Assessing the Migration System of New Hampshire and Vermont’s Connecticut River Valley

Part II - Impacts on Ecology and Social Systems from Human Migration and Public Desire

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Abstract

Current impacts of climate change, Covid-19, and political tensions are influencing the migration of human populations across the globe. As a result, communities and local planners must identify and respond to the impacts of changing demographics and settlement patterns. This report, the second in a three part series, identifies the impacts of migration patterns within the towns on the Connecticut River in New Hampshire and Vermont. Terrestrial impacts from development and urbanization include fragmentation and sprawl, increased impervious surface, runoff, and flooding, loss of biodiversity and forests, disruption of nutrient cycles and weakened climate resiliency. Watershed impacts include a disrupted hydrological cycle, loss of biodiversity and aquatic habitat, degraded water quality, loss of recreational opportunity, and water scarcity. It is expected that the quantity and type of social services demanded by the population will change with demographics. A key disparity affecting both public desire and social systems in the region is gentrification. Communities are experiencing an overburdening demand for economic and cultural resources spurred by widening gaps in social disparities. With a particular focus on watershed health and social equity, this report examines the newest analysis of migration impacts within New Hampshire and Vermont’s Connecticut River towns at a systemic level.

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Acknowledgements

This report, the second in a three part series, seeks to identify the impacts of migration patterns within the towns in the Connecticut River Valley of New Hampshire and Vermont. Researched and authored by Jo Corvus and Meagan Sylvia, these reports originally serve to meet the requests of The Connecticut River Joint Commision, a watershed-level planning board in New Hampshire and Vermont. We extend our appreciation to Collaborative Service Initiative Coordinator, Sarah Bockus, MS, and AUNE graduate students Raleigh Tacy, Shameika Hanson, and Jessica Poulin for their literature review completed in 2020 on Climate Migration in Vermont. Special thanks to the Connecticut River Joint Commissions for the opportunity to engage in meaningful work on issues relating to climate migration, equity, and resilience, to Olivia Chitayat Uyizeye of the Upper Valley Lake Sunapee Regional Planning Commission, to Marie Caduto of the Vermont Department of Environmental Conservation, and to our capstone project advisor, Christa Daniels, Ph.D., AICP.

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Introduction

This report will assess the potential impacts of human migration and changing populations on the Connecticut River's ecological and community health systems. As a prominent part of the Connecticut River riparian corridor, impacts on land continuity and watershed health are of particular interest. The ecological health of the region influences the local amenity economy, consisting substantially of outdoor recreation and tourism (Park et al., 2019). In addition, changing demographics of the region are bound to affect public desires and social systems. The second part of this paper will examine shifts in land use preferences, transportation needs, and basic social needs. This report is intended to serve as a systems assessment of migration impacts to inform future propositions in land use planning.

Impacts on Land Use

The study area includes 53 politically distinct communities covering 2,449 square miles and consisting of approximately 164,400 residents (U.S. Census Bureau, 2019). The regional population density is 67 people per square mile, ranging from 2.72 people per square mile in Lemington, VT to a maximum of 350 people per square mile in Brattleboro, VT. The region consists of approximately 70,000 households, 60 percent of which were built prior to 1980. The percentage breakdown of homeowners to renters varies from one community to the next, and in the study area renters represent approximately 21 percent of the units available. 17 percent of the housing stock in Vermont is intended for seasonal use (VHFA, 2020). New Hampshire's seasonal stock is approximately 10 percent (Kitch, 2017). Refer to Appendix A for housing stock data. In particular, a quarter of all housing located in Coos and Grafton counties, New Hampshire is seasonal. In Vermont Essex, Windsor, and Windham counties, more than twenty percent of all housing is seasonal. Essex represents as much as 43 percent seasonal housing (VHFA, 2020).

Currently, the major draw for in-migrants, or those moving into the area, are the region's ecological features. The most common in-migrants to the region are amenity migrants, those relocating due to proactive preference, free-will, and with ample resources. These amenity migrants, consisting of seasonal residents occupying second homes and new affluent permanent residents, often settle in ecologically rich regions, typified by dense forest and high aesthetic ratings. As a result, the very landscape that amenity migrants value often becomes fragmented and experiences higher disturbance due to increased population and sprawling development patterns. Increased use of recreational trails and trail access further impacts the homogeneity of the landscape, increasing demand for access roads and parking lots as well as impacting trail health. In the absence of preventative planning, these changes result in landscape erosion and habitat fragmentation as well as reduced ecological resilience and viewsheds. Furthermore, transportation infrastructure and local businesses may experience overcrowding (Park et al., 2019).

While it is true that larger population sizes correlate with larger environmental impact, per capita resource demand and growth rate compound the effects (Clement and York, 2017). The amenity migration experienced in this region consumes high quantities of resources per capita resulting in land subdivision, new residential development, changes in private land use, crossboundary effects, and a displacement of impacts to be experienced by targeted populations. That is to say, the negative externalities of land subdivision and high resource consumption by amenity migrants most greatly impacts residents in marginalized communities as their "piece of the pie" gets smaller and more polluted while not receiving any of the benefits of land development. Furthermore, amenity migrants often move from urban environments, arriving with the ideology of nature as holding primarily aesthetic and recreational value rather than a productive aspect of the local economy (Jokisch et al., 2019).

The second factor with great influence on land use is the growth rate of a community or region. Counties typified by recreation, amenity, and retirement are the fastest growing non-metropolitan regions, growing at double the rate of manufacturing, farming, and mining-centric regions. The growth rate of a region often correlates with whether migration to a region is planned or unplanned. The growth-rate of a region influences choices in relocation, public attitudes, resource accessibility, and controlled placement of a growing population. When the growth-rate is controlled through proactive planning, development can be targeted to produce more resilient outcomes such as conversion of brownfields to housing and safeguarding valuable watersheds and viewsheds (Park et al., 2019).

Over the last decade, approximately half of new homes in the study area are estimated to be built in moderate-density and rural communities (Mount Ascutney Regional Commission et al., 2021). Vermont and New Hampshire, along with Maine, are among the states with the highest percentage of vacation homes. Refer to Table 1 for information on housing stock. In general, Vermont housing has a 3 percent vacancy. The vacancy percentages for New Hampshire in the table likely include both seasonal and vacant housing, although this should be researched further. Prior to the COVID-19 pandemic, 17 percent of homes in the area were classified as second-homes (VFHA, 2020). This rate varies by community, with the highest rates of 50 percent or greater occurring in outdoor recreation communities near ski resorts and waterbodies. This seasonal housing stock is responsible for the majority of development in the region, increasing homeownership in spite of a decreasing local population. Much like amenity migrants, second-home owners, despite viewing the environment as an aesthetic and recreational resource, often develop housing in areas most degrading to the environment they value. Current speculations and lived experiences report that COVID-19 has led to the transformation of seasonal homes into full time residences, however the legitimacy of these experiences and the permanence of those who have relocated are not yet known (Mount Ascutney Regional Commission et al., 2021).

Unplanned migration often occurs as a response to a disturbance event such as climatic impacts, natural disasters, or the current COVID-19 pandemic. In such instances, large scale disturbance is often coupled with an economic decline, reducing regional and municipal capacity to invest in planning solutions. During the 2008 housing recession, land development slowed due to the unavailability of capital investment (Clement and York, 2017). Similarly, the current economic recession accompanying COVID-19 will likely reduce the region's capacity to implement planning and control measures to influence current migration growth-rates. By planning and investing proactively during times of economic health, communities can increase control of migration rates and forms, reducing reactionary responses.

Another correlated effect of disturbance events prevalent during the COVID-19 pandemic is an increased death rate. Birth and death rates, of course, impact land use in similar, though different, ways as migratory population shifts. In America, deaths result in burials requiring land conversion, regardless of a decrease in population (Clement and York, 2017). In addition, increased rates of death reduce household income and increase vacancy rates, shifting overall economics and increasing the burden on those financially interdependent with the deceased. Prior to the onset of COVID-19, the Upper Valley's vacancy rate was just below 2%, which is notably below the market standard of a 4 to 5 percent health vacancy rate, resulting in a high-demand, high-cost housing market. Preliminary data collected in the past year indicates a reduced housing stock as amenity migrants move in, particularly to this Upper Valley region (Mount Ascutney Regional Commission et al., 2021). With shifting household demographics and economics comes the potential for shifting housing desires and land use patterns. More research is needed to determine if the effects of COVID-19 will leave a lasting impact on housing preferences and land use patterns within the study area.

Even without the known effects of COVID-19, regional household sizes are decreasing. This trend, largely attributed to the desires of an aging population and smaller family sizes, demonstrates reduced resource demand per capita that may be used to inform land-use patterns with denser built environments. For instance, the majority of new homes are multi-family or single-family dwellings designed for an occupancy of 2-3 bedrooms. These homes, assessed under $300,000 are considerably smaller than the older buildings typical of the region (Mount Ascutney Regional Commission et al., 2021).

To accommodate current trends of adult population growth, it is estimated that "Vermont will need to increase the state's total housing stock by about 5,800 primary homes before 2025 to meet expected demand among new households while also housing the state's homeless and replacing homes likely to be removed from the stock" (VHFA, 2020). In New Hampshire, older residents are likely to "downsize" to smaller residences, yet housing units of 3+ bedroom far outnumber smaller units. Younger households are less likely to be homeowners compared to previous generations and due to financial pressures pursue nonconventional housing solutions like co-ownership and "doubling up," or prefer the flexibility associated with renting (Ray et al., n.d.). As every community is expected to require housing, this stock will need to be planned across each community intentionally to avoid adverse environmental impact (Mount Ascutney Regional Commission et al., 2021).

Transportation

In addition to housing development, the second largest factor in habitat fragmentation associated with migration is expansion of transportation infrastructure. In determining cost of living and housing expenses, one indirect cost is that of transportation. Migrants deciding where to live will be influenced by the overall cost of their location. In this region, personal cars are the dominant mode of transportation, being most prevalent among homeowners. An assessment of The Upper Valley found that ninety-eight percent of homeowners have access to personal cars compared to 84 percent of renters. Seventy-percent of homeowners have access to two or more cars whereas 51 percent of rental units only have one. Where the majority of renters are located in dense communities, active and public transportation options offer residents lower cost and lower impact commuting options (Mount Ascutney Regional Commission et al., 2021). However, these public transportation options are often inconsistent in timeliness and availability and rarely cover out-of-town transportation.

Due to the current sprawl of residents outside compact town centers, inter-municipality commuting for work is a norm in this region. An assessment of employment at some of the largest employers in the region show that over half of the workers travel from more than two communities away to reach their place of employment. Only 19 percent of workers live in the same municipality in which they work. This sprawling set up increases living expenses for the region, rises demand for road construction and maintenance, and expands the impervious surfaces of the region inefficiently, impacting environmental resilience and habitat continuity (Mount Ascutney Regional Commission et al., 2021).

Environmental Impacts of Fragmentation

Land use changes in housing, transportation, and associated community services significantly impact the resilience of environmental systems. The associated habitat fragmentation typical of the sprawling design of the region results in biodiversity loss, a disrupted nitrogen cycle, reduced stormwater management, and weakened climate resilience. These impacts, occurring both immediately and reaching into the future, compromise the very resilience drawing climate migrants to the region. Once a built environment is expanded, the infrastructure remains for many decades, possibly centuries, regardless of population changes (Clement and York, 2017).

In Vermont, an estimated 1 percent of forest loss over the past decade is attributed to sprawling development patterns. Prior to this past decade, Vermont's forests were in a 150-year long recovery state, gaining land rather than losing it. In addition to sprawling development patterns, New England's fragmentation and habitat deterioration is attributed to such factors as reduced state and federal public land funding, the introduction of non-native pests and pathogens, unsustainable forest and farm practices, and reduced public support for working-landscape economies. In New England, the amount of land conserved each year has been declining since 2008, with funding dropping by 50 percent between 2008 and 2014. Vermont, specifically, is 78 percent forested and consists of 23 percent conserved forest and farmland at a cost of $7 per person per year to continue conservation efforts. New England's forests absorb 760,000 tons of air pollution annually, saving an estimated $550,000 in health expenses. Additionally, this forest capacity offsets 20 percent of the region's carbon dioxide emissions (Ready-Campbell, 2020).

Watershed Health

The Connecticut River is the longest tidal river in the Northeastern United States. It starts at the Fourth Connecticut Lake near the Canadian border and flows south 410 miles before discharging into the Long Island Sound. The Connecticut River Basin includes a mosaic of landscapes and a high proportion of private land. It is important to the region for providing homes, jobs, and recreational opportunities to over 2 million inhabitants (Wang and Stephenson, 2018).

Within the study area, the Connecticut River is 255 miles long. Vermont's major drainage basins have been organized into 15 regions for assessment and planning purposes, and 7 of the drainage basins are located along the Connecticut River (Department of Environmental Conservation, n.d.). In New Hampshire, seven of the sixteen subregion drainage basins (based on level 4 hydrological units) are located along the Connecticut River. While New England is among the most heavily forested regions in the United States, the Connecticut River Basin is one of the few areas with more than 75 percent forest cover and more than 75 percent private ownership of forests (Wang and Stephenson, 2018).

Surface waters are an invaluable ecological resource. They provide habitat to aquatic species and wildlife, attract tourists, support economic and recreational opportunities, and provide sources of drinking water. Human activities influence water quality and on a broader scale watershed health. Typologies of land cover and cover changes and sources of pollution from human activities like road salting, fertilizer use, development of impervious surfaces (i.e., roads, parking lots and buildings), stormwater runoff, agriculture, lumber, industrial use, wastewater plants, and aging septic systems can contribute to the erosion of streambank soils, warmer waters, and the deposit of sediments and excess nutrients in water resources. These activities can lead to harmful algal blooms, nuisance aquatic plant growth, and dead zones, all of which adversely affect watershed health.

Examining water quality indicators, some of which are described in Table 2, informs the need for changing human activities and tracks how freshwater aquatic ecosystems respond to these changes. In New Hampshire, an analysis of data collected by volunteers between 1991 and 2018 shows that the percentage of beaches that issued fecal bacteria (E.coli) advisories and the number of days that advisories were in place significantly increased between 2003 and 2018. Plausible explanations include warmer temperatures, an increase in people using the beaches, an increase in waterfowl populations, and or an increase in stormwater runoff (Nelson and Neils, 2020). Specific conductance and alkalinity significantly increased over the long-term in mesotrophic and eutrophic waterbodies. This may be an indication of recovery from acid rain. Since the recovery response to acid rain is happening rapidly, it is additionally likely that an influx of salt is partially responsible (Nelson and Neils, 2020).

One indicator, total phosphorus, “significantly increased over the long-term in eutrophic waterbodies, but was unchanged in mesotrophic and oligotrophic waterbodies” (Nelson and Neils, 2020). Generally, increases in phosphorus reflects land use practices like stormwater runoff, impervious surfaces, loss of vegetation, and use of fertilizers while decreases may be associated with improved land management practices like vegetative buffers, pumping and upgrading septic systems, and reducing the use of fertilizers. Dissolved oxygen (at one meter below the surface) decreased in approximately 15 percent of waterbodies over the long-term, with a significant overall decrease for mesotrophic waters. The reduction of dissolved oxygen levels may be a response to an increase in temperature and increased plant growth from an increase in phosphorus. Water temperature (at one meter below the surface) significantly increased in mesotrophic and oligotrophic waterbodies over the long-term. Nelson and Neils (2020) report that warmer temperatures are likely a response to warming air temperatures and earlier ice-out dates. “Water temperature at 1-meter below the surface significantly increased in approximately 18% of lakes, with the mesotrophic and oligotrophic classes as a whole significantly increasing” (Nelson and Neils, 2020). This is mostly occurring in the Dartmouth/Lake Sunapee region and the Lakes and Monadnock regions, outside the study area. Water temperature may be responding to the increase in ambient temperature, earlier ice-out dates, or as a response to changing water color (Nelson and Neils, 2020).

While Vermont waters are generally high in quality, there are areas that are impacted primarily from human activities and non-point source pollutants, which denote pollution which cannot be definitively traced to a source. In Vermont, 20 percent of the streams and 15 percent of Vermont’s lakes have been identified for pollution at levels that restrict use and enjoyment (DEC, n.d.). Lake Score Cards are available for over 823 Vermont lakes, and like the New Hampshire lakes and ponds monitoring program, the Vermont Score Cards report parameters relating to health such as nutrients, aquatic invasive species, shoreland and lake habitat, and mercury pollution. In Vermont, watershed basin plans describe the condition and quality of the water resources in the watershed. They outline specific plans for how water quality impairment will be addressed to protect and restore watershed health. Because there are lakes in the study area that flow into tributaries that flow into the Connecticut River, watershed planning frameworks and data monitoring may be a vital source of planning for mitigating the impacts of population growth and migration. For further reference, view the drainage basin maps located in Appendix C.

The Connecticut River has impaired pH, likely due to atmospheric pollutant deposition, and sections of the river are impaired for metals like aluminum, copper, and lead. New Hampshire has ranked these impairments as low priority for the establishment of a regulatory pollutant discharge limit, called a Total Maximum Daily Load (TMDL). Monitoring river and stream flows is also a critical component to protecting healthy aquatic habitats and preventing disruptions to seasonal flows from unsustainable development. New Hampshire is currently managing two rivers (Lamprey and Souhegan) in the Instream Flow Program and may provide insight to protecting flows of the Connecticut River tributaries while maintaining water use and changing needs and conditions. In Vermont, the Agency of Natural Resources continues to work with many of the area ski resorts that depend on water withdrawals as an input for snow manufacturing, an important sector to the state economy, as it draws tourists, recreationalist, and amenity migrants to the area.

Wetlands commonly known as ponds, bogs, fens, marshes, and swamps are generally defined as areas inundated by surface or ground water with enough frequency to provide habitat and food that supports a suite of plants and animals (some of them rare and endangered) that depend on saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands perform valuable ecosystem services such as storing water that can mitigate flood damage and recharge groundwater, provide water filtration, control erosion, and provide open space and opportunities for recreation. One important method for protecting wetlands is through the conservation of the upland areas surrounding wetlands, commonly known as buffers. The wider the buffer, the greater the preservation success. Buffers protect wetlands by filtering sediment and nutrients from runoff before entering the wetland. They suppress the spread of invasive species and provide an invaluable source of habitat and food to wildlife.

Under Vermont wetland rules, buffer width protection is 100’ for Class I and 50’ for Class II, although wider or narrower buffers may be permitted based on case-specific site conditions. Lake buffers are 100’ and streams buffers vary based on site characteristics. In New Hampshire, there is no statewide buffer restriction, and municipalities may also adopt buffer width regulations. The New Hampshire Department of Environmental Services regulates buffer widths under wetland protection rules, Surface Water Quality Shoreland (SWQS) regulations, rivers protection, and alteration of terrain regulations. At the state level, a standard wetland buffer is 100’ although depending on the regulation and type of disturbance, it may provide restrictions from 50’ up to 250’ from a water resource.

Protection of wetlands and wetland buffers are becoming increasingly important for mitigating the effects of climate change due to the increase in extreme precipitation that is causing significant flooding and economic damage. Given the importance of ecosystem services, studies have been conducted to determine the economic value from wetland resources. A 2006 study funded by the EPA estimated that the economic benefit generated by a single acre of wetland is between $150,000 to $200,000.The same study found that wetlands increase the quality of life and surrounding real estate values by approximately 28 percent. In 2002, a study conducted by the Clean Water Network estimated New Hampshire’s remaining wetlands generate $1.2 billion dollars of economic value (Adams and Tilton, 2017).

The most significant driver for the existence and type of wetlands is hydrology. Parameters such as frequency, duration, depth, and source of water drive soil biochemistry catalyzed by bacteria and chemical reactions that foster nutrient cycling and biomass accumulation (Simpson, 2018). The rate of biotic response is influenced by complex factors like frequency, duration, and timing of aerated versus anoxic soil conditions, as well as atmospheric carbon dioxide concentration, temperature, parent material, and source of water. The shift of climate and parameters influenced by climate impact the biotic response. The resilience of a wetland to these factors and responses can cause a dynamic shift such that a wetland may or may not continue to exist or function in the same way (Simpson, 2018).

Since 1970, weather station data in southern New Hampshire shows that average annual maximum temperatures have increased on a range of 1.1 to 2.6 degrees Fahrenheit (Simpson, 2018). The recent change to New Hampshire USDA growing zones reflects a longer growing season by two to four weeks. Warmer winters in New Hampshire, with spring run‐off coming earlier, ice‐out on lakes coming sooner, more rain‐on‐snow events, and a decrease in snowpack by fourteen days over the last 50 years have significant ramifications for the ecology of aquatic systems, especially in the hotter and drier months. These shifts mean there will be less soil infiltration for the annual ground water budget, reducing aquifer supply and subsequently reducing the base‐flow of streams during the driest time of year (Simpson, 2018).

Projections demonstrate continually increasing temperatures throughout this century. The most optimistic scenario projects that by the end of this century the average temperature will increase 4-degrees Fahrenheit (Simpson, 2018). New Hampshire can expect that species ranges will see a corresponding increase, resulting in exotic species that are shifting poleward moving into this region. Increasing temperatures will impact soil moisture regimes, increase water temperatures, and increase evaporation rates within aquatic systems. The ramification of these changes could result in a loss of cold‐water species habitat, increase the frequency of cyanobacteria blooms and eutrophication, shorten the hydroperiod duration in critical aquatic habitats such as vernal pools, and drying and increasing rates of decomposition and subsidence of peat dominated wetlands. Changing precipitation patterns may also increase shoreline scouring and destabilization. Higher frequency of higher run‐off flows may also lead to lateral expansion of wetlands as waters migrate further inland at a greater frequency (Simpson, 2018).

Impacts on Watershed Health

Water Use

The USGS works with state agencies to compile a water use dataset every five years. The dataset contains public supply, domestic, irrigation, thermoelectric power, industrial, mining, livestock, and aquaculture water use categories for surface and groundwater withdrawals of fresh and saline water. (Dieter et al., 2018). Withdrawals represent the total amount of water removed from the source. Additional water may be used for the category from public-supply or reclaimed wastewater, and in most cases, some percent of the water withdrawal will be returned to the water source after use for other future uses. When water is returned to the source after use, it is considered non-consumptive (Dieter et al., 2018).

Between 2010 and 2015, the population in the United States increased by approximately 12 million people (4 percent), although a few northeastern states like Vermont experienced a population decline. In general, population growth increases pressure on existing public utilities and demand on areas already experiencing water supply limitations. Some communities develop additional water resources and adopt conservation measures to meet the increasing demands. Factors that influence changes in water use include demographics, economic trends, new manufacturing and cooling-system technologies, legal decisions, and climatic fluctuations. Upgrading cooling-system technologies, recirculating cooling water, and adopted dry-cooling systems are examples of thermoelectric and wastewater management practices that are implemented today. Industrial facilities are adopting more water efficient technologies to help reduce production costs and wastewater treatment costs (Dieter et al., 2018).

According to the USGS (n.d.), the New Hampshire total water withdrawals between 1990 and 2015 steadily declined by 29 percent while population increased by 10 percent. During this same period, Vermont water use declined 89 percent while the population increased by 10 percent. Although freshwater resources are considered abundant, especially compared to other regions of the country, they have become stressed in some areas particularly during periods of drought. Information pertaining to the 2015 water use for New Hampshire, Vermont, and the Connecticut River counties is shown in Appendix D.

In 2015, the majority of Vermont water use was attributed to the category "public supply." Aquaculture, domestic, and industrial consumption were the next largest sources of water use. Aquaculture water use is associated with raising organisms that live in water, conservation, or sport (i.e. snow manufacturing and golf). The water withdrawals in Vermont are concentrated in the north and west.

In New Hampshire, thermoelectric power plants accounted for 82 percent and were concentrated in the southeast. Refer to Appendix D for water withdrawal data by county and category. Approximately 46 percent of the water use in the Connecticut River study area consisted of groundwater withdrawals. The largest categories of water use are public supply and domestic self-supply. Industrial and aquaculture were also significant categories of use. Thermoelectric power plants use steam to drive turbines and generate electricity. The water that drives the turbines is often discharged back to the source, albeit significantly warmer. This is considered non-consumptive use. Vermont Yankee nuclear plant was located on the Connecticut River and shut down in 2014, the year before this data was collected.

The Connecticut River has over a thousand dams on its tributaries, 16 dams spanning its main stem, 12 of which are related to hydropower (CRC, n.d.). Refer to Appendix E for a visual representation. There are three hydropower dams on the Connecticut River located in Wilder, Bellows Falls, and Vernon that are currently under relicencing by the owner Great River Hydro (formerly known as TransCanada), a subsidiary of ArcLight Capital Partners (a private equity firm). Once the review process is complete, the license will likely be renewed with updated conditions that will bear a significant effect on the health of the river and its ecosystems for generations to come. At the time of writing this report, the permit renewal is likely to include conditions that require operation of the plant to maintain a more consistent and steady surface water elevation, shifting from an impoundment to run-of-river dam characteristics. The conditions are likely to require gradual up ramping in most cases, and gradual down ramping in all cases. These changes along with the seasonal restrictions should mimic natural fluctuations more than historic operations, reduce erosion, and improve natural habitat. Fish passage, recreational access, and cultural resources have not been addressed by the application at this time. Many dams in New Hampshire and Vermont are no longer used for their original purposes or used at all. Removal of these dams for socio-ecological reasons can make sense for some dams, although financial restraints can inhibit both restoration and removal.

Land Use and Land Cover Changes

Land use and land cover are inherently interconnected. Changes in land use practices affect the land cover, and vice versa (Sleeter, 2018). Human activities relating to land use (growing food, cutting trees, and development) change land cover (pavement, natural vegetation, and crops) and affect the weather and climate. Consequently, decisions about land use and land cover can dampen or exacerbate the effects of climate change. Public and private entities can work to positively or negatively affect how much the climate will change and how vulnerable or resilient communities and the natural systems will be to those changes.

Climate change in return, directly and indirectly affects land use and ecosystems by altering disturbance patterns, species distributions, and suitability for certain uses and ecosystems services In the Northeast, 63 percent of the land is forested, 12 percent settlements, 12 percent crops, 6 percent wetlands and grasslands, and 1.4 percent other. Refer to Appendix A for Land Cover Changes in the Northeast over the past several decades (Sleeter, 2018).

Population and economic growth rates can drive Land Use and Land Cover Changes (LULCC) and create tension in communities between the desire for economic growth and conservation. According to Brown et al. (2014), " by 2050, scenarios that assume continued high growth produce more rapid increases in developed areas of all densities and in areas covered by impervious surfaces (paved areas and buildings). Areas with more impervious surfaces like parking lots and roads tend to experience more rapid runoff, greater risk of flooding, and higher temperatures from the urban heat-island effect" (Brown et al., 2014).

Urbanization is generally the disturbance of the natural landscape and replacement of vegetated surfaces, often with impervious surfaces. When rainwater or snowmelt flows over impervious surfaces such as rooftops, parking lots, and roads, it collects and carries pollutants like oil and grease, sediment, nutrients, and salts into waterways. According to Shuster et al. (2005), the extent of impervious surface in an area has a significant effect on the watershed hydrology and can create complex networks of surface flow conveyances and runoff from housing and commercial development, sewerage, and transportation.

Communities can use impervious surface cover and growth rates of impervious surface cover as a proxy indicator for comparing relative impacts to water quality, flood control infrastructure, stream erosion, groundwater recharge, and habitat (EPA, n.d).

It can be difficult to establish a threshold limit to imperviousness because of how challenging it is to accurately predict ecosystem responses. However, the Vermont Shoreland Protection Act establishes a 20 percent limit on the maximum amount of impervious surface area for a landowner subject to the Act and New Hampshire has a similar Act that allows for a maximum of 30 percent. A maximum impervious surface limit overlay district can be an appropriate tool to use in areas where water quality is threatened or is likely to become threatened based on patterns of growth and development. Since changes occur over time, public perception and tolerance for hydrologic changes could be an important factor in developing the criteria and or the controls on where and to what extent development is allowed (Shuster et al., 2005).

In the past 50 years, severe storms have increased across the Northeast. “Since 2000, Vermont has had more than one federally declared disaster per year” (State of Vermont, 2021). Very few areas within the state have escaped disruption and repair due to flooding. Damage from Tropical Storm Irene incurred $63 million in insurance claims, $153 million in state and local costs, and $603 million in federal costs. In many Vermont and New Hampshire communities, river paths have been altered, floodplain capacities have been reduced through development, wetland buffers have been disturbed, in Vermont alone 10,000 buildings are located in hazardous areas (State of Vermont, 2021). Through planning, the adoption of policy and regulation, and the use of hazardous mitigation funds, climate change adaptation improvements to minimize flooding and damage can be taken. For example, emergency services and buildings located in floodplains can be relocated, culverts can be upgraded in size, aquatic ecosystems and habitats can be repaired and restored, and regulation can prevent future development from encroaching or disturbing wetlands and wetland buffers and reducing floodplain capacity.

Combined sewer systems are designed to collect stormwater runoff, domestic sewage, and industrial wastewater in the same pipe that is conveyed to a sewage treatment plant for treatment and then discharged to a nearby receiving water. During intense precipitation and snowmelt events, the volume of the combined wastewater inputs can exceed the design and treatment capacity of the plant. The excess untreated wastewater is discharged into nearby receiving waters such as a river, stream, or lake. The untreated discharge is called a Combined Sewer Overflow (CSO).

In the United States, over 772 communities have combined-sewer systems that are primarily concentrated in the Northeast and the Great Lakes Region (Evans, 2015). Unfortunately, many of these systems are old and in need of repair. An increasing population and demand for water, development, and climate change, these outdated systems are contributing more seriously to surface water quality impairment, algal blooms and fish kills, and polluted drinking water. The EPA estimates that treatment plants experience 23,000 to 75,000 CSOs each year discharging 3 to 10 billion gallons of untreated wastewater. Studies have found that emergency room visits for gastro-intestinal illness increase after heavy rains from pathogens discharging into lakes and rivers used for recreation and drinking water. (Evans, 2015). Due to the magnitude of this environmental and human health issue, the EPA has been working with municipal water systems for decades to address these problems.

Each municipality with combined-sewer systems must establish their own long-term plan for compliance with water quality standards and protecting the health of receiving waters. Methods for compliance may include elimination of CSOs, end of pipe compliance, receiving water compliance, or proposed alternatives. The capital investments for these remedial actions have massive price tags due to the complexity and of the history of CSO development and use. Vermont has over 92 municipal wastewater treatment plants and some of these municipal systems have CSOs. In 2020, there were 235 CSOs and partially treated or untreated discharges based on the state reporting system database (Vermont Official State Website, n.d.). In New Hampshire, there are six CSO communities. One, is being phased out in Lebanon due to an EPA Clean Water Act Administrative Consent Decree that mandates that the City of Lebanon take remedial actions to eliminate CSOs and achieve full compliance with its National Pollutant Discharge Elimination System permit and governing regulations. This is approximately a $75 million dollar effort and that involved separating 15 miles of sewer and stormwater pipes (Camerato, 2020). With an increase in disturbance migration to the area, it will be important to avoid the massive costs of installation, maintenance, and remedial actions associated with aging and or underdeveloped and underperforming CSO wastewater treatment systems and infrastructure.

Case Study: Population Growth and the Upper Merrimack River Watershed

In exploring potential impacts on watershed health for the Connecticut River study area from population increases through rapid or incremental growth related to climate change migration, the upper Merrimack watershed in New Hampshire, provides an informative case study on plausible impacts and management of ecosystem services. The upper Merrimack watershed shares a similar history, climate, and land cover to the area of study. Nearly eighty percent of the land in the Upper Merrimack River Watershed (UMRW) is undeveloped forest, farm, or wetland (Borsuk et al., 2019). According to Samal et al. (2017), eighty-two (82%) percent of the land cover consists of evergreen forest, nearly six percent (5.9%) is wetland, four percent (4.2%) is urban and four percent in open water (4.2%), and agriculture is nearly four percent (3.8%).

The UMRW has recently experienced rapid population growth and ongoing residential development that has led to land cover change, increases in water withdrawals, and increases in wastewater discharges. Population is approximately 410,000 and this area serves as an important tourist destination. The Merrimack watershed is ranked nationally in the top five watersheds projected to experience changes in water quality due to increased housing density on private forest lands leading to a variety of ecosystem services change and conditions such as increased water use, nitrogen fluxes, and chloride concentrations (Samal et al., 2017).

Climate change projections for the region will include an increase in temperature, and an increase in annual and extreme precipitation likely to contribute to an increase in flooding. The duration and magnitude of dry periods in the summertime coupled with a predicted increase in population will likely further stress water supplies similar to the Connecticut River Valley study area. The dual pressures of climate change and population increase will impact natural amenities, affecting the summer and winter recreation, tourism, and regional cultural and economic values (Borsuk et al., 2019). Significant climate and land cover changes typically result in altered ecosystem services and understanding these changes at the regional scale is important to scientists, planners, and decision-makers. These changes are interconnected, complex, and occur across spatial and temporal scales. For citizens to develop manageable strategies, they should be able to assess the values of the ecosystem services provided. Indicators of ecosystem services should be quantifiable and scalable, and sensitive to management change. Freshwater aquatic ecosystems are strongly influenced by terrestrial environments and climate conditions in their watersheds over time that affect the hydrological cycle causing changes in water availability, instream habitats, water temperatures, and nutrient fluxes, making it difficult to model and project likely impacts under different scenarios.

However, water is a fundamental resource for society, arguably the most important, which is why studies are critical for quantifying how water quantity and quality will respond to projected changes in land cover (influenced by population and development) and climate change. The primary purpose of the Samal et al. (2017) study was to develop estimates of ecosystem functions critical to the current and future watershed residents of the UMRW. Identifying tangible environmental indicators is an important step in the process of understanding the response of complicated human–environmental systems to change and to be able to track the performance of adaptive environmental strategies, plans, programs, and regulations.

In the study by Samal et al. (2017), the relative impact of climate change and land cover varies among the indicators represented. Scenarios that maintain greater areas of forest have slightly greater carbon sequestration, while scenarios with greater areas of agriculture increase food supply. Water supply shortfalls are influenced by population and land cover more than by climate. For Nitrogen export, climate is the primary driver of the response, however interactions with land cover were also observed. Fish habitat loss is primarily driven by climate change because increased temperatures impair the headwater streams. Residential development and associated impervious surfaces in the Backyard scenario, the scenario where development represents the greatest percent of land cover, resulted in a greater summertime heat flux to streams due to relative stormwater runoff (Samal et al., 2017).

The results of the Samal et al. (2017) study indicate that climate is expected to be the most significant driver of water-related impairment in the UMRW. Impacts to climate and aquatic conditions are expected to be modest until the mid-century. In the high emission scenario, after 2050 the impacts to aquatic conditions are projected to rapidly increase, and the degree of change is further influenced by land cover changes. The authors of this study recommend that the region prepare for changes in the ecosystem services and that the landscape be managed by residents to reflect the most important and desirable ecosystem services (Samal et al., 2017).

Land-cover management represents the leverage point for local and state decision makers to influence climate change adaptation in the area. Management interventions that mitigate changes from population and temperature will need to move beyond the simple land-cover formulations assessed in the study. For example, the study did not encompass management approaches that can mitigate adverse effects like vegetated buffers to reduce nonpoint source nitrogen runoff, blue-green infrastructure, flood control measures, exclusion of development in flood zones, or the use of constructed refugia to mitigate warming stream temperatures (Samal et al., 2017).

In a study conducted by Wang and Stephenson (2018) analyzing the impacts of climate change and human activities on the hydrological processes in the lower Connecticut River Basin found that between 1956 and 2014, significant increases in run‑off were influenced more by climate change than Land Use and Cover Change (LUCC) during the 59 years. This is a similar finding to Samal et al. (2017) although focussed on another region of the Connecticut River Basin. The four sub basins studied by Wang and Stephenson (2018) were the Ashuelot, Millers, Deerfield, and Westfield River watersheds and did not include the incorporation of agricultural related parameters and changes for predicting hydrological responses.

Public Desire for Freshwater Aquatic Ecosystem Services

An article by Hoffman (2017) on the need for community based collective land use planning and conservation in Vermont, finds that there is a disconnect between Vermonters stated conservation preferences and sprawling development patterns that he suggests can be bridged by focusing on bringing neighbors together for collective conservation practices and development planning. In the article, 95 percent of Vermonters are stated to value the rural working landscape as well as possess a knowledge of and care for environmental issues. However, the pace and patterns of land development do not match population increases (10% increase between 1982-1992) and the amount of land being developed (25% increase in developed land, with 40 percent of that being former cropland or pasture). The author suggests that this is due to development largely being an individualized, private decision on private property and recommends engaging landowners in collective conservation efforts (Hoffman, 2017). Can community engagement and collective planning be used to identify Vermonter's shared values for aquatic ecosystem services as a means of managing migration and development?

Building on the Samal et al. (2017) study, a recent survey of New Hampshire citizens revealed shared values for water management including provisioning a safe drinking water supply for the future, control of pollution and its effects on fish and wildlife, protection from flooding, and opportunities for recreation. Given that resources are often limited, it may be difficult to secure each of the values across the landscape. For this reason, Borsuk et al. (2019) conducted a multi-disciplinary study using a combination of multicriteria evaluation, varying scenarios, climate change projections, and linked terrestrial and aquatic ecosystem modeling to assess the desirability of alternative scenarios of population, land-use, and climate change by the inhabitants of the Upper Merrimack River Watershed (UMRW). The importance or desirability of local sites, amenities, and activities to a community's residents and visitors can be deeply related to a "sense of place" or "shared values". Shared values can be used to inform a broader meaning and significance attributed to ecosystems beyond individual use (Borsuk et al., 2019).

Incorporating the participation of eleven groups, the study found that across the different scenarios, climate change has the greatest potential to affect ecosystem service values over population growth or land-use decisions. Although land cover has the capacity to mitigate or exacerbate the effects in the future. This study showed that expected loss of snow cover, an increase in the hottest summer days, and indirect climate change effects on aquatic and forest ecosystems caused the most significant impacts relating to the public's desire for ecosystem services. Since avoiding climate change is largely out of the control of local and regional planners, mitigating the ecosystem service losses requires land-use and water management decisions that align with public priorities and values. According to the assessment for the UMRW inhabitants, this means concentrating future development to protect water supply and conserve or expand farmland and forest cover since forests critically impact aquatic freshwater conditions like water supply, water quality, and aquatic habitat (Borsuk et al., 2019). Conducting a study similar to the study performed by Borsuck et al. (2019), may further inform the Connecticut River area of the shared values are public preferences for protecting aquatic ecosystem services when comparing climate change and development scenarios.

Based on the studies reviewed, watershed and aquatic ecosystem services are influenced more by climate change than by land use and development decisions and the impacts will be relatively insignificant until the mid-century. Land use and development decisions have the potential to exacerbate or mitigate the effects of climate change and protect watershed health. Interdisciplinary and participatory processes can help communities evaluate different scenarios for land use, development, and climate change to identify shared values among a changing demographic, preferred ecosystem services, and to inform land use and planning decisions.

Impacts on Public Relations and Desire

Indigenous Impacts

Migration into the region will result in increased development of indigenous land and sacred spaces of which the entire region consists. With an increased regional population, each migrating with unique worldviews and subsequent effects on the regional culture, impacts on indigenous sense of place, along with all sense of place, can be expected. Losing indigenous space and knowledge is a tragedy for all, weakening cultural heritage and increasing injustice. In order to preserve the rich cultural heritage of the region, resilience planning should include the expert leadership of local indigenous communities and efforts of all co-conspirators for indigenous preservation and celebration.

In the current society of colonization, the cultural heritage of the Western Abenaki people and other indigenous groups has been ignored. At a federal level, the Western Abenaki people are considered a Canadian tribe, and under that determination, despite occupying this region for thousands of years, the Western Abenaki of this region are not recognized as a U.S. Native American tribe. As such, Western Abenaki do not possess U.S. citizenship and are considered "illegal aliens." As we plan for in-migration now, we must also be aware of the long history of unethical migration and colonization of the region, refusing to repeat historic patterns of abuse and power (Dion, 2020).

In order to inform migration decisions with regional history, it is necessary to separate indigenous history from colonial worldviews. Prior to colonization, many of the region's prominent transportation networks were indigenous trail networks. In addition to land networks, Indigenous transportation utilized waterways such as Lake Winnipesaukee, Oyster River, and the Connecticut River, as these allowed for efficient transportation to fishing grounds and seasonal camps (Price, 1967). The most recent cultural transformation prior to european colonization was the Woodland period. This period is characterized by the creation of pottery and agriculture. Both of these technologies created a more sedentary lifestyle, increased indigenous populations, and offered a stable food supply. Villages during these times were larger than those previous, consisting of more permanent structures. From the village center, farmland and "suburbs" expanded outward, creating satellite settlements closer to fishing sites and other resources (Indigenous New Hampshire, 2020).

When European colonizers arrived, carrying destructive disease, many indigenous communities were forced to abandon these large woodland settlements. Initially, some indigenous groups traded with the Europeans and introduced them to agricultural crops such as tobacco and corn. However, European colonizers soon expanded their communities to take over the best farm and hunting lands in the region. As a result, many indigenous people moved West to live on reservations or remained and were forced to assimilate into the new "American" culture (Indigenous New Hampshire, 2020). In considering how public relations and desires will change with changing demographics of the region, it is important to assess the current tensions and diversity of public desires in the region, as well as the history of prioritizing affluent white desires while destroying other cultural preferences.

Resident Demographics and Growth Rates

While some tensions do exist between the desires of permanent residents and that of seasonal residents, examining the nuance of preferences must move beyond these binary categories to examine various intersections of both permanent and seasonal residents. One added intersection to consider is the length of time in which a resident has lived in the area. Another factor is the growth-rate of the community.

A 2019 study assessing public desires in growing amenity communities found that both long and short term permanent residents rated community development measures to be significantly more important than seasonal homeowners did. Even so, both permanent and seasonal residents found increased job opportunities and wages and improving senior citizen assistance services to be the most important community development measures. Additionally, both permanent and seasonal residents were in favor of efforts to sustain clean air and water. When looking at the growth-rate of communities, the study found that slower-growing communities rated community development and environmental preservation as much more important than faster-growing communities did (Park et al., 2019).

Demographics such as the age and income of residents had no correlation to particular desires. In fact, the growth-rate of a community is a more substantial indicator of development preferences than resident demographics. One hypothesis for this is that fast-growing communities result in weakened social bonds, decreasing valuation of community resources and services. Other than growth-rate, the main indicator of public preferences was education level and community involvement, demonstrating that engagement may be a stronger influence on preferences than type and length of residence. One example of this is a 1974 study in Colorado which found that newer residents were more apt to be involved in historic preservation initiatives than longer term residents. A 1990 study conducted by Fortmann and Kusel further explained this by hypothesizing that new residents may amplify local marginalized voices rather than simply introducing new ideals (Park et al., 2019).

Closer to our study area, a 2013 study found that permanent residents in four New England states were more likely than second-home owners to perceive cultural differences between the two. Two factors for future focus on this finding are intersections of cultural capital and rural mobility (Park et al., 2019). It should also be highlighted that New England houses the highest rate of second-homeowners in the country, and thus, dynamics between primary and secondary residents may be different than the national average.

When individuals migrate to a new location, trends demonstrate a preference to locate in a region with a notable “skin network” of either relational or cultural ties. When migrants move to a community without a network of individuals with their shared ethnic, religious, cultural, or linguistic identity, they often travel frequently to more diverse areas that offer this social capital. This accrued travel is both costly and time consuming (Bose, 2018).

In addition to skin networks, the rate of growth has a significant impact on social capital as well. A 1998 study found that a consistent growth rate of tourism in a Vermont community aided increases in social capital and community assets. Rapid growth, however, weakened these same components. The growth rate also predicted the impact of second home construction. The size of the area, its capacity to support growth, and the size of new developments all predicted community cohesion, with the most substantial of each of these factors leading to the weakest community capital, potentially due to increased competition for resources. Furthermore, residents in fast-growing tourism communities are most likely to worry about negative impacts of development (Park et al., 2019).

Interracial Relations

The region along the Connecticut River consists primarily of white residents. This "rural whiteness", as a 2006 study by Vanderbeck suggests, is highlighted as a means to attract affluent tourists to the region. This capitalization of white supremacy marketing serves to attract more of an already prevalent white demographic (Bose, 2015). As an effect, when people of color (POC) migrate to the low region, they are met with a starkly homogeneous population. This homogeneity, coupled with the overarching prevalence of white supremacy in America, results in a social "othering" of POC identities. Refugees from Somalia, Sudan, and other parts of Africa are perceived as both black and muslim, receiving stereotypes attributed to both labels. African migrants and Black Americans report mistreatment by social services such as racial profiling by police and discrimination in school systems (Bose, 2015). Of the white-centric communities within the study area, Brattleboro, Vermont and White River Junction, Vermont harbor the most racially diverse communities. The revitalization of White River Junction's economy through the re-use, infill, and reclassification of the historic mill center has led to both an economic upturn and nuanced implications for marginalized communities.

Central European refugees such as Bosnians and Kosovars are othered due to their language or religion rather than appearance. These migrants are more apt to follow the same historic "whitening" cultural assimilation as done by the historic trends of European immigrants in the region (Roediger, 2005). Bhutanese migrants, one of the most prevalent resettled populations in America, have received labeling as the "model minority" due to perceived higher rates of employment and education than migrants of other ethnicities (Bose, 2015). This mentality of “racial excellence” is a symptom of the dominant toxic culture in which POC must “prove” their agency in order to receive social capital.

Overall, the region has not experienced notable inter-ethnic conflicts. Miscommunication between ethnic communities is more prevalent than outright ethnic conflict, harboring mistrust between communities (Bose, 2015). Mistrust particularly manifests between POC migrants and white-dominated service providers who may be perceived as having a paternalistic attitude towards migrants. One example of mistrust between migrants and service providers occurred in Manchester, NH when refugee children experienced lead poisoning and the newcomers reported insufficient response by the resettlement agency.

In order to avoid paternalism and receive more nuanced and diverse assistance, mutual aid among migrants has become prevalent. In some cases, formal Mutual Aid Associations (MAAs) receive state or federal funding, allowing refugees to attain jobs within these associations and serve one another in direct and effective ways. MAAs are most prevalent in larger communities, where resources and ethnic diversity is more substantial. MAAs in smaller communities often are harder to formulate and place heavier burdens on individual migrants who carry the burden of both newcomer and service providers (Bose, 2018).

Racial differences in climate perception and action vary notably across racial groups. In a Boston based study, surveyors found that all racial groups identify global warming as a high priority issue, though less white residents believed so than any other racial group. Across all racial groups, respondents felt that climate action requires policy changes at federal and state levels, with local and state governments initiating the actions. Climate action initiatives which received the greatest support across all racial categories were transportation improvement, flooding buffers, state funding for community projects, and wind energy subsequently. Support for changing zoning laws received the least support. Overall, residents of all races agree that combating climate change requires major to moderate changes in their personal lives. Approximately 75 percent agree that climate change will lead to exacerbated conditions and health concerns (Martínez et al., 2020).

Although respondents of all races expressed support for these initiatives, white respondents represented the largest percentage of those in opposition. White residents most strongly support improving transportation over other climate initiatives. Approximately 10 percent of white respondents, the most of any racial group, believe that climate change has not been occuring (Martínez et al., 2020). Diversifying who resides in the region and holds power in making community and policy changes will likely change how New Hampshire and Vermont implement climate initiatives.

Preferences in Building Community

The classification of community members according to their length of residence (indigenous, long-term, short-term, and seasonal) impacts feelings of "belonging" and entitlement to resources, with those deemed as the newest or least numerous receiving the least social and resource capital (Jokisch et al., 2019). Creating a cohesive community that harbors trust between social groups and offers equitable rights to capital allows for more equitable buy-in to community initiatives. Communities that provide outreach coalitions often find greater community engagement and mutual aid across diverse demographics (Hilligoss, 2017).

Many migrants relocating to rural communities may also originate from rural communities. As such, shared values of small communities, steady employment, affordable living expenses, often already exist amongst long-term and new residents. The cohesiveness of these shared values are most apparent when the communities offer programs, partnerships, and policies that welcome and engage new residents, sharing agency and space with new community members (Hilligoss, 2017).

Impacts on Social Systems: Housing, Transportation, and Economics

As the populations and demographics of the region change as a result of migration, it is expected that the quantity and type of social services demanded by the population will also change. This section will look at the impacts expected to affect social systems such as housing, transportation, and employment in the region. More in-depth social service nuances will be examined in the next planning report.

Currently in the Connecticut River study area, one in three households are considered cost-burdened. A cost-burdened household is defined as spending more than 30 percent of household income is spent on housing and utility expenses. With 70 percent or less of income remaining to pay additional expenses such as food, transportation, and childcare, many do not have money to spend beyond basic necessities. Renters in the region are the most likely to be cost-burdened, followed by rural homeowners, a quarter of which are cost burdened. Homeowners located in denser communities are the least cost burdened, with only 18 percent paying more than 30 percent of their income on housing (Keys to the Valley, 2020). The following sections will examine the state of housing solutions and economic influence on housing preferences and services.

Housing and Homelessness

A 2021 report on homelessness in New Hampshire found that the number of people experiencing homelessness in 2020 increased by 21 percent from the previous year. More specifically, there has been a 112 percent increase in chronic homelessness. This increase occurred prior to the impact of the COVID-19 pandemic, with an additional increase in homelessness occurring after the shock of the pandemic. During this time, issues of substance use and mental health also increased, straining the capacity of service workers and adding barriers to aiding this population. In total, a reported 4,451 people experienced homelessness in State Fiscal Year 2020. Due to the nature of homelessness data collection primarily consisting of families with service providers, the actual number of people experiencing homelessness is estimated to be far greater (NHCEH, 2020)

Sixty-percent of the unsheltered homeless population live outside of large urban centers. This demonstrates that homelessness in rural communities of the region is a significant issue without adequate services and housing initiatives. This trend is reflected at a national scale. Marginalized populations, such as disaster migrants, often require temporary housing and/or relocation services offered in a community-specific manner. A New Hampshire study found that 600 permanent supportive housing units would eliminate the state's current rate of chronic homelessness (NHCEH, 2020). Investing in permanent supportive housing may also be a service required by disaster migrants.

Of those experiencing homelessness, people of color are significantly over-represented. Multi-racial and Black residents are four times more likely to experience homelessness than white residents. Hispanic/Latinos, making up 2.68 percent of New Hampshire residents, account for 10.6 percent of those experiencing homelessness in the state. Rates of Black residents experiencing homelessness in New Hampshire are above the national average and rates of Hispanic/Latino homelessness are significantly higher than the national average. The population most likely to experience houselessness are Native Hawaiin/Pacific Islanders. While this population is the smallest ethnic demographic, the rate of homelessess (twice as likely as white residents) is the largest both at the regional and national scale (NHCEH, 2020).

Discriminatory housing practices and policies throughout the country, and including the Connecticut River, inhibit POC from meeting basic needs, building generational wealth, and formulating safety nets to survive the system that targets them. Systemic housing discrimination includes such practices as redlining, racial covenants, and segregated public housing to create ghettos.While those practices are now illegal, discrimination continues to occur in the form of zoning laws designed to segregate according to economic and social class and through the deterioration of The Fair Housing Act. In the Connecticut River Valley, such inhibitions to equitable acquisition of housing include limitations on multifamily units, affordable housing, group homes for those with special needs (Ross et al., 2019). Such limitations are particularly apparent in Lebanon, NH, where the housing stock primarily serves single-family middle-to-upper income families. Additionally, zoning which mandates large lot sizes and restricts multi-family dwellings intrinsically acts to prioritize the access and desires of affluent single-families, disproportionately restricting POC and low-income individuals from these communities. Often, as a result, marginalized communities are confined in areas more prone to environmental pollution (Ross et al., 2019). Across the board, POC experience higher rates of poverty and homelessness. Racial disparities cause similar vulnerabilities in health, food, and educational security, resulting in compounding issues of poor health and reduced life expectancies. Meanwhile, white residents are the least likely to experience homelessness (NHCEH, 2020).

In addition to racial disparities, inequitable growth in wages according to sector exacerbates housing insecurity. In the region, job opportunities in low paying jobs are increasing while job opportunities in high paying jobs are decreasing. This results in strained housing costs. Furthermore, New Hampshire towns in particular are impacted more significantly by low-paying jobs as this is the only state in New England still utilizing the federal minimum wage of $7.25 per hour. At this rate, a person would have to work 129 hours/week to afford a 2-bedroom apartment at New Hampshire's Fair Market Rent. Even for those earning more than minimum wage, New Hampshire has the 15th highest housing wage in the country, requiring an individual to earn $23.43 per hour for 40 hours in order to afford a 2-bedroom apartment (NHCEH). In comparison, Vermont's minimum wage is $11.75 per hour.

Gentrification

Gentrification, a term defined by sociologist Ruth Glass in 1964, describes the process of rapid neighborhood development in which the original inhabitants of a community are displaced and the culture of the neighborhood is dramatically changed. The displacement is often spurred by the in-migration of higher-income and higher-educated residents, which raises rent, cost of living, and accessibility barriers. In particular, job loss, fragmentation of small businesses, and high transportation costs significantly decrease livability and accessibility. (Golding, 2015).

In most cases, the in-migrants are white and those being displaced are socially or economically marginalized, likely by class or race. Rapid redevelopment, often followed by gentrification, rapidly increases inequity. In addition to displacement, gentrification results in reduced business longevity, sense of place, and public involvement (Ross et al., 2019).

With affinity migration often comes rural gentrification. Gentrified rural counties are more apt to experience home value segregation and, eventually, a homogenization of higher property values and a widening wealth gap. Due to the more limited housing supply typical of rural communities, gentrification is magnified by quicker price increases, and thus, outpricing of current residents. Gentrification not only increases cost of living, but also shifts the community culture (Golding, 2015).

Within the last decade, affinity migrants from some of the most expensive urban housing markets are relocating to rural communities in New England, the Mountain West, and the Great Lakes regions. As a result, these communities are experiencing an overburdening demand for economic and cultural resources spurred by widening gaps in social disparities. In these instances, many low-income residents are forced to leave the communities they call home. Those who choose to stay are likely to experience weakened social capital and resilience. Gentrification also impacts school districts, leading to student displacement that weakens student success and socioeconomic segregation in which the funding gap between schools greatly widens. (Golding, 2015; Nelson, 2010).

Communities in which amenity migrants proliferate find that the increased tax base still does not adequately fund the addition in school, police, road, and utility infrastructure needed to accommodate the growing population. “Bedroom” communities in which seasonal residents predominate also experience a shortfall in school enrollments, business activity, and social institutions compared to communities with permanent residents (Golding, 2015). Rural gentrification also typically occurs due to retirement and “downsizing” of adults whose children have moved out of the house, leading to an older regional age demographic (Nelson, 2010).

Rural gentrification in New England is compounded by the effects of climate gentrification. In regions where landscapes and climates are preferable for climate security, property values and housing demand are increasing. In particular, regions with more temperate climates, distance from the coast, and resilience to flooding are seen as the most preferable (Keenan, 2018).

One study by Sinha and Cropper, executed in 2013, analyzed data from 1995-2000 to investigate the "amenity value of climate—what people are willing to pay to experience warmer winters or to avoid hotter summers" (Sinha and Cropper, 2013). The study considers factors that influence household residential location choice in amenity migration such as climate amenities, earnings, housing costs, and other location-specific amenities like wages and property values. In the "location choice model, the marginal value of an amenity is the rate of substitution between the wage and the amenity in question" (Sinha and Cropper).

The authors found that while holding income constant, households between 46 and 55 years of age were willing to pay twice more than households between 26 and 35 years of age for a climate amenity. Households with more than two people were willing to pay 50% more than smaller households for a climate amenity. Higher summer temperatures influence the climate amenity more than low winter temperatures. Since the model considers wages, it is not suitable for estimating the preferred choices of retirees. (Sinha, 2013).

Currently, federal housing policies fail to effectively manage and mitigate the repercussions of rural gentrification. Federal incentives for affordable housing are often still far less economically incentivising than private developments in bedroom and destination communities, such as in many of the Connecticut River towns (Golding, 2015).

Demand for Social Services in Climate Havens

Rural communities choosing to act as receiving communities or climate havens often benefit from an influx of young residents amidst trends of aging long-term residents (Hilligoss, 2017). Climate havens spur the need for receiving services such as temporary housing, real estate locators, moving and storage services, and government and NGOs to process relocation documents (Clement and York, 2017). Rural climate havens in particular require additional transitional services traditional to more urban environments (Bose, 2015).

Offering adequate affordable housing is a dominant necessity for climate havens. Whereas the Connecticut River Valley study area currently receives largely seasonal and affinity migrants, these housing additions do not serve to meet the demands of new permanent residents in compact communities (Mount Ascutney Regional Commission et al., 2021; Bose, 2018). Regardless of the size of a receiving community, forced migrants are often targeted with systemic segregation, marginalization, and social exclusion" (Bose, 2015). In Vermont, African refugees report experiencing racial profiling by the municipal and state police, highlighting the systemic racism exerted by those in power (Bose, 2015). Communities serving as climate havens would require greater social services rather than targeted policing of diverse communities.

Even in climate havens, the effects of climate change will continue to be felt in various forms. A survey of Boston residents found that seventy percent of respondents believe climate change will result in an exacerbation of existing health conditions as well as new health conditions. In planning for social service improvements, Asian Americans, Black Americans, and Latinx Americans all rate health care policy improvements as the highest priorities. White Americans, however, are the only group to rate education as a higher priority than health care (Martínez et al., 2020).

In order to ensure long-term resilience as an established climate haven, receiving communities must proactively plan to mitigate and adapt to long-term impacts of climate change in their region. In the instance of the Connecticut River towns of New Hampshire and Vermont, this means careful management and response to riparian flooding, stormwater management, and ecological conservation.

Conclusion

Shifting populations, demographics, and settlement patterns in the region are expected to influence the state of local ecological and social systems. The study area, predominantly experiencing amenity migration, is vulnerable to habitat fragmentation, sprawling infrastructure, and high per-capita resource demand. Existing patterns of migration highlight existing inequities in land use patterns, access to affordable housing, and racial disparities (Park et al., 2019). In assessing current policies in place, it is clear that the study area, particularly New Hampshire, where the federal minimum wage of $7.25 remains, does not adequately address the needs of marginalized populations - current and future. Proposed actions on how to adapt to and mitigate the impacts of amenity migration by encouraging compact communities, adequate social services, and environmental protection measures are available in the third report of this series: *Identifying Planning Solutions for the Connecticut River Migration System of New Hampshire and Vermont.*

Appendices

Appendix A - Housing Stock

Table 1 - County Housing Stock

County	State	CRJC Subcommittee	Total Housing Units	% Owner Units	% Rental	% Seasonal	% Vacancy
Coos	NH	Headwaters	21,594	45%	19%		36%
Essex	VT	Headwaters	4,934	44%	13%	43%	
Grafton	NH	Riverbend	52,913	46%	20%		34%
Caledonia	VT	Riverbend	15,534	59%	22%	19%	
Orange	VT	Riverbend	14,541	70%	17%	13%	
Windsor	VT	Upper Valley	33,281	54%	22%	24%	
Sullivan	NH	Mount Ascutney	22,652	56%	20%		24%
Windham	VT	Mount Ascutney	29,234	45%	22%	33%	
Cheshire	NH	Wantastiquet	35,588	59%	26%		15%

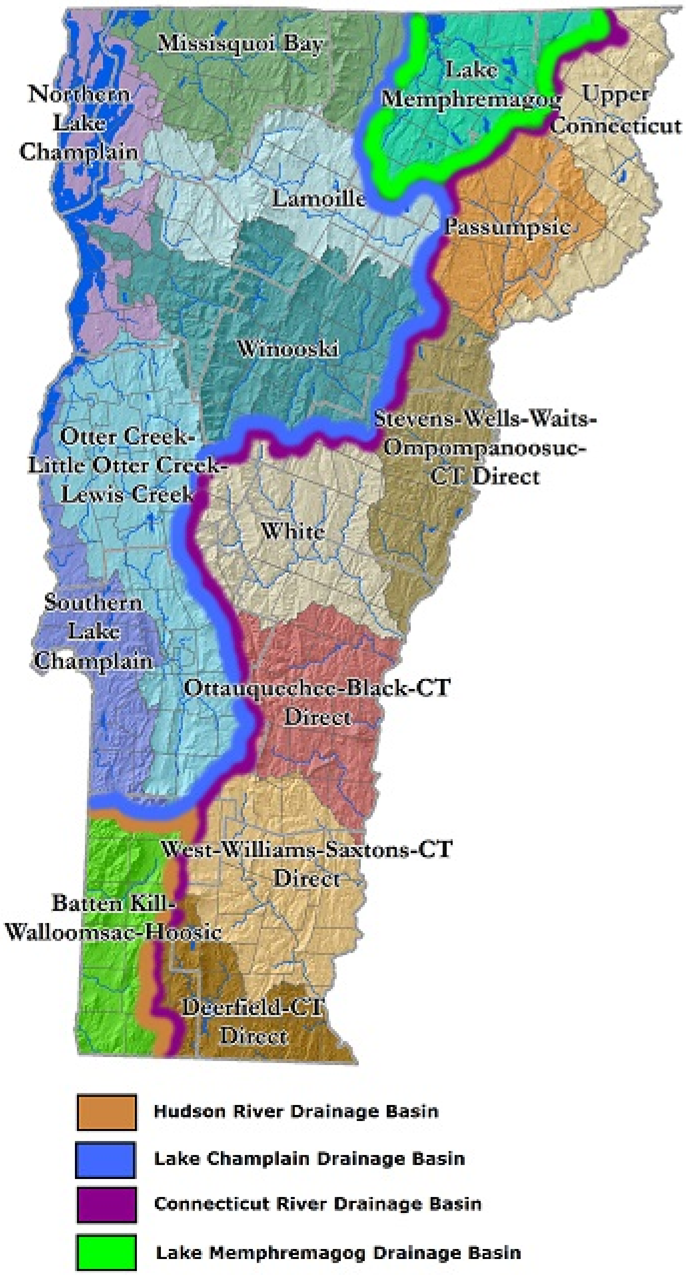
Note: This data is adapted from VHFA, 2020 and NHHFA, 2021.

Appendix B - Table 2 - Water Quality Indicators

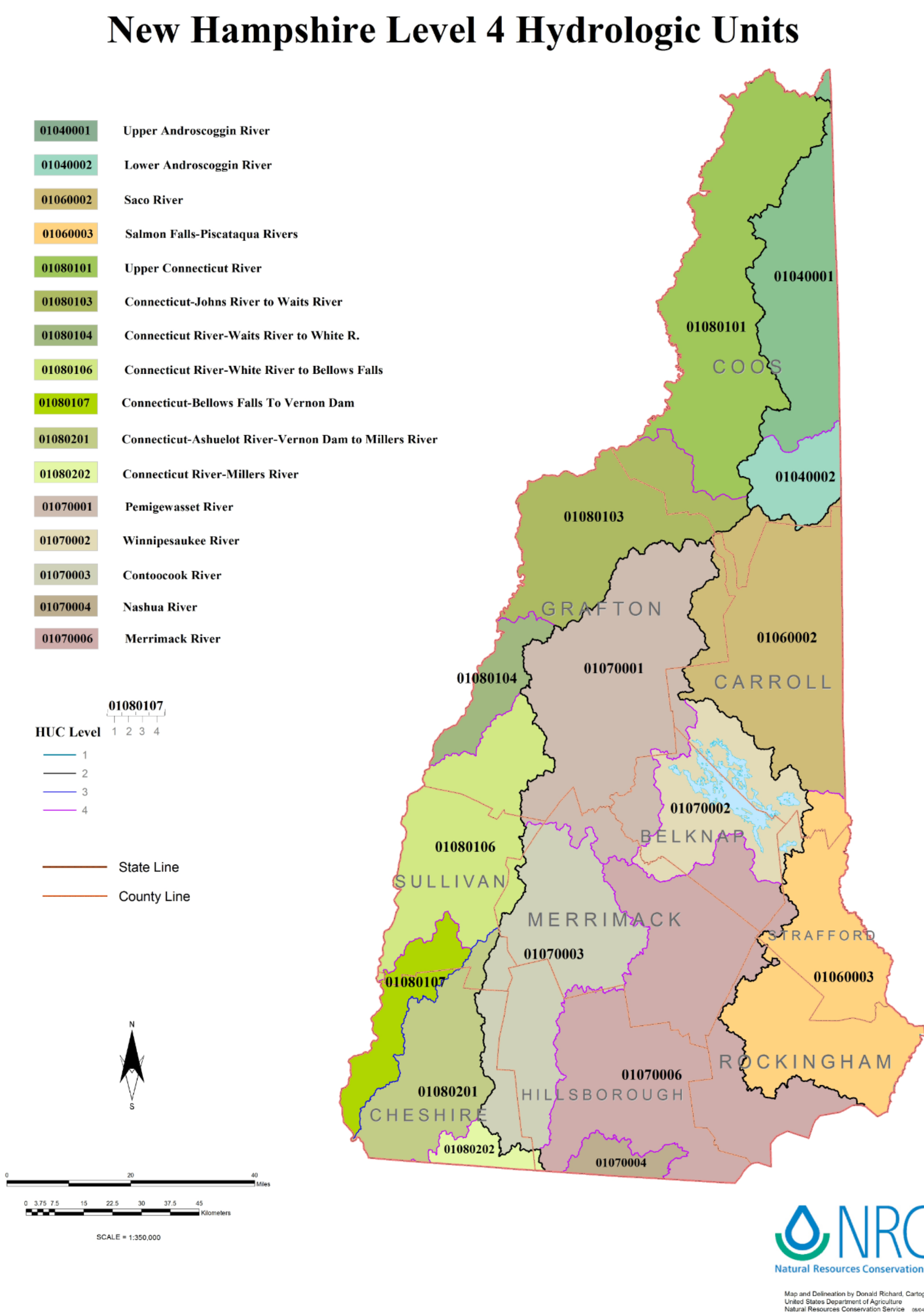
Indicator Parameter	**Parameter Description**
Alkalinity	A measure of a water's ability to resist acidic inputs (buffering capacity)
Bacteria	A measure of the concentration of E. coli, a common bacterium that is present in the fecal material of warm-blooded animals.
Chlorophyll-a	A photosynthetic pigment found in plants that serves as a measure of the abundance of suspended algae.
Cyanobacteria	Photosynthetic bacteria capable of producing toxic blooms. Occurs naturally in waterbodies, but can increase in abundance with excessive nutrients.
Dissolved Oxygen (1-meter below surface)	The concentration of oxygen in water used by plants and animals. Low or highly variable dissolved oxygen concentrations can result from decomposition of organic material or plant growth respectively.
Ice in/out records	Period of time a waterbody is covered in ice.
Invasive Aquatic Plants	Non-native species that are a threat to ecological, aesthetic, recreational and economic values of freshwater resources.
pH	A measure of the water's acidity.
Secchi Disk Transparency	A measure of water clarity.
Specific Conductance	A measurement of the water's ability to conduct electricity. Increased by road salts, fertilizers and other chemical compounds.
Total Phosphorus	Typically, the limiting nutrient for aquatic plants and algae in freshwater. Total phosphorus concentration controls, in part, the amount of plant and algae growth, which relates to trophic status.
Total nitrogen	Typically, the limiting nutrient for aquatic plants and algae in marine systems. Total nitrogen concentration controls, in part, the amount of plant and algae growth, which relates to trophic status.
Water Temperature (1m below surface)	Aquatic communities are adapted to specific water temperature conditions. This is affected by air temperature, water clarity and global climate patterns.

Note: This information is adapted from Nelson and Neils, 2020.

Appendix C - Drainage Basins



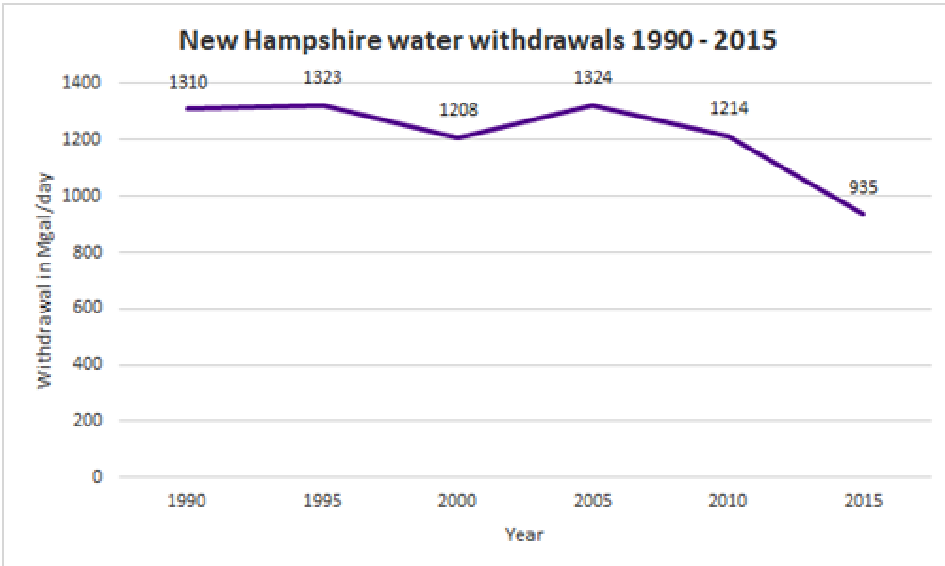
Note: Image from DEC, n.d. VERMONT'S MAJOR DRAINAGE BASINS.



Note: Image from NRCS, n.d.

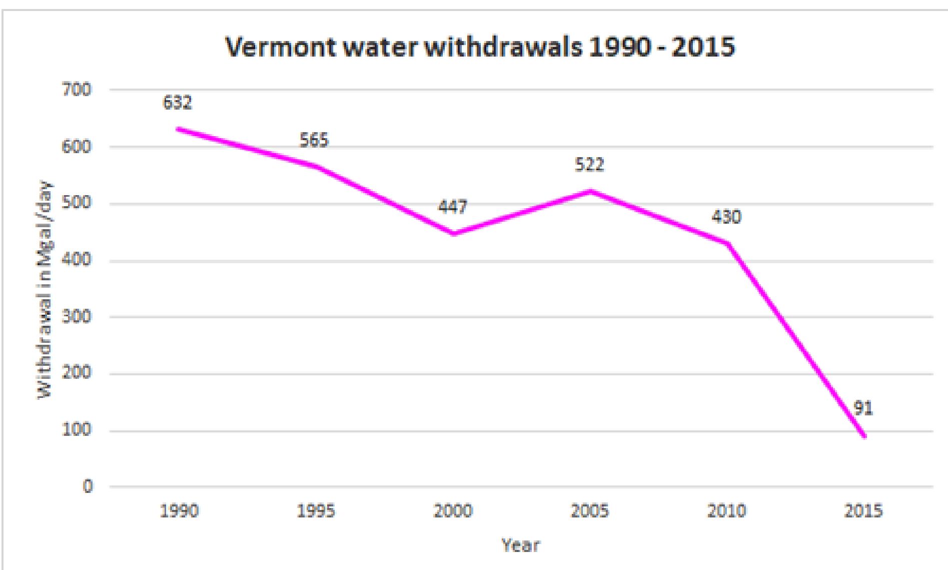
Appendix D - Water Use

Figure 1 New Hampshire Water Use (Million Gallons Per Day)



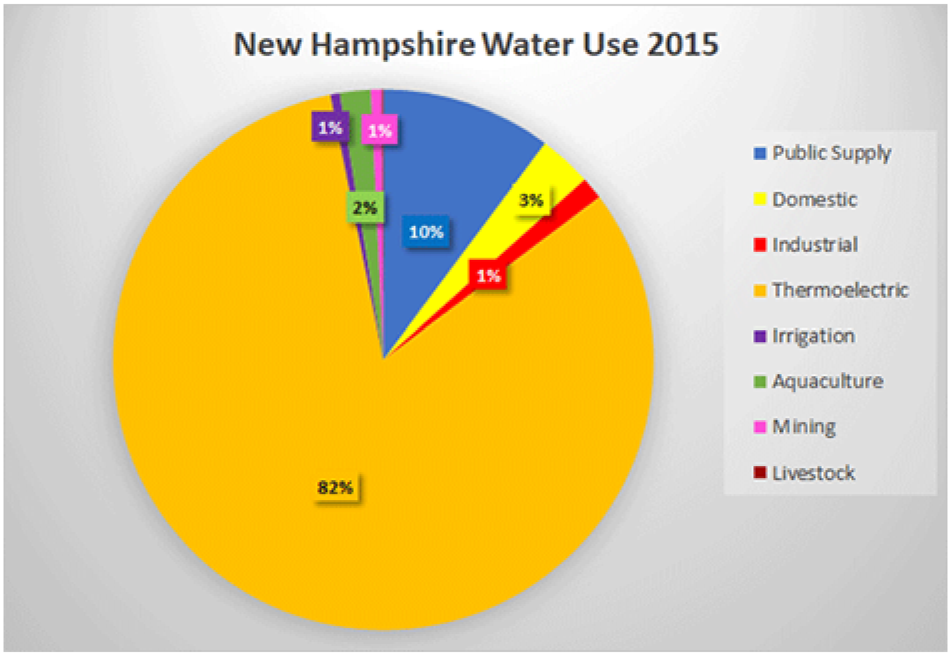
Note. This figure is from USGS, n.d.

Figure 2 Vermont Water Use (Million Gallons Per Day)



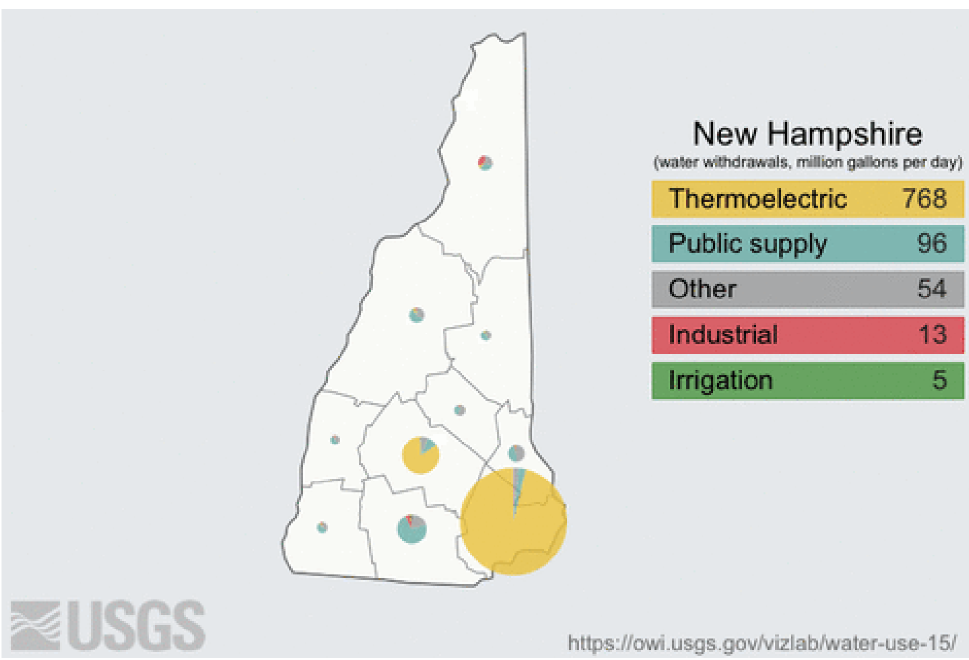
Note. This figure is from USGS, n.d.

Figure 3 New Hampshire Water Use by Category



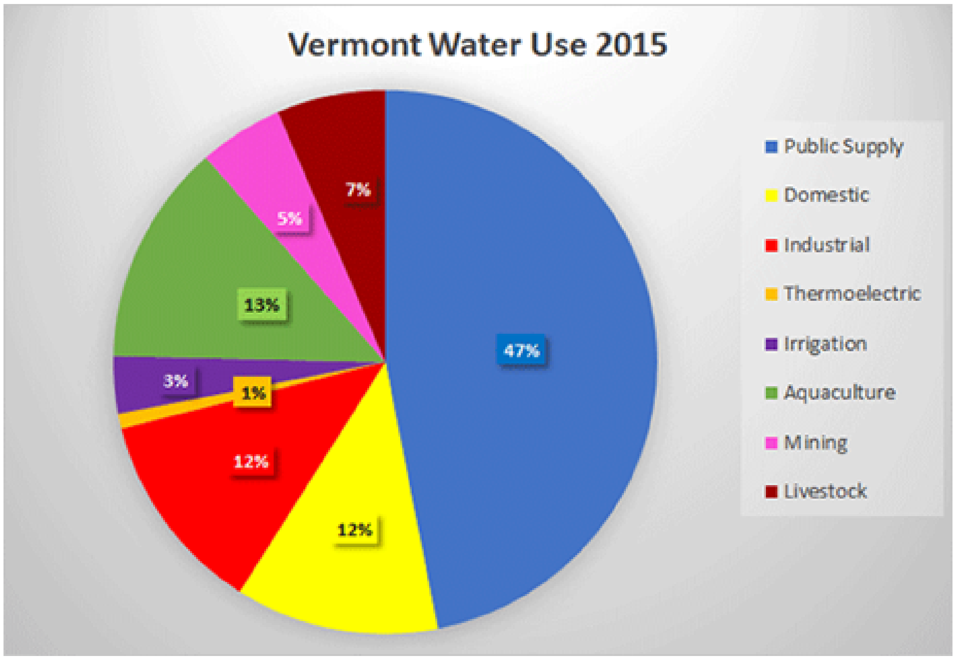
Note. This figure is from the USGS, n.d.

Figure 4 New Hampshire Water Withdrawals (Million Gallons Per Day) By Category



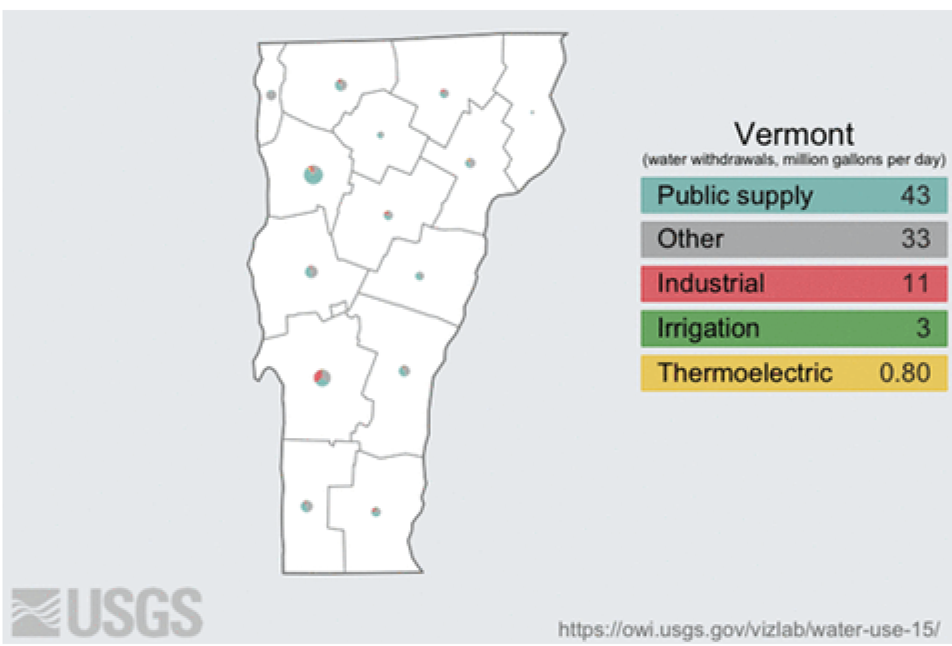
Note. This figure is from the USGS, n.d.

Figure 5 Vermont Water Use by Category



Note. This figure is from the USGS, n.d.

Figure 6 Vermont Water Withdrawals (Million Gallons Per Day) By Category



Note. This figure is from the USGS, n.d.

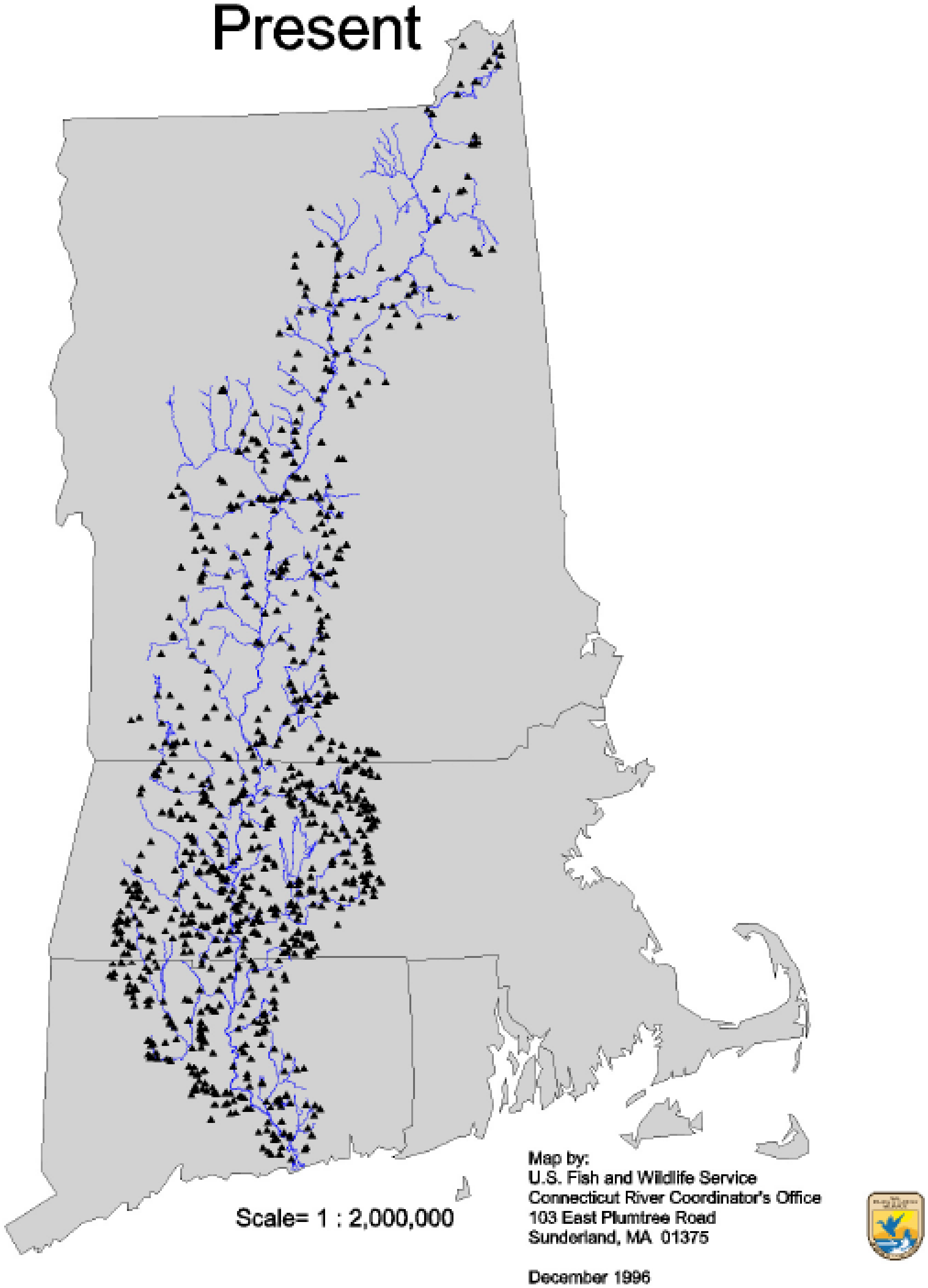
Table 5 Connecticut River Study Area 2015 Water Use

2015 Water Withdrawals Measured in Units (Mgal/d)													
County	**State**	**Public**	**Domestic**	**Industrial**	**Irrigation**	**Live-stock**	**Aqua-culture**	**Mining**	**Hydro Power**	**Ground-water**	**Surface**	**Total**	**Pop.**
Coos	NH	4.20	1.88	4.11	0.17	0.10	3.19	0.04	0.90	3.16	10.14	13.30	31k
Essex	VT	0.25	0.44	0.01	0.00	0.08	0.00	0.13	0.00	0.42	0.26	0.68	6k
Grafton	NH	7.57	5.78	0.52	0.38	0.17	1.44	0.74	0.71	2.82	4.75	7.57	89k
Caledonia	VT	1.77	1.30	0.48	0.08	0.31	1.45	0.13	0.27	1.87	3.22	5.09	30k
Orange	VT	2.16	1.54	0.07	0.11	0.40	0.00	0.04	0.00	2.21	1.58	3.79	28k
Windsor	VT	3.10	2.42	0.31	0.26	0.17	0.72	0.76	0.00	5.36	0.87	6.23	55k
Sullivan	NH	2.71	2.59	0.38	0.11	0.12	0.28	0.52	0.00	2.21	3.03	5.24	43k
Windham	VT	2.10	1.59	0.80	0.40	0.13	0.00	0.21	0.00	1.68	2.72	4.40	116k
Cheshire	NH	4.12	3.99	0.41	0.21	0.11	0.00	0.25	0.32	5.05	2.24	7.29	43k
Totals		27.98	21.53	7.04	1.72	1.59	7.08	2.82	2.20	23.93	28.44	52.37	404k

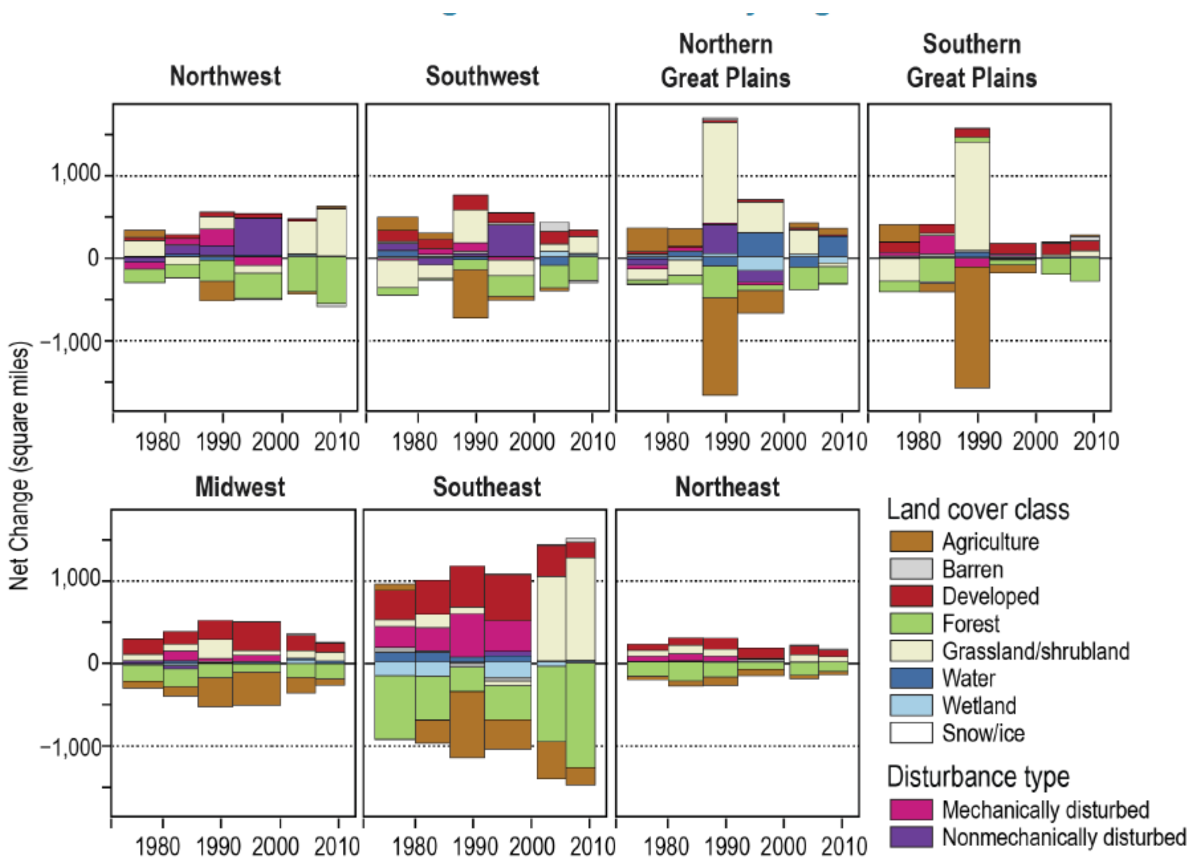
Note. This table is adapted from Dieter et al., 2018

Appendix E - Dams

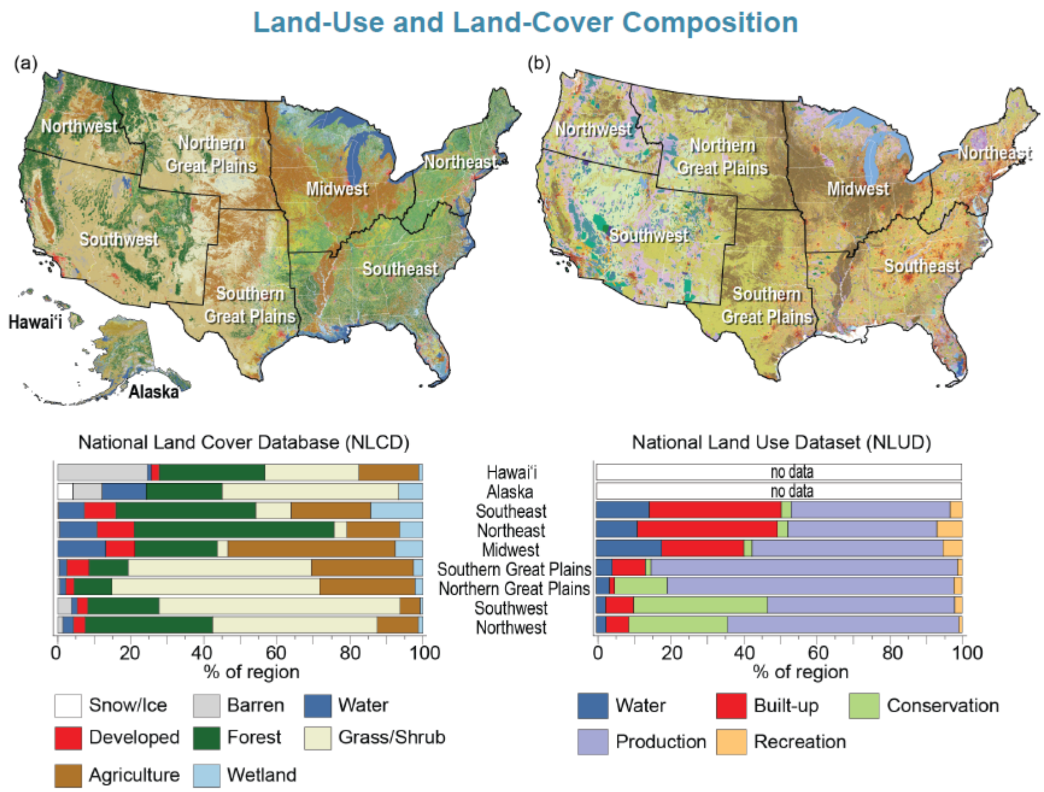
Dams Constructed in the Connecticut River Watershed to the Present



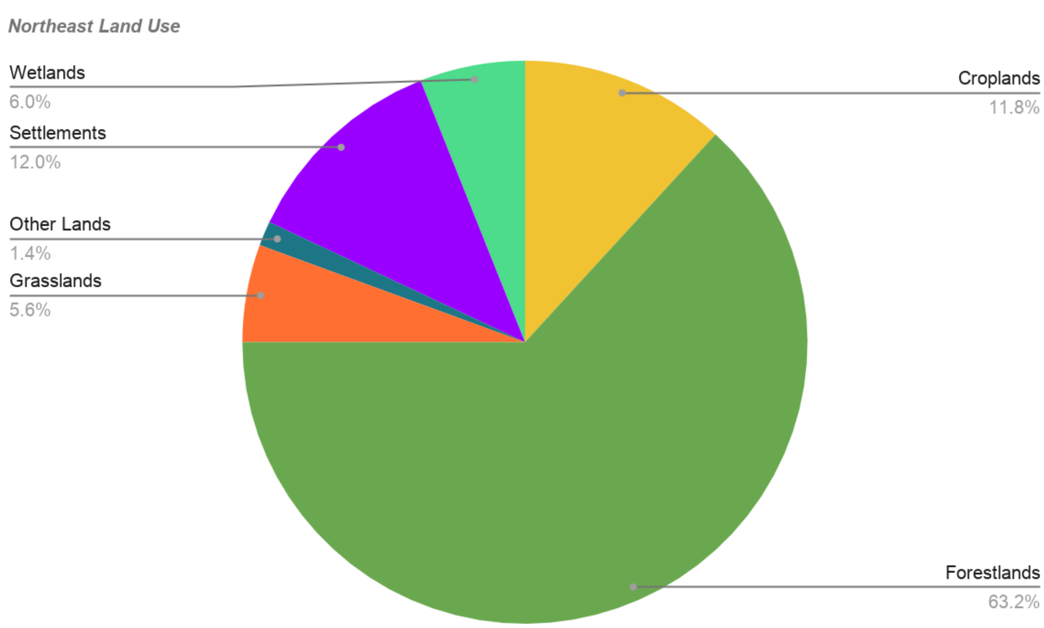
Appendix F - Land Cover by Region (1973-2011)



Note: Information from Sleeter, 2018.



Note: Information from Sleeter, 2018.



Note: Information from Sleeter, 2018.

Glossary

Adaptive Management - A systematic and evolving process for improving the effectiveness of natural resources management by learning from experience and utilising current knowledge and data to inform further decision-making over time (Brears, 2018).

Affinity Migration - Occurs by populations with ample resources who proactively move out of a non-ideal living environment (Bose, 2018).

Afforestation - Planting trees in new areas (Angus et al., 2020).

Climate Haven - There is no standard definition for this term. It generally refers to a place that is considered a haven to people migrating due to climate change.

Biophilia - The innately emotional affiliation of human beings to other living organisms (Beatley, 2016).

Blue-Green Infrastructure - "A planned network of natural and semi-natural areas that utilise natural processes to improve water quality and manage water quantity by restoring the hydrological function of the urban landscape and managing stormwater" (Brears, 2018).

Disturbance Migration - Disturbance migration results in both affinity migration and forced migration (Bose, 2018).

Eutrophic - Relates to water resource's trophic state. If the water resource is eutrophic, it has high nutrients and generally sees high plant or phytoplankton growth (DEC, n.d.).

Forced Migration - occurs without planning, often in response to an acute disturbance such as a natural disaster or political danger, and is undergone in order to survive a potentially mortal threat (Bose, 2018).

Green Streets - "Green streets incorporate nature-based solutions and green infrastructure elements such as trees and vegetation that help connect and integrate the natural and built environments while reducing urban heat island and other climate-related impacts" (Angus et al., 2020).

Mesotrophic - is a water resource with a trophic state that falls somewhere in between eutrophic and oligotrophic (DEC, n.d.).

Oligotrophic - is a water resource that has low nutrient concentrations and generally low plant growth (DEC, n.d.).

Receiving Communities - The communities where immigrants settle.

Resilience - The capacity of a system to absorb, utilize, and even benefit from perturbations.

and changes, and thrive without a qualitative change in the system's structure (Beatley, 2016).

Urban Heat Island Effect- "The urban heat island effect is a measurable increase in ambient urban air temperatures resulting primarily from the replacement of vegetation with buildings, roads, and other heat-absorbing infrastructure. The heat island effect can result in significant temperature differences between rural and urban areas" (EPA, 2009).

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