DESIRED FUTURE CONDITION: FOREST ECOYSTEM HEALTH AND ECOLOGICAL PRODUCTIVITY

Maintain and enhance forest ecosystem health and ecological productivity

OVERVIEW

Forest ecosystems are more than just trees. While it is true that trees are a defining feature of a forest, their connection to and interaction with other biotic and abiotic features is what forms a forest ecosystem. Understanding what organisms live in our forests and how they interact with their environment is essential to developing different approaches in forest management to promote long-term forest ecosystem health. The health of the forest includes the productive capacity of the soil, water, and air and their interaction to support all biota. Humans can have multiple impacts on forest ecosystems, including land conversion and forest structure conversion through harvesting, suppression of natural fire cycles and floods, degradation through incompatible uses, atmospheric pollutants, and the introduction of non-native species. These, in turn, influence ecological processes and ultimately forest-dependent plant and animal species[18]. Monitoring and research are essential for understanding our forest ecosystems and developing appropriate management strategies that promote healthy, productive, and sustainable forests.

Healthy forests are ecosystems that possess the long-term capacity for self-renewal of their ecological productivity, diversity, and complexity. Typical climate variability and natural disturbances may disrupt this capability in the short-term. Changes outside these historic factors may threaten long-term forest health. The ecological health of forests is essential if they are to provide their potential range of environmental, social, and economic benefits. The Division continues to place healthy forest ecosystems at the center of its programming. Accordingly, much of this plan is devoted to strategies to maintain or enhance forest ecosystem health. Through monitoring, education, and advocacy we seek to advance an understanding and ethic that places healthy forests first. Vermont is fortunate to

[18] Stein, Susan M., et al. 2005. *Forests on the edge: housing development on America's private forests.* Portland, OR : U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.

have a healthy forest core, but as this 2017 Plan details, many threats must be addressed, ranging from fragmentation and development to climate change and invasive species.

ASSESSMENT

ASSESSMENT: FOREST PRODUCTIVITY

Forest growth depends on soil productivity: the capacity of soil, which is a mixture of organic and inorganic materials, to support plant, animal, and other forms of life. The bedrock geology contributes much of the inorganic material, essentially pulverized rock, while all parts of plants and animals, living and dead, contribute to the organic matter.

Forest soil provides habitat for vascular plants, lichens, bryophytes, and fungi, essential to the diversity of a forest. The forest floor is a primary source of nutrients for trees, shrubs, and herbaceous plants and maintaining soil nutrients is essential to the health of both the current and future forest. Biological activity and climatic conditions affect forest soils. The structural characteristics of the forest floor including litter composition, depth and density, and topography also affect productivity and biodiversity. Protecting the organic layer and minimizing exposure of the mineral soil can reduce adverse effects on soil health and productivity. Changes to the canopy from harvesting or natural disturbances can affect the forest floor. Proper planning and management can mitigate the impacts of these events.

Retaining organic material during a harvest is important to minimize soil disturbance from log extraction and reduce erosion on roads and landings. Acid deposition from sulfur and nitrogen emission have changed soil chemistry, most notably in high elevation spruce-fir forests. Acid deposition strips soils of calcium and magnesium, which are essential for plant growth, through a process that also increases the concentration of aluminum in the soil. Aluminum can be toxic to plants and trees. The long-term effects of changes in soil nutrients are not well understood overall. Acceptable management practices for logging and other watershed protection strategies help conserve soil productivity and reduce erosion. Work is necessary to develop management recommendations that consider nutrient depletion when harvesting on acid sensitive sites and monitoring changes in forest soil nutrition.

Maintaining the health and ecological productivity of our working forest landscape is critical to sustainability. The growth to removal ratio, which is determined by monitoring the volume of wood products harvested annually relative to forests' annual growth and natural mortality, provides an indication of a forest's ability to provide a continual supply of forest goods and informs forest management opportunities. Another measure of forest productivity is the volume of trees, expressed as cubic feet, board feet, cords, or tons. Average annual net growth, mortality, and removals have higher sampling errors, indicating greater uncertainty in trend estimates; however, the

latest inventory shows a notable 23% decrease in average annual harvest removals of trees on forest land. All measures of forest productivity should be viewed broadly, considering all the goods and services produced from the forest including ecosystem services like water, air, and carbon (Chart 6).

FOREST PRODUCTIVITY ESTIMATES

	2009	2014
Above ground biomass of live trees (thousand oven-dry tons)	278,417	280,582
Net volume of live trees (million ft^3)	10,324	10,379
Annual net growth of live trees (thousand ft^3/yr.)	193,866	175,550
Annual mortality of trees (thousand ft^3/yr.)	110,220	115,832
Annual harvest removals of live trees (thousand ft^3/yr.)	90,258	85,533

Chart 6: Forest Productivity Estimates 2009 and 2014.

ASSESSMENT: CLIMATE CHANGE

Vermont's climate has and will continue to change, and these changes will affect forests in a variety of ways. Climate projections for our region include higher summer and winter temperatures, heavy precipitation events, less snow and more winter rain, and drier summers. Higher carbon dioxide levels may stimulate tree growth. A warmer climate will mean a longer growing season and better growth rates, but a more temperate climate may also increase insect pest reproduction and their expansion into higher elevations and farther north from their traditional habitats. Several web-based tools and projects help us understand Vermont specific climate impacts, including the Vermont Climate Assessment[19] and Climate Wizard[20].

The Third U.S. National Climate Assessment[21] provides a summary of climate changes already experienced and future projections for Vermont:

[19] The Gund Institute and The University of Vermont, 2016, http://vtclimate.org/.

[20] The Nature Conservancy, 2016, www.climatewizard.org.

[21] The National Oceanic and Atmospheric Administration (NOAA)- National Centers for Environmental Information, U.S. National Climate Assessment, 2014, https://statesummaries.ncics.org/vt.

- Average temperatures have increased by more than 2°F since the beginning of the 20th century. The last decade was the warmest on record. The intensity of extreme winter cold is projected to decrease.

- Average annual precipitation has increased nearly 6 inches since the early 20th century, with the largest increases occurring in mountainous regions of the state. Increased winter and spring precipitation is projected for the 21st century, and warming will increase the proportion falling as rain rather than snow.

- Extreme weather events, particularly floods and severe storms, are having an increased impact on Vermont. Extreme rainfall events are projected to become more frequent and intense in the future.

We have also noted that the beginning of spring is now generally earlier and has resulted in changes to season-associated ecosystem activities, such as the timing of maple syrup production. Likewise, there is evidence that elevation limits for tree species are rising. While our current climate supports a sugar maple-beech-birch forest, the future climate might favor additional species like oak and pine. It cannot be assumed that this transition will be orderly or without impacts to forest health.

In May 2013, ANR completed a Climate Change Adaptation Framework[22] with the purpose of "gathering information about climate change in Vermont as it relates to natural resources to propose a strategic framework for continued climate change vulnerability assessment and action planning." The report included information on projected climate changes, the vulnerability of various habitats, and potential strategies to reduce risk. Additionally, The Nature Conservancy's Northeast Resilience Project[23] identified places that will be more resilient to climate change and serve as natural strongholds for diversity into the future.

FPR applied this information on anticipated climate effects to create a guidebook titled "Creating and Maintaining Resilient Forests in Vermont: Adapting Forests to Climate Change[24]" to identify specific management activities that could be used by foresters to support resilience to climatic changes. Stand-specific, landscape-level, and species-specific recommendations are used to illustrate ways to plan for disruptions and reduce recovery time. Climate adaptation strategies from the guidebook are being implemented at demonstration areas on state and private forests, and training for natural resource professionals and tree stewards is ongoing.

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[22] Agency of Natural Resources, Climate Adaptation Framework, 2016, http://anr.vermont.gov/about_us/special-topics/climate-change/library.

[23] The Nature Conservancy, Northeast Resilience Analysis, 2016, www.conservationgateway.org/ConservationByGeography/NorthAmerica/UnitedStates/edc/reportsdata/terrestrial/resilience/ne/Pages/default.aspx.

[24] Vermont Department of Forests, Parks and Recreation. Creating and Maintaining Resilient Forests in Vermont: Adapting Forests to Climate Change, 2015.

OBSERVED CLIMATE TRENDS

PARAMETER	TREND	PROJECTIONS*
Temperature		
Annual temperature	Increase	By 2050, projected increase in average annual temperature by 3.7-5.8° F; by 2100, increase by 5.0-9.5° F.
Seasonal temperature	Increase	By 2050, projected increase in average winter temperature (December, January, February) by 4.3-6.1° F; average summer temperature (June, July, August) by 3.8-6.4° F
Hot days >90° F	Increase	More frequent and more intense; by the end of the century, northern cities can expect 30-60+ days with maximum daily temperatures >90° F
Cold days <0° F	Decrease	Reduction in days with minimum daily temperatures <0° F
Variability	Increase	Greater variability (more ups and downs)
Hydrology		
Annual precipitation	Increase	By the end of the century, projected total increase of 10% (about 4 inches per year)
Seasonal precipitation	Variable	More winter rain, less snow; by 2050, winter precipitation could increase by 11-16% on average; little change expected in summer, but projections are highly variable
Heavy rainfall events	Increase	More frequent and intense
Soil moisture	Decrease	Reduction in soil moisture and increase in evaporation rates in the summer
Snow	Decrease	Fewer days with snow cover (by the end of the century, could lose one-fourth to more than one-half of snow-covered days); increased snow density
Spring flows	Earlier, reduced volume	Earlier snowmelt, earlier high spring flows with reduced volume; could occur ten days to >2 weeks earlier
Summer low flows	Increase	Extended summer low-flow periods; could increase by nearly a month under high emissions scenario
Ice dynamics	Changing	Less ice cover and reduced ice thickness
Extreme Events		
Flood events	Increase	More likely, particularly in winter and particularly under the high emissions scenario
Number of short-term droughts	Increase	By the end of the century, under high emissions scenario, short-term droughts could occur as much as once per year in some places
Storms	Increase	More frequent and intense (ice, wind, etc.)
Fire	Increase	More likely
Phenology		
Growing season	Increase	By the end of the century, projected to be 4-6 weeks longer
Onset of spring	Earlier	By the end of the century, could be 1 to almost 3 weeks earlier
Onset of fall	Later	By the end of the century, could arrive 2-3 weeks later
Biological interactions	Changing	Could potentially be disrupted

Chart 7: Observed climate trends. High emission scenarios are based on A1 models.

ASSESSMENT: NATURAL DISTURBANCES

Forests are exposed to a multitude of environmental conditions. Populations of native species may change suddenly. These natural disturbances, including insects, diseases, animal feeding, and weather events that affect tree health, are a normal part of forest ecology, and influence forest composition, structure, and functions. They serve a valuable function in creating gaps in the forest canopy and allowing for a diversity of plants and animals to populate those gaps. Larger disturbances that kill entire stands of trees are more infrequent. Natural disturbances can detract from the commercial value but not the overall biological integrity of the forest.

Many natural disturbances have short-term impacts, and forests will rebound on their own. However, multiple stresses can have detrimental effects on long-term tree health. For example, insect defoliators periodically reach outbreak levels, reducing tree vigor due to less nutrition stored in the root systems. However, most trees recover in time. However, if a timber harvest or drought is followed by defoliation, trees are less likely to recover.

ASSESSMENT: WILDLAND FIRE

The term 'wildland fire' refers to any non-structure fire that occurs in vegetation or natural fuels. Wildland fire includes prescribed fire and wildfire. Each year Vermont experiences wildland fires during its two primary fire seasons in the spring and fall. Most wildland fires in Vermont are quickly reported and contained, though fires burning deep in ground fuels or in remote locations require more time and effort to fullly suppress. Town Forest Fire Wardens and local fire departments primarily handle wildland fire control with assistance from other towns and the state when necessary.

The Town Forest Fire Warden system, established in 1904, gives the responsibility of forest fire suppression to the Town Forest Fire Warden. Initially, these wardens were the First Selectman of each town, and now the Town Forest Fire Warden is an appointed position requiring the approval of the town Selectboard and the state. Over time, the scope of the Town Forest Fire Warden's duties have expanded from fire suppression to fire prevention and education through the adoption of a fire permit system in 1939. Per Vermont statutes, open burning of natural and untreated wood, brush, weeds, or grass requires a 'Permit to Kindle Fire' from the Town Forest Fire Warden. The fire wardens have the authority to regulate open burning within their towns by issuing burn permits when they consider local conditions will allow for safe burning. When fire danger is high, FPR has the authority to direct the fire wardens to cease issuing burning permits statewide. Escaped fires from open burning by homeowners is the most common cause of wildland fires in Vermont.

The Division's Fire Program works with state, federal, and regional agencies that share wildland fire suppression responsibilities. Within the state, the Fire Program works with the Division of Emergency Management and Homeland Security, the state Fire Marshall's Office, and the Vermont Fire Academy. Program staff provides wildland

fire training through the Vermont Fire Academy Firefighter I Certification and to local fire departments on an as-requested basis, and all Town Forest Fire Wardens attend an annual training session.

ANR fire staff maintains qualifications to be eligible for interagency assignments through national mobilizations. These firefighters complete annual safety refreshers, work capacity tests, and retain their availability for assignments regionally, nationally, and internationally. In addition, Division staff attend regional and national fire academies and training sessions available to qualify for specific Incident Command System (ICS) positions.

The Division works cooperatively with the local National Weather Service offices to daily monitor wildland fire danger throughout the fire seasons, and forecasts and observations are dissiminated through various means of outreach including posts on Twitter at @VTFireDanger. In addition to fire danger monitoring, the National Weather Service provides spot forecasts for ongoing fires and prescribed burns, issues Fire Weather Watches and Red Flag Warnings, and the Burlington office maintains a comprehensive fire weather web page[25].

Program staff are also involved with the Division of Emergency Management and Homeland Security to coordinate all emergency response for towns, utilities, and other state agencies, and are involved in training and planning exercises at the State Emergency Operations Center. If needed, Division staff are called on to assist in response to hazardous events such as severe ice storms and flooding.

COMMUNITY WILDFIRE PROTECTION PLANS

The Healthy Forests Restoration Act (HFRA) encourages communities to develop Community Wildfire Protection Plans (CWPPs). Vermont already has a robust community-based town forest fire warden program. CWPPs can build on that foundation, although with our history of low fire danger, encouraging towns to participate in CWPPs has been challenging. However, several CWPPs have been completed in all regions of the state with input from local fire departments, planning commissions, and representatives from state and federal wildland fire agencies. These plans identify both strengths and shortcomings in effective wildland fire response in a rural landscape. With the predicted changes to our climate, wildfire risk is likely to increase. The Department will continue to encourage communities to consider CWPPs and views these plans as an excellent tool to build trust and cooperation between all partners involved in wildland fire pre-suppression efforts, identify wildland urban interface areas, values at risk from wildland fire, response time by fire departments, and access to water including dry hydrants. The Forestry Division has provided funding to third parties for the installation and maintenance of dry fire hydrants throughout the state. These hydrants provide valuable water sources in a rural state, allowing for greater access and faster resupply of water for wildland fires. Volunteer fire departments view these dry hydrants as critical assets and depend on

[25] National Weather Service, Fire Weather, 2016, www.weather.gov/btv/firewx, 2016.

them for pre-planning of fire incidents. The Forestry Division believes this is a worthwhile program that benefits local towns and intends to continue to fund and promote dry hydrants.

PRESCRIBED BURNS

In Vermont, prescribed burns occur primarily on Wildlife Management Areas owned by the ANR. These burns are conducted by trained State of Vermont fire staff and follow a reviewed and approved burn plan. The burns maintain early successional habitat through periodic disturbance by fire. By burning on a four to five-year rotation, fuel loading of pioneer species and perennial and annual shrubs and grasses is reduced. Additionally, the opportunity to control and extinguish controlled burns provides an excellent training opportunity to the state's wildland firefighters. Prescribed burns also foster partnerships with the National Weather Service, through Spot Weather Forecasts and on-site NWS staff providing weather data to firefighters, and the Green Mountain National Forest who provides firefighters and equipment when available. The Forestry Division intends to expand its prescribed burn plan program and maintain its good working relationship with its partners.

ASSESSMENT: FOREST HEALTH MONITORING

Forest health in Vermont is monitored by periodically measuring tree condition and other ecosystem parameters. Surveys for insect and disease pests are conducted based on current or expected threats. The Division participates in the National Forest Health Monitoring Program and receives USDA Forest Service cooperative funds to promote the collection of forest stress and disturbance data using nationally standardized methods. Additional grants financed by the USFS Forest Health program or the NA S&PF competitive process have allowed more intensive monitoring of particular forest health issues.

Aerial surveys have been conducted since the 1960s to map forest health damage. Findings have included a recent outbreak of beech bark disease, which was brought on by a period of prolonged drought and has since subsided. These detection surveys also pinpointed several areas of rapid red pine mortality, highlighting the need for further monitoring.

The Division has been using our North American Maple Project (NAMP) plots to track the health of sugar maples and other tree species. Thirty plots are visited annually to monitor health changes. Although overstory maple crowns remain healthy, data from these plots indicate that a lack of sugar maple regeneration is an increasing concern.

Insect and disease monitoring has also provided information that has helped inform forest pest management. For example, monitoring hemlock woolly adelgid has demonstrated the impact of winter temperatures in Northern New England. Pheromone traps are used to detect increasing populations of major defoliators. Although emerald ash

borer and Asian longhorned beetle surveys in high-risk areas have been negative, these surveys do improve our chances for early pest detection.

Information about changes in tree phenology is important to understanding leaf-pest interactions as well as climate-related trends. Five locations across the state are monitored for stages of leaf and flower development in the spring. Fall color and leaf drop complement spring measurements by providing a measure of the length of the growing season for a subset of tree species.

The Forest Biology Laboratory supports the Division's mission of maintaining healthy and productive forests throughout the state. The lab provides information, identification, diagnoses and recommendations for insects and diseases to foresters, land managers and landowners, maple syrup producers and Christmas tree growers, pest control operators, landscapers, and the general public. Other activities include monitoring pest species, and maintaining historical records and collections, and promoting access to collected data, cataloged references, and curated specimens. Since then, additional efforts have focused on stabilizing the collection and planning for new facilities at the proposed interagency lab.

Created in 1990, the Vermont Monitoring Cooperative (VMC) is a unique forest health monitoring partnership between the State of Vermont, the University of Vermont, and the USDA Forest Service. VMC's work centers on improving our understanding of long-term trends, seasonal conditions, and interdisciplinary relationships among physical, chemical, and biological components of forested ecosystems. VMC long-term monitoring includes forest birds, amphibian, and reptile populations; forest soil chemistry; weather; atmospheric chemistry; tree health and phenology; carbon biomass; forest pests; and stream hydrology. Annually monitoring of the urban forest began in 2011, using i-Tree Eco methodology. The network of non-urban forest health monitoring plots has also been expanded to include plots statewide, and allow for yearly measurement across the full range of regionally common forest types. Over 50 cooperating agencies and organizations have contributed to the VMC database, including 17 colleges and universities, 11 state or federal agencies, and 17 private organizations. VMC's focus has recently broadened to include ME, NH, MA, and NY which contain the region's northern forest types. This change is reflected in a new name - Forest Ecosystem Monitoring Cooperative (FEMC).

ASSESSMENT: INVASIVE PESTS

Non-native invasive pests threaten many of Vermont's native tree species. Some invasive pests are well established in Vermont. Dutch elm disease, gypsy moth, chestnut blight, butternut canker, beech bark disease, and white pine blister rust occur throughout the state. Other pests are recent invaders to our region, including hemlock woolly adelgid, emerald ash borer, and Asian longhorned beetle. Emerald ash borer and Asian longhorned beetle have yet to be detected in Vermont.

Relatively unknown invasive pests such as oak wilt and red pine scale will likely be of concern soon. New pests will continue to be introduced.

Forest pests may be transported by infested wood products or live trees. Quarantines are in place to limit the spread of a few specific pests. Movement of firewood is of particular concern; when infested wood is salvaged, it may be left unburned for a year or more in its new location. In 2016, Vermont implemented a quarantine regulating the importation of firewood into the state. The VT Agency of Agriculture, Food and Markets (VAAFM) conducts a nursery inspection program to prevent introductions on live plants.

Other regional strategies aim to restore balance with native tree species, including introducing natural enemies and developing genetic resistance in host trees. Efforts are already underway to enhance genetic resistance and/or preserve germplasm, living tissue from which new plants can be grown, of Vermont's chestnut, butternut, elm, hemlock, beech, and ash. A variety of partners lead these projects, including the USDA Forest Service, the University of Vermont, the American Chestnut Foundation, The Nature Conservancy, and the Division. Introducing biocontrols, and even new genes in threatened tree species, requires careful research regarding organism selection appropriate for distribution. Pesticides are rarely practical in forested landscapes but can be a useful tool in urban landscapes or recreational areas.

Responding to pest invasions requires a multi-partner approach. VAAFM, the USDA Forest Service and USDA APHIS have collaborated with the Division in preparing an Invasive Forest Pest Response plan and conducting mock exercises to simulate a first detection. They also all conduct invasive pest surveys within Vermont. Personnel from agencies outside the state can be mobilized to assist under the auspices of the new Forest Health Working Team of the Northeastern Forest Fire Compact. Under the guidance and support of FPR and UVM Extension staff, municipalities have been developing invasive pest preparedness plans that outline actions that will be taken to mitigate the anticipated impact of forest pests on urban and community forests.

NON-NATIVE INVASIVE PLANTS

Non-native, invasive plants are species that originated elsewhere, were brought here - intentionally or not - and developed self-sustaining populations. They have a negative impact on the environment, are costly to manage, and can be harmful to human health. By competing with native species for space, nutrients, and water, they can reduce the abundance, density, and diversity of seedlings, degrade the quality of wildlife habitat, and alter natural communities.

Several grant opportunities have supported terrestrial invasive plant management efforts in Vermont. The program was jumpstarted in 2010 when an American Recovery and Reinvestment Act (Recovery Act) grant funded surveys of 37 state parks, 41 national forest recreation sites, and 160 miles of hiking trails, and plant control work on 62 of

these locations. FPR, in partnership with The Nature Conservancy and the help of many volunteers, has built on those efforts with additional special projects, partially funded by USDA Forest Service S&PF grants.

Accomplishments from these various projects include documenting and publicizing plant management demonstration areas, providing targeted information about existing cost-share programs, and training resource managers to assess, map, and manage invasive plant populations. Invasive plant management efforts have also been increasing on state lands, targeted on new invasions, and on priority landscapes. These include sites with rare, threatened, and endangered species and natural communities, sites where new invasions threaten large blocks of interior forest, and forest stands where invasive species threaten the recruitment of young trees.

These efforts created the foundation for a statewide invasive plant program. In partnership with the other departments within ANR, The Nature Conservancy, and NRCS which has been a primary funder of invasive plant control. FPR has created a position to coordinate invasive plant efforts, including technical support, volunteer training, data analysis, early detection, mapping, and supporting local management efforts. In 2016, 28 workshops were conducted and over 600 volunteers engaged, demonstrating the demand for invasive plant assistance, and the need for ongoing coordination.

⚠ PRIORITY LANDSCAPES AND FOCUS AREAS

PRIORITY LANDSCAPE: FOREST LAND THREATENED BY NON-NATIVE INVASIVE PESTS

The survival of tree species or entire genera is at stake with the introduction of non-native insects and diseases into locations where they have no effective natural enemies and their tree hosts have limited genetic resistance. Non-native pests such as Dutch elm disease, chestnut blight, beech bark disease, and butternut canker occur throughout Vermont, while other common tree species, like ash, hemlock and red pine are under threat from new invaders.

For both new and established invaders, conservation planning can identify individual trees or forest stands for protection and approaches for maintaining productivity and genetic diversity. It can outline management strategies, and plans for identifying resistant trees and preserving germplasm for the future.

In addition, these landscapes can be protected from new invaders by efforts to slow their spread, early detection, and rapid response. To address this issue, the Division must continue to promote a multifaceted approach including upholding our widespread monitoring program led by our Forest Health Program, and supplemented by private foresters, loggers, and engaged citizens; supporting our Urban and Community Forestry Program's active recruitment and engagement with citizen scientist volunteers; building capacity among our partners and natural

resource consultants to manage pest impacts; maintaining an active incident command plan to respond to outbreaks; and sustaining our knowledge, skills, and capacity to understand and manage non-native pests.

PRIORITY LANDSCAPE: WILDLAND URBAN INTERFACE

The wildland-urban interface (WUI), defined as the area where structures and other human development meet or intermingle with undeveloped wildland, creates an environment in which fire can move readily from forests and grasslands into neighborhoods. WUI expansion increases the likelihood that wildfires will threaten structures and people.

Although the WUI term originates in wildland fire management, the WUI is also a useful indicator of human influence on natural ecosystems. The WUI is an area where people and their homes affect the natural environment, contributing to the loss of habitat for native species, forest fragmentation, the introduction of exotic species, domestic pets that can disturb or prey on birds and other wild animals, and poorer water quality due to runoff from pavement and lawns[26]. These trends will threaten biodiversity and ecosystem health if WUI residents and communities are not attentive to the potential harms and actively caring for the environment around their homes.[27]

In Vermont, we use a housing density greater than 15.5 houses per square mile as the threshold for the WUI. The proportion of forest area in the WUI ranges from 8% in Essex County to 90% in Grand Isle County. Most importantly, the land area of the WUI in Vermont increased substantially across much of the state between 2000 and 2010. The proportion of forest land area in the WUI rose 11% within the state and in all counties; the largest increase was in Chittenden County at 19%. By contrast, an increase in forest land area in the WUI was less than 5% in Essex and Grand Isle Counties[28].

FOCUS AREA: VOLUNTARY HARVESTING GUIDELINES

In 2013, the Vermont Legislature required the Commissioner of FPR to “develop voluntary timber harvesting guidelines that may be used by private landowners to help ensure long-term forest health and sustainability.” In 2015, FPR published The Voluntary Harvesting Guidelines after a great deal of public input and guidance by a broad array of stakeholders. These guidelines are a proactive step with the goal of raising the bar for timber harvests that are sustainable and result in a healthy forest. The Voluntary Harvesting Guidelines address a vast spectrum of topics,

[26] Impervious surfaces and water quality: a review of current literature and its implications for watershed planning, E Brabec, S Schulte, PL Richards - Journal of planning literature, 2002.

[27] Bar-Massada, Avi, Volker C. Radeloff, and Susan I. Stewart. "Biotic and abiotic effects of human settlements in the wildland–urban interface." Bioscience 64.5 (2014): 429-437.

28 Morin, Randall S.; Riemann, R. 2015. Forests of Vermont, 2014. Resource Update FS-54. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 4 p.

including preparing for and conducting a harvest, protecting water resources and soil health, biodiversity and wildlife habitat, and newer issues such as climate change impacts. With 79% of Vermont's forests in private ownership, timber harvests on these working lands are an important part of Vermont's forest economy. These guidelines will assist the Division in making a serious effort to maintain forest productivity and supporting forest health.

To adequately address issues to promote sustainable timber harvesting that ensures long-term forest health and sustainability, we must shift our efforts to enhance our outreach to promote use of The Voluntary Harvesting Guidelines. Our county foresters are well positioned to promote the guidelines and the Division is developing brochures and a website, VTCutWithConfidence.com to help to spread the word.

FOCUS AREA: NON-NATIVE INVASIVE PLANTS

The threat of non-native invasive plants (NNIP) is a long-term stewardship issue that must become integrated into how we understand and manage forests. Once considered a localized issue, the threat of non-native plants to uninvaded forests and to future regeneration is now widely recognized. The skills and knowledge needed to identify new NNIPs and to manage existing invasions has been dispersed among government agencies, organizations, resource professionals, and concerned citizens, and the lack of a coordinated approach has limited our capacity to manage NNIPs. Coordination is needed to track the spread of NNIPs, support partnerships, encourage efforts across property lines, and promote integrated management of high priority invasions.

FOCUS AREA: CLIMATE CHANGE

Climate change directly threatens our native tree species and the many valuable goods and services they provide. Licensed foresters and forest landowners face considerable challenges adjusting land management practices to prepare for and avert the risk to long-term forest health as a result of current and future climate shifts. The issue of understanding, mitigating, and adapting to climate change is a priority of this plan.

To address this issue, FPR has initiated a variety of projects with principal partners, including the USDA Forest Service's State and Private Forestry, Green Mountain and Finger Lakes National Forest, and the Northern Institute for Applied Climate Science; DEC; VFW Department; and the Manomet Center for Sustainability. These partnerships focus on assessing forest vulnerability, anticipating forest responses, and developing resources to assist licensed foresters and forest landowners in preparing for anticipated changes. A central component of this effort will be to implement the recommendations of our 2015 document "Creating and Maintaining Resilient Forests in Vermont-Adapting to Climate Change."

GOALS AND STRATEGIES

In the 2017 Plan, we have reexamined and revised the goals and strategies from our 2010 Plan. They are intentionally broad and flexible and will be tied to specific projects and work plans during implementation. Although these goals focus around our DESIRED FUTURE CONDITION: MAINTAIN AND ENHANCE FOREST ECOSYSTEM HEALTH AND ECOLOGICAL PRODUCTIVITY they may apply to other Desired Future Conditions.

GOAL 3: UNDERSTAND AND MONITOR ECOSYSTEM HEALTH AND ECOLOGICAL PRODUCTIVITY.

Strategy 9: Enhance our understanding of forest ecosystems across rural and urban landscapes, including collaborating with the Forest Ecosystem Monitoring Cooperative, and supporting research by academic, government, and citizen science groups.

Strategy 10: Monitor for forest health and ecological productivity across all landscapes.

Strategy 11: Survey for potential forest health threats, including non-native invasive species.

Strategy 12: Support education and outreach on forest health and ecological productivity and sustainability.

Strategy 13: Support access to forest health data archives and collections.

GOAL 4: MANAGE HEALTH AND PRODUCTIVE CAPACITY OF FORESTS.

Strategy 14: Encourage landscape level planning and management activities that maintain health, productivity, and ecological functions across all forests.

Strategy 15: Promote widespread use of Vermont's Voluntary Harvesting Guidelines and climate resiliency recommendations.

Strategy 16: Prepare for, mitigate, and respond to emergency events such as wildland fires and significant weather events.

Strategy 17: Prepare for and respond to forest pest outbreaks.

GOAL 5: RETAIN NATIVE FLORA AND FAUNA ACROSS THE LANDSCAPE AND RESTORE WHERE APPROPRIATE.

Strategy 18: Prevent the introduction, slow the spread, and eradicate where appropriate non-native invasive species that have an impact on forest ecosystems.

Strategy 19: Work with the Department of Fish & Wildlife, researchers, and other partners to identify examples of hemlock and other forest species to be protected from non-native forest pests and diseases and to implement strategies to combat infestations while limiting impacts to non-target species.

Strategy 20: Monitor, plant, and retain native flora and fauna, including supporting native species restoration efforts with the Vermont Fish & Wildlife Department and other partners.

Strategy 21: Support efforts by the Vermont Fish & Wildlife Department to develop a collaborative, statewide monitoring, and adaptive management program and to evaluate and improve the effectiveness of conservation strategies.

Strategy 22: Identify and establish habitat for climate adaptation refugia.