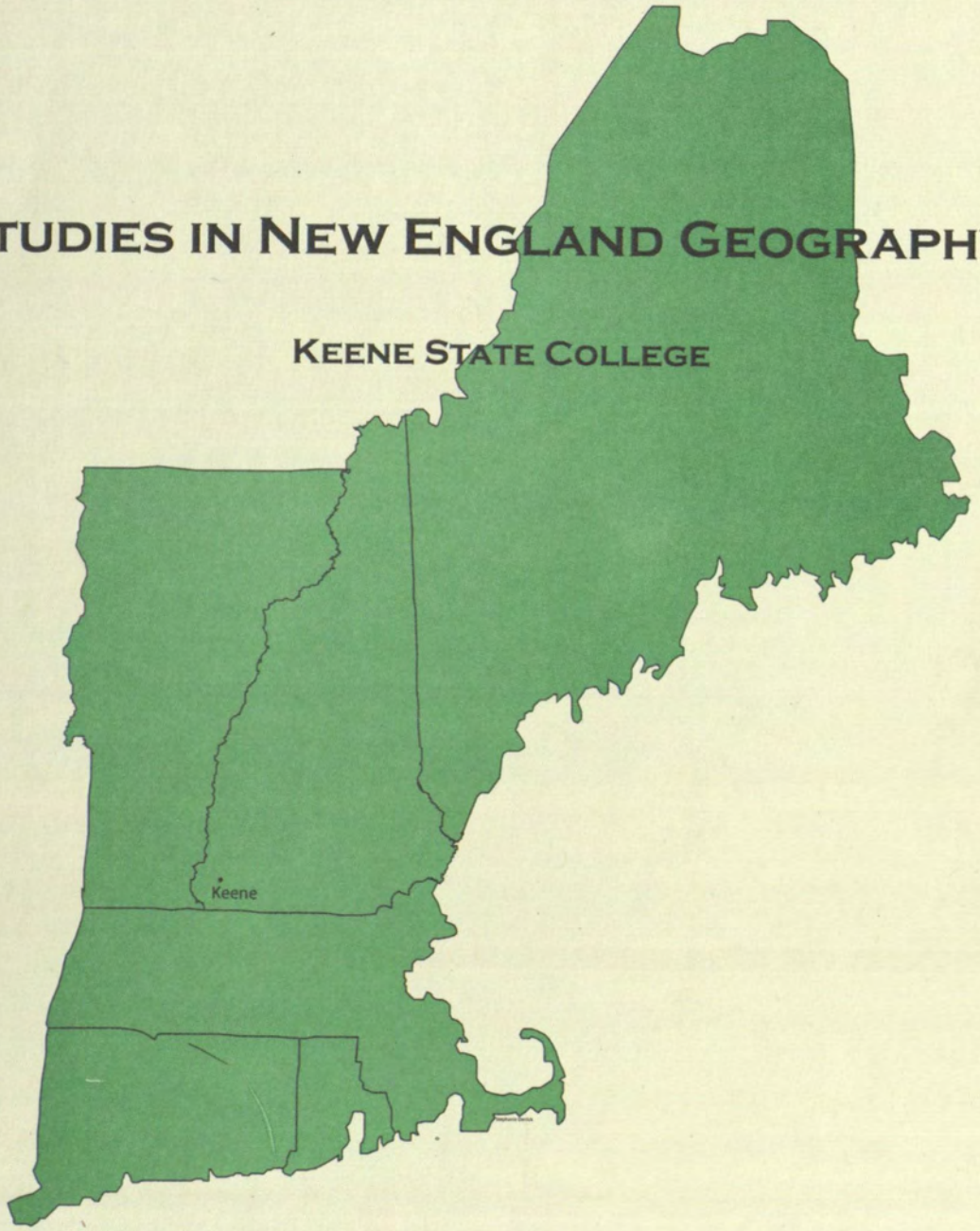
'Spring' into Action: The Identification and Protection of Vernal Pools in Nelson, New Hampshire



Studies in New England Geography

Keene State College

'SPRING' INTO ACTION:

THE IDENTIFICATION AND PROTECTION OF

VERNAL POOLS IN NELSON, NEW HAMPSHIRE

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INTRODUCTION

Seasonally inundated depressions in the forest floor, most widely referred to as vernal pools, are typically small in size, isolated from larger wetland features, and not permanently inundated making them hard to find. Vernal pools fill with water in the spring months when plant and animal species reproduction are profuse (Grant 2005; Keeley and Zedler 1998). As such, these 'ephemeral wetlands' are immensely important to the species that rely upon them for breeding purposes. However, the transient nature of vernal pools makes it difficult to place specific restrictions against the degradation of such habitats. New Hampshire is one of many states that does not classify vernal pools directly under wetland conservation regulation. The only instance in which vernal pools could potentially be protected is if they lie within a wetland's buffer zone.

As a result of the absence of government regulation and protection, public participation is central to the identification and safeguarding of vernal pools. This research project details coordinated efforts to identify, assess, and ultimately protect vernal pools in the town of Nelson, New Hampshire. Working in conjunction with Nelson residents and the Ashuelot Valley Environmental Observatory (AVEO), primary and secondary data were collected and processed in order to develop a threat assessment for known vernal pools in Nelson. The major impetus for this case study research is to build awareness and establish permanent regulations regarding the integrity of vernal pools in the town. The research further aims to foster interest in

amending existing ordinances and to establish a collection of habitat diversity maps and planning schemes within the town of Nelson.

In New Hampshire, a vernal pool habitat is typically surrounded by dense wooded land and canopy cover. This is ideal for the highly variable hydroperiods. The hydroperiod is the duration of time in which the pool is partially or completely inundated with water. A pool's hydroperiod is affected by various elements including underlying geology and soil structure, plant diversity and density, pool depth, and precipitation and evaportranspiration levels. Increased evaportranspiration and decreased precipitation in summer months cause vernal pools to desiccate either partially or completely (Brooks 2004). Vernal pools typically reach their maximum water levels in the early to mid-spring. These isolated wetlands characteristically dry up annually or every few years. The unpredictability and variability of precipitation over the years makes it so that some pools do not pond water for two or more years in a row, and then become inundated with water the following year (Bauder 2005). Factors that play into size, depth, and duration of the pool include weather-related conditions, land topography, and plant density surrounding the pool.

The inundation phase of vernal pools provides critical habitat to many amphibians, including Spotted Salamanders, Jefferson Salamanders, Fairy Shrimp, and Wood Frogs (Bartlett and Bartlett 2006). Such species thrive in vernal pools due to the lack of predation by fish (Trauth, Trauth, and Johnson 2006). They have also adapted over time to the variability in the length of time in which pools are filled with water. These species lay large quantities of egg masses to account for a number of them never

reaching the hatching phase. Often large clusters of egg masses can be observed no longer immersed in water and partially or completely dried on the banks of the pool where water once existed. Figure 1 is an archetypal image of Spotted Salamander egg masses that are partially immersed in water and will most likely become dried out before the eggs are able to mature and hatch.

Figure 1 *Partially inundated Spotted Salamander egg masses.* Source: Authors.

VERNAL POOL CONSERVATION

Federal regulations designed to protect aquatic wetlands are currently in effect, however, the criteria for preserving the upland areas surrounding wetlands are often vague or lacking. Porej, Micacchion, and Hetherington (2004) indicate that 200 meter buffer zones directly around wetlands are used to designate "core terrestrial habitats" and 200 meters to one kilometer as broader landscape context zones, or the maximum distance vernal pool species will travel. Vernal pool ecosystems contain species that are

very sensitive to changes within their habitats. Research has been conducted to measure the effects of human encroachment and habitat alteration on vernal pool hydrology, inundation duration, and species productivity (Taylor 1993). The main purpose of previous and current studies is to build public awareness of vernal pool and wetland sensitivity in hopes of initiating conservation at a more localized scale.

Preservation of breeding habitat is the most consequential action in the safeguarding of pond-breeding amphibians. Where preservation is not viable, buffer zones of sufficient extent are a second line of defense. In a study of ambystomatid salamanders, Morris and Maret (2007) detail the inadequacies of an overly limited buffer zone by determining that the 30 meter 'no cut' zone as designated by the Pennsylvania Bureau of Forestry fails to provide adequate protection from clear cutting. Such conclusions echo concerns previously voiced. Regosin et al., (2005), note that protection of only narrow buffer strips, for instance between 15 and 30 meters, leave a substantial percentage of vernal pool species at risk. Protection of vernal pools and conservation of the land that surrounds them is necessary throughout the United States. In a telling statistic, Gerhardt and Collinge note that only 3-10 percent of California vernal pools remain (2003).

Marty (2005) and Pyke (2004) have conducted experiments based on the manipulation of ecosystems including factors such as grazing of vegetation and its positive effects for native speciation and population control in the regions surrounding vernal pools. By removing grazing from an area, invasion of exotic flora often takes place with detriment to the area. Seasonal inundation varies even more significantly when the

plant species surrounding a pool are altered in some form. The type of land cover also plays a strong role in the biodiversity of amphibian species found in the pools. Rothermel and Semlitsch (2002) note the consequences of forest cover change on vernal pools. Salamanders, for instance, are more likely to survive deep migration towards forest habitats as opposed to shorter migrations to openings or fields. Desiccation and predation often limit the number of salamander species that survive migration into non-forested areas.

Wetland conservation across the United States has been limited to two different areas, land use regulation and preservation. Land use regulations define how the land can be used for an efficient and ethical purpose. Preservation refers to keeping something safe from alterations or destruction. Many laws have been passed to help preserve the nation's wetlands, though before these laws were passed a clear definition of what a wetland area consisted of was needed. According to the Environmental Protection Agency (EPA), a wetland is defined as an area that is saturated by surface or ground water at a rate and duration sufficient to support vegetation that is adapted to life in saturated soils (2008). These areas include marshes, swamps, bogs and other similar wetlands. Wetlands sustain more life than almost any other ecosystem. Three criteria classify an area as a wetland: the land must support an abundance of aquatic plants; must contain moist soils; and must be saturated with water for a majority of the year (EPA 2008).

Like other water bodies, vernal pools are affected by both point source and non-point source pollution. Point source pollution is any direct source of pollution from

which pollutants are released; examples of point source pollution include pipes, ditches, ships or factory smokestacks. Non-point source pollution is pollution that comes from many sources. Non-point source pollution is spread by runoff from rainfall and snowmelt. As the runoff moves over the surface of the earth it absorbs and carries away human-made pollutants, eventually disposing them into lakes, wetlands, rivers, and vernal pools (Mullens 2007). Wetlands are especially susceptible to these types of pollution due to the fragility of their ecosystems.

At the national level the protection of vernal pools has been overlooked. The national Clean Water Act (CWA) permits unregulated filling of wetlands under one acre (Burne and Griffin 2005). Since most vernal pools do not reach an acre in size, the CWA allows the filling of many vernal pools. Indeed the small size and isolation of vernal pools from other larger scale wetland features make them vulnerable to infill. This, in turn, makes the implementation of protection regulations difficult (Windmiller and Calhoun 2008). To protect these small vulnerable pools, laws and regulations need to be implemented on a local level as opposed to a national scale. In New Hampshire, vernal pools are not directly protected under current state wetland protection laws. The only instance in which a pool would be protected is if it lies within the wetland buffer zone. Therefore, enactment of laws on a local level may well preserve smaller wetlands, such as vernal pools, that are likely to be overlooked under national regulations.

A form of protection that has been used in some areas in the northeast is the idea of Best Development Practices (BDPs). BDPs are a form of local land use planning

that can complement regulatory and preservation efforts (Calhoun, Miller, and Klemens 2005). These Best Development Practices consist of three ideas for local governments to consider: identify the wetland areas; rank the areas with respect to their ecological value; and establish management procedures and guidelines according to the rankings given. This approach has so far only been applied to small parcels of ground within in the northeastern United States and has been used to protect vernal pools or seasonal wetlands from development and urban sprawl. Such localized conservation efforts, so important for the maintenance of the natural environment, may also serve to foster an ethos of environmental awareness and appreciation among local residents (Perlman and Milder 2005). The concepts of identifying and ranking wetland areas are also readily applied to vernal pools, as demonstrated by this case study of Nelson, New Hampshire.

NELSON, NEW HAMPSHIRE

The town of Nelson is located in southwestern New Hampshire and is situated near the northeast corner of Cheshire County (Figure 2). The rural character of the town is defined by many large lakes, including Nubanusit Lake, Silver Lake, and Granite Lake. Other features that define Nelson are its profuse number of ponds, streams, and wetlands, all part of the massive Connecticut River Watershed. The land is picturesque, with a small town center and its expansive wooded hills all backed by celebrated views of Mount Monadnock and its surroundings. The town's population in 2000 was 634 residents (US Census Bureau 2000). According to the NH Economic and Labor Market Information (2007) the estimated population of Nelson for 2006 saw only a slight increase to 654 individuals. Although Nelson has a relatively slow rate of population

growth, it is still developing. Between the years 1990 and 2003 Nelson saw a total of 63 new homes built (Nelson Master Plan 2008). The community experienced a 15 percent increase in the number of homes since 1990, bringing the total number in 2003 to 416 units. Such homes and such development can pose threats to the town's vernal pools and the species that inhabit them.

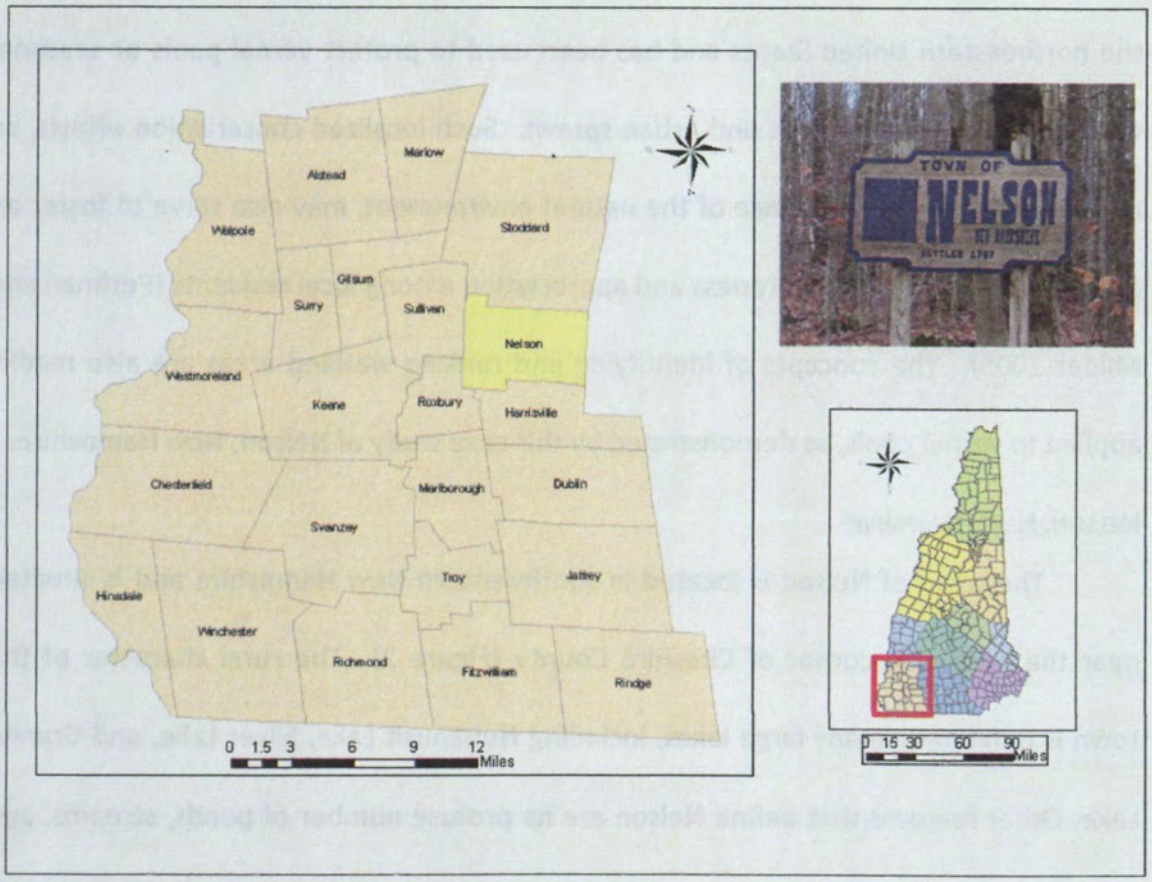

Figure 2 *Relative location of Nelson, New Hampshire.*

Nelson prides itself on its history and ability to retain its residential character (Nelson Master Plan 2008). In order to help preserve this character, and to maintain a balance over environmental protection and residential development, the Town Board created its first "Comprehensive Planning Program" in 1984, more commonly referred to today as a Master Plan. The current Master Plan update, now in its preliminary draft

phase, is a continuation of Nelson's long range, comprehensive planning effort. Recent drafts have been made available as of September 2008. Within the parameters of the new Master Plan, the town is endeavoring to classify vernal pools as a wetland feature for improved conservation (Nelson Master Plan 2008).

Primary data acquisition was obtained for this study by working closely with Kathy Schillemat, a Nelson resident and Chair of the Nelson Planning Board. Because of Schillemat's work, residents of Nelson have become increasingly aware of the fundamental habitats that wetland and vernal pool features provide to species diversity in the area. This increased interest has provoked a greater desire to learn more about previous studies and protection efforts across the United States, stretching from the effects of insect species and variety to the impacts directly related to humans. The largest concerns for the sensitive vernal pool habitats are rooted in human encroachment and population growth.

FIELD ANALYSIS

Field analysis spanned five weeks from early May to early June, 2008. Obtaining land owner permission where needed, fieldwork was carried out using handheld Global Positioning Systems (GPS) units to collect data for future mapping. Latitude, longitude, and elevation readings were collected for every pool where the presence of at least one indicator species was confirmed. Geographic coordinates were gathered to map the 19 vernal pools documented. Photographs were also taken of the setting of each pool and any species or egg masses immediately visible. Field documentation was performed based on the guidelines outlined in the Ashuelot Valley Environmental Observatory's

Vernal Pool Documentation Form which assesses pool proximity and orientation to wetlands, habitat, overstory, cover, substrates within the pool, as well as dominant plant species. Fieldwork was conducted over a five week period (Figure 3 and Figure 4).

Figure 3 *Authors surveying a pool.*

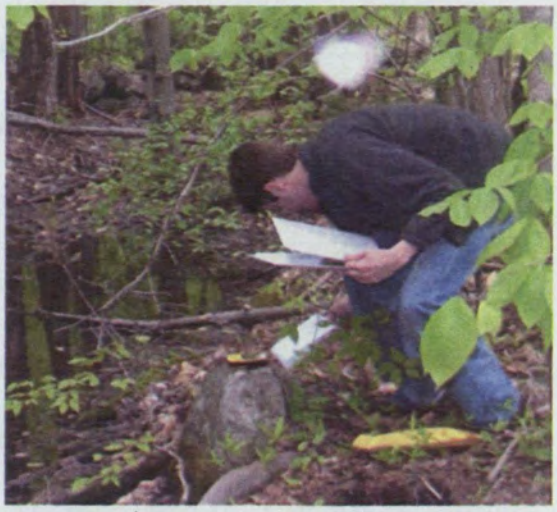

Figure 4 *Author collecting GPS data.*

Not all of the pools documented by the authors actually fall within the boundaries of Nelson (Figure 5). Although the pool documented as Nubanusit 3 lies just over the Harrisville border, for the purpose of the study, the pool lies in close enough proximity to the two remaining documented pools on Nubanusit Lake to be included. A concentration of identified pools are evident within western Nelson, near the most densely populated area by Granite Lake in the northwest. Vernal pools are frequently found near roads due to the fact that such pools are more likely to be discovered and eventually documented, as opposed to those deeply removed from cleared out human habitats. The clustering of pools is heaviest in northwest Nelson, and the identified pools extend geographically to the southeast corner. While pools may exist in the northeast portion of Nelson they have, as yet, not been identified.

Figure 5 *Documented vernal pools of Nelson, New Hampshire.*

A connectivity corridor was produced by applying buffers to each documented pool (Porej, Micacchion and Hetherington 2004). Buffers were placed around core terrestrial habitats of pool breeding amphibians as well as the broader agricultural context zones. Using these buffers allows for visual analysis of the interrelationships that exist between pools. Figure 6 displays the buffer zones of each pool, dissolved and overlapping where applicable, in regard to the current road systems present within Nelson. Sixteen of the 19 pools documented are shown to be connected through their broader agricultural context zones. While only relative estimates of forest cover are utilized, this assessment adequately illustrates those pools that should hypothetically be more productive – those falling within the interconnected pool zones and having moderate to heavy forest cover. Only three of the pools have minimal forest cover. This indicates that forest cover is a significant factor in the formation of vernal pools. Hence conservation of forest cover is important to the overall health of the vernal pool species.

In contrast to the potential road hazards faced by the indicator species it is also useful to show trends between the inundations of pools within Nelson. Using values outlined by Porej, Micacchion, and Hetherington (2004), a hydrography map created by the authors was manipulated to display 200 meter and one kilometer buffer zones detailing the proposed core habitat as well as broader area landscape zones surrounding the pools. The resulting map is intended to show patterns of connectivity of pools that are within the core area as well as broader landscape buffer. Inundation values were

approximated for the pools and displayed within their habitat buffers to attempt to illustrate the possibility of pool recharge, either temporary or permanent.

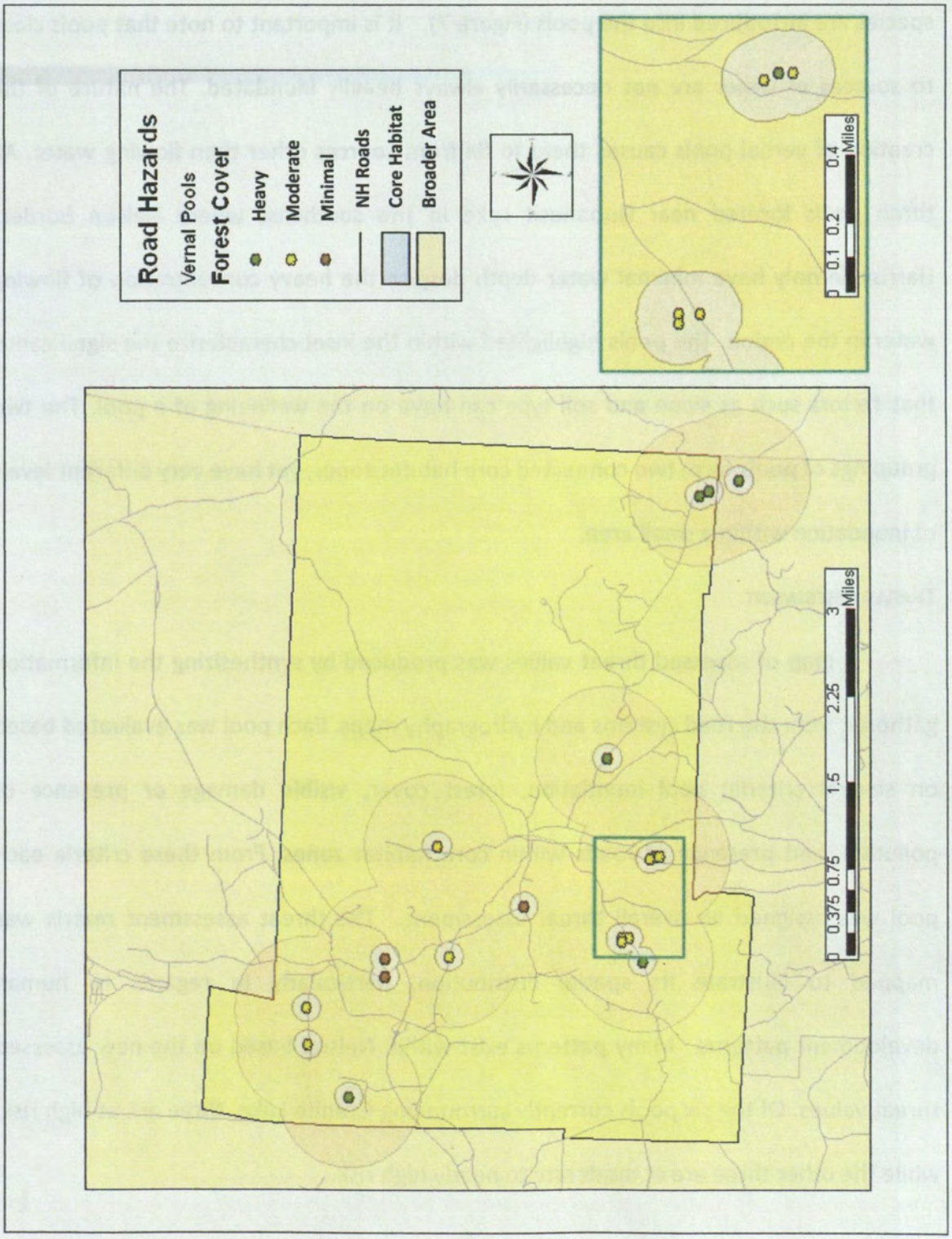

Figure 6 *Road systems in relation to documented vernal pools and their core habitats.*

In the case of a permanent connection of flowing water to a pool, it would most likely end in the migration or outright extermination of the indicator species as fish species are introduced into the pools (Figure 7). It is important to note that pools close to sources of water are not necessarily always heavily inundated. The nature of the creation of vernal pools causes them to fill from sources other than flowing water. All three pools located near Nubanusit Lake in the southeast where Nelson borders Harrisville only have minimal water depth despite the heavy concentration of flowing water in the region. The pools highlighted within the inset characterize the significance that factors such as slope and soil type can have on the wellbeing of a pool. The two groupings of pools form two connected core habitat zones, yet have very different levels of inundation within a small area.

THREAT ASSESSMENT

A map of assessed threat values was produced by synthesizing the information gathered from the road systems and hydrography maps. Each pool was evaluated based on several criteria: pool inundation, forest cover, visible damage or presence of pollution, and presence of roads within core habitat zones. From these criteria each pool was assigned an overall threat assessment. The threat assessment matrix was mapped to illustrate its spatial distribution, particularly in regards to human development patterns. Many patterns exist within Nelson based on the new assessed threat values. Of the six pools currently surrounding Granite Lake, three are at high risk, while the other three are at moderate to nearly high risk.

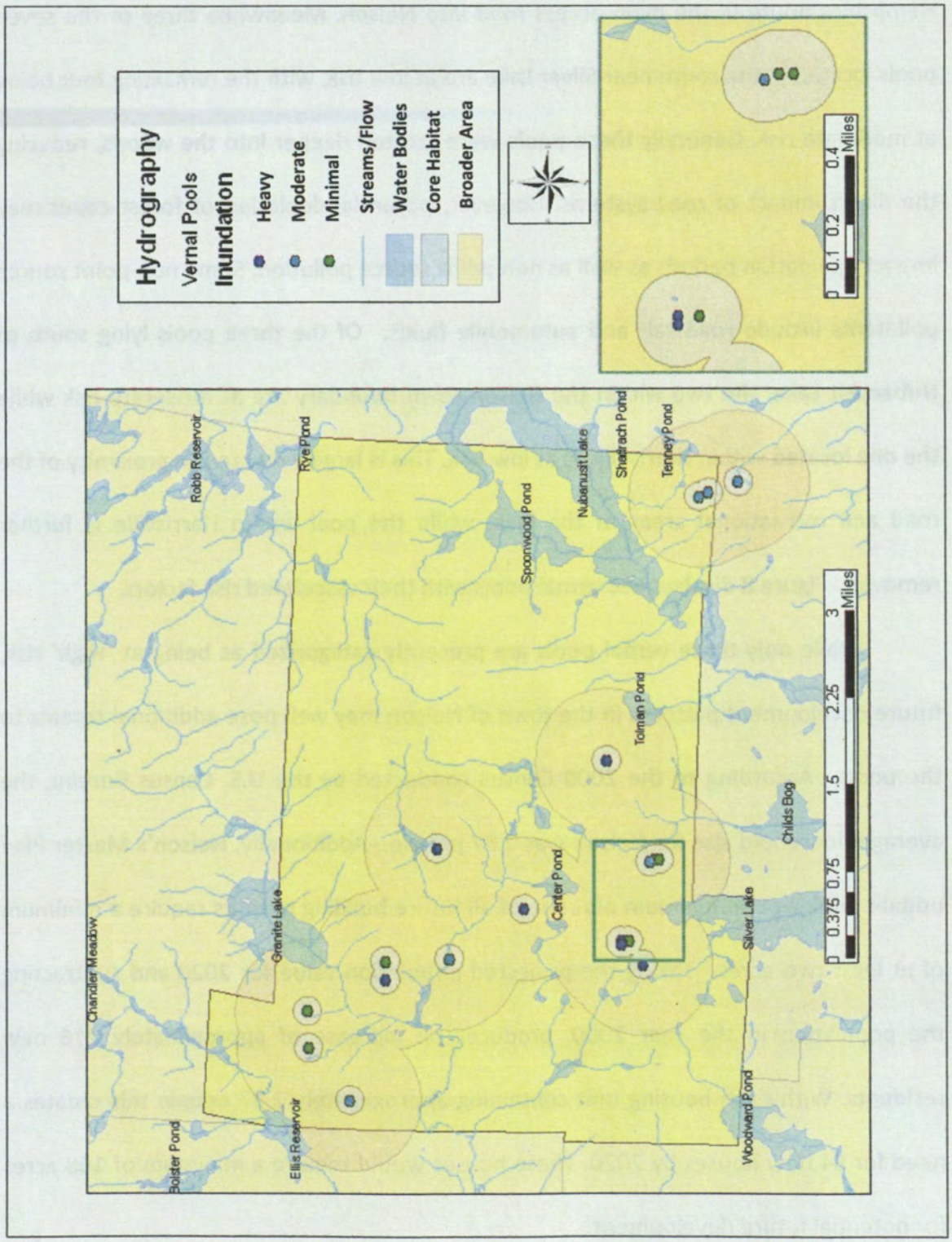

Figure 7 *Hydrography of Nelson, New Hampshire.*

This is explained by the increased traffic volume traveling towards New Hampshire Route 9, the main access road into Nelson. Meanwhile three of the seven pools located in the south near Silver Lake are at low risk, with the remaining four being at moderate risk. Generally these pools were located deeper into the woods, reducing the direct impact of road systems. However, potential depletion of forest cover may impact inundation periods as well as non-point source pollution. Some non-point source pollutants include road salt and automobile fluids. Of the three pools lying south of Nubanusit Lake, the two within the Nelson town boundary are at moderate risk while the one located within Harrisville is at low risk. This is largely due to the proximity of the road and recreational areas of the lake, while the pool within Harrisville is further removed. Figure 8 displays the vernal pools with their associated risk factors.

While only three vernal pools are presently categorized as being at 'High' risk, future development patterns in the town of Nelson may well pose additional threats to the pools. According to the 2000 Census conducted by the U.S. Census Bureau, the average household size for Nelson was 2.57 people. Additionally, Nelson's Master Plan update outlines the minimum plot size of all future building permits require a minimum of at least two acres. Taking the projected population value for 2020 and subtracting the population in the year 2000, produces an increase of approximately 216 new residents. With each housing unit containing approximately 2.57 people this creates a need for 84 new houses by 2020. These houses would require a minimum of 168 acres for potential future development.

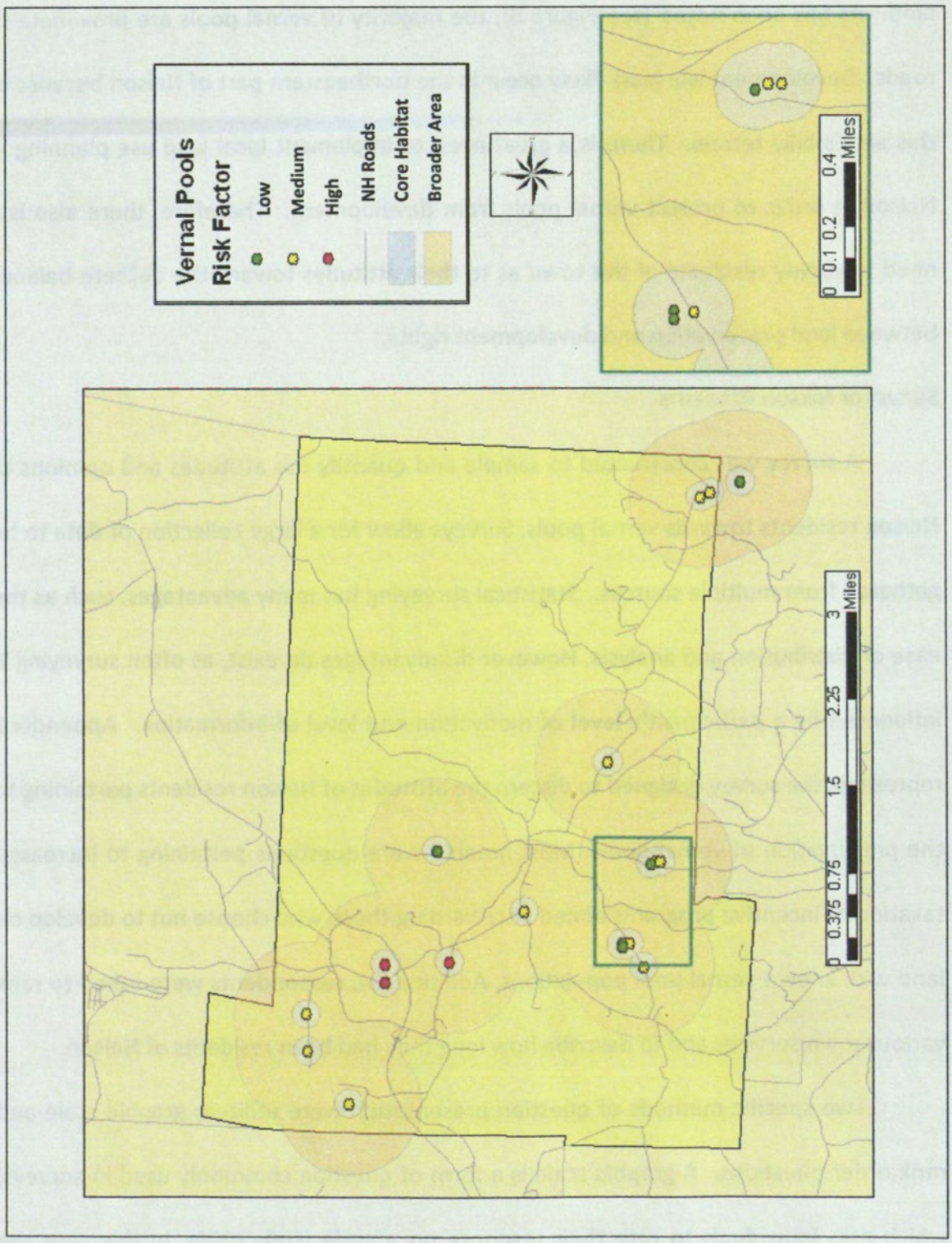

Figure 8 *Vernal Pool Threat Assessment for Nelson, New Hampshire.*

Future development in Nelson will most likely take place along roads and on flat land. As has been noted (see Figure 6), the majority of vernal pools are proximate to roads. Development will least likely occur in the northeastern part of Nelson because of this area's hilly terrain. There is a great need to implement local land use planning in Nelson in order to protect vernal pools from development. Therefore, there also is a need to survey residents of the town as to their attitudes toward the delicate balance between land preservation and development rights.

Survey of Nelson Residents

A survey was constructed to sample and quantify the attitudes and opinions of Nelson residents towards vernal pools. Surveys allow for a large collection of data to be gathered from multiple sources. Statistical surveying has many advantages, such as the ease of distribution and analysis. However disadvantages do exist, as often surveying is influenced by a participant's level of motivation and level of information. Appendix 1 represents the survey designed to discern the attitudes of Nelson residents pertaining to the preservation of vernal pools. Most notable were questions pertaining to increased taxation or incentive programs aimed at rewarding those who choose not to develop on land with known vernal pool populations. Additionally, respondents were asked to rank various town services and to describe how long they had been residents of Nelson.

Two specific methods of question presentation were utilized; graphic scale and rank order questions. A graphic scale is a form of question commonly used in surveys, which asks individuals to rate their response on a scale (Fink 2006). In this case the

graphic scale selected was a Likert scale, ranging from values of one to five. A series of declarations were posed and the respondents were asked to state their level of support for each statement. A response of a one would represent an opinion strongly agreeing with the statement, while a five would represent an opinion highly contesting the statement. A rank order question is a type of comparative rating scale that relies on relative judgment (Fink 2006). For the purpose of this sampling, respondents were asked to rank in order of importance a series of services provided by the town. This was intended to show the different dynamics that exist between participants of the survey and their answers to the various other issues. The rest of the questions in the survey asked for a specific "yes" or "no" response.

Thirty surveys, representing approximately one in every 20 Nelson residents, were completed and returned to the authors over a five week period. Importantly, over 80 percent of respondents agree that vernal pools should be considered a wetland feature, with 36.7 percent strongly agreeing and 46.7 percent agreeing. Only about 17 percent of respondents either had no opinion or were opposed to vernal pools gaining wetland status. Similarly, there was significant support for incentives, such as tax breaks, for landowners who choose not to develop land containing vernal pools. Eighty-two percent agree that it is important to provide such incentives. One respondent stated that additional conservation values aside from vernal pools would have to be present on land that would be eligible for tax incentives. Vernal pools being included as a wetland feature could be an important factor in incentive plans for future conservation. Eleven percent of respondents did not support tax breaks or incentives.

Many respondents who selected "No Opinion" left comments stating that they were not informed about the issue enough to make a rational decision at the time of the survey.

Opinions surrounding the idea of a tax increase for the protection of vernal pools were more varied. Those in favor of a tax incentive program were asked to quantify their economic willingness to support such plans. Thirty percent of respondents said that they would be in favor of a tax increase of 25 cents above the current rate of $13.15 per $1,000 of assessed value to fund vernal pool preservation in Nelson (Figure 9). An additional 45 percent would be willing to pay more than 25 cents of assessed value.

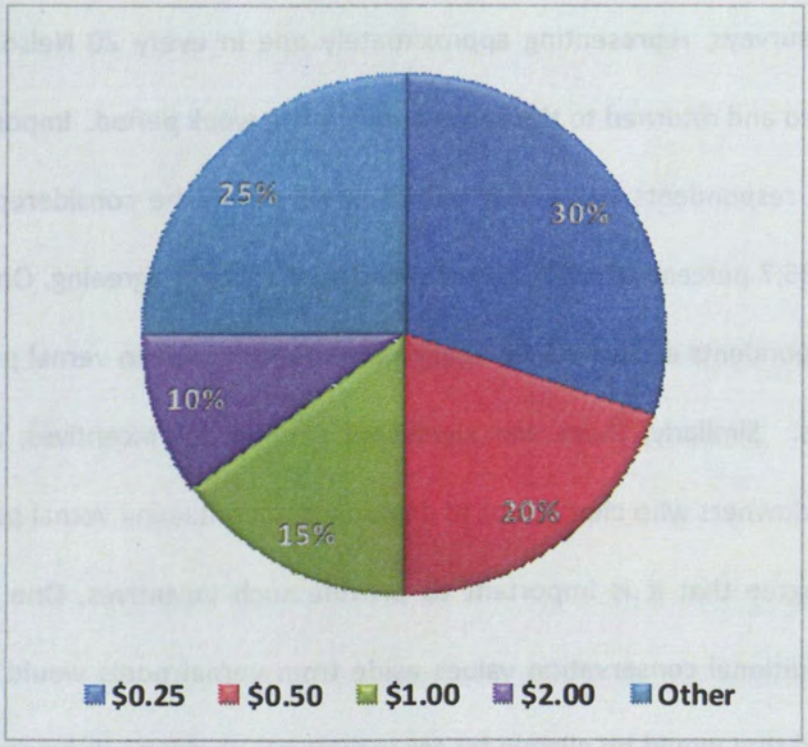

Figure 9 *Percent of respondents favoring a tax increase for conservation.*

As to protection of vernal pools and property rights, approximately 35 percent of respondents agree that town regulations should override the rights of a land owner in regards to development over vernal pools. Ten percent strongly agree with the same notion. This demonstrates that almost 45 percent of all respondents are in favor of preventing development over vernal pools in the town of Nelson. Conversely, 27% of the respondents either disagree or strongly disagree that regulations should supersede the rights of individual property owners. One respondent stated that town regulations should take into account the size and productivity of a vernal pool before the rights of the land owner are infringed upon. While another respondent simply stated that the subject was a volatile issue.

A final main point of interest was to determine whether previous experience in environmental protection resulted in a significantly higher appreciation for the defense of vernal pools. A two-sample t-test was therefore performed to test for significance between those involved in previous environmental projects and their opinion on proposed tax incentives offered to land owners who do not develop land containing vernal pools. A significance value of 0.824 results in a failure to reject the null hypothesis that states no significanct difference. Therefore, past involvement in environmental activity was not an indicator of the level of support for vernal pool protection. Survey results displayed some variation of response. Certain questions, such as the general value and importance of vernal pools elicited strong agreement. However, questions designed to ascertain what specific action should or could be taken to protect vernal pools resulted in far less accordance of response.

SUMMATION

Though there is no national standard that covers the conservation of vernal pools, some towns in the northeastern United States are beginning to explore different options for their protection. Each option, however, requires time-intensive research and documentation that must be carried out in order to successfully cover vernal pools under existing conservation plans. It is not only important to classify the pool depression for conservation; the identification of the surrounding terrestrial habitat used by all of the vernal pool species is also extremely significant (Calhoun, Miller and Klemens 2005). Further research should be conducted to expand and improve the understanding of vernal pool resources across the United States. Many of the methods and techniques used to document and conserve vernal pools are still unproven and must be treated as scientific experiments before being accepted (Dodd and Smith 2003). Due to the fact that vernal pool conservation has not been a substantive issue across the United States in the past, there is no set standard for the documentation and conservation of pools.

This study assesses a small area in southwestern New Hampshire and may assist with the conservation of vernal pools in the town of Nelson. The methodology and findings of this research also have the potential to assist other communities address the ecological ramifications of future development. Nineteen vernal pools were documented throughout this study, many more pools need to be documented in order to have a better understanding of the importance of vernal pools in Nelson. The nature of vernal pools' seasonal inundation makes them difficult to locate year-round. The pools that were documented in this study were found based on information provided by

the residents of Nelson. This leads to an incomplete documentation of pools, and a more extensive search is necessary in order to find and record the more remote pools in the area. However, this case study does afford a valuable initial assessment and provides a baseline from which future research may be launched.

The threat assessment of the 19 pools identified in the town reveals that only three pools are designated as being at 'High' risk. These three pools, not surprisingly, are at the center of town and are most affected by traffic, pollution, and clearing of trees. Of the remaining 16 pools, 11 are associated with 'Moderate' risk, and 5 with 'Low' risk. This bodes well for the vernal pool habitat, as residents have the time to plan for the protection of these pools. The survey of residents reveals also an ethos of environmental awareness that bodes well for the future of vernal pools in the town. That said, there is always a need for better education about the characteristics, importance, and documentation of these vital habitats. Such education is likely to spawn a greater interest in the conservation of vernal pools, and more time and effort will be spent documenting pools. As they develop and implement their Master Plan, residents of Nelson have a unique opportunity for improved regulation and conservation planning in regards to vernal pools. As a result, it is likely that such pools will receive heightened safeguards as the town moves forward. The threat assessment outlined in this study may thus be utilized to afford protection to vernal pools in the town's Master Plan and may serve as a standard by which other towns model their own vernal pool protection and Master Plan processes.

Literature Cited

Bartlett, R.D., and P.P. Bartlett. 2006. *Amphibians of Eastern and Central America.* Gainesville: University Press of Florida.

Bauder, E.T. 2005. The Effects of an Unpredictable Precipitation Regime on Vernal Pool Hydrology. *Freshwater Biology* 50: 2129-2135.

Brooks, Robert T. 2004. Weather related effects on woodland vernal pool hydrology and hydroperiod. *Wetlands* 24 (1): 104-114.

Burne, Matthew R. and Curtice Griffin. 2005 Protecting vernal pools: a model from Massachusetts, USA. *Wetlands Ecology and Management* 13: 367-375.

Calhoun, Aram J.K., Nicholas A. Miller, and Michael W. Klemens. 2005. Conserving pool-breeding amphibians in human-dominated landscapes through local implementation of best development practices. *Wetlands Ecology and Management* 13: 291-304.

Dodd, Jr., C.K. and L.L. Smith. 2003. Habitat destruction and alteration: Historical trends and future prospects for amphibians. Pp. 94-112 in *Amphibian Conservation*, Semlitsch, R, (ed.). Washington, DC: Smithsonian Press.

Economic and Labor Market Information. 2007. *Nelson, NH*. http://www.nh.gov/nhes/elmi/htmlprofiles/nelson.html (last accessed 3 November 2008).

U.S. Environmental Protection Agency. 2008. *America's Wetlands: Our Vital Link between Land and Water.* Washington, DC: Environmental Protection Agency.

Fink, A. 2006. *How to conduct surveys: A step by step guide*. Thousand Oaks: Sage Publications.

Gerhardt, Fritz and Sharon K. Collinge. 2003. Exotic plant invasions of vernal pools in the Central Valley of California, USA. *Journal of Biogeography* 30: 1043-1052.

Grant, Evan H.C. 2005. Correlates of vernal pool occurrence in the Massachusetts, USA, landscape. *Wetlands* 25 (2): 480-487.

Keeley, Jon E. and Paul H. Zedler. 1998. Characterization and global distribution of vernal pools. Pp. 217-223 in *Ecology, Conservation, and Management of Vernal Pool Ecosystems – Proceedings from a 1996 Conference*, Witham, C.W., Bauder, E.T. Belk, D., Ferren Jr., W.R. and R. Ornduff (eds.). Sacramento: California Native Plant Society.

Marty, J. 2005. Effects of cattle grazing on diversity in ephemeral wetlands. *Conservation Biology* 19 (5): 1626-1632.

Morris, Katrina M. and Timothy J. Maret. 2007. Effects of Timber Management on Pond-Breeding Salamanders. *Journal of Wildlife Management* 71(4): 1034-1041.

Mullens, J.B. 2007. Class Lecture: Global Water Resources. Keene State College.

Nelson Master Plan. 2008. http://www.nelsonmasterplan.net/ (last accessed 12 November 2008).

Perlman, Dan L. and Jeffrey C. Milder. 2005. *Practical Ecology for Planners, Developers, and Citizens*. Washington, DC: Island Press.

Porej, D., M. Micacchion and T. E. Hetherington. 2004. Core terrestrial habitat for conservation of local populations of salamanders and wood frogs in agricultural landscapes. *Biological Conservation* 120: 399-409.

Pyke, Christopher R. 2004. Habitat loss confounds climate change impacts. *Frontier Ecological Environment* 2(4): 178-182.

Regosin, Jonathan V., Bryan S. Windmiller, Rebecca N. Homan, and J. Michael Reed. 2005. Variation in Terrestrial Habitat Use by Four Pool-Breeding Amphibian Species. *Journal of Wildlife Management* 69(4): 1481-1493.

Rothermel, B. B. and R. Semlitsch. 2002. An experimental investigation of landscape resistance of forest versus old-field habitats to emigrating juvenile amphibians. *Conservation Biology* 16 (5): 1324-32.

Taylor, J. 1993. *The Amphibians and Reptiles of New Hampshire.* Concord: New Hampshire Fish and Game Department.

Trauth, Joy B., Stanley E. Trauth, and Ronald L. Johnson. 2006. Best Management Practices and Drought Combine to Silence the Illinois Chorus Frog in Arkansas. *Wildlife Society Bulletin* 34(2): 514-518.

U.S. Census Bureau. 2008. *New Hampshire- place and county subdivision: population, housing units, area and density 2000.* http://www.factfinder.census.gov (last accessed 7 November 2008).

Windmiller, B. and A.J.K. Calhoun. 2008. Conserving vernal pool wildlife in urbanizing landscapes. Pp. 233-252 in, *Science and conservation of vernal pools in northeastern North America*. Calhoun, A.J.K. and P.G. deMaynadier (eds). Boca Raton: CRC Press.

APPENDIX 1: SURVEY INSTRUMENT

Greetings, we are working in collaboration with Kathy Schillemat and the *Ashuelot Valley Environmental Observatory (AVEO)* to assess vernal pools in Nelson. The purpose of this survey is to sample Nelson residents' opinions on vernal pool conservation. Vernal pools are defined as small temporary wetlands that are recharged by snow melt and spring rains. These pools are a vital habitat to many amphibians, including spotted salamanders and wood frogs.

1. **Male_____ Female_____**

2. **Age**

   ___16 to 24 years ___40 to 59 years
   ___25 to 39 years ___60 and above

3. **How many years have you been a resident of the Town of Nelson? _____**

4. **Please rate your level of support regarding the following statements:**

   a. **It is important to preserve vernal pools in Nelson.**

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
1	2	3	4	5

   b. **If necessary, changes should be made in the Master Plan that would allow for vernal pools to be classified as a wetland feature.**

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
1	2	3	4	5

   c. **Town regulations should override the rights of land owners with respect to development over vernal pools.**

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
1	2	3	4	5

   d. **If I were aware of vernal pools on my land I would preserve the area.**

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
1	2	3	4	5

e. **I would support incentives, such as tax breaks, for land owners who choose not to develop land containing vernal pools.**

Strongly Agree	Agree	No Opinion	Disagree	Strongly Disagree
1	2	3	4	5

5. **If you answered *Strongly Agree or Agree* to the previous question (4e) how much of a tax increase would you be willing to fund? (The 2006 tax rate for Nelson, NH services was $13.15 per $1,000 assessed valuation).**

A property tax increase of...
____ .... $0.25 per $1,000 of assessed valuation
____ .... $0.50 per $1,000 of assessed valuation
____ .... $1.00 per $1,000 of assessed valuation
____ .... $2.00 per $1,000 of assessed valuation
____ .... $3.50 per $1,000 of assessed valuation
____ Other_____

6. **Please rank the priorities of services in your town 1-6 (1 being the least, 6 being the most important).**

City Services (police, fire) _____
Workforce Housing _____
Education _____
Property Taxes _____
Conservation (including vernal pools) _____
Other _____

7. **Do you have any knowledge of any vernal pools that exist on your property?**

Yes _____ No _____

8. **If you are a land owner, are you likely to sell your land in the next five years?**

Yes _____ No _____

9. **How many acres of land do you own?**

Less than 1 _____
1 to 5 acres _____
6 to 19 acres _____
20 to 39 acres _____
40 to 100 acres _____
More than 100 acres _____

10. **Are you currently involved in any environmental projects or have you been involved in such projects in the recent past?**

Yes _____ No _____

Any additional comments would be beneficial. Thank you for your time and attention.