Now You See Them, Now You Don't:

Vernal Pool Identification and Conservation in Keene, NH

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Acknowledgements

For the duration of this study, several individuals contributed many hours to help this report become a success. The research team would like to thank these individuals for their time, effort, and guidance during the long hours spent researching and writing to put this report together.

First, we would like to give thanks and show gratitude to our Keene State professor and faculty supervisor, Dr. JoBeth Mullens. Without your support, guidance, and encouraging words, our report would not have been possible. We would also like to thank several other faculty members in the Keene State College Geography Department for their feedback and help:

- Dr. Christopher Brehme, Professor of Geography, Keene State College
- Dr. Christopher Cusack, Professor of Geography, Keene State College
- Dr. Al Rydant, Professor of Geography and Department Chair, Keene State College

Throughout this report, our team also interviewed and worked with several professionals from the City of Keene. We would also like to thank these individuals for their time and helpful resources:

- Emily Hague, Stewardship Manager at the Monadnock Conservancy
- David Moon, Executive Director of AVEO
- Andrew Smith, Planning Department, City of Keene
- Brett Thelen, Research Associate in the Environmental Studies Department, Keene State College
- Pete Throop, Project Director, Monadnock Community Conservation Partnership (MCCP), City of Keene
- Dr. Susan Whittemore, Professor of Biology at Keene State College, Chair of the City of Keene Conservation Committee

Lastly, we would like to extend our thanks and appreciation to Nathan Buzby; for providing comic relief during stressful days, supporting our project when we were doubtful, and lending a helpful hand.

Abstract

Vernal pools of the Northeast are ephemeral wetlands characterized by spring periods of inundation followed by extensive dry periods. These small pools are host to a variety of amphibious species who depend on them for their reproductive cycle. Unfortunately, the brief nature of vernal pools and the current identification methods make it difficult to identify these important wetlands. This in-turn can result in their omission from protection under current wetland regulations. Additionally, private landowners may have limited knowledge of vernal pools on their property. This project explores the use of geographic information systems (GIS) to identify and model specific characteristics common to vernal pool sites in Keene, New Hampshire. The public was also surveyed to determine their knowledge about and willingness to participate in vernal pool protection. The research concluded that GIS used elsewhere in New England - which correlates the occurrence of vernal pools with specific geophysical characteristics - would be effective in Keene. Results from the survey indicate that the public has more knowledge of vernal pools than anticipated and are supportive of conservation efforts.

Chapter 1:

Introduction

Keene is a beautiful city known for its stunning fall foliage, extensive green spaces, and vibrant community. Residents take pride in their town's image as evidenced in the Keene Comprehensive Master Plan (CMP) adopted in September 2010 (City of Keene Planning Department 2010). A culmination of a two and one-half year public process, the CMP focuses on many of the same issues found in most city planning frameworks - land use, transportation, and economic needs. What makes Keene's CMP so distinctive, however, is that it also addresses less traditional urban planning issues such as the need for an adaptive plan to combat climate change, promote population diversity, support community health and wellness, and foster the arts. The City's commitment to using sustainable planning innovations led the International Council for Local Environmental Initiatives (ICLEI) - an international association of local governments and government organizations who have made a commitment to sustainable development – to recognize the City of Keene with the Sustainability Leadership Award in 2010 (Meneses 2010). Keene is also unique in its dedication to remain committed to community goals originally established in the 19th Century. These included the importance of creating and protecting green spaces, trails, parks, and natural wildlife corridors (City of Keene Planning Department 2010).

In protecting its natural environment, Keene's conservation rules require a strict adherence to several federal and state laws. According to the CMP, however, the City's primary wetland conservation concern is to "allow the natural system space to work, such as when wetlands are flooded after heavy rains, or when a stream naturally shifts its location slightly over time" (City of Keene Planning Department 2010, 96). While this focus on the benefits wetlands offer to the community is expected - due to Keene's location within the Ashuelot

River's flood plain - it has created a gap in the City's conservation efforts. By focusing on wetlands as only a tool to combat flooding, the city ignores the wetland's role in the ecosystem particularly in the key role wetlands play for specific species in both the catchment and downstream (Calhoun et al. 2005). This view also fails to acknowledge the variety of forms wetlands can take as part of the greater surface-water system. In particular, smaller wetlands that fulfill a distinctive niche in the environment, such as vernal pools, are often not recognized.

Vernal pools are a unique type of wetland. These pools, which can vary in size, shape, and location, are characterized as a water body that generally fills in spring with rains and/or winter snowmelt, and are dry for at least part of the year (Witham 1998). Occasionally pools may remain at least partially filled with water over the course of a year or more, but all vernal pools dry up periodically. The term vernal pool relates to the fact that the pools are most often at their peak depth in the spring and early summer.

Vernal pools are essential to a healthy ecosystem, as they provide seasonal habitat for many organisms. As seen in Figure 1, vernal pools are most prominent in wooded areas. They form in small depressions where water accumulates. According to Tappan (1997), vernal pools fulfill essential needs for many species. Key among these are the obligate species, which require a vernal pool for at least part of their lifecycle. In the Northeast United States, the most common obligate species include the wood frog, members of the mole salamander family - such as the blue-spotted salamander - and fairy shrimp.

Unfortunately, the short duration of vernal pools make them difficult to identify; therefore, they are less likely to be included in existing wetland protection. Current methods used to identify potential sites require extensive remote sensing training and access to up-to-

date aerial photographs taken during early spring when leaves are absent. These methods can be time consuming and produce inaccurate results (Burne and Lathrop 2008). More importantly the lack of efficient and accurate methods for vernal pool identification has led, in part, to an omission of vernal pools in current wetland conservation regulations in the City of Keene.

Based on the work of Smith and Verrill (1996), however, it is possible that a correlation exists between specific geophysical characteristics and vernal pool locations. If so, geographic information system (GIS) analysis utilizing readily available public domain data sets may help identify potential vernal pool locations much more efficiently. This analysis could create a database of potential location that could be made accessible to both government officials and private citizen. Such a database would provide needed information for groups connected to

Figure 1: Vernal pool found in Ashuelot River Park.

vernal pool conservation efforts.

An accessible database of potential sites could also be used to reach out to members of the public that are not currently involved on citizen-based conservation efforts in Keene. Non-profit organizations throughout the region currently run citizen-scientist programs. These programs focus on amphibian conservation efforts on public lands that are easily accessible by the citizen-scientists. However, these activities have not addressed vernal pools on private lands, which cover 88.8 percent of the Keene area. An accurate listing of potential vernal pool location on private lands could give conservation organizations an opportunity to reach out to private landowners with educational material and information on self-conserving and the benefits these actions would bring to the landowner (Oscarson and Calhoun 2007).

Ashuelot Valley Environmental Observatory (AVEO) is an example of a citizen-scientist program working with vernal pools in Cheshire County. This nonprofit organization has been working with the residents of Keene to conduct the spring salamander crossing events, and to identify vernal pools on public land. AVEO also has many partnerships throughout Cheshire County to educate and encourage people to participate in vernal pool identification. These include Keene State College, Franklin Pierce University**,** the Monadnock Conservancy, and the New Hampshire Department of Resources and Economic Development, Division of Forests and Lands. In the Fall of 2010, AVEO merged with the Harris Center in Hancock, NH. The Harris Center is a foundation dedicated to advocating respect for the natural environment through public education and conservation. This merger, along with a database of potential vernal pool locations, may lead to more progress with vernal pool conservation (Ashuelot Valley Environmental Observatory 2010).

This study addresses the lack of vernal pool identification and conservation efforts on private property in the City of Keene, NH. Currently, the City of Keene does not have any ordinances or laws specifically protecting vernal pools. Additionally, conservation groups in the area have made minimal progress in vernal pool conservation on private lands. This study attempts to identify an effective and efficient method for locating potential vernal pool sites within the City of Keene. However, identification is pointless without citizen conservation knowledge and interest. To that end, this study also intends to gauge how important vernal pools are to the public and whether individuals that are more knowledgeable about vernal pools have more interest in conserving the pools. With the help of the public, particularly private landowners, conservation and protection of vernal pools in the City of Keene is possible.

Chapter 2:

Literature Review

Vernal Pools

The decline of amphibians, a group of organisms that play important roles in healthy ecosystems and that may act as indicators of environmental problems, has become a global concern. The 2008 International Union for Conservation of Nature (IUCN) Red List of Threatened and Endangered Species states that approximately one-third of the world's amphibian species are either endangered or extinct (Stuart et al. 2008).

A growing body of research indicates there is a strong relationship between habitat fragmentation, particularly spring habitat used for reproduction, and the degree of amphibian decline (Gates and Thompson 1982; Wyman 1990; Blaustein et al. 1994; Pounds et al. 1999; Homan 2004; Leibowitz and Brooks 2008). Research on amphibians and attributes of habitat loss and fragmentation has clearly shown the negative effects on juvenile dispersal (Swihart et al. 2003; Cushman 2006; Greenwald et al. 2009; Stuart et al. 2008). Recent research also shows a strong relationship between habitat loss and fragmentation and the impact on amphibian populations (Harper et al. 2008).

Certain amphibian species, particularly wood frogs and spotted salamander, show a strong attachment to specific breeding pools and upland habitats. Several studies have linked this site fidelity with the species' inability to cope with habitat fragmentation (Husting 1965; Williams 1973; Berven and Grudzien 1990). Site fidelity may actually cause species to remain in an area that has become inhospitable even if a more suitable area is within the population's dispersal range (Berven and Grudzien 1990; Windmiller 1996). More importantly, species that attempt to disperse may be poorly equipped to handle the difficulties of features of a developed environment, such as paved roadways and pets (Homan 2004).

Assuring the protection of these essential habitats and making corridors that safely connect the different habitat areas, is therefore essential to any amphibian conservation policy. Unfortunately, vernal pools, the primary breeding site for these species are often underrepresented in land use policy. This is largely due to the difficulty in locating pools and verifying them as a breeding habitat (Calhoun et al. 2005).

Current Methods for Pool Identification

Current methods for locating potential vernal pool sites typically rely on remote sensing images, most commonly aerial photography, followed by field-verification through various ground-truthing techniques (Tappan 1997; Brooks et al. 1998; Burne 2001; Calhoun A. J. K. 2003). This approach, which requires extensive training in remote sensing techniques, can be quite costly and inefficient (Grant 2005). As noted, the lack of efficient and accurate techniques for vernal pool location hinders amphibian and pool conservation efforts.

In his groundbreaking study, Smith and Verrill (1996) argues that vernal pool occurrence is not random. In fact, the probability of potential vernal pool occurrence is positively related to a number of geophysical features such as slope and soil composition, and negatively related to other features such as development. They and others argue that, until new remote sensing technology becomes widely available, using readily-available geo-spatial data layers to locate potential vernal pool sites is a far more efficient and cost-effective method (King 1992; Smith and Verrill 1996; Grant 2005; Calhoun and Reilly 2008; Leibowitz and Brooks 2008). This approach has the added benefit of streamlining the assessment of a landscape for its potential to support amphibian populations.

Conservation in New England

Vernal pool habitat protection is largely ineffective or absent at all levels of government in North America (Preisser et al. 2000; Snodgrass et al. 2000; Leibowitz 2003; Calhoun et al. 2005). Federal wetland protection efforts primarily focus on two issues: water quality and species recognized as threatened or endangered under the Endangered Species Protection Act (Calhoun A. J. K. 2003). In the Northeast, only a few states - Massachusetts, Maine, Connecticut, and New Jersey - have adopted state-level regulations that go beyond the federal efforts to protect wetlands in general and specifically protect vernal pools (Preisser et al. 2000; Calhoun A. J. K. 2003; Burne and Griffin 2005; Lathrop et al. 2005; Raymond and Olive 2008). Of these states, Massachusetts has the longest history of land-use regulations that explicitly include vernal pools protection. However, these regulations only go into effect after an extensive field verification process confirms the pool as a vernal habitat (Burne 2001).

Once a wetland body in Massachusetts is certified as a vernal pool, any project that could alter the pool - through changes in the surrounding topography, soil composition, or hydrography - must demonstrate that there would be no reduction in the ability of the pool to provide a viable habitat for wildlife (Burne and Griffin 2005). While this may be the best mechanism currently in use for protecting vernal pools, Burne (2001) found that Massachusetts is only protecting 24.6 percent of those vernal pools recommended for certification through this approach. Since Burne's original report, the Massachusetts *Guidelines for the Certification of Vernal Pool Habitat* have been updated. According to the Natural Heritage and Endangered Species Program (NHESP) this was done to "increase the confidence that pools that become certified provide essential breeding habitat for certain amphibians that require vernal pools."

(2009, 1). Others have expressed concern that the more stringent standards in the new guidelines may actually reduce the chances that a vernal pool will be certified and protected.

Of primary concern are changes in the requirements for certification that increases the number of indicator species and/or egg masses required for certification. For example, new guidelines now require documentation that if, at the time of ground-truthing, wood frogs are used to meet the NHESP biological criteria a total of five or more mating pairs of wood frogs are in residence. Should egg masses be used as evidence of a vernal pool "region" there now must be proof of five or more egg masses in the pool; up from three in previous regulations (Natural Heritage & Endangered Species Program 2009). Those who expressed concerns point out that, due to the character of vernal pools, most ground-truthing occurs during cooler weather occasionally in areas that are hard or possibly even dangerous for volunteers to traverse. By narrowing the requirements for certification, the state may actually be deterring individuals from volunteering (Winn 2009).

To address the lack of vernal pool protection at the federal and state level, several local governments in the northeastern U.S., such as Litchfield, NH, have proactively developed wetland regulations and ordinances to specifically include vernal pools as regulated wetlands (Preisser et al. 2000; Burne and Griffin 2005; Calhoun et al. 2005; Lathrop et al. 2005). Although these regulations attempt to fill the gap in state or federal measures by taking into account the local needs, the ordinances often do not require land-use planning at scales that consider wetland connectivity, nor do these ordinances effectively ensure protection on private land (Calhoun et al. 2005).

New Hampshire follows the trend found in most northeastern states with vernal pool conservation efforts primarily left to the towns. Unlike some states, however, these local ordinances in New Hampshire are supplemented by guidelines set out by the New Hampshire Department of Environmental Services Wetlands Bureau. The primary objective of the N.H. Wetlands Bureau is "...to afford the maximum degree of protection for the natural environment while allowing individual landowners the freedom to use and enjoy their land as is consistent with this public purpose" (New Hampshire Wetlands Bureau WT102.01). If a vernal pool occurs in a wetland, then the Wetlands Bureau has regulatory authority over activities that may affect the area, such as construction and fill usage. However, vernal pool protection at the state or local level can only occur if these often small, seasonal pools are identified and documented.

Even with some local governments attempting to be proactive in vernal pool protection, the focus of most ordinances are still based on a permit-by-permit response rather than resource planning strategies (Calhoun et al. 2005). Many town commissions or boards often consist of local volunteers who lack the necessary expertise in ecology to construct effective vernal pool conservation ordinances. Town planning commissions therefore often require permit applicants to hire environmental consultants who collect and interpret data on the wetland area being assessed. Since most towns do not have standardized methods for collecting the data the consultant needs, the result is a report that may be missing key information for a cohesive site review process, which can prolong the process, and in some cases result in poor decision-making (Klemens and Johnson 2005). Towns also tend to be unpredictable in their permitting process, resulting in a lack consistency in vernal pool

protection (Cort 1996; Preisser et al. 2000; Theobald et al. 2000; Brody et al. 2003; Calhoun et al. 2005).

The Citizen-scientist

The idea of complementing government resource management with a citizen-scientist participatory approach is an increasingly relied upon strategy (Calhoun and Reilly 2008). This approach is particularly important in vernal pool identification and conservation. Encouraging citizen participation in land use planning and conservation can encourage the building of partnerships to bridge the gaps between local needs and the agendas of other stakeholders (Calhoun and Reilly 2008). Citizen-scientists can act as a means for change at both the local and state level by collecting data on information to help develop responsible comprehensive plans and ordinances that are more attentive to local environmental concerns (Calhoun et al. 2005).

Attempts to train citizen-scientists to identify and assess a town's resources and collect ecological data intended for use in regulatory decisions have been well documented (Fore et al. 2001; Harvey et al. 2001; Byron and Curtis 2002; Engel and Voshell 2002; Savan and Sider 2003; Calhoun and Reilly 2008). However, these programs often have limited success across municipal boundaries due to different regulations in effect from place to place (Preisser et al. 2000; New Hampshire Fish and Game Department 2006).

To address a growing need for standardized methods in local data collection for planning, Calhoun and Klemens (2005) published *Best Development Practices: Conserving Pool-Breeding Amphibians in Residential and Commercial Developments in the Northeastern United States* (BDP). The BDP outlines steps for conducting municipality-wide pool inventories and guides municipalities on how to use citizen-scientist programs in land use planning and as a

complement to any existing vernal pool conservation efforts. Oscarson and Calhoun (2007) then implemented the assessment portion of the BDP in four New England towns to test the practical applicability of the BDP and to serve as models for towns interested in local conservation of vernal pool habitat. The authors discovered that overall the implementation of the BDPs with the help of citizen-scientists was successful and by keeping volunteers involved in the process, they tended to maintain an interest and ownership of community conservation efforts (Oscarson and Calhoun 2007).

Efforts to identify vernal pools have been undertaken in Keene, NH. These efforts both adopt measures from elsewhere in the US Northeast and are unique to the Keene area. Among the many issues, Keene faces in its conservation efforts are the need for an effective way to identify potential vernal pool sites and a set of clear, comprehensive, and enforceable regulations for protection of certified sites. As shown by various studies, the use of volunteers through citizen-scientist programs can help officials in many aspects of vernal pool verification and policy development, as well as long-term enforcement. Since various citizen-scientist programs already exist in the region, Keene is perfectly positioned to further its vernal pool conservation process.

Chapter 3:

Vernal Pool Background

Vernal pools are a unique type of seasonal wetland. The term vernal pool was originally coined to describe small, intermittently filled wetlands found in the Mediterranean-type climate of areas such as California. Today it is used more broadly to include similar wetlands found countrywide. Vernal pools are depressions filled by shallow water during variable periods from winter to spring, but may be completely dry for most of the summer and fall. These wetlands range in size from small puddles to shallow lakes. Although generally isolated, they are sometimes connected to each other by small drainages known as vernal swales.

Changes in weather patterns associated with each season cause dramatic changes in the appearance of vernal pools. The pools collect water during winter and spring rains, changing in volume in response to varying weather patterns. During a single season, pools may fill and dry several times. In years of drought, some pools may not fill at all. In the spring, wildflowers often bloom in brilliant circles of color that follow the receding shoreline of the pools. By early summer, the water has often evaporated, and the clay pools appear brown, barren, and cracked.

However, appearances may be deceiving. The unique environment of vernal pools provides habitat for numerous rare plants and animals that are able to survive and thrive in these conditions. Many of these plants and animals spend the dry season as seeds, eggs, or cysts, and then grow and reproduce when the ponds are again filled with water. In addition, birds such as egrets, ducks, and hawks use vernal pools as a seasonal source of food and water.

A vernal pool, because of its periodic drying, does not support breeding populations of fish. Many organisms have evolved to use these predator free temporary wetlands for at least part of their lifecycle. These organisms are the "obligate" vernal pool species, so called because

Figure 2: Wood Frog

they must use a vernal pool for various parts of their life cycle. If the obligate species are using a body of water, then that water is defined as a vernal pool. In New England, the easily recognizable obligate species are the wood frog, fairy shrimp, and members of the mole salamander family.

Obligate Species

One of the most commonly seen obligate species in New England is the wood frog, *Rana sylvatica* (Figure 2). Wood frogs are amphibious frogs that are found in upland forests throughout the northeast (Tappan 1997). They venture down from their forest habitats to vernal pools where they mate and lay their eggs before returning to the forests. Once the eggs hatch, the tadpoles remain in the pool until fully developed, at which time they move into the upland forests (Ashuelot Valley Environmental Observatory 2010).

The fairy shrimp (Figure 3), *Branchinecta lynchi*, is a species unique to vernal pools. Fairy shrimp are a crustacean that only measure about 1 inch (Ashuelot Valley Environmental Observatory 2010). Unlike wood frogs and mole salamanders, they spend their entire life cycle

Figure 3: Adult fairy shrimp (USFWS 2009)

in vernal pools. Fairy shrimp hatch in late winter/early spring after the pools fill. They live for only a few weeks until the female drops an egg case, which remains at the bottom of the pool after it dries (Tappan 1997). The eggs then enter a state of cryptobiosis and remain dormant until water and temperature conditions are ideal for the eggs to hatch. Fairy shrimp eggs are capable of remaining in this state for fifteen years before becoming unviable (Munuswamy et al. 2009).

The mole salamander family, genus *Ambystoma*, is another group of upland organism's dependant on vernal pools for their nymph and reproductive cycles. Species of mole salamanders include the Jefferson's and Blue-Spotted salamanders (Figure 4). Both are currently threatened due to habitat destruction that has led to hybridized, all-female populations (Gates and Thompson 1982). Mole salamanders spend most of their life in burrows in upland forest floors. Annually they migrate from their burrows to vernal pools to mate and lay eggs. Like the wood frog, the nymph salamander will remain in the pool until mature, at which time they become terrestrial and will migrate to nearby upland forests (Tappan 1997).

Figure 4: Jefferson's Salamander (left) and Blue-spotted Salamander (right) (USFW 2009).

Threats

The effects of development in human-dominated landscapes on vernal pools and the amphibians that rely on them are many. Development activities, such as land clearing, as well other human-created environmental alterations like climate change and pollution from both direct and indirect sources, degrades habitat quality in pools and in adjacent terrestrial areas. This degradation of the vernal pool habitat could result in a subsequent decline in the local amphibian population (UNH Cooperative Extension 2009).

Site clearing around pools for construction of roads and buildings can alter and devastate critical overwintering habitat causing a loss of adult members of obligate species (Windmiller 1996; Regosin et al. 2003). Development occurring in forested land can also harm vernal pools directly because of the loss of tree cover.

> The loss of surrounding trees results in decreased shading, rising water temperatures, decreased oxygen content, increased evaporation, and shorter flooding cycles. There may also be less debris to provide cover, nutrients, and attachment sites for egg masses. Many of the amphibians and reptiles that use vernal pools spend most of their year in the surrounding habitat, both uplands and wetlands (Department of Environmental Protection 2010).

In an attempt to lessen the impact of the loss of natural wetlands, many regulations require the creation of new wetlands. Often these artificially created wetlands cannot replicate the habitat of natural wetlands, leading to insufficient structural diversity, microhabitats, and hydrology to support pool-breeding amphibians (Lichko and Calhoun 2003; Oscarson and Calhoun 2007). Since these constructed wetlands are often placed near the original pool they can intercept amphibians as they disperse to natural breeding pools; eggs laid in these pseudo-wetlands often do not survive (Lichko and Calhoun 2003).

According to Calhoun and Klemens (2002) the post-construction issues following development can create various other problems that could cause a decline in local pool-breeding populations. The introduction of non-native plant species from landscaping could lead to the attraction or introduction of species that prey on amphibians. Additionally, attempts to control these species through increased use of pesticides can have negative impact native populations. Roads and storm water management systems, which are numerous in human-dominated landscapes, also have negative effects on amphibian populations either through direct mortality or by acting as barriers to dispersal. Of immediate consequence is the use of vernal pools as storm water detention basins (Keddy 2000). Often municipalities in cold-weather regions use deicers on roads, such as salt and calcium carbonate, during winter months. These chemicals build up over the winter and in spring increased precipitation and snowmelt wash the deicer through the storm water system into the water body. Many of these pollutants are toxic to amphibians, particularly at the larval stage, and have been linked to cancer and developmental issues in many species (Department of Environmental Protection

2010). In the end, this could have a serious negative effect on the amphibian population and their breeding cycles.

Climate change can also have a significant impact on vernal pools and the amphibians that use them. Most of the amphibians that use vernal pools thrive in a cooler spring temperature and relatively stable weather patterns; therefore, climate change may make the environment more difficult to live in.

> Relatively small changes in precipitation timing or amount, with or without changes in temperature regime, could alter this balance. A small change in average temperature may not directly affect a species, but it could alter pool longevity enough to reduce the chances of a particular species being able to reproduce in that pool (Graham 2006).

Poor management and planning practices related to development, pollution, and climate change have resulted in the destruction of woodlands, and the draining and filling of wetlands and vernal pools. As well, the infrastructures associated with the human-dominated landscape threaten vernal pools and their wildlife. As more is learned about the complex characteristics and functions of vernal pools, the opportunity presents itself for communities to effectively plan and manage human land use activities for the purpose of protecting these unique features and ensure their role in the maintenance of a healthy environment.

Chapter 4:

Case Study: Keene, NH

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Keene, New Hampshire, as shown in Figure 5, is located in the heart of Cheshire County. Characterized by its vibrant, historical downtown district, unique college population, and appealing autumn scenery, Keene holds onto its small town feel while combining historic preservation with current trends. Keene comprises a total land area of 34.7 square miles, or approximately 22,020 acres. It contains 9,099 residential units and lies at the intersection of New Hampshire routes 9, 10, 12, and 101. From Keene, a traveler can reach the borders of Vermont and Massachusetts with a short 20-minute drive. Keene is also a short distance from Mount Monadnock, the most climbed mountain in New Hampshire, located just a few miles east of the City.

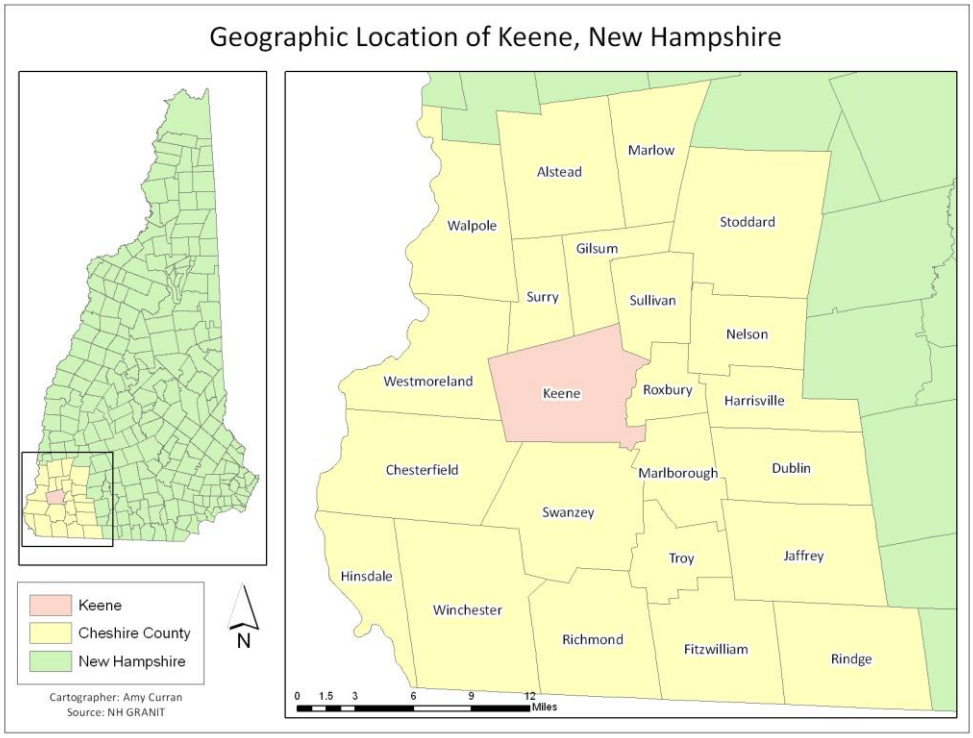

Figure 5: Location of Keene in Cheshire County, southwest New Hampshire

Brief History

Keene, New Hampshire was built in a valley that was once a glacial lakebed. Officially settled in 1737, the City of Keene was known as the Upper Ashuelot, representing the Ashuelot River; a tributary of the Connecticut River which flows through the valley. Originally settled as an agricultural community, Keene was made the heart of Cheshire County in 1771. By 1775, at the start of the Revolutionary War, the population had grown to 750 people. Mills began to open along the Ashuelot River in the 1800s as people realized the power that the river had to offer. Stores, shops, and hotels began to open around the central square of the City in the 1830s which began to draw tourists to the region. In 1848, the railroad system was brought to Keene which made it a transportation center in southwestern New Hampshire. By 1874, there were more than 6,000 people living in Keene when it was named a city (Rumrill 1995).

In 1909, the Keene Normal School, a small college dedicated to educating and preparing future teachers opened its doors. Known today as Keene State College (Figure 6) it has

Figure 6: Keene State College

expanded its offerings and now offers nearly 40 majors in the liberal arts and sciences, professional programs, and selected graduate degrees. The opening of the college brought more people to the area and the population of Keene continued to grow. Figure 7 shows Keene's population growth beginning in 1900. This illustrates that the population increased rapidly for a few decades, from 1930 to 1970. Then, in 1970, the growth rate slowed. From 1990 until present day, the population in the City Of Keene has remained relatively constant.

Demographics

According to the U.S. Census Bureau estimates, in July 2009 the City of Keene was home to roughly 22,395 people. As shown in Figure 8, individuals' age 15 to 24 years constitutes the largest portion of Keene's population, 25 percent. This reflects the influence of Keene State College, which draws approximately 5000 students to Keene annually. The second largest age group is between 25 and 34 years of age.

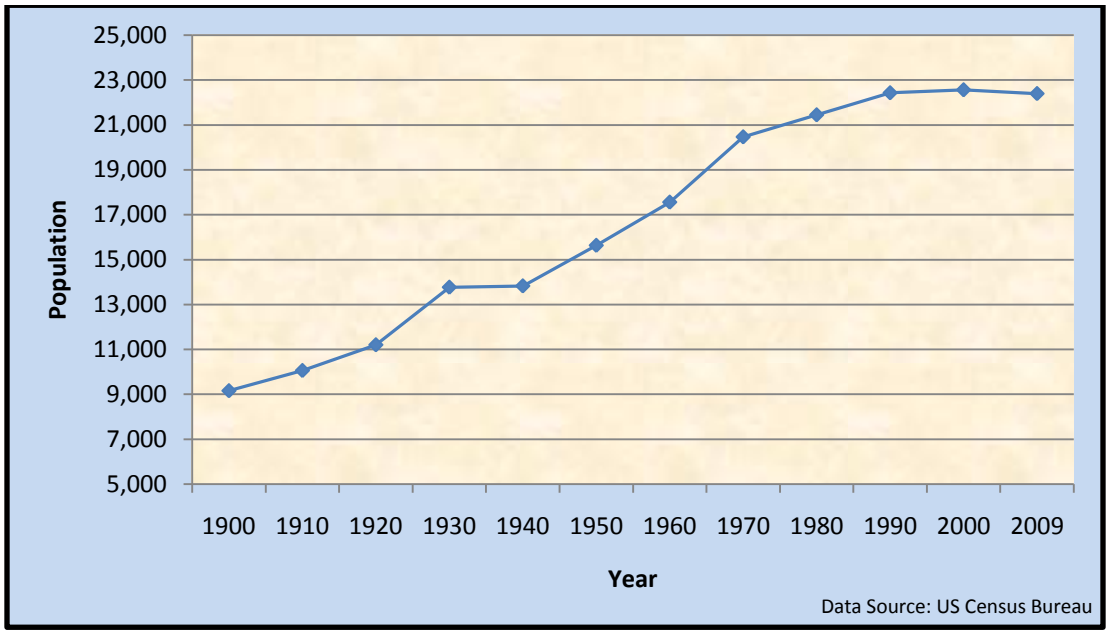

Figure 7: Population Trends - Keene, NH

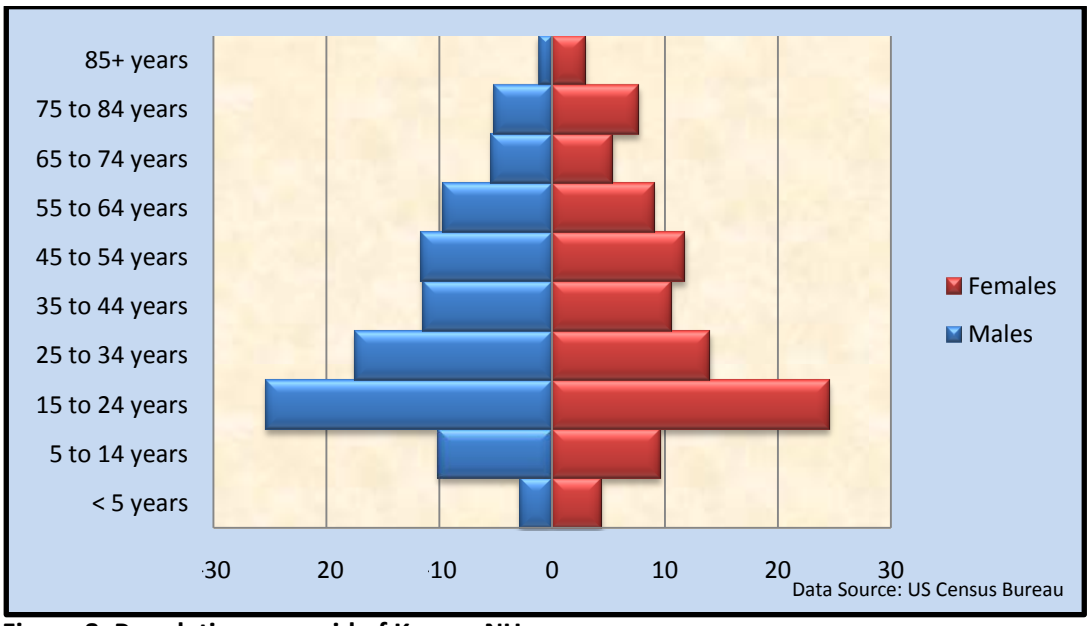

Figure 8: Population pyramid of Keene, NH

For most age groups, the gender difference in percent of males to females is small. For example, 9.7 percent of people aged 55 to 64 years are male, whereas 9 percent are female. It is interesting to see that there are very few children under the age of five in Keene. Only 2.8 percent of the children under five are male and 4.4 percent are female. This gender breakdown is also very similar in the over 75 years of age cohort. In this older age range, over half of the population is female.

Ethnic Composition

The City of Keene, like many northern New England small cities is limited in its ethnic diversity. In the 2006 to 2008 demographic estimates from the U.S. Census Bureau (2008), 22,760 residents or 96 percent, of Keene declared themselves white (Figure 9). The other 4 percent of the population is a mixture of African American, Asian, other races, or two or more races combined. Majority of the diversity that is present in Keene is partly due to Keene State College.

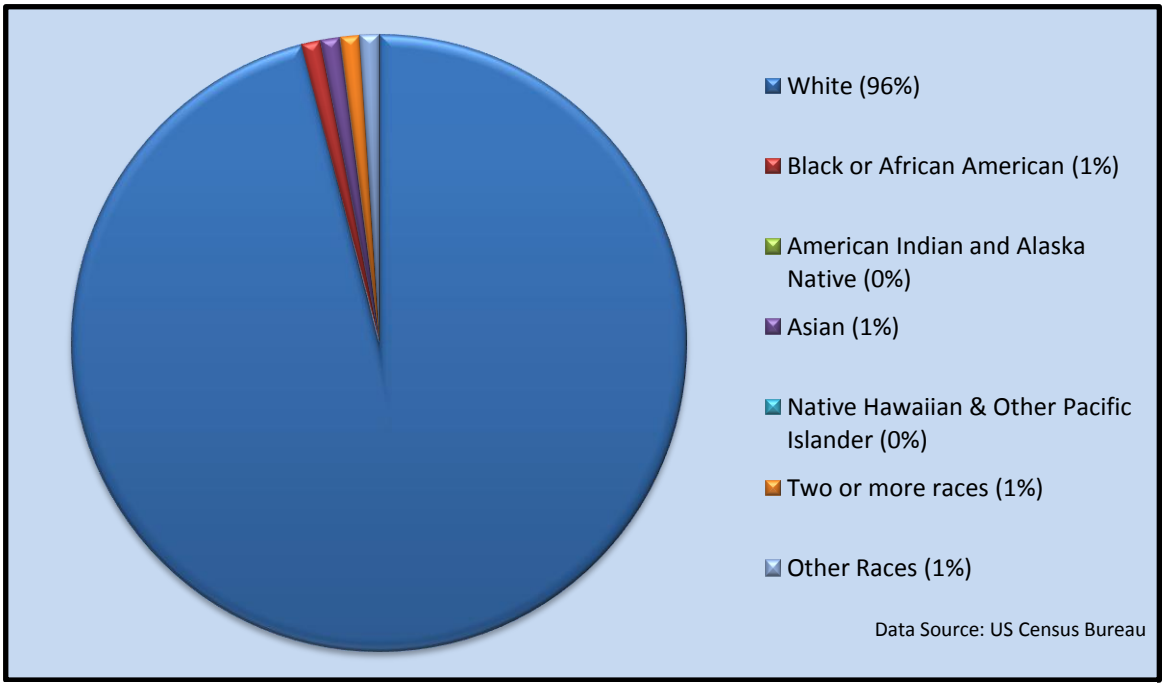

Figure 9: Ethnic Composition of Keene, NH

Employment

Keene State College (KSC) is located in downtown Keene on Main Street. KSC along with another institute of higher education, Antioch University New England Graduate School employ a number of individuals in the Keene area. Keene State College and Antioch University are only two of the twelve major employers in the City of Keene. Other major employers include the Cheshire Medical Center/Dartmouth-Hitchcock – Keene, the Kingsbury Corporation, SAU29 School District, and Smiths Medical.

In the year 2008, the employment rate in the City of Keene was at 61.2 percent for all people 16 years of age and older. The individual age bracket ratios are shown in **Error! eference source not found.**. The highest rates of employment are those that are aged 45 to 54 years with an employment rate of 82.7 percent. The lowest rates of employment are those that are 75 years of age and older with an employment rate of 4.5 percent.

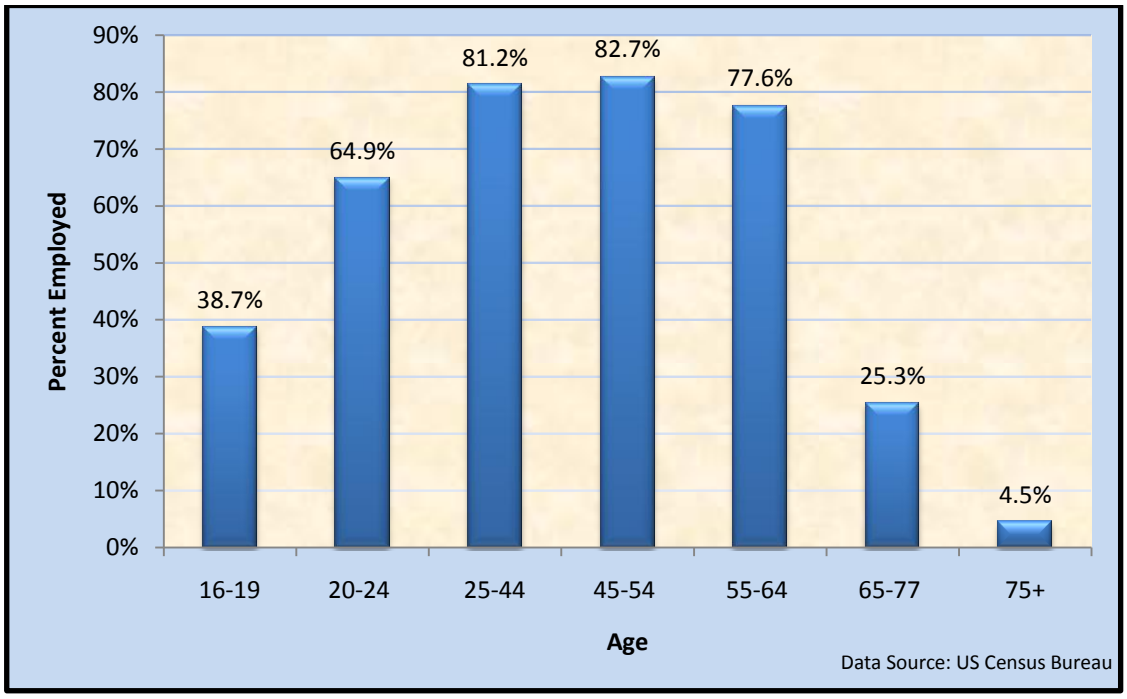

Figure 10: Employment Rates for Keene, NH 2010

Greenspaces

The Parks, Recreation, and Cemeteries Department oversee the outdoor recreation and greenspaces in the City of Keene. The department's primary mandate is to "provide a set of leisure activities and park facilities that are current and varied, and respond to the wants of the general public" (City of Keene 2010).

Out of Keene's total 22,020 acres, approximately 4,300 acres of land is either zoned as conservation or permanently protected through conservation easements. Approximately 1,000 acres of this total is city-owned lands (City of Keene Planning Department 2010) with the remaining 3,300 acres placed in conservation easements by private landowners. These protected lands include the Ash Swamp Brook, Ashuelot River Park, Beaver Brook Falls, Beech Hill Preserve, Central Square, Dinsmoor Woods, Ellis-Harrison Park, Elsie Priest Park, Fuller Park,

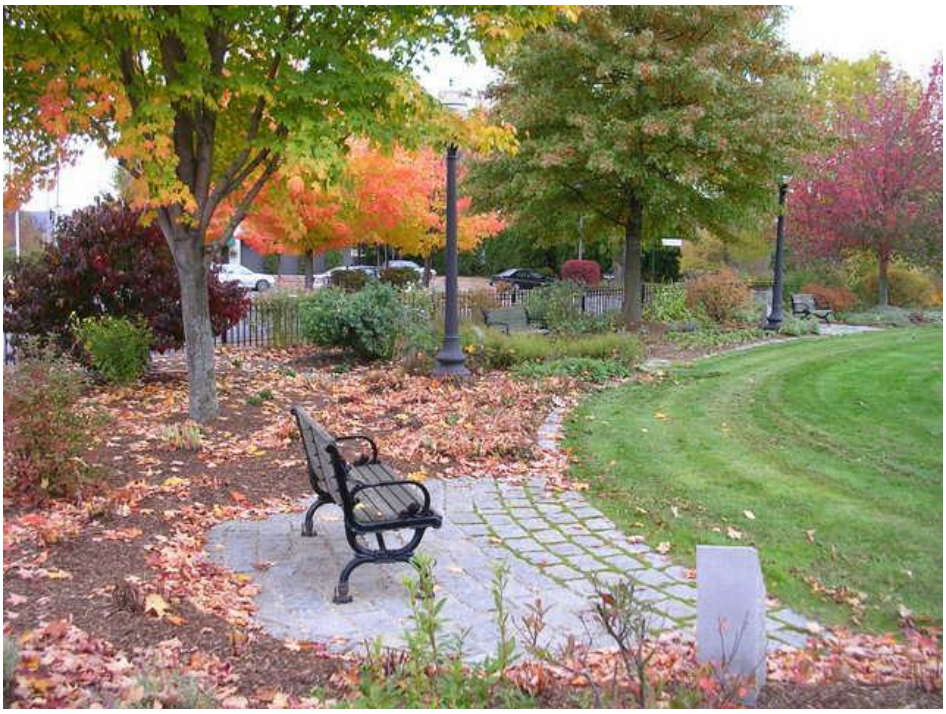

Figure 11: Photo of the Ashuelot River Park located in Keene, NH. (Project for Public Spaces 2010)

Greater Goose Pond Forest, Ladies' Wildwood Park, Robin Hood Park and Forest, Shadow Lake, Stearns Hill, the Three Mile Swamp, and Wheelock Park. In total, these parks cover approximately 830 acres throughout the City. Most of these areas are used for recreational activities as well as conservation of the natural landscape. **Error! Reference source not found.** shows a picture of the Ashuelot River Park on a beautiful fall day. This park is important to the City of Keene because it provides residents with easy access to the Ashuelot River for canoeing, fishing, as well as numerous trails for walking, running, or bicycling. Like the Ashuelot River Park, each of the parks and forests in the City are beneficial to both the community and the environment.

Chapter 5:

Conservation in Keene

Several organizations in the Keene area support conservation efforts that directly or indirectly influence vernal pool protection. These organizations were created to inform the public on relevant issues in the region, provide educational programs to schoolchildren, and conduct citizen science research. While vernal pool activities have only recently been undertaken in the Keene area, local conservation groups have the necessary resources to provide education to the public on this issue. Key organizations that promote vernal pool conservation and awareness in the Keene area include the Ashuelot Valley Environmental Observatory (AVEO), the Monadnock Conservancy, the Harris Center, and the Bonnyvale Environmental Education Center.

The Ashuelot Environmental Observatory, an organization founded in 2003, developed several citizen science programs, which rely on volunteers from the general public as well as professional scientists. These individuals work together to collect useful data on specific aspects of the environment. AVEO has initiated programs including efforts to monitor invasive plants, aquatic habitat connectivity, water quality, birds, and migratory amphibians.

AVEO contributes to vernal pool conservation through two volunteer-based programs- Vernal Pool Documentation and Salamander Crossing Events. Documenting vernal pools for AVEO involves several layers of documentation. First volunteers use an in-field data sheet on which they record the many characteristics of a vernal pool such as GPS coordinates, number and type of species present, site type, and tree cover. Volunteers must then take several pictures of the pool, which shows any egg masses, breeding adults, or tadpoles. All images must also include visual documentation of the location, date, and name of the documenter as demonstrated in Figure 12.

Figure 12: Alexandra McKillop during a truthing training session.

During the first spring rains, when amphibians migrate to vernal pools to reproduce, AVEO facilitates the Salamander Crossing Brigades in Keene and surrounding towns such as Swanzey and Westmoreland. For these night events, volunteers are stationed at specific locations along well-traveled roads that are known to interfere with the amphibians' annual migration from their upland habitats to their spring breeding sites. The volunteers will either stop traffic so that the amphibians can cross the roads themselves, or put the amphibians in buckets and carry them to safety. This protects the animals from potential death by automobiles and increases the probability that they will arrive at a pool and be able to reproduce.

The Monadnock Conservancy was founded in 1989 by a group of area residents attempting to protect open land in the Monadnock Region. Currently the Monadnock Conservancy works to protect land that supports clean water, forestry, agriculture, wildlife, natural areas, recreation, scenery, and cultural areas. With help from volunteers, the

Conservancy works to monitor conservation easements on private property. A conservation easement is a legally binding agreement, made between the owner of a property and a qualified conservation organization. These easements restrict development and other intensive uses of the land. The landowner retains ownership, including the right to sell, give, or transfer the property to a new owner at any time, but gives up the right to certain uses that are prohibited by the easement (Monadnock Conservancy 2010).

Monitoring easements involves annual parcel visits, in-depth record keeping, and maintaining relationships with land donors. Protecting the land in the Monadnock Region is important to the Conservancy because it in turn protects natural habitats and environmental landscapes that may have otherwise been developed. While the Monadnock Conservancy does not have any specific plans or projects focused around vernal pool protection, the conservation of lands in the area protect the environment in which vernal pools may form.

The Harris Center, located in Hancock, NH was founded in 1970 to integrate environmental learning initiatives into local schools. Currently, their school programs include an Environmental Studies Institute, youth programs, and summer programs. The objective of the school programs is to introduce children to nature and wildlife experiences while building knowledge and appreciation for the natural world. The Harris Center is also a land trust that currently conserves more than 17,000 acres. This includes lands that protect the natural habitats of bobcat, moose, black bear, and migratory songbirds. While the Harris Center does not have any programs specifically related to vernal pools, they protect and conserve a variety of natural habitats. The Harris Center has also recently adopted AVEO as a part of their

organization. This collaboration will most likely result in the Harris Center putting more emphasis on vernal pool awareness and conservation within their programs.

Founded in 1991, The Bonnyvale Environmental Education Center (BEEC) based in West Brattleboro, Vermont is an organization centered on educating and motivating citizens to care for the natural environments of Southern Vermont. This organization offers many different types of programs including teacher trainings and workshops, winter, spring, and summer camps, and classroom activities for school-aged children. The public can enjoy participating in trail hikes, workshops, and salamander crossing brigades. Among the multiple initiatives to protect the wildlife of Southern Vermont, BEEC has specific plans in place for the protection and inventory of vernal pools and for the protection of amphibians. The vernal pool plan has volunteers visiting vernal pools once a week from April to early May recording characteristics of the pools and any egg masses observed.

While both AVEO and BEEC collected important information on amphibians and vernal pools, currently, none of the organizations discussed are involved in policy-making for local governments. According to David Moon, executive director of AVEO, the primary goal of the organization is to “inform constituents of management approaches that address the issue [AVEO] examines” (Ashuelot Valley Environmental Observatory 2010). These organizations make a substantial effort to inform and educate the public on vernal pool-related issues. Additionally the information they have collected could be useful for future town legislation. Until that time, these organizations will continue to educate and inform the public and continue to work towards vernal pool and wetland conservation.

Chapter 6:

Methodology

To achieve the objectives of the study the team used four different methods to gather data. These methods included fieldwork, GIS analysis, semi-structural interviews, and a public survey. The methods, detailed below, allow an examination of the use of GIS in identifying potential vernal pool locations and determine the public's opinion about the importance of these natural areas.

Fieldwork

Fieldwork was conducted during the spring of 2010 in Keene, NH. This fieldwork was necessary in order to become more familiar with identifying vernal pools as well as learning more about the pools themselves. Thirty potential vernal pool sites identified through previous remote sensing work, carried out by volunteers for AVEO, were selected to verify and document. These pools were located in one of three public greenspaces found within the City of Keene- Ashuelot River Park, Robin Hood Park, and Beech Hill Conservation Area. All data was recorded in the field using AVEO's Vernal Pool Field Data Sheet (See Appendix A).

The Universal Transverse Mercator (UTM) coordinates of each potential site were used to navigate to its location in the field. If a water body was present, the pool was surveyed to determine if it met the biological and physical criteria for vernal pool certification. These criteria are specified in the New Hampshire Fish and Game Department, Nongame and Endangered Wildlife Program's guide, *Identification and Documentation of Vernal Pools in New Hampshire* (Tappan 1997).

The presence of amphibian breeding activity or obligate species was necessary to certify a site as a vernal pool. Breeding activity was evidenced by the presence of frog or salamander eggs masses, juveniles, or adults in congress (mating ritual). The presence of wood frogs,

members of the mole salamander family, or adult fairy shrimp in the pool also indicated a site as a vernal pool.

Team members followed several steps to identify and truth potential vernal pools. First, the team determined if a pool occupied a closed basin without a permanently flowing outlet and did not contain fish. Next, it was necessary to determine the land cover composition of the area immediately surrounding the vernal pool based on the 2001 New Hampshire Geographically Referenced Analysis and Information Transfer System (NH GRANIT) land cover classifications. Nearby land use information (agricultural, residential, industrial, etc.) and the location of the nearest perennial water source were noted. After conducting this fieldwork, fifteen of the thirty sites chosen were confirmed as vernal pools an additional seven sites were included in the database from previous truthing done by AVEO volunteers. As sites were truthed, the data was put into a database for use in the GIS analysis.

Geographic Information System (GIS)

Geographic Information System is a beneficial tool that can be utilized for different types of projects. Ranging from the spatial distribution of houses in a neighborhood to the spread of influenza, GIS allows the user to visually present spatial patterns that may have before simply been numbers on a page. The spatial element of vernal pools and their characteristics easily allow the GIS user to explore and analyze the given data in numerous ways.

For this project, the methods used for mapping and analyzing the vernal pools and their geomorphic characteristics were chosen based upon previous research by Smith and Verrill (1996). Vernal pool locations have common geomorphic traits in the City of Keene; therefore

using the previously verified vernal pools, ArcMap10, a GIS software program, was used to plot their locations and natural site characteristics. Based on this and similar analysis found in the literature review, the characteristics chosen were soil type, hydrography, slope, land ownership, and land cover. Soil type was deemed necessary because vernal pools may be more likely to form in soils that have poor drainage. Hydrography is useful because most vernal pools tend to be located close to a larger permanent body of water (Brooks and Hayashi 2002; Leibowitz and Brooks 2008). Slope is indicative of vernal pools because they can only form in depressions of the land. Land cover is also necessary since vernal pools are generally located in areas with moderate tree cover (Grant 2005).

Using the US Department of Agriculture (USDA) *Soil Survey of Cheshire County* (1999), a list of soil series was determined for Keene. After determining which soils were present in Keene, the areas with those soil types were selected and categorized within the GIS software. Categorization was done by simply grouping the areas with similar soil types and creating a new file within the software. The soils were then overlaid with the locations of the ground-truthed vernal pools. Using the intersections of ground-truthed vernal pools and the soil series from the soil survey, the most relevant soil types for the formation of vernal pools were determined.

Another relevant characteristic selected was land cover. Using the metadata that accompanied the land cover GIS data from the NH GRANIT (2010), the land cover classes present in Keene were aggregated into larger units by general land-cover type. The original classes were broken into six very specific categories. They were identified as water, forest, wetlands, cleared/open land, active agricultural land, and commercial/industrial/residential land. Aggregating the classes into larger categories allowed for a shift from classes such as row

crops, hay/pasture, and orchards to a general class like active agricultural land. After aggregating the classes, a new file was created for each individual class allowing for ease of visualization and analysis. The new files, like the soils files, were overlaid with the locations of the ground-truthed vernal pools. Those locations allowed for the selection of the most likely land cover classes in the area where vernal pools may form.

The next characteristic chosen was hydrography. Hydrography encompasses rivers and streams, and permanent bodies of water in Keene. The hydrography GIS data was chosen due to the potential impact of permanent bodies of water on ephemeral bodies of water. Mapping the hydrography of Keene allowed the vernal pool locations to be overlaid and analyzed.

The final characteristic chosen was slope, or topographic relief. Using the GIS data obtained on slope in Keene (NH GRANIT 2010), a map was created showing slope in Keene and overlaying the ground-truthed vernal pools file. The vernal pool sites overlain with the slope layer gave details on what type of slope would be expected in an area where a vernal pool may form.

Interviews

Another method used in this project was to interview individuals involved with natural resource planning in the region. To help structure the interviews, the team constructed a general template of four questions (See Appendix C). By using this template in each interview, comparison of what each professional shared was possible. This template was also flexible enough to allow the interviewees to add anything else that would be helpful to the research. Once the interview template was framed the team determined who would be most beneficial to interview and why. Vernal pools protection involves professionals in a diversity of fields. The

professionals selected helped the team better understand vernal pool conservation, public perception/awareness of vernal pools, and survey development.

At Keene State College, there are many accomplished faculty and staff members with extensive knowledge of vernal pools. Brett Thelen is a research associate in the Environmental Studies Department. She is currently working on a biodiesel project but previously was the AVEO staff member who organized salamander crossing events and vernal pool identification training. When discussing this research project, Thelen stated that she was very confident that it was going to help vernal pool protection by getting the public more involved.

A second faculty member at Keene State that was interviewed is Dr. Susan Whittemore, Biology professor and Chair of the City of Keene Conservation Commission. Dr. Whittemore gave feedback on how to reach out to the public and promote vernal pool education. When looking over our public survey draft, she gave us many useful ideas about how to interest the public. Whittemore also gave information to help tie in the biological aspect of the project.

Pete Throop, Project Director of the Monadnock Conservancy, gave his opinion about the public's view of vernal pools. He believed the public had little interest in vernal pools due to their lack of knowledge. Throop's responsibilities at the Monadnock Conservancy often involve working closely with the public. Therefore, he was able to give a generalization on what the public knows about vernal pools and what types of questions they usually ask. He also emphasized that the public is not aware of how important amphibians are to overall ecosystem health and how easily their habitats can be destroyed. He felt this information would be crucial to bring into the public eye.

Emily Hague, also of the Monadnock Conservancy, is the Stewardship Manager. Hague works closely with vernal pool identification projects and understands the importance in conserving vernal pools. She strongly believes that the public is interested in learning more about vernal pools and how to conserve them. However, Hague believes the public has received limited information due to the lack of education opportunities available to the community about vernal pools. Working at the Conservancy, Hague states that the public has many questions regarding how to manage vernal pools on their land.

Andrew Smith of the Planning Department in Keene was very helpful in explaining how the City deals with vernal pools and the possibility for enhancing conservation in the future. He felt, considering the current state of the economy, it would be unrealistic for Keene to take on vernal pool conservation today. However, he did believe that the public's increased involvement in vernal pool conservation would eventually result in the City's cooperation.

After the interviews were completed and complied, the team had a better understanding of the public's knowledge about vernal pool conservation. The team was then able to put forward possible reasons concerning the attitudes of the public towards vernal pool and amphibian conservation. This enabled the creation of a public survey to determine their actual knowledge and attitudes.

Surveys

In order to understand the public's knowledge of and attitudes towards vernal pool conservation it was apparent that a public survey was needed. Prior to beginning designing the survey, however, the team constructed two hypotheses based on a review of literature and the semi-structured interviews.

- Conservation of vernal pools in the City of Keene, NH is important to the public.
- Awareness of vernal pools leads to the public's willingness to conserve.

After settling on these hypotheses, the team began to create the survey by considering questions that could be used to test the two hypotheses. Survey development required several structural and informational drafts before a pilot test was run to gauge clarity and comprehensiveness of the survey. The survey was broken into three parts. The first part focused on demographic information such as age, sex, and homeowner status in the City of Keene. Next, the survey included a series of questions to determine the individual's knowledge of vernal pools and conservation efforts in the area. The last section asked a series of questions using a Likert scale to determine the individual's attitudes towards vernal pool conservation and the possible effect conservation would have on private landowners. A formal introduction explaining the project and a definition of vernal pools and obligate species was added to ensure that each person had some knowledge of a vernal pool (Appendix B).

To acquire a sample which accurately represented public affected by possible future vernal pool ordinances, the team determined the best opportunity to administrate the survey would be at the Keene Pumpkin Festival on October 16, 2010. This event draws thousands annually from both in the region and internationally (Center Stage 2010). After deciding who would administer surveys and the best time, the group talked about how to approach people on Main Street and ask them to complete the survey.

The next step was to administer the survey. Each team member went to the festival during either the morning or afternoon to collect surveys from the public. As many surveys as possible were collected during the festival, although there were not enough gathered.

Therefore, the team decided to attend sporting events at both Keene State College and Keene High School, as well as walk up and down Main Street in Keene to collect more surveys. The team also administrated surveys to town meetings in Keene. This was the most successful because it really connected to our target sample survey population. The process of collecting surveys took about three weeks. Once the surveys were collected, the team could start to analyze the results.

Chapter 7:

Results

GIS Analysis

Analysis of the GIS data created and collected on vernal pools in Keene shows that common geomorphic traits among the pools do exist. Of the twenty-two confirmed vernal pool locations documented in this study, 95 percent were within a quarter mile of a perennial water source (stream, river, lake, or pond) (Figure 13).

When comparing vernal pool locations to surrounding land cover, 77 percent of vernal pools were within forested areas, 18 percent were in wetland areas, and 4.5 percent of vernal pools were within an area in the industrial/commercial/residential (Figure 14).

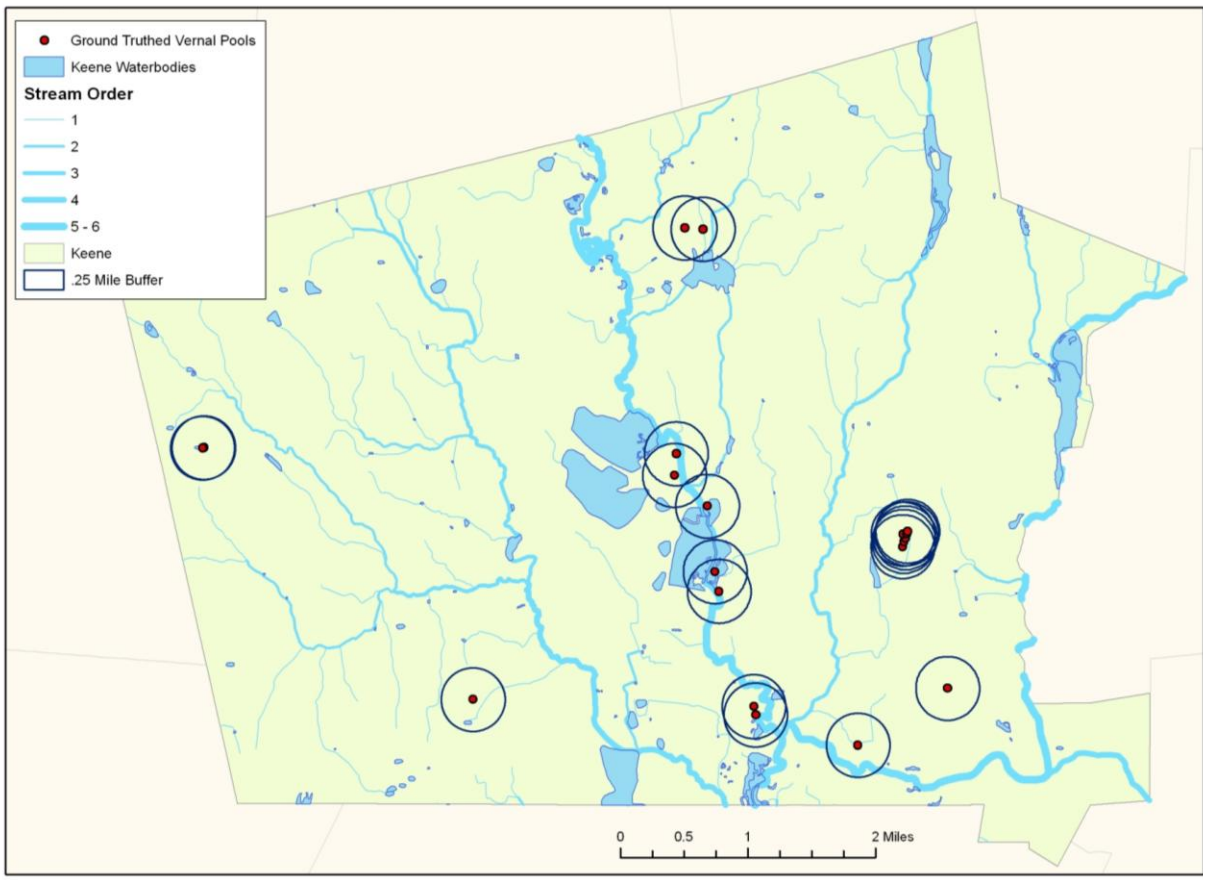

Figure 13: Map of ground-truthed vernal pools with a .25 mile buffer.

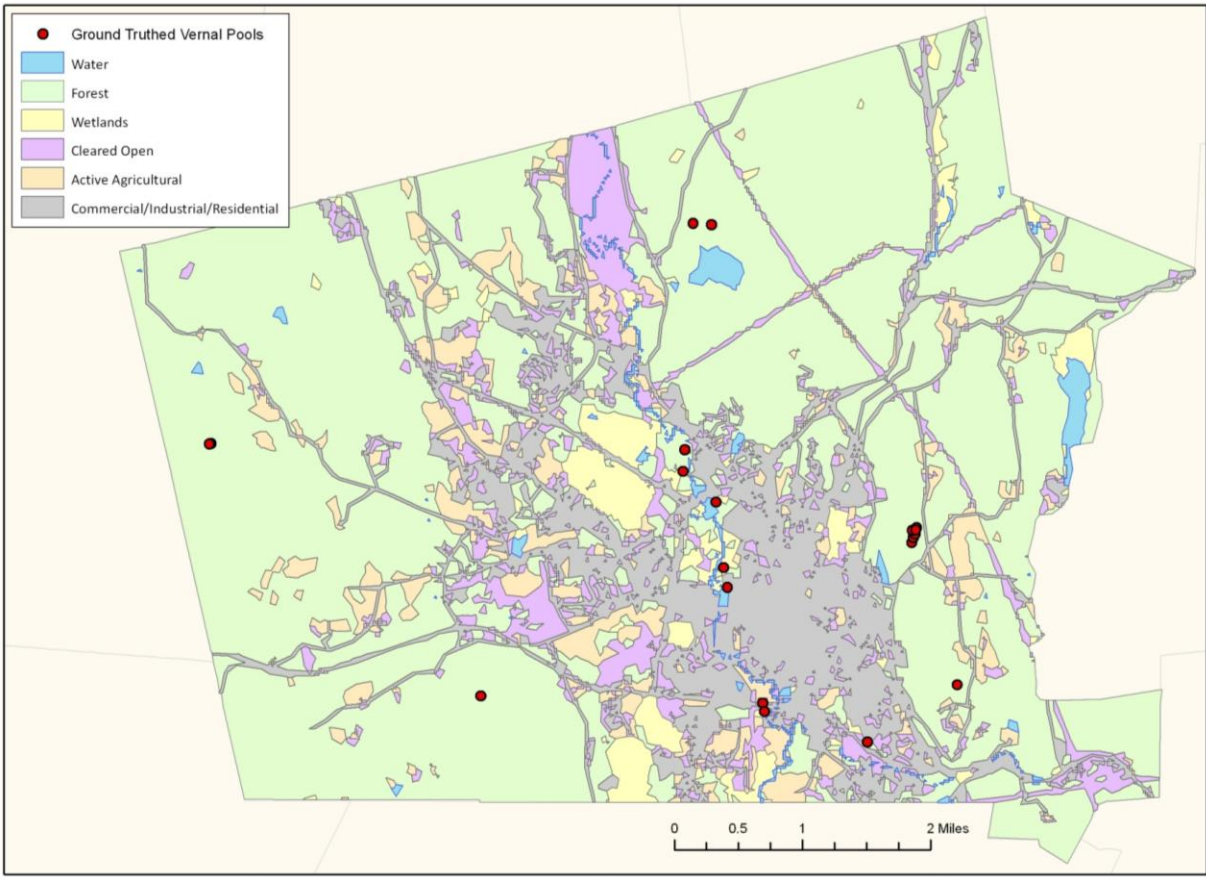

Figure 14: Land cover categories in Keene, NH

The USDA (2010, para. 3) defines hydric soils, as those that "formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part". Though it was originally thought that the majority of vernal pools would fall within areas having hydric soils, 72 percent fell in areas with non-hydric soils (Figure 15). The remaining 18 percent of pools fell within areas that had very poorly drained soils series that promote ponding. These series included Ossipee Mucky Peat (9 percent), Rippowam Saco Complex (4.5 percent), Rippowam Fine Sandy Loam (4.5 percent), and Raynham Wareham Complex (4.5 percent).

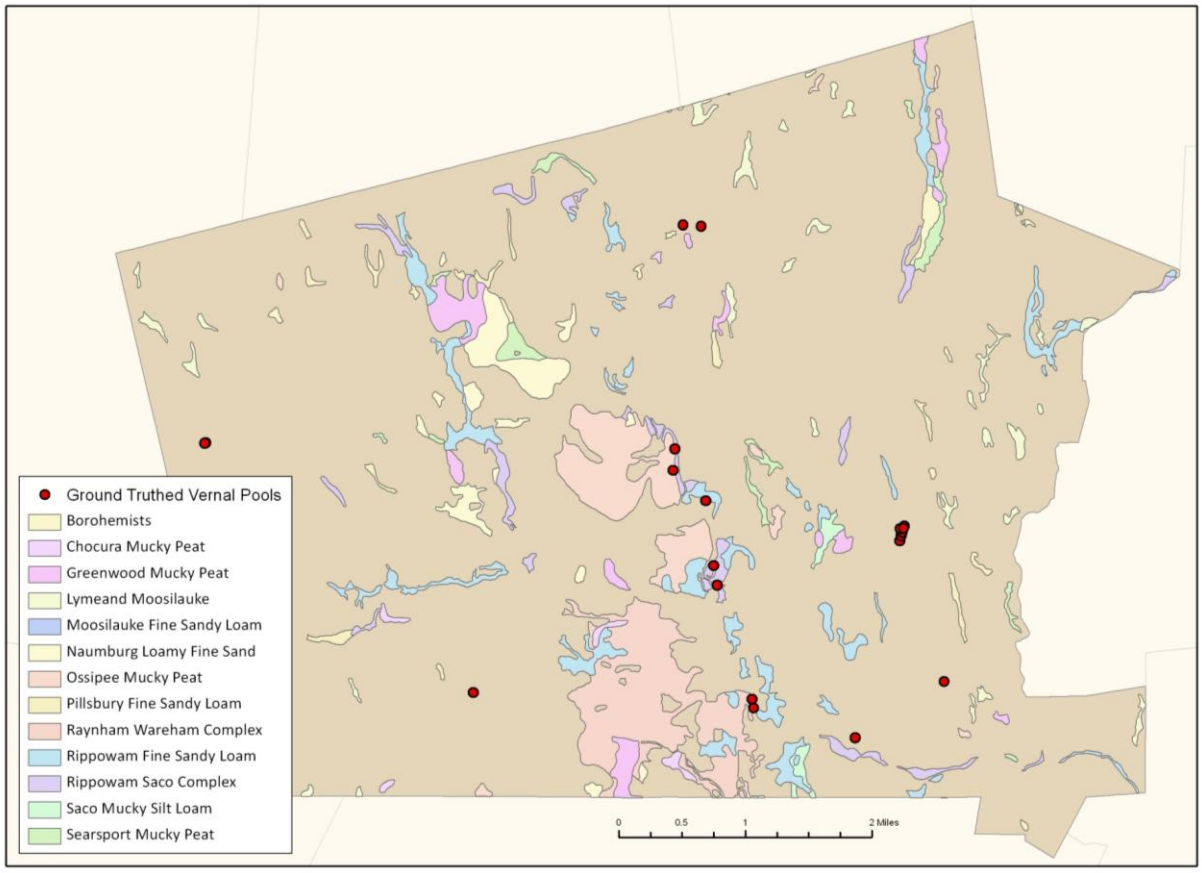

Figure 15: Soil series in Keene, NH

Slope is the final characteristic that was analyzed to determine if pool locations have common traits in Keene. Of the vernal pools used in the study, 90 percent were located in areas with a slope of 1 percent or less (Figure 16). Low slope creates areas where water can safely pool to form protected areas for the obligate species that inhabit vernal pools. While there is some variation within soil type, vernal pools in Keene do have common geomorphic traits.

Based on the GIS analysis, it is determined that slope, land cover and distance to a permanent water body are the three variables with the most impact on whether or not a vernal pool will form in a certain location. Although soils were originally thought to have a significant impact on vernal pool formation, only 18 percent of the vernal pools used in the study were

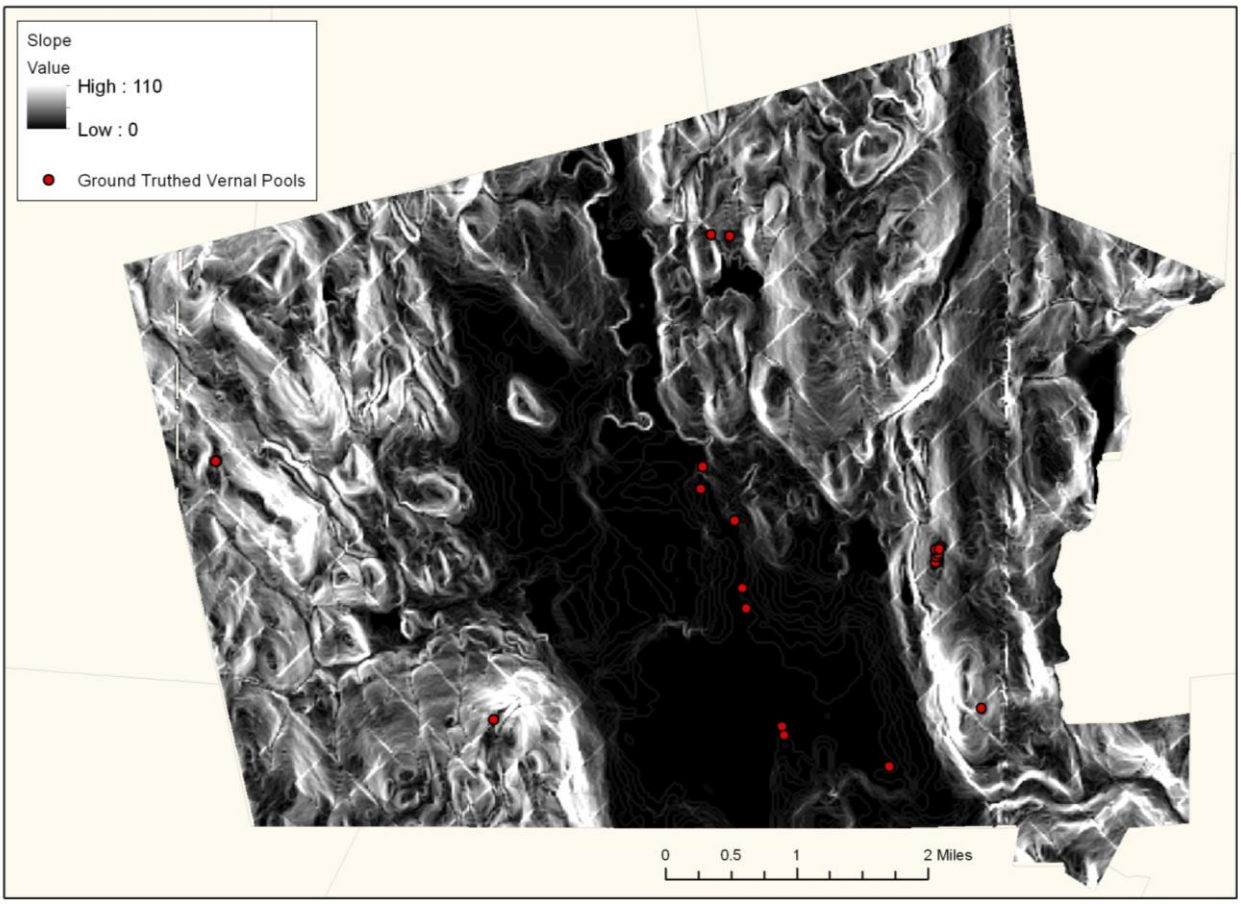

Figure 16: Slope in Keene, NH

located in areas with soils that promoted ponding. Areas with low slope encompassed 90 percent of predetermined vernal pools in Keene, 95 percent of the vernal pools were within a quarter mile of a permanent water body, and 77 percent were within forested areas.

Surveys

Between October and November 2010, 151 surveys were administered to the public in the City of Keene. The survey data was entered into SPSS, a statistics analysis program developed by IBM for the social sciences. SPSS was used to compute descriptive statistics such as the mean, range, standard deviation, as well as test for significant differences between

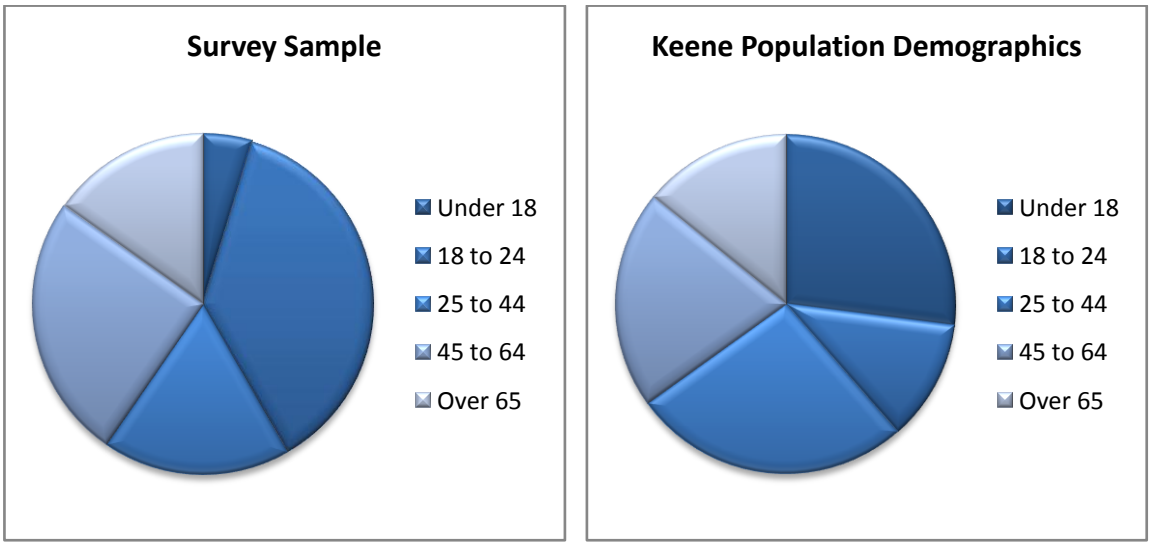

Figure 17: Demographic comparison of survey sample to Keene population.

classes of data. The ease of this computer based statistical program allowed the team to run multiple analyses on the survey data.

Collecting an appropriate survey sample based on the population statistics is vital to the research. The results of a basic descriptive statistical analysis allowed the team to determine whether the survey sample reflected Keene's demographics (Figure 17). Out of the 151 survey samples, the sample most closely represented Keene's demographic breakdown in the upper age categories. In the 65 years and older age category, this age bracket made up 15.2 percent of the survey sample, whereas 14.1 percent of the population in Keene is within this age bracket. In the 45- to 64-age category, 25.2 percent made up the survey sample compared to 20.8 percent of the population in Keene. The other three age brackets in the survey sample - under 18, 18 to 24, and 25 to 44 years - did not reflect the Keene's demographics for these age categories. The largest age group capture were individuals between 18 and 24 at 37.1 percent compared to Keene's 11.5 percent.

The survey sample showed that 28.5 percent of those surveyed were residents of Keene. The majority of the individuals surveyed were non-residents (71.5 percent). From the population surveyed, only 17.9 percent owned property in Keene and 82.1 percent did not own property in Keene. Since college age students, those 18-24, make up the highest percentage of the city's population this not surprising and reflective of a college town.

Table 1: Vernal Pool Awareness among Survey Respondents

Vernal Pool Knowledge	Percentage
Previous Knowledge of Vernal Pools	84.8
No Previous Knowledge of Vernal Pools	15.2

One of the most important aspects in promoting vernal pool protection is the level of vernal pool education in the community. An independent sample test was run to determine the knowledge level of the survey sample. Of the survey respondents, 84.8 percent of those surveyed stated they had previous knowledge of vernal pools. While non-residents do play an important role in the economic health of any community and should be taken into account when considering any implementation of a conservation plan, resident buy-in is important if such a plan will be successful. To determine if there was statistically significant difference in knowledge between residents and non-residents, a two-tailed test of significance was performed. The value of this test defines the level of confidence in which an analysis statement can be considered, with a value of 0.05 being the equivalent of 95 percent confidence. The test showed no significant relationship found between these groups ($t=0.389$). In a similar test, neither was there a significant relationship found based on home ownership ($t=1.272$).

Contrary to what the team found during the professional interviews, a higher percentage of those sampled did have previous knowledge of vernal pools than expected

(**Error! Reference source not found.**). This posed a question as to whether those sampled had n awareness of current vernal pool protection projects in the region. Interestingly enough most of the sample group (84.8 percent) said they had not heard of any conservation projects in Keene that protect vernal pools or amphibians. Those that were aware of vernal pool conservation projects primarily cited activities conducted by national groups such as the National Wildlife Federation or projects carried out by Antioch. Very few individuals sampled, 15.2 percent, indicated knowledge of the work carried out by AVEO, BEEC, or the Harris Center except by indicating "salamander crossing."

Despite the lack of awareness of existing vernal pool and amphibian protection activities, further analysis revealed a strong desire among those surveyed to protect them. In the survey, individuals were asked to indicate their level of agreement with a specific statement on a five Likert point scale of strongly disagree, disagree, neutral, agree, and strongly agree. On average, the majority of respondents (64 percent) agreed or strongly agreed to the statement "Keene should create a vernal pool protection plan". To discern whether there was a statistical relationship between Keene homeowners and non-owners, an independent sample test comparing owner and non-owner mean responses to this statement was necessary. The resulting significance of 0.386 lies outside of the significance level (0.05) indicating that the difference in agreement to this statement between owner and non-owner is not statistically significant (Table 2).

Table 2: SPSSx Independent Sample Results: Homeowner v. non-owner opinion on need for protection plan.

Ownership	N	Mean	Std. Deviation	Std. Error Mean	Sig. (2-tailed)
Yes	27	3.6296	1.14852	.22103	.386
No	124	3.7984	.85521	.07680	

Another key in protecting vernal pools is private landowner buy-in. Previous studies show that if homeowners feel vernal pool protection will negatively impact them, by increasing taxes for example, the owner will be less likely to support a protection plan (Yung and Belsky 2007; Raymond and Olive 2008). Since a comprehensive vernal pool protection plan is not possible without the assistance of private landowners, the team wanted to find out whether those surveyed believed that a vernal pool protection plan would negatively affect private landowners. Here the survey results indicate that most people do not feel strongly either way with 77.5 percent of those surveyed indicating they disagreed or were neutral about the statement "Identifying a vernal pool on private land could negatively affect the land owner."

An additional key component was to look at the importance of vernal pool conservation to those property owners and non-owners. As noted of the survey respondents, 18 percent owned property in Keene while 82 percent did not. A significant relationship was found between homeownership and the importance of vernal pool conservation ($t=0.002$). Although it was found that non-owners of property in Keene were more likely to state that protecting amphibians is important to Keene's community image ($t=0.026$) than property owners.

Tests ran in SPSS show that there are several significant relationships between the respondent's knowledge of vernal pools and responses to statements made on the Likert scale portion of the survey. The relationship between vernal pool conservation importance and knowledge is significant ($t=0.000$), meaning those knowledgeable about vernal pools are more likely to find vernal pool protection important. There is also a significant relationship between knowledge of vernal pools and Keene's community image associated with protecting amphibians ($t=0.002$), which indicates that those with knowledge on vernal pools are more

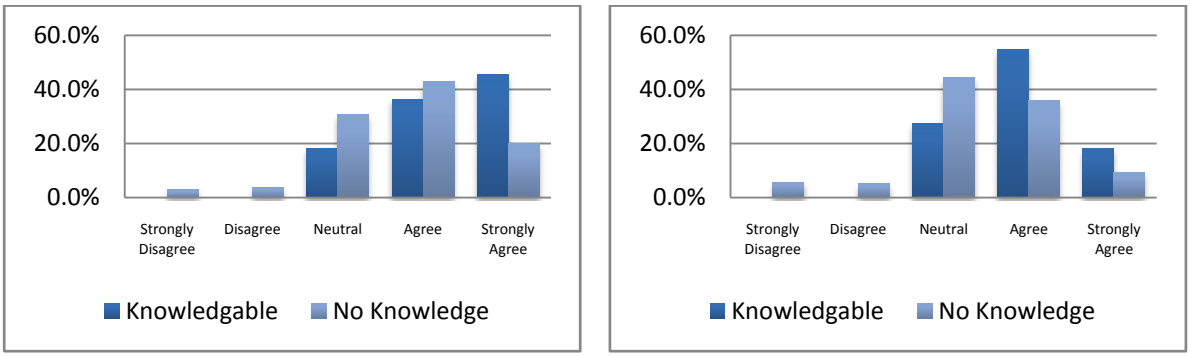

Figure 18: Responses to the statements "Vernal pool conservation is important to me" (left) and "Keene should develop a vernal pool conservation plan" (right)

likely to believe that protecting amphibians is important to Keene's community image. Results also showed a significant relationship between knowledge about vernal pools and agreement with Keene creating a vernal pool protection plan (t=0.000). Therefore, subjects are more likely to be in favor of a vernal pool protection plan for Keene if they are knowledgeable.

Surveys showed that there was not a significant relationship between knowledge on vernal pools and agreement that it is difficult to identify vernal pools (t=0.568). This indicates that survey subjects that are knowledgeable on vernal pools are not likely to believe that vernal pools are difficult to identify.

There was also a significant relationship (t=0.000) between knowledge about vernal pools and the perception that identifying a vernal pool on private land could negatively affect the landowner. This shows that those knowledgeable were more likely to agree that it will negatively affect the landowner if a vernal pool is identified on the private land. However, there was not a significant relationship between survey subjects with knowledge about vernal pools and agreement that Keene acts as a conservation model to neighboring cities. This indicates that respondents that are knowledgeable of vernal pools are less likely to see Keene as a conservation model.

Based on the information provided in the surveys it is possible to argue that the lack of a comprehensive vernal pool plan in Keene, NH is neither due to the public's lack of awareness of vernal pools nor due to a disinterest in vernal pool protection. Instead, it seems to be a failure on the part of those trying to protect the pools to educate the public about existing conservation efforts. The public is much more aware and concerned in vernal pool conservation then what was anticipated after gathering information from professional interviews.

Chapter 8:

Conclusion

Vernal pools, a type of ephemeral wetlands, are globally distributed. While the function and inhabitants of these ecosystems may vary from region to region, the difficulties in identifying and conserving them are nearly universal. In the City of Keene, such difficulties have led to gaps in both governmental and nonprofit attempts to protect vernal pools, particularly on private property. This oversight has left these sensitive ecosystems and the species that rely on them vulnerable to the dangers of habitat fragmentation caused by pollution and urban development. The aim of this project was to address this lack of vernal pool identification and conservation efforts on private property in the City of Keene, NH.

Vernal Pool Identification

A review of vernal pool literature found several studies that have occurred throughout New England to determine if GIS could be used as an effective and efficient method for locating potential vernal pool sites. In each study, a relationship between the location of a vernal pool and specific geomorphic traits – such as slope, soil type, and distance from a perennial water body – was indicated. Our study offers an initial look at the feasibility of adopting a similar methodology for the City of Keene.

Since GIS models using these traits have been successful in locating vernal pools elsewhere in New England, we hypothesized that vernal pool sites in the City of Keene, NH would likewise share common geomorphic traits. Based upon the literature reviewed it was determined that slope, soil type, distance from a perennial water source, and land cover were the geomorphic traits most likely to be similar from site to site. After extensive fieldwork to certify, or groundtruth, potential vernal pool sites from an existing database, a series of twenty two confirmed vernal pool sites were analyze based on these traits. GIS analysis found three of

the traits – slope, soil, and nearby perennial water source – were common among most groundtruthed vernal pools sites. Based on this analysis it is determined that vernal pools in the City of Keene do share some common geomorphic traits. Therefore, initial analysis of GIS modeling using such traits to locate potential vernal pool sites as used elsewhere in New England does have a high likelihood of being applicable in Keene.

Vernal Pool Conservation

Identification alone will not lead to vernal pool conservation. Government agencies and nonprofits looking to protect vernal pools need a public who is knowledgeable and interested in conservation efforts before initial steps can begin. In order to determine public attitudes toward vernal pool conservation efforts, a survey was developed and distributed to the public over a two-month period at various venues. The survey looked to establish two things: 1) Does knowledge of vernal pools led to a willingness to conserve; and, 2) Is vernal pool conservation in the City of Keene important to the public. Analysis of the surveys collected found that a high percentage (84.8%) of those surveyed were aware of vernal pools. This result contradicted information collected from interviews with professionals related to vernal pool conservation in the City of Keene. This was not surprising as it was found that few participants knew of any of the existing vernal pool conservation efforts in the area.

It was also concluded that a relationship exists between knowledge of vernal pools and an individual's willingness to conserve them. Based upon this relationship, as well as the increased awareness of vernal pools in the public, it is possible that the disconnect between the public and conservation efforts is a lack of knowledge about those efforts as opposed to about vernal pools or low interest in conservation.

Limitations and Moving Forward

One of the most challenging aspects of working with vernal pools is their fleeting nature. During an average spring in New England, a vernal pool can be determined as such for approximately 6 to 8 weeks before disappearing. The sensitivity of the ecosystem means that the slightest variance in water temperature, quantity, or quality could change a pools status as a habitat from one year to the next. An unusually hot season with unreliable precipitation, as occurred during this research, creates a scenario where even pools known to consistently support obligate species may disappear earlier than usual or not sustain obligate species, particularly the fairy shrimp, at all. This led to the sample of groundtruthed pools utilized for GIS analysis being smaller than was desired for truly comprehensive results. To increase the number of locations in the sample, a multi-year assessment of various potential vernal pool locations to determine if they can support obligate species would be necessary.

While initial indications of the relationship between public knowledge and willingness to conserve are promising, it is important to note that much of the City of Keene's land is in the hands of private landowners. While some private landowners were surveyed over the course of this project, the project did not specifically target this portion of the City of Keene's population. Moving forward, collecting and analyzing data to determine likelihood of private landowner buy-in is essential. As shown previously, without a partnership that includes private landowners any attempts at conservation will meet with opposition and possibly fail.

In order to determine the best path to protecting vernal pools and the species that rely on them, a method for identifying potential vernal pool sites must first be determined. The information collected then can be used to develop a framework for conservation that is

sensitive to the needs of the ecosystem as well as the needs and desires of the public. While this research set the preliminary groundwork in place, much more work is needed before the City of Keene can say with confidence that vernal pools are protected within the city boundaries. However, if work on finalizing a working GIS model to identify potential vernal pool sites coupled with increased outreach by conservation groups to both the general public as well as private landowners continues it is likely that this aspect of Keene's conservation efforts may one day be resolved.

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Appendix A:

Vernal Pool Field Data Collection Sheet

Field Collection Sheet

Pool Name and Number: Size: Depth:

Date: Time: Weather:

Observer's Name(s):

GPS Latitude: Longitude: Elevation/Altitude:

Slope: Direction:

Site/ Type: upland-isolated bottomland-isolated wetland complex

Habitat: woodland- deciduous woodland- coniferous woodland- mixed
agricultural pasture gravel pit
residential (density: _____) roadside
urban/commercial other: _____

Overstory: heavy moderate open site
>50% shrub & tree <50% shrub & tree mostly grasses

Cover: Any material in the pool that can provide egg attachment sites and offer concealment to adults and/or larvae

shrubs branches, twigs
emergent vegetation (grasses, cattails) sphagnum moss
submergent vegetation
other (please specify):

Soil type: fine-grained floodplain/alluvial sand/gravel till/bedrock

Nearest perennial water body: GPS: Elevation/Altitude: Type:

Observed Species

	Breeding Adults	Estimated Egg Masses (circle one)	Tadpoles
Spotted Salamander		1-25 26-100 > 100	
Jefferson Complex		1-25 26-100 > 100	
Wood Frog		1-25 26-100 > 100	
Fairy Shrimp			
OTHER			

Written Directions to site:

Other Observations/Sketches:

Appendix B:

Survey

Greetings! We are students from the *Keene State College Department of Geography* working on a project associated with the Ashuelot Valley Environmental Organization (AVEO) and the Harris Center. Would you please fill out this confidential survey to help our research? It is designed to help our research group determine the importance of vernal pools in Keene, New Hampshire.

- **Gender:** ☐ Male ☐ Female

- **Please indicate your age:**

  ☐ Under 18 ☐ 18-24 ☐ 25-44 ☐ 45-64 ☐ 65+

- **Are you a current resident of Keene, New Hampshire?**

  ☐ Yes - How many years have you lived in Keene? _____

  ☐ No- Where are you from? _____

- **Do you currently own property in Keene?** ☐ Yes ☐ No

  If "Yes," what street do you live on in Keene and what is the size of your lot? _____

  _____

  What is your street number? (optional) _____

A vernal pool is a temporary pool of water that fills in early spring from winter runoff and dries by mid-June. Unique amphibians, like the blue-spotted salamander and the wood frog, migrate to these pools and reproduce, leaving eggs to grow and develop. On the back of the clipboard you will find a picture of a vernal pool.

- **I have heard of a vernal pool before today...** ☐ Yes ☐ No

- **Are you aware of any vernal pools in Keene?** ☐ Yes ☐ No

  If "Yes," please specify: _____

  _____

- **Have you heard of any conservation projects in Keene that protect vernal pool or amphibians?**

  ☐ Yes ☐ No

  If "Yes," please specify: _____

  _____

- **Have you been involved with any conservation plans in Keene?** ☐ Yes ☐ No

  If "Yes," please specify: _____

Please Continue on Back

- **Are you aware of any vernal pools on the property where you live?**

☐ Yes ☐ No

If "Yes" are you willing to let either AVEO or the Harris Center confirm the location of the potential vernal pool?

☐ Yes ☐ No

If "No," please explain: _____

_____

Please indicate your level of agreement with each of the following statements:

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
▪ Vernal pool conservation is important to me.	☐	☐	☐	☐	☐
▪ Protecting amphibians is important to Keene's community image.	☐	☐	☐	☐	☐
▪ Keene should create a vernal pool protection plan.	☐	☐	☐	☐	☐
▪ It is difficult to identify vernal pools.	☐	☐	☐	☐	☐
▪ Identifying a vernal pool on private land could negatively affect the land owner.	☐	☐	☐	☐	☐
▪ Keene acts as a conservation model to neighboring cities and towns.	☐	☐	☐	☐	☐

Would you be interested in learning more about vernal pools and wetland conservation?

☐ Yes ☐ No

Comments? _____

_____

_____

Appendix C:

Interview Template

Interview Form

Interviewer: Date:

Interviewee: Title:

1) What is your experience with vernal pools?

2) What is your experience with vernal pools and the public? How do you perceive the public feels about vernal pools?

3) What projects are you or your department involved in to promote or educate people on vernal pool conservation?

4) Are you aware of any projects outside of your department or organization that we should be aware of?

5) Additional Comments/Notes: