Southwest New Hampshire NATURAL RESOURCES PLAN

2014

Prepared by the Southwest Region Planning Commission

SOUTHWEST NEW HAMPSHIRE NATURAL RESOURCES PLAN

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INTRODUCTION

The quality and accessibility of the Southwest Region's natural resources are an important component of how many residents and visitors define quality of life. When asked, "What do you like best about where you live?" residents frequently describe attributes of the Region's landscape - rural ambiance, clean water, scenic beauty, productive farms and forests, lakes and ponds, Mount Monadnock, etc. These rich and varied resources shape our sense of place and community identity. They serve not only as links to the past, but contribute to our health, well-being, and economic prosperity.

Yet, with this appreciation comes concern for the protection and sound management of these assets. As a rural area, we have not experienced the same degree of development and growth as other parts of Southern New Hampshire. While we are fortunate to have abundant natural resources, these resources cannot be taken for granted. If they were to disappear or degrade, much of what is valued about the Region would be threatened, and there would be significant impacts on public health and the economy. For these reasons and many others, it is important to care for and protect our natural and cultural resources to ensure that future generations can experience the same benefits from them as we do today.

Given the diversity of interests and values related to our landscape, establishing collective priorities for resource conservation and management is a challenge. Priorities range from maximizing the commodity value of resources to ensuring the availability of clean air and water to preserving scenic value and rural character. Management strategies must balance meeting diverse needs and uses of our resources and natural systems, with protecting them from current and future threats such as the loss of biodiversity and resource degradation as a result of human activities, development pressure, and the impacts of a changing climate.

To assist the planning process and facilitate dialogue among communities and others around natural resource protection and management, this Plan provides an overview of the significant conditions and trends, issues and challenges and opportunities facing the Region's diverse natural resources, and the infrastructure we rely on to safely access and utilize these resources. It is not intended to serve as a comprehensive inventory of or management plan for the Region's natural resources. Nor, is it intended to establish regional policy or regulation. It highlights strategies for communities, organizations, and others to consider in addressing natural resource, water infrastructure, energy, and climate challenges at the regional and local level. Additionally, it addresses opportunities for regional coordination and action, and outlines some of the many resources communities and others can use to advance certain objectives.

Plan Structure

This Plan is divided into six sections. Following an introductory section, there are four chapters that each explore a different theme.

- The first describes the Region's predominant natural resources (water, forest lands, air, wildlife, agriculture, open space) and highlights the most pressing challenges currently facing these resources.
- In the second, the needs and issues related to the Region's water infrastructure, including drinking water, waste water, and storm water, are addressed.
- The focus of the third is energy, specifically the efficient use, management and conservation of energy resources.
- The fourth reviews the predicted changes to our Region's climate and related impacts on the environment, public health, and economy.

Methodology

Much of the content of this document incorporates or builds on existing statewide and regional plans, reports and guidance documents. To better understand the current conditions, issues and needs related to the topics covered in this Plan, the Southwest Region Planning Commission (SWRPC) conducted a series of focus groups with regional stakeholders and knowledgeable representatives. These focus groups took place in the fall of 2013 and were organized around the topics of energy and climate change, working landscapes, natural resources, and water infrastructure. In addition, SWRPC staff utilized information collected and gathered through *Granite State Future*, a statewide initiative of New Hampshire's nine regional planning commissions, multiple state agencies and partners to develop long-range regional plans.

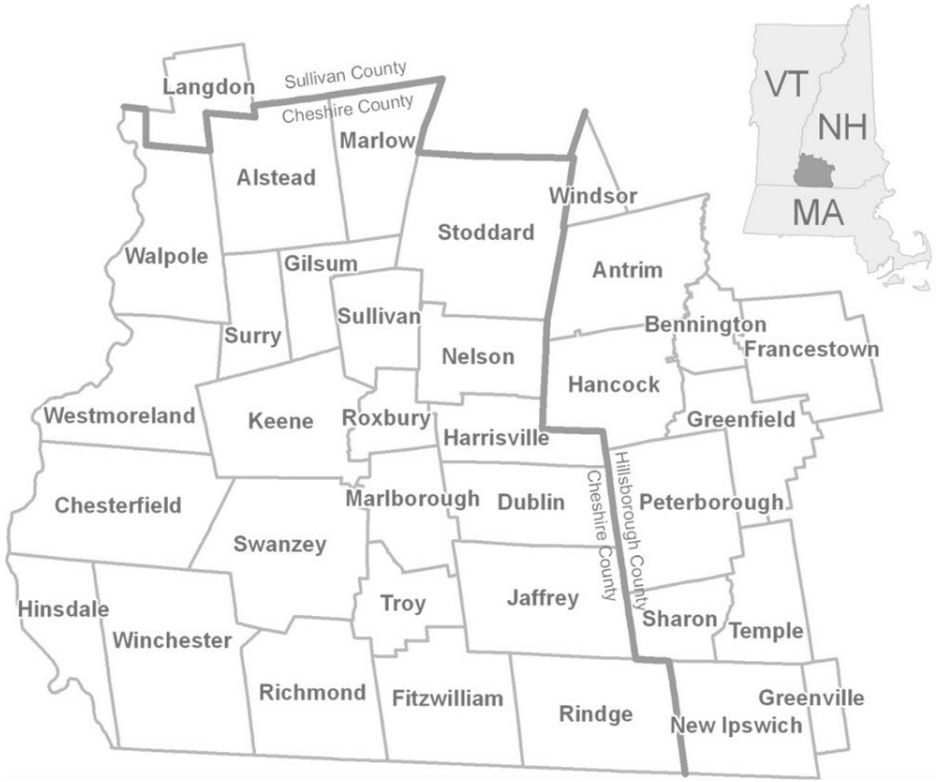
A portion of the data incorporated in this document was shared by the New Hampshire Department of Environmental Services for regional planning purposes. Data and resources were also shared by technical subcommittees formed to advise the *Granite State Future* initiative on topics such as climate change, energy efficiency, water infrastructure, and natural resources.

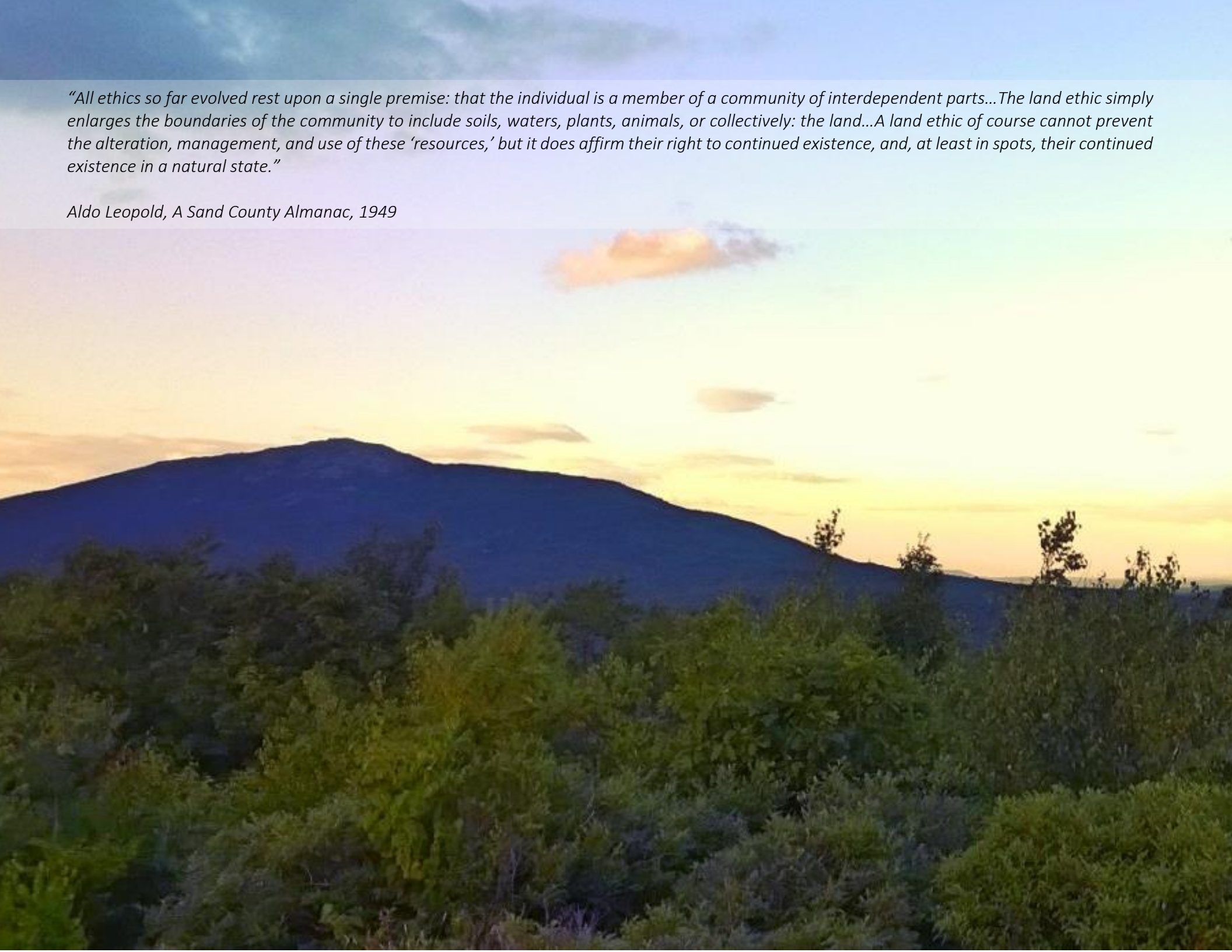
Regional Overview

The Southwest Region is geographically defined as the 35 municipalities in the southwest corner of New Hampshire that comprise all of Cheshire County and parts of Hillsborough and Sullivan Counties. According to the U.S. Census Bureau, there were 102,313 people living in the 1,007 square-mile region in 2010 - an overall population density of approximately 101 people per square-mile. Municipal populations range from 23,409 in the City of Keene to 224 in the Town of Windsor. Excluding Keene, the average population of communities in the Region is 2,321.

A central and defining feature of the Region is Mount Monadnock, which rises 3,165 feet above sea level. The Mountain and its highlands shape the landscape, which is comprised of rolling hills and valley floors. Forests cover 83% of this land with rural and suburban residential development emanating from village centers and small downtown areas. With the exception of Keene and other small downtown centers, much of this development is dispersed with one house for every ten or more acres.

Mount Monadnock and its highlands bisect the landscape into two sub-regions. One is dominated by the City of Keene as an employment, commercial and population center and the other is a more linear configuration of the Contoocook River Valley's population centers of Peterborough, Jaffrey, and Rindge.





"All ethics so far evolved rest upon a single premise: that the individual is a member of a community of interdependent parts…The land ethic simply enlarges the boundaries of the community to include soils, waters, plants, animals, or collectively: the land…A land ethic of course cannot prevent the alteration, management, and use of these 'resources,' but it does affirm their right to continued existence, and, at least in spots, their continued existence in a natural state."

Aldo Leopold, A Sand County Almanac, 1949

CHAPTER I. NATURAL RESOURCES

This chapter provides an overview of the significant conditions and trends, challenges and opportunities facing the Region's forest, water, air, wildlife, and agricultural resources. Each section provides a review of the various resource types and conditions, followed by an overview of some of the primary issues threatening the quality or availability of the resource in the Region. Potential strategies or options for addressing some of the challenges described are included as well as a sample of resources that communities and others can utilize in their planning and management efforts.

FOREST RESOURCES

In the Southwest Region, forest lands are a defining feature of the landscape and an asset for economic development and tourism. Forests, which cover approximately 83% of the Region's land area, play an important role in providing clean air, clean water, and essential habitat for plants and animals. Other roles of forestlands include protecting watersheds; reducing the impacts of floods; and, storing carbon from the atmosphere.

In addition to these ecosystem services, forests have significant economic value. They serve as a renewable and local resource for heating fuel and electricity generation and for products such as lumber and paper. Furthermore, they contribute to the scenic quality and rural character of the Region, drawing visitors from near and far to enjoy their beauty and changing colors and to participate in recreational activities such as hiking, hunting, mountain biking, cross country skiing, etc. New Hampshire's forest products industry totals nearly $1.4 billion annually, while the forest-based recreation economy is also worth approximately $1.4 billion each year.[1]

FOREST TYPES

There is a diversity of forest types in the Region, the predominant being the hemlock-hardwood-pine forest, which is comprised mostly of hemlock, white pine, beech, and oak trees. This forest type is the most common in the state and provides habitat for numerous species. Forest types are distinctive associations of trees, shrubs and herbaceous plants, named after the predominant tree species. Climate, elevation, soil conditions and land use history all have an impact on which forest type is growing in a particular area. The variety of tree species and ages present in a forest determines everything from the kinds of wildlife that can be supported to the threats it can withstand.

Other common forest types in the Region are Appalachian oak-pine forests, which are mostly found below 900 feet elevation along the Connecticut River and much of Cheshire County; Northern hardwood conifers, which occur mostly in the central and northern areas of the Region and are habitat for threatened species such as bald eagles and peregrine falcons; and, Lowland spruce-fir forests are found between 1,000 and 2,500 feet in elevation and provide habitat for over 100 vertebrate species including the state endangered Canada lynx and the state threatened American three-toed woodpecker and American marten.[2]

THREATS & CHALLENGES

The threats facing these forests and the services they provide are varied and complex; however, fragmentation, development, invasive species, disease, climate change and unmanaged forest practices are among the most critical. The sections below describe some of these challenges in more detail and outline potential strategies and opportunities for protecting and managing forests into the future.

Invasive Species & Disease

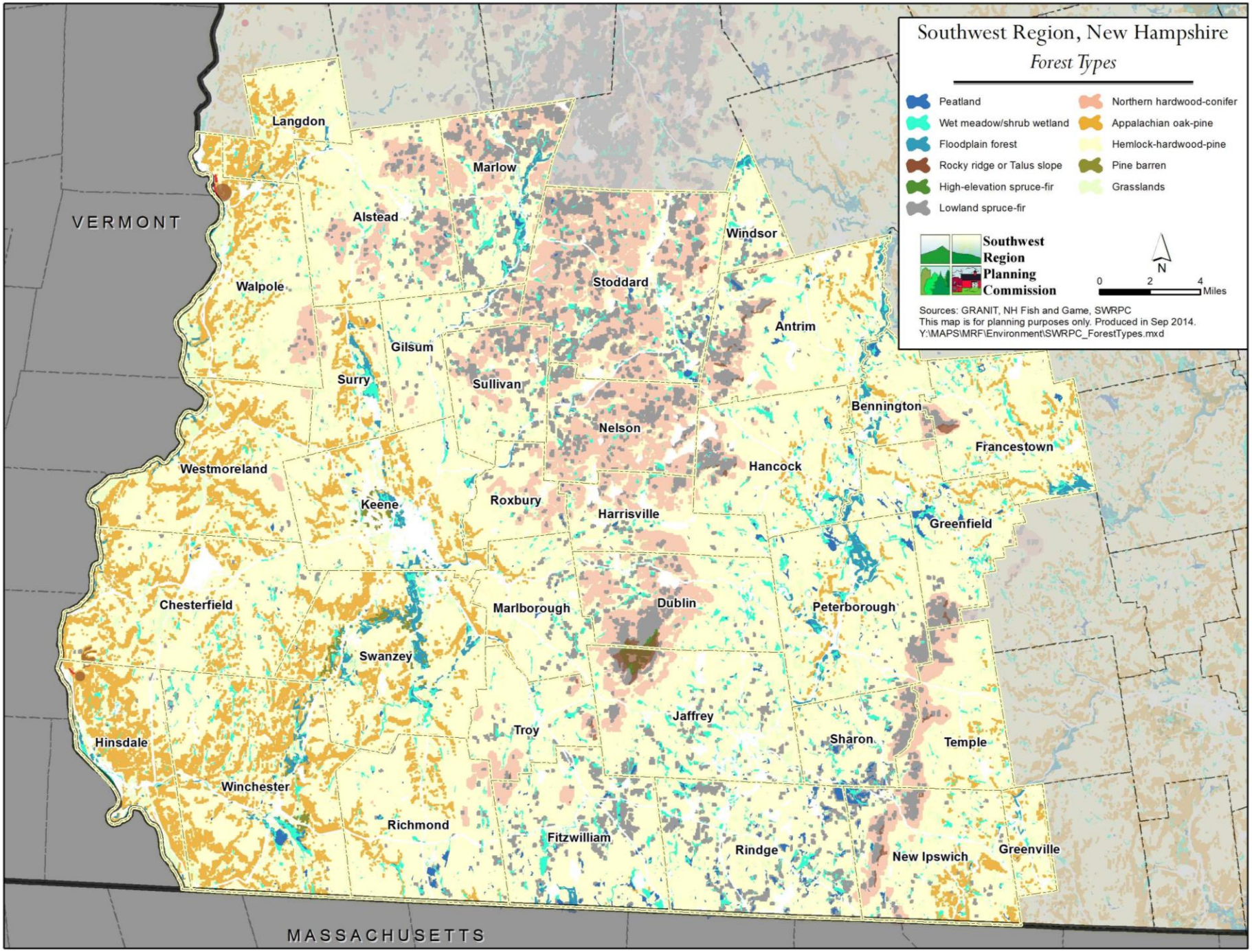
While native insects and pathogens are important in a healthy forest ecosystem, the introduction of some non-native species can cause excessive damage.[3] Non-native plants, animals, and other organisms (e.g. microbes) whose introduction to an ecosystem has the potential to cause environmental harm are called invasive species.

These species typically possess certain traits that allow them to be highly competitive and, in many instances, suppress native species. Invasives can become problems for forests when populations reach out-of-balance epidemic levels, which can lead to tree-growth loss and mortality. These outbreaks are often most devastating in areas where there are no natural enemies to these invasive species.

- Invasive insects that have impacted forest resources in the United States include the emerald ash borer, hemlock woolly adelgid, Asian long-horned beetle, gypsy moth, and pear thrips. Many of these non-native insects are introduced to an area through the transportation of firewood from an infested region. Although the Asian longhorned beetle has not yet been found in New Hampshire, the threat of findings in nearby states is a serious concern. This insect poses a serious risk to hardwood forests as it causes the death of many tree species and is difficult to eliminate.

From Top: Asian longhorned beetle, emerald ash borer, hemlock woolly adelgid infestation.

Map 1. Southwest Region Forest Types



The emerald ash borer, which bores distinctive D-shaped holes into trees, has not been reported in the Region; however, it was identified in Concord in 2013. Experts have estimated that this insect is responsible for the death of nearly 50 million ash trees since its discovery in 2002 in Michigan. The hemlock woolly adelgid is a small wingless insect that feeds on hemlock twigs and, if left untreated, can weaken and kill trees. Since 2001, more than 50% of the Southwest Region's municipalities have confirmed woolly adelgid infestations.

- Exotic diseases such as Dutch elm disease, chestnut blight, and butternut canker have nearly eliminated their host species in the state and across the nation. Tree diseases are often caused by pathogens such as fungi and bacteria that are spread by insects, wind and soil-borne organisms that move pathogens through soil moisture, taken up by tree roots and spread by grafts to other trees. Damage to the protective cover of tree bark from equipment (e.g. chain saws, graders) and from weather related events (e.g. wind and ice storms) can open the way for tree disease and decay. In addition, drought and, conversely, too much water can impact the health of a tree, weakening it to disease.

- Invasive plants are found in a variety of forms including trees, vines, shrubs, grasses, terrestrial herbaceous, and aquatic species. Many of these invasive plants become established in areas that have been disturbed either by natural or human means. Once established, invasive plants produce seeds or other propagules that travel by wind or water, animal transport or inadvertently through human activity and spread into other areas.

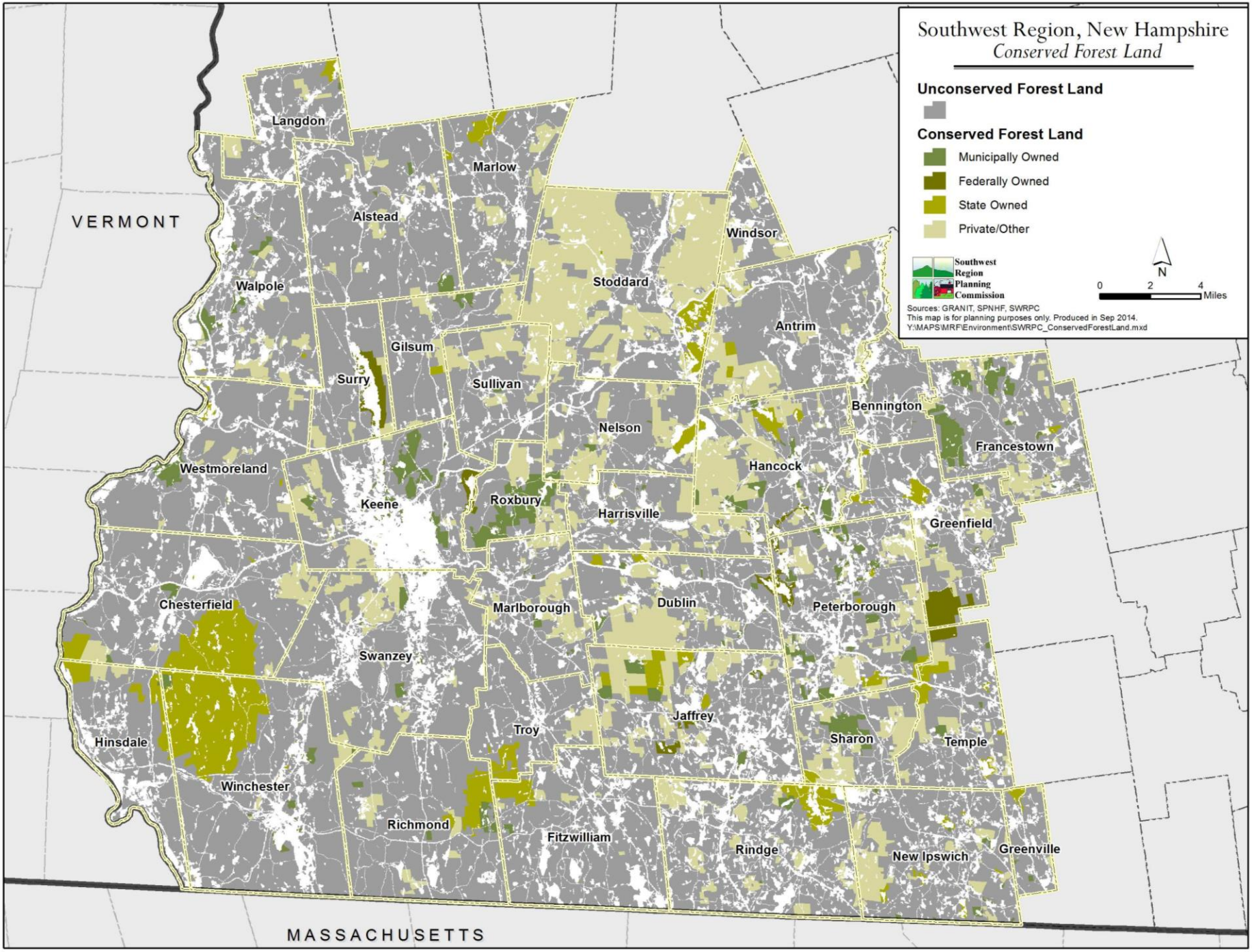
By outcompeting native species and disrupting ecological processes, invasive plants can displace natural plant and animal communities, altering species composition, increasing fire hazard, and decreasing the quality of forest habitats for native wildlife. In the state of New Hampshire, it is illegal to knowingly collect, transport, sell, distribute, propagate or transplant any living or viable portion of any plant species included on the state's list of prohibited invasive plant species. The complete list of these prohibited plants in included in Table 1.

In New Hampshire, some of the most troubling invasive plant species occurring within riparian zones include Japanese knotweed, glossy buckthorn and Asian bittersweet. These species shade-out natives, lower native plant diversity and reduce habitat value. In upland habitats, invasive species of concern include honeysuckle, glossy buckthorn, autumn olive and multiflora rose.[4]

Table 1. New Hampshire Prohibited Invasive Species List

Scientific Name	Common Name
Acer platanoides	Norway maple
Ailanthus altissima	Tree of heaven
Alliaria petiolata	Garlic mustard
Berberis thunbergii	Japanese barberry
Berberis vulgaris	European barberry
Celastrus orbiculatus	Oriental bittersweet
Centaurea biebersteinii	Spotted knapweed
Cynanchum nigrum	Black swallow-wort
Cynanchum rossicum	Pale swallow-wort
Elaeagnus umbellata	Autumn Olive
Euonymus alata	Burning bush
Heracleum mantegazzianum	Giant hogweed
Hesperis matronalis	Dame's rocket
Iris pseudocorus	Water-flag
Lepidium latifolium	Perennial pepperweed
Ligustrum obtusifolium	Blunt-leaved privet
Lonicera japonica	Japanese honeysuckle
Lonicera morrowii	Morrow's honeysuckle
Lonicera tatarica	Tartarian honeysuckle
Lonicera x bella	Showy bush honeysuckle
Microstegium vimineum	Japanese stilt grass
Polygonum cuspidatum	Japanese Knotweed
Polygonum perfoliatum	Mile-a-minute vine
Reynoutria x bohemica	Bohemia knotweed
Rhamnus cathartica	Common buckthorn
Rhamnus frangula	Glossy buckthorn
Rosa multiflora	Multiflora rose

Map 2. Southwest Region Conserved Forest Land



Development & Fragmentation

Although New Hampshire is ranked the second most forested state in the nation, its forested area is declining steadily. Each year the state loses approximately 13,000 acres of forest, about half the land area of an average sized town.[5] While this loss is most pronounced in the densely-populated southeastern portion of the state, the Southwest Region is not immune to this threat. Between 2010 and 2025, Cheshire and Sullivan Counties are each projected to lose 2% of their forest cover, while Hillsborough County is projected to lose 4%.[6] This decline is due largely to the conversion, parcelization and fragmentation of forestlands as a result of population growth and development.

The loss of large, un-fragmented blocks of productive forest to development can have significant long-term ecological and economic consequences. Five hundred acres of intact forest canopy can provide adequate habitat for some species, protect water quality, allow for sustainable forest management and offer opportunities for outdoor recreation.[7] Larger parcels of productive forest lands are important to ensure the economic viability of forest management and commercial forest interests in the Region.

Rising land values, increased population and changing attitudes have led to the parcelization of large tracts of forestland for residential and commercial development among other land uses. Many property owners note aesthetic and recreational enjoyment as the primary reason for owning forest lands with timber harvesting as a secondary goal.[8] In addition, the areas of the Region that contain the soils most productive for forests (lower elevations, valley floors and deep soils) also happen to be areas most favorable for development of roads, infrastructure and buildings.

Climate Change

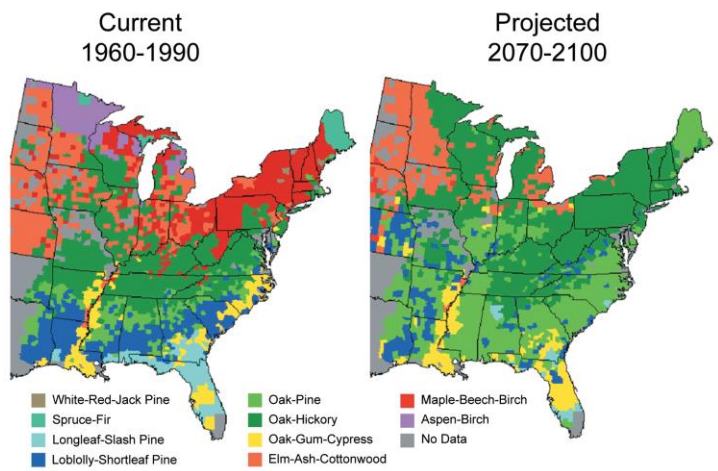
By the end of the century, the forested landscape may look very different from what it looks like today. Changes to the climate such as increased temperatures, changes to precipitation and threats of droughts are expected to greatly impact the Southwest Region's forests.[9] These changes will effect what kinds of tree species thrive or die off and will significantly impact the biodiversity and sustainability of forest ecosystems.

While certain trees and forests may flourish due to longer growing seasons and more abundant carbon dioxide, native boreal tree species such as spruce, fir, and pine are not expected to survive in a warmer climate and are predicted to migrate north. If current emissions of greenhouse gases persist, maple, beech and birch trees are also not expected to survive a warmer climate. These changes in forest types will influence the availability of habitat for certain species of wildlife and will likely impact the presence of certain bird species and mammals currently inhabiting the Region.

Increased temperatures are likely to bring invasive plant species and pests that the current forest is not accustomed to competing with or guarding against. Forests are expected to have higher fallen timber and slash due to increases in dying trees, the introduction of pests and extreme events such as periods of winter thaw followed by intense cold, spring and summer drought, and summer heat stress.[10]

These predicted changes will impact the economy as much as the forest ecosystem. According to the New Hampshire Forest Management Plan, forest related business (industrial, recreational, and tourist) contribute approximately $2.6 billion annually to the state's economy. This also accounts for approximately 7,200 forest-based manufacturing jobs, and 11,500 forest-based recreation jobs. The expected decline of sugar maple trees along will changes in the freeze and thaw cycles are expected to significantly reduce the quantity of maple syrup harvested. Statewide, maple syrup production is worth approximately $4 million annually.[11] Commercial forests will become more susceptible to pests, diseases, fire, and the die-off or migration of certain tree species. The loss of fall foliage will greatly impact the tourism industry and the revenue associated with foliage visitors, which is estimated to be approximately $292 million annually.[12]

Figure 1. Current and Projected Forest Types 1960-2100



The maps above show current and projected forest types. Major changes are projected for many regions. For example, in the Northeast, under a mid-range warming scenario, the currently dominant maple-beech-birch forest type is projected to be completely displaced by other forest types in a warmer future.

FOREST MANAGEMENT OPTIONS

Land Conservation

- To ensure the protection of large forest blocks and productive forest lands, there is a need for strategic land conservation efforts and for local policies that balance growth with conservation. Conservation efforts in the Region vary from community to community. There are approximately 164,072 forested acres in conservation in the Region, which is equivalent to 25.5% of the total land area.[13] Six towns have 40% or more of their total land area in conservation. These towns include Chesterfield, Gilsum, Richmond, Stoddard, Surry, and Westmoreland.

- Regional approaches to conservation of forestland are important for coordinating large, un-fragmented tracts of land; especially, where these lands cross over multiple jurisdictions.

- Some municipalities in New Hampshire have designated forest conservation zoning districts. These zones are intended to encourage the continuation of large contiguous tracts of forestland in private ownership to provide forest resources and outdoor recreation. The Town of Lyme created a Mountain and Forest Conservation District, which has a minimum lot size of 50 acres.

Inventory and Monitoring

- Forest resources should be included in natural resource inventories (NRIs), which are tools to identify and describe important naturally-occurring resources within a community, watershed or region. NRIs provide a strong foundation for informed decision-making and serve as a basis for land conservation planning. With respect to forest resources, an NRI can improve the understanding of available productive forestland, the extent of forest fragmentation, and the degree to which these lands are protected from development.

- Aside from prevention, early detection is one of the most effective management options for invasive plants. Surveying forest stands to determine whether invasives are present, mapping the location of identified infestations, and conducting ongoing monitoring are recommended practices to help detect and prevent the spread of invasive species and diseases in the Region's forests.

Best Management Practices

- Sound forest management, including the use of best management practices, is important to keep forest ecosystems healthy and resilient. Best management practices (BMPs) include a wide range of recommended techniques that can be used before, during, and after logging operations to protect water quality, wildlife habitat, soil integrity and productivity, aesthetics, and other aspects of the forests. While some BMPs may be mandatory, depending on the site, others may be voluntary. It is important to educate about and encourage the use of BMPs by woodlot owners, loggers, foresters and others involved in harvest operations.

- Forest management and BMPs will be important actions to adapt to climate change. One approach being discussed by foresters and scientists is to increase the forest's capacity to resist expected climate impacts such as pests, disease and wildfires. This approach could include thinning dense stands of trees, controlled burning, removing invasive plant and tree species and restoring native species.

- Another broad approach would be to increase the forest's resilience, which would provide the forest the capacity to function after climate change disturbances. Potential strategies might include ensuring that forests remain unfragmented so that trees can migrate more easily across the landscape as they adjust to new climate pressures, promoting diversity in species with planting programs, and reforesting after disturbances such as wildfires, disease or pest eradication.

Planning

- Communities can support conservation of forestland by developing visions for their forests and forestry, and express these as goals in their master plans. Communities can also develop open space and forest conservation plans that set priorities. An example priority would be to conserve the remaining large blocks of forestland and linkages between them within the community.

- In addition to conservation, forest management plans are an important part of sustaining forest health and vitality. A forest management plan can help a landowner meet their needs without negatively impacting productivity. Plans are typically developed by a licensed forester and can be as basic or complex as the landowner needs. A good forest management plan includes an inventory of species and size classes, location of critical wildlife habitats, notable areas (historic sites, scenic vistas, trails, etc.), soil types (including areas of compaction and erosion), and goals and objectives. Plans should be reviewed every 10 years and before timber harvesting or other management activities.

RESOURCES FOR COMMUNITIES

Some of the many resources available to communities and others in the Region related to forest resources and forest management are described below.

- *The University of New Hampshire Cooperative Extension (UNH CE)* helps citizens and landowners learn about and care for the state's forests, trees, wildlife and habitat through landowner visits, workshops, and professional and community assistance. The UNH CE website offers information on a variety of topics ranging from woodland management, to tree identification and care, invasive species, and forest related industries such as sawmills, logging, and wood energy. www.extension.unh.edu/Best-Management-Practices-BMPs

- *Society for the Protection of New Hampshire Forests (SPNHF)* is a non-profit organization dedicated to protecting the state's most important landscapes while promoting the wise use of its renewable natural resources. SPNHF provides assistance to land trusts, municipalities, state and federal agencies and other conservation organizations to protect open space in the state, promote good land stewardship through education and outreach, and advocate for public policies that encourage conservation of natural resources. www.spnhf.org

- *The Forest Management Bureau* within the NH Division of Forests and Lands is responsible for forest management activities on woodlands under state jurisdiction. The Southwest Region of New Hampshire has approximately 20,493 acres under the States' jurisdiction and care including Pisgah State Park, which is the largest State Park in New Hampshire with 13,361 acres. www.nhdfl.org/new-hampshire-state-lands/state-forest-management-program.aspx

- *The Monadnock Conservancy* is a regional private non-profit land trust whose purposes are to identify, promote and actively seek protection of lands with natural, aesthetic and historic significance in the Southwest Region, and to monitor and enforce the protection of lands in the Trust. www.monadnockconservancy.org/

- *The New Hampshire Timber Owners Association* is non-profit, statewide coalition of landowners, forest industry professionals, government officials, and supporters who work together to promote better forest management, conserve working forests, and insure a strong forest products industry. www.nhtoa.org

WATER RESOURCES

The economic well-being, public health, and quality of life in Southwest New Hampshire depend on the continual availability of high quality water resources. Whether it is needed for drinking, agriculture, wildlife, recreating, manufacturing, energy generation or ecosystem health, water is a vital resource. In order to ensure there is access to safe and reliable sources of water in the Region, now and into the future, proper management and protection of water quality and quantity is critical.

Compared to other parts of the country, the Southwest Region of New Hampshire has relatively abundant and clean water. Even so, there is a finite amount of water available each year. Approximately 43 inches of water falls in the Region as rain and snow annually, which ultimately drains to the ocean and evaporates back into the atmosphere.[14]

SURFACE WATERS

Approximately 3% of the Region, or 21,696 acres, is surface water (lakes, ponds, perennial streams). There are more than 3,000 perennial water bodies, ranging in size from less than an acre to 715 acres (Nubanusit Lake in Hancock and Nelson). Among the region's water bodies, there are 164 great ponds (water bodies 10 acres or larger) and 5,869 miles of shoreline including all rivers, lakes, ponds, and perennial streams.

Two major drainage basins, the Connecticut River and the Merrimack River, encompass the Region. The Connecticut River is the largest river in New England and runs along the border of New Hampshire and Vermont. Its watershed, which spans 11,250 square miles, drains 3,063 square miles in New Hampshire, about one-third of the state.[15] This basin covers approximately 60% of the Southwest Region. The Merrimack River Watershed covers 40% of the Region and encompasses a total 5,010 square miles in New Hampshire and Massachusetts. However, 75% of the watershed is located in New Hampshire.

These surface waters provide important habitat and travel corridors for wildlife and aquatic species; offer recreational opportunities such as boating, fishing, and swimming; and, are a major attraction for seasonal visitors and residents. A study conducted in 2002 determined that just four uses of NH's surface waters – boating, fishing, swimming, and drinking water supply contribute up to $1.5 billion annually in total sales to the state's economy and surface waters boost property tax revenue by an estimated $247 million per year.[16]

GROUNDWATER

Approximately 98% of the region's population is dependent on groundwater for their drinking water supplies.[17] The majority of residents (56%) rely on private wells to access water. Groundwater is water that resides beneath the surface of the land within bedrock fractures and between particles of soil and sediment. It is closely connected to surface waters, replenishing rivers, lakes and wetlands during dry periods. It provides an estimated 40% of total flow in the state's rivers, which in turn feed the state's lakes, reservoirs, and estuaries. Maintaining the high quality and availability of groundwater is important to protect public health and the environment.

WETLANDS

Wetlands are an integral part of our Region's water resources and are essential to the health of waterways and to flood prevention. In New Hampshire, a wetland is defined as "an area that is inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal conditions does support, a prevalence of vegetation typically adapted for life in saturated soil conditions (NH RSA 482-A)." Wetlands generally include swamps, marshes, bogs, vernal pools, and other similar areas.

Approximately 5% (32,370 acres) of the Region is classified as wetlands by the National Wetland Inventory of the U.S. Fish and Wildlife Service.[18] Of these wetlands, about 25% are conserved. The different types of wetlands in the Region include emergent wetlands (marshes, meadows, and fens), scrub-shrub wetlands (bogs), and forested wetlands (predominantly Red Maple Swamp).

It is important to note that not all wetlands are created equal and can vary widely because of differences in soils, topography, climate, hydrology, vegetation and other factors. However, there are important ecosystem functions attributed to these resources including water purification, sediment trapping, flood protection, shoreline stabilization, and recharge for both groundwater and surface water. They also provide food and shelter for a variety of aquatic and upland plants and animals. A 2002 study by the Clean Water Network estimated that the economic value of New Hampshire's remaining wetlands to be approximately $1.2 billion.[19]

THREATS & CHALLENGES

There is great connectivity among the different types of water resources in the Region and all are directly influenced by what happens on the landscape. Surface waters are a part of a larger ecosystem – the watershed, which is an area of land where all of the water that is under it or drains off of it goes into the same place. Within a watershed, surface and groundwater are generally connected as water flows across the landscape through waterways or vertically thorough layers of soil and substrate. Any activity that affects water quality, quantity or flow rate in one part of the watershed may affect locations downstream. While many of our water resources are relatively healthy and abundant, threats to clean and adequate waters are present and constant. Some of the more significant challenges to surface water quality and quantity faced in the Region are described in the sections below.

Non-Point Source Pollution

As water from rainfall and snowmelt flows over and through the ground, it absorbs and carries contaminants from many different sources, depositing them into lakes, rivers, wetlands, groundwater, and eventually the ocean. Once these contaminants, which can include chemicals (e.g. pesticides, petroleum), nutrients (e.g. phosphorous from fertilizers or faulty septic systems), pathogens (e.g. E. coli from animal wastes) and sediment (e.g. soils), enter waterways it is very difficult to identify their source of origin. For this reason, they are classified as non-point source pollution.

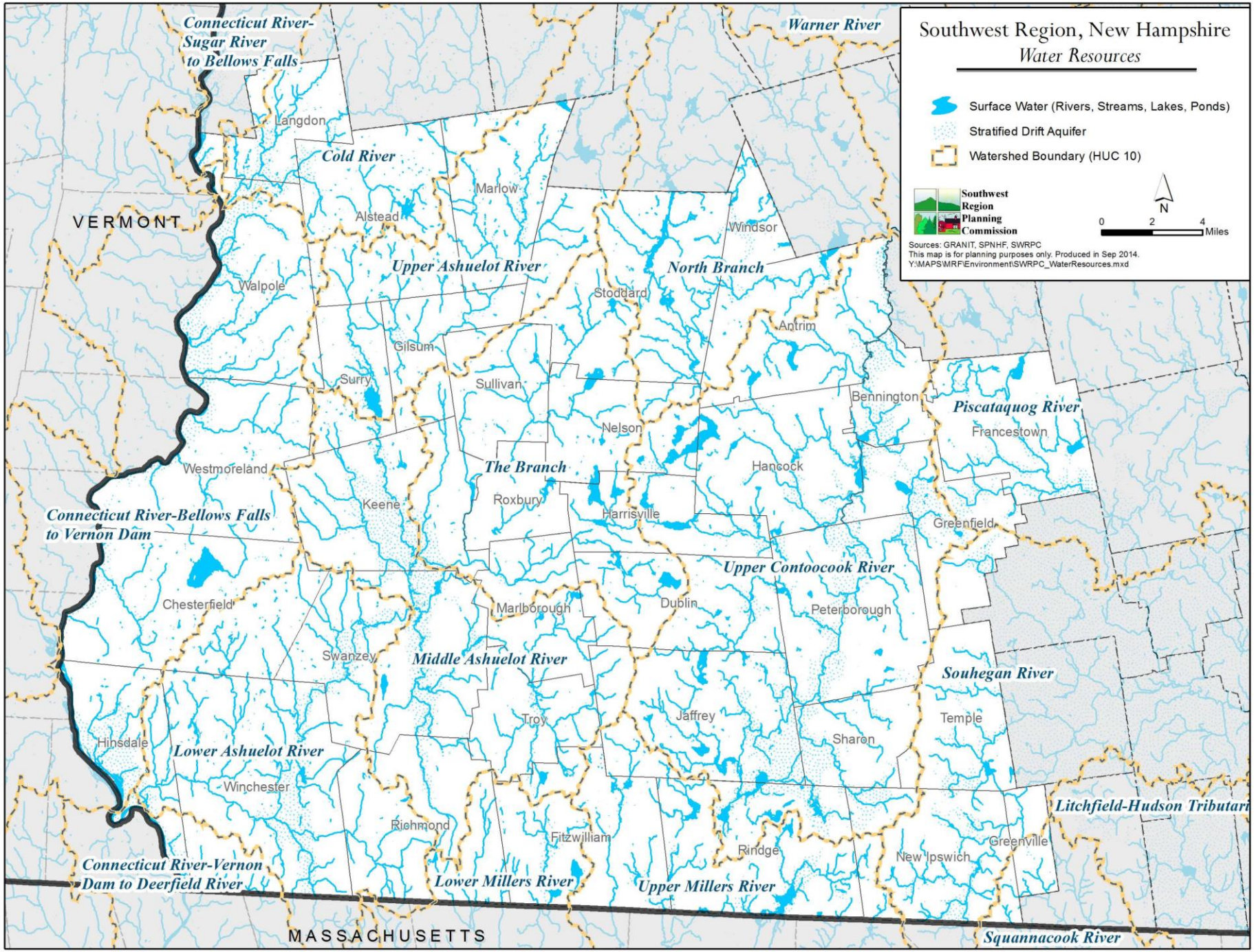
Non-point source pollution contributes to over 90% of water pollution in New Hampshire and is the leading cause of water quality problems in the United States.[20] While the effects of non-point source pollutants on specific waters vary, contaminants can have harmful effects on drinking water supplies, recreation, fisheries and wildlife.

Different types of contaminants impacting water quality in the Region include excess nutrients, sediments, pathogens, toxic contaminants, excess chloride, and thermal stress. Although many of these pollutants are naturally occurring substances, they can have negative impacts on aquatic flora and fauna in high concentrations. A few of these contaminants and their impact on Regional waters are described below.

- Acid Deposition - In the Southwest Region, the most common impairment to aquatic life in all water bodies is low pH. According to data from the NH Department of Environmental Services (NH DES), the five year average pH for the Region's water bodies is 6.4. The majority (70%) of aquatic life impairments in New Hampshire's lakes and ponds are due to pH values that fall below the minimum water quality standard of pH 6.5. Although surface waters in New Hampshire are naturally acidic due to the low acid-neutralizing capacity of granite bedrock, acidification caused by human activities has stressed most natural communities.

  Low pH is largely attributed to the deposition of acidic compounds, which are primarily from fossil fuel burning power plants and motor vehicles, from the atmosphere in the form of acid rain. Since 1991, New Hampshire has taken active steps to reduce emissions from within the state; however, the majority of emissions, which influence acid deposition in New Hampshire, originate from sources outside the state.

Map 3. Southwest Region Water Resources



- **Excess Nutrients** - Low dissolved oxygen and high total phosphorus and chlorophyll-a levels are typically caused by excessive inputs of nutrients, such as phosphorus, which can cause algae in lakes and ponds to grow faster than the ecosystem can handle. Eventually, as excess algae die off and decompose, the dissolved oxygen that fish and other aquatic organisms need to survive decreases. In some instances, algae blooms can produce toxins that are harmful to people and animals. High concentrations of chlorophyll are the number one impairment to swimming use in lakes in both the Region and state, followed by cyanobacteria blooms.

  Sources of excess nutrients include fertilizers, wastewater effluent, agricultural waste and sediments. Reducing the overall amount of nutrients entering our Region's waterways will help to improve the dissolved oxygen necessary for fish and other aquatic life and overall water quality.

- **Excess Sediments - Excess** sediments include sand and silt that erode from soil or are carried with storm water flows. Many contaminants attach to sediments and contribute to excess pollution in receiving waters. Excess sediments reduce water clarity and smother aquatic habitat. Sources of sediments include erosion from disturbed areas and construction sites, freshly plowed agricultural fields and road sand.

- **Excess Chloride - Elevated** chloride levels can create mineral imbalances for plants and animals in freshwater ecosystems. The main source of chloride in fresh water bodies is de-icing salts from winter road maintenance operations. In 2008, New Hampshire listed 19 water bodies impaired by chloride; in 2010 that number increased to 40. Trends shows that chloride levels continue to rise with increasing use of road salt.

Exotic Aquatic Species

According to NH DES, the fifth most common impairment to aquatic life for lakes in the Region is aquatic plants. Exotic aquatic species are aquatic plants or animals that are not naturally found in New Hampshire and were introduced from other areas. With no established relationships with native flora or fauna to keep their growth in check, these exotic plants often encroach upon and replace the habitats of native plants disrupting the food chain, stunting fish growth and degrading wildlife habitat.

Preventing infestations can be challenging as exotic plant fragments can easily attach to boats, motors, and trailers and can spread from one water body to another through transient boating activities. Managing infestations of these plants involves continuous control practices that can be costly and have negative ecological impacts. In addition, infestations can have detrimental effects on the ecological, recreational, aesthetic, and economic values of the Region's surface waters.

Below left: Freshwater algal bloom; Below right: Variable milfoil infestation

Over 40% of New Hampshire's water bodies are impacted by various species of exotic aquatic plants.[21] As of 2011, there were 11 water bodies in the Southwest Region with known infestations of exotic aquatic plant species.[22] By far, the most widespread of these species in New Hampshire is variable milfoil, which has infested approximately 64 water bodies in the state since the late 1960s.[23] Other problematic aquatic plant species include fanwort, water chestnut, Eurasian milfoil, purple loosestrife and didymo (*Didymosphenia geminate*).

Table 2. Common Impairments to Aquatic Life by Waterbody Type

Waterbody Type	Region	#1	#2	#3	#4	#5
Lake by count	Southwest Region	pH	Dissolved oxygen saturation	*Chlorophyll-a	*Phosphorus (Total)	Non-Native Aquatic Plants
Lake by count	New Hampshire	pH	Dissolved oxygen saturation	*Chlorophyll-a	*Phosphorus (Total)	Non-Native Aquatic Plants
Impound-ment by acres	Southwest Region	pH	*Dissolve d oxygen saturation	*Oxygen, Dissolved	2-Methylnaphthalene, Acenaphthene, Benzo(a)pyrene (PAHs), Benzo(a)anthracene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Chrysene (C1-C4), DDD, DDE, Deldrin, Endrin, Heptachlor, Indeno[1,2,3-cd]pyrene, Lindane, & Pyrene *~Many may tie from a single AUID with sediment data*	
Impound-ment by acres	New Hampshire	pH	Non-Native Aquatic Plants	Dissolved oxygen saturation	Phosphorus (Total)	Chlorophyll-a
River by miles	Southwest Region	pH	Oxygen, Dissolved	Benthic-Macroinverte brate Bioassesments (Streams)	Aluminum	Fishes Bioassessments (Streams)
River by miles	New Hampshire	pH	Oxygen, Dissolved	Aluminum	Dissolved oxygen saturation	Benthic-Macroinvertebr ate Bioassesments (Streams)

*Indicates a tied rank on a given row

Source: NH Department of Environmental Services, 2014

Development & Fragmentation

Water resources and aquatic ecosystems are subject to the same pressures and impacts from land use conversion and development as forests. Water quality degradation begins to occur when a watershed changes from its natural state to a more developed state (i.e. more impervious surface area such as paved roadways and parking lots, and rooftops).[24] The presence of forests and vegetation in a watershed helps improve water quality by reducing the volume and rate of water flowing over the ground from rain or snowmelt, allowing for greater infiltration into the ground. In addition, when more land in a watershed is covered with impervious surfaces, water flows more quickly at higher volumes, increasing the potential for flooding, erosion and sedimentation.

Natural vegetated riparian buffers – the undisturbed land bordering rivers, streams and other water bodies, are the most effective protection for the Region's surface waters. They reduce runoff, filter pollutants and provide transitional zones between aquatic habitat and human land use. Depending on the width and the vegetation in place, 50-100% of the sediments and nutrients from runoff can settle out or be absorbed by the buffer.[25]

Development pressures also have the potential to affect the flood storage benefit that wetlands provide. Wetlands that have been filled in or altered will reduce flood storage capabilities. The increase in impervious surface, along with severe storm events, magnifies the need to protect these areas. According to a study completed in 1990 of wetland losses in the United States, New Hampshire had lost 9% of freshwater wetlands statewide. A more recent 2004 analysis suggests that about 10% of non-tidal wetlands have been filled or drained for roads, residential development and industrial development.[26]

Climate Change

Within the Southwest Region, climate change is expected to put new pressures on water resources in a number of ways. A wetter Southwest New Hampshire will change the quantity of storm water flowing into water bodies, change water depths, and the time period in which water is introduced, stored and filtered in wetland environments. Depending on the location, existing wetlands may not be sufficient for absorbing extreme precipitation events that are expected to occur more frequently as a result of climate change. New wetland environments may occur naturally to respond to a wetter climate or they may need to be engineered to accommodate more direct precipitation and storm water runoff. Water quality in wetlands, lakes, ponds, rivers and streams are expected to be threatened by insufficient storm water design and increasing runoff. With more anticipated heavy rains, some rivers and streams are anticipated to change course and impact existing developed lands and cause severe erosion problems. Increases in temperature may upset the balance of natural water resource ecosystems.

Inventory and Monitoring

- Routinely collecting and analyzing information about the quality of the Region's water resources and watersheds allows for early detection of water quality changes and the ability to trace potential problems to their source. Water quality measurements repeated over time help determine long term water quality trends and identify where improvements or preservation might benefit the resource and the communities it supports.

- Although the Southwest Region is keeping pace with sampling its waterbodies as compared to the rest of the state, there is a long way to go before there is a complete picture of water quality. Within the Region, 39% of lakes and 35% of rivers have some data available from water quality testing and monitoring. Additional sampling will help improve the understanding of water quality in the Region.

- NH DES relies heavily on data collected by volunteers to assess the water quality of surface waters. The NH DES' Volunteer River Assessment Program (VRAP) and Volunteer Lake Assessment Program (VLAP) train volunteers in the use of water quality monitoring equipment to regularly collect samples from water bodies. The data is reviewed for quality assurance and entered into a database at NH DES. VRAP and VLAP are partnerships between NH DES, river and lake advisory committees, watershed associations, and individuals. Table 3 shows the list of lakes participating in VLAP in the Region. There are four rivers in the Region monitored as part of VRAP - the Ashuelot, Cold, Connecticut, and Contoocook.

- NH DES also relies on volunteers to routinely monitor for and identify the presence of exotic aquatic invasives in surface waters through its Weed Watcher program. Early detection is the best available strategy to prevent exotic aquatics from infesting surface waters.

- Another way to prevent infestations is through inspecting boats and trailers before they enter the water. As boats travel from one waterbody to another they risk introducing invasive aquatic species, which can attach to motors, trailers, fishing gear, etc., from an infested lake into an uninfested one. The NH Lakes Association administers a courtesy boat inspection program, through which paid and volunteer 'Lake Hosts' check boats for aquatic invasive plant or animal specimens before they enter and leave a waterbody.

Table 3. Southwest Region Lakes Participating in NH DES' VLAP

Lake	Town
Warren Lake	Alstead
Gregg Lake	Antrim
Spofford Lake	Chesterfield
Dublin Lake	Dublin
Laurel Lake	Fitzwilliam
Rockwood Pond	Fitzwilliam
Pleasant Pond	Francestown
Scobie Pond	Francestown
Norway Pond	Hancock
Chesham Pond	Harrisville
Childs Bog	Harrisville
Harrisville Pond	Harrisville
Russell Reservoir	Harrisville
Silver Lake	Harrisville
Skatutakee Lake	Harrisville
Contoocook Lake	Jaffrey
Frost Pond	Jaffrey
Gilmore Pond	Jaffrey
Thorndike Pond	Jaffrey
Stone Pond	Marlborough
Sand Pond	Marlow
Nubanusit Pond	Nelson
Pratt Pond	New Ipswich
Emerson Pond	Rindge
Monomonac Lake	Rindge
Pearly Pond	Rindge
Pool Pond	Rindge
Granite Lake	Stoddard
Highland Lake, North Station	Stoddard
Highland Lake, South Station	Stoddard
Island Pond	Stoddard
Chapman Pond	Sullivan
Swanzey Lake	Swanzey
Wilson Pond	Swanzey
Forest Lake	Winchester

Source: NH Department of Environmental Services, 2014

Collaboration & Planning

- Management plans can be an effective tool for protecting water quality. These plans, which can be for a lake, river, or watershed, are an effort to balance the multiple uses of water resources, while maintaining natural ecosystem structure and functions. Often these documents identify goals and action items for the purpose of creating, protecting, and/or maintaining desired conditions in a lake, river, or watershed. The process of developing these plans can involve multiple partners, including municipalities, lake and/or river associations, landowners, local and state agencies, and the general public.

- Planning for and managing water resources at the watershed scale is an important measure for resource protection. The interconnectedness of water, land and people within a watershed warrants a more comprehensive planning effort. Collaborating across multiple jurisdictions between diverse stakeholders can be a challenge to planning at this scale.

- Advisory committees are a resource to support and facilitate ongoing monitoring of and planning for water resources in the Region. Lake associations are voluntary organizations composed of people who own land on or near a lake. They provide a forum for residents to raise concerns, become educated about problems, and work towards solutions.

- In New Hampshire Designated Rivers are overseen by local advisory committees. These groups are tasked with developing and implementing a River Management Plan[27] and coordinating activities affecting the River on a regional basis. There are six Designated Rivers in the Region. These rivers, which include the Ashuelot, Cold, Connecticut, Contoocook and North Branch, Piscataquog, and the Souhegan, are managed and protected for outstanding natural and cultural resources in accordance with NH RSA 483, The Rivers Management & Protection Act.[28]

Best Management Practices (BMPs) & Low Impact Development (LID)

- BMPs are techniques and strategies to manage land or activities to reduce or prevent pollution of water resources. The use of use of LID and other types of BMPs can help reduce contaminants such as sediment and nutrients from entering waterbodies by minimizing erosion and soil disturbance, and decreasing the rate and volume of runoff from impervious surfaces such as roads and parking lots.

- LID is an approach to stormwater management that strives to reduce the impact of built areas and promote the natural movement of water within an ecosystem or watershed. Instead of conveying and treating stormwater off site using pipes and conventional infrastructure, LID focuses on techniques to infiltrate, filter, store, evaporate and detain rainfall close to its source. LID can be applied to new development, redevelopment, or as retrofits to existing development at all scales. Common LID BMPs include: bioretention, rain gardens, permeable pavements, vegetated roofs, and rainwater harvesting.

- The University of New Hampshire Technology Transfer Center has assembled information on appropriate BMPs to reduce the impact of Chloride from road salt on surface waters in the Region. These salt reduction BMPs include pre-wetting de-icing chemicals to reduce bounce and scatter of materials, calibrating salt spreading equipment to measure how much material is put down on the roads, applying anti-icing before precipitation begins, etc. The Center also offers a half day training course (Green SnowPro) focused on efficient and environmentally friendly winter maintenance practices.

- In 2001, the New Hampshire Department of Transportation (DOT) prepared the manual, *Best Management Practices for Routine Roadway Maintenance Activities in New Hampshire*. This guide identifies techniques to minimize the potential degradation and impacts to water quality of roadway maintenance activities. Roadway maintenance personnel should look to this guide to select practices that are appropriate to specific sites and conditions and employ the most responsive control measures for protecting the environment.

Policy & Regulation

- Sensitive areas can be protected or buffered from development impacts by establishing conservation overlay districts that prohibit or restrict development and certain land use activities in critical natural resource areas such as drinking water or wellhead source areas, wetlands, shoreland buffers, wildlife corridors, etc.

  The Innovative Land Use Planning Techniques handbook produced by the NH DES provides model ordinances that can be adopted at the municipal level to establish these overlay districts. This handbook includes ordinances and guidance information for the protection of groundwater and surface water resources, improved stormwater management, and erosion and sediment control.

- One of the simplest and most effective ways to protect surface waters is to leave an area of undisturbed vegetation adjacent to the water body, often referred to as a vegetated riparian buffer. These vegetated shoreland areas help slow the

flow of surface runoff and capture nutrients, sediments and other pollutants before they enter the water. The New Hampshire Shoreland Water Quality Protection Act (SWQPA) protects the shoreland areas of the Region's larger waterbodies (i.e. ponds greater than 10 acres and all 4th order and greater streams and rivers) from future development or disturbance. Some communities have adopted regulations that extend protection of the SWQPA to other streams and surface water bodies in the community not covered by the Act. Others have developed their own ordinances and regulations to address shoreland protection.

- While adopting ordinances and regulations can be an important measure for resource protection, they are most effective when local officials and residents adequately understand the restrictions they impose and the reason for doing so. Enforcing regulations can be especially challenging in communities where there is limited staff or a code enforcement officer.

Outreach and Education

- Having an understanding of how human and land use activities impact the quality and availability of water that we rely on for daily living is one of the best ways to protect water resources. Even the best plan for managing watersheds and controlling nonpoint source pollution cannot succeed without community participation and cooperation. Therefore public outreach and education of the importance of water quality protection is essential.

- How messages about water quality are communicated to the public is important for water resource protection. Outreach efforts need to effectively communicate the importance and benefits of protecting water resources and to inspire citizens to action.

Volunteer Support

- Currently, communities in the Region rely heavily on local volunteers or Regional organizations to work on environmental protection and resource management initiatives. There is a need to acknowledge and support the efforts of these volunteers and to encourage more involvement from diverse groups in a community such as youth.

RESOURCES FOR COMMUNITIES

Some of the many resources available to communities and others in the Region related to water resources are described below.

- *NH Department of Environmental Services (NH DES) Water Division* conducts a variety of programs designed to ensure the protection of the state's surface water and groundwater resources. Some of these programs include the Exotic Species Program, the Lake Management and Protection Program, the Watershed Assistance Section, the Rivers Management and Protection Program, the Wetlands Bureau, and the Shoreland Program. More information about NH DES programs and services is available on their website. des.nh.gov/organization/divisions/water/index.htm

- *NH Lakes Association* is a statewide nonprofit organization that serves as a source of information and resources about lakes and lake stewardship to lake/pond associations and watershed associations and other community groups through education and member services programs. www.nhlakes.org

- *NH Rivers Council* is a statewide nonprofit organization committed to the conservation and ecologically sound management of New Hampshire's rivers, watersheds, and related natural resources. It works to educate the public about the value of the state's rivers, designate rivers in the state's protection program, and advocate for strong public policies and wise management of the state's river resources. www.nhrivers.org

- *University of New Hampshire (UNH) Stormwater Center* is a research, testing, and educational facility, which serves as a technical resource to water managers, planners, and design engineers in the New England Region and throughout the United States. The Center hosts a field testing facility to test and demonstrate various stormwater management and LID technologies. www.unh.edu/unhsc

- *The Connecticut River Joint Commissions (CRJC)* is a partnership between the New Hampshire and Vermont Connecticut River Advisory Commissions with the goal of protecting and preserving the resources of the Connecticut River Valley, and to guide its growth and development. CRJC has informative resources on water quality protection and the Connecticut River through their website. www.crjc.org

AIR RESOURCES

The air we breathe is vital to quality of life in the Southwest Region. Breathing polluted air can cause respiratory problems, making it difficult for some to breathe; especially, individuals with asthma and other respiratory afflictions. Air quality not only affects public health and the natural environment, but also our economic performance as a Region. Loss of work and school as a result of illness caused by air pollution, damage to agricultural and forest products, and impacts of pollutants on breathability and visibility can have significant economic repercussions.

There are many complex and inter-related air quality issues facing New Hampshire and the Region. These issues include, but are not limited to, ground-level ozone, small particle pollution, regional haze (visibility), mercury contamination, climate change, acid deposition, and air toxics. Both human and natural actions contribute these types of air pollution; however, the latter is less common. Human activities include emissions from industries and manufacturing activities, burning fossil fuels, and household and farming chemicals. Natural events that pollute the air include forest fires, pollen dispersal, evaporation of organic compounds, and volcanic eruptions.

During periods of unhealthy air quality for ozone and small particles in New Hampshire approximately 92-100% of this pollution originates from sources located outside New Hampshire.[29] These pollutants are transported into the state with the wind over great distances. However, there are incidents in which unhealthy air is a result of local activities and sources.

THREATS AND CHALLENGES

While most air pollution in the Region is transported from outside areas, some comes from within the Region. Some of these local threats to the Southwest Region's air quality are described in the sections below.

Health Impacts of Radon Gas

Radon, a radioactive gas, occurs naturally, throughout New Hampshire, but it can be toxic in high concentrations. According to the United States Environmental Protection Agency (EPA), radon is the leading cause of lung cancer among non-smokers.

According to NH DES, elevated radon levels may be found throughout NH; however, the north, east and southeastern portions of the state tend to have elevated levels more frequently. The United States Surgeon General issued a Health Advisory stating that levels of 4 pCi/L[30] or greater should be remedied as soon as possible. The EPA's map of radon zones, shows Southwest New Hampshire counties having a predicted average indoor radon screening level between 2 and 4 pCi/L.

The primary source of radon is migration up from underlying rock and soil. Older homes with granite basements, which are common in the Region, are at greater risk of elevated radon levels. While testing for radon can be inexpensive, the cost to remedy a radon problem, such as improvements to a structure's foundation or drinking water aeration system, can be costly.

Fine Particulate Matter

Particulate matter (PM) is a general term for solid or liquid particles in the atmosphere. Fine particles less than 2.5 microns in diameter (PM 2.5), which is much smaller than the diameter of a human hair, can deeply penetrate the lungs affecting the health of people with heart and lung conditions. Fine particulate matter typically results from fossil fuel combustion and wood-burning.

Over the past few years there has been documented increases in small particle pollution in the Keene area during the winter. Scientific evaluations conducted by NH DES have targeted smoke from residential wood burning as the significant contributor to this issue. While the Keene area currently meet EPA's health based standards for small particle pollution, there have been instances where this standard is exceeded, particularly on calm, cold winter nights.

Pollution from wood stoves is a concern in the winter when cold, stagnant air and temperature inversions limit the vertical movement of air. A temperature inversion occurs when warm air traps cooler air at the ground level. This is particularly common in valley areas like Keene, which act as a "bowl." As small particles from wood burning and other sources are emitted into the air, the inversion traps these pollutants, similar to placing a lid on the bowl, affecting the quality of the air we breathe. Trapped small particle pollution can also seep into houses through closed doors and windows causing potential health issues.

Pollution of this sort is particularly a concern for people with existing heart or lung conditions or breathing difficulties. Very small particles that make up wood smoke can be inhaled deep into the lungs, collecting in the tiny air sacs where oxygen enters the blood. This can cause breathing difficulties and sometimes permanent lung damage. Inhalation of small particles can increase cardiovascular problems, irritate lungs and eyes, trigger headaches and allergic reactions, and worsen respiratory diseases such as asthma, emphysema, and bronchitis.

National Air Quality Standards

Poor air quality, particularly high levels of PM 2.5, can directly affect the regional economy through the impacts of national air quality regulations if imposed. Such regulations could result in putting the Region at a competitive disadvantage compared to adjacent areas and result in economic hardship.[31]
Under the federal Clean Air Act, if an area is not meeting EPA air quality standards, they must work with the state to implement steps to improve air quality. EPA's preferred area for non-attainment designation is a county. Therefore, a documented air pollution issue in one area could result in enforcement action for an entire county.

Examples of enforcement include stricter permitting and potentially costly controls on industry emissions and additional planning requirements for transportation-related sources. Local and state transportation departments would be required to coordinate planning to ensure transportation projects, including road construction projects, do not negatively impact air quality within designated non-attainment areas. This will require significant financial resources with no direct funding source.

Figure 2. How Air Inversions Impact Air Quality

AIR RESOURCE MANAGEMENT OPTIONS

Outreach & Education

- To better alert the public about current air quality, programs should be developed or continue that promote public awareness and education about current air quality, negative consequences, and proactive ways to improve air quality. In particular, more public education is needed to raise awareness of the health, environmental and economic implications for exceeding EPA's acceptable air quality limits.

- Communities in the Region can help in raising awareness by adding links to their website with information created and maintained by SWRPC, NH DES, EPA and others regarding air quality. They can include articles in community newsletters or as part of town mailings that can help educate the public on such matters. These articles can include information on recommended practices for improving air quality such as promoting the use of clean burning appliances as well as dry seasoned hardwood fuels, testing for radon gas in your home or business, avoiding vehicle idling, etc.

- NH DES maintains a web-based resource for the public to learn what the current air pollution levels are in all areas of the state. The Air Quality Forecast is available at: http://www2.des.state.nh.us/airdata/air_quality_forecast.asp. This information can be used to help citizens plan their daily activities with regard to air quality conditions.

- The Greater Keene Education and Outreach Campaign is an initiative to assemble and distribute basic science and messaging materials promoting proper wood burning practices throughout the greater Keene area. The Campaign includes partners such as Cheshire Medical Center, the Greater Monadnock Public Health Network, Keene State College, SWRPC, NH DES as well as business and community leaders.

Routine Monitoring

- Radon testing is routinely required by financial institutions at the time of inspecting a residential property for sale. This represents a good practice to inform residents of any potential for raised radon levels since radon is not detectable without laboratory analysis. In the event elevated levels of radon are present, radon remediation specialists are available to address and/or mitigate high concentrations of radon in the air or water.

- Since the 1960s, NH DES has operated a network of air quality monitors throughout the state to measure levels of ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide, particulate matter, and a number of other pollutants in the outdoor (ambient) air. Within the Southwest Region there are air monitoring stations in Keene and Peterborough. The data collected from these sites are sent to EPA for evaluation to determine pollutant trends and to see if levels of pollutants exceed air quality standards.

Wood Stove Change-out Programs

- Woodstove change out programs support the adoption of cleaner-burning stoves and heating appliances by reducing the cost of these appliances to the consumer. Funding these programs has traditionally come from federal sources, but other entities could sponsor and promote a woodstove change out. The use of cleaner burning EPA-certified appliances, wood pellets, and high-quality seasoned cord wood all reduce small particle air pollution by burning fuel more cleanly and efficiently than an uncertified stove or a lower quality fuel such as "green" or unseasoned cord wood.

RESOURCES FOR COMMUNITIES

- *NH Department of Environmental Services (NH DES) Air Resources Division* is responsible for achieving and maintaining air quality in New Hampshire and is committed to promoting cost-effective, sensible strategies and control measures to address the air quality issues facing the state. More information about NH DES programs and services is available on their website. http://des.nh.gov/organization/divisions/air/index.htm

- *Greater Keene Air Quality Education and Outreach Campaign is* a partnership of Cheshire Medical Center, The Greater Monadnock Public Health Network, NH DES, SWRPC, and Keene State College, to raise awareness about air quality issues, specifically small particle pollution, in the Keene area, and to share information about proper wood-burning practices. www.swrpc.org/airquality

- *U.S. Environmental Protection Agency (EPA)* is committed to improving air quality, and has developed national programs, technical policies and regulation for controlling air pollution in the United States. EPA's work on these issues fall under the Clean Air Act. More information and resources to help improve air quality can be found on their website. http://www.epa.gov/air/

WILDLIFE RESOURCES

Native fish and wildlife species are valued by residents and visitors for a variety of reasons. Some merely enjoy their presence while others rely on them for sport, food or income. For many, it is a combination of these factors that plays a role in their appreciation of this resource.

In addition to their recreational and economic benefits, fish and wildlife serve important ecological functions. The interactions between animals, plants, and microorganisms are vital to maintaining ecosystem balance and resiliency, and to the adaptability and long-term health of food supplies.

Within the Southwest Region there are many different types of habitat that provide food and shelter to hundreds of birds, amphibians, reptiles, fish and mammals. These habitats include floodplains, wetlands, forests, grasslands, rivers, ponds, etc. The amount and distribution of food, water, cover, and space in a specific habitat influences the types of wildlife that can survive in an area.

The most common habitat type in the Region is the hemlock-hardwood-pine forest, which provides habitat for numerous wildlife species such as the cerulaean warbler, bobcat, and black bear. Other types include the Appalachian oak-pine forest, which is found at lower elevations along the Connecticut River and in much of Cheshire County; the northern hardwood conifer forests, which occur mostly in the central and northern areas of the Region, and is habitat for threatened species such as bald eagles and peregrine falcons; and, lowland spruce-fir forests, which provide habitat for over 100 vertebrate species including the state endangered Canada lynx and the state threatened American three-toed woodpecker and American marten.

According to the New Hampshire Natural Heritage Bureau most of New Hampshire's landscape is covered by relatively common natural community types (i.e. groups of plants and animals that recur in predictable patterns under similar conditions). However, scattered throughout the state are distinctive communities found in few other places. These rare communities include animal populations identified as either threatened, endangered, or of special concern.

Threatened wildlife are those species that may become endangered if conditions surrounding them either begin or continue to decline. Endangered wildlife are native species whose prospects for survival are at risk because of loss or change in habitat, over-exploitation, predation, competition, disease, disturbance or contamination. Species that could become threatened in the foreseeable future are listed as "special concern." A list of the rare animal species recorded in the Southwest Region as of 2013 by the Natural Heritage Bureau is included in the Table 4.

Table 4. NH Natural Heritage Bureau's List of Rare Animal Species in Southwest New Hampshire

Species Type	Species Name	Town In Which Species Was Found / Identified	Status*
Ants & Wasps	Fen Ant	Francestown	N/A*
Beetles	Cobblestone Tiger Beetle	Walpole	State Endangered
Butterflies & Moths	Graceful Clearwing	Jaffrey	N/A*
	Phyllira Tiger Moth	Jaffrey	State Species of Concern
Dragonflies & Damselflies	Arrowhead Spiketail	Chesterfield	N/A*
	Big Bluet	Hinsdale	N/A*
	Blue-fronted Dancer	Hinsdale	N/A*
	Citrine Forktail	Hinsdale, New Ipswich, Surry	N/A*
	Ebony Boghaunter	Antrim, Greenfield, Nelson, Rindge	State Species of Concern
	Incurvate Emerald	Stoddard	N/A*
	Martha's Pennant	Antrim, Nelson, Rindge, Stoddard	N/A*
	Pygmy Snaketail	Antrim	N/A*
	Rapids Clubtail	Antrim, Chesterfield, Hinsdale	State Species of Concern
	Riverine Clubtail	Chesterfield, Hinsdale, Walpole	State Species of Concern
	Skillet Clubtail	Chesterfield, Hinsdale, Walpole	State Species of Concern
	Spatterdock Darner	Chesterfield, Surry	N/A*
	Spot-winged Glider	Swanzey	N/A*
	Tule Bluet	Hinsdale	N/A*
Mollusks	Dwarf Wedge Mussel	Hinsdale, Keene, Surry, Swanzey	Federal & State Endangered
	Eastern Pond Mussel	Keene	State Species of Concern
Amphibians	Jefferson Salamander	Chesterfield, Keene, Westmoreland, Winchester	State Species of Concern
	Marbled Salamander	Hinsdale	State Endangered
	Northern Leopard Frog	Swanzey	State Species of Concern
	Slimy Salamander	Rindge	N/A*
Birds	Bald Eagle	Antrim, Bennington, Chesterfield, Greenfield, Hancock, Hinsdale, Nelson, Surry, Walpole, Westmoreland	State Threatened
	Cerulean Warbler	Chesterfield, Hinsdale	State Species of Concern
	Common Loon	Antrim, Dublin, Francestown, Hancock, Harrisville, Jaffrey, Marlow, Nelson, Rindge, Stoddard, Sullivan, Keene	State Threatened
	Common Nighthawk	Keene, Marlborough, Marlow, Roxbury, Richmond, Sharon, Swanzey, Winchester	State Endangered
	Grasshopper Sparrow	Swanzey	State Threatened
	Horned Lark	Swanzey	State Species of Concern
	Osprey	Jaffrey	State Species of Concern
	Peregrine Falcon	Walpole	State Threatened
	Pied-billed Grebe	Antrim, Peterborough	State Threatened
	Vesper Sparrow	Swanzey	State Species of Concern
Fish	American Eel	Keene, Marlborough, Marlow, Roxbury, Richmond, Sharon, Swanzey, Winchester	State Species of Concern
	Banded Sunfish	New Ipswich, Peterborough, Rindge	State Species of Concern
	Northern Redbelly Dace	Alstead, Langdon	State Species of Concern
Mammals	Northern Long-eared Bat	Peterborough	State Species of Concern
	Small Footed Bat	Hinsdale, Surry	State Endangered
Reptiles	Blanding's Turtle	Fitzwilliam, Francestown, Hancock, Jaffrey, New Ipswich, Peterborough, Rindge	State Endangered
	Northern Black Racer	Francestown, Winchester	State Threatened
	Smooth Green Snake	Francestown, Marlow, Rindge, Surry, Winchester	State Species of Concern
	Spotted Turtle	Antrim, Francestown, Keene, Nelson, Richmond, Stoddard, Winchester	State Threatened
	Wood Turtle	Antrim, Bennington, Chesterfield, Fitzwilliam, Francestown, Hancock, Harrisville, Jaffrey, Keene, Marlborough, Marlow, New Ipswich, Peterborough, Roxbury, Richmond, Rindge, Stoddard, Sullivan, Surry, Swanzey, Temple, Walpole, Westmoreland	State Species of Concern

**Some species that are biologically rare in the state may not be listed as either endangered, threatened, or of concern.*

The New Hampshire Fish and Game Department worked together with partners in the conservation community to create the New Hampshire Wildlife Action Plan. Through this effort, the condition of wildlife habitats was analyzed by ranking the biological (e.g. rare plant and animal species), landscape (e.g. size and type of habitat) and human (e.g. pollution) impact factors most affecting each habitat type. All habitat types, including surface waters, in the state were assessed and ranked to identify those that are in the best ecological condition. The highest ranked habitat in the Region are colored in bright pink on Map 4.

Since the state is so ecologically diverse, habitats were also ranked within the state's 9 ecoregional subsections. The areas in bright green on the map indicate the highest ranked habitat within these ecoregions. Finally, the areas in tan show supporting landscapes, which are important to maintaining habitat condition. These habitat rankings were updated in 2010.

THREATS & CHALLENGES

Many of the threats described in preceding sections to our Region's forest, water and air resources have a direct impact on the health, abundance and diversity of wildlife species in the Region. How some of the threats that affect wildlife within the Region are described below.

Land Conversion & Development

According to the New Hampshire Wildlife Action Plan, the loss of habitat due to the conversion of land to other uses, like farming, commercial and residential development, and roadways is one of the greatest threats to wildlife in the state. Activities associated with development can result in the loss or fragmentation of habitats, wildlife mortality, nonpoint source pollution, introduced species, etc. For example, light pollution can expose animals to predation; nonpoint source pollution can degrade water quality and aquatic habitat; and, roadways can be barriers to animal movement.

Species or habitats with a limited distribution, restricted habitat requirements, and/or low population sizes are at greatest risk. Effects can be extensive and critical for some species such as the common loon, Blanding's and spotted turtles, and Jefferson salamander.

Invasive Species

Not only do invasive plant and animal species have an impact on forest and water quality, as described in previous sections of this document, they pose a significant threat to native wildlife. In the United States, approximately 42% of species on the Federal Threatened or Endangered species lists are at risk primarily because of invasive species.[32] Invasive species can cause harm to wildlife in many ways. Direct threats of invasive species include preying on native species, which may not have evolved defense against the invader or they cannot compete with a species for food or other resources. Indirect threats include destroying or replacing native food sources, altering the abundance or diversity of species and the conditions of habitats that are important for native wildlife.

Climate Change

Climate change, which has an effect on regional air and water temperatures, precipitation patterns, and storm intensity, will broadly impact species and habitats in New Hampshire. However, it's anticipated that impacts will be most severe for habitats with narrow temperature and water level regimes such as alpine, high and low elevation spruce fir forests, vernal pools, and aquatic habitats. Increased storm intensity, warmer periods, and droughts will stress many forest habitats and the wildlife dependent on them, and invasive species and diseases will likely become more problematic.

In addition, decreased lake ice duration and snow cover, and increased freeze-free periods will have an impact on many animal species. Snow depth and frequency are important factors affecting the American marten and lynx. Changes to lake ice duration and surface water temperatures will affect invertebrate and fish communities. The arrival dates of many species of migratory birds have shifted as much as three weeks earlier over the last several decades as the date of the last hard frost has become significantly earlier in New England.[33]

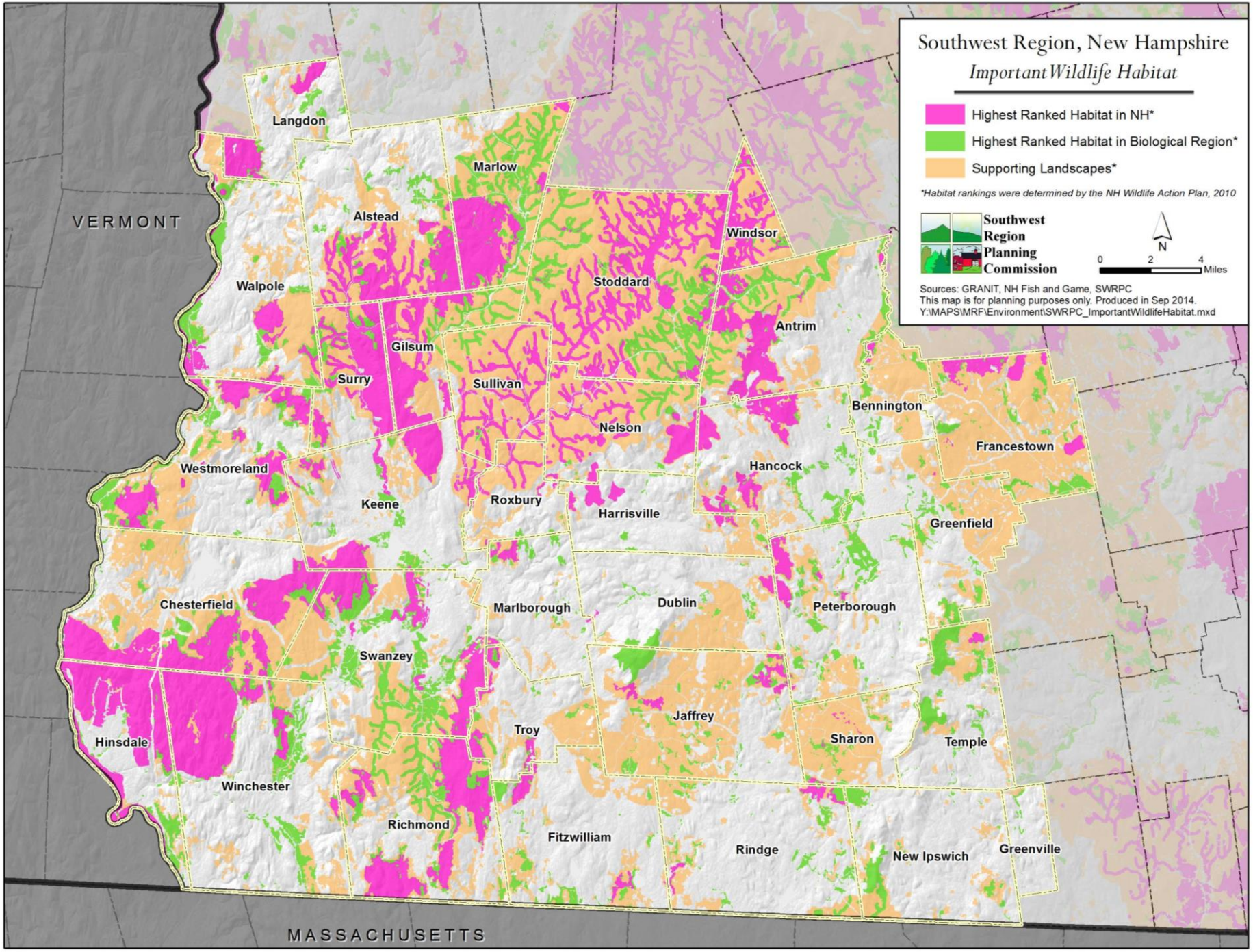
WILDLIFE RESOURCE MANAGEMENT OPTIONS

Land Conservation

- Land protection through conservation easements and acquisition ensures the long-term protection of wildlife resources and habitat. Approximately 23% of the Region's highest ranked wildlife habitat and supporting landscapes is currently in conservation through ownership by natural resource agencies, conservation organizations, municipalities or by permanent conservation easement. This land is distributed across the Region with large segments of conserved habitat in the areas encompassing Pisgah State Park in Chesterfield and Winchester, portions of the Wapack Range in Sharon, Mount Monadnock, and the Town of Stoddard.

- Land conservation efforts should be focused on connecting important habitats to facilitate the migration of species and support intact ecosystems. There should also be a focus on protecting large, unfragmented areas of diverse habitat types.

Map 4. Important Wildlife Habitat in Southwest New Hampshire



- The NH Wildlife Action Plan's assessment of highest ranked wildlife habitat and natural resource inventories conducted by communities can be useful resources in identifying which areas of the Region are most important to protect from future development.

Habitat Management

- Some habitats that have been impacted by development or natural processes such as succession (i.e. the change in plant species composition and structure over time) require periodic management or restoration to maintain their unique and diverse characteristics. Management often involves controlling the types, amount, or arrangement of food, water and cover within a habitat for the purpose of making it more suitable for a specific species or group of species.

- Effective habitat management often requires the use of an array of tools or activities. Depending on the objective or site condition, these can include everything from backyard landscaping to improved habitat for songbirds to replacing culverts to restore stream flow and wildlife passage to using best management practices to reduce the impacts of tree harvesting on sensitive habitats.

- There are numerous resources available for both public and private land owners seeking to improve wildlife habitat. The New Hampshire Forestry and Wildlife Program has been a model partnership between the New Hampshire Division of Forests and Lands and the New Hampshire Fish and Game Department to ensure that forest practices on state lands can help enhance wildlife habitat. The National Resource Conservation Service offers financial assistance to landowners who want to develop and improve wildlife habitat on agricultural land and nonindustrial private forestland. The University of New Hampshire Cooperative Extension provides technical assistance and guidance to private land owners on how to identify and improve wildlife habitats on their property.

- For owners of property larger than 25 acres, the NH Fish and Game Department's Small Grants Program, can be an opportunity to help finance the creation and/or maintenance of wildlife habitat within the property.

RESOURCES FOR COMMUNITIES

Some of the many resources available to communities and others in the Region related to wildlife resources and wildlife management are described below.

- *NH Fish and Game Department* works in partnership with the public to conserve, manage and protect the state's fish, wildlife and marine resources and their habitats. The Department also works to inform and educate the public about these resources. www.wildlife.state.nh.us

- *NH Audubon Society* is focused on protecting and restoring New Hampshire's natural environment for wildlife and for people. The nonprofit organization provides conservation and education programs, research and wildlife monitoring, and protection of nearly 8,000 acres of wildlife habitat in 38 sanctuaries across the state. www.nhaudubon.org

- *Natural Resource Conservation Service (NRCS)* works cooperatively with soil conservationists and scientists, agronomists, engineers, economists, biologists, foresters and others to help landowners and land users with conservation. www.nrcs.usda.gov/wps/portal/nrcs/main/nh

- *NH Natural Heritage Bureau* finds, tracks and facilitates the protection of New Hampshire's rare plants and exemplary natural communities. It is a bureau within the NH Division of Forest and Lands within the NH Department of Resources and Economic Development and is a service to help landowners and land managers protect the state's natural heritage while meeting their land use needs. www.nhdfl.org/about-forests-and-lands/bureaus/natural-heritage-bureau

- *University of New Hampshire Cooperative Extension (UNH CE),* in partnership with NH Fish and Game, has developed a series of tools to help municipalities plan and implement projects that protect, conserve, restore or manage wildlife habitats. extension.unh.edu/fwt/tafw/CommunitiesTakingActionforWildlife.htm

- *The Monadnock Conservancy* is a regional private non-profit land trust whose purposes are to identify, promote and actively seek protection of lands with natural, aesthetic and historic significance in the Southwest Region, and to monitor and enforce the protection of lands in the Trust. www.monadnockconservancy.org

- *The Harris Center for Conservation Education* is a nonprofit organization dedicated to promoting understand and respect for the natural environment through education, direct protection and stewardship of the Region's natural resources, conservation research, and programs that encourage participation in the outdoors. www.harriscenter.org

- *The NH Land and Community Heritage Program (LCHIP)* is an independent state authority (NH RSA 277-M) that makes matching grants to communities and non-profits in the state to conserve and preserve New Hampshire's most important natural, cultural, and historic resources. Since the program started in 2000, over 260,000 acres of land have been conserved, and 142 historic structures have been preserved or revitalized statewide.

AGRICULTURAL RESOURCES

The Southwest Region has a rich history and tradition of agriculture that continues today. Like other parts of the state, the Region has seen the number of farms diminish over the past fifty years. However, there are many areas that retain vibrant and diverse agricultural operations from commercial enterprises to hobby farms. In recent years, Cheshire County has experienced a substantial increase in the number of acres of land in farms. In 2012, there were 22,036 more acres of land in farms in the County than in 2002, a 53% increase. Yet, there are still 35% fewer acres of farms and 131 fewer farms in Cheshire County than there were in 1959.[34]

Productive farming is dependent on the presence of healthy, high quality soils. The United States Department of Agriculture's (USDA) Natural Resource Conservation Service (NRCS) has developed a classification system to identify those soils most suitable for farming. These classes include prime farmland, unique farmland, farmland of statewide importance, and farmland of local importance. Prime farmland is defined as land that is best suited to produce food, feed, forage, fiber, and oilseed crops and is also available for these uses. These soils are of the highest quality and can economically produce sustained high yields of crops when treated and managed according to acceptable farming methods. Unique farmland is land other than prime farmland that is used for the production of specific high-value food and fiber crops (e.g. apples, raspberries, blueberries, pumpkins). Land that is neither prime nor unique but important for the production of food, feed, fiber, forage and oilseed crops in New Hampshire is classified as farmland of statewide importance. Farmland of local importance is determined on a county-wide basis by the County Conservation Districts.

The benefits of these agricultural resources are vast. Farmland soils have many desirable qualities including a moderate pH, fine textured particles, infrequent flooding during growing season, deep bedrock depth, gentle slopes and few surface stones. Agriculture and related activities contribute to local and state economies through the sale of farm products, job creation, support services and businesses. In addition these working landscapes are important to an area's rural character, heritage, tourism, and the provision of ecosystem services such as wildlife habitat.

In New Hampshire, the best agricultural soils comprise only 6.6% of the state's total land area. In terms of farm acres, that amounts to approximately 380,000 acres statewide. Of the 49,300 acres of prime farmland and farmland of statewide importance in the Southwest Region, 7.5% is developed, and only 10.5% is conserved from future development.[35]

THREATS & CHALLENGES

Although there are many benefits to agriculture, there are some significant challenges. The sections below explore some of these issues in greater detail.

Loss of Farmland to Development

Agricultural soils have, and will continue to be, desirable for development. The features of these lands, which are generally clear of forest and have relatively flat terrain, are well-suited for most types of development. Because of this suitability, farmland often has a greater market value for future residential or commercial development than for farming. These high land values can make selling agricultural lands to developers an attractive option. It can also impose pressure on the Region's farms to generate incomes substantial enough to justify keeping the land in agriculture.

During the latter half of the 20th century, development pressure as a result of high population growth led to the conversion of thousands of acres of farmland to residential and commercial development. In 1945, 146,722 acres or 31% of Cheshire County was land in farms. In 1992 this number decreased to 33,935. However, a resurgence of interest in and support for local agriculture in the past decade has led to an increase of land in farms, with 63,292 acres or 14% in 2012.[36]

Generational Changes and Economic Viability

The long-term viability of agriculture in the Region depends on profitable farms that can support individuals and families and be passed on to future generations. As mentioned in the previous section, it can be a challenge for some farmers to generate enough income to support highly valued agricultural land. According to the 2012 Agricultural Census, the average net cash income of farm operations in Cheshire County was $3,047, and 295 of 407 farms reported net losses.

It can be economically challenging for younger farmers to either start a new enterprise or to take over an existing farm. In comparison to many other occupations offering more money, less risk, and better benefits, farming is not always the most attractive or viable option for employment. Of the 4,391 principal operators of farms in New Hampshire in 2012, only 201 (4.6%) were 34 years or younger. In contrast, 30.5% were 65 years or older.

Land Use Regulations

Agriculture, which often involves multiple land uses and is located where resources such as suitable soils and adequate water are available, is not easy to regulate via traditional zoning methods. Although many farms are commercial enterprises, they do not operate like most businesses. Most farms support residential housing onsite for farm owners, employees, and/or families. However, it is also common for them to have roadside signs and farm stands to advertise and sell their produce. Farms may also diversify their operations by supporting home-based or sideline enterprises such as making jams from fruit or wreaths from dried plant materials, or harvesting of timber or cordwood. They can also cause noise from truck traffic or the use of heavy equipment, and/or odor from the spreading of fertilizers and manure. It can be challenging to develop a zoning district that is flexible enough to meet both the needs of an agricultural enterprise as well as the needs of surrounding land uses, which is often residential development.

Climate Change

There are a number of climate change conditions that are expected to greatly impact agriculture, including changes to temperature, levels of carbon dioxide, sea level rise, and relative levels of precipitation or drought. All of these factors will affect the Southwest Region's ability to produce food locally, as well as the resilience of the global agricultural system. The effect on the global agricultural system is a key concern, because most of the food that the Region consumes comes from other parts of the world. More warming, more water evaporation, more droughts and more severe storm events will put new pressures on agriculture worldwide. Specifically, changes in climate patterns may make for an unstable food market with more crop failures.

There are a number of climate change risks to agriculture that are anticipated to affect the Region. Locally, the Region is expected to face challenges to crops and livestock well-suited to the traditional New England climate including maple syrup, blueberries, apples and dairy products. While some traditional foods may not survive climate changes, other warmer weather crops may be able to be introduced into the Region. Although there may be new opportunities to grow warmer weather crops, scientists also anticipate the in-migration of new pests and invasive species, causing new management problems and costs for area farmers and local gardeners. The in-migration of new pets, invasive species and diseases could lead to increased use of pesticides, herbicides and insecticides, introducing potentially dangerous chemicals into our soils and groundwater.

The global food system that we depend on in the Southwest Region could severely influence availability of foods and food costs. More excessively hot days are expected to increase the risk of endangering livestock health and survival globally, which could diminish the supply of meats and other byproducts from livestock such as dairy products and eggs as well as drive costs for those products up. Drought events and erosion, already reported with frequency around the world and in the United States'

more agricultural states, will challenge the agricultural sector's ability to deliver and process crops and livestock to consumers. At the same time, the US and global population are anticipated to continue to grow, increasing demand for agricultural production. These factors may translate into Southwest Region supermarkets not stocking some foods we purchase with relative frequency today, as well as rising costs of foods due to their limited supply and the new costs of agricultural adaptation practices.

AGRICULTURAL RESOURCE MANAGEMENT OPTIONS

Conservation

- Protection through conservation is an effective way to ensure that important agricultural lands will remain for future generations. A conservation easement is a legal agreement that permanently restricts most development on a parcel of land. The agreement is between a willing landowner and a certain type of entity such as a land trust.

- Conservation easements can provide financial advantages to landowners. In some instances, landowners can be paid for placing a conservation easement on their land, they may also be eligible for federal income tax deductions if they donate the land without being paid. Conservation easements may lower the value of the land, which can reduce the burden of high property taxes.

Agricultural Commissions

- One of the tools available to communities to protect agricultural land is to establish an Agricultural Commission pursuant to NH RSA 674:44-e. An Agricultural Commission has no regulatory authority or enforcement powers, but acts in an advisory capacity to the Planning Board, as well as other boards and commissions, to advocate for the agricultural needs of the community. The primary purpose of an Agricultural Commission is to protect agricultural lands, provide a voice for the farmers, encourage agricultural-based businesses, and preserve the rural character of the community.

Farmers Markets & Agritourism

- Increased awareness of the important role that the local farms and markets play in supporting the local food system is important to sustaining support for preserving the Region's agricultural resources. As farmers markets and local farm stands increase in number and popularity in the Region, more residents have access to local farmers and their produce and goods. This direct connection helps to enhance awareness of where food comes from and helps support the local economy. Some farmers markets are accepting Electronic Benefit Transfer (EBT), which enables recipients of Food Stamps to use their EBT cards to purchase locally grown produce.

- Another way to promote agriculture is through agritourism, which is a growing concept that connects visitors to farming operations and related activities. According to NH RSA 21:34-a, VI, the term agritourism means attracting visitors to a working farm for the purpose of eating a meal, making overnight stays, enjoyment of the farm environment, education on farm operations, or active involvement in the activity of the farm which is ancillary to the farm operation.

  The types of activities visitors can experience varies with each farm, and can include such activities as feeding animals, milking cows, picking fruit or vegetables, overnight lodging, and many other chores. There are many examples of agritourism in the Region, which include working farms, those with production and processing facilities, educational and recreational programs, and overnight lodging options. Agritourism benefits not only the farm and farming industry, but it also brings visitors into the community which may lead to the support of other local businesses.

Agricultural Incentive Zoning

- Some communities have chosen to adopt or modify their land use regulations to support the retention or encouragement of agricultural activities and open space. Communities seeking to encourage agriculture should consider reviewing their existing land use regulations to identify potential barriers to agriculture. There may be opportunities to increase flexibility in the zoning, subdivision, and site plan review regulations for agricultural uses and/or related activities. For example, a community might consider exempting agricultural signage as temporary signs that change with the season and crop availability can be critical to the success of farms. They could also remove impediments to home based business or accessory dwelling units, which can be critical to farm operations.

- A community could also develop and adopt ordinances such as an Agricultural Conservation District or a Right-to-Farm ordinance that are sensitive to the unique needs of farm businesses, seek to protect areas of the community that are well suited for agriculture, and help to minimize conflicts between incompatible uses.

RESOURCES FOR COMMUNITIES

Some of the many resources available to communities and others in the Region related to agricultural resources and wildlife management are described below.

- *Monadnock Farm to Community Connection (MFCC)* is a regional coalition whose mission is to support a sustainable food system by cultivating community action and building collaboration to implement effective programs, projects and policies. The coalition has developed a strategic plan to identify what the Southwest Region can do to improve the local food system. www.mfccoalition.org
- *Cheshire County Conservation District (CCCD)* is focused on strengthening the viability of working farm and forestland in Cheshire County through technical, financial, and educational resources that promote the conservation and response use of natural resources. www.cheshireconservation.org
- *NH Department of Agriculture, Markets and Food* is focused on promoting agriculture in the public interest and serving farmers and consumers in the marketplace. The Department assures safe and healthy food supplies, provides accurate information on prices and availability of farm commodities and crops and develops markets for the state's farmers. www.agriculture.nh.gov
- *UNH Cooperative Extension (UNH CE)* offers an array of workshops, research, and diagnostic services to help those involved with agriculture and related activities in New Hampshire. www.extension.unh.edu/Agriculture
- *Monadnock Conservancy* is a regional private non-profit land trust whose purposes are to identify, promote and actively seek protection of the lands with natural, aesthetic and historic significance in the Southwest Region, and to monitor and enforce the protection of lands in the Trust. www.monadnockconservancy.org
- *NH Farms Network* is a nonprofit organization focused on strengthening the connection between farmers, businesses and consumers in the state by developing a greater public understanding of the importance of farming for food security, community health, economic development and conservation. They maintain an online directory of farms and farmer markets in New Hampshire. www.newhampshirefarms.net
- *Land for Good* is a nonprofit organization based in Keene, NH that supports and provides guidance to help farmers, landowners and communities improve access to farmland. The mission of Land for Good is to ensure the future of farming in New England by putting more farmers more securely on more land. www.landforgood.org

CHAPTER 2. WATER INFRASTRUCTURE

Having access to adequate water infrastructure is critical to public health and safety, environmental quality, and economic vitality in the Southwest Region. All residences and businesses need access to clean drinking water, and the safe disposal of human waste. Whether it is via private wells, on-site septic systems, public sewers, or low impact development, infrastructure is needed to convey and in some instances treat our important water resources.

This chapter examines the availability and condition of drinking water, waste water, and stormwater infrastructure in the Region, and explores the primary threats and challenges to maintaining and sustaining this infrastructure. It also identifies opportunities for addressing these challenges and for improving the quality of our Region's water infrastructure.

DRINKING WATER INFRASTRUCTURE

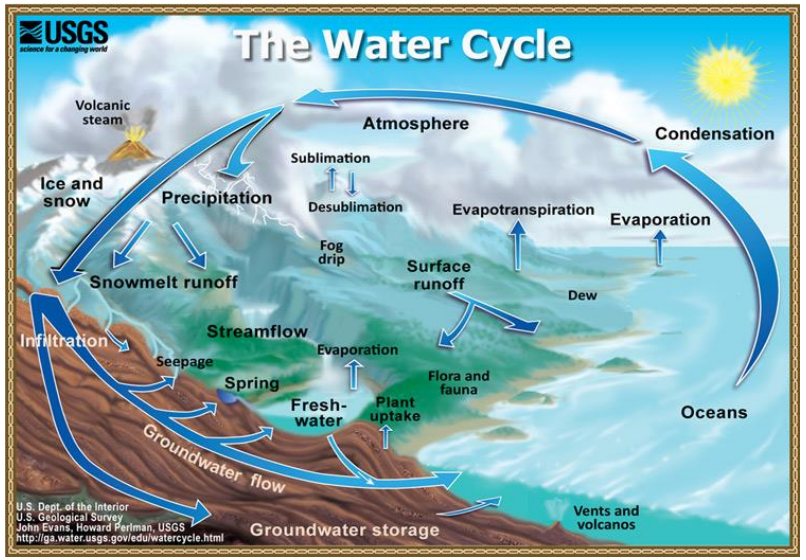
Reliable access to clean, high quality drinking water is critically important to the Region's current and future residents. Fresh water is vital for personal health and well-being, as well as sanitation and disease prevention. It is also needed to support the economic development activities that financially sustain our Region.

Sources of drinking water can include surface water such as lakes and rivers, and groundwater, which is water found between rock and soil particles beneath the land surface and in cracks in the bedrock. Within the Southwest Region, the vast majority (approximately 98%) of the Region's population is dependent on groundwater for their drinking water supplies.[37] Given this heavy reliance, maintaining the availability and quality of our groundwater resources is critically important.

Private Wells

According to the United States Geological Survey (USGS), the majority of the Region's residents (56%) rely on private wells to access drinking water. This is higher than the rest of New Hampshire, where 42% of residents rely on private wells, and is markedly higher than the national average of 14%.[38] This difference can be attributed to the rural nature of the Region, where low density development and hilly terrain constrain the extent to which public water infrastructure can expand.

Figure 3. The Water Cycle



The water cycle (*see figure above*) highlights the interconnected nature of our water resources. This is especially apparent when considering the relationship between drinking, waste, and stormwater infrastructure.

How we process and dispose of waste and storm water can have direct, sometimes negative effects on the quality and availability of our drinking water. Stormwater infrastructure and severe storm events can impact water infiltration, runoff and flooding, and ultimately water quality.

How we use our land, especially areas adjacent to water resources, can also impact drinking water quality. Pollutants and contaminants from human activities can be picked up and carried by water flowing over the surface of land and can enter water resources. These contaminants can be harmful to our surface and ground water resources.

Private wells can be either drilled, driven or dug. Drilled wells access bedrock aquifers and can provide a fairly consistent source of drinking water. Driven and dug wells draw water from the water-saturated zone above the bedrock. Although driven wells can be deeper than dug wells, they are still relatively shallow. Due to their shallow depths, both have a moderate-to-high risk of contamination from nearby land use activities and are susceptible to going dry during drought conditions.

The USGS estimates that private wells in the Region withdraw an estimated 4 million gallons per day.[39] In comparison, all private wells in New Hampshire are estimated to withdraw 41.6 million gallons per day, and the United States, a total of 3,740 million gallons from private wells per day.[40]

Public Water System

A public water system is defined under NH RSA 485:1-a as "a piped water system having its own source of supply, serving 15 or more services or 25 or more people, for 60 or more days per year. [41] There are three types of public water systems - community water systems, non-transient non-community systems, and transient non-community systems. The U.S. Environmental Protection Agency (EPA) defines these three types as follows:

- Community Water System - A public water system that supplies water to the same population year-round.
- Non-Transient Non-Community Water System - A public water system that regularly supplies water to at least 25 of the same people at least six months per year, but not year-round. Examples include schools, factories, office buildings, and hospitals that have their own water systems.
- Transient Non-Community Water System - A public water system that provides water to a place such as a gas station or campground where people do not remain for long periods of time.

The EPA classifies water systems according to the number of people they serve, ranging from very small water systems that serve 25-500 people to very large water systems that serve 100,001+ people. Depending on the type of system, the requirements vary, with more stringent requirements for larger systems and for those serving residential populations.[42]

Figure 4. Estimated Water Supply Sources by NH County, 2005

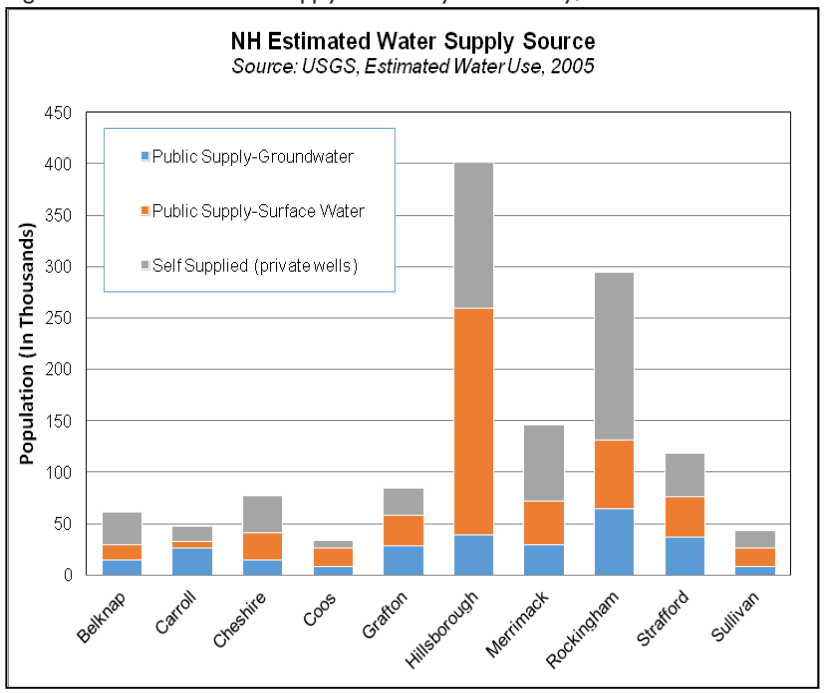


Table 2. Estimated Water Use by Southwest Region County, 2005

County	Population (2010)	Public Supply (Groundwater)	Public Supply (Surface Water)	Total Public Supply	Total Self-Supplied (Private Wells)
Cheshire	77,177	19%	35%	54%	46%
Hillsborough	400,721	10%	55%	65%	35%
Sullivan	43,742	19%	41%	60%	39%

Source: USGS, Estimated Water Use, 2005

Within the Region, there are 306 active public water systems. Of these systems:

- 82.4% are classified as very small *(serving 0-500 people);*
- 13.7% are classified as small (serving 501-3,300 people);
- 2.3% are classified as medium (*serving 3,301-10,000 people*); and,
- 1.6% are classified as large (*serving 10,001-100,000 people*).[43]

Medium sized systems are located in Peterborough and Jaffrey and the large systems are located in the City of Keene.

A significant portion (46%) of the publicly supplied water in the Region comes from transient non-community water systems. Many of these systems supply water to campgrounds and outdoor recreation areas, inns, convenience and grocery stores, and restaurants. Community water systems comprise 33% of all active public water systems in the Region.[44] Municipalities including Antrim, Bennington, Greenville, Hancock, Hinsdale, Jaffrey, Swanzey, Keene, Marlborough, Peterborough, Troy, Walpole, and Winchester own many of these systems. Some towns contract with private companies to manage these systems. The only non-municipal public water system in the Region that is regulated by the Public Utilities Commission (PUC) is located in West Swanzey and serves approximately 82 customers.

The vast majority of these public water systems (98.7%) in the Region rely on groundwater resources. The USGS estimates that public wells in the Region withdraw an estimated 3 million gallons of water per day.[45] An estimated one million gallons of water per day is withdrawn from surface water sources in the Region to be used as drinking water.[46]

Non-domestic Water Uses and Large Water Withdrawals

In addition to public and private users of surficial and ground drinking water resources, some commercial and industrial users of drinking water exist in the Region. Commercial water withdrawals account for an estimated 1.4 million gallons per day in the Region and the vast majority (95%) is from groundwater sources. Industrial water withdrawals account for an estimated 38 million gallons per day in the Region.[47] In comparison to the commercial water withdrawals, industrial withdrawals are primarily from surficial water sources, with only 15.4% withdrawn from groundwater sources. Non-domestic uses of water include snowmaking, irrigation, mining, and hydroelectric power production.[48]

Large groundwater withdrawal is regulated by the NH Department of Environmental Services (DES). A large groundwater withdrawal permit is required for any withdrawal from groundwater of 57,600 gallons or more in any 24-hour period. Wells that were installed prior to August 1998 do not require a large groundwater withdrawal permit but do require approval from the Large Groundwater Withdrawal Permitting Program.[49] The permit holder is required to undertake long-term impact monitoring based on pumping observations made during the permitting process.[50] In the Region there are only two systems that have active large water withdrawal permits - the community water supply for the Town of Marlborough and the community water supply for the Town of Jaffrey.

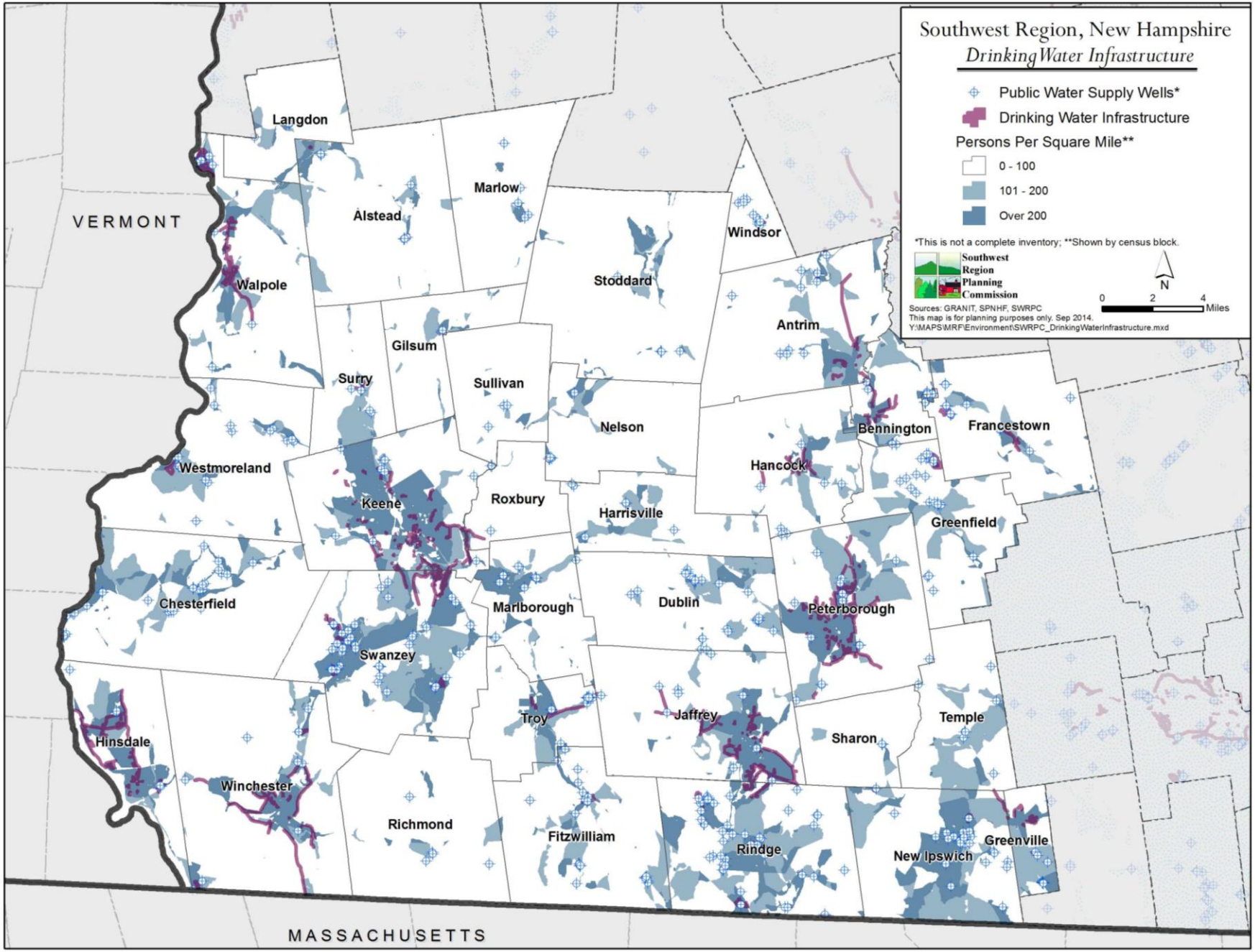
High Yielding Aquifers

An important source of groundwater are aquifers, which are geologic formations composed of rock, sand or gravel that contain supplies of potentially recoverable water. Especially important are stratified drift aquifers, which occur in glacially deposited formations of well sorted sand and gravel and can store and yield a significant amount of water.[51] Of the high capacity wells in New Hampshire, 79% are located in stratified-drift material.[52] Approximately 81,597 acres (12.6%) of the Region are underlain by stratified drift deposits; however, of the 7,443 acres of high or very high yield aquifers in the Region only 1,210 (16%) are conserved.

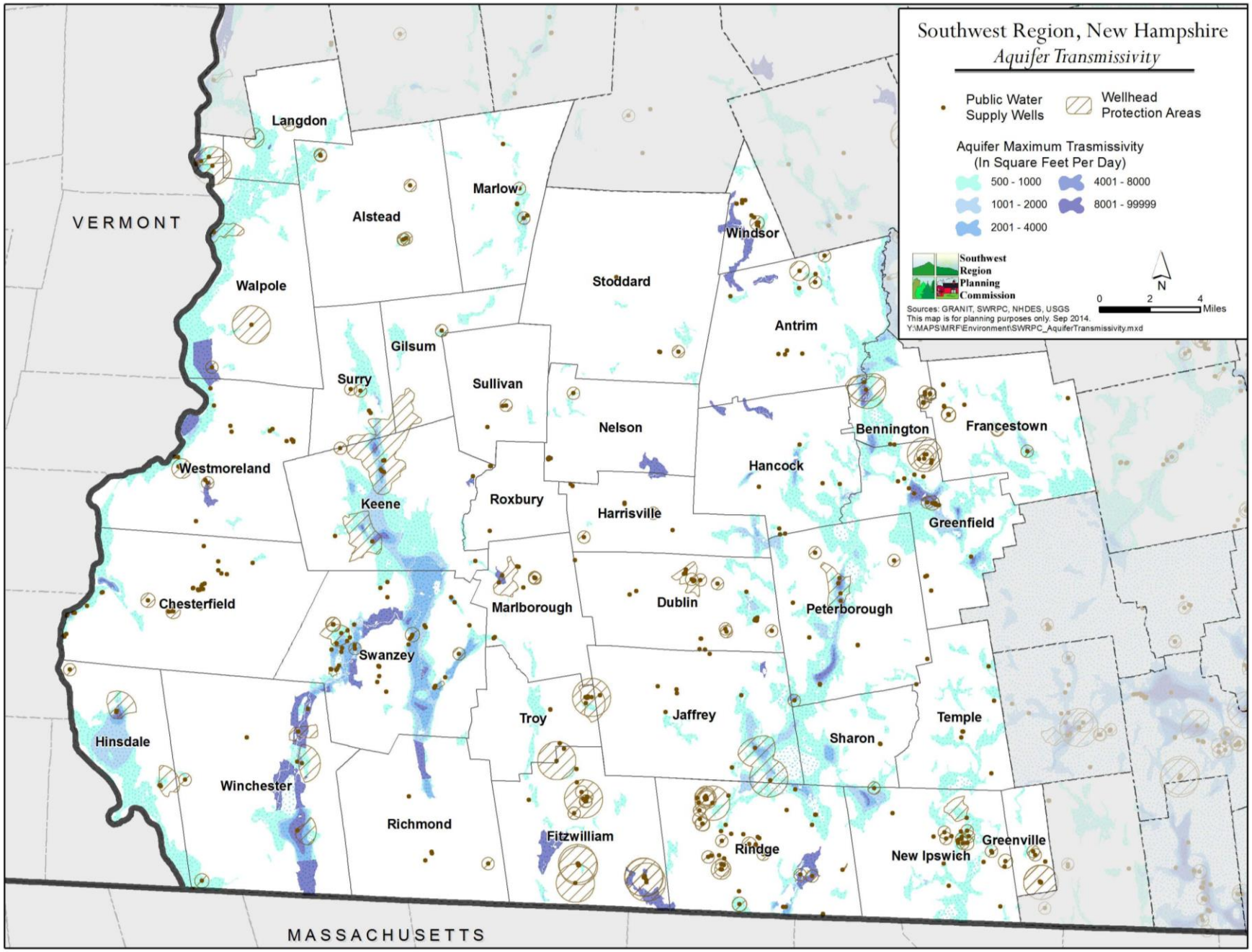
The rate by which groundwater flows horizontally through an aquifer is called transmissivity. Rates of transmissivity and porosity can differ greatly between stratified drift, glacial till, and bedrock aquifers. High yielding aquifers usually exhibit good porosity to store large amounts of water, and good transmissivity to allow the water to be pulled from the ground in adequate quantities for public water supply usage. The United States Geologic Survey USGS) defines the threshold of high transmissivity as greater than 2000 ft^2 per day.[53]

Areas with the highest yielding aquifers are not always located within a reasonable proximity of larger communities, or in proximity to communities with existing public water supply systems. As our population grows, pressure on the existing water supplies will also increase. Finding new water supplies and connecting them to existing water supply systems could pose a challenge if the new supplies are not easily accessible. Groundwater contamination issues may also arise in areas where dense populations exist directly over or adjacent to these high yielding aquifers.

Map 5. Publicly Owned Drinking Water Infrastructure in Southwest New Hampshire



Map 6. Aquifer Transmissivity in Southwest New Hampshire



Water Quality Impairments

The number of surficial waters that have been identified as impaired in the Region is a significant challenge. Impairments, which range from naturally occurring conditions to human-caused, can have an impact on the availability of safe drinking water supplies in the Region. A water body is said to be impaired when it repeatedly fails to meet state or federal water quality standards. In New Hampshire, these waters are listed on NH DES' 303(d) list, which is comprised of surficial water bodies that meet the following criteria:

- Impaired or threatened by a pollutant or pollutant(s);
- Not expected to meet water quality standards within a reasonable time, even after application of best available technology standards for point sources or best management practices for nonpoint sources; and,
- Require development and implementation of a comprehensive water quality study (a Total Maximum Daily Load (TMDL) study) which is designed to meet water quality standards.[54]

There are numerous threats to drinking water supplies and water quality in the Region. Despite abundant groundwater, this resource is often located in the soils or bedrock below developed areas or in the vicinity of known potential contaminants. Some public water supplies in the Region are protected from potentially dangerous land use activities through the designation of wellhead protection areas or ordinances such as groundwater protection overlay districts. The map on the next page shows the locations of Wellhead Protection Areas in the Region and potentially contaminated sites from DES's *Site Remediation and Groundwater Hazard Inventory*. There are currently 138 potentially contaminated sites located within Wellhead Protection Areas in SWRPC towns. NH DES has identified approximately 759 potentially contaminated sites in the Region.

Some contaminants such as dissolved particles, sediment, bacteria, viruses, and parasites can be removed or destroyed through filtering and water treatment processes. Other contaminants such as pharmaceuticals and personal care products (PPCPs) are not entirely removed by available technologies.[55] More common contaminants include microorganisms, disinfectants and disinfectant byproducts, inorganic and organic chemicals, and radionuclides.[56]

Salt used to treat roadways for snow and ice can pose a significant risk to water resources. When salt washes off roads into water sources, it breaks down into sodium and chloride ions. Chloride is harmful to aquatic life and can be toxic above certain levels. Sodium in drinking water can be a health hazard, especially for individuals on low sodium diets. It can also increase nutrient concentrations in water resources.[57]

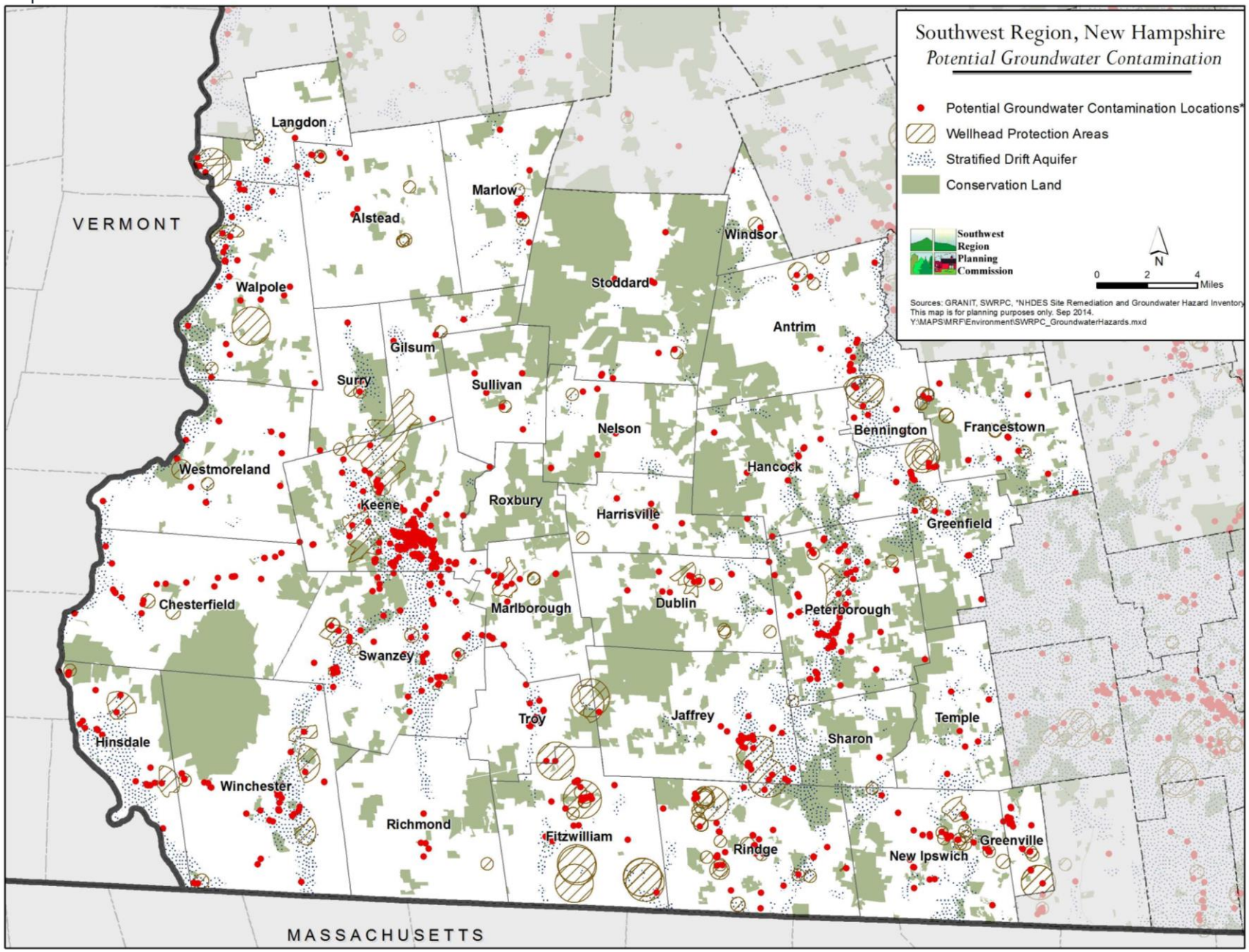
PPCPs are an emerging concern for water quality. PPCPs include prescription and over the counter drugs, nutritional supplements, and other consumer products such as fragrances, cosmetics, bug repellant and sun-screen agents.[58] These materials typically enter water resources through the wastewater system, after people use or flush these products. Low levels of PPCPs have been detected in groundwater, streams, rivers, lakes, and reservoirs across the United States.[59] PPCPs have also been detected in combinations of chemicals that have been found in the natural environment. These combinations occur when various chemicals combine and react to form new compounds.[60] Although PPCPs have mostly been found in very low concentrations, their presence has been linked to changes in aquatic organisms.[61] This impact on aquatic organisms, coupled with the fact that many PPCPs were specifically designed to have biological impacts on humans, have some scientists concerned about potential human health impacts.[62]

Table 3. Potential Drinking Water Contaminants

Category	Examples Contaminants	
Microorganisms	• Giardia lamblia • Cryptosporidium	• Fecal coliform • E. Coli
Disinfectants	• Bromate	• Chlorite
Disinfection Byproducts	• Chloramines (as Cl_2) • Chlorine (as Cl_2)	• Chlorine dioxide
Inorganic Chemicals	• Arsenic • Asbestos • Cadmium	• Lead • Nitrate • Nitrite
Organic Chemicals	• Acrylamide • Atrazine	• Benzene
Radionuclides	• Radium 226 and Radium 228 (combined)	• Uranium (Radon)

Source: US Environmental Protection Agency

Map 7. Potential Groundwater Contamination Locations



Lack of Well Testing

Testing of drinking water varies greatly between public and private sources. While public and community drinking water resources are subject to stringent testing to ensure compliance with state and federal regulations, there is limited oversight of private well water quality.

Since 2000, private wells have been regulated in terms of their placement and construction.[63] Yet, as of 2014, there is no apparent oversight of private well water quality or yield.[64] Some mortgage lenders require private well water testing as part of the loan approval process. When selling a home, property owners must disclose the results of any testing done on their drinking water system, but they are not required to perform any tests.[65] The State Plumbing Code requires domestic plumbing systems to be connected to a "potable" water source, however the lack of a definition for "potable" or specific water quality standards makes the code challenging to apply.[66]

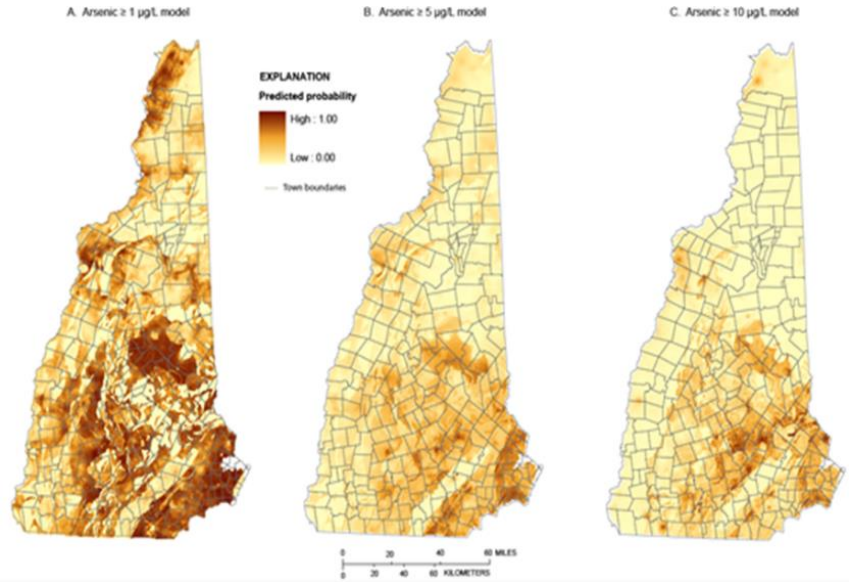
A small number of towns in New Hampshire require testing of private drinking water, but there are no state regulated testing requirements. This is problematic from a health and safety standpoint for drinking water, as there are few occasions when private wells are required to be tested for quality or quantity.

A common naturally occurring contaminant found in well water in the Region is arsenic. Arsenic is a tasteless, odorless semi-metal that can be introduced into water sources from natural deposits in the earth like bedrock.[67]

NH is known as the "Arsenic State." At one point in the state's history there were over 300 active arsenic mines.[68] Today, 1 in 5 private wells are expected to exceed the health-based standard for arsenic in NH.[69] However, the occurrence of arsenic in groundwater is most prevalent in southeastern areas of the state.

Long-term exposure to arsenic in drinking water can have many negative health impacts, including cancer of the bladder, lungs, skin, kidneys, nasal passages, and liver and prostate.[70] In a 2006 study, the USGS found a positive correlation between the prevalence of private well use and bladder cancer mortality rates in New England.[71] In 2009, bladder cancer rates in NH were 29% above the national average and are increasing over time[72].

Figure 5. Probability of Arsenic in Groundwater from NH's Bedrock Aquifers, USGS



Short term, non-cancer impacts can include thickening and discoloration of the skin, stomach pain, nausea, vomiting; diarrhea; numbness in hands and feet; partial paralysis; and blindness.[73]

Age of Infrastructure

Many of the municipal drinking water systems in New Hampshire, and similarly in the Southwest Region, are estimated to be between 50 and 100 years of age.[74] As our ability to detect and evaluate contaminants has increased over time, so too has the need for costly infrastructure improvements to treat water adequately and meet more stringent environmental regulations.[75] However, many communities are finding it difficult to keep up with these needed repairs and upgrades.[76]

Very small community systems, which are more common in rural areas, face significant challenges. These systems encounter many of the same issues as larger municipal drinking water systems, yet they have fewer resources to draw upon to address their needs.[77] They are typically overseen by volunteer boards that are subject to frequent turnover and have little, if any, staff

assistance.[78] They also tend to lack the capital reserves or access to funding required for upgrades and repairs.[79]

Climate Change

Climate change could challenge the ability of municipalities and homeowners to maintain their drinking water systems. Extreme weather events, shifting precipitation and runoff patterns, and temperature changes are expected to result in changes to water quality and availability. Excessive downpours could endanger drinking water quality due to increased volumes of stormwater runoff.

Climate change drought conditions as well as limits to groundwater recharge are expected to challenge water supplies. In arid parts of the world, such as the Southwestern United States, impacts on water supply and quality may lead to mass human migrations to more water rich Regions, including New England and southern New Hampshire. While there are resources and best practices information available to manage water infrastructure, there are a number of challenges that must be overcome to do it effectively.

Much of the drinking water is stored and delivered using older systems that were not designed for climate change impacts. Many of these systems are expensive to maintain because they have reached their useful life. However, rebuilding systems are expensive and resources for homeowners and communities are scarce for updating drinking water infrastructure.[80]

OPPORTUNITIES

The Region is fortunate to have access to diverse water resources, both above and below ground. By protecting these diverse water sources the Region can help ensure continued to access drinking water well into the future.

Conservation of Land

- Drinking water resources can be protected by placing the land areas surrounding sensitive surface waters or groundwater resources into conservation through conservation easements. This would limit the potential threat of water quality impairment as a result of human-caused activities and development in areas near critical water resources. Map 7 identifies areas of the Region that are currently conserved from development.

Local Land Use Regulations

- Another way to protect drinking water resources is through land use restrictions in the vicinity of the resource. Of the 35 municipalities in the Southwest Region, 15 have ordinances in place designed to protect drinking water and groundwater resources. Most of these ordinances focus on the protection of aquifers, public wellheads, and groundwater.

- In New Hampshire, all areas within 250' of the shoreline of all lakes, ponds and impoundments greater than 10 acres, 4th order and greater streams and rivers, and designated rivers/river segments are regulated by the New Hampshire Shoreland Water Quality Protection Act (SWQPA). This act establishes minimum standards for the subdivision, use, development, and permit notifications for activities on shorelands adjacent to the state's larger water bodies.

- Towns can develop and adopt ordinances that are as comprehensive as or more extensive than the SWQPA.[81] As of 2013, 12 towns in the Region (Antrim, Chesterfield, Francestown, Harrisville, Jaffrey, Marlborough, Marlow, Peterborough, Richmond, Stoddard, Swanzey, and Winchester) had adopted ordinances to protect shoreland/riparian corridor areas of surface waters in their communities.[82]

- However, many communities face challenges with routine enforcement after adopting regulations. Some municipalities may not have the funding or resources needed to effectively enforce regulations. An opportunity to address this challenge would be for towns to share the costs of employing a code enforcement officer to monitor compliance.[83]

Cross Border Collaboration

- Many of the Region's water bodies extend beyond town and even state borders. In some cases, upstream towns can impact the water quality experienced by towns downstream. By acknowledging the shared nature of water resources and quality issues, discussions with neighboring communities can help foster collaborative and innovative efforts to restore and protect these resources. Communities might consider working together to develop a water resource management and protection plan.

Asset Management

- Implementing an asset management plan is an option for communities needing to plan for costly repairs and upgrades to water infrastructure. The goals of asset management planning are to ensure that existing infrastructure is meeting customer needs and operating in an efficient manner, and that the financial resources will be available to rehabilitate and replace assets as needed.[84]

- Asset management plans are highly integrative, and can include the following components: mapping, equipment inventories, condition assessments, preventative maintenance plans, critical infrastructure identification, desired level of service, capital budget based on replacement costs and life expectancy schedule, and rate design that covers life-cycle costs.[85] Four key elements to enacting asset management plans include inventorying assets, prioritizing assets, developing the asset management program, and implementing the asset management program.[86] By bringing this information together into one plan, asset management helps to inform and guide planning, management, and future decision-making.[87]

Table 4. Southwest Region Towns with Drinking Water Protection Ordinance

Town	Ordinance Title
Antrim	Aquifer and Wellhead Protection District
Bennington	Water Resource Protect Zone
Fitzwilliam	Groundwater Protection Overlay District
Francestown	Aquifer Protection District
Greenfield	Groundwater Protection Ordinance
Hancock	Groundwater Protection District
Hinsdale	Wellhead/Aquifer Protection District
New Ipswich	Protection of Groundwater & Surface Water
Peterborough	Groundwater Protection Overlay Zone
Richmond	Aquifer Protection District
Rindge	Aquifer Protection Ordinance
Temple	Aquifer Protection Ordinance
Troy	Water Resource Protection Ordinance
Walpole	Town Well Source Protection Ordinance
Winchester	Aquifer Protection District

Table 5. Benefits of Asset Management

Challenges Faced by Water Systems	Benefits of Asset Management
• Determining the best (or optimal) time to rehabilitate / repair / replace aging assets. • Increasing demand for services. • Overcoming resistance to rate increases. • Diminishing resources. • Rising service expectations of customers. • Increasingly stringent regulatory requirements. • Responding to emergencies as a result of asset failures. • Protecting assets.	• Prolonging asset life and aiding in rehabilitation / repair / replacement decisions through efficient and focused operations and maintenance. • Meeting consumer demands with a focus on system sustainability. • Setting rates based on sound operational and financial planning. • Budgeting focused on activities critical to sustained performance. • Meeting service expectations and regulatory requirements. • Improving response to emergencies. • Improving security and safety of assets.

Source: US Environmental Protection Agency, Asset Management: A Best Practices Guide

WASTEWATER INFRASTRUCTURE

The ability to adequately treat and safely dispose or reuse wastewater is critical to maintaining the health and safety of the Region's residents and natural systems. Proper wastewater treatment and disposal or reuse helps to protect residents from pathogens and harmful chemicals and protects our natural environment from harmful pollutants and excessive nutrient loading.

There are two primary methods for wastewater treatment and disposal in the Southwest Region: private on-site septic systems and public centralized sewer systems that flow to a wastewater treatment facility. Approximately 71% (72,722 residents) of the Region is served by on-site waste disposal systems. The remaining 29% (29,786 residents) are served by public sewer systems.[88]

On-Site Private Septic Systems

On-site, private septic systems are the most common domestic wastewater treatment systems in New Hampshire. On-site wastewater disposal has evolved over time from the early pit privies and out-houses to highly sophisticated systems. Today these systems typically consist of a septic tank and a soil absorption field. When properly installed and maintained, an on-site septic system removes settle-able solids, floatable grease and scum, nutrients, and pathogens from domestic wastewater. The septic tank removes most solid material and partially digests organic matter through anaerobic processes. The remaining wastewater still contains pathogens and nutrients, which are removed as the effluent flows through the soil absorption field. The level of filtering required by the soil absorption field depends on the conditions of the site and proximity to critical areas.[89]

Sewer Collection Systems & Wastewater Treatment Facilities

Community sewer systems consist of a sewage collection system connected to a centralized wastewater treatment facility (WWTF). Depending on their size, treatment processes, and complexity, some on-site systems can belong to this category, but are subjected to higher regulatory oversight than smaller onsite systems.[90]

The following communities in the Region operate WWTFs: Antrim, Greenfield, Greenville, Hinsdale, Jaffrey, Keene, Swanzey, Peterborough, Troy, and Winchester.[91] Towns that maintain collection systems but do not have a WWTF include Bennington, Marlborough, and Walpole.[92] Other wastewater treatment plants in the Region include the Cheshire County Maplewood Nursing Home and Franklin Pierce University.[93]

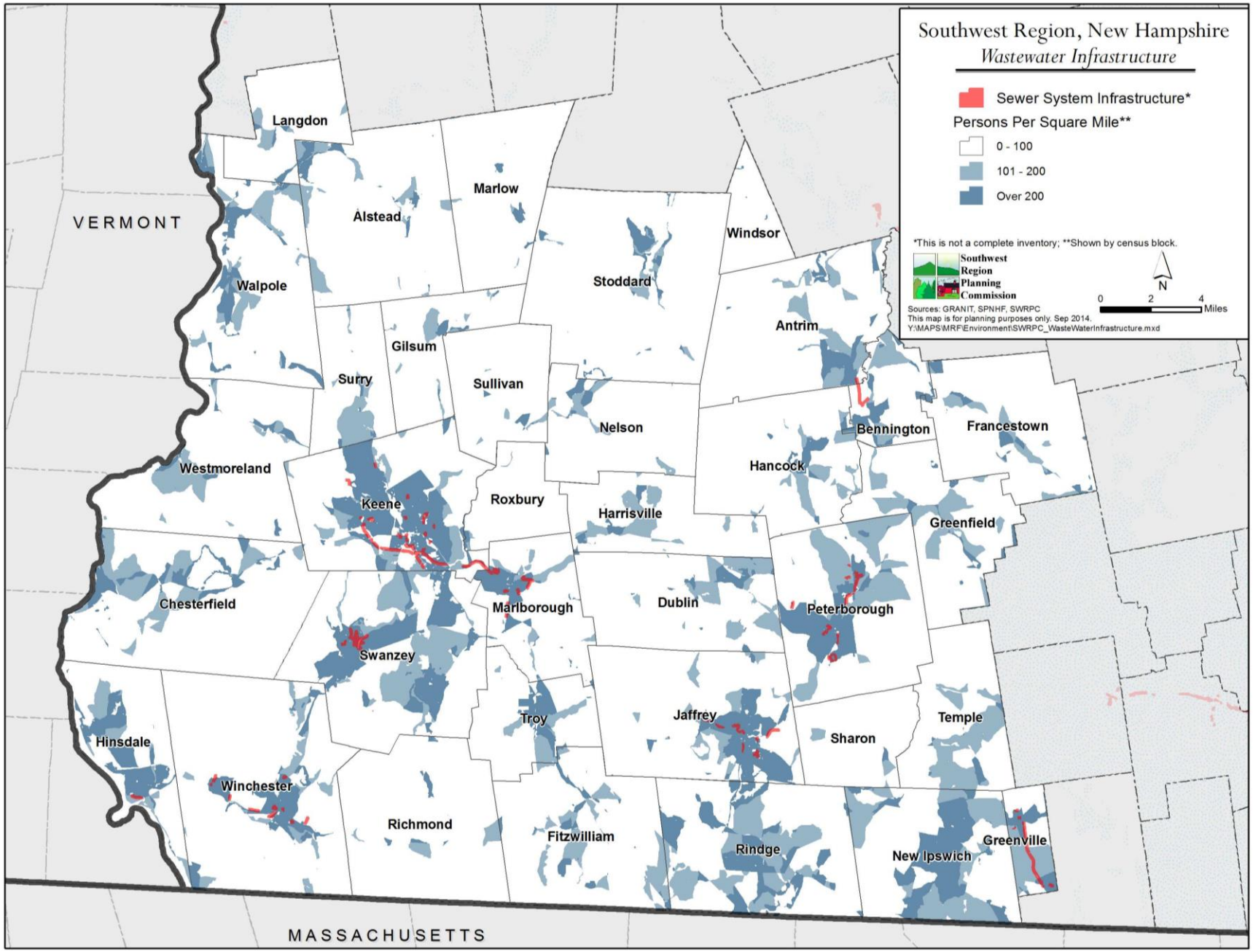
WWTFs are limited by their flow capacities. The majority of the Region's WWTFs are using 50% or more of their available flow capacities, with one using 90% of its available flow capacity.[94] The average daily design flow of these plants varies dramatically, with the largest being the City of Keene at 6.0 million gallons per day and the smallest being Cheshire County Maplewood Nursing Home at 0.040 million gallons per day.[95] Most of these plants were originally built in the 1970's and 1980's, with only 3 having been built in the past 20 years.[96]

Table 6. WWTF Capacity & Age in Southwest New Hampshire

WWTF	Average Daily Design Flow (gallons per day)	Long Term Average WWTF Flow (gallons per day)	WWTF Flow Capacity Used (Percent)	WWTF Flow Capacity Available for Growth (gallons per day)	Year Built
Antrim	0.210	0.110	52.38%	0.100	1980
Cheshire County	0.040	0.027	67.50%	0.013	1976
Franklin Pierce	0.140	0.042	30.00%	0.098	1994
Greenville	0.233	0.145	62.23%	0.088	1974
Hinsdale	0.300	0.270	90.00%	0.030	1979
Jaffrey	1.250	0.520	41.60%	0.730	2009
Keene	6.000	3.300	55.00%	2.700	1985
Peterborough	0.620	0.350	56.45%	0.270	2012
Swanzey	0.160	0.069	43.13%	0.091	1980
Troy	0.260	0.070	26.92%	0.190	1983
Winchester	0.284	0.200	70.42%	0.084	1978

Source: NH DES Data, WWTP Process Data 2013

Map 8. Community Sewer System Infrastructure in Southwest New Hampshire



These community systems treat wastewater through a number of treatment methods that target different pollutants. Primary treatment consists of removing larger particles and solids through chemical and physical processes to coagulate and settle the particles. Secondary treatment involves the use of microorganisms to digest organic matter to decrease oxygen-demanding pollutants and suspended solids. All WWTFs in the Region provide some type of secondary treatment. Tertiary treatment removes additional nutrient pollutants to protect aquatic life in the receiving waters. Eight of the Region's WWTFs include tertiary treatment in their processes. These include Franklin Pierce University, the City of Keene and the towns of Greenville, Jaffrey, Peterborough, Swanzey, Troy, and Winchester.[97]

Disinfection occurs through the use of chlorine or ultraviolet radiation to remove or deactivate pathogens and microbes that can cause human illness.[98] In our Region, the majority of wastewater treatment plants disinfect through the use of ultraviolet radiation or chlorination with dechlorination.[99]

After the treated water has been discharged, the remaining residuals, referred to as sludge or "biosolids" must be processed for use as fertilizer or fuel, or be properly disposed.[100] The majority of WWTFs in the Region transfer residual sludge or biosolids to a separate facility. Some facilities store the sludge and biosolids onsite in lagoons or send it to a landfill.[101] Communities that do not have their own WWTF can contract with some of these towns for septage disposal services. Many towns in the Region contract with the City of Keene's treatment facility for this service.

Byproduct Disposal

Each year, New Hampshire generates nearly 100 million gallons of septage (i.e. material removed from septic tanks, cesspools, holding tanks, or other sewage treatment storage units, not including sewage sludge from public treatment works or any other sludge). Of this amount, an estimated 17 million gallons is exported from the state for processing. The solid or semisolid material produced by water and wastewater treatment processes is called sludge.

Of the 81,672 wet tons of sludge produced in New Hampshire in 2012, 28% was incinerated, and 29% was sent to landfills. The remaining materials were treated and tested to become biosolids. In 2012, 24% of sludge was turned into Class A biosolids, and 16% was turned into Class B biosolids for land application uses. The remaining 3% was disposed of out-of-state.[102]

Table 7. Class A and B Biosolids

Class A Biosolids	• No detectible levels of pathogens. • When used in small quantities by general public there are no buffer requirements, or restrictions on crop type, crop harvesting or site access. • When used in bulk, they are subject to buffer requirements, but not to crop harvesting restrictions.
Class B Biosolids	• Treated but still contain detectible levels of pathogens. • Almost all forms are subject to buffer requirements, and restrictions on public access, and crop harvesting.
Source: U.S. EPA http://water.epa.gov/polwaste/wastewater/treatment/biosolids/genqa.cfm	

Class A and B biosolids can be used as fertilizer and composting material for gardening and farming activities. A major distinction between Class A and Class B biosolids in New Hampshire is that Class B biosolids require a site-specific permit. The majority of WWTFs in the Region discharge effluent into the Ashuelot River or Contoocook River; although, a couple discharge into the Connecticut or Souhegan River.[103] In terms of return flow, community wastewater systems in the Region return 6 million gallons of water to surficial water sources each day. Domestic sources (private, on-site sewer systems) return approximately 5 million gallons of water per day.[104]

Less common methods of effluent disposal for community sewer systems include land treatment and wastewater infiltration.[105] Land treatment consists of applying wastewater to soil. As gravity pulls the wastewater down, natural processes filter and remove excess nutrients.[106] Wastewater infiltration involves spraying, flooding, or infiltrating wastewater into soil and allowing natural processes to filter and remove pollutants.[107] In the Region, five community sewer systems utilize lagoons for wastewater infiltration.[108]

Industrial processes can produce pollutants that are problematic for WWTFs. NH DES requires pretreatment for some industrial discharges before it enters a collection system.[109] This pretreatment helps protect against pollutants that could disrupt the effectiveness of the treatment process, and reduces the likelihood of untreated contaminants entering receiving waters.[110]

THREATS & CHALLENGES

Wastewater Infrastructure Issues and Costs

Most of the wastewater treatment plants in New Hampshire were built in the 1970s or 1980s and were expected to last 20 years. As such, most have been in service 10-20 years beyond their expected lifetime and are due to be upgraded, repaired, or replaced.[111] Aging infrastructure can carry the risk of accidental release of sewage into the environment.[112] The infiltration of "clean" ground water into wastewater systems through damaged and deteriorating conduits can increase the cost of plant operations and the risk of potentially overloading the system.[113]

The estimated cost of wastewater treatment upgrades, new sewers, and sewer rehabilitation work needed in the Southwest Region based on a 2012 needs assessment by Clean Watersheds is $47,300,000.[114] This number represents the costs of projected needs over the next 10-20 years. While many towns have traditionally depended on the State Aid Grant Program through NH DES to fund system repairs, this source has been less reliable in recent years due to state budget cuts. There are currently no direct federal grants available for the design and construction needs of wastewater infrastructure.[115]

In order to operate and maintain wastewater treatment systems, users are charged fees for utilizing the system. These sewer user charges have been increasing over time and have been historically higher in the Southwest Region than the state overall. The Region's rates have also been higher than the state benchmark value, which is 120% of the statewide average annualized rate. Communities with residential sewer user charges in excess of the benchmark value are eligible for an additional 10% of State Aid grant funds for municipal water pollution control projects.[116]

Table 8. Average Annualized Sewer Charges

	2011	2010	2009	2008	2007	2006	2005
Southwest NH Average	$744	$743	$701	$667	$641	$614	$511
NH Average	$596	$575	$540	$519	$512	$469	$427
Bench Mark	$715	$690	$648	$623	$615	$562	$511

Regulatory Compliance

Compliance with federal and state regulatory requirements is a significant challenge for WWTFs in the Region. Today, the character and quantity of contaminants confronting water quality are far more complex than those presented in the past. It is becoming increasingly more difficult for WWTFs to meet stringent environmental standards, specifically pollutant discharge limits, without making upgrades to their facilities.

Although meeting these requirements is in the best interest of the Region's health and well-being, it can be incredibly costly to do so; especially, in the absence of financial assistance. It is important for state and federal agencies to work with municipalities that operate WWTFs to develop an understanding of the regulatory requirements they face, and to establish compliance schedules that allow for the sequencing of critical upgrades and projects within their financial capabilities.

Failing and Improperly Located Septic Systems

Septic systems can affect ground and surface water quality in several ways. Failing systems or improperly located systems can discharge inadequately treated sewage, which can contaminate surface waters and/or drinking water supplies. Wastewater and sewage discharged from failing systems can contain potentially harmful bacteria and viruses. Additionally, excess nitrogen or phosphorus can contribute to nutrient loading issues in water supplies, which can lead to algal blooms and decreased water quality.

A number of factors can cause on-site septic systems to fail, including unsuitable soil conditions, improper design and installation, and inadequate maintenance practices. Other conditions that can affect the proper functioning of septic systems include separation distance from the water table and bedrock, topography, flooding frequency, density of development, and distance to streams or shorelines.

A significant challenge to addressing this issue is detecting individual failed systems. Private on-site septic systems are typically only inspected during home construction and homes sales. Individuals may be unaware that their system has failed, or not have the funds available to replace the system.

Natural Challenges

Difficult terrain and surficial geology can present significant challenges for some towns in the Region seeking to develop or expand their community sewer systems. Installing sewer lines in an area with steep and hilly terrain can be costly and challenging to implement. High water tables can also make the installation of sewer collection systems a challenge. For some communities, these challenges have become barriers to implementing much needed wastewater infrastructure projects.

Energy Consumption

Both water and wastewater treatment facilities require a significant and constant source of energy to operate. According to the EPA, drinking water and wastewater systems account for approximately 3% to 4% energy use in the United States, and are typically the large energy consumers of municipal governments.

All WWTFs in the Region rely on Public Service of New Hampshire (PSNH) for their primary source of electricity.[117] Three plants in the Region (Jaffrey, Keene, and Peterborough) utilize energy or heat recovery systems and the City of Keene's WWTF utilizes solar panels as an alternative energy source.[118] While almost all of the facilities in the Region have incorporated energy efficiency upgrades into their systems, only three have undergone comprehensive energy audits.[119]

OPPORTUNITIES

Technological Improvements & Innovation

- Although much of the Region's wastewater infrastructure is in need of repairs and upgrades, this can be viewed as an opportunity. In planning for and implementing facility upgrades, communities can be considerate of accommodating future demand, adapting to climate change, and increasing energy efficiency and conservation. For example, there may be opportunities to remove infiltration and inflow from wastewater collection systems reducing their vulnerability to severe storm impacts, or to incorporate alternative energy systems into the design and operation of a facility.

- Alternative collection systems could be utilized to alleviate some of the natural challenges faced by the Region. There are two main categories of alternative collection systems: pressure sewer systems and vacuum sewer systems.

  Pressure sewers are a means of collecting wastewater from multiple sources and delivering the wastewater to an existing collection sewer or WWTF. This type of sewer is not dependent on gravity to move wastewater, therefore topography is less of a concern. Because the lines are pressurized sewer pipe installation can follow the surface topography and remain at a relatively constant depth below the soil surface. It is an option for areas with hilly terrain, shallow bedrock, or high water tables.

  Vacuum sewer systems rely on the differential pressure between atmospheric pressure and a partial vacuum to collect wastewater. These systems are most economical in flat sandy soils with high ground water.[120]

Energy Audits

- Energy audits are a tool to evaluate a facility's energy usage and determine options for improving efficiency, decreasing energy use, and decreasing operating costs. The results of audits can help communities to prioritize energy projects on a cost-benefit basis. The cost to undertake an energy audit can vary depending on the size of the wastewater treatment plan and level of energy audit undertaken.

Asset Management

- Similar to drinking water infrastructure, implementing an asset management plan is an option for communities needing to plan for costly wastewater infrastructure repairs and upgrades. More information about asset management planning is described in the previous section on drinking water.

STORMWATER INFRASTRUCTURE

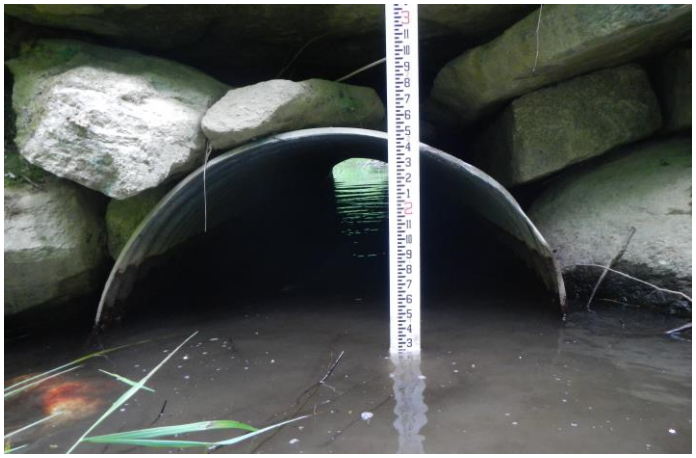
Stormwater is water that originates during precipitation events and is either absorbed by soil or vegetation, evaporated, or flows over the ground towards surface waters. Natural processes work to slow down, filter and purify water; however, impervious surfaces such as roofs, parking lots, and roadways impact these processes by changing how and where stormwater infiltrates. These surfaces prevent water from being absorbed into the ground, and can increase the speed and volume of stormwater entering surface waters. This can contribute to flooding, decreased water quality and quantity, and stream channel erosion.

Stormwater management is critical to protecting water supplies from contaminants and for flood protection. Traditionally, conventional stormwater management has been focused on collecting stormwater in piped networks and transporting it off site as quickly as possible, either directly to a stream or river, detention basin or pond, or a combined sewer system flowing to a WWTF. Although this is an efficient way to remove water quickly and prevent on-site flooding, it can have negative impacts on the quality and quantity of water supplies, and can potentially increase the frequency and magnitude of floods.

Alternatives to conventional methods include Low Impact Development (LID) and green infrastructure. These methods focus on managing and treating stormwater as close to the source as possible, in a way that promotes the natural movement of water within an ecosystem or watershed. LID techniques, including strategic site planning, promote water infiltration and absorption by soil and vegetation, which helps filter out potential pollutants and promotes groundwater recharge. Examples of LID technologies include vegetated swales, pervious pavement, rain gardens, and filter/buffer strips.

By using materials such as native plants, soil and gravel, LID systems can be more easily integrated into the landscape and appear more natural than engineered systems. They can also be implemented at a reduced cost compared to conventional techniques, because they typically require less engineering materials such as steel and concrete.[121]

This section explores some of the challenges facing the Region's existing stormwater infrastructure and identifies opportunities for improving stormwater management design and implementation.



Above photo: Example of drainage infrastructure - under-road culvert in Temple; Below photo: Example of LID - rain garden at the Lake Sunapee Protective Association facility.

THREATS & CHALLENGES

Inadequate Infrastructure

The effectiveness of stormwater infrastructure, which can include drainage ditches, culverts, and dams, is dependent on its capacity to adequately manage the volume of water flowing to or through it, and its overall physical condition. In recent decades, increased frequency and intensity of flooding has tested the capacity of existing drainage infrastructure (e.g. culverts) in the Southwest Region. Much of this infrastructure was constructed using outdated standards, and is not designed to safely handle the amount of water generated by recent extreme storm events.

Undersized culverts can lead to sedimentation and debris accumulation, potentially causing structural failures and major flooding downstream. The damage caused by these failures to road infrastructure and property can have tremendous economic impacts. For example, the federal, private, and individual assistance for damage resulting from three flood events in New Hampshire in October 2005, April 2006, and May 2007 totaled $60 million.[122]

This trend of increased storm events is only expected to continue into the future. Yet, studies in New Hampshire have shown that the state's existing drainage infrastructure is seriously under-sized to accommodate the increases in storm intensity and frequency expected in the coming decades.[123]

Limited Adoption of New Technologies

As our understanding of stormwater impacts has increased, so too has the need for improved management strategies. Conventional techniques focus on removing stormwater from a site as quickly as possible through curb, gutter, and piping systems that discharge stormwater directly into the nearest receiving waters or detention basins.[124] These processes disregard the natural hydrology of a site and can negatively impact downstream waters by increasing the frequency and magnitudes of floods, altering stream channel morphology, and reducing groundwater recharge.[125]

The use of technologies such as LID, which promote infiltration of stormwater onsite, can be a more environmentally sensitive alternative to conventional management practices. Although many innovative examples of LID exist in the Region, these strategies have yet to be widely utilized by municipalities in the Region. This may be due in part to the perception that LID is more

Above photo: Roadway damage caused by the Alstead Flood of 2005

costly than conventional management practices, even though LID is often less expensive to install and maintain.[126] It could also be due to limitations imposed by local ordinances, lack of confidence in the performance of LID systems, and/or a limited understanding of LID infrastructure maintenance requirements.[127]

Compliance/Monitoring Issues

Permitting processes related to stormwater infrastructure can be difficult to navigate with multiple steps and agencies involved. Depending on the site and level of disturbance, multiple state and federal programs might be needed. Obtaining these permits can also be expensive and can create costly project delays.

The programs that permit land disturbance activities for the protection of water quality and stormwater management include Section 401 Water Quality Certification, New Hampshire Alteration of Terrain Permit, New Hampshire Wetland Permit, New Hampshire Shoreland Permit, and the National Pollutant Discharge Elimination System (NPDES) Program Permits. The NPDES Construction General Permit is the farthest-reaching program as it applies statewide to any construction activity that disturbs as little as one acre of land.

In some instances, municipalities that have separate storm sewer systems (known as MS4s) are required to comply with additional regulations (NPDES Phase I, NPDES Phase II) for stormwater management. This additional oversight is intended to help prevent untreated stormwater from being discharged into water bodies. Currently, only large municipalities or counties and urbanized areas are required to go through the MS4 permitting process. As of 2014, there are no MS4 communities in the Region.

Inadequate Funding

The projected cost of stormwater infrastructure upgrades and management activities needed in the Southwest Region over the next 20 years is $45,961,195.[128] This number represents the costs estimated by municipalities in the Region in a 2012 needs assessment by Clean Watersheds. Yet, there are very limited funding sources available for meeting these needs. Most municipalities are expected manage stormwater with no increase in staff or budget. This is a challenge, especially as outdated and undersized infrastructure could pose significant safety and economic threats.

OPPORTUNITIES

Encourage Low Impact Development

- Communities have the opportunity to encourage the use of LID by requiring it in land use regulations, and implementing demonstration projects. Often, elements of municipal ordinances, such as minimum roadway widths, minimum parking requirements, and curb and gutter conveyance design, can conflict with LID principles. Local regulations can be modified to allow for and encourage LID best practices and techniques in the design and development of lots and streetscapes.

- Municipalities can also adopt ordinances that require stormwater management and LID as a part of development activity. The Innovative Land Use Planning Techniques handbook produced by the NH DES provides a model ordinance that addresses considerations for post-construction stormwater management.

- A few municipalities in the Region have implemented noteworthy LID projects. For example, in 2008, Peterborough completed a stormwater improvement and LID demonstration project in its downtown. This project incorporates LID techniques such as rain gardens, infiltration beds, and pervious brick sidewalks, to address nonpoint source pollution and stormwater concerns, and to protect the water quality of the nearby Contoocook River and important drinking water aquifers located downstream from the project.[129]

Upgrade Stormwater Infrastructure

- As indicated in the threats and challenges section, stormwater infrastructure, culverts in particular, is undersized for both the current climate and expected climate change. In order to avoid costly road washouts and damaging floods, existing infrastructure needs to be upgraded to accommodate anticipated flows and future conditions.

- The state of New Hampshire has undertaken a variety of efforts to address the impacts of inadequately sized or failing stream crossings (e.g. culverts) on river systems, habitat and public safety. In May 2010, DES adopted rules for the permitting of stream crossing structures. The New Hampshire Stream Crossing Guidelines are intended to serve as a central location for providing guidance on the design, construction, and maintenance of new or replacement road/stream crossings. The goal of

these guidelines is to provide for aquatic life passage during high and low flow conditions and maximize the passage of high flows, particularly floodwaters, so that losses to infrastructure and adjacent property and threats to public safety are minimized.

- The State of New Hampshire has also developed protocol for assessing the physical condition and site characteristics of bridge and culvert stream crossings. The State based this protocol on previous assessments conducted in Massachusetts and Vermont. The NH Geological Survey, NH DES, and the NH Department of Transportation have been working with regional planning commissions and other organizations to inventory and survey stream crossings using this protocol.

Implement Stormwater Utilities

- Municipalities in the Region have the ability, under NH RSA 149-I, to form a stormwater utility as an option for raising the funds needed to maintain and upgrade stormwater infrastructure. A stormwater utility generates funding through user fees that are typically based on the impervious surfaces (e.g. roofs, roads, driveways, parking lots) of each property within the stormwater utility district.

- Revenues generated from the fees are placed in a dedicated fund to implement a stormwater program that directly supports maintenance and upgrades of existing storm drain systems, development of drainage plans, flood control measures, and water quality programs that service the users. Funding can also be used for catch basin cleaning, street sweeping, infrastructure upgrades, and a variety of other stormwater management activities. This utility is similar to the type of fee charged for public water and sewer service.

- As of 2010, no municipalities in New Hampshire had adopted storm water utilities. However, these utilities have been adopted in many areas across the Unites States.

Above photo: Peterborough Town House walkway prior to 2008 LID installation; Below photo: Peterborough Town House walkway following 2008 LID installation of rain garden and pervious brick walkway.

RESOURCES FOR COMMUNITIES

- *NH Department of Environmental Services (NH DES)* is a resource for municipalities and the general public to receive technical assistance, training, and information on drinking water, wastewater, and stormwater management in New Hampshire. www.des.nh.gov

- *US Environmental Protection Agency (EPA)* carries out a wide variety of programs that include research and monitoring, planning and remediation, education and publishing, grant-making, policy analysis and development, and environmental regulation. www.epa.gov/Region1/eco/nh/nh_contacts

- *United States Geologic Survey (USGS) Water Resources of New Hampshire and Vermont* provides hydrologic data, investigative studies, and research on the characterization and management of water resources. The USGS works in cooperation with many Federal, State, and local agencies to evaluate the source, distribution, use, quantity, quality, and biology of water resources. nh.water.usgs.gov

- *Community Development Finance Authority* provides financial and technical assistance to community development projects that primarily benefit low to moderate income families, including water and sewer projects. www.nhcdfa.org

- *NH Public Utilities Commission (PUC)* has general jurisdiction over water and sewer utilities, according to NH RSA 362:2, for issues such as rates, quality of service, finance, accounting, and safety. The PUC's website contains useful information on a wide range of water and sewer-related utility issues. www.puc.state.nh.us

- *Granite State Rural Water Association* is an educationally-based non-profit, whose mission is to provide its members with professional technical assistance, training, and legislative representation. Their staff of water, wastewater and technical experts is available to provide assistance and answer questions relating to water and wastewater systems. www.gsrwa.com

- *NH Water Works Association* is a nonprofit, professional membership organization consisting of municipal water systems, community water systems, investor-owned water utilities, water works equipment/ materials manufacturers and suppliers, engineers, consultants, government regulators and others. www.nhwwa.org

- *NH Water Well Association* is a membership organization of well-water professionals dedicated to providing services, products and education to homeowners and institutions throughout New Hampshire regarding water well issues. www.nhwaterwell.com

- *USDA Rural Development* provides funding opportunities in the form of payments, grants, loans, and loan guarantees for the development and commercialization of water utility services. www.rurdev.usda.gov/nh-vthome.html

- *UNH Center for Technology Transfer (T^2 Center)* houses the NH Public Works Association and the NH Public Works Mutual Aid. It also has a Technical Assistance program that can assist municipalities with a variety of challenges, including culvert issues. http://www.t2.unh.edu

- *UNH Stormwater Center* provides studies, outreach, and technical assistance on stormwater issues in New England and around the United States. www.unh.edu/unhsc

CHAPTER 3. ENERGY RESOURCES

Energy plays a significant role in many aspects of our lives. It shapes how we transport and store food, heat our homes and buildings, power our vehicles, and many other important applications. Needless to say, access to affordable and reliable energy is essential to our economic stability and growth, both globally and at the community level. However, this heavy reliance, specifically on non-renewable and imported energy sources, has made our Region vulnerable to changes in its supply and price. It can also have substantial impacts on the quality and stability of the environment as a result of emissions, land use impacts, and waste from the production and use of certain energy sources.

Although energy is a global commodity and the issues described above are broad in scope, there are opportunities to address these challenges within the Southwest Region. Communities have much to gain by taking charge of their energy future and making sustained investments in the built environment and energy infrastructure. By using energy more efficiently and producing more energy locally, communities can help lower energy costs, increase energy security and reduce environmental impacts.

This chapter is intended to highlight some of the pressing energy challenges facing the Region and to identify opportunities for communities, organizations, businesses, and residents to address these issues.

Energy Consumption

Although the Southwest Region relies on many different types of energy sources, petroleum products dominate our energy consumption. New Hampshire households are among the most dependent on petroleum in the nation, with more than half of homes using fuel oil as their primary source for home heating. This is especially true In the Southwest Region, where 65.8% of residents rely on petroleum products to heat their homes.[130] However, it is the transportation sector that consumes more petroleum-based products than any other sector in the state. In 2012, this sector accounted for 35.5% of the state's total energy consumption.

New Hampshire receives natural gas by interstate pipelines from Maine and Canada, yet more than 50% of the natural gas in these pipelines travels through the state to reach consumers in Massachusetts. Approximately two-

thirds of this natural gas is used to generate electricity in the state, and the remainder is distributed to commercial, residential and industrial sectors.

New Hampshire is among the lowest states in per capita natural gas consumption, in part because large areas of the state do not have natural gas distribution infrastructure. As a predominantly rural area, there is less use of utility supplied gas for home heating use in the Southwest Region than in New Hampshire as a whole (3% compared to 20% statewide). However, 6% of renter occupied housing units in the Region, compared to 1.7% of homeowners, identified utility gas as the primary source of heating fuel.

As a densely forested Region and state, it is not surprising that nearly 1 in 12 homes depend on wood products as a primary heat source. Use of biomass for heating fuel is higher in the Southwest Region (14%) than in the state (6%) or nation (2%).

Energy Supply

Having no fossil fuel reserves, the Region imports the majority of its energy from other states or abroad. In 2011, New Hampshire ranked 44th in the United States for total energy production. The highest energy producer in the Northeast is Pennsylvania, who ranks 4th in the nation to 1st ranked Texas. [131] This dependence on foreign fuels makes the Region vulnerable to fuel oil shortages and price spikes, especially during winter months. In 2000, the U.S. Department of Energy created the Northeast Heating Oil Reserve to give consumers adequate supplies for about ten days (the time required for ships to carry heating oil from the Gulf of Mexico to New York Harbor) in the event of a supply shortage. The Reserve's storage terminals are located in New Jersey and Connecticut.

New Hampshire produces electricity using a mix of energy sources, the most predominant being nuclear energy (42%) and natural gas (33%). The state also uses renewable sources to produce electricity such as hydroelectric power, biomass, wind power, and to a small extent, solar power. As of 2013, 16% of the state's net electricity generation came from renewable energy, up from 10% in 2011. [132]

Figure 6. NH Energy Consumption by End Use Sector, 2012

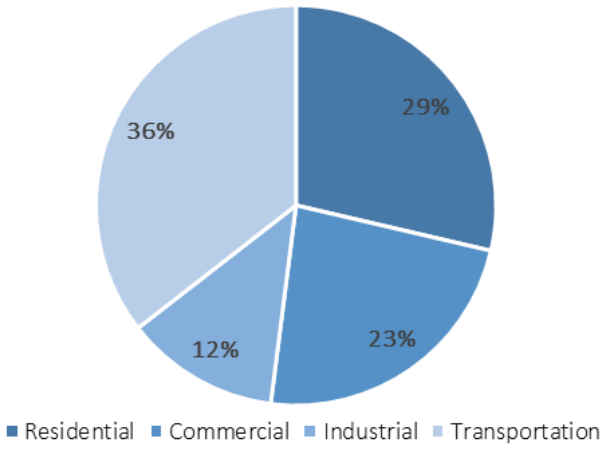
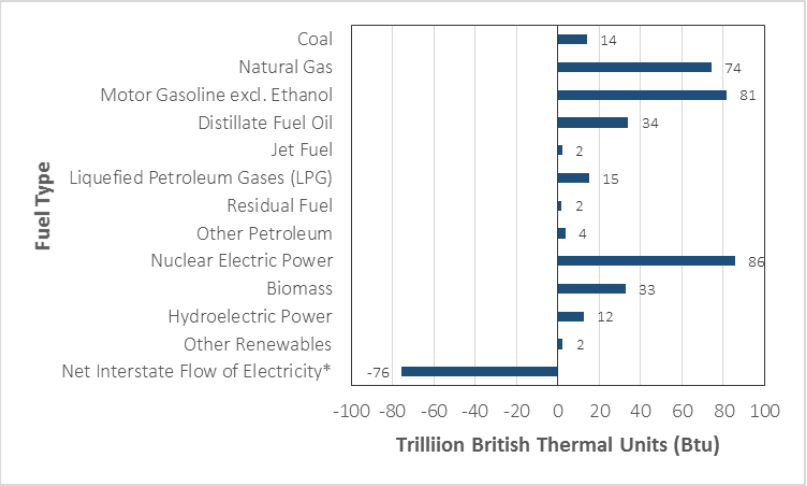


Figure 7. NH Energy Consumption by Source, 2012



**Represents the difference between the amount of energy in the electricity sold within a state (including associated losses) and the energy input at the electric utilities within the state. A negative number indicates that more electricity (including associated losses) went out of the state than came into the state.*

Source for above figures: U.S. Energy Information Administration, State Energy Data Estimates, 2012

Energy Expenditures

Even though the state's per capita energy use is relatively low (NH ranked 42nd in the nation in 2012), it ranks 23rd nationally for per capita energy expenditures, indicating a disproportionately high cost per unit of energy. In 2013, New Hampshire citizens, businesses, and industries spent nearly $6 billion on energy, which is approximately 9% of the state's Gross Domestic Product (GDP).

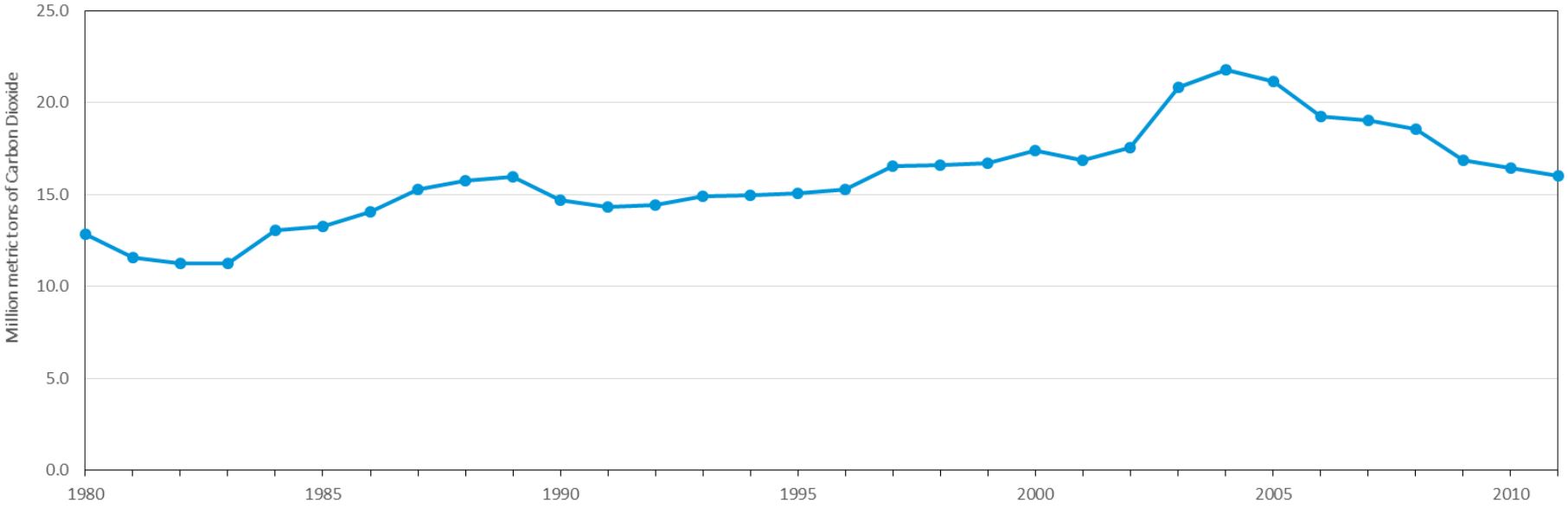
The majority (50%) of the state's estimated energy expenditures in 2012 were on transportation, followed by residential (26%), commercial (17%), and industrial (7%) uses. In the same year, New Hampshire ranked 4th in the nation for highest motor gasoline annual expenditures per person ($1,893 per person).

Environmental Impacts

Much of the energy produced and consumed in Southwest Region is through the use of nonrenewable fossil fuels (e.g. coal, natural gas, and oil), which can have significant health and environmental impacts. According to EPA, the burning of fossil fuels was responsible for 79% of greenhouse gas (GHG) emissions in the United States in 2010.[133] GHGs, which include carbon dioxide and methane, exist naturally in the atmosphere and contribute to the warming of the Earth's surface by trapping heat from the sun, in what is known as the greenhouse effect.

They become problematic when the concentration of GHGs in the atmosphere exceeds stable levels. This concentration causes average temperatures to rise, resulting in numerous climatic shifts and impacts around the world. In 2011, carbon dioxide emissions from fossil fuel consumption was 16 million metric tons, compared to 19 million metric tons in 2007.

Figure 8. NH Carbon Dioxide Emissions from Fossil Fuel Consumption, 1980-2011



Source: U.S. Energy Information Administration, State Energy Data Estimates, 2012

ENERGY EFFICIENCY

Energy efficiency is one of the most cost-effective ways to address the challenges of high energy consumption and expenditures. Investing in efficiency reduces the Region's reliance on imported and nonrenewable fuel supplies, which can lead to cost savings for consumers and increased energy independence. It can also be an opportunity to increase local economic development since energy improvements typically involve the purchase of local goods and services. A 2013 independent study[134] conducted for the NH Office of Energy and Planning (OEP) found that if all buildings in the state were improved to the highest level of cost-effective energy efficiency, this investment would create 2,300 jobs and add $160 million each year to the state's GDP. In addition to providing economic benefits, efficiency also reduces harmful emissions produced by burning fossil fuels, can decrease stress on the electric grid, and can increase comfort and safety in buildings.

THREATS & CHALLENGES

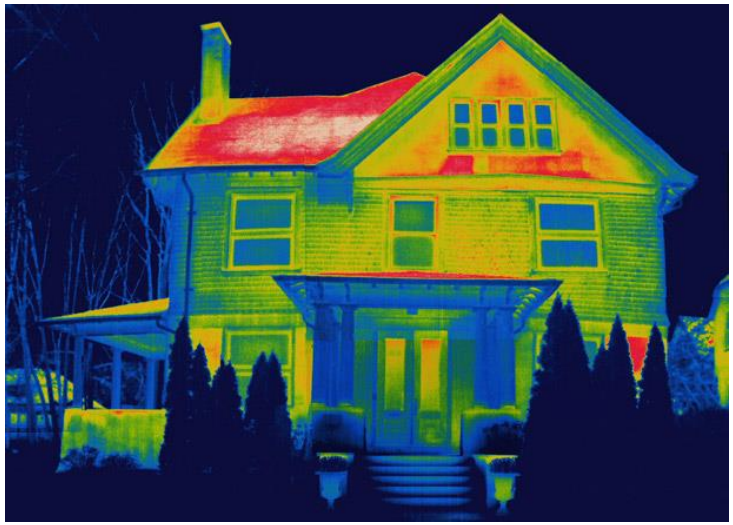
The section below explores some of the greatest challenges to energy efficiency in the Region.

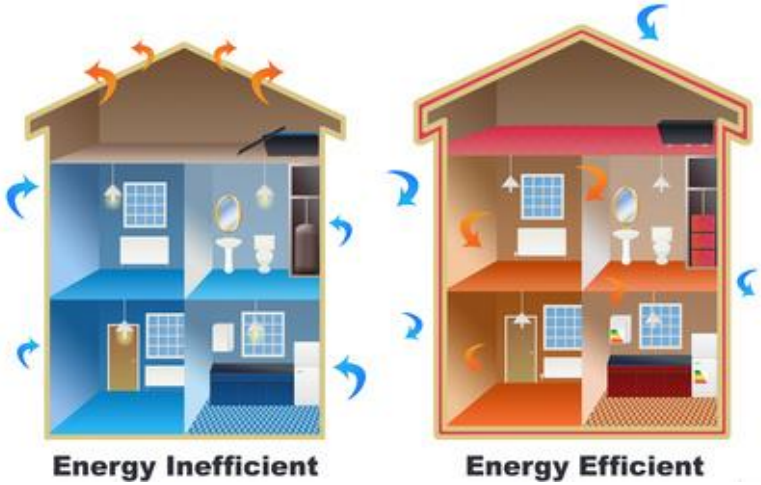
Older Building Stock

As of 2011, 80.5% of the housing stock in Southwest New Hampshire was built in 1989 or earlier. Of this total, 31% was built in 1939 or earlier. [135] While many of these older structures are important to the Region's heritage and character, they consume a great deal of energy.

Older buildings tend to have inferior building envelopes and less efficient heating equipment than newer construction. According to the U.S. Energy Information Administration (EIA), the typical home built after 1999 consumes 21% less energy for space heating than those built in previous decades. As a whole, commercial and residential buildings in the United States accounted for 41% of primary energy consumption, 74% of all electricity consumed domestically, and 40% of carbon dioxide emissions in 2010.[136]

Given the significant energy demands of the building sector and the Region's aging housing stock, there is a need to improve the energy efficiency of existing and new buildings in the Region. Buildings often represent the single largest financial investment for families or business owners, and the lifespan of new buildings can be 30 to 50 years or more. Incorporating energy





Above photo: Thermal image of a residential structure. The warmer colors represent areas of heat loss; Below photo: Heat loss comparison between an energy inefficient and efficient structure.

efficient design in new and promoting energy retrofits in existing buildings can lead to lasting energy benefits through reduced energy bills, reduced air pollution, improved health and comfort and increased building durability.

Limited Incentives

There are few incentives or policies in place to encourage energy efficiency improvements in the state and Region. Those that do exist are either underutilized or underfunded.

In the past, many incentive programs were funded by the New Hampshire Greenhouse Gas Emissions Reduction Fund (GHGERF), which received revenue from carbon dioxide auctions held under the Regional Greenhouse Gas Initiative (RGGI). This fund directed a minimum of 10% of program allocations to low income energy efficiency programs. The remainder went to support energy efficiency programs such as energy audits, weatherization of buildings, building code compliance, education and outreach, energy efficiency related workforce development, revolving loan funds for energy efficient investment, etc.

In 2012, a bill[137] was passed that replaced the GHGERF with the Energy Efficiency fund, lowering the rebate threshold for auction proceeds to $1, and allocating the remaining proceeds received by the state to core energy efficiency programs, which are administered by the state's utilities. These changes, which were made effective at the start of 2013, reduced the funds available for energy efficiency investments.

Some of the efficiency programs that are currently offered by the state and utility companies are limited and not all residents or businesses are eligible to receive assistance. For instance some programs only offer incentives to customers who meet a minimum energy demand. Other programs impose income limitations on who is eligible to receive services.

Although these program have had some success, they are currently insufficient to help the state realize its full efficiency potential. A 2013 study found that New Hampshire's current levels of investment in energy efficiency amount to roughly one-third of those necessary to put the state on track to achieve all cost effective gains in efficiency. [138]

Lack of Enforcement

According to the U.S. Department of Energy (DOE), the single most important step to reducing energy use in buildings is to implement and enforce compliance with building energy codes.[139] A building code is a set of rules that specify the minimum acceptable level of safety for constructed objects such as building and non-building structures. Energy codes, which are a subset of building codes, set minimum efficiency requirements for new and renovated buildings.

However, for many communities, especially those with limited resources, routine enforcement of codes and regulations can be a significant challenge. In New Hampshire, it is the local building official that enforces energy requirements of the State Building Code. Municipalities with code officials conduct plan reviews and on-site inspection, as well as issue building and occupancy permits. These communities may consult with the Public Utilities Commission (PUC) and the Department of Safety (DOS) on enforcement issues as necessary.

However, it is not uncommon for smaller or more rural municipalities to have a part-time or no code official on staff. In 2010, only 13 municipalities in the Region had either a part time or full time code official.[140] In jurisdictions without a code official the PUC is responsible for conducting plan reviews for the State Building Code for any municipality that requests it, and the DOS is responsible for inspections. In practice, neither entity has sufficient resources to conduct adequate plan reviews and on-site inspections for all construction projects that fall under their jurisdiction.[141]

As part of the New Hampshire Building Energy Code Compliance (NHBCC) program,[142] it was estimated that the baseline level of compliance with building energy code in NH in 2012 was approximately 45%.[143] This initiative found that some of the common issues impeding compliance or enforcement of codes include: limited knowledge or awareness of the codes or their benefits; lack of resources and training; insufficient funding to support code officials; competing priorities, constrained or limited resources; and, the general sentiment of 'this is the way we have always done it.'

OPPORTUNITIES

Adopt and Enforce Improved Building Energy Codes

- It is important for communities and the state to adopt building codes that promote energy efficiency and conservation. Including energy as a central part of the construction process and making early investments in efficiency can yield significant, long term benefits for building owners and occupants.[144] Especially since it can be significantly more expensive to achieve high efficiency levels in buildings post-construction.

- Since 2010, New Hampshire has referenced the 2009 International Energy Conservation Code (IECC), which applies to both residential and commercial buildings. The most current version of this code is the 2012 IECC, which has proven to be more cost effective than the 2009 IECC. Energy costs, on average, are 27% lower with the 2012 IECC, and homeowners could save an estimated $10,635 over a thirty year period.[145] Local governments have the ability to adopt the 2012 IECC or another code, as long as the requirements are more energy efficient than the state's.

- To encourage compliance and enforcement of codes, is important to have trainings, resources and tools available to building trade professionals and enforcement officials that explain the code's requirements and benefits. In recent years, the NHBCC has developed hands-on training curriculum for NH code officials and building professionals. Also, the PUC offers online training on a variety of code, beyond code and related building science issues.[146]

Table 9. Comparison of 2009 and 2012 IECC Requirements

Example Requirement	2009 IECC	2012 IECC
Building envelope sealing	Caulked and sealed, verified by a visual inspection against a more detailed checklist	Caulked and sealed, verified by a visual inspection and a pressure test against leakage requirement
Ducts and air handlers	Sealed, verified by visual inspection, and pressure tested, or all ducts must be inside building envelope	Sealed, verified by visual inspection, and pressure tested against a leakage requirement, or all ducts must be inside building envelope
Insulation on hot water pipes for water heating systems	None	R-3 except where pipe run length is below a diameter-dependent threshold
% of High-efficacy lamps in the home	50% of lamps	75% of lamps or 75% of fixtures

Source: U.S. Department of Energy, 2012

Increase Efficiency of Existing Buildings

- Although the adoption and enforcement of improved building energy codes can lead to significant energy reductions, this measure is largely focused on new construction. Promoting increased energy efficiency in existing buildings through weatherization and retrofits is essential to reducing the Region's overall demand for energy and to realizing energy cost savings for home and business owners.

- As noted earlier, much of the Region's building stock was built prior to 1940, predating the adoption of the state's first energy code in 1979. Although the Region experienced an influx of construction between 1970 and 1990, when its population grew by 39.4%, new construction has steadily slowed since this time along with population growth. As of 2011, only 3.4% of houses in the Region were built in 2005 or later, compared to 5.1% at the national level.[147]

- Currently, the community action agencies serving the Region, Southwestern Community Services and Southern NH Services, administer programs to help reduce energy usage and costs through free weatherization services. Eligibility for these programs is based on income with priority given to the elderly, disabled, and families with young children.

- Some utility companies offer assistance for implementing energy efficiency improvements; however, these programs are not widely advertised and typically involve some investment from the building owner or occupant.

- Button Up NH is a program that holds home weatherization workshops conducted by energy professionals in communities across the state. These free workshops are open to the public and teach basic building science concepts and information about air sealing, insulating, and conservation measures that reduce fuel and electricity use.

Implement Energy Financing Programs

- An important step for encouraging building owners to invest in energy improvement and retrofits is to identify and implement strategies to help minimize upfront project costs. Over the past decades, a number of innovative energy efficiency financing programs have emerged to help individuals achieve this goal. These strategies include on-bill financing,

property tax financing (also known as Property Assessed Clean Energy financing), and energy efficiency mortgages. Although these programs are not without limitations, they offer opportunities to overcome some of the challenges to investing in energy improvements.

- On-bill financing - In many instances, this option allows customers to pay back part or all of the cost of their energy efficiency improvements with the money saved on their monthly utility bills. In New Hampshire, the NH Electric Co-op offers SmartSTART, an on-bill financing alternative to pay for energy-efficient lighting and other approved energy-saving measures such as air sealing and insulation improvements. Rather than paying up front, the costs of these projects are distributed on monthly electricity bills equal to 75% of the monthly savings realized by the customer. If the customer moves and the installed products stay, the obligation to pay for them ends. The next occupant will "pay as they save."

- Property Assessed Clean Energy (PACE) - In 2010, New Hampshire adopted legislation (NH RSA 53-F) that enables municipalities to create districts to finance energy conservation and efficiency improvements in residential, commercial, and industrial structures. Residential and commercial property owners living in these districts, which may be all or part of a municipality, can finance their project and pay it back over time as a voluntary property tax assessment through their existing property tax bill. While paying the assessment included in the property bill, the current building owner and any future owner profit from lower utility bills made possible by the energy efficiency improvements.

- Energy efficient mortgage (EEM) - An EEM is a mortgage that credits a home's energy efficiency in the mortgage itself. Conventional EEMs increase the purchasing power of buying an energy efficient home by allowing the lender to increase the borrower's income by a dollar amount equal to the estimated energy savings. EEMs can also be used to finance energy improvements as part of a mortgage. To acquire an EEM, a borrower typically has to have a home energy rating system (HERS) evaluation before financing is approved.

Community Energy Planning & Action

- Many communities and organizations within the Southwest Region are working to address energy efficiency and conservation at the local and Regional level. In 2007, residents in 27 of the Region's 35 communities voted to adopt the NH Climate Change Resolution. This Resolution encourages the people of New Hampshire "to work for emission reductions within their communities," and it calls on selectmen in each town to "consider the appointment of a voluntary energy committee to recommend local steps to save money and reduce emissions."

- Noting the high concentration of municipalities in the Region that adopted this Resolution, Clean Air-Cool Planet (CA-CP) and the Antioch New England Institute (ANEI) partnered to form Cool Monadnock, a three year initiative to help communities manage energy issues at the local level. With the assistance of Cool Monadnock, many of the Region's municipalities established energy committees, began to track

Below photo: Button Up NH Workshop in Milford, NH

energy use and costs, and started planning for energy efficiency and conservation improvements.

- Cool Monadnock culminated in 2011, with the development of a regional climate and energy plan. This Plan, called the Monadnock Sustainability Action Plan, is designed to serve as a practical guide for local energy committees, residential groups, businesses, organizations, educational institutions and other sectors to easily identify and implement actions to reduce energy demand.

- Although funding for energy projects has been limited in recent years, communities and energy committees continue to work on energy improvements and raise awareness for energy efficiency and conservation at the local level. Some communities have been successful at procuring funding for energy initiatives at their annual town meeting. In 2011, voters in the Town of Richmond approved the establishment of an expendable trust fund for energy retrofits of town buildings. In the following year, voters appropriated $15,000 into this fund for energy improvements to the Town's Veterans Hall.

In 2010, the City of Keene adopted a Sustainable Energy Efficient District, which gives developers incentives for constructing green or energy-efficient buildings. Other local actions include but are not limited to the development of energy chapters to Master Plans, participation in the New England Carbon Challenge, and hosting local workshops on energy efficiency and weatherization.

While the focus of these committees has traditionally been on municipal energy savings and improvements, there may be opportunities for Regional collaboration and coordination with other energy use sectors including the commercial, residential, and education sectors. Committees can partner with neighboring municipalities and other organizations and institutions to host events and workshops like Button Up NH, plan for projects like community shared solar, and realize cost savings through joint purchasing practices or demand aggregation.

Above photo: Town of Jaffrey Energy Committee

ENERGY DIVERSITY

The Southwest Region like the rest of the state and nation has developed a strong reliance on foreign, non-renewable fossil fuels to meet its energy needs. Traditionally, fossil fuels have been relatively easy to obtain. However, resource depletion combined with political and market volatility could lead to dramatic price increases and reduced availability of these energy sources in the future. To stabilize the price and supply of energy, and to reduce the environmental impacts of fossil fuels, it is important for the Region to encourage the development and expansion of renewable energy resources such as hydropower, wind, solar, biomass, geothermal and methane generation.

As of 2013, nearly one-seventh of New Hampshire's net electricity generation comes from renewable resources, with hydroelectric facilities providing slightly more than half, and biomass facilities supplying most of the rest. Renewable energy can produce viable energy at a small scale (individual commercial building or house) or at a large scale (producing energy for multiple buildings or to sell to other energy consumers). Within the Region, there are currently few large scale renewable energy facilities in operation. However, recent projects and proposed developments might increase the Region's renewable energy capacity.

Some of the Region's existing renewable energy resources as well as challenges and opportunities to expanded renewable energy production are described below.

Hydropower

- Hydropower offers an emissions-free, reliable and locally distributed source of electricity. In the mid-1700s, early settlers of the Region built saw-mills and grist-mills and used the power of rivers to operate these facilities. However, advancements in technology, increased regulations and environmental challenges led to the decline of hydropower generation and consumption in the Region.
- According to the EIA, 35 of the New Hampshire's 60 power plants are small hydropower plants, and hydropower accounts for 7.1% of total electricity generation in the state. PSNH currently owns and operates nine hydroelectric power plants throughout the state, several of which are over a century old. The PSNH facility closest to the Region is the

Jackman Hydroplant, located on the North Branch of the Contoocook River in Hillsborough. This plant is capable of generating 3.6 MW. A smaller hydropower producer in the Region is Monadnock Paper Mills. The Bennington-based company generates up to 49% of its own power through low-impact hydroelectric generation using the Contoocook River.

- In addition to providing a clean source of energy, hydropower has provided noteworthy economic benefits to the state. According to the Granite State Hydropower Association, in 2010, hydropower operators paid $750,000 in local and utility property taxes, employed over 50 state residents, and spent over $1,000,000 on NH products and services.[148]

- Although well maintained dams can provide many benefits, they can also cause a number of environmental problems, including blockages of fish passage, interruption of sediment and nutrient transport, interference with the reproduction of aquatic life and fragmentation of natural habitats. The effects can be felt significantly downstream, where flows can be reduced, stranding aquatic life and cutting off usable upstream habitat.[149]

Wind Power

- Currently, there are three large-scale wind farms operating in the state. In 2008, Iberdrola, a large renewable energy company based in Spain, established the first New Hampshire-based wind farm on the hill-top ridges in Lempster, which borders the Southwest Region town of Marlow to the north. Since then, two other wind farms have been established near Groton and Dixville Notch and more operations are seeking permitting or are in development.

- Within the Region, a 15 MW wind project is proposed for the top of Kidder Mountain in New Ipswich and Temple. The project is currently under the review of the Towns. A commercial wind farm in Antrim was proposed for construction in 2014; however, the NH Site Evaluation Committee (SEC) rejected the proposal for reasons related to the visual and aesthetic impact of the proposed turbines. This marked the first time the SEC has turned down a wind project.

- Regional challenges associated with wind energy are largely related to the impact of wind development on scenic views and wildlife resources. The hill-tops and mountain ridges that are most suitable for generating larger scale wind power are also valued for their scenic beauty, recreational value, and natural resources. Some of the proposed sites for wind energy in the Region are also areas that support important wildlife habitat and critical flyways for migratory birds.

- In 2008, the New Hampshire legislature created a framework for municipalities to regulate the construction of small-scale wind turbines that have a generating capacity of up to 100 kW. The law (NH RSA 674:63) identifies several possible restrictions to small wind facilities that would be considered unreasonable, and required OEP to develop a model Small Wind Energy System Ordinance. Municipalities can tailor this model ordinance to meet local goals and priorities.

- In the wake of increased development pressure from commercial wind companies, communities across the state have been developing and adopting large scale wind ordinances. Both New Ipswich and Temple adopted large scale wind ordinances in 2010. Large scale wind systems have a generating capacity of greater than 100 kW up to 30 MW. Any utility scale electric generation facility of 30 MW or more is regulated under the Energy Facility Siting Process before the SEC.

Above photo: Wind farm on Crotched Mountain in Greenfield, NH. In December of 1980, US Windpower installed the world's first wind farm, consisting of 20 wind turbines rated at 30 kW each. For a variety of reasons, including unreliable equipment and poorly understood wind resources, the project was not a commercial success and dismantled after a year.

Biomass

- With its strong biomass resources, particularly in the forestry sector, the Region has the opportunity to increase its role in the production of bioenergy. Although wood has historically been the largest biomass energy resource, other sources can be used including food crops, grasses, residues from agriculture, and algae. Biomass can be used for fuels, power production and products that would otherwise be made from fossil fuels.

- The primary biomass feedstocks for power are paper mill residue, lumber mill scrap and municipal waste. Biomass energy plants often burn wood chips made from tree tops and other low value wood scraps from harvesting projects. Currently, there are 7 existing and 2 proposed biomass energy plants in the state, none of which is located is the Region. On average, NH's existing biomass facilities are about 25 years old and produce more than 39% of the state's renewable power.[150]

- Although the Region is not home to a biomass energy plant, it is the location of one of the Northeast's largest wood pellet manufacturer, New England Wood Pellet, which is headquartered in Jaffrey.[151] Use of biomass for home heating is higher in the Southwest Region (14%) than in the state (6%) or nation (2%).

- While cord wood for heating fuel is relatively inexpensive and is a renewable source of energy, improper burning practices can pose environmental challenges. Older woodstoves are a significant source of wood smoke and emissions of harmful fine particle pollution.

Solar Energy

- In recent years, the adoption of solar energy has become more apparent in the Region, with the installation of solar arrays at municipal buildings, local elementary schools, colleges, and organizations and businesses. In 2013, Keene State College became the third largest producer of solar power under PSNH in the state. The College's Technology, Design and Safety Center is home to a solar array that produces 15% of the building's power needs.[152] A project is being proposed in Peterborough to develop a 1 MW solar farm for distributed generation at the site of the Town's waste water treatment facility (WWTF).

- In 2012, a group of individuals interested in energy efficiency and renewable energy formed the Monadnock Area Resource Initiative (MERI). MERI is a grassroots, non-profit organization that offers affordable opportunities for communities and residents of the Region to improve the energy efficiency of their homes, schools, and non-profit centers through solar hot water installations and neighbors-helping-neighbors weatherization trainings.

  This organization was modeled after the successful Plymouth Area Renewable Energy Initiative (PAREI), which has popularized the concept of 'energy-raisers' in the state. An energy raiser is a neighbor-helping-neighbor effort, similar to a barn-raising, where trained individuals, tradespeople and community members volunteer their time and expertise to install a solar energy system on a home or building.

  MERI has expanded this concept to include deep energy retrofits and weatherization of homes and buildings. Through education, community building, increasing accessibility to professional energy related services and cost savings, the approach employed by MERI has encouraged residents and others in the Region to support energy conservation and energy efficiency practices.

Above photo: Solar Array on top of Keene State College's Technology, Design and Safety Center.

OPPORTUNITIES

Renewable Energy Rebate Program

- The PUC administers rebate programs for a variety of renewable energy systems. These programs offer rebates to qualifying homeowners for residential small renewable systems, wood pellet central boilers, and solar hot water heating and space heating systems. There are also rebate programs available for commercial and industrial solar electric and thermal systems and bulk fuel-fed wood pellet central heating systems. However, the eligibility requirements and amounts available for rebates vary by program and fiscal year.

Renewable Energy Tax Exemption

- An incentive currently available at the local level is the renewable energy property tax exemption (NH RSA 72:61-72), which permits cities and towns to offer exemptions from local property taxes for certain renewable energy installations. These include solar systems (thermal and photovoltaic), wind turbines, and central wood-fired heating systems, excluding woodstoves and fireplaces. The goal of this exemption is to create a tax neutral policy that neither increases an individual's property tax nor decreases the municipality's property tax revenues. This policy serves to eliminate the potential disincentive of higher property taxes for installing a renewable energy system.

- To date, only 16 of the Region's 35 municipalities have adopted this property tax exemption for one or more renewable energy sources. Among these communities, all have adopted a solar energy property tax exemption, 10 have adopted a wind energy exemption, and 7 have adopted a wood energy exemption. OEP has developed guidance for municipalities seeking to adopt these tax exemptions including a sample warrant article.

Group Net Metering

- An opportunity for encouraging increased renewable energy in the state is the passage of legislation (NH RSA 362-A:9, XIV) in 2013 that enables group net metering. Net metering allows the owners of certain small electric generating systems to receive credit for the electricity produced by those systems, above what is consumed on the premise. Group net metering allows for certain small renewable energy generating systems to form a group with multiple customers (or multiple electric meters) within the same utility service territory, in order to offset the electric bills of the group members against the production of the system. In other words, the output of a renewable energy system at a particular location can be shared among multiple accounts, not necessarily located at the same location. This tool is seen as an innovative way to encourage investment in renewable energy.

Community Solar

- An opportunity to expand access to the benefits of solar power is community shared solar. This is an option for individuals who are unable to pursue a solar energy system because they lack a favorable site, do not own property, lack sufficient funds, etc. to access and share in the costs and benefits of solar power. There are numerous models for designing and financing community solar projects.

- The National Renewable Energy Laboratory developed a guide[153] for groups or individuals interested in developing community shared solar power, which focuses on three different project models. The utility sponsored model is where a utility owns or operates a project that is open to voluntary ratepayer participation. In the special purpose entity model, individuals join in a business enterprise to develop a community shared solar project. The nonprofit model is based on a charitable nonprofit corporation administering a community shared solar project on behalf of donors or members.

- Although community solar projects are developing across the country, there are still many considerations and challenges to ensuring the success of these initiatives. Some of the primary issues to this concept are financial and institutional barriers including raising necessary capital, limited access to federal and state tax incentives, and the need for policies and regulations at the state level for community solar.

RESOURCES FOR COMMUNITIES

- *NH Office of Energy and Planning (OEP)* provides information, data and guidance to assist decision-makers on issues pertaining to development, land protection, energy use and community planning. OEP operates several energy programs in partnership with private and public entities that promote energy efficiency and reduced energy costs as well as the expanded use of renewable, domestic energy resources. www.nh.gov/oep/energy

- *NH Department of Environmental Services (DES) Energy Program* is a resource for municipalities and the general public to receive information on energy related topics and programs in New Hampshire. This program is housed within the Air Resources Division of DES. des.nh.gov/organization/divisions/air/tsb/tps/energy/

- *NH Public Utilities Commission (PUC)* Sustainable Energy Division assists the PUC in implementing specific state legislative initiatives focused on promoting renewable energy and energy efficiency and to advance the goals of energy sustainability, affordability, and security. The Division helps the Commission in administering the Renewable Energy Fund and the Greenhouse Gas Emissions Reduction Fund. These funds finance energy efficiency and renewable energy initiatives across the state. http://www.puc.state.nh.us

- *NH Sustainable Energy Association (NHSEA)* is a nonprofit organization focused on educating citizens, businesses and organizations in New Hampshire about sustainable energy and on advocating for favorable sustainable energy projects in the state. www.nhsea.org

- *NH Local Energy Working Group (LEWG)* is an ad hoc group focused on supporting the work of local energy committees and commissions, municipalities and schools in New Hampshire. It manages a web-based clearinghouse of information on resources and tools available in New Hampshire to address energy issues and challenges. They also host the annual Local Energy Solutions Conference. www.nhenergy.org

- *Button Up NH* is a home weatherization workshop designed to provide citizens with information and techniques to help save money on home energy use. Communities host these workshops, which are conducted by an independent certified energy professional and are free and open to the public. www.myenergyplan.net/buttonup

- *NH Saves* is a collaboration of New Hampshire's electric and natural gas utilities working with the PUC and other interested parties to provide customers, including businesses and municipalities, with information, incentives, and support designed to save energy, reduce costs, and protect our environment statewide. www.nhsaves.com

- *Jordan Institute* is a nonprofit organization focused on advanced environmental and economic health by improving energy performance and resiliency in how buildings are designed, built, renovated, operated and financed. http://www.jordaninstitute.org

- *US Energy Information Administration (EIA)* collects, analyzes, and disseminates independent and impartial energy information. EIA maintains the State Energy Data System, which is source of historical information on energy production, consumption, prices, and expenditures by state. www.eia.gov

- *U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE)* plays a key role in advancing the nation's energy strategy by leading a large network of researchers and other partners to deliver innovative technologies and market-based solutions. energy.gov/eere/office-energy-efficiency-renewable-energy

CHAPTER 4. CLIMATE CHANGE

"Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased." - Intergovernmental Panel on Climate Change, "Climate Change 2013: The Physical Science Basis"

Climate scientists overwhelmingly agree that global climate change is happening and caused by human activity. In the latest demonstration of this scientific consensus, a recent study of 2,258 climate-related articles, published in peer-reviewed journals between November 2012 and December 2013 written by a total of 9,136 authors, found all but one climate scientist supported the theory of anthropogenic climate change as an explanation for changes we are observing to our global climate.[154]

Despite the scientific consensus that climate change is occurring and a threat to human societies and natural ecosystems, the issue is far from settled by the American public. Global climate change is viewed by Americans from multiple perspectives. Some feel it is a natural fluctuation of climate, some are uninterested and know little about it, and others are very worried and motivated to take action to reduce what they consider a major threat. Regardless of the perspective, the idea of *anthropogenic climate change* represents major risk potential to human settlements and natural ecosystems.

Planning for risks posed by increased temperatures and precipitation, as suggested by the scientific community, is similar to taking out an insurance policy. For example, a building owner typically does not take out a fire insurance policy, install smoke alarms, and plan an emergency fire exit knowing that there will be a fire. In contrast, the homeowner respects the possibility of a house fire as a potential risk for which they must be prepared.

This Plan views the risks of climate change similarly. The question is not should the Region plan for the risk. As the next sections will demonstrate, there are already some activities underway to do so. The question, instead, is at what lengths is the Region willing to go to prepare for the risks of climate change? Ultimately, this decision rests with a community, and is based on their individual and collective assessment of the risk and what they are willing to do to prevent the possibility of future hardship.

CLIMATE CHANGE 101

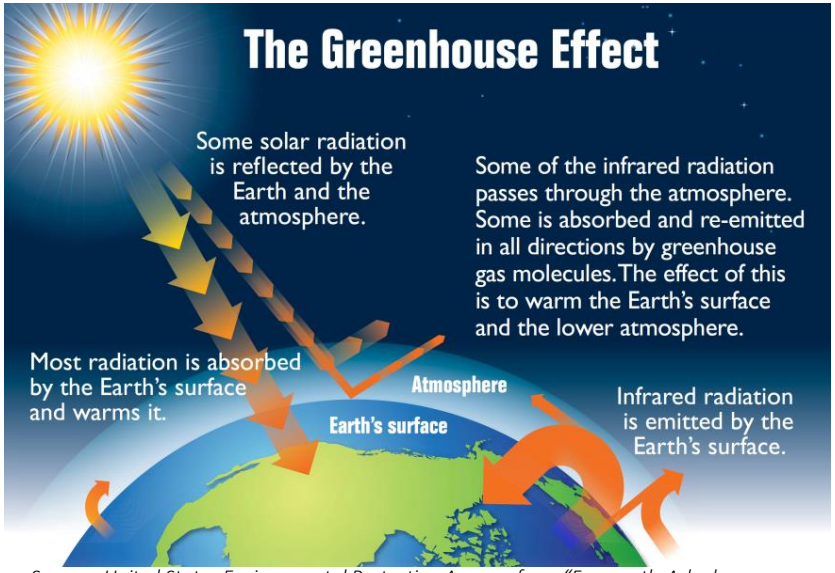
Although the Supreme Court ruled that carbon dioxide and other greenhouse gases (GHGs) can be legally classified as pollutants in 2007, it can be difficult to think of them as air pollution. Carbon dioxide and other naturally occurring GHG gases, such as water vapor, methane, nitrous oxide, and ozone, have always been present in the atmosphere, helping to keep Earth hospitable by trapping heat and warming our atmosphere. It is the increase in GHGs, which evidence shows has been accelerating since the industrial revolution, that is what scientists believe is accelerating radiation absorption in Earth's atmosphere. Carbon dioxide is the primary GHG emitted through human activities.

This phenomenon is sometimes described as the greenhouse effect. Just like the radiation from the sun that is trapped in a greenhouse to artificially extend the growing season for plants, radiation from the sun is trapped by certain gases to extend the warming period on Earth. This natural process unfolds first as sunlight passes through the atmosphere and strikes the earth. Some of this light is absorbed in the earth's surface and converted to heat, which in turn warms the surface. The surface emits heat to the atmosphere where some of it is absorbed by GHGs and re-emitted back towards the surface. Some heat escapes into space.

As GHG emissions increase over time, more radiation is absorbed and re-emitted back to Earth. Aside from water vapor, which has an atmospheric lifetime of a little over one week, major GHGs take many years (some over 100 years) to leave the atmosphere. The accumulation of GHG emissions upsets a balance of warming and cooling on the earth by creating more warming impacts in the lower atmosphere, the ocean and over Earth's surface. The result, scientists predict, is a changed climate which leads to new weather patterns.

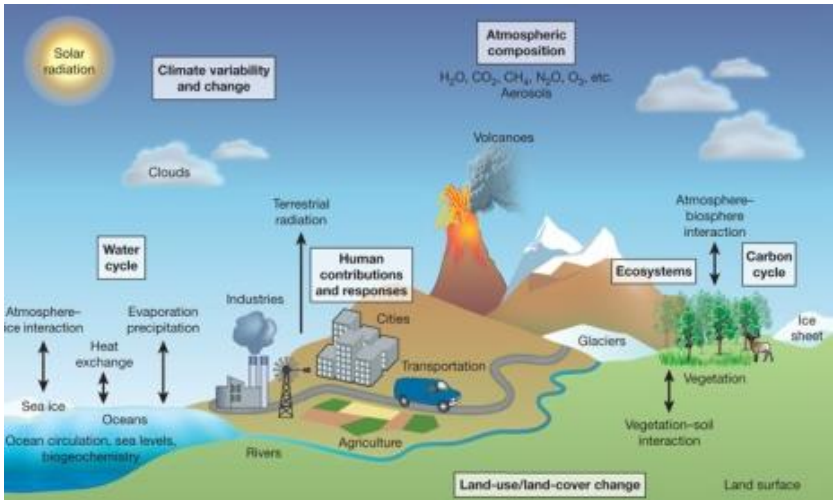
While scientists document a general global warming trend, they recognize that climate changes vary from place to place, based on a variety of interactions between local, regional and global changes to the atmosphere, hydrosphere, and biosphere. For example, changes to the hydrosphere (*surface and ground water*) can affect precipitation, evaporation and surface heat storage trends. Likewise, changes to the biosphere such as the presence or lack of forest or vegetation, can affect the ability of land cover to absorb or re-emit heat. Due to the unique circumstances of a local environment and its relationship to the rest of the climate system, places may have different experiences with temperature or levels of precipitation.

Figure 9. The Greenhouse Effect



Source: United States Environmental Protection Agency, from "Frequently Asked Questions about Global Warming and Climate Change: Back to the Basics," 2009.

Figure 10. Interactions between the Atmosphere, Hydrosphere & Biosphere



Source: Richard H. Moss et al., "The Next Generation of Scenarios for Climate Change Research and Assessment" Nature 463, February 11, 2010, pp. 747-756

Scientists recognize that although a trend of increased carbon dioxide emissions and temperature has risen since the industrial revolution, more rapid and extreme change has occurred since the 1970s. While the average temperature in the northern hemisphere increased about 1°F during the 20th century, the pace at which warming began to accelerate was when the carbon content of the atmosphere increased to a threshold of 340 to 350 molecules of carbon dioxide for every million molecules of dry air. The atmospheric concentration of carbon in 2013 was between 393 and 396 ppm, compared to a preindustrial value of 280 ppm.[155]

EXISTING CONDITIONS

Although temperature, precipitation and other weather patterns vary year to year and place to place, data shows the overall average trend is one that has included more warming and more precipitation. Residents that have lived in Southern New Hampshire for several decades, have been witnesses to changes in the environment including:

- more frequent extreme-heat days where the maximum temperatures are greater than 90°F;
- plants blooming, leafing or flowering earlier in the spring;
- longer growing seasons for gardening and farming;
- earlier snow melting resulting in earlier high spring river flows;
- an increase in heavy rainfall events;
- earlier breakup of winter ice on ponds, lakes and rivers;
- less precipitation falling as snow and more as rain; and,
- less snowpack.[156]

Southern New Hampshire is fortunate to have three long term meteorological stations in Keene, Durham, and Hanover, recording reliable temperature data for as far back as 1895. Each location has experienced climate change differently, but the trends are consistent with global trends - namely that our environment is getting warmer and we are experiencing more precipitation.

Increased Average Temperatures

The historical data shows that since 1895 there have been long-term temperature increases. Between 1970 and 2012, there have been significant warming trends in annual and most seasonal temperatures. The rate of warming in the Southwest Region's maximum temperatures over the past four decades increased by a factor of seven relative to the 1895-2012 trend.

The warming trend seems to be affecting winters in Southern New Hampshire more than other seasons. Between 1970 and 2012, Keene experienced an increase of minimum winter temperatures of 1.7°F per decade.

Increased Precipitation

Precipitation has also increased over time. Due to warmer temperatures, scientists postulate that water is evaporating at a higher rate, and rain is falling in higher concentrations. Sometimes precipitation falls heavily in microbursts, which are short duration, heavy downpours or blizzards in very-localized areas. The result of heavy downpours and increased evaporation is that water is not recharging into the ground in the same way it has historically, creating a situation where there is more precipitation in many parts of the country, including New Hampshire. These events also contribute to the risk of greater drought periods.

According to data reported by the Keene meteorological station since 1895, the Region experienced an increase of 0.32 inches of precipitation per decade. While the overall increases in precipitation have been modest, the frequency of the most extreme precipitation events (4 inches in 48 hours) has increased four to ten times since the 1960s. The amount of precipitation falling on the wettest day of the year is also rising, with overall increases of about 0.1 inches per decade, equivalent to about half an inch more rain on the wettest day of the year over the past five decades.

Though they have not been unequivocally connected to climate change, the Southwest Region has experienced several severe storm events within the last ten years. At the very least, these storm events are examples of what climate scientists predict we can expect to happen more frequently in the Region. The larger storm events, which were Federal Emergency Management Agency (FEMA) Disaster Declarations, include but are not limited to the events listed below.

- June to July 2013 - Severe storms, flooding, and landslides especially in Westmoreland, Surry, Walpole, Alstead, Keene, Gilsum and Sullivan that washed out roads and bridges and damaged personal property.
- May 2012 - Severe storm and flooding, particularly in Keene, which compromised infrastructure and damaged personal property.

- December 2008 (Ice Storm) - Severe ice storm throughout the Region, which damaged personal property and left some residents without power for 7-10 days.
- May 2006 (Mother's Day Flood) - Severe storms and flooding throughout Region, which damaged personal property and permanently shut down businesses including Paper Mill Service Limited in Winchester.
- October 2005 - Severe storms and flooding, especially in Alstead and Keene, which washed out roads and bridges and damaged or washed away personal property and took lives.
- September 2003 - Severe storms and flooding in Westmoreland, Walpole, Gilsum, Surry, Chesterfield, Acworth and Sullivan, which washed out roads and damaged personal property.

Figure 9. Climate Change Trends in Southern New Hampshire, 1985-2012

Parameter	Durham		Keene		Hanover	
	1895-2012	1970-2012	1895-2012	1970-2012	1895-2012	1970-2012
TMAX (°F per decade)						
Annual	**0.21**	**0.55**	**0.09**	**0.61**	0.05	0.25
Winter	**0.20**	**0.80**	0.10	**0.71**	0.08	0.37
Spring	**0.32**	**0.72**	0.10	0.58	**0.15**	0.29
Summer	**0.27**	**0.47**	**0.12**	0.35	0.08	-0.05
Fall	**0.11**	**0.48**	0.04	**0.68**	-0.05	**0.60**
TMIN (°F per decade)						
Annual	**0.20**	**0.58**	**0.50**	**0.82**	**0.25**	**0.74**
Winter	**0.28**	**0.93**	**0.58**	**1.70**	**0.36**	**1.45**
Spring	**0.18**	0.24	**0.45**	0.31	**0.23**	**0.60**
Summer	**0.25**	**0.71**	**0.49**	**0.47**	**0.27**	**0.60**
Fall	**0.14**	**0.83**	**0.50**	**1.11**	**0.22**	**0.61**
Precipitation (inches per decade)						
Annual	**0.56**	1.63	0.32	2.02	0.26	1.16
Winter	-0.03	-0.61	0.45	0.16	0.37	-0.11
Spring	0.08	0.20	0.21	0.14	0.20	0.22
Summer	0.14	**0.93**	0.31	0.57	0.27	0.55
Fall	**0.27**	0.26	0.32	1.12	0.24	0.19
Snowfall	NA	**-9.14**	NA	0.34	NA	-3.44
Snow Covered Days (days per decade)						
Winter	NA	**-6.6**	NA	0.0	NA	-2.9

NA means data not available

Source: Cameron Wake and Elizabeth Burakowski, Climate Change in Southern New Hampshire: Past, Present and Future, 2013.

FUTURE TRENDS

Climate Solutions New England's (CSNE) 2013 report "Climate Change in Southern New Hampshire: Past, Present and Future" provides two scenario-based predictions of the impacts that climate change will have on Southern New Hampshire. The scenarios examine climate change patterns based on levels of fossil fuel use and GHG emissions standards produced by the Intergovernmental Panel on Climate Change (IPCC) in its 2000 Special Report on Emissions Scenarios (SRES). Both scenarios account for world population growth over time and GHG emissions are examined at a global scale. The IPCC scenarios are explained in this way:

> *"At the higher end of the range, the SRES higher-emissions or fossil fuel intensive scenario (A1fi for fossil-intensive) represents a world with fossil fuel-intensive economic growth and a global population that peaks mid-century and then declines. New and more efficient technologies are introduced toward the end of the century. In this scenario, atmospheric CO2 concentrations reach 940 parts per million by 2100, more than triple preindustrial levels of 280 ppm.*
>
> *At the lower end, the SRES lower-emissions scenario (B1) also represents a world with high economic growth and a global population that peaks mid-century and then declines. However, this scenario includes a shift to less fossil fuel-intensive industries and the introduction of clean and resource-efficient technologies. Emissions of greenhouse gases peak around mid-century and then decline. Atmospheric carbon dioxide levels reach 550 parts per million by 2100, about double pre-industrial levels. Associated global temperature changes by end-of-century range from 4°F to 9°F based on the best estimate of climate sensitivity."*

Like today, future climate is expected to be variable depending on your location on the globe. The CSNE report provides some insights on what climate would look like in Southern New Hampshire through a combination of methodologies known as statistical and dynamic downscaling. Major global impacts will include arctic ice cover melts and sea level rise.

Future Temperature

According to the CSNE report, average temperatures in the Southwest Region are expected to continue to rise during all seasons regardless of whether or not a lower or higher emissions scenario unfolds over time. However, it is

clear that the magnitude of warming will depend on which emissions scenario is followed.

Under the high emissions scenario, warming trends are expected to begin to diverge more dramatically around the middle of the 21st century. By the end of the century, high emissions temperature increases will be approximately double the low emissions scenario. By the end of the 21st century, the number of extreme temperature days under the high emissions scenario is expected to be more than double the number of days under the low emissions scenario.

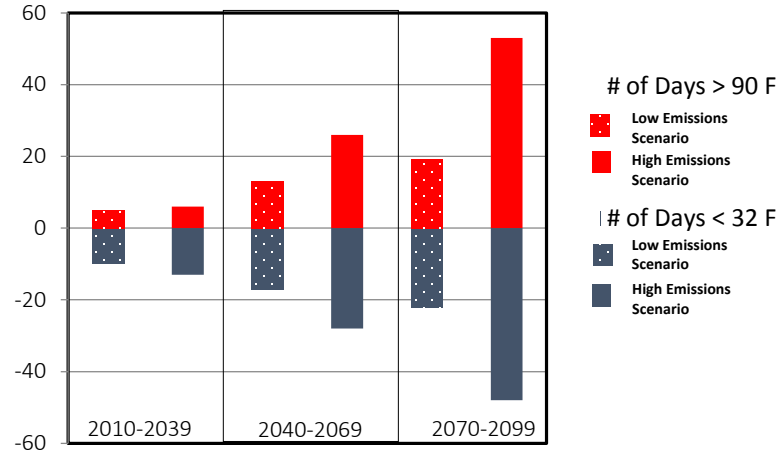
In Keene, by 2099 the study forecasts that there may be 53 more days during the year that will reach temperatures greater than 90°F. The number of days that will reach below freezing could decrease by 48 days. The same study suggests that the number of "growing season" days would increase by 51 days and the Southwest Region might see 46 fewer snow cover days. This is a very abrupt change in climate in such a short period of time.

Future Precipitation

The Southwest Region is expected to get wetter over time. As is the case with temperature, the higher emissions scenario is not anticipated to result in higher rain levels until the middle of the 21st century, when the Region is predicted to start experiencing marginally more precipitation. Under a low emissions scenario, Keene is expected to get approximately 7 more inches of rain than it has historically, and 9 more inches under a high emissions scenario.

Extreme precipitation events are expected to be slightly higher under a high emissions scenario in the latter half of the 21st century, but in either case, more extreme precipitation events are expected. By 2099, Keene is expected to have between 7 and 8 more extreme precipitation events of four-inches in 48 hours per decade, compared to the low emissions scenario of between 6 and 7 events. Between 1980 and 2009, Keene averaged only 1.5 four-inch precipitation events in 48 hours per decade.

Figure 10. Projected Change in Number of Extreme Temperature Days Based on Emissions Scenario and Time Period – Keene, NH*



**Baseline is 1980-2009 measurements, in which the average number of >90° F days and < 32° F days in Keene was 9 and 163, respectively.*

RESPONSES TO CLIMATE CHANGE

The Southwest Region is not alone in assessing the risks of climate change. Efforts to prepare for and mitigate climate change are happening at various scales from the local to global level. While many of these efforts have done a good deal of work identifying existing conditions and predicting expected future conditions, the implementation of measures to reduce GHGs or adapt to a changing climate have not approached the scale believed to be necessary to manage the problem.

Adaptation and Mitigation

- Strategies to address climate change are often categorized as either adaptation or mitigation. Adaptation describes a response to climate change that seeks to lessen vulnerability to climate change impacts by adapting to the new challenges caused by climate change. For example, climate change is expected to increase extreme rain events, which make housing, roads, utilities and other built environment infrastructure susceptible to destruction. This threat is greater in areas where storm water infrastructure has not upgraded to allow for heavier flows of water to be directed away from that infrastructure.

- Mitigation, on the other hand is a response to climate change that significantly reduces or stops GHGs from entering the atmosphere. Examples include development of renewable sources of energy that do not produce GHGs, carbon sequestration strategies, and conservation or energy efficiency programs to reduce GHG emissions.

Local Responses

- According to the New Hampshire Carbon Coalition, 27 of the 35 towns in the Southwest Region of New Hampshire have adopted resolutions to implement local solutions to mitigate or adapt to climate change.[157]

- Many towns have active energy committees working to address energy efficiency and/or climate change issues at the local level.

- Some communities, such as Antrim and Temple have adopted energy chapters in their Master Plans. Keene has adopted a Climate Change Action Plan and a Climate Change Adaptation Action Plan.

- Many communities have reduced municipal demand for fossil fuels and GHG emissions by making municipal buildings more energy efficient.

- Other local groups outside of government, such as Transition Keene, have emerged, focusing on climate change education and awareness.

Regional

- In 2010, Antioch University, Clean Air Cool Planet and SWRPC, worked with communities throughout the Region through a partnership called, Cool Monadnock, to assess local priorities and capture ideas and insights from local citizens on energy and climate change issues. The result of this process included the development of the Monadnock Sustainability Plan, which is an advisory document that provides recommendations, tools and resources for various sectors to take action on climate change and energy issues. This document is a reference and guidance tool that communities across the Region can utilize as part of local initiatives.

- A promising development for improving local and regional climate preparedness is the creation by Antioch University of New England (AUNE) of a Center for Climate Preparedness and Community Resilience. The Center was launched in 2014 in response to a White House Climate Data Initiative, which urges public and private organizations to use data on climate change risks to help communities, businesses and other stakeholders make better-informed decisions about such issues as building new roads and bridges or preparing for flooding.

State

- The State of New Hampshire has made a number of strides to address climate change. In 2009, the state created a Climate Action Plan, which recommends actions by state agencies and other stakeholders to reduce GHGs and adapt to climate change. The New Hampshire Energy and Climate Collaborative is measuring progress on implementing the Plan as well as monitoring New Hampshire's GHG emissions and the impacts of climate change.

- In 2013, the New Hampshire Fish and Game Department developed the Ecosystems and Wildlife Climate Change and Adaptation Plan, an addendum to its Wildlife Action Plan. The Plan contains vulnerability assessments for various freshwater, terrestrial and coastal habitats, as well as short term and long term strategies to conserve species and habitat while adapting to climate changes.
- New Hampshire is a member of the Regional Green House Gas Initiative (RGGI), the first market-based regulatory program in the United States to reduce GHGs. RGGI is a cooperative effort among the states of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont to cap and reduce CO_2 emissions from the power sector. States sell emission allowances through auctions and invest proceeds in measures that increase energy efficiency, renewable energy, and other clean energy technologies.

National

- At the time of writing, the White House has created a President's Climate Action Plan as well as an executive order requiring various departments and agencies of the federal government to adjust various management practices in an effort to reduce their carbon footprint and adapt to climate change. The Environmental Protection Agency (EPA) is working on GHG emissions rules for power plants, but these rules have not yet been implemented.

- In May of 2014, the White House released its third National Climate Assessment document, which is also an interactive website. Perhaps the most important message of the document, which provides an assessment of existing conditions and forecasts changes to all regions of

the United States, is that it makes the observation that climate change and its serious impacts are already occurring.

Global

- For 19 years running, representatives from around the world have been meeting to develop a global pact to decrease GHG emissions and prepare for climate change. The 19th session of the Conference of the Parties to the U.N. Framework Convention of Climate Change, held in 2013 in Poland, were recently described as laying the groundwork for a global agreement in time for talks in Paris in 2015.[158] Over 190 countries participated.

OPPORTUNITIES

Government institutions are viewed by scientists as an important actor to address climate change because they view widespread and sweeping policy actions as an efficient way to address climate change risks. However, government is not the only forum for assessing climate change risk. Decisions can be made and in many cases are being made by businesses, nonprofit organizations, individuals and other local actors.

Within the Southwest Region, businesses, nonprofit organizations and individuals as well as local and county governments are the entities that are able to make decisions regarding climate change risk and affect change within their own spheres of influence. There are many opportunities for collaboration between these entities as well. Implementation by local and regional actors can ensure significant risk protection as well as enhance regional preparedness for climate change risks.

Information Sharing

- One way to help these actors address climate change risk is to provide meaningful and trustworthy information to help with decision making processes, whether it is in a setting at a town meeting, a staff meeting, board room, or at the family dining room table. Although some regional information has been created about climate change risks, most information is larger than local, making it difficult for stakeholders to make risk management decisions within their own sphere of influence.
- More effort is required to produce, disseminate, and facilitate the use of local and regional data and information to improve decision-making across the various settings in the region. For effective decision making to take place, there will need to be greater effort put into relating complex scientific information about climate change threats to the values and concerns of each stakeholder audience and into effectively disseminating this information.

Decision Making Tools

- In addition to providing more customized and easier to use information, there is a need to introduce decision support tools to Regional stakeholders such as methods for exploring the impacts of alternative decisions, vulnerability and impact assessments, maps of projected climate impacts, case studies, and tools that help users locate, organize, and display data in new ways.
- Tools with good visuals will ensure that information reaches a wider audience. Significant thought should be put into tools that are able to show possibilities for achieving positive outcomes that are achievable by the tool user in order to motivate actions to prevent climate change risks.

Collective Impact

- Collaborative, communicative and participatory consensus-based decision making will be important to building relationships and trust between data disseminators and various stakeholders in order to support longer-term problem-solving.

RESOURCES FOR COMMUNITIES

- *Climate Solutions New England (CSNE)* promotes collaboration and collective impact towards the goal of greater energy self-reliance and weather resilience. CSNE is an initiative of The University of New Hampshire Sustainability Institute and is led by faculty and staff from the Sustainability Institute and the University of New Hampshire. www.climatesolutionsne.org
- *NH Energy & Climate Collaborative* is a network of energy and climate leaders and organization focused on leverage opportunities and removing barriers to implementation of the New Hampshire Climate Action Plan. nhcollaborative.org

- *U.S. Environmental Protection Agency (EPA)* is a national resource on climate change trends as well as mitigation and adaptation strategies. epa.gov/climatechange

- *Antioch University New England (AUNE) Center for Climate Preparedness and Resilience* is focused on helping communities to prepare, respond and recover in the face of climate impacts and other disrutpions through collaborative and innovative solutions. The Center delivers applied research, consulting, and education and training that is focused on building stakeholder capacity for preparedness and resilience at the local scale. www.antiochne.edu/community/center-climate-preparedness-community-resilience

- *NH Fish and Game* has developed an amendment to the NH Wildlife Action Plan which explores the impacts of climate change on wildlife and habitats in the state and recommends related adaptation strategies. This 2014 amendment is titled, "Ecosystems and Wildlife: Climate Change Adaptation Plan." www.wildnh.com/Wildlife/Wildlife_Plan/climate.html

- *NH Department of Environmental Services (DES) Climate Change Program* offers comprehensive information on the issue of climate change in New Hampshire in a way that is accessible and meaningful to communities, individuals, business, and state and local government. des.nh.gov/organization/divisions/air/tsb/tps/climate/index.htm

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