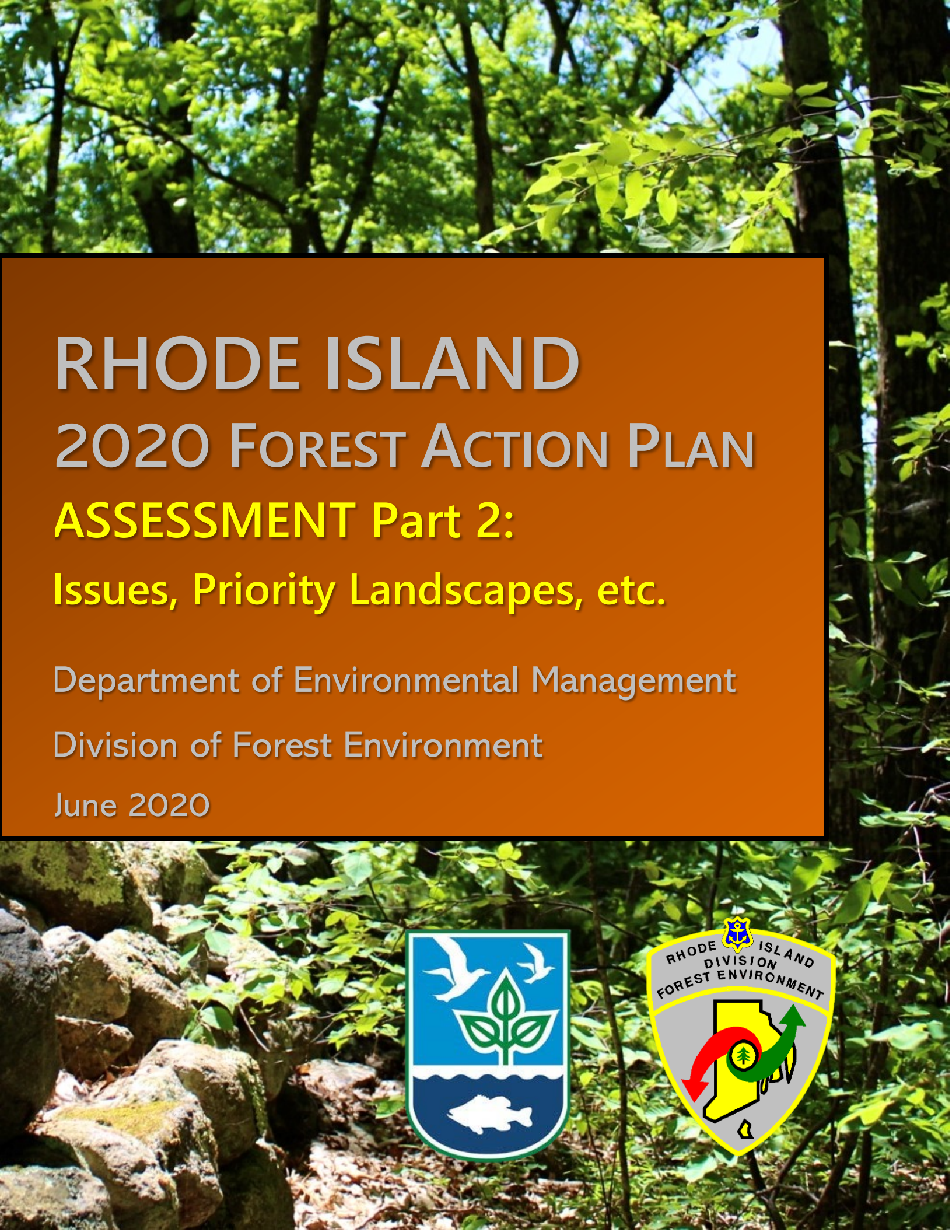


RHODE ISLAND
2020 Forest Action Plan
ASSESSMENT Part 2:
Issues, Priority Landscapes, etc.

Department of Environmental Management

Division of Forest Environment

June 2020

ISSUES, THREATS & OPPORTUNITIES

The *Rhode Island 2020 State Forest Action Plan: Assessment* has identified five *issues of concern*. These priority issues also present challenges to existing DFE capacity, but all five Cooperative Forestry Programs recognize their significance to a viable and resilient forest and address these issues within their strategies and program delivery.

The priority issues, or issues of concern, are:

1. **Forest loss, fragmentation and parcelization** – wildlife habitat, landscape functionality and sustainability, interface and intermix, and invasive species
2. **Forest health** – invasive plants, wildlife habitat, diversity and resiliency, pests and diseases
3. **Water** – stormwater, riverine/wetlands, water quality
4. **Fire** – increasing intermix and expanding interface combined with increasing fuel loading
5. **Climate change** – increasing disturbances, alterations in species distributions and relationships, and compounding forest health threats

It should be noted that fragmentation exacerbates the issues that threaten Rhode Island's forests or impact its management and response for the priority issues two through five. Fragmentation is an underlying issue that contributes to, speeds, and intensifies the rate of change, the severity of conditions, and the exposure of forest types and habitats to these threats. Therefore, although fragmentation is addressed as the first priority issue, it will also be referenced as a factor in the discussion of Forest Health, Water, and Fire as priority issues. Climate change is also a driver impacting forest resiliency and the rate of change, further complicating forest management and planning.

RELATIONSHIP TO NATIONAL PRIORITIES

The Priority Issues for Rhode Island incorporate the National Priorities and are addressed in the *Rhode Island 2020 Forest Action Plan: Strategies* section.

1. **Conserve** and Manage Working Forest Landscapes for Multiple Values and Uses
   Forest landscapes, whether under public or private management, must be conserved to protect landscape functionality, habitat, and environmental benefits.

2. **Protect** Forests from Threats
   Rhode Island's forests face threats on multiple fronts: development leading to the loss and fragmentation, ease of spread of invasive plants and pests/diseases, loss of habitat, loss of economic and environmental benefits, and wildfire risk.

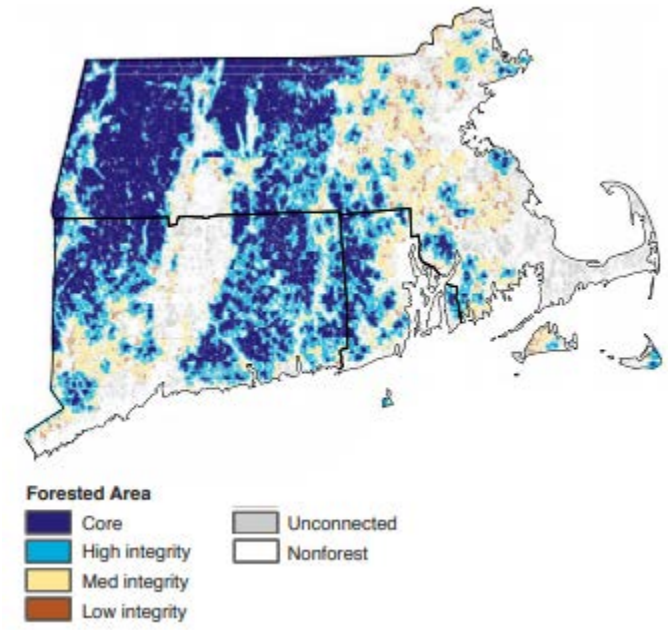
3. **Enhance** Public Benefits from Trees and Forests
   Support and promote the management and retention of forest lands for multiple benefits: water and air quality, carbon sinks and sequestration, temperature moderation, forest products, wildlife habitat, outdoor recreation and human health.

RI SFAP Priority Issues	Conserve	Protect	Enhance
Fragmentation	✓	✓	✓
Water			✓
Fire	✓	✓	✓
Forest health	✓	✓	✓
Climate Change		✓	

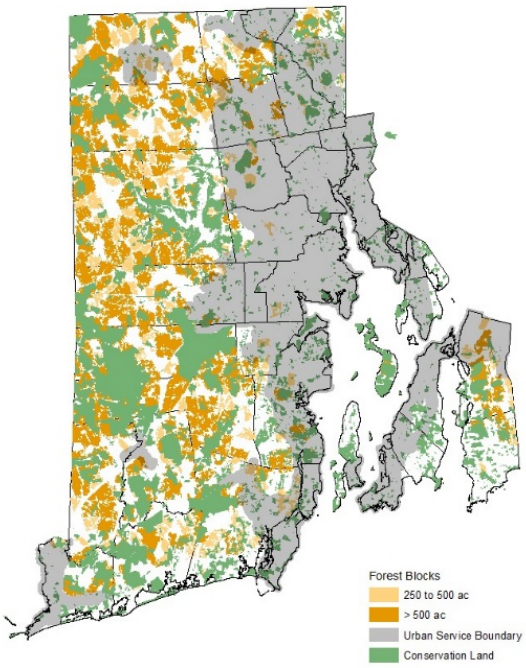
Issue: Forest Loss & Fragmentation

According to a 2015 study, 70% of the world's trees are within 1 km (0.62 miles) of the forest edge. The study authors concluded that "Fragmentation experiments—some of the largest and longest-running experiments in ecology—provide clear evidence of strong and typically degrading impacts of habitat fragmentation on biodiversity and ecological processes." Established well beyond anecdotal observations, "habitat fragmentation reduces biodiversity by 13 to 75% and impairs key ecosystem functions by decreasing biomass and altering nutrient cycles." The impacts of fragmentation are a major threat to the species of greatest conservation need (SGCN) identified and addressed in the RI WAP, and are a consequence of human habitation and infrastructural needs. As populations grow and demand continues to increase, the resulting subdivisions, roads, utility corridors, and transmission installations result in smaller and smaller parcels with less and less connectivity, impacting the movement and subsequent genetic diversity of plants and animals, and removing necessary habitat for species with specific interior forest requirements.

Fragmentation is not only impacting Rhodes Island it is a national and regional issue as well. However, the compact size of the state means that there is less area available that could be retained as core forest (i.e. blocks of unfragmented forest 250 acres or larger), as population density increases:

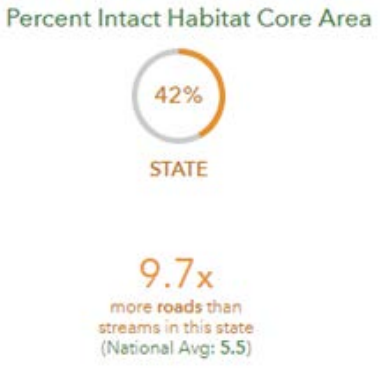


Forest Land Integrity in Rhode Island, Massachusetts, and Connecticut. *Source: The Forests of Southern New England, 2012*



Forest Blocks by Area

The impacts of fragmentation are a major contributor to the number SGCN in Rhode Island. Fragmentation of forests into smaller patches reduces the value of these habitats for forest interior species, which is reflected in the 236 SGCN. The map and text on the right shows the distribution of blocks greater than 500 acres in size and illustrates the degree to which forests have been fragmented in Rhode Island. Not only are the biological process altered, but the economics of forest management, and increase in decision makers, make it more difficult to educate landowners and coordinate management on the landscape.



Source: ESRI Green Infrastructure Strategy

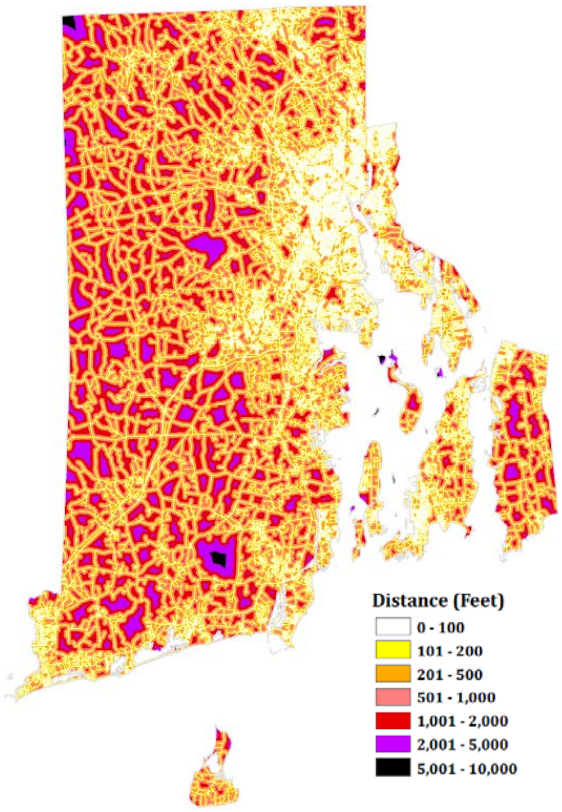
This can cause numerous issues:

- Opening intact natural habitats to invasive species
- Increased wind & erosion potential
- Windthrow on the newly exposed edges of forest stands
- Loss of interior forest species
- Loss of diversity, and
- Economically, can result in forested areas too small to manage for harvest

A 2019 GIS research brief by the University of Rhode Island, Loss of forest in large unfragmented blocks of forest in Rhode Island, identified significant loss of forest within large, previously unfragmented blocks of forest greater than 250 acres. These blocks of remaining core forest were mapped by RIDEM during the preparation of the RI WAP. The URI analysis compared statewide aerial imagery of forest cover in 2011 and 2018. Over the seven-year period, 1,914 acres classified as large, unfragmented forest in 2011 were converted to non-forest use, with most of the forest conversion occurring as small, scattered patches. Moreover, 66% of the forest loss (1,267 acres) occurred within blocks larger than 500 acres, which are particularly valuable for wildlife habitat.

Another way to estimate forest fragmentation is the distance to the nearest road from a given point. URI researchers performed a statewide analysis with RIGIS land use classification data (based on a 30m x 30m pixel) and found that the mean distance to a road in Rhode Island in 2019 is only 613 feet (0.12 mile), with a standard deviation of 702 feet.

Even with a more generous interpretation of a core forest, by including locations more than 2,000 feet from a road, URI researchers found that the only mainland locations where forest blocks are large enough to be more than a mile from a road are found in DEM's Buck Hill and Great Swamp Management Areas as well as land along the Connecticut border.



Distance to Nearest Road
Source: Peter August, Department of Natural Resources Science, University of Rhode Island

PRESSURES CONTRIBUTING TO THE BURGEONING LOSS & FRAGMENTATION OF RHODE ISLAND'S FORESTS:

State Development Trends

As reported by RI Statewide Planning, the conversion of forest land to developed uses in the late 20th century was higher than historic trends, increasing by 43% from 1970 to 1995: developing more residential, commercial, and industrial land during that time than in the previous 325 years. While forest loss generally occurs near urban areas and roads, the trend is changing as pressure to convert forest to residential use continues, and as pressure for the development of renewable energy threatens large forest parcels, even in more rural areas.

Building permits and aerial photography confirm that Rhode Island's recent development continues to follow sprawling land use patterns, and forest acreage continues to decline as land is developed. A USFS

report on forest statistics (1985 and 1998) noted a decrease in timberland area of 9% from 1985 to 1998. A similar decrease between 1998 and 2007 means that Rhode Island had the greatest forest loss in southern New England in that timeframe.

Renewable Energy Demands

The desire for energy independence has also fueled forest conversion. Rhode Island's Clean Energy Goal, calling for 1,000 megawatts of solar energy by 2020, has created a demand for large parcels of land to site ground-mounted solar installations. The 2020 State of the State speech presented a new target: all electric energy from renewables by 2030. The opportunity for forest landowners to derive income from their property is naturally tempting and has broad implications for state forest land.

As of 2019, 150 "solar farm" projects are generating 58 megawatts on 262 acres, a mere 6% of the projected goal. As each megawatt has required an average of 4.5 acres of land, mostly forested, meeting that goal through solar farm installations alone would require an additional 4,239 acres. This would require a significant increase, from historical average rate of land conversion of 838 acres per year. Solar farms are becoming a source of forest loss to achieve Rhode Island's clean energy goals.

Cities/Towns	Solar Farm Projects	Megawatts generated	Total Acres Used
Bristol	6	0.3	1.35
Burrillville	1	0	0
Charlestown	1	0	0
Coventry	1	0.1	0.45
Cranston	9	6.4	28.8
Cumberland	4	1.8	8.1
East Greenwich	1	0.1	0.45
East Providence	8	3.8	17.1
Exeter	2	1.8	8.1
Foster	1	2	9
Glocester	6	0.9	4.05
Hopkinton	3	0.7	3.15
Jamestown	2	0.2	0.9
Johnston	4	1.6	7.2
Little Compton	1	0.2	0.9
Lincoln	4	1.4	6.3
Middletown	12	1.9	8.55
Narragansett	1	0	0
Newport	1	0.3	1.35

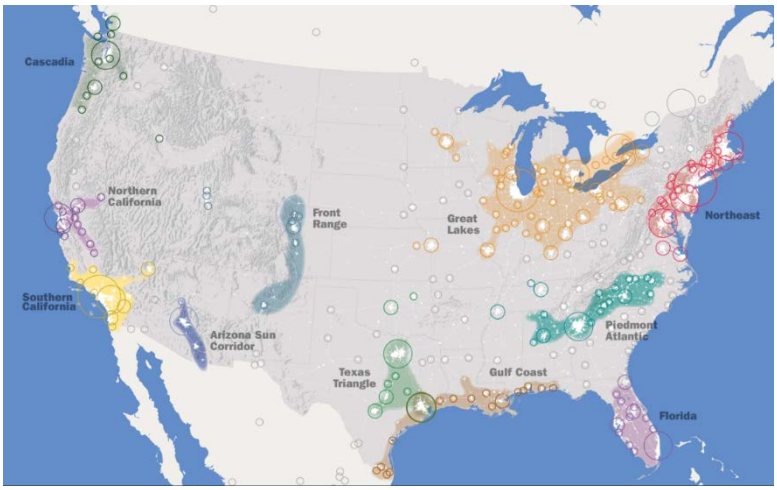
Cities/Towns	Solar Farm Projects	Megawatts generated	Total Acres Used
North Kingstown	8	6.9	31.05
North Scituate	2	1.4	6.3
North Smithfield	6	3.2	14.4
Pawtucket	1	0.2	0.9
Portsmouth	1	0.5	2.25
Providence	25	4.4	19.8
Richmond	4	7	31.5
Scituate	1	5	22.5
Smithfield	3	0.3	1.35
South Kingstown	7	1.4	6.3
Tiverton	2	0.2	0.9
Warren	1	0.1	0.45
Warwick	5	0.4	1.8
West Greenwich	1	2	9
West Warwick	6	1.1	4.95
Westerly	7	0.4	1.8
Woonsocket	2	0.3	1.35
Total	150	58.3	262.35

The Total Number of Solar Projects in Rhode Island by Town, Acres Used, and Megawatts Generated by Project by 2019.

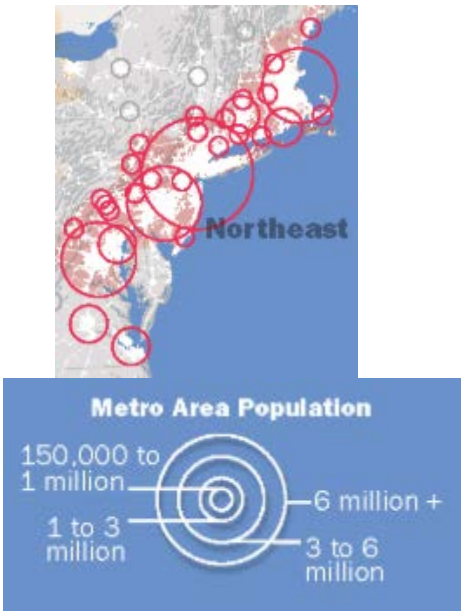
Regional Development Trends

While Rhode Island has not experienced the rapid population growth similar to other areas in the US, according to America 2050, Rhode Island is a part of the Northeast megaregion, stretching from Washington D.C. to Boston, which produces 20% of the nation's GDP with 17% of the population on 2% of the nation's land area. It is predicted that by 2050 that the Northeast will add 17 million new residents over the 2010 census (from 52 million to 71).

The impact in Rhode Island is predicted as being an outward expansion from the edges of existing urban areas, infill of green spaces within urban areas, and continued dispersal of humans and their related development into the smaller communities and forested areas of the state.

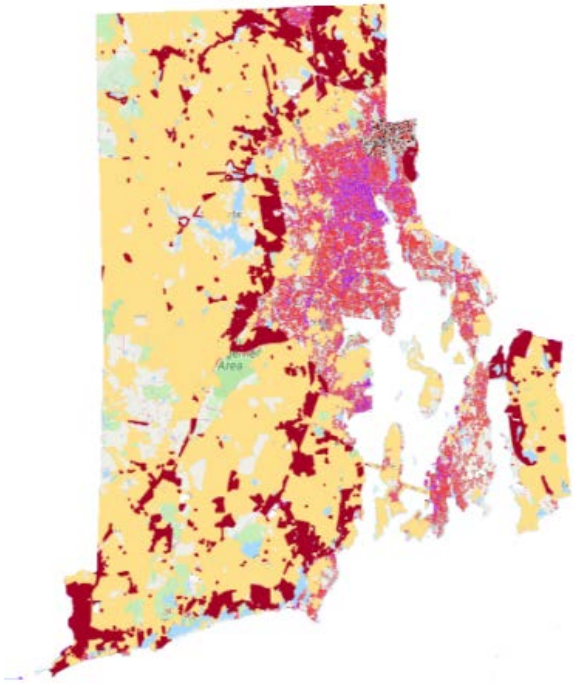


US Megaregions
Source: America 2050



Expansion of Wildland-Urban Interface & Increasing Intermix

The impact on core forest is not the only consequence of fragmentation. While Rhode Island is the 2nd-most densely populated state per capita, the western part of the state is still largely forested. Although parcel size is typically small, and tracts of forest land are surrounded by non-forest uses, the continued encroachment into the forested areas also expands the Wildland-Urban Interface (WUI).



This map, derived from the i-Tree Landscape Tool, shows the Wildland-Urban Interface (WUI) in red and Wildland-Urban intermix in yellow.

Wildland-Urban Interface refers to a distinct area of wildland fuel adjacent to a developed area.

Wildland-Urban Intermix refers to a specific type of wildland-urban interface in which the homes or other structures are intermixed with wildland fuels, scattered or in small groupings.

A comparison of WUI in Rhode Island in 1990, 2000 and 2010, completed by the Silvis Lab in 2013 shows an increase in the area of forest land acres designated as WUI, with an increase in housing units and population. The maps provided under Priority Landscapes (page 53 of this plan) show the change in designation of land between 1990 and 2010.

The number of housing units within the WUI increased by 20% between 1990 and 2010 (below).

HOUSING UNITS		1990	2000	2010	1990%	2000%	2010%
Rhode Island	WUI	114,310	128,646	142,751	27.6	29.2	30.8
	-Intermix	*49,555*	*57,005*	*63,127*	*12.0*	*13.0*	*13.6*
	-Interface	*64755*	*71641*	*79624*	*15.6*	*16.3*	*17.2*
	Non-WUI	300,262	311,191	320,637	72.4	70.8	69.2
	TOTAL	414,572	439,837	463,388			

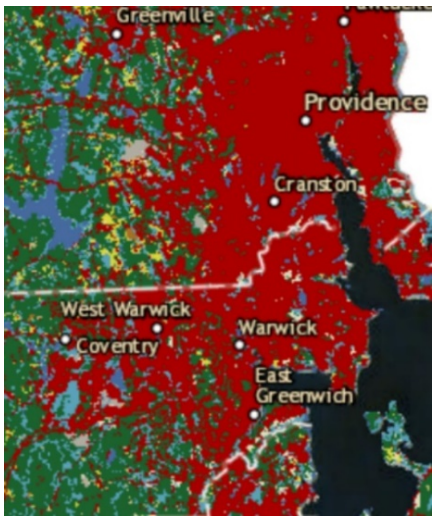
Meanwhile, in that same period, while the overall state population increased by only 5%, the population within the area designated as WUI increased by 12% (below).

POPULATION		1990	2000	2010	1990%	2000%	2010%
Rhode Island	WUI	289,689	316,066	327,152	28.9	30.1	31.1
	-Intermix	*130,658*	*147,034*	*151,766*	*13.0*	*14.0*	*14.4*
	-Interface	*159031*	*169032*	*175386*	*15.8*	*16.1*	*16.7*
	Non-WUI	713,775	732,253	725,415	71.1	69.9	68.9
	TOTAL	1,003,464	1,048,319	1,052,567			

As the table below further shows, the area assessed as WUI also increased during that time, meaning not only were more people moving into forested areas, but development was occurring in new areas of forest land. This trend has continued past 2010, and is a likely contributor to the fragmentation of the largest blocks of contiguous forest (>500 acres) reported in the RI WAP.

AREA (square km)		1990	2000	2010	1990%	2000%	2010%
Rhode Island	WUI	1,514	1,580	1,634	37.8	39.5	40.8
	-Intermix	*1,299*	*1,343*	*1,376*	*32.5*	*33.6*	*34.4*
	-Interface	*215*	*237*	*258*	*5.4*	*5.9*	*6.4*
	Non-WUI	2,487	2,421	2,368	62.2	60.5	59.2
	TOTAL	4,001	4,001	4,001			

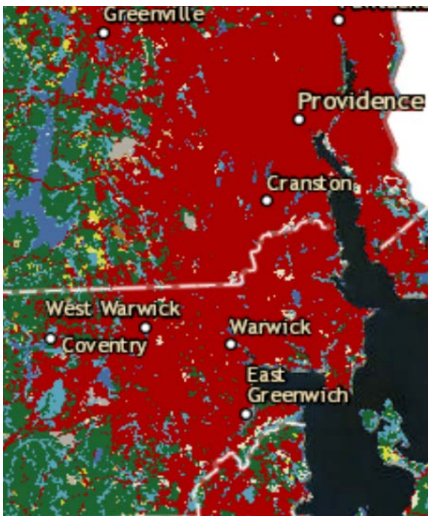
Predictive models of future development, such as the ESRI Green Infrastructure Strategy, use imagery that is rather coarse (30m pixels) to communicate change in Rhode Island. These models do not show change within the Wildland-Urban Intermix well, but they can show the expected development in the Wildland-Urban Interface. The ESRI predictor compares changes between aggregated 2011 National Land Cover Database land cover categories with similarly aggregated land cover categories from The Clark Labs 2050 Conterminous US Land Cover Prediction.



2011

These models for future development predict the continued loss of forest, showing continued expansion from existing high-density areas in the eastern part of the state, and infill of many remaining green spaces in urban Rhode Island. Unfortunately, the 30m scale is too coarse to realistically capture/predict change in the western part of the state.

Source: ESRI Green Infrastructure Strategy



2050

Issue: Forest Health

Forest health is a broad term that can refer individually or comprehensively to the health and condition of forest types, forest succession, wildlife habitat, invasive plants, pest and disease concerns, fire fuel conditions, and future state. Forest health, through the lens of forest management, can be considered a condition where forest ecosystems sustain their complexity while, at the same time, provide for human needs.

By their very nature forest ecosystems are in a constant state of change. Even healthy forests are continually disrupted:

- Ice and snow break tree branches, destabilizing structure or opening trees to decay.
- Strong winds topple trees providing new material to decay into the soil, opening the understory to increased sunlight, releasing suppressed trees, and allowing dormant seeds to germinate.
- Native and non-native insects and diseases stress trees, resulting in decline and, often, mortality.
- Invasive plants often outcompete native species for growing space, soil nutrients and water, affecting wildlife habitat and food sources.
- Fires can disrupt forest successional stages, resetting the forest to earlier stages; or fire can revitalize ground cover and understory, enhancing habitat and plant biodiversity.

As the forest flora changes, fauna respond to the new conditions and either adapt in place or migrate in response to altered conditions. Some wildlife populations thrive, others decline or perish. Human activity is an additional complication to the ebb and flow of forest conditions and "health": plats are plotted and developed, resulting in fragmentation of continuous forest land; passive to intensive recreation, while encouraging an appreciation of a forest's values, leave a distinct, and sometimes, damaging footprint on the land. Forest ecosystems are resilient and able to withstand or recover from such disruptive events provided they don't threaten the sustainability of the ecosystem itself.

Pests and diseases, invasive plants, and wildlife habitat are not only elements reflective of forest health, but they are further impacted by fragmentation. In fact, humans are the leading contributor to the spread of forest pests and diseases, exotic invasive plant species, and degradation or destruction of wildlife habitat:

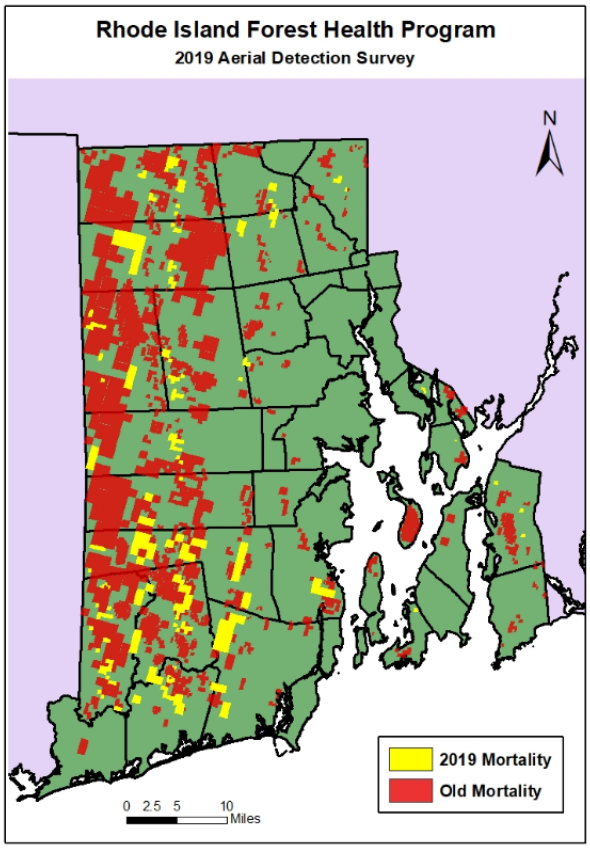
- movement of commercial goods
- transportation of firewood
- movement of plant material
- transportation corridors
- development

These are only a few of the mechanisms that contribute to often catastrophic impacts on forest health, forest structure, and stability. Eons of localized stand equilibrium, forest succession, structure and habitat can be undone with a single shipment of infested packing materials, infested plant material, soil, or seeds, which may ultimately disrupt entire ecosystems. Movement along transportation corridors increases ease of movement and migration of invasive species, while development and construction interfere with native plant and wildlife movement, gene flow, and resiliency.

INVASIVE INSECTS & DISEASES

Native insects and diseases are a normal part of healthy forests, but the introduction of non-native insects and diseases (even earthworms) can have devastating effects on forests. During the past 100 years, the forests of Rhode Island have been impacted by gypsy moth, chestnut blight, Dutch elm disease, hemlock woolly adelgid, and now emerald ash borer. Other non-native invasive insects, currently not present in Rhode Island, are being monitored for their spread and inevitable arrival.

Given the size of DFE with a field staff level of 11, and only one staff person within Forest Health, the capacity of the state to respond/react/treat pest and disease issues is limited. In addition, even if staffing and funding levels were suitable for the forest management needs of DFE, some actions would still not be considered appropriate, such as widescale insecticide treatment for gypsy moth. The programmatic capacity to address Forest Health is focused on meeting the requirements of the USDA Cooperative Grants Program and relies on in-state partners to assist with delivery, mainly RIDEM Division of Agriculture and the University of Rhode Island.



Aerial detection surveys are flown yearly, as needed and where budget exists. Surveys in 2019 showed mortality expanding the over 45,000 - 50,000 acres impacted by gypsy moth (2014-2018), nearly 14% of Rhode Island's forest land. Contributing factors to that continued mortality include two-lined chestnut borer, forest tent caterpillar, and residual pockets of gypsy moth. Ash mortality due to emerald ash borer is expected in future years but, due to its distribution in natural areas in Rhode Island, is not expected to have the obvious mortality margins of gypsy moth outbreaks.

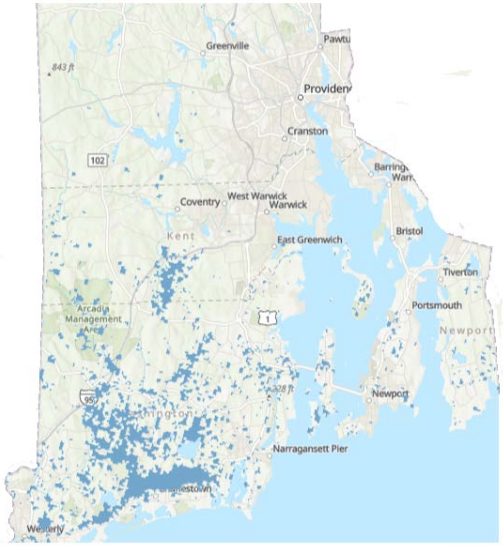
Insect Pests of Continuing Concern

Gypsy Moth *Lymantria dispar*

Gypsy moths remain as permanent residents within eastern forests and will continue to reach outbreak status periodically. Changes in seasonal weather patterns and precipitation amounts will have the greatest impact on the periodicity of outbreak occurrence. Cool April temperatures and sufficient precipitation to support the life cycle of *Entomophaga maimaiga,* a fungus that kills gypsy moth caterpillars, are necessary to maintain gypsy moth at low population levels. However, additional stressors to trees, particularly chronic ones such as drought, will continue to increase tree mortality where repeated defoliation occurs.

Southern Pine Beetle *Dendroctonus frontalis*

Trapping for the SPB continues with variability in collection numbers observed from year to year. In 2019 there was a significant reduction (92 beetles in 2018, 1 in 2019) but concern remains that an endemic population exists and has the potential to reach outbreak status. Not only will warming temperatures provide conditions conducive for SPB outbreak, but they may also contribute to chronic stress factors to Rhode Island's pitch pine (*Pinus rigida*). URI continues to collect other species of concern, as well as predators of SPB.

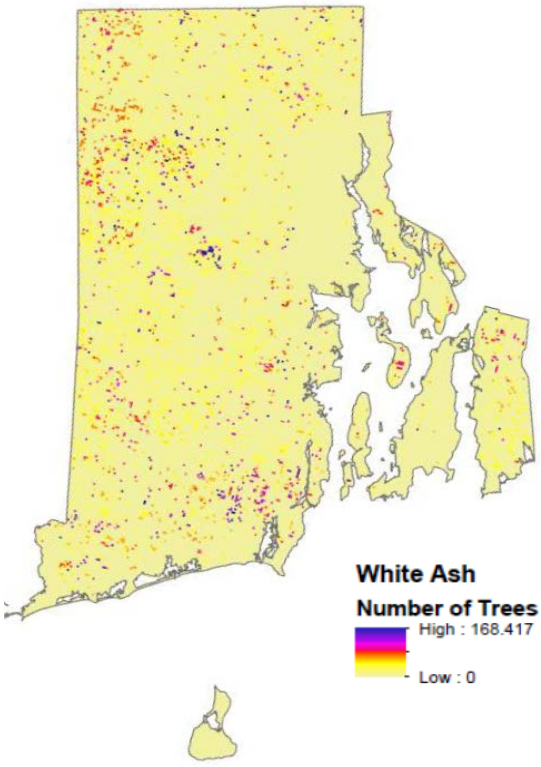


Pitch Pine Distribution
Source: Lisa Tewksbury, URI

Emerald Ash Borer *Agrilus planipennis*

Adults were found in Rhode Island in 2018 and larvae in 2019. Given the prognosis for the spread of this pest, treatment is not a feasible option for forest trees. Individual landscape trees and trees deemed significant by the owner/manager may be suitable for prophylactic treatment for long term management. DFE provides information regarding the options on the Forest Health webpage. Workshops and educational sessions for the public, communities, and green industry professionals are ongoing. Surveying and monitoring activities, mainly trapping with baited and unbaited traps, and *Cerceris fumipennis* (no common name) biosurveillance, also occur as appropriate to help determine the location and extent of the EAB population and direction of spread.

2018 FIA data indicates that there are nearly 1.4 million ash in Rhode Island, mainly comprised of white ash (1.3 million), plus green and black ash. Over 600K of those trees are less than 3" dbh. Information on ash trees in urban areas is limited to anecdotal observations of tree species planting selection. (Urban FIA data collected over 200 plots (1/2 a full cycle, 2015-2018) in Providence tallied 2 white and 2 green ash, which may not indicate municipal and private exposure to EAB at the time of this report).

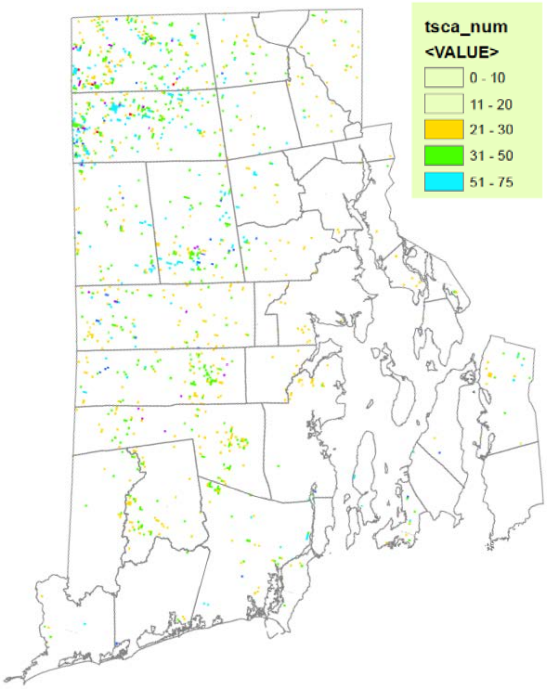


Ash Species Distribution
Source: FIA data

Hemlock woolly adelgid *Adelges tsugae*

First confirmed in Providence and Washington Counties in 1986 and Newport County in 1993, HWA is established through the southern and eastern range of Eastern hemlock and has made its way to southern ME, NH and VT. In Rhode Island, little has been done since initial insect predator research releases in the early 2000s. The hemlock population is scattered, with the largest population in the northwest of the state, including state lands at George Washington State Management Area and Campground.

Continued predatory insect research, and release and recapture of west coast native lady beetle, *Laricobius nigrinus*, from GA to MA suggests that there may be opportunities to revisit this issue. Since HWA thrives on stressed urban trees, a predator population would have a beneficial impact, reducing HWA population levels on individual, as well as forest, hemlocks.



Eastern Hemlock Distribution
Source: FIA data

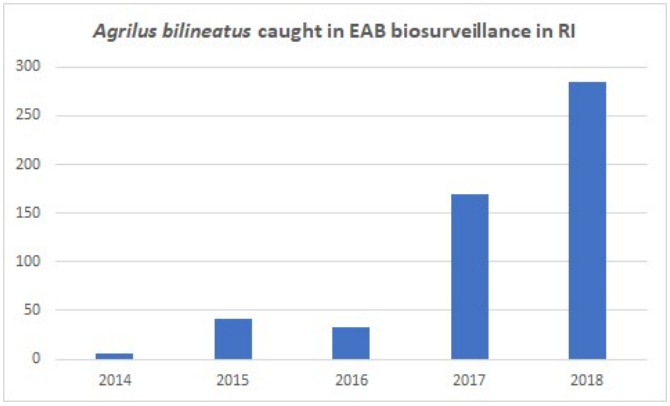
Winter Moth *Operophtera brumata*

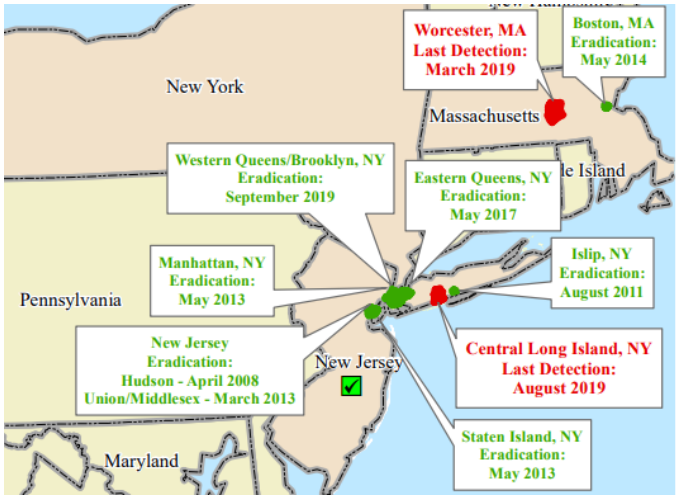
Recent years have seen a reduction in the occurrence of Winter Moth with much of the credit going to the release of a parasitic fly, *Cyzenis albicans*, 2011-2017, and as an increase of native predators and parasitic insects. Recently, URI's monitoring program is been finding it difficult to find areas with sufficient winter moths to trap and monitor. While this pest remains on the list of pest concerns in Rhode Island, the hope is that outbreaks will be localized and of short duration due to a rapid buildup of established predatory insects.

Source: Heather Faubert, URI

Monitored Insects of Concern

- Two-lined chestnut borer (*Agrilus bilineatus*) –
  may be contributing to post-gypsy moth outbreak mortality, specimens collected from EAB biosurveillance program increased during the 2017-2019 seasons.
- Forest Tent caterpillar (*Malacosoma disstria*) –
  populations rise and fall as does public concern; identifiable mortality during aerial detection surveys is periodically reported.
- Orange-striped oakworm (*Anisota senatoria*) –
  skeletonized leaves on host species in Providence & Kent counties occurred in 2019, but no mappable areas of defoliation/mortality were observed.
- White pine weevil (*Pissodes strobi*) –
  is not specifically tracked, however monitoring bycatch data suggest that populations of *Pissodes spp.* are robust; understory white pine recently released due to oak mortality may see impact in future years.
- Monitoring continues for: Cynipid gall wasp (*Bassettia ceropteroides*), Black Turpentine Beetle (*Dendroctonus terebrans*) and the exotic invasive Asian longhorned beetle (ALB) (*Anoplophora glabripennis*)



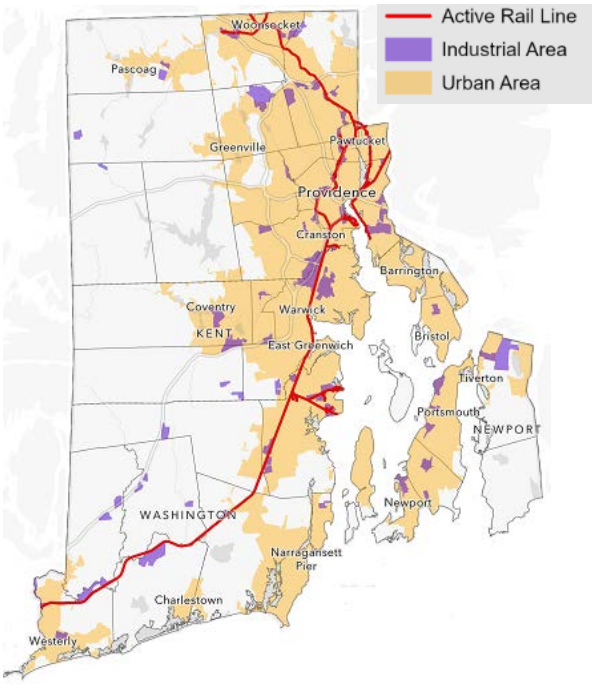


Status of Asian Longhorn Beetle Spread and Control
Source: 2019 National ALB Program Overview

Anticipated Pests

Spotted lanternfly (SLF) (*Lycorma delicatula*)
While still only documented in mid-Atlantic states, DFE, in partnership with the Division of Agriculture has begun educating itself about SLF. SLF's impact on agricultural plants (hops, grapes and fruit trees) is a concern, but the degree of impact on forests and forest species is less clear at this time. There is a high likelihood that SLF will create a nuisance factor in residential and urban areas, requiring DFE engagement/education of the Forest Health, Stewardship, and Urban Forestry Programs.

The preponderance of the preferred host, *Ailanthus altissima*, particularly along railway lines (and former railway lines) provides a corridor for population expansion through the eastern/central portion of the state.



Transportation corridors and industrial areas conducive to transportation and introduction of invasive pests, plants and diseases, particularly spotted lantern fly.

Monitored Diseases of Concern

Monitoring/awareness continues for:

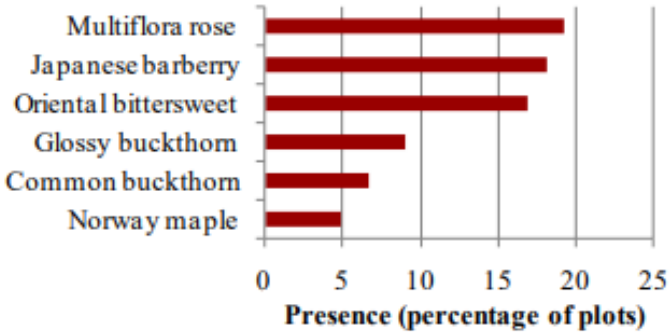
- Rhizosphaera Needle Cast (*Rhizosphaera kalkhoffii*) – a disease of spruce, commonly seen on stressed landscape trees.
- Oak anthracnose (*Apiognomonia errabunda*) – periodic; associated with wet springs that promote *Entomophaga maimaiga.*
- Beech bark disease (*Nectria coccinea* var. *faginata* or *Nectria galligena* vectored by *Cryptococcus fagisuga*) – present throughout the state but limited in number of trees affected and observed mortality at this time.
- White pine blister rust (*Cronartium ribicola*) – considered nearly eradicated in the eastern US, has seen a resurgence and is a rising concern; understory white pine recently released due to oak mortality may see impact in future years.

INVASIVE PLANT SPECIES

Invasive pests and diseases can thrive because of either: 1) a lack of genetic resistance or evolved response tactics by native local species to attack and infestation; or 2) a lack of predators or organisms that can attack and overcome introduced pests. Invasive plant species, on the other hand, typically outcompete native species through processes that include high seed yield and seed movement, seed banking, allelopathy, clonal growth, and aggressive rooting. These processes give invasive plant species a competitive advantage in the fight for colonization, growth, and dispersal. Invasive plants can overwhelm native plant communities and reduce biodiversity of the native plants and the wildlife that relies on them – especially when an area is disturbed, cleared, or developed – and can have significant ecological and economic impacts. Land development, urbanization, and fragmentation exacerbate the introduction and spread of invasive plants.

In 2015, almost half (48%) of all invasive species identified in the RI WAP were associated with forest edge habitat and were listed as threatening Rhode Island's key habitats. Included was information from the report Identifying relationships between invasive species and species of greatest conservation need, which identified 238 non-native species with the potential to adversely impact species of greatest conservation

need (SGCN) in the Northeast, and 68% of these were invasive. According to the Forests of Southern New England, 2012, the most common invasive plants in the southeastern New England region are multiflora rose, Japanese barberry, and Oriental bittersweet. Between the 2007 and 2012 FIA reports, 19% of regional monitoring plots noted an increase in occurrence: multiflora rose and Oriental bittersweet each increased by 8%, and Japanese barberry, 5%.



Presence of the six most common invasive plant species found on invasive monitoring plots, Southern New England, 2007-2009. *Source: Rhode Island's Forest Resources, 2010*

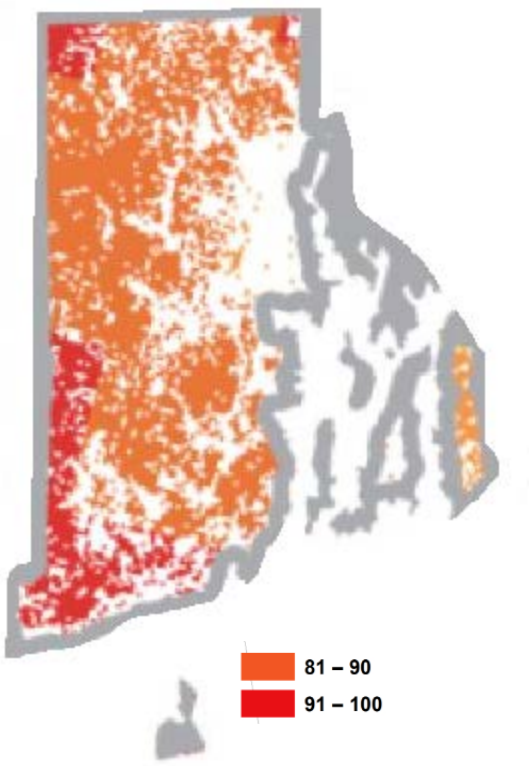
WILDLIFE HABITAT

Healthy forests are not solely determined by tree or stand heath. As previously mentioned from the RI WAP, the state's varied soil, vegetation, and hydrology support plant communities that support a wide range of wildlife, many of which utilize forest habitat for at least some portion of their life cycle. Whether generalists or specialists, the largest forested tracks, or core forests, support the greatest biodiversity of species throughout the forested landscape. Even with increasing fragmentation, retaining green corridors connecting these core sites can play a crucial role for the sustainability of wildlife populations.

The lack of age class diversity also affects wildlife, particularly those species dependent on early successional habitat, such as the New England Cottontail. The RI WAP estimates less than 4% of forest land is in the early successional stage (the RI WAP included shrubland in that calculation, in addition to young stands 0-20 years). Natural disturbances, like severe storms, do not create early successional habitat on a regular basis to support SGCN wildlife species, like New England Cottontail. Birds associated with early successional communities, including grasslands, scrub-shrub habitats, and young forests, have also declined. Several bird species, including: northern bobwhite, American woodcock, prairie warbler, and field sparrow, are listed in the 2019 Partners in Flight (PIF) assessment as being on the Continental watch-list for concern or decline due to a lack of early successional habitat. In contrast, according to the Guidelines for Managing Wood Thrush and Scarlet Tanager Habitat in the Northeast and Mid-Atlantic Regions, wood thrushes and scarlet tanagers do best in forested blocks of over 250 acres and "consistently reach their highest breeding densities in mature to old forests that are dominated by hardwoods and contain a mix of large and small trees."

Fragmentation is the main reason for habitat degradation, dividing large contiguous areas of forest into smaller patches, increasing edge habitat and reducing interior habitat. This loss of ecological integrity not only has a negative impact on certain species, but also subjects the core area to deeper penetration of predatory and/or parasitic species (e.g. blue jays, brown-headed cowbirds, cuckoos). Few areas in Rhode Island contain core habitats large enough to support the full complement of expected species and natural ecosystem processes, which is reflected in the decline of forest interior species. The increasing number of landowners and collective small parcel size makes management for species that require large tracts of forested habitat difficult. RIDEM has prioritized the acquisition of large tracts of forest land as well as parcels adjacent to existing State-owned Wildlife Management Areas to address this concern.

Landowners who actively manage their forest land can be benefit wildlife by creating a range of forest types and age classes distributed across the landscape. A partnership of organizations including the Natural Resources Conservation Service (NRCS), RIDEM, RIFCO, and RI Tree Farm Committee provide financial and technical assistance to create and manage forest habitat for the needs of a variety of species, committed to increasing the abundance of young forests and early successional forests across the forested landscape in Rhode Island.



Probability of Occurrence (%) for Moderate or High Ungulate Browse Impacts on Forest Land, Midwest and Northeast, 2017
Source: Subcontinental-Scale Patterns of Large-Ungulate Herbivory and Synoptic Review of Restoration Management Implications for Midwestern and Northeastern Forests

WHITE-TAILED DEER

One particular concern for overall forest health and future forest cover composition is herbivory. White-tailed deer (*Odocoileus virginianus*) are highly adaptive to fragmentation, thriving in the wildland-urban interface. The spreading of suburban landscapes and increasing fragmentation of forests combined with the long-ago extirpation of most natural predators and a decrease in hunting has caused an increase in white-tailed deer populations. In western Rhode Island, deer densities of 15-20 per square mile are common, although higher densities may occur in some areas where hunting access is limited. An overabundance of deer can have a negative impact on forest vegetation since an individual deer can browse between 5-9 pounds of food a day, including tender shoots, buds, twigs, and leaves of trees and shrubs.

A 2017 USFS study looking at ungulates and forest management implications noted that Rhode Island forests have a high probability of forestland with moderate or high deer browse impacts. The study indicated that forest type most subject to high deer browse was oak-hickory of which 61% of Rhode Island forest is composed. Deer browsing preferences have been studied for many years and is well-documented. An increase in tree species unpalatable or of low-preference to deer would have a significant impact on forest composition and habitat characteristics.

Addressing the impact of browse on regeneration may require silvicultural practices that are not commonly used in Rhode Island, as forest management typically practices clearcutting and rely on natural regeneration. In addition, evidence indicates that there are other factors which may be as significant in species composition, such as fire suppression and the resulting forest densification, as noted in the 2019 study, Does white-tailed deer density affect tree stocking in forests of the Eastern United States?. Once again, reminding forest managers of the complexity of interactions, causes and effects, and the implications of decisions that play out to unexpected consequences over time.

A 2019 Landscape Scale Restoration grant was awarded for a multi-state, multi-partner effort (MA, RI and CT): *Increasing Resiliency in Southern New England Oak Forests*. This project will address deer browse while looking at the various aspects of forest health and managing for resilience. The project is discussed in the Multi-State Priorities further in this document.

Issue: Water

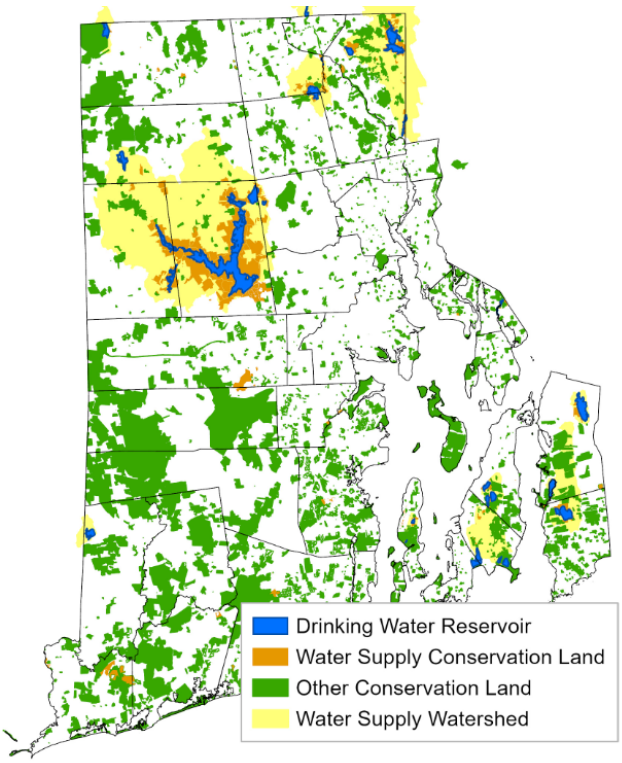
Water is of particular interest and concern in Rhode Island, whether large (or small) inland waterbodies, waterways and wetlands, or Narragansett Bay and salt marshes. Water quality and stormwater management affect all residents and habitats, human and wild. A USFS 2009 analysis of 540 large watersheds ranked several of Rhode Island's watersheds as having some of the greatest development pressure on private forests important for drinking water supply in the east: Blackstone, Pawtucket-Wood, Narragansett, and Quinebaug.

In addition to providing a safe drinking water supply, protecting clean water is critical to maintaining Rhode Island's aquatic ecosystems, fish and shellfish populations for safe consumption, and safe water recreation opportunities. The federal Clean Water Act requires states to create water quality standards and monitor and report on water quality conditions in the state. The RIDEM's Office of Water Resources (OWR) monitors and reports on:

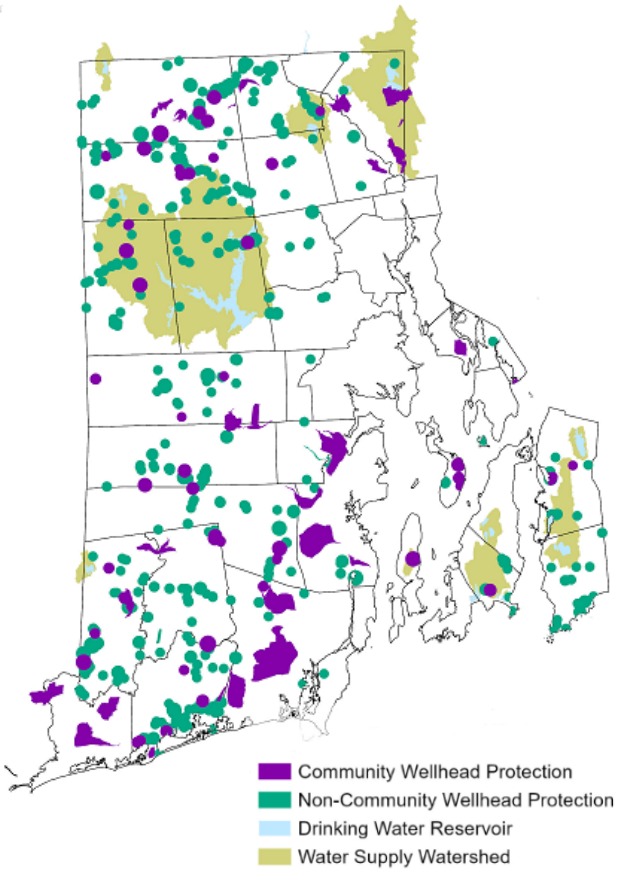
- 1,420 miles of rivers
- 20,749 acres of lakes and ponds
- More than 15,000 acres of freshwater swamps, marshes, bogs and fens
- 72,000 acres of forested wetlands, and
- 159 square miles of coastal waters like Narragansett Bay estuary and coastal ponds.

Rhode Island is home to some of the US's first public water systems. These systems were expanded in size and scope of their operations as the populations in the area they served grew – this is no longer feasible due to increased private land development. Other large public water suppliers now rely on the Providence Water Supply Board (PWSB) as a water source due to contamination from intensive land use activities. Although it was never intended to be the single source supply for the state, the Scituate Reservoir of the Providence Water Supply Board (PWSB) water system now provides water to the metropolitan areas of the State (600,000 persons or about 60% of State's residents) either directly or through other utilities purchasing water from the PWSB.

The Scituate Reservoir watershed's drainage area is about 60,000 acres. The PWSB controls 28% of the watershed (including 12,000 acres of managed forestland), the rest is privately owned. The watershed is subject to development pressure due to its proximity to Providence. The PWSB works to acquire critical parcels of land within the watershed to ensure important watershed resources are protected. Since less than a third of the land in the watershed is protected, stewardship of the remaining land by private landowners is identified as critical by the Forest Legacy Program. In 2019, the state received a grant through the Forest Legacy Program to focus on easements on the Scituate Reservoir Watershed. The grant application identified 716 acres on 14 targeted properties.



The Scituate Reservoir was never designed to be serve as the main source of supply for over 50% of Rhode Island's residents, but there is no large-scale alternative since the EPA prohibited construction of the Big River Reservoir in 1989. Initial efforts to



develop an alternative water supply by constructing a reservoir was determined by the EPA to likely cause serious environmental damage. The Big River Reservoir land (about 8,000 acres) was designated as open space by the Rhode Island Legislature. This land is protected and cannot be sold or developed except for the development of wells and well sites for the distribution of drinking water.

According to the EPA's Safe Drinking Water Information System (SDWIS), as of 2017 more than 80% of the 1.06 million people living in Rhode Island rely on surface reservoirs for clean drinking water. With few exceptions, the rest of the population relies on groundwater. Most of the State's groundwater is considered suitable for drinking water use. Four groundwater aquifer systems of the State have been classified as Sole Source Aquifers by the EPA, since they serve as the principal source of drinking water for an area and no other water supplies are available. About 26% of the state's population depend on other public water sources for their water supply and there is a total of 490 public water supply systems ranging in size from small rural residences to 28 major suppliers.

WATER QUALITY

Forests act as a water filter as surface and subsurface water flow moves over and through soil into wetlands, creeks, and ponds, rather than across asphalt and concrete where the water picks up oils and pollutants before flowing into Rhode Island's waterways. This does not only affect those waterways: a 2002 study by the Trust for Public Land and the American Water Works Association found that for every 10% increase in forest cover in the source watershed, treatment and chemical costs decreased by about 20%. Similarly, a study of the High Rock Lake watershed in North Carolina showed water treatment costs trending lower in watersheds at least 70% covered in forest. A 2014 article in the Journal of the American Water Works Association discusses how protecting and sustainably managing forested watersheds makes economic sense as a strategy for water that complements traditional infrastructures by reducing costs and, in some cases, even opening new funding streams.

Currently, OWR has enough data to assess water quality in 65% of the river miles, 77% of the lake acres and nearly 100% of the estuarine waters. OWR's 2018 Impaired Waters Report identified 96 named water bodies as "impaired". For example, multiple junctures of the Blackstone River where it flows through Pawtucket, Central Falls, Woonsocket, North Smithfield, Cumberland, and Lincoln have been designated "impaired" due to the presence of lead, mercury in fish tissue, and fecal coliform (among other pollutants), rendering it unsafe for drinking, fishing, wildlife habitat, and recreation.

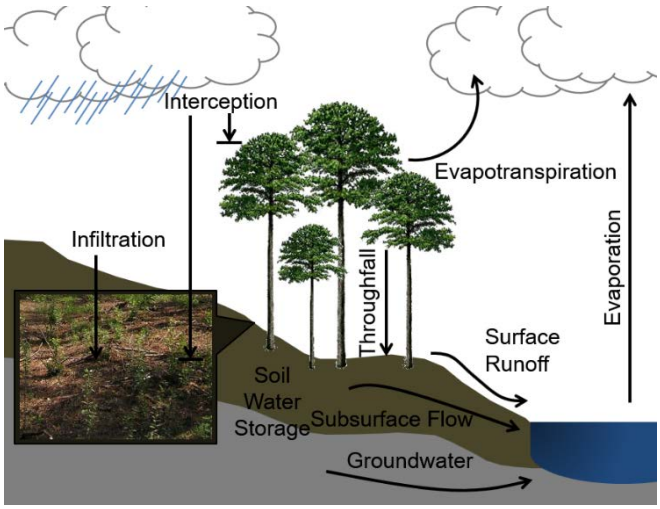
Forests play a monumental role in both water quality and stormwater management, filtering and protecting the water supply, and all other waters, for all residents in Rhode Island. Forest fragmentation and loss to development and other land uses is a major contributor to water availability and quality concerns. The impact of water quality and availability on wildlife habitat and species diversity, whether salt or fresh water, is a significant management issue discussed throughout the RI WAP. Whether the concern is a physical loss

of pools, streams, wetlands, or a degradation of the quality of those waters, the impacts on wildlife and plants is of importance to maintaining a healthy and resilient landscape.

STORMWATER

Forests and other natural and well-managed working lands also play a significant role in stormwater management, slowing the rate of water flow into waterways and into built stormwater management infrastructure by intercepting rainfall, reducing rainfall intensity, and increasing storage capacity of soil. Trees and vegetation slow and redirect waterflow through multiple mechanisms, reducing peak flows by:

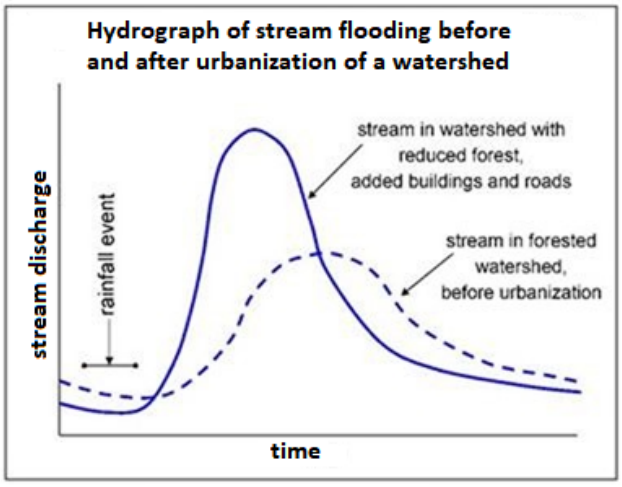
- Interception by the crown, branches and trunk reduces amount of precipitation reaching the ground
- Throughfall is slowed so it impacts the ground with less speed and more opportunity to infiltrate
- Pervious soils allow infiltration and subsurface flow into waterways



Precipitation Movement in the Landscape
Source: How Trees & Forests Really Affect Stormwater

In fact, a one-acre parking lot releases 36 times more water than one acre of forest (Changing Landscapes, USDA NA–TP–01–14 A3, page 6). According to the USFS, 100 mature trees can intercept and filter over 100,000 gallons of rainfall per year in their crowns, reducing the need for expensive stormwater controls and

Simply by slowing the rate of flow, forests protect water. As we see changes in amounts and seasons of precipitation, forests mitigate those impacts. Increased volumes of water, either in single events or multiple events occurring within narrow timeframes, can result in:



Source: Lehman College

- Increased flooding, making 50- and 100-year floods more common
- Increased velocity of water flow, eroding soils and streambanks
- Decreased water quality from surface flows carrying pollutants and high amounts of soil particles.

Trees and green spaces in urban areas can also make significant contributions to stormwater management where planning and management maximize impact.

As summarized Oct 2016 in Stormwater (Journal for Surface Water Quality Professionals):

- "Open-grown trees, as found predominantly in municipalities, generally have greater leaf area than comparable sized trees grown in forested stands. Because of this, municipal trees have been shown to retain greater rainfall volume than trees in forests."
- "Coniferous trees (i.e., pine) tend to retain greater volumes than deciduous trees."

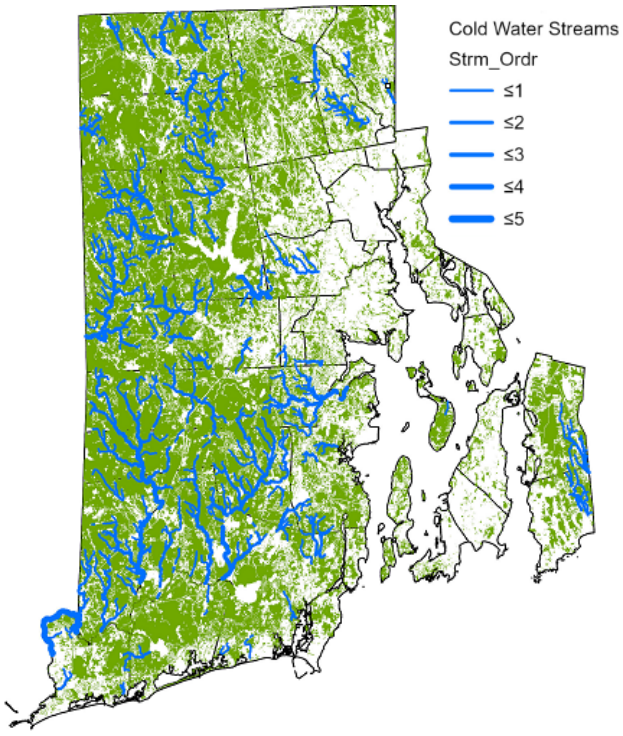
- "Urban trees have been shown to retain from 20% of the annual rainfall where rainfall volume and intensity can be great, such as in the southeastern United States, to as much as 80% in regions with relatively light rainfall intensity and volume, such as in the Pacific Northwest."

WATERWAYS

The RI WAP identifies the conditions of, and threats to, waterways in Rhode Island and their value and use for wildlife. Waterways of all sizes and characteristics are necessary to provide the aquatic habitat needed for resilient and diverse populations of plants and animals. Besides the benefits that forests provide by filtering and slowing water entering these waterways, the forests also contribute other essential qualities.

1. Shade – the cooling effect provided by canopy cover along and over streams is very important to regulate water temperatures needed for habitat and life-cycle completion needs, as well as basic survival by maintaining oxygen levels. In Rhode Island, obligate cold-water stream species (like the native brook trout) are threatened by warming waters.
2. Food – leaves, flowers, seeds, droppings from tree canopies, and insects, can enrich the water and provide suitable nutrients for decomposers at the base of the food chain
3. Cover – branches, leaves and even the occasional limb or trunk contribute to a varied environment that can support a variety of organisms, insects, fish and other wildlife.

The majority of cold-water streams in Rhode Island are located in traditionally forested landscapes where obligate cold-water stream species, like native brook trout, are threatened by warming waters. Maintaining tracts of forest land protects the values and conditions needed to maintain living and vital waterways.



Distribution of Cold Water Streams Within the Protected Surroundings of Rhode Island Forests.

SOIL

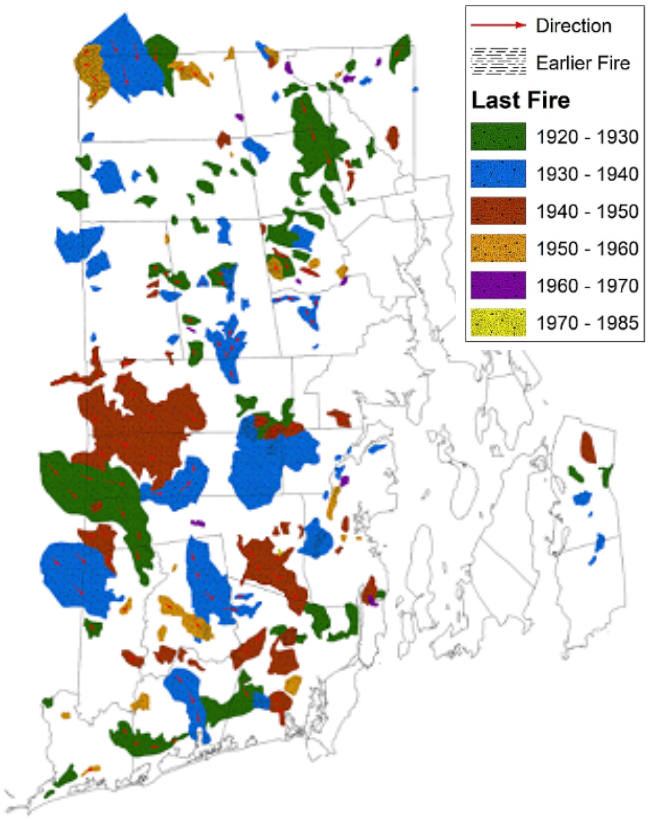
While the impact of fragmentation on Rhode Island's forests and habitats has been discussed previously, the source of that fragmentation has deeper implications for water quality, stormwater management, waterway health, and for forest health itself.

The replacement of these soils with impervious surfaces and the redirection of water movement, whether to built stormwater management or by changes due to grading, fill, or other reasons, affect the forests themselves, not just the waterways. Removal of topsoil, compaction of soil surfaces, changing the flow of surface and subsurface water flows also affect the forest functionality and benefits:

- Forest soils hold microorganisms, fungi, nutrients and moisture that is lost with their removal.
- Compaction of soils for infrastructure installations, and access to those structures, limits water infiltration, root penetration, and microorganisms.
- Grading changes can redirect water: reducing availability to trees adapted to historical water levels and/or increasing availability to trees in excess of what they are adapted to.
- Loss of soil carbon storage and decrease in site capacity to sequester soil carbon in the future.

Issue: Fire

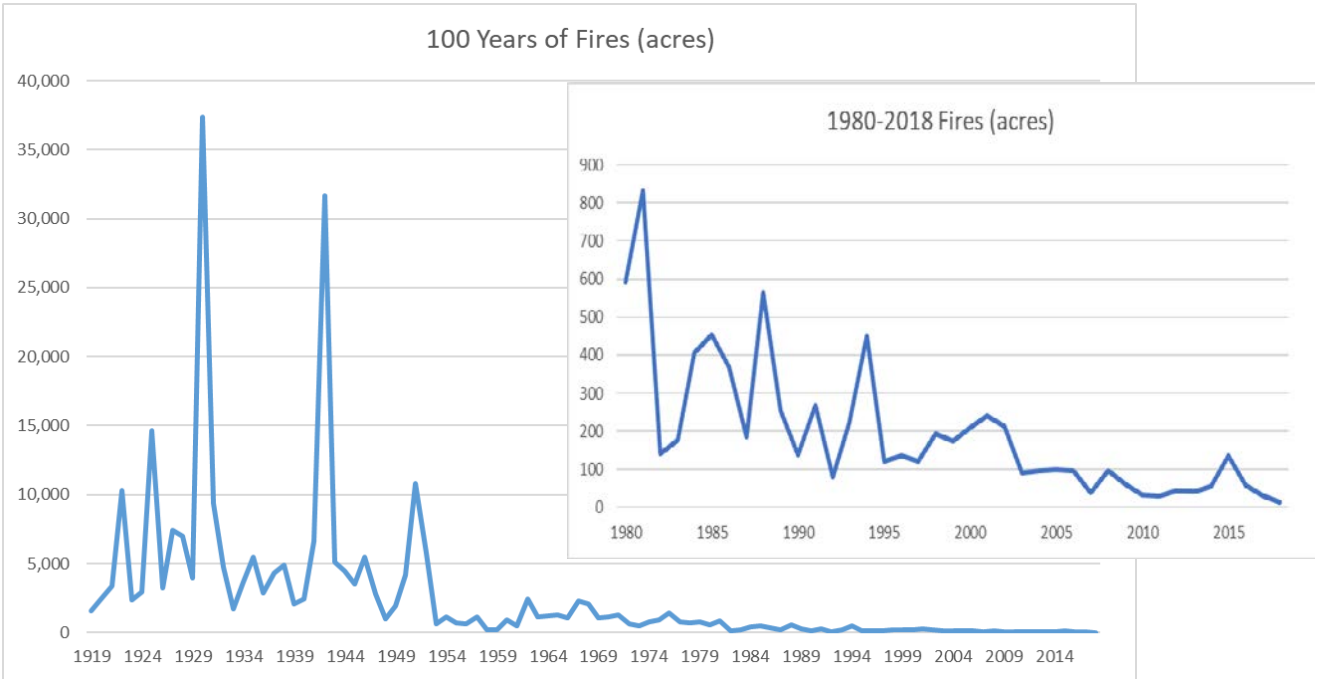
DFE's Forest Fire Program has existed since 1906 with the establishment of the Rhode Island Forest Commission, followed almost immediately by chestnut blight. During its 114 years, the Division of Forest Environment has seen various departmental names, and numerous large-scale event fires and large-scale disturbances leading to event fires or hazardous fuel conditions. The dynamic nature of the environment seems to be the constant.



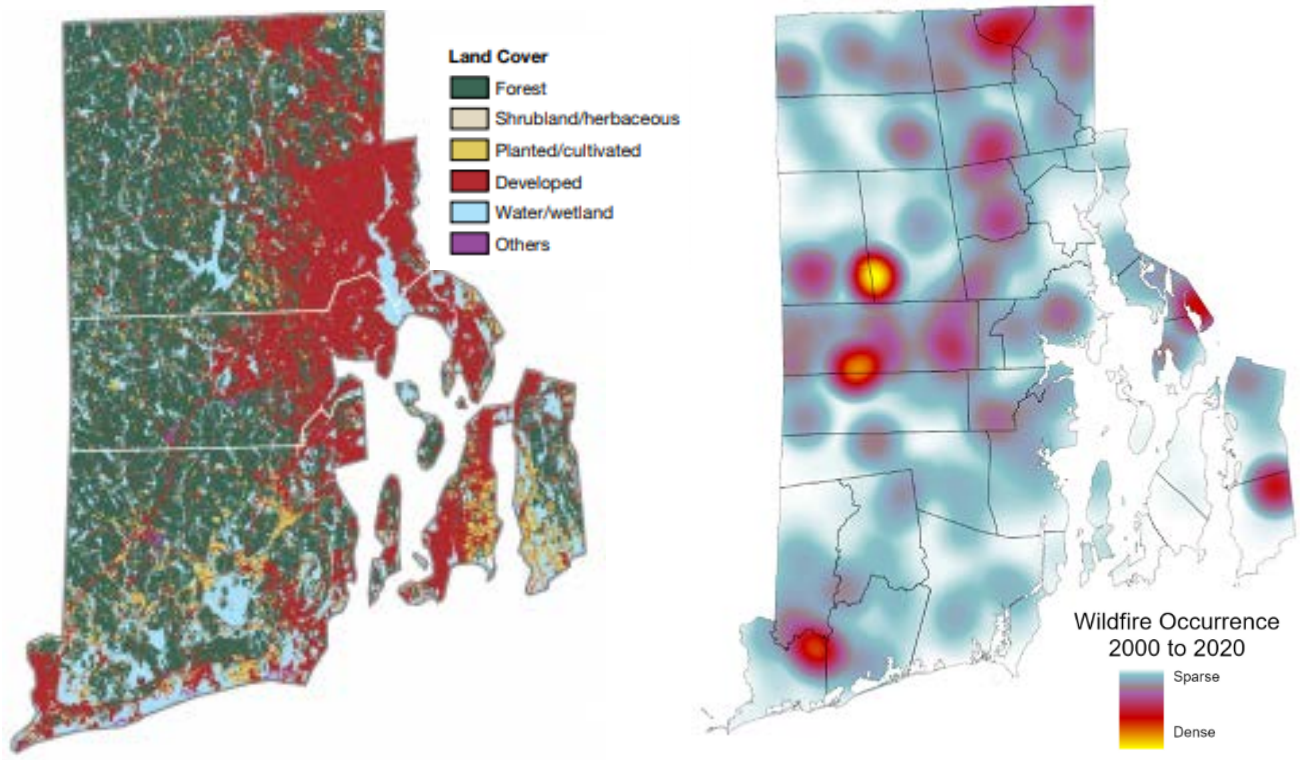
Rhode Island's fire occurrence from the 1920's to 1970 shows the size of fires in areas, many of which are still predominantly forest today, but now with more population and infrastructure than in the 20th century.

As the western part of the state has experienced an increase in development, the values at risk have increased significantly. However, this increase in wildfire risk is partnered with:

- decreases in resident awareness, concern, and preparedness for wildfire;
- communities and fire departments focused on increasing demands for EMS and HAZMAT services;
- reduced fire department reporting of small fires to DFE, affecting fire statistics; and
- decreases in DFE staffing capacity for wildfire response, mitigation, and preparedness.



The expansion of the wildland-urban intermix/interface, with the associated increase in monetary, infrastructure and human values, combined with an unmanaged accumulation of dry fuels, and a lack of local and state preparedness and capacity, is of concern to DFE.



Source: ESRI Green Infrastructure Strategy

Fire location occurrence 2000 - 2020

Data from 2000 - present shows hot spots where human-caused fires commonly occur. When considered with respect to fire-adapted ecosystem information, historical fire occurrence, and population centers, escaped fires have the potential for rapid spread and impact to values at risk.

COMPOUNDING FACTORS

More recently, changes in seasonal weather patterns and precipitation have decreased moisture availability in the summer months, increasing tree mortality. Severe pest and disease mortality have also increased. All these factors combined have led to increased fuel loading and drier fuels across the state.

Oak mortality, due to gypsy moth defoliation, 2017.

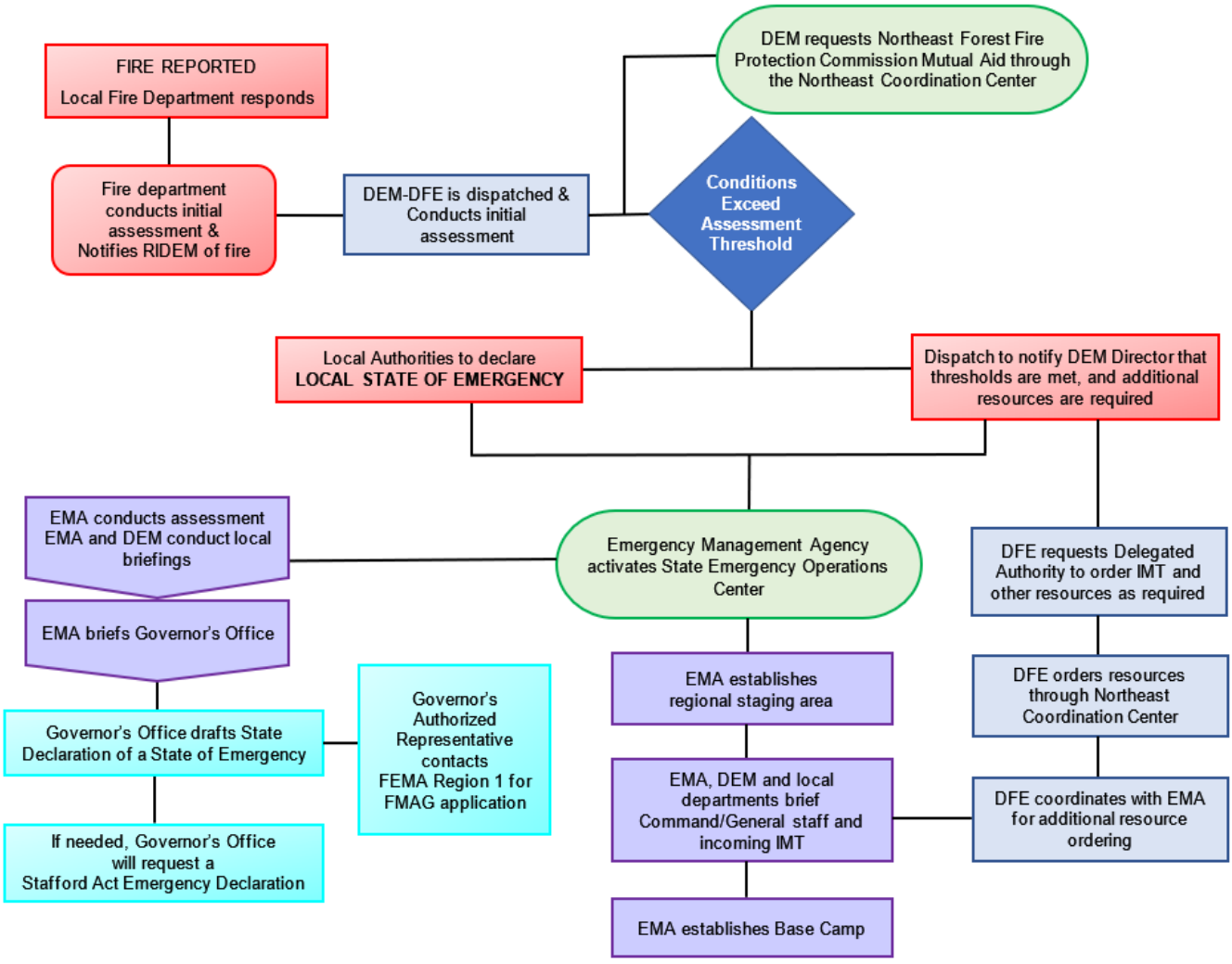
After 3 years of intensive defoliation by gypsy moth, and droughty summers, many oak trees failed to recover, resulting in an estimated 45-50,000 acres of forest loss. Mortality in 2019 was attributed to the lingering effects of the chronic stress and other factors, such as continued drought during the growing season and other pests.

An increase in the population of two-lined chestnut borer (*Agrilus bilineatus*) developed as oak trees were increasingly stressed by gypsy moth defoliation. This borer contributed to late-season oak mortality in 2018 and is expected to be a significant contributing factor to oak mortality in the future, until the population levels naturally subside. Additionally, ash species mortality is anticipated over the next several years as emerald ash borer spreads through the state.

FOREST FIRE PROGRAM STATUS

Although prevention and enforcement efforts have been successful in reducing the incidence and size of fires in recent years, DFE has been unable to sustain response capacity and leadership to support local wildfire suppression efforts, primarily due to past substantial funding cuts. As the development continues to expand into rural and forested western Rhode Island, fuels continue to build due to declining management and forest health issues as weather and precipitation patterns become more extreme. This combination of elements indicates the potential for significant wildfire events in the future.

Over the past 20 years DFE has seen a shift in responsibilities and staffing levels, from 80 staff handling forestry, recreation (3 campgrounds, 4 beaches), law enforcement responsibilities, maintenance, etc., to an 80% reduction to 15 employees (of which 11 are field staff), with significant carry-over of non-forestry/fire responsibilities. With respect to fire suppression, presently there are 5 allocated Fire staff (Fire Science Officer vacant since early 2018) resulting in an extremely limited response capacity as a suppression force. This, combined with a lack of surge capacity/emergency firefighters, means that once local fire department capacity is exceeded, so too is state capacity, thus requiring external assistance. As a result, small scale incidents with a higher complexity due to urban interface would require a declaration of a state of emergency and mobilization of resources.

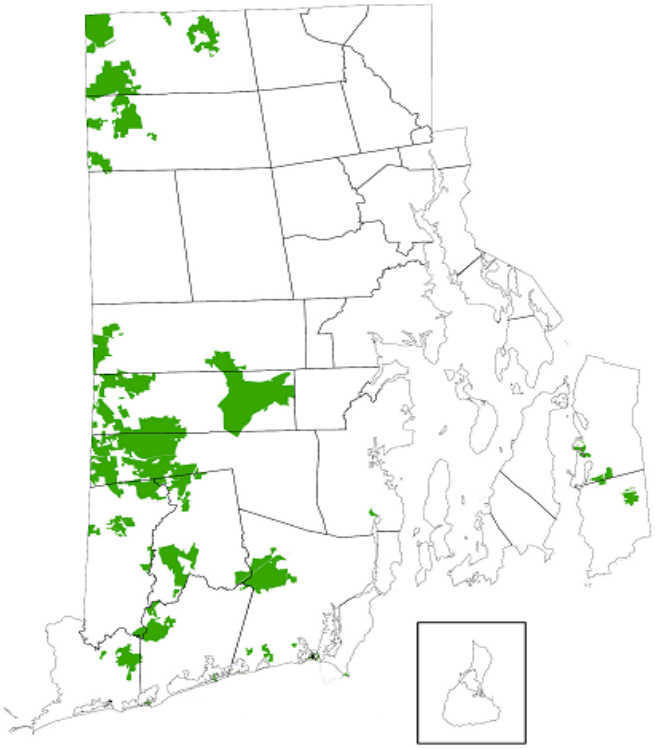


The pending state legal review of the Stafford Act further compounds the lack of suppression capacity. This has resulted in a cap on operational qualifications DFE that can be developed and utilize. The 2020 Fire Plan seeks to address these shortfalls by providing detailed information and guidance on the policies and procedures associated with fire suppression and an emergency declaration. Further effort is required to develop in-state capacity to limit the potential for small incidents to require a declaration in order to meet response objectives.

In addition to a lack of staff capacity, and a lack of agency level and public awareness, there is a lack of equipment and technology to allow the Forest Fire Program to communicate and deliver fire information, awareness and management:

- *Fire danger prediction* using a standardized prediction system, National Fire Danger Rating System (NFDRS), requires weather station measurements for: wind speed and direction, air temperature and relative humidity, precipitation, barometric pressure, and solar radiation. The Forest Fire program cannot meet the NFDRS standards with the current weather stations which, while comparatively new, lack the ability to integrate data with the GOES16 satellite system, and do not collect solar radiation data. *Presently, Rhode Island's danger rating is calculated manually using 1967 indices which do not correlate well to more recent iterations, and will be completely obsolete when a new, updated danger rating system is released in 2020*. Due to the differences between the 1967 FDRS and the 2016 NFDRS indices, DFE is unable to communicate effectively to federal partners the actual fire danger.
- *Fire risk assessment* based on fuels, flame heights, and terrain at a scale appropriate to Rhode Island, requires data and mapping capabilities beyond existing budget and capacity.
    - Scale: 30m resolution results in many of Rhode Island's wildland-urban interface communities being labeled as developed land and, thus, classified as non-burnable and are reported as such in the federal budget allocation. However, these areas contain the same highly flammable fuels with a significantly high concentration of values at risk.
    - Ease of use: data is not easily available to municipalities, land managers, and fire departments, requiring a high degree of experience with, and access to, ESRI software.

Multiple efforts to access competitive federal funding have not been successful to date, that would allow DFE to develop the maps and strategies to effectively engage with local governments, residents and fire departments.



RI DEM Management Areas

FOREST FIRE PROGRAM EFFORTS

- The Forest Fire Program has been working to develop program delivery through its 2020 State Fire Plan and increased engagement with RIEMA to increase awareness of fire risk and incorporate fire into hazard response planning.
- A WRR grant in 2019, Increasing Fire Awareness & Management in Rhode Island, is focused on utilizing Firewise® messaging to educate and empower communities, homeowners, and fire departments to understand and mitigate wildfire hazards by modifying their landscaping and land use to be fire adaptive.

- The general goal is to institute a culture of preparedness and establishing defined actions at the time of an emergency (e.g. clearing brush around buildings, orderly evacuation, etc.)
- A specific target is to provide communities assistance with risk assessment, plan development, and implementation.

- Continued engagement with the Division of Fish and Wildlife to assist with prescribed burns for wildlife habitat and management; assistance with federal Fish & Wildlife prescribed burns; and to increase Incident Management Team (IMT) qualifications within DFE and other state agencies.
- A Wildfire Risk Reduction (WRR) grant in 2015 funded Rhode Island's first Community Wildfire Protection Plan (CWPP) for Prudence Island.
  - Prudence Island has 88 year-round residents and is 3,565 acres, of which 85% is protected from development, and addressed within the plan. Further prescribed burning is planned for the spring of 2020.
  - Future efforts will be made to procure funding for development of CWPPs for Management Areas. The WUI intermix/interface would be served by such plans, and they would provide an example to Rhode Island communities.

Pitch pine barrens are a fire-adapted ecosystem, requiring periodic ground fire to maintain plant species and support pitch pine regeneration. Light-intensity fires help limit ground and ladder fuel accumulation and reduce the incursion of competitive species, which shade and out-compete pitch pine and its associated species.

Not only do prescribed fires reduce fuel accumulation and reduce competition for nutrients and light, as shown three years post-treatment at Nicholas Farm; they also reduce the intensity of wildfires, protecting habitat for wildlife and humans alike.

Issue: Climate Change

As discussed within the Benefits section (page 18), forests simultaneously provide a myriad of benefits to the natural and built habitats of creatures and humans. The complex interactions within, and by, the forest is still barely understood but has withstood millennia of disruption and change. Given enough time, forests and the species that rely on and support forests can adapt. But today, the combined onslaught of climate change, fragmentation and parcelization, interference with migration, loss of biodiversity, invasive plant and insect species, overuse and overgrazing, and more extreme weather events occurring more frequently – all contribute to forest lands with less biological resilience to change and less time to adapt to those changes.

Climate change is affecting natural ecosystems and human communities in Rhode Island. As reported in Resilient Rhody, temperatures in Rhode Island have increased more than 3 degrees since the beginning of the 20th century, and sea level has risen 10 inches since 1930. The joint NOAA and RIDEM publication, Overview of a Changing Climate in Rhode Island, reports that over the past 80 years, Rhode Island and southern New England have experienced a significant increase in both flood frequency and severity, including a doubling of the frequency of flooding and an increase in the magnitude of flood events. Other research shows that spring is arriving sooner in southern New England, with leaf-out for trees and woody plants occurring more than two weeks earlier than in the 1850s.

Temperatures are projected to continue increasing, leading to longer growing seasons and more extreme hot days. Climate models predict additional changes in the future. Climate change is increasing stress on the state's forests and playing a role in more complex, compounding factors, as Resilient Rhody noted:

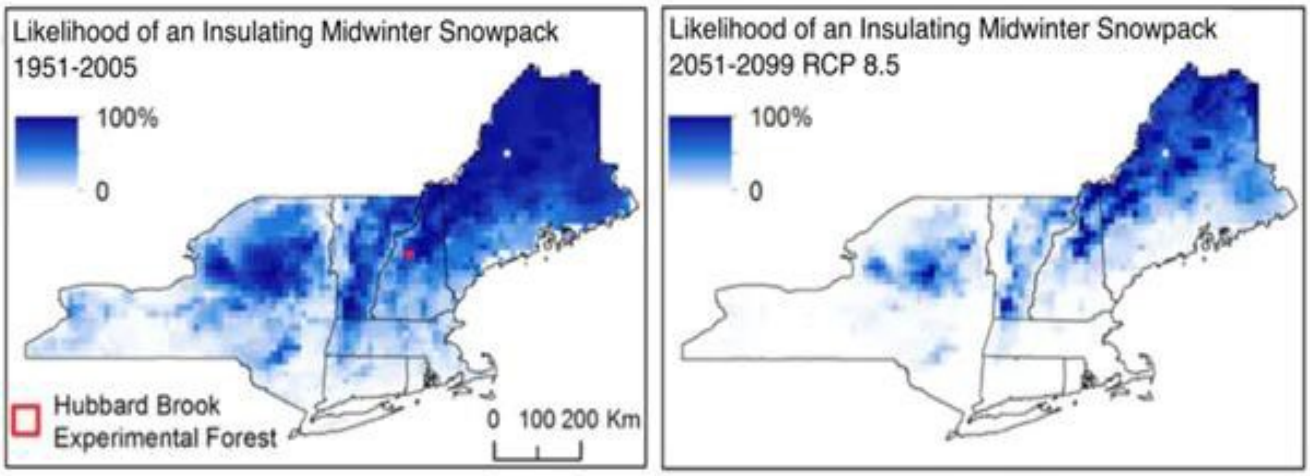
- Annual precipitation is expected to continue increasing, particularly during the spring and fall, and heavy precipitation events will occur more often. Warmer temperatures will result in more rain than snow. More rainfall during concentrated periods will significantly affect hydrological patterns, including more flooding events;
- A longer growing season, warmer temperatures, and more variable summer rain are likely to increase summer moisture stress on plants and could lead to harmful droughts;
- As the climate changes, forest composition will change, becoming less favorable to species that are adapted to cold climates, promoting typically southern species at the northern edge of their range;
- Warmer winters with fewer periods of sustained cold weather may lead to increased activity of forest insects and pests that have the potential to cause greater impacts to forests, as well as migration of more southerly pests as conditions become more favorable; and
- Changes in the timing of leaf-out, flowering, and fruiting in plants can be very disruptive to plant pollinators, seed dispersers, and migratory wildlife.

Similarly, the New England and Northern New York Forest Ecosystem Vulnerability Assessment and Synthesis: A Report from the New England Climate Change Response Framework Project assessed the impacts of climate change on tree species and forest ecosystems across the region. These impacts were summarized in the online resource Climate Change and Adaptation: New England and Northern New York Forests and include:

CLIMATIC IMPACTS	**FOREST IMPACTS**
Warmer temperatures	More variable soil moisture
Longer growing seasons	Increased risk of drought
Shorter, warmer winters	Stress from forest pests and diseases
Rising sea levels	Competition from invasive plants
Changing precipitation	Changes in suitable habitat
More extreme precipitation	Changes in tree establishment
Changes to the water cycle	Changes in tree growth
	Changes in forest composition

Overall, the complexity of ecosystems makes accurate predictions challenging, longer growing seasons can mean desynchronized pollinators and food sources, bird nesting, and migration, etc., which may have unforeseen impacts. These increasing threats and rapid rate of change have the potential to exceed an ecosystem's resilience or capacity to adapt.

New information regarding climate change impacts on forest ecosystems continues to emerge. For example, recent research suggests that a decline in snow pack will have a detrimental effect on northern forest growth – even where temperatures remain cold. The amount of snowpack may not be a significant factor in many forests in Rhode Island, but it shows the overall climatic impacts that will affect forest establish and health, as well as forest management decisions.



Source: Climate Change is Shrinking Winter Snowpack

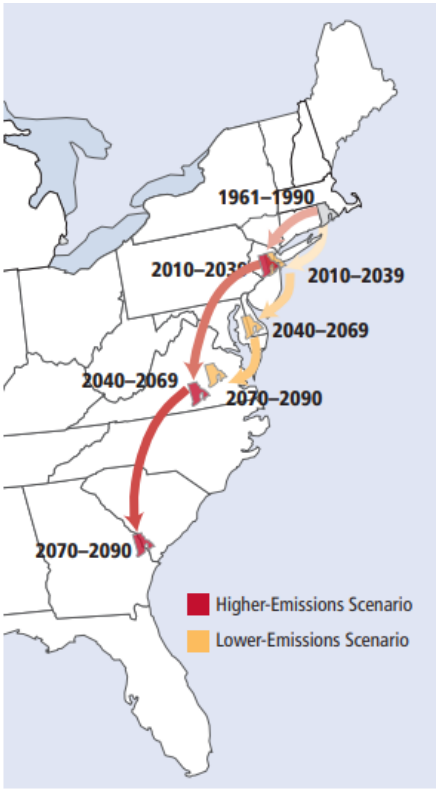
Increasing winter temperatures also increase the threat from many invasive plants and insect pests (native and exotic) because these species may no longer have to withstand or recover from extremely cold winter conditions. A warmer climate may facilitate the establishment or increase the competitiveness of these threats, and compound damage within ecosystems.

It isn't only forests in the traditional sense that are affected by climate change. Climate change will also have direct and indirect consequences for urban forests, already under stress from localized temperatures and moisture regimes due to the urban environment, as well as atmospheric pollution, salt damage, and exposure to novel pests and diseases. Urban forests are distinct from natural or managed forest ecosystems, not only because of their structure and composition, but also the many specialized benefits they provide for residents of cities and towns. But climate change is expected to amplify existing stressors in a similar way to forests in natural environments. Expected consequences include increased activity of insect pests and diseases and higher infestation levels; more extreme exposure to heat waves and drought; and phenological mismatches with pollinators and dispersal agents. Well-managed urban forests, like well-managed forest land, can yield additional climate benefits with management and maintenance.

SPECIES COMPOSITION

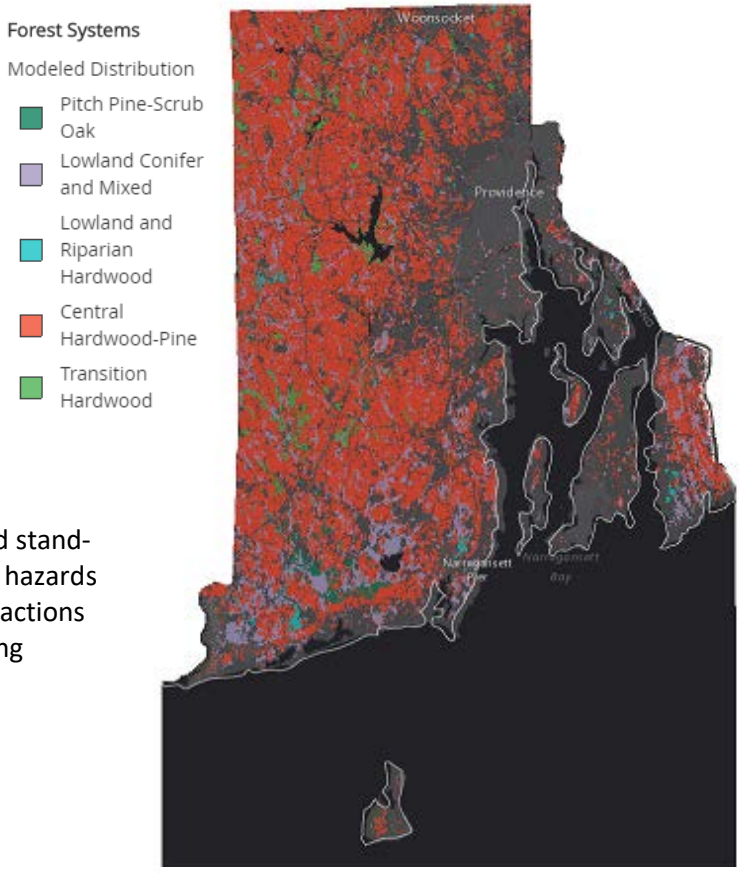
Increased temperatures and altered climate conditions are also expected to shift suitable growing conditions for individual species of trees, shrubs, and plants. This means that many species growing at their more southerly extent in Rhode Island may be unable to withstand the changes in growing conditions and become locally less common or disappear entirely. Meanwhile, species growing at their more northerly extent may find growing conditions conducive to expanding their range northward. The natural shift in growing range and dispersal is a slow process but, in the 21st century, it is complicated by grey infrastructure, permanent land conversion, and other impacts of fragmentation and forest loss which impede species migration.

Predictive models for anticipated climate change look at the effects of various emission rate scenarios. An example on the left, from the 2006 Northeast Climate Impacts Assessment, shows the effects of two emission scenarios on the heat indices for Rhode Island over the next 80 years and the impact on summer temperatures. While these changes are speculative estimates, and modeling has advanced considerably since 2006, this visually captures changes in local temperatures that would affect habitat and species composition.



The impact of climate change will not only impact individual species but also the composition of entire plant communities. Such communities, as expressed as forest types or systems for example, may be more vulnerable to climate changes, which can also affect wildlife habitat availability and quality. As one example, the Lowland Conifer and Mixed type relies on a relatively narrow range of soil and moisture conditions, making it vulnerable to impacts from droughts and extreme weather events. By comparison, the Central Hardwood-Pine type occurs naturally across a wide range of habitats and, at the northern extent of its range, is expected to persist.

Such shifts are expected to ultimately impact forest management decisions. The New England and Northern New York Forest Ecosystem Vulnerability Assessment and Synthesis presents an assessment of vulnerability for forest ecosystems for the end of the 21st century, shown in the table below. The assessment includes the level of evidence and degree of confidence in the vulnerability of forest types (which is not summarized here) and provides context for the ratings.



Forest Systems in Rhode Island. *Source: Climate Change and Adaptation: New England and Northern New York Forests*

Although many of the common forest types across Rhode Island are generally expected to have some capacity to adapt to changing conditions, the likely effects of climate change also need to be considered at the property- and stand-levels where local site conditions and potential hazards can be evaluated. This allows for management actions to be focused on reducing stressors and enabling ecosystems to adapt to changing conditions.

Forest System	Vulnerability
Pitch Pine – Scrub Oak	low
Lowland Conifer & Mixed	moderate-high
Lowland & Riparian Hardwood	moderate
Central Hdwd - Pine	low
Transition Hardwood	low-moderate

RESPONDING TO CHANGE

These complex interactions can seem beyond the individual, or even the state, to manage. However, there are forest management practices that support healthy forests and also incorporate climate change considerations. Meanwhile, DFE and its partners work to educate landowners and professionals of ways to keep their forests healthy through the years. One method is to encourage the planting of a variety of forest tree species that will be suited to the changing climate patterns. This can assist the migration of such species, avoiding interruptions caused by fragmentation and development, and speeding up the very slow movement of trees beyond their existing ranges.

The main challenge for post-harvest tree planting in Rhode Island is two-fold:

1. tree planting after harvesting is not a typical practice in the state, as regeneration is typically left to understory release and natural regeneration; and
2. the impacts on planted growing stock from overbrowsing by deer would be as severe and more expensive than presently occurring on natural regeneration.

These are two significant challenges that do not have a quick solution, and will require working with stakeholders and partners, as well as identifying possible funding sources to develop and support a programmatic effort.

The issue of climate change ultimately influences planning and management actions within DFE also, affecting commonly understood forest processes and progressions. Not only does forest change compound existing agency management challenges, but political or legislative responses to climate change, whether at the local and national level, adds additional complexity that may either enhance or impair the functioning landscape.

DFE's role in the midst of this uncertainty is education and technical support to encourage the retention and management of forest lands, as ever. It is necessary for DFE to advocate and support adaptive forest management practices that maintain a resilient forest able to withstand the effects of stress related to changing climate zones and pests and diseases (whether native or exotic). Communicating research and information for changes to management methods and resources requires adaptiveness and leadership. DFE will also need to explore funding and partnerships to initiate efforts that will benefit Rhode Island, based on good science, such as planting and protection of seedlings, assisted migration, demonstration sites, and financial assistance.

PRIORITY LANDSCAPE AREAS IN RHODE ISLAND

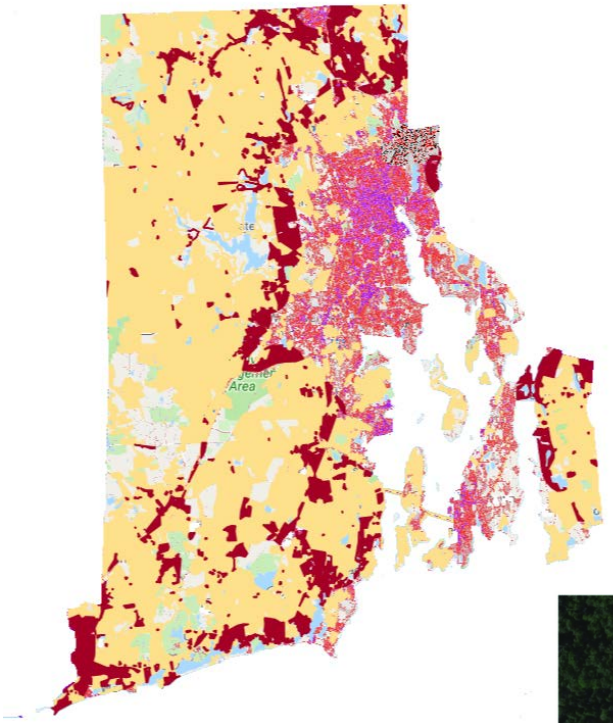
The determination of Rhode Island's priority areas for the Stewardship, Forest Health, Fire, and Urban Forestry programs is relatively straightforward in such a compact state. The priority areas for these four cooperative programs is where expansion of urban areas and ingress into forested areas is occurring: the wildland-urban interface and intermix – with each program focused on their audience and providing cross-messaging with the other programs.

Stewardship – landowners in the interface – managing their forests, and keeping their property as working lands; engaging and educating rural municipalities remains a significant challenge

Forest Health – introduced and invasive pests/diseases/plants – the interface is often where they appear and are more easily spread via human transport and developed corridors; educating professionals and homeowners to promote awareness and initiate management practices

Fire – wildfire risk – most fires are ignited by humans in the WUI – new outreach to municipalities with the Firewise message and assisting communities to develop plans and implement them for wildfire risk reduction

Urban & Community Forestry – expansion of urban areas and the loss of interior greenspace – an important part of the urban message is maintaining and planning for green space to limit the impact of landscape change.



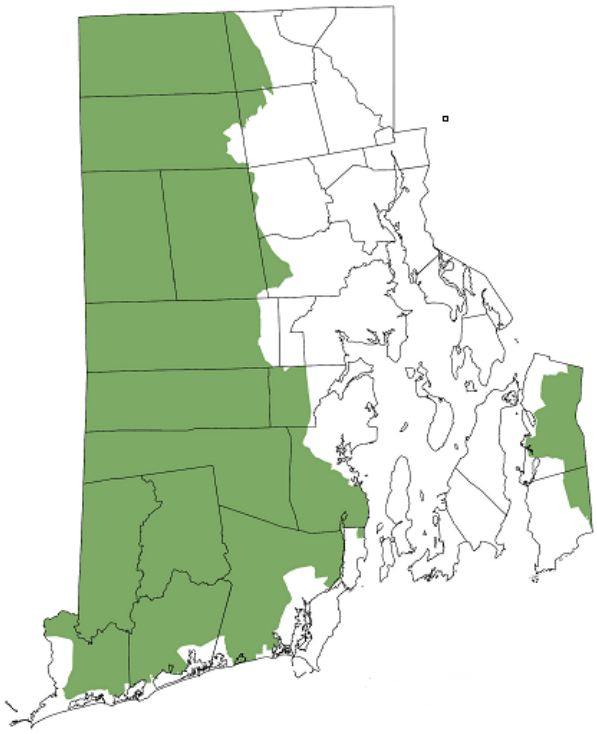
This map, derived from the i-Tree Landscape Tool, shows the Wildland-Urban Interface (WUI) in red and Wildland - Urban intermix in yellow.

Wildland-Urban Interface refers to a distinct area of wildland fuel adjacent to a developed area.

Wildland-Urban Intermix refers to a specific type of wildland-urban interface in which the homes or other structures are intermixed with wildland fuels, scattered or in small groupings.

Intermix **Interface**

Source: Researchgate.net

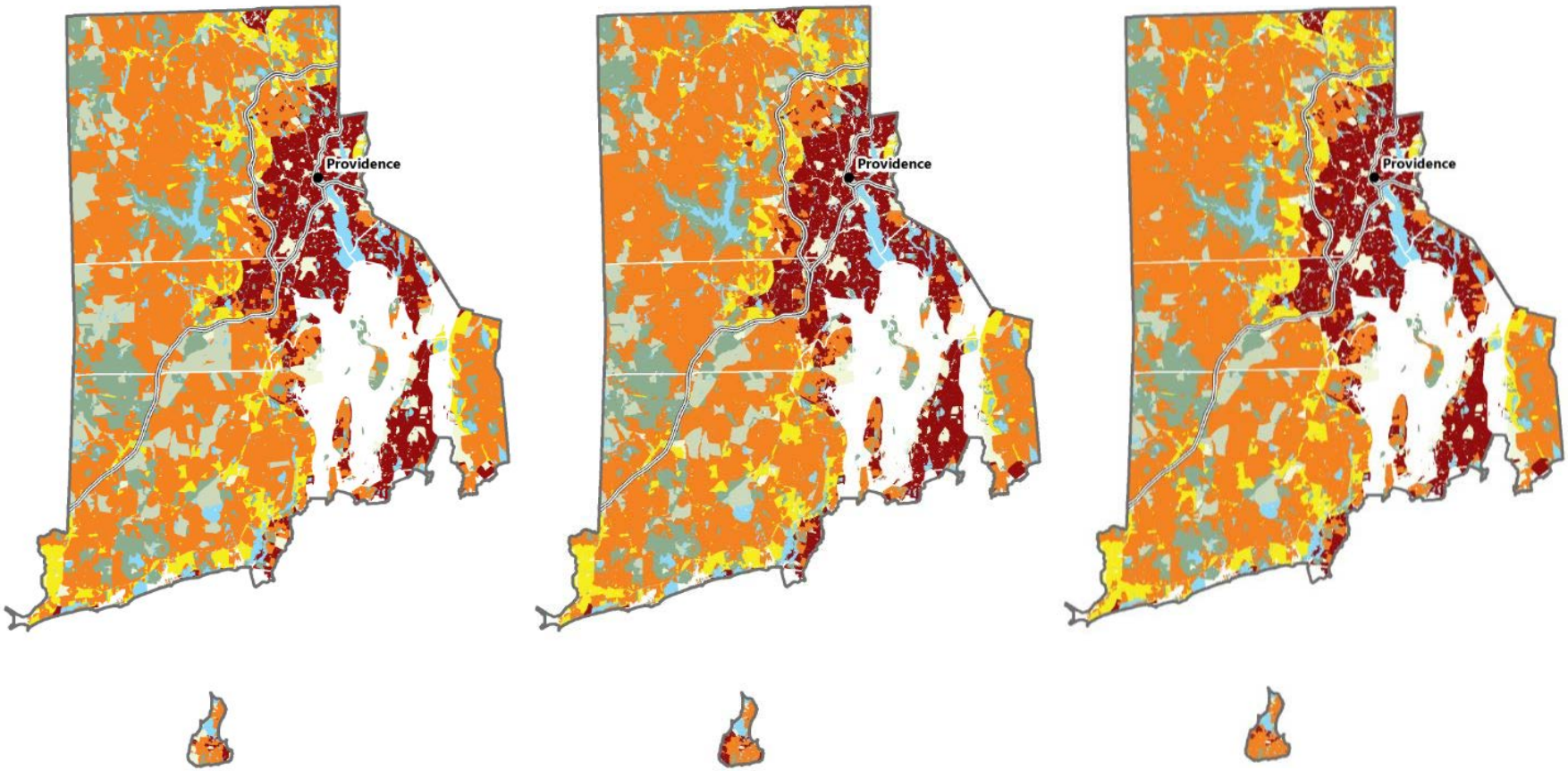


Forest Legacy Priority Areas

The *Forest Legacy Program* can be considered as the primary "land acquisition" element of the five Cooperative Forestry programs in Rhode Island and is a potential source of funding considered by the DEM Land Acquisition Committee. The program prioritizes significant forest tracts, watersheds for public drinking water, public open-space tracts and recreational areas, location of rare, threatened and endangered species and/or their habitats, and significant mineral resources. Forest Legacy also considers population growth statistics and communities identified as experiencing significant population increases. The Forest Legacy Program identified its two distinct priority areas in its 2020 document (see Appendix F):

1. Mainland – comprised of the forested and intermix areas on the west side of the state, and
2. East Bay – where some of the last forested tracts remain in eastern Rhode Island.

The basis for the four other cooperative program priority areas can be further described using data from Silvis Labs, University of Wisconsin-Madison. The maps on the following page show Wildland-Urban Interface (WUI) Change from 1990-2010. It is clear, even with the relatively coarse resolution, that while increasing interface (yellow) has been occurring in the more urbanized and highly populated areas of the state, the decrease of yellow in areas with no housing or very low housing (greens) is a result of conversion to intermix (orange). Besides protected, conserved, and state lands, Rhode Island has little land remaining that is unaffected by, or at risk from, human habitation or infrastructure in Rhode Island; there are few landowners, communities, and other stakeholders who are outside the priority target audience. Similar to the priority areas determined in 1993 for the Forest Legacy program, the forested areas of the state and their owners, comprising over 50% of Rhode Island, are significant for all DFE Programs. Landowner education, technical support for forest land management, management of state lands, and land acquisition comprise the outcomes of the Cooperative Forestry Programs delivered in Rhode Island.



Source: Silvis Labs, University of Wisconsin-Madison

MULTI-STATE PRIORITIES

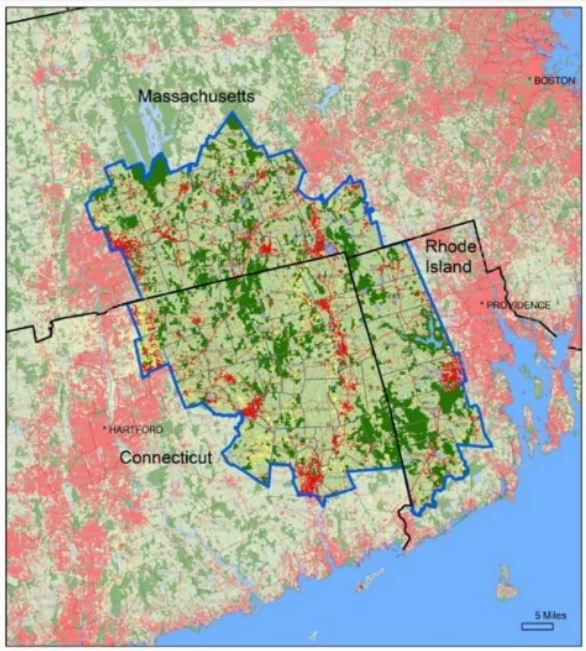
Rhode Island contributes to several multistate or joint efforts that involve RIDEM-DFE or its partners, whether federal, regional, or local. Some of these efforts are programmatic in nature, related to the cooperative forestry programs where shared efforts and grant proposals occur:

- Northeastern Forest Fire Protection Compact
- Eastern White Pine Multi-state LSR grant FFY2016
- Urban Forest Inventory Analysis

Other multi-state efforts involve multi-tasking stakeholders and partners who ably represent Rhode Island and ensure its regional representation and contribution:

THE SOUTHERN NEW ENGLAND HERITAGE FOREST REGIONAL CONSERVATION PARTNERSHIP PROGRAM (RCPP)

This Program is a partnership between the Natural Resources Conservation Service, The Last Green Valley, MassConn Sustainable Forest Partnership, and the Northern Rhode Island Conservation District (NRICD). The program's target area includes the Southern New England Heritage Forest (SNEHF) a 11.4 million-acre corridor where 76% remains forested. An analysis by Harvard Forest shows that by 2030, as much as 20-40% of this forest will be lost or fragmented to development.



Source: The Southern New England Heritage Forest

SNEHF's over-arching goal is to keep forests as forests, maintaining as much unfragmented, core forest as possible; a goal that supports both federal and state concerns.

Goals include: improve forest habitat for fish, wildlife, and invertebrate species of concern; support the recovery of endangered or threatened species and improve biodiversity; protect water quality and quantity; foster forest resiliency and stand diversity; and enhance air quality and carbon sequestration.

Funded through the USDA NRCS Regional Conservation Partnership Program, the program has funding for five years for work within Rhode Island:

- Identifying easement opportunities in perpetuity (13 applications, resulting in 3 projects), with restoration plans that incorporate threatened and endangered interior bird species.
- Incorporating Audubon bird surveys and habitat plans into forest management plans within the SNEHF, either new plans or incorporating the bird plans into existing plans.
- Implementing forest management plans (3rd phase of project not yet active).

INCREASING RESILIENCY IN SOUTHERN NEW ENGLAND OAK FORESTS

This program is a multi-state Landscape Scale Restoration grant awarded by the USFS to the Forest Stewards Guild in 2019. The RI Woodland Partnership (RIWP) was instrumental in developing the project and connecting with partners in neighboring states (MA and CT). Through education and outreach the project aims to:

- Increase forest stewardship activities that increase oak resilience;
- Empower natural resource professionals with tools for assessing oak forest health;
- Increase landowner awareness of regeneration challenges and solutions; and
- Foster communication between states and agencies about strategies for addressing oak forest resilience and regeneration challenges.

Besides the Forest Stewards Guild (FSG), partners include:

- CT Agricultural Experiment Station (CAES)
- CT Forest & Park Association (CFPA)
- University of Connecticut Cooperative Extension Service (UConn)
- CT Dep't of Energy & Environmental Protection (CT DEEP)
- MassConn Sustainable Forest Partnership
- MA Dep't of Conservation and Recreation Bureau of Forestry and Forest Fire Control Service Forestry Program (MA Forestry)
- MA Dep't of Conservation and Recreation Division of Water Supply Protection (Quabbin)
- RI Dep't of Environmental Management Division of Forest Environment (RIDEM DFE) and Division of Fish and Wildlife (RIDEM DFW)
- Providence Water Supply Board (Providence Water)
- RI Woodland Partnership (RIWP)

FOREST ECOSYSTEM MONITORING COOPERATIVE (FEMC)

FEMC is a multi-state cooperative effort to gather and synthesize trends in forest ecosystem health across the Northeast. The USFS funded program is housed at the University of Vermont where it provides resources to states, and supports ongoing research, monitoring, outreach and data synthesis. Rhode Island has recently joined FEMC and is required to maintain a state partnership committee to identify FEMC priorities and state needs. RIWP acts as the State Partnership Committee for Rhode Island, with its broad representation across the state, and with DFE represented on the FEMC steering committee.

STAKEHOLDER ENGAGEMENT

Stakeholder engagement in the development of this action plan included public input, partner review and stakeholder committees.

- Public input was solicited through a survey on the DEM Facebook page in 2019. Results are summarized in 2019 Public Survey & Responses.
- Preliminary reviews of the Assessment and Strategies sections by cooperative program partners: URI, DFW, RIWP, RITC, occurred in 2019 and 2020.
- Meetings with stakeholder committees in early-mid 2020, including State Technical Committee, Stewardship Committee, Fire Advisory Committee, DFW and RIWP. In many cases, people representing different groups were on multiple committees, and all partner groups were given the opportunity to provide input and feedback into the draft.

Public Input Summary

An electronic survey, adapted from the New Hampshire SFAP survey, requested input from the public and stakeholder groups made available for 6 weeks in summer of 2019. The survey was created on the www.wwufoo.com website and shared directly with groups and posted multiple times on DEM's Facebook page. DEM utilized Twitter and sent out a press release towards the end of the time frame to garner further participation.

Responses exceeded expectations with a response rate of 0.13% from an estimated 2019 state population of 1.06 million. 67% (863) of the respondents expressed one or more written concerns, ranging from tree removal for ground-mounted solar installations to climate change, water, deer browse, and garbage in state parks, in nearly 2,000 comments, whether a single word or a lengthy statement.

The comments could be organized into several main themes corresponding to DFE priority issues:

- Fragmentation
- Water Quality
- Forest Health (including deer and wildlife)
- Fire
- Climate Change

In addition, other themes of concern included:

- Private Land Management
- Actions, Policy & Legislation
- DEM & DFE Capacity & Funding
- Urban Forestry
- Education/Knowledge
- Solar
- Recreation

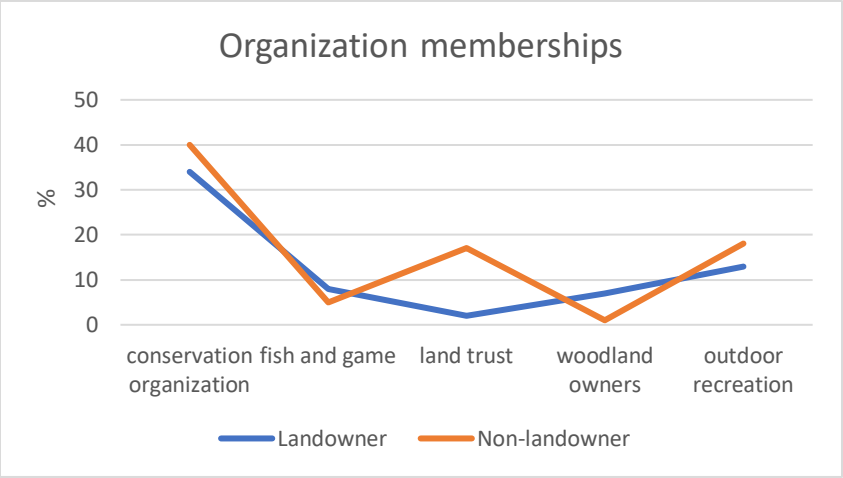
Many of these concerns are addressed within the DFE strategies and are part of the larger picture of holistic program delivery, where sufficient capacity exists. Other concerns expressed can only be acknowledged due to the existing DFE capacity, such as larger scale actions, policy and legislation, Department/Division funding, or solar issues. Some, like recreation, fall under the purview of multiple programs.

The following word cloud was created using the 100 most commonly occurring relevant words in the 1930 comments, after the most common words of forest(s) and tree(s) were removed.

Overall, responses between landowners and non-landowners were quite similar; however, there was no statistical analysis done on any of the results. Several identifying questions were asked, including land ownership and organizational memberships.

	Non-Landowners		Landowners	
# of Respondents	910	70%	383	30%
Club membership - 0	405	45%	178	46%
Club membership - 1	325	35%	124	32%
Club membership – 2 to 4	180	20%	84	22%

Level of organization memberships were similar between the two groups, although the breakdown of the groups varied somewhat. The most common combination of multiple memberships for both groups was conservation, land trust, and recreation.

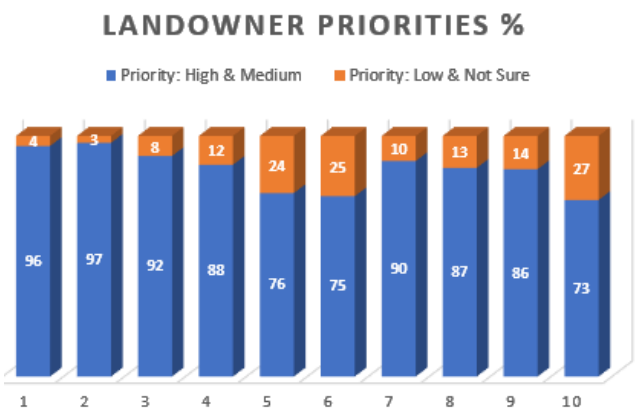


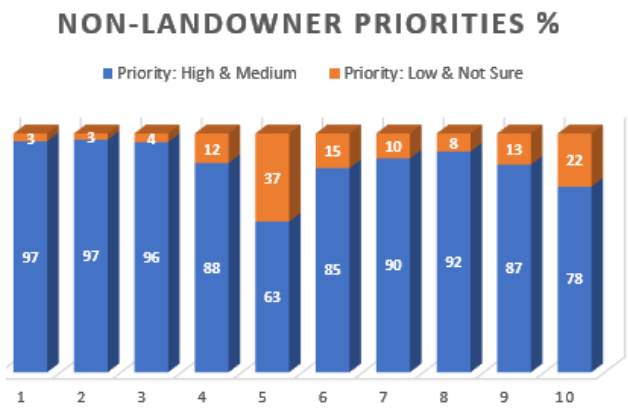
More non-landowners were members of land trusts. The other memberships were quite similar between the two groups, with even a few non-landowners being part of woodland owner groups.

The rest of the survey was comprised of 2 questions that required the respondents to prioritize the 10 listed challenges and 10 desired outcomes.

CHALLENGES TO ADDRESS IN RHODE ISLAND IN THE NEXT 10 YEARS:

1. Forest ecosystem health and biodiversity issues: e.g. invasive species, deer browse, species and age diversity, threatened and endangered species, natural disturbance, extreme weather.
2. Loss of forest land and increasing forest fragmentation.
3. Public values provided by forests: e.g. water, climate, carbon storage, forest products, recreation, education, culture.
4. Public land management challenges: e.g. staffing and funding for planning, maintenance, etc.
5. Challenges and opportunities facing private forest landowners.
6. Climate change.
7. Public awareness and support for funding for management of state forests and assistance to landowners and communities.
8. Funding for effective forest planning and policy (e.g. land use planning, use of open space lands, regulations).
9. Land use conversion pressures on public and private forests.
10. Urban forestry management capabilities in Rhode Island's communities.



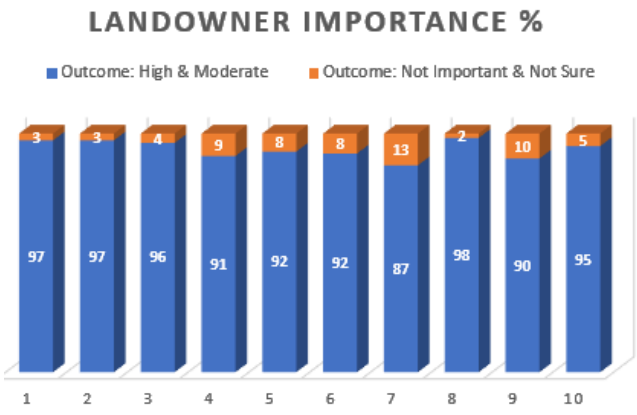


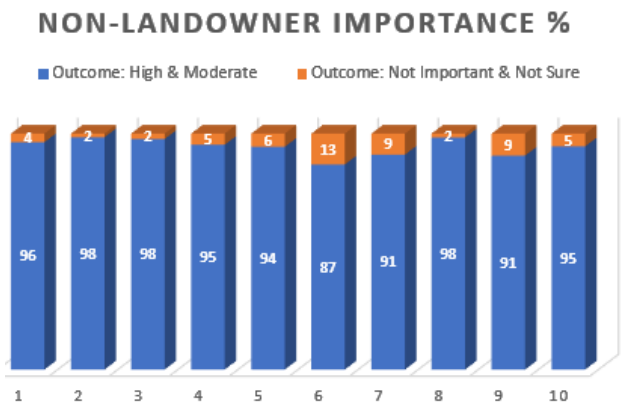
Forest health and diversity and *fragmentation* (# 1 and 2) were not only the two issues with the greatest support in both groups, but also garnered a substantial number of comments. People are concerned about where Rhode Island is headed and the lack of resources to address these issues.

The biggested difference between the two groups was that fewer non-landowners (63%) considered *challenges facing private landowners* (#5) to be a priority issue; although only 76% of landowners considered it a concern, which suggests a question to be explored. Non-landowners considered *climate change* (#6) to be more of a priority issue than did landowners (85% vs 75%). Overall, issues 5, 6 and 10 (*urban forestry capabilities*) garnered the most "low" or "not sure" votes. The differences in priorities between the two groups for the other priorities, were minimal. The results suggest that some demographically targeted messaging might be appropriate to increase understanding of the three lowest priority issues.

IMPORTANCE OF OUTCOMES TO THE FUTURE OF RHODE ISLAND'S FORESTS:

1. Businesses, public decision makers, the forestry community, and the public have the information they need to make informed decisions about the ecological integrity and sustainability of the resource.
2. Contiguous blocks of forest and working lands remain intact to provide environmental benefits and ecosystem services.
3. Landowners, resource professionals, and the public understand that forest lands contribute to the protection, availability, and sustainability of high quality, cost-effective drinking water.
4. Healthy and sustainable urban & community forests support livable, desirable, and ecologically healthy communities.
5. Residents and visitors support and understand the value of Rhode Island's forests: the benefits they receive from the forest and the relationship between a healthy environment and a healthy, vibrant forest-based and tourism economy.
6. Privately owned forest lands are supported to remain working lands for landowner, community, and state benefits.
7. Rhode Island forests contribute to mitigation of global climate change, managed for resiliency to climate change with minimal adverse environmental and economic impacts.
8. Rhode Island's forests are able to support healthy and sustainable populations of native plants and animals.
9. Residents and local fire departments are prepared for wildfires through planning, implementation, and response, reducing risks to people and structures; and protecting Rhode Island's forests and natural communities.
10. Rhode Island citizens and professionals are well prepared to respond to threats from invasive species; supporting adequate monitoring, response plans, and suppression programs to minimize the impact of invasive plants, insects, and diseases.





The ratings for the outcomes were even more similar and consistent between the two groups than the priorities, with 7 of the 10 outcomes within 0-2%. The outcomes with the greatest support were *healthy and sustainable plants/animals* (#8) and *contiguous blocks of working lands* (#2). These were narrowly followed by *resources needed to make decisions* (#2) and *importance of forests to drinking water* (#3) pointing to the concerns of residents and the need for decisive action and implementation of planning standards.

The outcome with the greatest number of "not important" or "not sure" reponses was *mitigating climate change* (#7), followed by *wildfire preparedness* (#9). Again, the results suggest that some targeted messaging might be appropriate to increase understanding of these issues. While large wildfires have not occurred with any severity for many years, smaller fires are frequent during the fire season and the possibility for larger wildfires has not decreased.

The intent of this survey was to narrow down or refine the priorities and concerns of residents, in order to identify the priority issues for DFE's next 10 years. It is apparent that the agency and the residents are in sync in what they see as threats to their state, communities, and ways of life. Clearly, many Rhode Island residents are not unaware of the interconnectedness of many of the issues and see effective leadership and action, and even funding, as necessary to protect the natural inland environment.

Stakeholder/Partner/Agency Input

RIDEM-DFE solicited input and feedback from various partner individuals and committees. Program partners provided input on the plan's accuracy, clarity, and perspective, prior to sharing with the larger committees.

- The DFE U&CF contracted report, The Value of RI Forests, which was written by the Rhode Island Forest Conservation Advisory Committee and RITC (also members of the RIWP), provided significant information regarding Rhode Island-specific resources and practices, context and insight, and are identified as contributing to this report.
- RI DEM's DFW and the Division of Planning & Development, which houses the Forest Legacy Program, provided initial feedback and input in the early drafts, as well as opportunity for input in later drafts, and are acknowledged for their contributions.

Due to COVID-19, stakeholder meetings were held virtually in the spring of 2020.

- A draft was shared with the Forest Fire Advisory Committee, and the Forest Stewardship Advisory Council was convened for feedback and comments:
    - RIWP, RITC, RIFCO, DFW, NRICD, URI, DFE
- The State Technical Committee and Division of Fish & Wildlife attended a shared meeting organized by RI NRCS.
    - NRCS, DFW, RI Land Trust Council, NRICD, RIRC&D

Federal Lands management agencies in Rhode Island include Naval Station Newport, which was not affected by this plan, and five coastal wildlife refuges. The person associated with the National Wildlife Refuges was given the opportunity to provide input on the plan.

Input from USDA Forest Service Region 9 federal program managers was provided in a preliminary review early February 2020, and a virtual introduction to the plan and further program manager feedback and initial requirements review in May.