WETLANDS, Vol. 27, No. 1, March 2007, pp. 80–95
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DEVELOPING VERNAL POOL CONSERVATION PLANS AT THE LOCAL LEVEL USING CITIZEN-SCIENTISTS

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Abstract: Use of citizen-scientists to collect data on natural resources is gaining credibility globally and is now considered a valuable tool in the conservation tool box. We conducted town-wide vernal pool inventories using citizen-scientists in four New England towns (USA) using voluntary best development practices (BDPs) for vernal pools. We tested the efficacy of using citizen-scientists to collect field data on vernal pools using published BDP guidelines. Steps included pool mapping and inventory, training of citizen-scientists, vernal pool field assessments, and guiding town development of local conservation strategies using data provided by the project. Potential vernal pools were remotely identified and photointerpreted. Partnerships among the University of Maine, the towns, and non-governmental organizations were forged to implement the project in spring 2003. Local coordinators in each town recruited volunteer citizen-scientists to conduct ground assessments. Volunteer training sessions were held prior to and during the field season. Fifty-two citizen-scientists surveyed and assessed 262 vernal pools. Quality control tests in the field confirmed that citizen-scientist data on amphibian egg mass counts were not significantly different from data gathered by biologists. Each pool was given a conservation priority rating based on the BDP assessment. Data were entered into a Geographic Information System database and delivered to each town. All towns initiated conservation plans and are developing conservation mechanisms to protect pools recognized as having conservation priority. Town strategies ranged from amending existing ordinances to improve wetland protection to incorporation of vernal pool resources into larger biodiversity mapping and planning projects. These four case studies illustrate that vernal pool conservation initiatives can be developed in local communities using the skills of trained citizen-scientists to collect accurate data. Communities are then better able to incorporate pool conservation strategies into the local planning and regulatory processes.

Key Words: best management practices, community based research, isolated wetlands, local regulation, natural resource planning, town planning, volunteers, wetland regulation

INTRODUCTION

Conservation of vernal pool habitat (breeding pool and associated terrestrial habitat) for amphibians is largely ineffective at federal, provincial, and state levels of government in North America (Preisser et al. 2000, Snodgrass et al. 2000, Leibowitz 2003, Calhoun et al. 2005, Mahaney and Klemens, in press). Although some jurisdictions regulate the vernal pool depression, few include restrictions of development in the critical terrestrial habitat (an area of at least 300 m) used by pool-breeding amphibians for migrating, dispersing, foraging, and hibernation (Semlitsch 2002, Regosin et al. 2003, Semlitsch and Bodie 2003, Smith and Green 2005). Conservation measures for pool-breeding amphibians, particularly ambystomatid salamanders (*Ambystoma* spp.) and wood frogs (*Rana sylvatica* L.), need to address conservation of the breeding pool, its adjacent terrestrial habitat, and connections among other pools and wetlands (Pope et al. 2000, Joly et al. 2003, Cushman 2006).

Given the inadequacy and inconsistency of regulations (see Downing et al. 2003 for discussion of The *Solid Waste Agency of Northern Cook County v. U.S. Army Corps of Engineers*, 531 U.S. 159 [2001;

SWANCC] and its effect on isolated wetlands), much of the power in regulating land use in and around small, seasonal wetlands in North America remains in the hands of local governments. Many local governments in the northeastern U.S. have proactively developed wetland regulations and ordinances, and some specifically include vernal pools as regulated wetlands (e.g., Redding, Conn.; Groton, Mass.). These regulations are often an improvement over state or federal measures, but often they lack adequate protection (protections rarely exceed 30 m) for the adjacent terrestrial habitat, and they do not require land-use planning at scales that consider wetland connectivity. Recent studies recommend protection of adjacent habitat of a minimum of 164 m for pool-breeding amphibians in general (Semlitsch 2002) and 368 m for anurans (Semlitsch and Bodie 2003). Cushman (2006) suggests dispersal distances may be far greater than current studies suggests.

Existing local regulations still focus on a permit-by-permit response rather than proactive resource planning strategies. Many towns are unpredictable in their permitting process and lack consistency in the level of protection across municipal boundaries (Preisser et al. 2000, Calhoun et al. 2005). Local governments are often unable to plan proactively for pool conservation as they lack the necessary data (Rockwood 1995, Cort 1996, Theobald et al. 2000, Brody et al. 2003). Town commissions or boards often consist of local volunteers who have limited expertise in ecology and need to rely on data and interpretation provided by environmental consultants hired by applicants. Most towns do not have standardized methods for data collection required from environmental consultants. This often results in insufficient information (either not enough data collected or data collected at the wrong time) necessary in the site review process and can prolong the costly review process, and in some cases result in poor decision making (Klemens and Johnson 2005).

Given the difficulty of remotely identifying vernal pools, involvement of local citizens to conserve vernal pool resources is essential. Citizens are often motivated to become involved at the local level because today many local governments play a lead role in land use planning. Community efforts using citizen-scientists can be a grassroots catalyst for change by developing responsible comprehensive plans and municipal ordinances that are attentive to important environmental issues at the local scale. The idea of complementing "top-down" resource management with a "bottom-up" participatory approach is an increasingly respected strategy and encourages building partnerships to bridge the gaps between local needs and the agendas of other stakeholders (Calhoun and Reilly, in press).

Citizen-scientists can be trained to identify and assess a town's pool resources. With the growing interest in using citizen-scientists to collect ecological data intended to be used in regulatory decisions (Byron and Curtis 2002, Savan and Sider 2003), methods for ensuring reliability and accuracy of volunteer data are now well-developed (Fore et al. 2001, Harvey et al. 2001, Engel and Voshell 2002, Calhoun and Reilly, in press). To address this need for local data collection to inform planning, Calhoun and Klemens (2002) published *Best Development Practices: Conserving Pool-Breeding Amphibians in Residential and Commercial Developments in the Northeastern United States* (BDPs) as guidance for municipalities to use in land use planning and as a complement to any existing vernal pool conservation efforts. The BDPs outline steps for conducting municipality wide pool inventories. We implemented the assessment portion of the BDPs in four New England towns to test the practical applicability of this document and its premise that using citizen-scientists is an effective method for gathering reliable data for local communities to conserve vernal pool habitats. Our overarching goal was to prepare four town case studies to serve as models for other towns interested in local conservation of vernal pool habitat. In this paper we report the results of the assessment we conducted following the steps described in the BDPs: 1) Mapping and inventory of the pool resources; 2) recruitment and training of citizen-scientists; 3) data collection using citizen-scientists; 4) ecological assessment of inventoried vernal pools; and 5) use of study results by towns for implementing vernal pool protection plans.

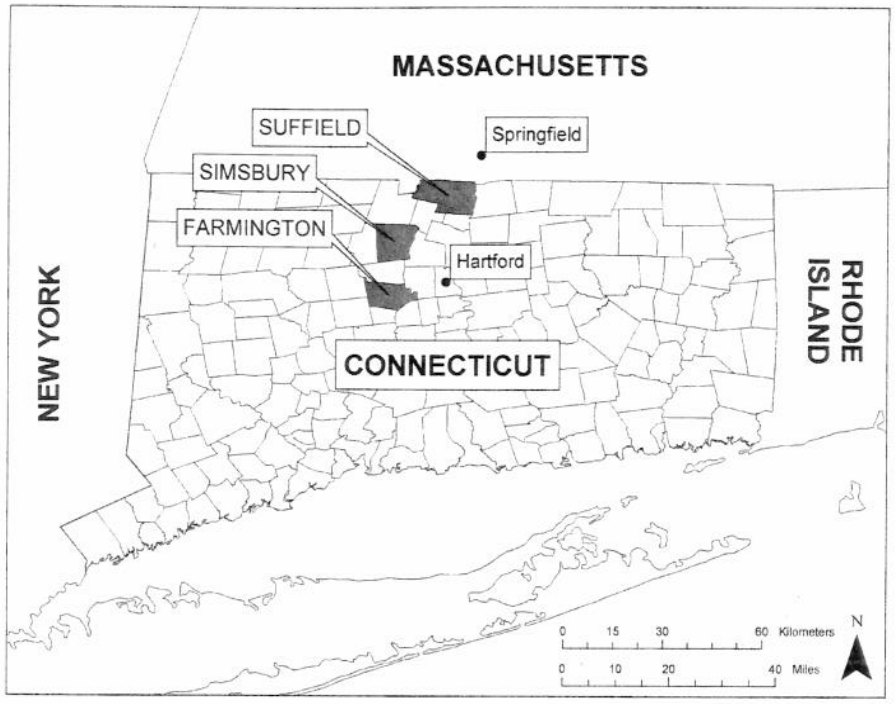
In addition, we tested the validity of citizen-scientist data and developed a profile of successful volunteers to aid others in their recruitment strategy.

METHODS

Site Description

Vernal pool conservation initiatives were initiated in Falmouth, Maine, USA, and three Connecticut towns: Farmington, Simsbury, and Suffield (Figure 1). We selected towns interested in town-wide conservation planning that had access to a Geographic Information System (GIS). The towns were within 30 km of major cities and therefore faced similar development pressures. Population ranged from 10,000–24,000, with per capita income within the range of $30,000–$45,000.

A.



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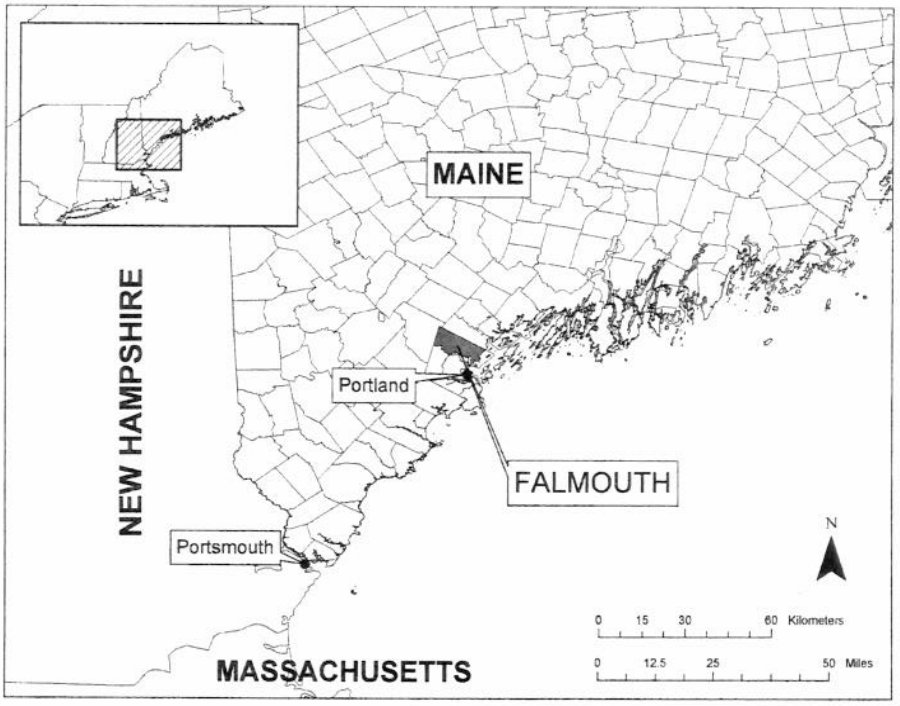

Figure 1. Study town locations.

Each town had an elected governing body consisting of several officials responsible for governing and establishing policy within the town. Planning boards (or their equivalent) were responsible for reviewing subdivision applications submitted under the land use ordinances and zoning and site plan review ordinances and regulations. In Falmouth, vernal pools were regulated by the Planning Board and the town through town land use ordinances. In the Connecticut study towns, vernal pools were regulated at the municipal level by Inland Wetlands Commissions. Each town also planned for development around vernal pools by drafting ordinances, cluster regulations, zoning codes, and subdivision regulations. While each town had regulations to protect the vernal pool basin, none adequately protected the adjacent terrestrial habitat. Terrestrial review areas and regulated setbacks were designed to protect the hydrologic functions of the wetland from the impacts of surrounding anthropogenic activities and ranged from 15–30 m.

Implementation of BDPs

Project Coordination. The University of Maine (UME) oversaw the project with the help of local partners. We established partnerships with environmental non-governmental organizations (ENGOs) to facilitate project logistics and conservation planning activities. The Connecticut towns partnered with Farmington River Watershed Association (FRWA), a local non-profit organization, and the Metropolitan Conservation Alliance (MCA), a program of the Wildlife Conservation Society. These towns participated in a larger biodiversity project designed to integrate scientific information into land use policies to protect important local biological resources. Falmouth partnered with Maine Audubon Society. The partners were located within the study towns and coordinated training sessions, provided GIS and mapping assistance, and offered administrative and staff assistance. Database management and volunteer coordination were carried out by UME.

We selected town planners or members of conservation commissions to serve as town project coordinators who oversaw daily activities. These town officials were familiar with the town planning processes, active in local conservation, and willing to recruit and manage volunteers within their town. Planning department staff within each town provided administrative support and a central location for volunteers to receive and return materials.

Funding. In Connecticut, funds for aerial photography and photointerpretation were provided by MCA and various foundations. Photography costs dropped substantially with contiguous towns pooling resources for one flight. Falmouth was able to justify purchase of aerial photography and photointerpretation of pools for their town by using the new photographs for tax maps and other planning exercises. UME contributed faculty and graduate student time (project presentations, data management, citizen training, and data analysis). In-kind support was provided by the Partners. The MCA provided financial support for the graduate student coordinating the project.

Vernal Pool Mapping and Selection for Inventory

Potential vernal pools in Connecticut were remotely identified on black-and-white aerial photographs (1:12,000, spring 2000, leaf-off). Falmouth pools were photointerpreted from color infrared photos (1:12,000, spring 2002, leaf-off). We created a data layer of potential pools (each with an identification number) to overlay tax parcel maps in order to identify pool land owners (Figure 2).

We sent letters to landowners requesting permission to access their land during the spring of 2003. In some cases, we sent letters to adjacent private landowners requesting access through their property to target properties. Letters were sent at least one month in advance of the start of the spring surveys. We explained the purpose of the surveys and the type of data the surveyor would be collecting on the property and invited landowners to accompany citizen volunteers in the field. Two weeks following the first letter request, we mailed follow-up postcards to landowners who did not respond after the first mailing requesting access to their land.

Recruitment and Training of Citizen-Scientists

Volunteer Recruitment and Training. Citizen-scientist volunteers were recruited by the town coordinators. Coordinators recruited volunteers by contacting naturalists and ecologists, educators, and other active members of the community. We did not advertise through media as we were targeting volunteers who were likely to have some field and data collection experience and who might be candidates for post-project education and conservation initiatives. Previous volunteer recruitment efforts had proven that lower numbers of well-trained volunteers are more effective than masses of interested, but inexperienced citizens (Calhoun et al. 2003).

Figure 2. Aerial photograph (1:12,000 panchromatic, spring 2000 leaf-off) of vernal pools identified in Suffield, CT, USA.

We conducted two training sessions for citizen-scientists prior to the field season. The first indoor training session included presentations on the broader project and partners, vernal pool ecology, and identification of vernal pool fauna. We followed this session with an outdoor training session where volunteers practiced collecting data and filling out data forms (Figure 3). Volunteers recorded observations of pool-breeding amphibians, extent of development surrounding the pool, and other wildlife present in the pool and or in the immediate terrestrial habitat. We provided volunteers with regional field guides and some field equipment to assist in recording observations.

Figure 3. Outdoor training session for citizen-scientists (photo: Laurie Whitten).

Volunteer Supervision and Coordination. Local support for the citizen-scientists was provided by the town coordinators. Volunteers in Falmouth received 11″×17″ color aerial photo maps, which included assigned pools and tax parcel lines. Two maps were provided to the Connecticut volunteers: 1) 8 ½″ × 11″ black and white aerial photography and 2) an 8 ½″ × 11″ map showing the same pools on USGS topographic maps. Larger maps of the town showing the location of each pool for reference were also provided and displayed at a central location throughout the project. Maps were produced by the Falmouth Planning Department and the Farmington River Watershed Association using GIS.

Coordinators helped volunteers choose pools to survey (many volunteers were comfortable working in their own neighborhoods or with pools owned by people they knew). Number of pools assigned per person was based on volunteer's physical ability, time constraints, and pool location.

Communication among citizen-scientists, coordinators, and biologists was maintained through a Listserv. Participants were encouraged to ask

questions and send photographs of questionable egg masses or other issues regarding field data gathering. Field assistance or phone conversations were provided when requested.

Data Collection

Volunteers surveyed potential vernal pools in early April 2003 in Connecticut and mid-April 2003 in Maine. Two field visits were conducted: once following the peak wood frog breeding event (Round 1), and again at least two weeks later to capture peak salamander egg counts (Round 2). Data were collected on egg mass numbers by species and condition of the terrestrial habitat within 30 m of the breeding pool. Presence of breeding amphibian species, state-listed species, and other pool indicators (spermatophores, egg masses, larvae) observed were documented with a photograph. Volunteers noted the extent of development and condition of the vernal pool habitat during each visit and we asked them to document this through photographs of the pool and the adjacent terrestrial habitat from the north, south, east, and west edges of the pool. The volunteers labeled photographs with the pool identification number and date. Upon completion of field visits, coordinators and biologists evaluated the amount of development in the critical terrestrial habitat zone (30–230 m from the pool) remotely from aerial digital and print photography.

Quality Control. We contacted the 52 citizen-scientist volunteers and asked them to participate in a quality-control field check. We were able to assess 32 volunteers during each round of data gathering. Participants were limited to those individuals who could meet the schedule of field visit dates posted by the project biologists. Volunteers gathered data on amphibian breeding and the condition of the pool envelope at one of their pools. Biologists conducted a survey immediately after the volunteers. We compared "yes" or "no" answers for four variables listed on the data sheet: 1) $\geq$ 25 wood frog egg masses, 2) $\geq$ 25 spotted salamander egg masses, 3) the presence of wood frog tadpoles, and 4) 75% or more undeveloped land within 30 m of pool boundary. Using a Kappa Coefficient, we compared data collected by biologists to the volunteers' data.

Complete egg mass counts (as opposed to the preceding range counts) conducted by 16 volunteers were compared to those of biologists. Using Kruskal-Wallis One-Way Analysis of Variance, we compared the results of volunteer egg mass counts to that of the biologist for all trials (N = 12 for wood frogs, N = 21 for spotted salamanders). Since wood frog egg masses differ from spotted salamander egg masses in size, shape, and location in the pool, a comparison of egg mass counts was made on an individual species basis.

Egg mass numbers varied from pool to pool, so we performed another test using Spearman rank correlation (r_s) to determine if there was a strong correlation among all of the volunteer counts and all of our counts as egg mass numbers increased or decreased. We also reviewed volunteer photographs to determine if volunteers accurately identified spotted salamander egg masses, wood frog egg masses, wood frog tadpoles, and spermatophores.

Ecological Assessment and Prioritization

Pools were assessed using the Vernal Pool Assessment Sheet (Table 1) in the BDP Manual and were based on two parameters: 1) biological rating of the pool and 2) condition of the adjacent terrestrial habitat within 230 m of the pool. The biological rating was based on the presence of federal or state-listed species, the number of pool indicator species (two or more), and the number of egg masses present (25 or more). Assessment of the adjacent terrestrial habitat includes the integrity of the pool's envelope (habitat within 30 m from the pool's edge) and critical terrestrial habitat (habitat 30–230 m from the pool's edge). Based on these data, pools were given a conservation priority rating of Tier I, Tier II, or Tier III. Tier I pools by definition have both relatively high breeding activity and an intact terrestrial habitat and are therefore high priority pools for protection. Tier III pools represent pools with lower amphibian productivity and fragmented associated terrestrial habitat (they may still warrant protection but at a lower priority and may be appropriate opportunities for restoration; see Calhoun and Klemens 2002).

Initiating a Conservation Plan

We completed the final step in the BDPs — initiating a conservation plan — by presenting the results of the study to the Conservation Commission in each town. Each town was provided with a GIS database of the surveyed pools and their Tier ratings (Figure 4), spreadsheets with all the vernal pool raw data, the ecological assessment, and photographs. Follow-up meetings were conducted with decision-makers and commission members to discuss various conservation mechanisms including:

- Developing vernal pool ordinances or strengthening of existing ordinances;

Table 1. Vernal Pool Assessment Sheet (source: Calhoun and Klemens 2002).

VERNAL POOL ASSESSMENT SHEET

A. Biological Value of the Vernal Pool

(1) Are there *any* state-listed species (Endangered, Threatened, or Special Concern) present or breeding in the pool?
Yes_____ No_____

(2) Are there two or more vernal pool indicator species breeding (i.e., evidence of egg masses, spermatophores [sperm packets], mating, larvae) in the pool?
Yes_____ No_____

(3) Are there 25 or more egg masses (regardless of species) present in the pool by the conclusion of the breeding season?
Yes_____ No_____

B. Condition of the Critical Terrestrial Habitat

(1) Is at least 75% of the land 100 feet from the pool undeveloped?
Yes_____ No_____

(2) Is at least 50% of the habitat from 100-750 feet of the pool undeveloped?
Yes_____ No_____

NOTE: For these purposes, "undeveloped" means open land largely free of roads, structures, and other infrastructure. It can be forested, partially forested, or open agricultural land.

C. Cumulative Assessment

Number of questions answered YES in category A	Number of questions answered YES in category B	Tier Rating (I=highest priority)
1–3	2	Tier I
1–3	1	Tier II
0	1–2	Tier III
1–3	0	Tier III

- Acquiring vernal pool habitat through town or local land trusts;
- Soliciting conservation easements or other incentives for private landowners;
- Creating overlay zones to encompass high priority pools;
- Incorporating pool resource data into larger biodiversity plans led by the partners;
- Creating stewardship programs to enhance public awareness and private landowner education.

We worked closely with each town to assist and observe the development of plans to focus protection efforts on high priority pools.

Profile of Successful Vernal Pool Citizen-Scientists

At the conclusion of the project, we asked each volunteer to complete a questionnaire. The purpose of the questionnaire was to create a profile of successful volunteers based on characteristics such as age, town residence time, local involvement, outdoor interest, and knowledge. Another goal of the questionnaire was to determine what motivated volunteers to participate in this project and what effect the project might have had on their community involvement (Appendix A).

RESULTS

Implementation of the BDPs

Project Coordination. Successful town-wide initiatives require participation of a diverse array of stakeholders (Preisser et al. 2000, Savan and Sider 2003). For this reason, before project initiation, two to three meetings were held among project organizers in Connecticut and Maine to be sure the towns would want to pursue such a project and to identify key stakeholders. These included non-governmental partners, scientists, citizens, landowners, and town officials (Table 2).

Pool Mapping and Selection for Inventory. More than 1,000 potential vernal pools were remotely delineated (Table 3). The number of pools ultimately surveyed (382) was the result of pool accessibility (landowner permission or geographic location). Permission was needed to access 87.8% (389/443) of tax parcels identified as having pools in the four towns. Falmouth, Maine, had both the most pools

Figure 4. GIS map of tier-rated vernal pools delivered to Simsbury, CT, USA.

on private land and the highest landowner response rate. The majority of the Connecticut private landowners did not return request letters (Table 4).

Recruitment and Training of Citizen-Scientists. The number of hours for coordinators to oversee volunteers ranged from less than 1 to 4 hours a week during the field survey period. Total number of hours each coordinator spent during the project ranged from 10 to 30 hours. Time demands were highest during volunteer recruitment, start of the survey periods, and during collection of data from volunteers. Coordinators also spent time assisting volunteers in locating pools. Most volunteers were contacted through electronic mail (others without access by phone). During the course of the project, volunteers were contacted by coordinators up to five times by phone and 10 times by e-mail. Since the lead organizers (UME) supervised all the coordinators and the volunteers, more hours were required in communication with towns. Approximately 100 hours (39 visits) were spent visiting volunteers during field surveys to assist in locating pools and collecting vernal pool data. More than 150 hours were spent designing field data forms for volunteers, conducting terrestrial habitat assessments on aerial photos, and entering and analyzing

Table 2. Organizations and personnel involved in implementing the BDPs in each of the participating towns.

	UME	MCA	FRWA	MAS	Farm.	Sims.	Suff.	Falm.
Project organizers	2	2	3	1	2	1	2	1
Town coordinators					1	1	1	1
Volunteers	1			1	10	12	15	15

UME = University of Maine, MCA = Metropolitan Conservation Alliance, FRWA = Farmington River Watershed Association, MAS = Maine Audubon Society, Farm. = Town of Farmington, CT, Sims. = Town of Simsbury, CT, Suff. = Town of Suffield, CT, Falm. = Town of Falmouth, ME.

Table 3. Potential vernal pools identified, assigned, and assessed by town.

	Remotely Identified	Pools Assigned	Additional Pools Located	Pools Surveyed	Remotely Identified Pools Surveyed (%)
Farmington	75	48	9	42	44
Simsbury	136	93	11	96	63
Suffield	687	198	11	149	20
Falmouth	131	92	5	95	73
Total	1029	431	36	382	34

volunteer data. Meetings, phone calls, and e-mails constituted the rest of the organizer's time. During the course of the project, approximately 50 e-mails and 20 phone calls were made by the organizer to volunteers and coordinators.

The amount of work involved supervising a vernal pool project varies temporally. Most volunteers were fairly independent and periods existed between surveys and during surveys where minimal supervision was necessary.

Data Collection. Fifty-two volunteers surveyed 34% (382/1,029) of potential pools based on accessibility (Table 3). Volunteers were assigned 1–23 pools each; numbers varied by town with median pool assignments ranging from 5–12 pools. Some volunteers worked in pairs and could be assigned a large number of pools. Volunteers in Suffield were assigned higher numbers of vernal pools because many of the pools were clustered. Older volunteers often had trouble accessing pools. In all four study towns, most of the accessible pools (88%) in our sample set were surveyed. Thirty-six pools, not identified remotely, were located during volunteer ground investigations. These were surveyed, resulting in more pools being assessed than assigned.

Two hundred and sixty-two (69%) of the 382 potential surveyed pools were confirmed as vernal pools. One hundred and twenty (31%) of the surveyed potential pools were erroneously identified as vernal pools by aerial photointerpretation procedures (Table 5). Ground surveys by volunteers confirmed that 103 of the misidentified pools were other wetland types including permanent ponds, seepage wetlands, or shallow wet depressions. Seventeen pools were never located.

Quality Control. Thirty-nine trials with 32 volunteers were used to compare "yes" or "no" answers for four variables: 1) $\geq$ 25 wood frog egg masses, 2) $\geq$ 25 spotted salamander egg masses, 3) the presence of wood frog tadpoles, and 4) 75% or more undeveloped land within 30 m of the pool boundary. All four variables had a Kappa Coefficient value greater than 0.75 (strong agreement beyond chance).

When we compared exact wood frog and spotted salamander egg mass counts, volunteer counts were not significantly different from those conducted by the biologists (wood frog egg masses: $U = 77$, $n = 12$; $P = 0.772$, spotted salamander egg masses: $U = 254$, $n = 21$; $P = 0.399$) (Figure 5). During every trial, volunteers were able to locate egg masses in the pool when the biologist successfully located egg masses. Volunteer egg mass counts exceeded those of the biologist 31% of the time. In 53% of the trials, volunteer egg mass counts were less than those of the biologist. When analyzing all the counts combined, regardless of species, volunteer count error was higher when egg mass numbers were low. However, when comparing all of the counts there was a strong consistency between volunteer egg mass counts and biologist egg mass counts ($r_s = 0.899$, $n = 31$; $P < 0.05$).

We evaluated the diagnostic skills of the volunteers by reviewing their photographs of amphibian breeding signs. Ninety-six percent (318/332) of photographs reviewed were correctly identified. The success rate would have been higher overall,

Table 4. Request-for-permission results from private landowners by town.

	Contacted	Permission Granted	Permission Denied	No Response	Percent Response (%)
Farmington	24	7	0	17	29
Simsbury	43	10	1	32	26
Suffield	130	19	0	111	15
Falmouth	140	66	4	70	50
Total	337	102	5	230	32

Table 5. Results of vernal pool field reconnaissance by town.

	Misidentified Pools	Pools Surveyed	Total # of Confirmed Pools
Farmington	15	42	27
Simsbury	41	96	55
Suffield	43	149	106
Falmouth	21	95	74
Total	120	382	262

but spermatophores were misidentified 45% of the time.

Ecological Assessment and Prioritization

Biological Conservation Value of the Vernal Pool. State-listed species were identified by volunteers near or within only 5% of the confirmed pools. Just over half (56%) of the confirmed pools contained two or more pool indicator species and half (50%) contained 25 or more egg masses. Approximately 52% of the pools in the Connecticut towns contained two or more indicator species, while Falmouth had a substantially higher percentage (69%) of pools with two or more species.

Condition of the Critical Terrestrial Habitat. Most of the pools (92%) were associated with undeveloped land immediately surrounding the pool, and almost all the pools (97%) had at least 50% of the land undeveloped up to 230 m from the pool edge.

Tier Rating. Most of the pools surveyed were rated as high priority or low priority pools (Tier I or Tier III), while very few of the pools were rated as Tier II (Table 7).

Initiating a Conservation Plan

We worked closely with each town to assist and observe the development of plans to focus protection efforts on high priority pools. Only long-term monitoring can determine if the project was successful in implementing conservation plans. However, the four study towns have begun to propose and develop conservation plans and apply conservation mechanisms to protect high priority vernal pools.

The Connecticut towns are working to incorporate the vernal pool data along with other biological data sets into the Farmington Valley Biodiversity Project. Results from the Biodiversity Project are being used to identify priority areas within each town to focus conservation efforts, and to guide

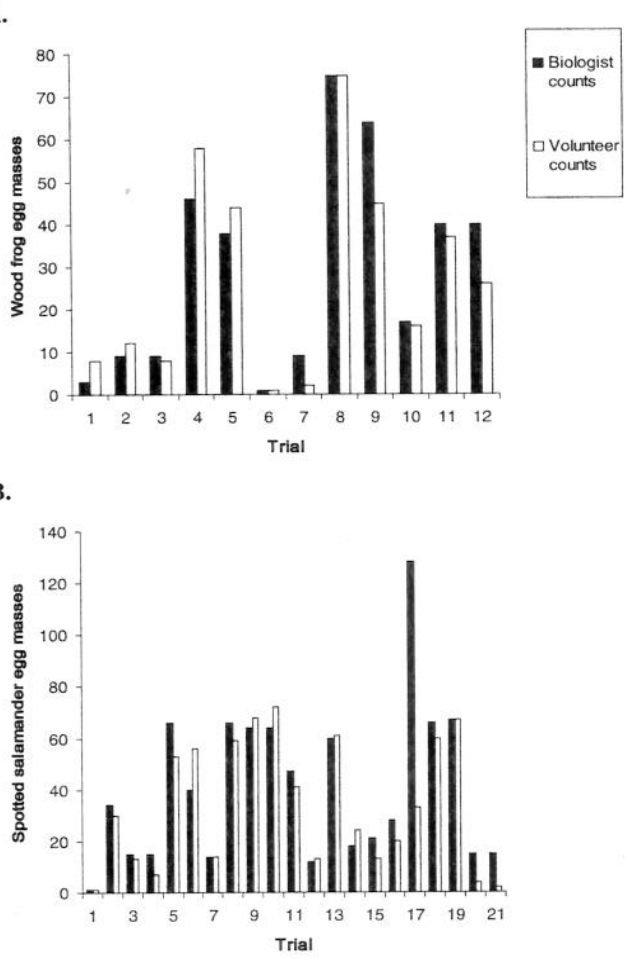

Figure 5. Exact egg mass count comparison between volunteers and biologists for a) wood frogs and b) spotted salamanders.

town planners in how to incorporate the results within the municipal planning and regulatory process. Follow-up efforts with the towns are focusing on developing regulatory language for use by specific municipal commissions, such as Inland Wetlands and Planning and Zoning Commissions, which will support the conservation objectives set forth in the comprehensive and master plans.

Farmington. Farmington has been using the results from this study in their pre-application process. The staff members use the information to assist landowners in the building application process to better protect the pool resource early in the development planning stage.

Simsbury. Simsbury is updating their Plan of Conservation and Development, which will include maps and databases from the Farmington Valley Biodiversity Project, along with the necessary "language" to define and facilitate the incorporation of this information into the plan. The vernal pool information from our study is included within the

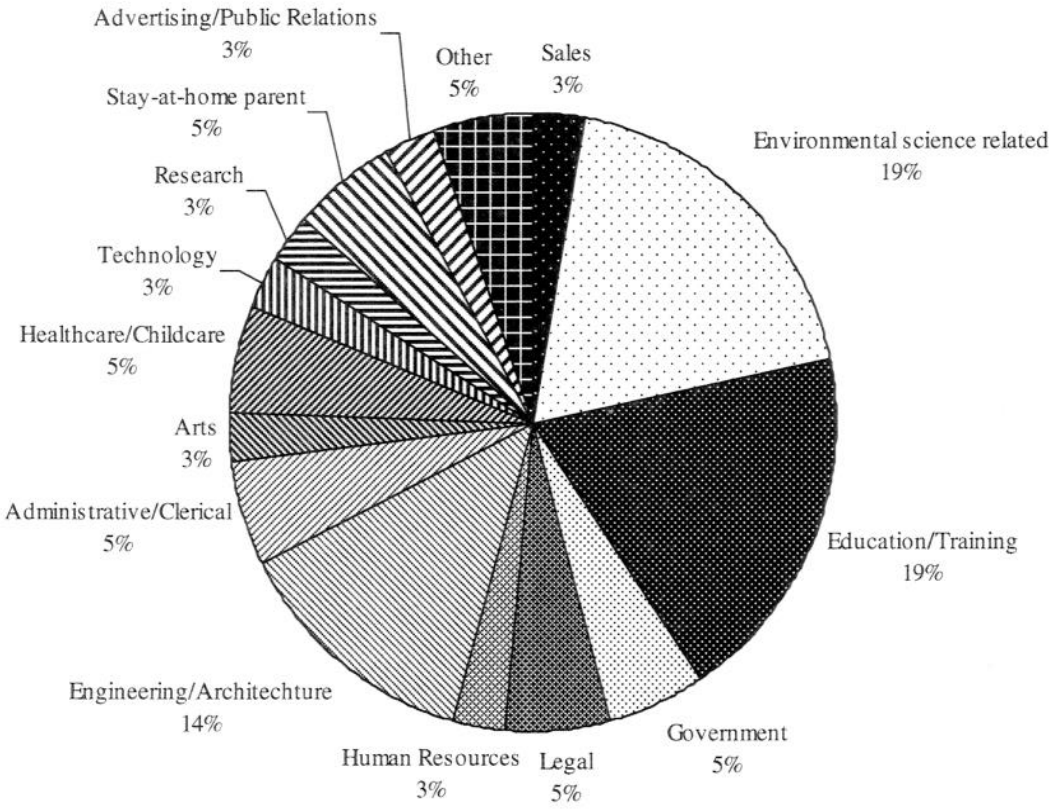

Figure 6. Current and former (if retired) occupations of 37 citizen-scientists who responded to the questionnaire.

biodiversity project. If adopted, the plan will encourage the conservation of environmentally sensitive areas within the town and if development is permitted, it will encourage environmentally sensitive site designs, the preservation of open space, and the use of best development practices. The plan calls for the adoption of the BDPs (Calhoun and Klemens 2002) into the Town's land use regulations as a tool for use in site design review for proposed development projects.

Suffield. Suffield is also using vernal pool data in their land-use decisions and the town has increased wetland regulations around pools from 15–30 m.

Falmouth. Falmouth has recently passed amendments to their Zoning and Site Plan Review Ordinance, which includes a Resource Conservation Zoning Overlay District (RCZOD). The new RCZOD covers the remaining undeveloped areas in the town and sets standards for subdivisions to preserve areas on each site that have high natural resource value. These conservation subdivisions allow for cluster development and require 50% of the residential area plus the unsuitable area to be set aside for open space preservation. The open space area must contain important conservation areas, which include vernal pools and their associated terrestrial habitat as mapped by the town. The Conservation Commission has also formed a Vernal Pool Subcommittee to discuss and pursue other conservation strategies. The commission has published a vernal pool brochure to educate the public about efforts to protect vernal pools in their town. The brochure is posted on their Web site, which includes other vernal pool resource materials (Calhoun and Klemens 2002, Calhoun and deMaynadier 2004).

Evaluation of Citizen-Scientists

Thirty-seven volunteers (71%) returned completed questionnaires within two months of mailing. Most of the volunteers who responded (84%) were between the ages of 40 and 69 years, with both sexes roughly equally represented. A majority of the volunteers (65%) had resided in the area for 11–30 years. Almost all of the volunteers who responded participate in other community volunteer activities including conservation commission membership, land trust membership, various religious activities and events, and community recreational activities. Sixty-five percent of the respondents hold or have held positions on community board or commissions such as conservation commissions,

land trusts, school boards, planning and zoning boards, and parks and recreation boards. Occupations varied greatly and many of the volunteers listed careers relating to natural sciences (19%) (Figure 6).

Volunteers chose this project based on personal interest, time requirements, and its benefit to the community and their environment. They saw participating as an opportunity to learn and work with new people. The top three reasons for volunteering for this project (of a select list) were "to help protect nature" (65%), "to be part of a worthwhile cause" (59%), and "to learn about nature" (56%). In an open-ended question, the volunteers were asked to describe what influenced them to decide to participate in the project. The most common answers were "to be a part of the biodiversity project" and "an opportunity to do field work."

On a scale of 1 to 5, with 5 being high, respondents rated their experience from Medium (3) to High (5). The mean rating score for their level of satisfaction was 4.4. When asked if they would be willing to volunteer for this kind of work in the future, 32 of the 37 respondents (86%) indicated that they would be willing to volunteer again. However, when asked if they would be willing to take on a larger role by helping organize or become a town coordinator, only 12 of the respondents (32%) stated they would. The remaining volunteers indicated they were not willing or unsure. Some of the reasons mentioned for unwillingness to volunteer in the future were time constraints, too physically challenging, and involvement in other projects and volunteer work.

Forty percent of the 30 respondents indicated they had become more active as a result of this project by attending commission meetings, joining committees, and bringing more knowledge to commissions and land trusts. The majority of respondents (21/30) indicated they had an increased awareness and concern for the impacts of development in their town. Ninety-four percent of the volunteers have shared their knowledge with friends, family, and coworkers about the importance of conserving vernal pools.

DISCUSSION

Vernal pools (or ephemeral wetlands) are global in distribution. Ecological functions vary from central Australia to California or the forested glaciated northeastern North America, but the issues (e.g., conserving pool functions and pool-associated biota) and challenges (e.g., ephemeral wetlands are often on private lands and poorly protected) are similar. For over 100 years, citizens across North America have successfully collected data on natural phenomenon (including flowering phenology, leaf-fall, migration events), documented presence/absence of wildlife (call surveys, tracking), and measured environmental variables in association with diverse groups including the Cornell Laboratory of Ornithology, the National Ecological Observatory Network (NEON), and Citizen Science Canada (Calhoun and Reilly, in press). In our study, we illustrated that citizens can be engaged to collect data on vernal pools through locally controlled initiatives. Even though every pool is different and the politics and biology may vary across regions, we are able to offer key steps in pool conservation gleaned from our experience working with local communities. Details of the process and the ultimate implementation of a plan, however, will be shaped by the community itself. We cannot provide the formula for effecting conservation in any given community, but we can provide an example of a successful project in New England that underscores the value of citizen-science in pool conservation efforts in North America and perhaps in other regions with participatory political systems.

Implementation of BDPs

Communities choosing to implement Best Development Practices should use a collaborative approach. Regional or town-wide conservation projects must have the support of partners and stakeholders including scientists, local environmental groups, decision makers, and concerned citizens (Vasseur et al. 1997). Partnering with ENGOs or federal, provincial, or state agencies potentially lends credence to a project, provides opportunities for financial or logistical support, and elevates the importance of the project in the eyes of the citizens (Ludwig 2001, Moore and Koontz 2003, Berkes 2004). Local officials (e.g., planners and conservation commission members) make excellent volunteer coordinators as they have local knowledge of the citizenry and are familiar with local geography and resources (e.g., maps, Geographic Information Systems). They serve as a clearinghouse for information among all the participants and stakeholders involved in the project and implementation process. We recommend working with communities receptive to conservation planning and using these successes as a model to encourage more skeptical municipalities.

Developing a vernal pool conservation plan is expedited when it is integrated with other natural resource planning projects. Vernal pool data can easily be incorporated into other resource data layers; areas particularly rich in resource elements may stand out as conservation priorities. For example, data from Connecticut towns were integrated into the Farmington Valley Biodiversity Project to create overlay maps identifying significant biodiversity areas. Maine Audubon has used the Falmouth project as a model for working with two towns on Mount Desert Island in Maine. Data from the Maine projects may be integrated into the State's "Beginning with Habitat" program (Beginning with Habitat 2003).

Pool Mapping and Selection for Inventory

Aerial photography is an efficient tool to use for remotely identifying potential pools, but some error is involved. Pools may be missed owing to seasonality, human error, topography, and forest cover types (i.e., coniferous vs. deciduous) (Calhoun et al. 2003, Lathrop et al. 2005; see Burne and Lathrop, in press). Volunteers will often discover pools missed by photography. A method for including these pools should be developed in advance of field work. This way volunteers could independently number new pools without duplication and without having to check in every time a new pool is discovered.

Protection of vernal pools is in part limited by resource managers' ability to map them on a large scale (Grant 2005). It is important to obtain the best possible resources to conduct a comprehensive remote inventory. New Jersey, Massachusetts, and other states have started mapping programs that solicit citizen assessment. Vernal pool resources for helping citizens identify pools are now widely available (Burne 2001, Calhoun and Klemens 2002, Tappan and Marchand 2004, Lathrop et al. 2005).

The drawback of voluntary measures is that landowner permission rates vary by region. Yet even when only a subset of pools have been surveyed and assessed for each project area, we believe the process is still largely beneficial to the resource. It raises the public profile of pools, encourages community wide planning, and, in the long run, will make the costs of development decrease as developers are informed of preexisting significant resources. The mapping layer of "potential" vernal pools is still a very applicable data layer for local planners who can provide guidance to an applicant with plans to develop near a potential vernal pool site. "Green" developments, or developments sensitive to conservation constraints, are attractive to many citizens. An intact, protected pool may be used as a selling point (Wilson et al. 1997). Knowing the location of priority pool areas will also help regulators determine mitigation opportunities. Furthermore, local officials can direct the applicant to use standard methods for data collection, such as outlined in the BDPs, making the site plan review more consistent.

Recruitment and Training of Citizen-Scientists

The volunteers in this study were very successful in collecting biological field data on vernal pools. We feel our approach to targeting local naturalists, ecologists, educators, and other active community members led to the success of the project. Most communities will have skilled citizens who can be trained easily to conduct pool surveys and who will likely continue to be involved in the community to help incorporate data into the community planning and policy making process.

For overall success of the project it is essential to have a biologist/ecologist with a comprehensive understanding of vernal pool ecology to serve as the project manager or at least be available for consult. An expert with experience in surveying vernal pools will be able to properly train volunteers, organize field surveys during appropriate periods, answer technical questions about the organisms and pool resources, and accurately identify signs of vernal pool associated organisms.

Volunteer satisfaction may have an impact on continuing involvement in the project. Overall, our volunteers were quite satisfied participating in the project and most would continue if asked. Comprehensive surveys on vernal pools should run for multiple seasons given the natural variability of breeding populations from year to year (Calhoun et al. 2005). Maine successfully retained citizen pool monitors for over five years in a statewide survey of vernal pools (Calhoun et al. 2003). Keeping volunteers involved in other aspects of the project outside the spring field season keeps volunteers connected to the project and may help retain commitment.

Organized and thorough training sessions are essential to the success of gathering reliable volunteer data on vernal pools. Field visits were especially important because many of the volunteers were more confident in their data gathering abilities after further training in the field. It is difficult to train volunteers to locate and identify state-listed species as many of the species can be difficult to identify, or they occur outside the amphibian breeding season.

Table 6. Results of vernal pool assessment by town (after Calhoun and Klemens 2002).

	State Listed Species	≥ 2 Indicator Species	≥ 25 Egg Masses	≥ 75% of Envelope Undeveloped	≥ 50% of CTH* Undeveloped	Number of Confirmed Pools
Farmington	5 (19%)	13 (48%)	14 (52%)	24 (89%)	24 (89%)	27
Simsbury	3 (5%)	24 (44%)	24 (44%)	48 (87%)	54 (98%)	55
Suffield	5 (5%)	60 (57%)	49 (46%)	102 (96%)	105 (99%)	106
Falmouth	0 (0%)	51 (69%)	43 (58%)	68 (92%)	70 (95%)	74
Total	13	148	130	242	253	262

*CTH – Critical terrestrial habitat

If a region has a species of special concern, an additional survey period to target that organism could be incorporated into the assessment. If a species is located, confirmation by an expert should be provided. Photo documentation of all species is essential.

Town coordinators and the lead investigator found it quite easy to communicate with volunteers. Listservs or group e-mails were the most efficient way to communicate with people involved in the project. Questions can be answered quickly and documents (e.g., data sheets) and photos are readily exchanged. The flow of communication fosters a sense of community in the group.

Ecological Assessment and Prioritization

The majority (97%) of pools in this study were rated Tier I or Tier III. This does not support Calhoun and Klemens (2002) prediction that most pools rated using the Vernal Pool Assessment Sheet would be rated as Tier II. A reason for the lack of Tier II pools was that an answer of "YES" is required in Category A and only one "YES" answer in Category B (Table 1). In this study, most uplands surrounding pools were undeveloped at both 30-m and 230-m zones. This phenomenon may be typical in developed settings where remaining pools are relegated to public lands or other otherwise protected resource areas (particularly shoreland zones).

If few pools are rated as Tier II, then this rating does not represent an intermediate between the Tier I and III pools. In such cases, if Tier I pools are scarce, further evaluation of Tier III pools is warranted. For instance, if a pool is surveyed and has 23 spotted salamander egg masses and both upland zones are undeveloped, it qualifies as a Tier III pool. If it is visited the following year and contains wood frogs or 25 or more egg masses it is bumped directly to a Tier I. This is why we suggest that towns use the BDPs as a guideline, not a regulation. Flexibility is needed to make informed decisions (see Baldwin et al. 2006). Clearly, if a pool has the borderline number of egg masses to be considered Tier I, and is surrounded by high quality terrestrial habitat, it should potentially be considered a Tier I pool. Eggs mass numbers will vary with region (Calhoun et al. 2003). For example, pools surveyed in Falmouth had higher egg mass numbers than those in Connecticut (Table 6). The assessment criteria need to be evaluated to determine if there should be an adjustment made to egg mass count thresholds for particular regions. For example, because of recently passed legislation on significant vernal pools in Maine (with egg mass thresholds that differ from those published in the BDPs), we changed the assessment data form to match the egg mass thresholds stated in the new regulations. Another adjustment to the assessment sheet we recommend is to change the bottom box in Category A from 1–3 to 0–3 (Table 1) to include pools with a small number of egg masses, or at least the proper hydrology, and rate them accordingly. This may be important particularly if other wetlands in the region are lost.

Table 7. Tier ratings assigned to each surveyed pool by town.

	Tier I	Tier II	Tier III	Total
Farmington	15	2	10	27
Simsbury	26	2	27	55
Suffield	64	3	39	106
Falmouth	51	2	21	74
Total	156	9	97	262

Although the BDPs were written for pool-breeding amphibians, we recommend that invertebrates, such as fairy shrimp, be included as indicator species. In this case, protecting the majority of amphibian breeding pools may not adequately protect pools important to fairy shrimp and other invertebrates (Colburn 2004, Colburn et al., in press).

Key concepts to maintain in an assessment form include rating the pool as breeding habitat and rating the condition of the adjacent terrestrial habitat. The biological criteria used (egg mass

counts, number of species, use of plants and invertebrates) will (and should) be tailored to local reference wetlands (Calhoun et al. 2005).

Finally, the BDPs do not address the issue of the spatial configuration of pools. In some cases, clusters of pools may be the conservation target, while a geographically isolated pool may be a high priority pool in that it is the only breeding habitat available. Identifying and maintaining habitat connections between pools in the landscape is important and should be emphasized in local planning efforts (Baldwin et al. 2006). Municipalities are in a better position to do watershed-scale conservation planning that considers resource connectivity than are federal, provincial, and state governments.

ACKNOWLEDGMENTS

Funding was provided by the Metropolitan Conservation Alliance, a Program of the Wildlife Conservation Society, the Sweet Water Trust, and Sand County Foundation's Private Land Stewardship Initiative. We thank the Farmington River Watershed Association and the Maine Audubon Society for their help in developing this project and their continued assistance throughout the project. The Towns of Farmington, Simsbury, and Suffield, Connecticut and the Town of Falmouth, Maine, provided us with staff and technical resources. Laurie Whitten, Elizabeth Dolphin, Amy Bauchiero, and Daniel Hildreth devoted time by serving as town coordinators. Thanks to all the citizen-scientists who volunteered to conduct field research for the project. We also thank Michael W. Klemens, John J. Daigle, and Hank Gruner for their constructive reviews of this manuscript, and William Halteman who provided statistical assistance. This is Maine Agricultural Experiment Station Paper # 2916.

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Manuscript received 6 July 2006; revisions received 13 November 2006; accepted 28 November 2006.

APPENDIX A: VERNAL POOL QUESTIONNAIRE

1. How many years have you lived in the area?
2. What other volunteer activities are you involved in?
3. Please check the age group you belong in.
4. What is your current (or former, if unemployed or retired) occupation?
5. Do you currently hold or have you in the past held a position on a community board or committee?
6. What are your main criteria or considerations in deciding where to volunteer your time?
7. Please rank your top 3 reasons for volunteering for the vernal pool project.
8. How did you originally become interested in vernal pools?
9. How did you learn about the opportunity to participate in this vernal pool survey?
10. When you were asked to become a part of this project, what influenced you to decide to participate?
11. Please rate the level of satisfaction of your volunteer experience with this project.
12. Would you be willing to volunteer for this kind of work in the future if asked?
13. If you were asked to, would you be willing to take on a larger role by helping to organize future projects or become a coordinator for your town?
14. Do you feel you are more active (or will be more active) in the community as a result of your experiences with vernal pools? Explain how and why.
15. Do you have more awareness and concern for the impacts of development in your town? Please explain.
16. Have you shared your knowledge about the importance of conserving vernal pools? Please explain.

Are there any suggestions for improvement or comments regarding the Best Development Practices Manual?

Are there any suggestions for improvement or comments on this project?