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Managing Forest Health through Collaboration on the Allegheny High Unglaciated Plateau

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Abstract

Forests in the High Allegheny Unglaciated Plateau Subsection of Pennsylvania and New York, including the Allegheny National Forest, have been increasingly impacted by an array of native and introduced forest insects, pathogens, plants, and other disturbances for decades. An unbalanced age-class distribution, changing soil nutrient status, seedling establishment issues, droughts, and storm events also threaten forest health and structure. In 2017, the Allegheny National Forest convened a broad cross-section of forest stakeholders to collaboratively assess and prioritize these threats and develop effective strategies to address them. Relying on consensus and shared learning, the Allegheny Forest Health Collaborative assigned priorities and created working groups to address priority threats. This paper describes the collaboration and features a case study of followup, multilandowner work to assign treatment priorities to affected stands and develop silvicultural strategies for stands with poor and decreasing seed source.

Keywords: collaboration, Allegheny Plateau, forest health, shared stewardship, silviculture, mixed hardwood forest types

Collaborative approaches to solving complex forest-management issues have been gaining momentum for the last 15 years. Collaboration is defined as processes that involve "partnering and sharing decision making to the maximum extent possible" (IAP2 International Federation 2018). In a collaborative process, publics and agencies work together to define problem scope, develop options, and assess options against agreed upon criteria and attempt to arrive at consensus. Characteristics of effective collaboration include inclusion of diverse voices, shared learning, transparency, and trust.

The benefits of collaboration include improved social, economic, and ecological outcomes (Ansel and Gash 2008). Social benefits include reduced conflict because of improved dialogue, development of new relations, and improved levels of trust (Conley and Moote 2003, Mandarano 2008). Economic benefits include increased efficiency based on sharing and leveraging resources (Thomson and Perry 2006). It is theorized that collaborative processes also result in improved environmental outcomes, although more research is needed to document this connection (Cannon et al. 2018).

Faced with a suite of converging forest health challenges, managers of the Allegheny High Unglaciated Plateau ecoregion joined with other forest stakeholders in a collaborative approach to addressing these challenges. This paper highlights the forest health challenges, early collaborative responses, and

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Management and Policy Implications

The Allegheny Forest Health Collaborative (AFHC) highlights the benefits of a collaborative approach to address rapid ecological change. Skilled facilitation, clear objectives, a working agreement about how members would work together, and a timeline were critical to its early success. It was also important that the collaborative, while organized by the Allegheny National Forest, was a forum in which all stakeholders could share ideas and practices to sustain the forest, while benefiting from the insights of scientists and forest health experts. Changing forest conditions require all stakeholders to reevaluate and adaptively revise desired future conditions. In the AFHC, all regional land-management agencies have benefited from the development of a Treatment Priority Index that identifies the areas where forest health challenges are most urgent. Forest-management tactics are revised as managers develop an adaptive approach to silvicultural decisionmaking. This approach lays the foundation for systematic monitoring, learning, adaptation, and new research. Finally, the duration of the AFHC (nearly 2 years since the Forest Service-sponsored initial period) and enduring participant interest in developing a long-term leadership structure demonstrate the high value participants place on this shared stewardship approach.

the Collaborative itself, and then gives a case study of some of its products that are still under development.

The High Allegheny Unglaciated Plateau[1] occupies approximately 2.5 million acres in northwestern Pennsylvania and western New York (see Figure 1). The Allegheny National Forest (ANF) is the largest tract of publicly owned land within the ecoregion (Johnson et al. 2016), which is characterized by broad ridges deeply incised with stream and river valleys.

Forests are the dominant land use in the ecoregion, and the ecoregion is valued for its many core forest areas with less human disturbance than is found in other parts of the mid-Atlantic region. Most forested areas in the ecoregion are in midsuccessional stages, 21–149 years old (93.8 percent), whereas only a small proportion of the forest is less than 21 years old (5.3 percent) or greater than 149 years old (<1 percent) (USDA Forest Service, Forest Inventory and Analysis Program 2019). Land and resource managers are working to balance age classes and sustain diverse community composition in an aging forest, to reduce the risk of insect and disease outbreaks and subsequent mortality (see Waring and O'Hara 2005, Nyland 2016).

The ecoregion falls on the transition zone between the Mixed Mesophytic and Hemlock–White Pine–Northern Hardwoods regions as described by Braun (1950). Forest vegetation in the ecoregion is diverse, with 53 tree species documented (USDA Forest Service, Forest Inventory and Analysis Program 2019). Forest types include Allegheny hardwoods, northern hardwoods, mixed upland hardwoods, and oak hardwood forests, with lesser amounts of coniferous forest types including eastern hemlock (*Tsuga canadensis*). Black cherry (*Prunus serotina*) and red maple (*Acer* rubrum) are the two most abundant species on the ANF, comprising 52 percent of the total basal area, followed by American beech (*Fagus grandifolia*) and eastern hemlock (Morin et al. 2006).

Historically, the primary forest disturbance factors in the region were wind and ice storms (Lutz 1930, Hough 1959, Bjorkbom and Larson 1977), native insects and disease (USDA Forest Service 2007), droughts (Lutz 1930, Bjorkbom and Larson 1977), flooding along rivers (Pierce 1981, Walters and Williams 1999), periodic use of fire along larger river valleys by indigenous people (Black et al. 2006), passenger pigeons (*Ectopistes migratorius*) (French 1919), and white-tailed deer (*Odocoileus virginianus*) overabundance (reviewed in Royo and Stout 2019). Harvesting at the turn of the 19th century brought dramatic changes in species composition from a forest with about 80 percent beech and hemlock to the current dominance of black cherry and red maple (Whitney 1990).

The last century brought new impacts from both native and introduced forest insects and pathogens. These included chestnut blight (*Cryphonectria parasitica*), butternut canker (*Sirococcus clavigignenti-juglandacearum*), and more recently beech bark disease complex (*Cryptococcus fagisuga* and *Neonectria* spp.*)*, gypsy moth (*Lymantria dispar dispar*), emerald ash borer (*Agrilus planipennis*), and hemlock woolly adelgid (*Adelges tsugae*). Native pests such as fall webworm (*Hyphantria cunea*), forest tent caterpillar (*Malacosoma disstria*), elm spanworm (*Ennomos subsignaria*), and cherry scallopshell moth (*Hydria prunivorata*) periodically increase to damaging levels. Continuous changes in deer management policy and deer abundance complicate the predictability of tree regeneration and reduce understory plant diversity (Horsley et al. 2003, Pendergrast et al. 2016).

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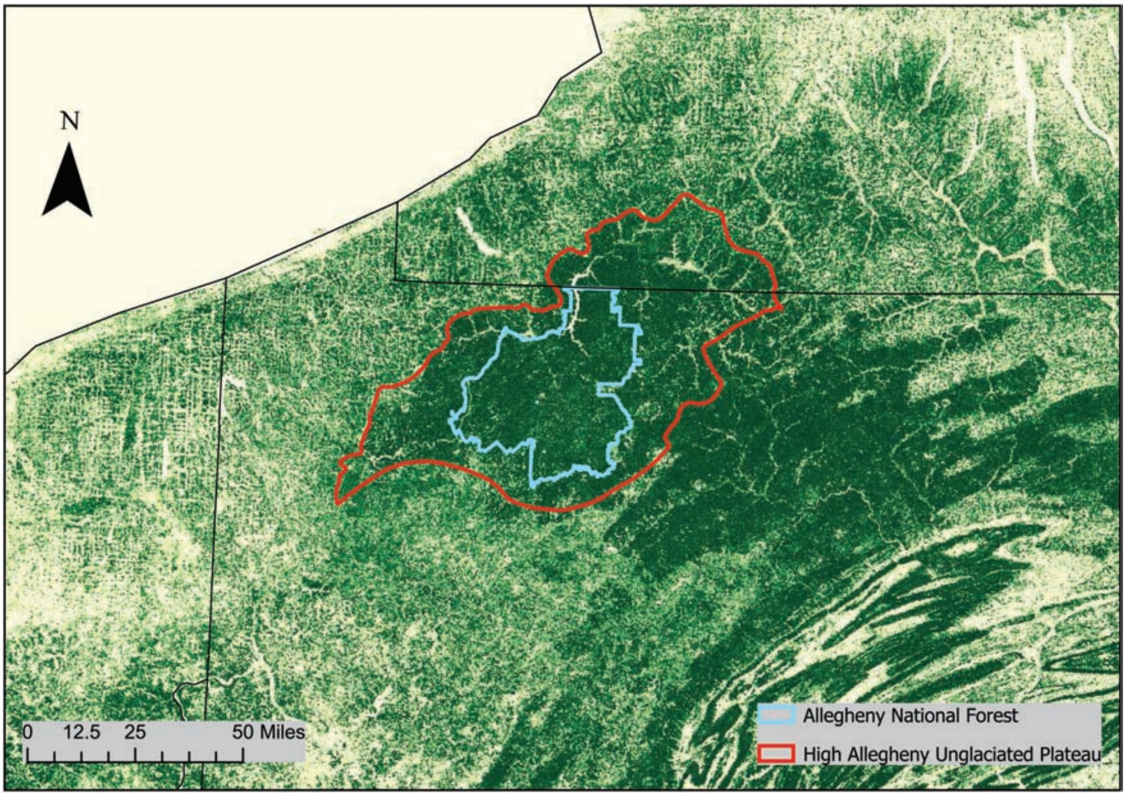

Figure 1. Vicinity Map of the High Allegheny Unglaciated Plateau, 2020 (USDA Forest Service Forest Inventory and Analysis). The intensity of color reflects the proportion of each 250-m pixel that is forest land. Base map from Wilson et al. 2012.

Non-native plant introductions and subsequent invasions of forest understories further threaten diverse and resilient forests and their native plant communities.

Environmental factors such as changing soil nutrient status (Bailey et al. 2005), droughts (Long et al. 2009), wind (Ruffner and Abrams 2003, Evans et al. 2007), other storm events, and climate change are also affecting the heath and structure of forests in the ecoregion. Recently, observed increases in mortality and crown dieback of now common black cherry trees (Figure 2) combined with apparent changes in seed production (Long and Ristau 2020) and seedling establishment issues further complicate and challenge managers' ability to sustain healthy and diverse forests. Taken together, current challenges threaten to reduce diversity by great reductions in the abundance of four historically important species: American beech, eastern hemlock, black cherry, and white ash.

Collaboration as a Response

The ANF recognized that addressing age-class imbalance and converging forest health problems concurrently is a problem that all landowners in the ecoregion were facing. Changes in ecosystems and the services they provided would affect every stakeholder in the region's forests. Trails and roadways would face increased risk of treefall, scenic vistas would have a changed appearance, wildlife habitat would be altered by changing forest composition and structure, and the economic contribution of forests to the region would be affected by tree mortality and changes in species composition. Addressing these issues would require a broader approach with a greater number of partners than previous participatory efforts.

Like other ecoregions and National Forests, this region has had historical conflicts over national forest planning and management, most recently as the ANF revised its Land and Resource Management Plan in 2007. Forest land managers in the ecoregion also have a history of cooperating with partners to solve complex resource issues. For example, the USFS Northern Research Station (NRS)-led Silviculture of Allegheny Hardwoods (SILVAH)[2] training sessions have provided a common framework and understanding for silvicultural and ecological processes for land-resource managers for the last 50 years (Stout et al. 2019), and informal science/management cooperation influenced changes in Pennsylvania deer management policy (Stout 2013, Royo and Stout 2019).

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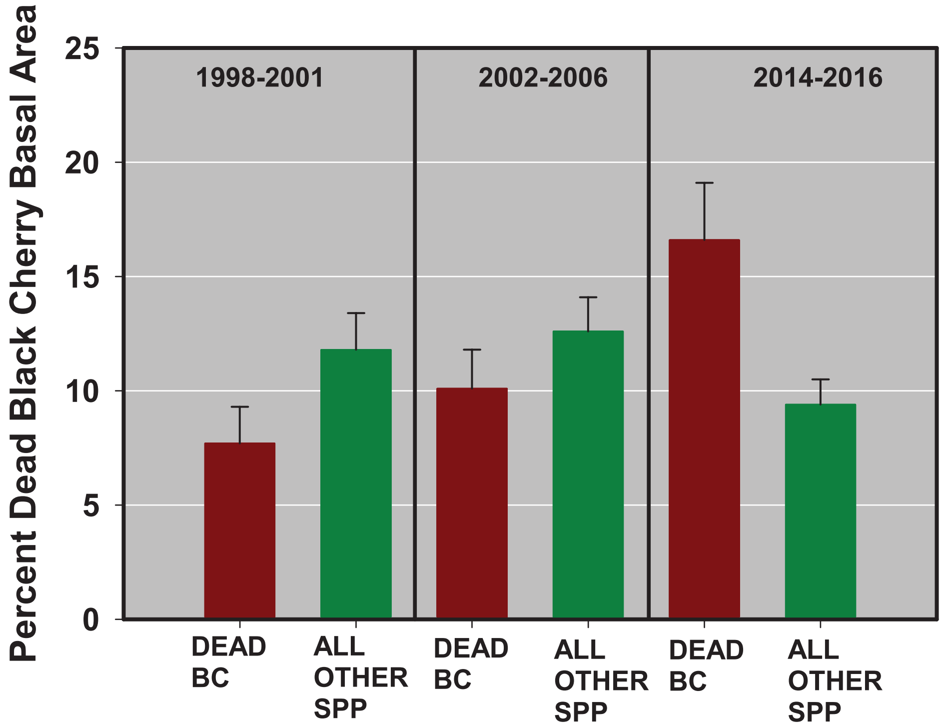

Figure 2. Percentage standing dead stems at three different inventory periods, based on long-term monitoring plots on the Allegheny National Forest. Black Cherry (BC) is shown in red, and all other species are shown together in green.

An early forest health collaborative effort in the ecoregion centered on identifying and sustaining high-priority hemlock conservation areas in advance of the invading hemlock woolly adelgid. In 2012, the Forest Service and The Nature Conservancy organized a diverse partnership to develop a strategy for landscape-level conservation of hemlock in the ecoregion (Johnson et al. 2016). Representatives of almost 50 groups, agencies, organizations, and institutions, representing nearly 50 percent of the land area in the ecoregion, participated. Cooperation continues through a communication network consisting of e-mail, phone, and in-person contact at workshops, meetings, and trainings.

Often public-participation efforts are labeled collaborative, although they may not meet the definition of a collaboration as outlined in the introduction of this paper. Regardless of whether or not they were fully collaborative, earlier efforts at participatory problem solving in this ecoregion laid the groundwork for the ANF to build a true collaboration focused on developing comprehensive alternative approaches to regional forest health challenges and engaging the greatest number of participants possible.

Launching the Forest Health Collaborative

The ANF's prior experience with the benefits of cooperation led the ANF to initiate a forest health collaborative. A Forest Service core team engaged external facilitators to help develop the framework for a comprehensive Forest Health Collaborative for forests of the ecoregion.

The first meeting of the core team with the facilitators occurred in mid-December of 2016. The facilitators helped the Forest Service define the type of public participation or partnership they were seeking, relying heavily on definitions from the International Association of Public Participation. The group agreed to invite stakeholders to engage in a collaborative process. Choosing true collaboration, as defined above, meant that whereas the ANF, as sponsor, could identify goals for the collaborative, members would need to set the agenda for achieving those goals. Although final decisionmaking for management on the ANF would follow federally mandated processes, the leadership of the ANF committed to fully considering the perspectives and input of the Collaborative as it addressed the shared forest health challenges.

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The initial meeting of the ANF Core Team with facilitators produced a diverse list of organizations who would be asked to send representatives to participate in the Collaborative. The core team also developed a draft working agreement for how the Collaborative would do business, with the expectation that Collaborative members would refine it at their first meeting.

It was important to the Core Team that the invitation list include a balanced group of stakeholders with as many forest values and benefits as possible represented. Representatives of recreation groups, watershed groups, conservation interests, the oil and gas industry, the forest products industry, local governments and business interests, regional tribes, academics and other scientists, and state agencies and interests were invited. Fifty-eight groups were invited, with e-mail and phone followups. Only one invited group failed to respond at all, and 51 groups sent representatives to the first meeting. At that meeting, participants suggested addition of representatives from local school districts and township governments, and this was done.

The draft working agreement was based on collaboration best practices and included tasks, products, and the mechanics of how the group would function. Final working agreement details as agreed to by the members of the collaborative are listed in Table 1.

Meetings

The Allegheny Forest Health Collaborative (AFHC) met five times between March and November of 2017. Stakeholders chose the frequency and length of meetings by consensus. As the group began to realize the benefits of the collaborative process, they were eager to spend the time needed to achieve the objectives, including working in subgroups between meetings. At the first meeting, participants discussed, refined, and agreed to a final working agreement, objectives, and products. At this meeting, the ANF shared parameters for the process. Specifically, this included placing a priority on staying within the existing ANF Land and Resource Management Plan, as well as biophysical constraints and legal requirements. At the second meeting, participants were introduced to a local risk-assessment map (https://tinyurl.com/yy67ufwe). Then, participants worked with ecoregion maps to focus on the rough spatial distribution of forest values and services at risk. Finally, the group identified and agreed upon the top eight threats (Table 2) to the region's forests. The process used to develop this list, and the list of strategies that followed, was a consensus process among stakeholders with vastly different interests in, and scientific familiarity with, the forest, and reflects the definition of collaboration and the AFHC Working Agreement. Participating forest-management

Table 1. Summary of Allegheny Forest Health Collaborative Working Agreement.

Working agreement category	What was included
Tasks	- Work collaboratively as part of a diverse team - Bring local knowledge, scientific data and experience to validate and refine forest condition and health data - Identify values and services threatened by forest health challenges - Develop strategies to address these threats - Prioritize the implementation of these strategies - Develop a communication strategy for those not engaged in the collaborative
Products	- Jointly identified and mapped forest attributes at risk from current and anticipated forest health threats - Prioritized list of threats requiring integrated management strategies to improve landscape-level resilience, - Recommended strategies for the ANF to achieve Forest Plan Implementation - A communication strategy to inform, consult with, and involve broader publics
Expectations for working together	- Collaborative members are equal partners - Diverse opinions, values and perspectives are respected - Collaborative members will be prepared for meetings - Collaborative mechanics: decision space, meeting guidelines, achieving consensus, stakeholder representation, and changes to the working agreement - Goal of finishing the specified products within an eight month time period

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personnel and scientists informed but did not dominate the process.

Relying on working-group efforts between the meetings, the lists of values and services threatened were refined and, where possible, combined, and initial strategies to address the threats were developed and shared. The group critiqued the efforts of each working group as part of the refinement process, and strategies were further developed and prioritized. Finally, AFHC members were able to identify several strategies that were common across multiple threats, named composite strategies (Table 3). At the conclusion of the initial five meetings, participants finalized the products, identified next steps, volunteered for ongoing strategy groups, and identified initial communication needs and opportunities to highlight the work of the AFHC.

Table 2. Eight top threats to forest values and services as a result of changing forest health as identified by the Allegheny Forest Health Collaborative.

1. Age-Class Imbalance
2. Emerald Ash Borer
3. Safety and Aesthetics along Multimodal Corridors
4. Loss of Diversity
5. Threats to Eastern Hemlock
6. Black Cherry Decline
7. Non-native Insects and Diseases
8. Non-native, Invasive Plants

Products

By the end of the 8-month initial period, participants had completed several of the products identified at the beginning of the process. The composite strategies were the "prioritized list for integrated management strategies." "Jointly identified … forest attributes at risk" were captured in the forest threat matrices, although the objective of mapping these in detail was not accomplished. "Strategies for ANF to achieve Forest Plan Implementation" were also found within the composite strategies. Although "a communication strategy to inform, consult with, and involve broader publics" was not completed during the initial period, a Communications Working Group was established to develop and implement communication strategies as the AFHC's work continued.

Table 3. Composite strategies for addressing forest health threats identified by the Allegheny Forest Health Collaborative.

Composite Strategy	Definition	Working Group(s) tackling this Strategy
Sustain Forest Resilience	Create and maintain resilient forests (age and structural diversity, carbon storage, climate change refugia, species of concern, low-impact harvesting, adaptive management, invasives, species shifts)	USFS—PA Bureau of Forestry Joint Team Silviculture Working Group
Black Cherry Sustainability	Develop and sustain short and long-term research strategies to document and explain changes in black cherry health, ecology, and regeneration challenges; develop, test, and monitor adaptive management strategies	Silviculture and Research Working Groups
Rapid Response Planning Approaches	Managers need flexible planning processes that allow rapid response to changing forest health conditions, invasive plants, insects, diseases, and threats on new and existing corridors from dead and dying trees	USFS—PA Bureau of Forestry Joint Team
Integrated Pest Management Strategies	Including prevention, early detection and rapid response, cultural, chemical, mechanical, and biocontrol techniques to make an integrated pest management response to invasive plants, insects, and diseases	Invasive Plant Working Group Monitoring Working Group
Creating or maintaining understory resiliency	This is especially important in forest areas affected by hemlock disturbances, and includes research and adaptive management work on appropriate species for underplanting and replanting	Silviculture, Research, and Invasive Plant Working Groups
Monitoring	To include citizen science and professional monitoring of forest health status, adaptive management outcomes, identifying and conserving resistant or tolerant individuals (e.g., ash, beech, and hemlock), and an aspirational objective of sharing monitoring across land ownerships	Monitoring and Research Working Groups Communication Working Group

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Followup Activities by Members and Working Groups

The group's enthusiasm to continue the work of the AFHC has resulted in ongoing collaboration at both the whole-group and working-group levels.

Since 2017, various AFHC member organizations have sponsored three AFHC meetings. At each, the working groups updated the entire AFHC on their accomplishments and explored opportunities to continue to work together and learn from each other. The AFHC hosted a visit from Forest Service Chief Vicki Christensen in October of 2018 at which she observed, "We have climbed the ridge together and are now well poised with a common view ahead, so we can share stewardship efforts moving forward." The Pennsylvania Good Neighbor Authority Master agreement has been signed, and activities under that agreement will soon begin. After the April 2019 meeting, members of the AFHC have formalized a shared leadership structure, including the leaders of the working groups and representatives of the ANF, with a balance among the various stakeholder groups. AFHC members continue to report that they benefit from the shared learning that occurs whenever the group convenes.

In addition, many members have signed up for working groups associated with the high-priority strategies produced during the first year of AFHC work (Table 3). One group, consisting of US Forest Service and Pennsylvania Department of Conservation and Natural Resources Bureau of Forestry leaders, is investigating partnerships like the Good Neighbor Authority to facilitate implementation of appropriate management activities more efficiently. A Communications Working Group has refined the AFHC key messages, developed a Facebook page for the AFHC, published an annual report for 2018, and hosted an event for Pennsylvania Outdoor Writers and other media. A third group combined with the Allegheny Plateau Invasive Plant Management Area to begin citizen science and collaborative treatment activities related to non-native invasive plants. A fourth group continues the work of the Hemlock Conservation Initiative. A fifth group is prioritizing research needs and exploring funding and collaborative mechanisms to ensure those research needs are addressed.

The work of the sixth group is described as a case study in more detail below. The Silviculture Working Group (SWG) of the AFHC includes land managers from state and federal agencies and forest industry and others from Penn State Extension and the USDA NRS. At its first meeting in November 2017, the group set out to share experiences regarding management of forest-health challenged stands and to develop two products: (1) consistent criteria to prioritize treatment needs in stands affected by these challenges; and (2) silvicultural decisions charts for declining or compromised stands.

The AFHC process highlighted the impacts of native and introduced forest insects, pathogens, plants, and other disturbances; changes in white-tailed deer abundance and associated browsing impacts; soil nutrition; and seedling establishment. These are creating new and uncharted forest dynamics across the ecoregion.

The SWG started by sharing the strategies that member management organizations were using to address changing conditions. For some stands, especially those of the mixed upland hardwood and mixed oak forest types, current composition is dominated by species less affected by current forest health challenges, and sustaining that composition, using familiar and established silviculture techniques, is a realistic, if sometimes challenging, option. In others, such as northern and Allegheny hardwood types with high proportions of black cherry, ash, hemlock, or American beech, maintenance of the existing species composition of a stand is no longer feasible, and land managers are working to determine how to allow changes in species composition and age-class balance to occur while still sustaining overstory and understory resilience. In still other stands, especially hard-hit by these forest health challenges, managers are recognizing a need to actively accommodate changes in species composition, encouraging previously rare species such as yellow poplar (*Liriodendron tulipifera*), cucumbertree (*Magnolia acumminata*), or previously less acceptable species such as black birch (*Betula lenta*). Overall, land managers are already redefining desired future conditions in light of the changing conditions.

Because the science to support decisionmaking in these changing conditions is lacking, land managers "need to be nimble, to manage our forests alongside the science as it develops, and be courageous in trying innovative and collaborative practices" (Nagel et al. 2017). In partnership, local scientists and managers need to use adaptive approaches as they continue to strive for species and age-class diversity. Adaptive management, an approach for simultaneously managing and learning about natural resources, is not a new idea, but the urgency of adopting adaptive strategies is heightened in places and times of rapid ecological change. Reducing uncertainty occurs by iteratively developing and implementing science-based

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management approaches, closely monitoring outcomes to improve understanding of resource systems, and improving management based on that understanding (Baskerville 1985, Williams 2011). Collaborative efforts, like the AFHC, facilitate communication of successes and failures that are needed to share what is learned. Thus, it was no surprise that managers were eager to have the framework of the SWG to learn from each other and develop courageous and nimble strategies to respond to the changing environment. Even in this area, where cooperation between managers and scientists is well established, changes in culture are needed because of the fast pace of change. The time to evaluate changes in the context of traditional designed studies will not always be available; agreement on which issues are so urgent that setting aside time for traditional studies becomes one of the functions of the AFHC and especially its Research and Silviculture Working Groups.

Treatment Priority Index

Managers across the Allegheny High Unglaciated Plateau are facing extensive landscapes in which mature stands already impacted by forest health challenges are increasingly difficult to regenerate. So, the SWG wanted to develop a tool for prioritizing these stands for regeneration treatments. Every participating land-management agency was doing this in various informal ways and agreed that something more formal shared across boundaries would have advantages for documenting current conditions and communicating them to superiors, to the public, and to future foresters who would be managing affected stands. The Treatment Priority Index (TPI) is essentially a triage tool for ensuring that the stands with the most urgent need for regeneration are identified and, as resources allow, treated. It also creates a quantitative launching point for a collaborative adaptive management process.

Following an existing approach used by The Collins Companies, the group worked over the course of several meetings to develop a stand-level decision guide and scoring system that quantifies seven factors responsive to the forest health threats identified by the larger collaborative (Table 4): stand health, seed tree abundance and composition, disturbance history (stands with more frequent disturbances are deemed more at risk of further health declines), merchantable stand diameter, existing seedling regeneration, site quality (the weight put on this factor will vary among landowners and with management objectives), and landscape forage availability (Royo et al. 2017) (a way of assessing whether additional regeneration harvests may be needed to reduce the impact of deer on regeneration success). The group struggled with how and whether to include the presence of invasive plant species as a factor. Ultimately, the variation in infestations, invasive capacity, and treatment options for different invasive plants led the group to decide to make decisions at the project level, instead of individual stands. Once invasive species have been identified and prioritized at the project level, existing treatment options will be incorporated in the silvicultural prescriptions for regeneration treatments.

Multipliers for each factor reflect the group's beliefs that some factors have more influence on stand health and regenerative capacity than others. For some factors, treatment priority was highest for stands in the midrange, rather than the extremes. For example, a mature stand with 50 percent overstory mortality is a higher priority than one with 10 percent or 90 percent because treatment can be deferred in one and is perhaps too late for silvicultural intervention in the other (Table 3).

The sum of the weighted scores for the seven factors is used to classify overall stand treatment priority. Five classifications, including not a priority, low priority, moderate priority, high priority, and very high priority (regenerate as soon as possible) were developed by the working group to describe a stand's treatment priority score. The "very high priority" category is primarily intended to highlight stands in which desirable regeneration is already established, or stands with overstory species at risk that have had few prior defoliations.

Collins Pine Company has been using a variant of this system with success for several years; the Pennsylvania Game Commission and the ANF are now piloting its use. The TPI was demonstrated in 2018 on the USDA Forest Service's 29,200-acre Yette project area. Like most of the ANF, this area is largely even-aged and midsuccessional (21–149 years old), and has been impacted by several native and introduced forest insects and pathogens. The abundance of stands with high black cherry basal area and observed concerns regarding black cherry crown condition, mortality, and lack of seed production (Long et al. 2017, unpublished) were important factors that influenced the selection and timing of the project.

Prior to any fieldwork being completed, existing spatial data were analyzed to narrow the focus of the demonstration to stands appropriate for TPI assessment and possible regeneration treatments. Forested

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Table 4. Treatment Priority Index factors, possible scores, multipliers, and AFHC threats addressed.

Factor	Criteria	Score	Multiplier	AFHC threat addressed*
Stand Health (percentage of total basal area dead/ dying)	<25	2.0	1.3	Emerald Ash Borer Hemlock Threats
	25–50	10.0	1.3	Black Cherry Decline
	50–75	15.0	1.3	Non-native Insects & Diseases
	>75	0.0	1.3	
Seed Tree Composition† (ft^2/ac of desirable seed trees, weighted by crown dieback & reliability of seedling establishment)	<30	0.0	1.2	All of the above plus
	30–50	15.0	1.2	Loss of Diversity
	51–80	10.0	1.2	
	>80	2.0	1.2	
Disturbance History (number of events in the last decade)	<2 nonconsecutive	0.0	1.0	Non-native Insects &
	2–3 nonconsecutive	2.0	1.0	Diseases Black Cherry Decline (Native Insects & Diseases)
	2–3 consecutive	10.0	1.0	
	>3 consecutive	15.0	1.0	
Merchantable Stand Diameter‡ (dbh in inches)	<12.0	0.0	1.0	(Timber Value at Risk)
	12–14	2.0	1.0	
	15–19	10.0	1.0	
	>19	15.0	1.0	
Regeneration (percentage of plots stocked)	≤50 percent acceptable§ w/o interference	0.0	1.4	Loss of Diversity Non-native Insects & Diseases
	≤50 percent w/ interference	2.0	1.4	
	>50 percent desirable¶ and/or >70 percent acceptable	10.0	1.4	Non-native, Invasive Plants Age-Class Imbalance
	>70 percent desirable	15.0	1.4	
Site Quality	Poor	2.0	1.2	(Timber Value at Risk)
	Medium	10.0	1.2	
	High	15.0	1.2	
	Inoperable	0.0	1.2	
Landscape Forage Availability (percentage of landscape in a forage producing condition‖)	>20 percent	10.0	1.3	(Impact of Deer on Regeneration)
	<20 percent	15.0	1.3	Age-Class Imbalance

Note: *Threats in parentheses were not explicitly listed by the collaborative.
†Includes red maple, yellow poplar, cucumber, oaks, healthy black cherry, etc.
‡Consider stand age when diameter is deceptively low.
§Black cherry, red maple, yellow poplar, cucumber, northern red oak, white oak, chestnut oak, white pine, eastern hemlock and birch.
¶Same as above, excluding birch.
‖Shelterwood harvests <7 years old; removal harvests <10 years old.

stands younger than 60 years old, stands already approved for some type of regeneration treatment, and minor forest types were excluded, along with stands on steep slopes or that were primarily riparian areas. The remaining stands included areas defoliated by cherry scallop shell moth in 2015 and 2016, Allegheny hardwood stands greater than 100 years old, and other Allegheny and mixed upland hardwood stands.

Field assessments were completed for 4,780 acres. Existing conditions were evaluated, scores were assigned for each of the seven factors, and total weighted scores were calculated at the stand level (n = 159). Of the 159 stands evaluated, 36 (1,170 acres) were identified as low priority, 77 (2,525 acres) as moderate priority, and 46 (1,085 acres) as high priority. Overstory species composition (forest type) appeared to be an important sorting factor (Figure 3). A greater proportion of Allegheny hardwood stands (91 percent) were scored as moderate or high priority than the more species-rich mixed upland hardwood stands (68 percent). Such

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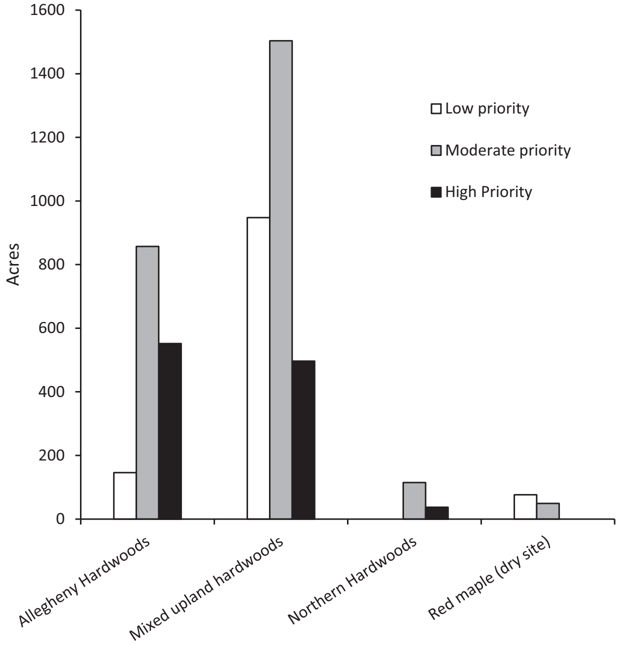

Figure 3. Distribution of acres examined in the Yette project by Treatment Priority Index priority group and forest type.

stands, often with a high proportion of black cherry, had high scores for overstory mortality, lack of reliable seed source, recent disturbance history, and lack of established, free-to-grow regeneration.

Even-aged regeneration treatments were proposed for all the high-priority stands and 83 percent of the moderate priority stands. The standardization of evaluation criteria promoted consistent evaluation between stands and required foresters to quantify important factors regarding stand health and regenerative capacity that have historically been documented as written narratives. Individual factor and total scores, along with other relevant field data, were stored spatially so they could be viewed, queried, and used for map production and analysis—now and in the future. The ANF has plans to continue its use of the TPI, and other members of the AFHC SWG are planning to incorporate it into their project planning.

Silviculture Decision Guides

The USDA NRS has a long history of providing decision support for managers of Allegheny hardwood and mixed oak ecosystems that rely on natural seedling establishment for stand-regeneration treatments (Stout and Brose 2014). These recommendations are captured in the SILVAH (Marquis et al. 1992, Brose et al. 2008) system and have worked well in stands with reliable seed source in the overstory. In Allegheny and upland hardwood stands, these silvicultural recommendations frequently include stand-level interference removal treatments that sacrifice a regeneration cohort on the assumption of prompt replacement.

Traditional SILVAH prescriptions are not appropriate for stands that score in the High Priority for Regeneration Treatment class from the TPI. These stands are already limited in reliable seed source and free-to-grow regeneration, so much more effort is placed on cultivating the survival and growth of existing regeneration, even if patchy and less abundant than desired. Desired future conditions include some change in species composition and working to achieve better age-class balance through regeneration. Very often, regeneration treatments in these stands will be patchy. For example, in stands with 30–50 percent stocking of reliable seed source and some desirable established regeneration, the SWG recommends retaining healthy seed source where advanced regeneration is absent, and releasing the existing desirable regeneration from interference through selective herbicide applications. We recognize that patchy treatments will increase the area of early successional forest in the landscape, but will also create multiaged stands that may be challenging to manage in the future. This underlines the importance of the spatially explicit use of the TPI as part of the record keeping on managed landscapes and for individual stands.

Stands with less than 30 percent stocking of reliable seed source actually receive lower scores on the TPI. Where the salvage value of the current overstory is high relative to the landowner's objectives, or where other landscape considerations suggest overstory removal, with or without artificial regeneration efforts, treatments may occur, but in general, scarce resources should be focused on stands with more promise of return on treatment investments.

Monitoring and Adaptive Management

By assigning TPI scores in a consistent way across land-ownership boundaries, and continuing to collaborate in the development of appropriate silvicultural strategies for stands in the various treatment categories, SWG members are laying the groundwork for more formal adaptive management processes. Good record keeping, close monitoring of silvicultural prescription outcomes, and information sharing will be essential for the work of the SWG to yield maximum benefits. Partnerships with research may provide opportunities for systematic and consistent

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measurements in stands receiving these adaptive treatments, and provide the analyses of these data to show which ones are providing desired results. Effective monitoring will require that prescriptions include stand treatment history, a detailed narrative describing the existing condition (including TPI scores), rationale for the proposed treatment (using a consistent format), a desired future condition that includes both desirable and acceptable outcomes, and monitoring requirements. In addition, prescriptions need to be maintained in a format that can be accessed and adjusted by future land managers as needed. As the SWG continues to work together, and evolves from developing strategies to monitoring their outcomes, the group will become a truly adaptive management working group.

Summary and Lessons Learned

Changing forest health conditions impact forest ecosystem dynamics and services, increasing both environmental variation and management uncertainty. In the High Allegheny Unglaciated Plateau ecoregion, forest land managers and stakeholders are using a collaborative approach (the AFHC) to prioritize threats and develop treatment strategies and priorities. The AFHC provides a forum for information sharing, shared learning, and collaboratively developed strategies to address changing ecosystem dynamics. Collaboration generates synergy, helps identify cooperative opportunities, and benefits all who participate. In our experience, early attempts at public engagement labeled "collaboration" were unsuccessful, did not meet participant expectations, did not meet the "shared decision making" standard, and resulted in enduring negative impressions regarding public engagement. The AFHC offers equal influence and participation by all participants. Professional facilitation, development of a consensus working agreement, well-planned meeting agendas, and an emphasis on developing trust in the process were key to our success with the AFHC. We are building on this success by formalizing the collaborative and sharing leadership moving forward. We have also learned that changing forest dynamics create a need to reevaluate desired forest conditions and develop more adaptive silvicultural approaches that evolve with our understanding of environmental variables and treatment outcomes. Voluntary continued participation in the AFHC demonstrates the value of this approach to participants.

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End notes

1. Under the National Framework of Ecological Units, this Subsection is located within Province 212—Laurentian Mixed Forest, Section 212G—Northern Unglaciated Allegheny Plateau, Subsection 212Ga. The Section was recently renumbered as Section 211. In this paper, we will use the term ecoregion to refer to the High Allegheny Unglaciated Plateau Subsection.
2. SILVAH has come to mean the community of practice formed by scientists and managers to sustain the region's forests. It includes training sessions that include research results, recommended stand inventory techniques, and computer software that prescribes treatments based on inventory data. It also includes formal and informal meetings of scientists and managers to share observations of the forest.

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