous business course will be developed and disseminated to equine industry practitioners.
- Extension Outreach and Resources Comments: Extension-focused outputs will consist of educational materials such as fact sheets, webinars, written articles, business-planning tools, and podcasts designed to deliver practical, research-based guidance to producers. Research findings will be prepared for submission to peer-reviewed journals, ensuring scientific rigor and broad dissemination. Annual conferences held across the participating states that will bring stakeholders together to learn about project results. The project will culminate in a final multistate integrated report summarizing economic, welfare, and management findings across all participating regions.

Outcomes or Projected Impacts

- Short-Term Short-term outcomes include measurable increases in producer awareness of cost-effective horsekeeping strategies and documented adoption of recommended best-management practices (BMPs) related to feeding, forage selection, pasture care, welfare efforts, and facility design. Stakeholders will gain improved capacity to interpret economic trends such as hay price fluctuations and veterinary cost inflation.
- Medium-Term Medium-term outcomes are expected to include quantifiable cost savings among equine operations that adopt evidence-based management strategies. Welfare outcomes will improve among equine rescues and welfare organizations as a result of better resource allocation and diagnostic clarity. Increased financial resilience among small and mid-size equine operations will reflect more efficient management and better-informed decision-making.
- Long-Term Long-term impacts include strengthened regional and national equine economic stability. Ultimately, these impacts contribute to a more sustainable, economically viable, and welfare-centered equine industry. Progress will be assessed using quantitative indicators such as percentage reductions in feeding and forage costs, and changes in adoption rates of recommended BMPs. Additional indicators include the percentage of operations reporting improved financial stability and the total dollar value of documented cost savings across longitudinal survey efforts.

Milestones

(**2027**):Milestone 1 (Oct 2026–Sept 2027): (a) Survey Instrument Development, Testing, IRB Approvals, and Initial Distribution; (b) IACUC Approval and Some Project Activities. (a) During the first project year, the multistate team will collaboratively design the longitudinal survey instrument, incorporating economic, welfare, and management measures. Activities include pilot testing, instrument refinement based on stakeholder feedback, and completion of all required Institutional Review Board (IRB) approvals across participating institutions. Upon approval, states will coordinate the initial survey distribution using Extension networks, industry partners, and equine organizations. Completion of this milestone is essential before data collection, longitudinal tracking, and subsequent modeling can begin. (b) Project leaders will work on their individual Institutional Animal Care and Use Committee (IACUC)/Agriculture Animal Care and Use Committee (AACUC) before initiation of any research activity with animals. Some projects will be implemented in 2027, such as project #1 listed under objective 2.

(**2028**):Milestone 2 (Oct 2027–Mar 2028): (a) Initial Survey Data Cleaning, Analysis, Multistate Synthesis, and Results Dissemination; (b) Additional IACUC Approval and Other Project Activities. (a) Following data collection, participating institutions will collaboratively clean, verify, and pool responses into a shared multistate repository. Initial analyses will include descriptive statistics, regional comparisons, and identification of priority economic and welfare challenges. This milestone enables the team to determine early patterns in management costs, forage access, facility investments, and welfare concerns. Completion of this analysis is necessary for refining research directions, prioritizing field studies, and informing the development of educational resources. Results from the initial survey effort will be shared via Extension pathways, such as webinars or articles. (b) Project leaders will work on their individual Institutional Animal Care and Use Committee (IACUC)/Agriculture Animal Care and Use Committee (AACUC) before initiation of any research activity with animals.

(**2029**):Milestone 3 (Apr 2028–Sept 2029): (a) Development and Implementation of Follow-Up Research (Nutrition & Forage Studies); (b) Biennial Survey Re-Administration and Longitudinal Trend Analysis. (a) Building on initial survey insights, the team will launch targeted research initiatives across states after IACUC/AACUC approval. These include forage and hay price monitoring, feeding-efficiency studies, and pasture and grazing system evaluations. Completion of these research activities is required before developing national recommendations and decision-support tools. (b) At the project midpoint, the survey will be repeated to track shifts in economic pressures, adoption of best management practices, changes in welfare challenges, and impacts of earlier Extension interventions. Completion of this milestone enables longitudinal modeling and measurement of overall project impact.

(**2030**):Milestone 4 (Oct 2029–Sept 2030): Development of Extension Tools and Producer Resources. As research outputs emerge, the team will generate coordinated educational materials, including fact sheets, webinars, producer guides, feeding calculators, and forage budgeting tools. An online asynchronous business course will be developed. Multistate collaboration ensures consistency across regions while allowing for climate-specific adaptations. Completion of this milestone is essential prior to broad dissemination and evaluation of producer adoption.

(**2031**):Milestone 6 (Oct 2030–Sept 2031): Final Multistate Integration, Impact Assessment, and Report Development. In the final project year, data from all research streams-survey results, forage and nutrition studies, pasture management trials, footing modeling, and technology validation- will be synthesized into a comprehensive multistate report. This milestone supports development of policy recommendations, industry guidance documents, and final Extension outputs. Completion of this milestone marks the end of the project and establishes the foundation for future multistate collaborations.

Outreach Plan

Results will be disseminated through a coordinated multistate Extension network using webinars, fact sheets, digital tools, producer workshops, peer-reviewed publications, and presentations at regional and national equine industry conferences. Tools such as cost calculators, budgeting templates, and footing decision models will be made freely accessible online. Educational materials will be developed to meet accessibility standards, including plain-language summaries and closed-captioned video formats.

Special emphasis will be placed on reaching underserved rural communities, small-scale owners, and equine welfare organizations that experience disproportionate financial strain. Partnerships with state horse councils, rescues, Cooperative Extension, and community groups will ensure broad outreach. The project will engage peer groups to facilitate rapid translation of research findings into practice. Multistate collaboration ensures that outputs serve diverse ecological and economic contexts.

Organization/Governance

Committee of the Whole

Chair- Dr. Robert Causey, UMaine

Secretary- Dr. Rachel White, UMaine

Survey Subcommittee

Nutrition Subcommittee

Literature Cited

Allen, E., C. Sheaffer, and K. Martinson. 2013. Forage nutritive value and preference of cool-season grasses under horse grazing. Agronomy Journal, 105(3), 679–684. doi:10.2134/agronj2012.0300.

American Horse Council. 2024. *Results from the 2023 National Equine Economic Impact Study released*. AHC Press Release. The American Horse Council

American Horse Council. (n.d.). *2023 Economic Impact of the Horse Industry in the USA – Summary report*. The American Horse Council

Bowman, M. A., J. L. Moore, and P. D. Siciliano. 2017. Effect of restricting time allowed for grazing on fecal microbial fermentation parameters. Journal of Equine Veterinary Science, 52, 82. doi:10.1016/j.jevs.2017.03.110.

Daniel, A. D., B. J. McIntosh, J. D. Plunk, M. Webb, D. McIntosh, and A. G. Parks. 2015. Effects of rotational grazing on water-soluble carbohydrate and energy content of horse pastures. Journal of Equine Veterinary Science, 35, 385-386 (Abstr.). doi:10.1016/j.jevs.2015.03.014.

DataPaddock. (2016). *Annual cost of owning a horse in the U.S., 2003 versus 2016*. Retrieved from https://datapaddock.com/cost-of-owning-a-horse-in-the-us-2003-versus-2016-ahc/

DeBoer, M. L., M. R. Hathaway, K. J. Kuhle, P. S. D. Weber, A. S. Reiter, C. C. Sheaffer, M. S. Wells, and K. L. Martinson. 2018. Glucose and Insulin Response of Horses Grazing Alfalfa, Perennial Cool-Season Grass, and Teff Across Seasons. Journal of Equine Veterinary Science, 68, 33–38. doi:10.1016/j.jevs.2018.04.008.

DeBoer, M. L., C. C. Sheaffer, A. M. Grev, D. N. Catalano, M. S. Wells, M. R. Hathaway, and K. L. Martinson. 2017. Yield, Nutritive Value, and Preference of Annual Warm-Season Grasses Grazed by Horses. Agronomy Journal, 109, 2136. doi:10.2134/agronj2017.02.0099.

Dowler, L. E., P. D. Siciliano, S. E. Pratt-Phillips, and M. Poore. 2012. Determination of Pasture Dry Matter Intake Rates in Different Seasons and Their Application in Grazing Management. Journal of Equine Veterinary Science, 32, 85–92. doi:10.1016/j.jevs.2011.06.006.

Glunk, E.C., and P.D. Siciliano. 2011. Effect of restricted grazing on dry matter intake rate.Journal of Equine Veterinary Science, 31(5–6), 296–297. doi:10.1016/j.jevs.2011.03.124

Grev, A. M., C. C. Sheaffer, M. L. DeBoer, D. N. Catalano, and K. L. Martinson. 2017. Preference, Yield, and Forage Nutritive Value of Annual Grasses under Horse Grazing. Kenny, L. B. 2016. The effects of rotational and continuous grazing on horses, pasture condition, and soil properties (Master's thesis). Rutgers University, Graduate School–New Brunswick. Retrieved from: https://rucore.libraries.rutgers.edu/rutgers-lib/49246/

Macleay, C., and Buckley, P. 2019. Poor pasture management results in Australian horse owners using expensive daily supplementary feeding. In *19th Australian Agronomy Conference 2019*. Australian Society of Agronomy.

Mastellar, S. L., Rosenthal, E. J., Carroll, H. K., and Bott-Knutson, R. C. 2018. Assessment of Equine Feeding Practices and Knowledge of Equine Nutrition in the Midwest. Journal of Equine Veterinary Science, 62, 109–115. doi:10.1016/j.jevs.2017.12.007.

Martin, P., & Bateson, P. 2007. Recording methods. Measuring behaviour: an introductory guide.

Ringmark, S., Skarin, A., and Jansson, A. 2019. Impact of year-round grazing by horses on pasture nutrient dynamics and the correlation with pasture nutrient content and fecal nutrient composition. Animals, 9(8), 500. doi:10.3390/ani9080500.

Rueda-Ayala, V. P. andHöglind, M. 2019. Determining thresholds for grassland renovation by sod-seeding. Agronomy, 9(12), 842. doi: 10.3390/agronomy9120842.

Siciliano, P. D. 2012. Estimation of pasture dry matter intake and its practical application in grazing management for horses. In: Proc. 10th Mid-Atlantic Nutrition Conference. N.G. Zimmermann ed., Timonium, MA.

Skelly, C., Bodle, A., Heyboer, G., and Lambur, M. 2011. Measuring Impact and Subscriber Engagement of an Extension Electronic Newsletter. Journal of Equine Veterinary Science, 31(5–6), 339–340. doi:10.1016/j.jevs.2011.03.181.

Penn State University 2024 Equine needs assessment — unpublished data, internal report.

Vasco, A. C. C., Brinkley-Bissinger, K. J., Bobel, J. M., Dubeux Jr, J. C., Warren, L. K., & Wickens, C. L. (2021). Digestibility and nitrogen and water balance in horses fed rhizoma peanut hay. Journal of Animal Science, 99(11), skab284.

Vasco, A. C., Dubeux, J., Sollenberger, L., Wallau, M., Santos, E., Lance, J., Warren, L., and Wickens, C. 2023. Diurnal Variation in Forage Nutrient Composition and Metabolic Parameters of Horses Grazing Warm-Season, Perennial Grass-Legume Mixed Pastures. In Proc. XXV International Grasslands Congress. Covington, KY.

Vasco, A. C. C. M., da Silva Santos, E. R., Batista Dubeux Junior, J. C., Sollenberger, L. E., Wallau, M. O., Soares Vasco Neto, H. L., Lance, L. M., Warren, L. K., and Wickens, C. L. 2025. Herbage Responses and Grazing Performance of Mature Horses in Warm-Season Perennial Grass–Legume Mixed Pastures. Grasses, 4(2), 15. doi:10.3390/grasses4020015.

Virostek, A. M., B. McIntosh, A. Daniel, M. Webb, and J. D. Plunk. 2015. The effects of rotational grazing on forage biomass yield and botanical composition of horse pastures. Journal of Equine Veterinary Science, 35, 386. doi:10.1016/j.jevs.2015.03.015.

Webb, G., C. Duey, and S. Webb. 2009. Continuous vs. Rotational Grazing of Cool Season Pastures by Adult Horses.Journal of Equine Veterinary Science, 29, 388–389. doi:10.1016/j.jevs.2009.04.090.

Webb, G., S. Webb, C. Duey, and K. Minton. 2011. Continuous vs. Rotational Grazing of Cool Season Pastures During the Summer Months. Journal of Equine Veterinary Science, 31, 285. doi:10.1016/j.jevs.2011.03.109.

Wickens, C., Waite, K., Garey, S., and Fraze, S. 2011. An assessment of the educational needs of Delaware equine owners. Journal of Equine Veterinary Science, 31(5–6), 332–333. doi:10.1016/j.jevs.2011.03.172.

Williams, C. A., Kenny, L. B., Weinert, J. R., Sullivan, K., Meyer, W., and Robson, M. G. 2020. Effects of 27 mo of rotational vs. continuous grazing on horse and pasture condition. Translational Animal Science, 4(3), txaa084. Doi: 10.1093/tas/txaa084.

Land Grant Participating States/Institutions

ME,FL,MT,PA

Non Land Grant Participating States/Institutions

Participation

Participant	Is Head	Station	Objective	Research			Extension
				KA	SOI	FOS	KA

Response to Reviewer Comments for Proposal NE_TEMP2650: Building a Resilient Equine Economy: Sustainable Pathways for Horses and Communities

1. Scope Too Broad

Reviewer Comment Summary: Two reviewers noted that the project scope was too broad and recommended focusing on a single theme, ideally feed, forage, nutrition, and economic resilience. Reviewers indicated there was strong evidence of capability and feasibility for investigating: (1) economic pressures, horse health, and management practices; (2) cost-effective pasture, forage, nutrition, and climate-adaptive management; (3) horse nutrition practices and cost-saving feeding strategies; and (6) extension and outreach activities. However, reviewers found insufficient evidence of capability and feasibility for objectives related to arena footing design and early lameness detection technologies. They recommended removing Objectives 4 and 5.

Response: We agree that the original scope was ambitious. The primary objectives focused on economic pressures, management practices, nutrition, grazing, and extension outreach represent a cohesive and complementary research and extension program. In response to reviewer feedback, we have removed Objective 4 (arena footing) and Objective 5 (early lameness detection technologies). The revised proposal is now more focused on improving the economic resilience of equine operations through management, forage, nutrition, and outreach efforts.

Specific Comments on Removed Objectives:

Objective 4: Reviewers noted that while the need for evaluating arena footing was well justified, the objective lacked sufficient detail regarding how horse health, rider safety, and operational viability would be quantified. This objective has been removed from the proposal.

Objective 5: Reviewers requested additional information regarding Fit Gait technology, ownership, project implementation, and anticipated outcomes. This objective has also been removed from the proposal.

2. Objectives Vary in Detail and Formatting

Reviewer Comment Summary: Objectives varied considerably in depth, detail, formatting, and citation practices. Some objectives contained substantial methodological information and references, while others lacked sufficient detail, creating a piecemeal appearance.

Response: We recognize that contributors provided varying levels of detail across objectives during proposal development. With the removal of Objectives 4 and 5, we have revised the remaining objectives to improve consistency in organization, level of detail, and formatting. Additional methodological information has been incorporated where appropriate to provide a clearer understanding of proposed activities.

We also reviewed and corrected citations throughout the proposal. References that were no longer relevant or cited have been removed, and remaining citations have been standardized to improve consistency and readability.

3. Omissions

A) Milestones (IRB but not IACUC)

Reviewer Comment Summary: Milestones referenced IRB approvals but did not address IACUC approvals.

Response: Discussion of IACUC approvals has been added to Milestones 1 and 2, where applicable, to ensure that all necessary regulatory approvals are clearly identified within the project timeline.

B) Comparison of Motion Detection Technologies

Reviewer Comment Summary : The proposal did not clearly describe how motion detection technologies would be compared.

Response: The project involving motion detection technologies was associated with the former lameness detection objective, which has been removed from the revised proposal. Therefore, this concern is no longer applicable.

C) Outputs and Milestone Alignment

Reviewer Comment Summary: Outputs were not completely aligned with milestone years. For example, survey data could become available before 2030, yet no corresponding outputs were listed until later years.

Response: We revised the timeline to better align outputs with anticipated project milestones. Outputs associated with survey collection, data analysis, and extension products will now be identified in years that more accurately reflect when results are expected to become available.

4. Editorial and Consistency Issues

Reviewer Comment Summary: Numerous editorial inconsistencies were identified throughout the proposal, including inconsistent heading formats, missing punctuation, repeated sentences, inconsistent capitalization, and references included in the literature cited section that were not cited within the proposal.

Response: We conducted a comprehensive editorial review of the proposal to improve consistency in formatting, organization, and style. Revisions included:

- Standardizing headings and subheadings throughout the document.
- Correcting punctuation errors.
- Removing duplicated text.
- Standardizing capitalization and formatting conventions.
- Reviewing all references and removing sources that were not cited within the proposal.
- Ensuring consistency between objectives and corresponding sections in the "Related, Current, and Previous Work" section.

5. Objective 2 – Consideration of Vitamins and Minerals

Reviewer Comment Summary: Will vitamins and minerals be considered? Beyond digestible energy requirements, micronutrients are often the primary reason commercial concentrates are recommended. It is generally recognized that many cool-season grass hays, particularly those containing alfalfa, can adequately meet energy and protein requirements.

Response: We agree that vitamin and mineral nutrition is an important component of equine feeding programs. When evaluating forage quality, digestibility, and intake, commercial concentrates that primarily supply energy and protein should not be included because they may confound evaluation of the forage itself. However, appropriate vitamin and mineral supplementation will be provided as necessary to meet animal requirements throughout all studies.

To clarify this distinction, we revised the project descriptions within Objective 2. The revised language distinguishes between evaluation of forage-based feeding strategies and the nutritional management practices required to maintain animal health. Consideration of potentially limiting nutrients and micronutrient deficiencies will be incorporated into project-specific analyses based on forage composition and the physiological class of horses participating in each study.

Appendix G: Peer Review (Submitted)

Status: Complete

Project ID/Title: NE_TEMP2650: Building a Resilient Equine Economy: Sustainable Pathways for Horses and Communities

Rate the technical merit of the project:

1. Sound Scientific approach:
Approve/continue project with revision
2. Achievable goals/objectives:
Good
3. Appropriate scope of activity to accomplish objectives:
Good
4. Potential for significant outputs(products) and outcomes and/or impacts:
Good
5. Overall technical merit:
Good
Comments
The proposal addresses an important and highly relevant issue for the equine industry, and the overall vision of strengthening economic resilience is both timely and impactful. After reviewing the proposal, I believe the overall scope is currently too broad and would benefit from strategic narrowing to strengthen feasibility, cohesion, and depth of impact. As written, the project spans multiple largely independent domains, including longitudinal economic surveys, nutrition and forage systems, grazing ecology, arena footing engineering, lameness detection technology validation, and commercialization, each of which could reasonably stand alone as a full multiyear project. This breadth risks diluting scientific depth, overextending personnel and resources, and creating concerns about integration and the likelihood of successful completion. To improve clarity and competitiveness, I recommend focusing the project on a single cohesive theme, ideally feed, forage, and nutrition-driven economic resilience, since feed represents the largest recurring cost in equine operations and aligns strongly with existing expertise and methodological strengths. Concentrating on nutrition, grazing efficiency, and economic decision support tools would create a tightly integrated framework with clear outcomes, measurable impact, and a stronger probability of successful execution, while removing the arena footing modeling and lameness technology commercialization components would substantially improve focus and feasibility.
Your Recommendation:
Approve/continue project with revision

Appendix G: Peer Review (Submitted)

Status: Complete

Project ID/Title: NE_TEMP2650: Building a Resilient Equine Economy: Sustainable Pathways for Horses and Communities

Rate the technical merit of the project:

1. Sound Scientific approach:
Approve/continue project with revision
2. Achievable goals/objectives:
Good
3. Appropriate scope of activity to accomplish objectives:
Good
4. Potential for significant outputs(products) and outcomes and/or impacts:
Excellent
5. Overall technical merit:
Good
Comments
This multistate project proposal aims to improve economic resiliency within the equine industry by investigating and addressing common challenges facing horse owners, equine professionals, and related businesses. By employing an integrated, collaborative approach that builds on prior multistate efforts, the research team plans to generate meaningful knowledge and practical tools that reduce costs and foster sustainability across the equine community. The work is both timely and important, as recent years have brought sharp increases in operational expenses for equine enterprises that reflect broader trends across the U.S. economy. The team argues successfully that failure to meet these economic challenges may result in reduced industry participation, negative horse health and welfare outcomes, and/or decline in rural communities that depend on equine activities.

In general, this proposal has significant potential to deliver products and impacts that would benefit the intended stakeholders. Objectives are clearly stated, the questions addressed concern more than one state or region, and the timeline and anticipated deliverables appear reasonable. However, some parts of the proposal are more successful than others. Specific concerns include:

1. An inconsistent level of detail in methodology described. For example, Objective 2 states ‘Some specific projects are listed below’ for the feeding-efficiency research, but then describes only one project, in somewhat granular detail (albeit without statistical methodology described). This contrasts with Objective 4, which is painted with such a broad brush it is difficult to assess how modeling will be done or whether it will be successfully accomplished. Additionally, references are cited for some objectives but not others. While each objective will of course require a different approach, this lack of consistency, combined with differences in formatting between objectives, sadly contributes to a piecemeal effect in this section.

2. Potential omissions. Milestones include IRB approval, but not IACUC approval. How will you compare data from the force-based kinetic gait analysis system (FitGait) to data from motion-based kinematic gait analysis systems like Sleip (or other IMU/OMC/computer vision systems)? Will you field validate FitGait against other force-based systems (e.g., TekScan, force shoes, other force plates)? No cost analysis for adoption and utilization of FitGait vs. Sleip or other systems is proposed, yet the overarching theme of the proposal is one of increasing cost effectiveness for the benefit of the horse owner. If any of the listed outputs are to be produced during the life of the project, they should be included in their respective milestone years; as written, it appears there will be no outputs expected for any objectives until at least 2030, but it would seem like at least the initial survey data/results would be available before then?

3. Editorial issues. While admittedly this is a more minor concern, the proposal contains many, many formatting, capitalization, and punctuation issues that make this proposal appear to be a draft, rather than a final version. Some of these appear to be cut-and-paste issues related to the online submission process, but others are not. For example, in the ‘Statement of Issues and Justification’ section, (1) one of the bold headings has a colon while the others don’t; (2) descriptions for each start with ‘Justification:’ except for one; (3) there is a missing period after ‘escalate’ in the ‘Assess horse nutrition practices and develop cost-saving feeding strategies’ section; and (4) a sentence is repeated under the ‘Technologies for early lameness detection’ section. As another example, in the ‘Related, Current and Previous Work’ section, (1) some of the bolded subheadings have all capital letters and others don’t; (2) two end with a colon and the other with a period; and (3) only three of the previous five topic areas/objectives are presented here vs. five in the previous section. Numerous additional inconsistencies are found throughout the rest of the document. Additionally, the literature cited includes several references which are, in fact, not cited at all. A more critical editorial eye will reduce these unnecessary mistakes and distractions.
Your Recommendation:
Approve/continue project with revision

Appendix G: Peer Review (Submitted)

Status: Complete

Project ID/Title: NE_TEMP2650: Building a Resilient Equine Economy: Sustainable Pathways for Horses and Communities

Rate the technical merit of the project:

1. Sound Scientific approach:
Approve/continue project
2. Achievable goals/objectives:
Excellent
3. Appropriate scope of activity to accomplish objectives:
Excellent
4. Potential for significant outputs(products) and outcomes and/or impacts:
Excellent
5. Overall technical merit:
Excellent
Comments
The proposed Multi-State project has great potential to support equine industry in the Northeast through targeted research efforts and clear plan for outreach and dissemination of results. The coordinated efforts of the project will no doubt support continued profitable equine operations in the region.
Your Recommendation:
Approve/continue project

Appendix G: Peer Review (Submitted)

Status: Complete

Project ID/Title: NE_TEMP2650: Building a Resilient Equine Economy: Sustainable Pathways for Horses and Communities

Rate the technical merit of the project:

1. Sound Scientific approach:
Approve/continue project with revision
2. Achievable goals/objectives:
Good
3. Appropriate scope of activity to accomplish objectives:
Good
4. Potential for significant outputs(products) and outcomes and/or impacts:
Excellent
5. Overall technical merit:
Good
Comments
The overall breadth of this multistate proposal is strong and provides good justification for investigating feed and footing from an economic standpoint. Questions/Comments:

Objective 2 - Will vitamins/minerals be considered? Beyond DE requirements, micronutrients are the main reason why commercial concentrates are recommended. It seems well known that most cool season grass hay, especially with alfalfa inclusion, provides adequate energy/protein.

Objective 4 - The authors make a strong case for evaluating footing in the introduction, but this objective is weak/needs expansion. How will health, "viability of the equine operation", and "protection of horse and rider" be quantified?

Objective 5 - Is Fit Gait proprietary technology? Who owns it? The project seems sound but needs more details. Project 3 is confusing. Will this group realize profits? Overall, this objective needs expansion.
Your Recommendation:
Approve/continue project with revision

Appendix G: Peer Review (Submitted)

Status: Complete

Project ID/Title: NE_TEMP2650: Building a Resilient Equine Economy: Sustainable Pathways for Horses and Communities

Rate the technical merit of the project:

1. Sound Scientific approach:
Approve/continue project with revision
2. Achievable goals/objectives:
Fair
3. Appropriate scope of activity to accomplish objectives:
Fair
4. Potential for significant outputs(products) and outcomes and/or impacts:
Good
5. Overall technical merit:
Good
Comments
This multistate project offers six objectives, all of which are timely and important. However, I have substantial concerns regarding the proposals scope. There is strong evidence for the teams capability and feasibility to investigate (1) economic pressures, horse health, and management practices; (2) cost-effective pasture, forage, nutrition, and climate-adaptive management; (3) horse nutrition practices and cost-saving feeding strategies; and then communicating these findings via extension (6). However, there is poor evidence in capability and feasibility for the two other objectives (4) modelling cost-effective arena footing designs; and (5) technologies for early lameness detection.

My recommendation, if this project is to move forward, is to remove the arena surface and lameness objectives. These are two large and independent projects in their own right; that could be conducted together if there was more information about their integration. Barely a paragraph was included on the methods for these objectives, so it is unclear how exactly they will be conducted. Pertinent references, particularly on the work already being conducted on lameness detection, are also missing.

Focus on advancing knowledge, assessing strategies, decision support tools, and developing extension resources surrounding the goal of sustainable feeding for equine health and welfare should be the goal of this project. If this project were to be revised with this reduction in objectives and one major goal in mind, then more thorough expansion of the methods surrounding these objectives would strengthen the proposal.
Your Recommendation:
Approve/continue project with revision