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EXPERT PERCEPTIONS OF APPROACHES TO PROTECTING ISOLATED WETLANDS IN THE NORTHEASTERN UNITED STATES[1]

Kristin Floress, Mary Beth Kolozsvary, and Jean Mangun[2]

ABSTRACT: In this article, we describe how protecting vernal pools was discussed by experts in the northeastern United States (U.S) within the context of a theoretical policy framework. We offer insight about characteristics of feasible vernal pool policy solutions, and identify gaps in our understanding, particularly regarding conditions in states currently lacking specific vernal pool protections. Vernal pools are geographically isolated, intermittent wetlands that provide important habitat for a variety of plants and animals. Many may not be federally protected as a result of judicial decisions over the past two decades, and the rule intended to clarify what qualifies for federal protection is currently being reviewed by the courts. Thus, state or local policy approaches may be alternatives to conserving vernal pools. We interviewed vernal pool experts in the northeastern U.S. regarding approaches to vernal pool protection and analyzed their perceptions through the lens of Kingdon's (2011) multiple streams policy development framework. The framework denotes 13 characteristics of three processes associated with policy development: problem identification, policy solution development, and the impacts of politics. While analyzed for all 13 components, we found participants most often discussed feasibility of policy formulation and implementation, particularly with regard to protecting vernal pools of high value while also remaining within the bounds of what public opinion supports.

(KEY TERMS: environmental regulations; Rapanos; seasonal wetlands; SWANCC; water policy; interviews; Clean Water Rule; multiple streams framework.)

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INTRODUCTION

Expert information and scientific knowledge is incorporated into developing and implementing policy tools in various ways (Weible, 2008; Oliver *et al.*, 2014). Frameworks developed to understand the policy process account, at least to some extent, for the use of expert information, but studies tend to focus on how experts provide information for regulatory policy processes (*e.g.*, Kingdon, 1984, 2011) or how policy makers use expert information (Oliver *et al.*, 2014) rather than developing knowledge of how experts perceive conditions related to policy solutions. In this article, we document how a set of experts in the northeastern United States (U.S.) discuss existing and potential state and local approaches — regulatory, voluntary, and capacity-building policy tools — to protecting vernal pools and the species they are likely to harbor. We explore their opinions about

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[2]Research Social Scientist (Floress), Northern Research Station, U.S. Forest Service, 1033 University Place, Evanston, Illinois 60201; and Assistant Professor (Kolozsvary) and Professor/Chair/Associate Dean (Mangun), Department of Environmental Studies and Sciences, Siena College, Loudonville, New York 12211 (E-Mail/Floress: kfloress@fs.fed.us).

policies for conserving vernal pools and the factors they view as constraining or facilitating feasible policy development and implementation.

Context of Vernal Pool Protection

Vernal pools are small, seasonally flooded wetlands that reach their maximum size in spring and lack connections to permanent surface waters (*e.g.*, streams, ponds, lakes) (Colburn, 2004; Paton, 2005). These pools harbor a unique suite of species — including aquatic invertebrates [*e.g.*, fairy shrimp (Family: Chirocephalidae) and pool-breeding amphibians (*e.g.*, wood frogs (*Lithobates sylvaticus*), ambystomatid salamanders (*Ambystoma* spp.)] — that are able to use them for breeding or foraging (Wellborn *et al.*, 1996; Snodgrass *et al.*, 2000; Colburn, 2004; Paton, 2005). Seasonal timing and the length of time vernal pools are inundated, along with their association with surrounding forested uplands, determine the diverse biological communities they support (Snodgrass *et al.*, 2000; Babbitt *et al.*, 2003; Paton, 2005; Werner *et al.*, 2007). The periodic dry phase and isolation from permanent surface waters prevents predatory fish populations from becoming established, allowing vulnerable species to successfully reproduce (Semlitsch, 2000; Zedler, 2003). Declines in these vernal pool-breeding species have become a concern in recent decades (Paton, 2005; Windmiller *et al.*, 2008), and Zedler (2003, p. 599) states that, for these species, "...vernal pools are not marginal, but essential [habitat]."

Despite their importance to biota, the status of vernal pools with regard to environmental protection at state and federal levels is uncertain due to their ephemeral nature and lack of visible hydrologic connectivity to permanent surface waters. This uncertainty has largely stemmed from two Supreme Court of the U.S. decisions that have impacted what can be considered "waters of the U.S.," and thus within the jurisdictional reach of Clean Water Act §404 (Table 1).

The 2001 *Solid Waste Agency of Northern Cook County v. U.S. Army Corps of Engineers* (531 U.S. 159, commonly referred to as "*SWANCC*") and 2006 *Rapanos v. United States* (547 U.S. 715, commonly referred to as "*Rapanos*") decisions created a *de facto* category of "vulnerable waters" (ELI, 2011). It included many small, perennial, intermittent, and ephemeral streams and geographically isolated wetlands, and required case-by-case evaluation to determine whether the water body individually or with "similarly situated" waters represented a "significant nexus" to traditional navigable waters. Assessing such geographic, hydrologic, and ecologic connections to a downstream navigable water can be arduous and expensive.

In 2011, the Corps and U.S. Environmental Protection Agency (USEPA) drafted revised guidance intended to further clarify jurisdictional waters (United States Environmental Protection Agency and United States Army Corps of Engineers, 2011; see Table 1), but it was not finalized due to considerable backlash from a number of interest groups (Meltz and Copeland, 2015; Copeland, 2016). Instead, the formal rulemaking process was undertaken and a finalized definitional rule was published in June 2015 (the "Clean Water Rule," 80 FR 37054-37127, June 29, 2015). The Clean Water Rule focuses on clarifying the regulatory status of the types of waters directly affected by the *SWANCC* and *Rapanos* rulings and is intended to reduce the number of waters requiring case-specific review and the costs associated with such an analysis (Alexander, 2015; Copeland, 2016). However, lawsuits were filed by regulated interests, environmental interest groups, and individual states before the rule became final (Copeland, 2016), and its implementation is currently stayed (see Table 1). The stay remains in place pending a determination by the courts on jurisdiction to review the rule (Copeland, 2016).

Thus, some states, local governments, and nongovernmental organizations have taken policy actions over the past two decades to protect and conserve vernal pools (Kusler and Christie, 2006; ELI, 2011). A number of studies on approaches to developing vernal pool policies and programs have been conducted in the northeastern U.S. Notably, Preisser *et al.* (2000) used a participatory process to describe stakeholder interests regarding vernal pool protection and a number of papers coauthored by A.J.K. Calhoun also examine policy development processes (*e.g.*, Oscarson and Calhoun, 2007; Calhoun and Reilly, 2008; Hart and Calhoun, 2010; McGreavy *et al.*, 2012). Solutions offered to protect vernal pools have included Best Development Practices through local planning (Calhoun and Klemens, 2002), using citizen science to inform local, proactive vernal pool policies (Oscarson and Calhoun, 2007; Calhoun and Reilly, 2008), and communicating with landowners more effectively to garner support for protecting vernal pools (Jansujwicz *et al.*, 2013). Many of these earlier studies are rooted in human dimensions but outside of a specific policy framework. More recently, Levesque *et al.* (2017) used an institutional analysis approach to understand a collaborative approach to developing vernal pools policy tools and McGreavy *et al.* (2016) investigated the impacts of citizen science on vernal pools policy and governance. Regardless of the lens used, the research on local and state level vernal pool conservation in the Northeast has focused on identifying

TABLE 1. Major Legislative, Judicial, and Administrative Actions Related to Vernal Pool Jurisdictional Authority.

Date	Legislative, Judicial, or Administrative Action	Description
1972	Federal Water Pollution Control Act Amendments (CWA)	§404 enacted through amendments
1975	*Natural Resources Defense Council v. Callaway*, 392 F. Supp. 685	D.C. District Court orders the Corps to broaden the scope of its jurisdiction (thus "waters of the United States"; as a result, Corps (with USEPA guidance) promulgated regulation extending its jurisdiction to wetlands and other waters "contiguous or adjacent to coastal waters, including periodically inundated saltwater and freshwater wetlands"
1985	*Riverside Bayview Homes, Inc. v. United States*, 474 U.S. 121	Decision found the Corps' interpretation of "navigable waters" as encompassing adjacent wetlands reasonable
1985-2001	Migratory Bird Rule (MBR)	The Corps and the USEPA used the MBR to protect intrastate surface waters used as habitat by migratory bird species that crossed state lines whether or not these water bodies could be classified as traditionally navigable
2001	*Solid Waste Agency of Northern Cook County (SWANCC) v. U.S. Army Corps of Engineers*, 531 U.S. 159	Decision effectively excluded isolated wetlands from WOTUS, finding that the statutory authority of the Corps extended only to wetlands exhibiting a "significant nexus" to a traditional navigable water. Presence of migratory birds alone exceeds authority under CWA
2001-2006	The Association of State Wetland Managers, Inc. SWANCC guidance	"...field staff should, based on court decisions to date, have confidence that courts will support a broad interpretation of 'waters of the United States' and a narrow interpretation of SWANCC"
2006	*Rapanos v. United States*, 547 U.S. 715	Supreme Court vacates Sixth Court ruling that immediate adjacency is not required to be considered WOTUS. Decision interpreted that a "significant nexus" is required instead
2008	Corps and USEPA Guidance	Issued guidance for implementing CWA jurisdiction
2011	Corps and USEPA proposed revised guidance	Guidance for regulated entities intended to clarify jurisdiction. The proposed revisions were "...built on the existing guidance with modifications that the agencies believed were consistent with the CWA, the Court's rulings, and science"
2014	Corps and USEPA begin rule promulgation process	A formal notice-and-comment rulemaking process began to clarify what types of water bodies constitute WOTUS
August 2015	Final rule effective August 28	Rule clarifies WOTUS; recognizes the interrelatedness of water bodies and codifies jurisdiction over upstream sources to traditional navigable waters; clarifies the regulatory status of the types of waters directly affected by the SWANCC and *Rapanos* rulings; intended to reduce the number of waters requiring case-specific review and costs associated with such an analysis
October 2015	Stay on implementation of the Clean Water Rule	U.S. Court of Appeals for the Sixth Circuit placed nationwide stay on implementation; the stay remains in place pending a determination by the court on jurisdiction to review the rule
January 2017	Supreme Court of the United States	The U.S. Supreme Court agrees to determine which federal court has authority to hear challenges to the Clean Water Rule

Note: Corps, Army Corps of Engineers; CWA, Clean Water Act, as the Federal Water Pollution Control Act came to be known; USEPA, U.S. Environmental Protection Agency; WOTUS, waters of the United States.

various issues with and approaches to developing policies to protect vernal pools.

Policy Choices and the Multiple Streams Framework

Several prominent frameworks examine policy choices and include the role of different actors in the process. The advocacy coalition framework (Sabatier and Jenkins-Smith, 1988), for example, examines how coalitions around issues compete to achieve their policy goals. The institutional analysis and development framework (described in detail in Ostrom, 2011) provides a systems approach to examine multilevel governance structures. In this research, we use Kingdon's (1984, 2011) multiple streams framework that was further operationalized by Zahariadis (2007) and which has been used to understand local to transnational policy choices (Jones *et al.*, 2016).

Kingdon's (2011) framework was developed through empirical study of federal policies in the U.S. related to transportation and public health, and is based on the premise that policies are developed at the confluence of three "streams" — problem, policy, and political — called the policy window. Table 2 defines the key elements of multiple streams.

TABLE 2. Description of Multiple Streams Framework* and Uses of Science.**

Multiple Streams Component	Subcomponents and Definition
Problem stream	**Indicators** — information used to illustrate a condition and its magnitude
	Focusing events — events that draw attention to conditions
	Feedback — information about programs through formal and informal channels
	Load — the institutional capacity to address problems
	Categories — distinctions between concepts that help define problems
Policy stream	**Technical feasibility —** the technical feasibility of proposed solution
	Resource adequacy — financial capacity for proposed solutions
	Values acceptability — acceptability of proposed solutions with regard to the role of government
Politics stream	**Party ideology** — political party norms for acceptable solutions
	Public opinion — how the public feels about conditions, problems, solutions
	Balance of interests — balancing the interests of affected stakeholders
Policy window	**Coupling** — attaching solutions to problems and vice versa
	Coupling logic — the "...arguments used to couple streams..." (Jones *et al.*, 2016, p. 16)
	Election/change in elected officials — elections can trigger changes in administration and open, close, or shift policy windows
	Decision style — the level of caution of elected officials
Actors	**Visible participants** — people such as elected officials receiving media attention who set the agenda
	Hidden participants — people such as agency staff, academics, consultants who work on policy solutions
	Policy communities/networks — groups of specialists across governmental and nongovernmental organizations who have some degree of interaction
	Policy entrepreneurs — people who couple streams; need resources, access to agenda setters; can be visible or invisible
Uses of science	**Instrumental** — based on rational planning, science is objectively incorporated into policy during the policy development process.
	Learning — decision makers slowly accumulate knowledge over time, and change their beliefs about an issue and its solutions
	Political — expert information is used or distorted (potentially selectively) to support decisions

*Adapted from Zahariadis (2007) and Jones *et al.* (2016) figures. Our adaptations are informed by Kingdon (2011). While Zahariadis and Jones include "Policy community" as a part of policy stream, Kingdon was careful to draw a distinction between people and process. Thus, we include "Actors" as separate component representing people. There are interactions among components. A focusing event, for example, can open a policy window.

**Adapted from Weible (2008).

The problem stream requires recognizing when conditions are mismatched with what people value (their "ideal state," Kingdon, 2011, p. 116). *Focusing events* can suddenly trigger this recognition (Kingdon, 2011), while *indicators* used over time to track conditions may draw attention less dramatically (Jones *et al.*, 2016). For example, Brunner (2008) identified reports on the state of the science and public opinion (indicators) along with the movie *An Inconvenient Truth* (focusing event) contributing to the development of emissions trading policy in Germany. Other processes, like f*eedback* from monitoring, draw attention to problems, but attention to problems can wane because the condition normalizes over time (Kingdon, 2011) or because the *load* — institutional costs of addressing it — are overwhelming (Downs, 1972; Kingdon, 2011). Finally, *categorization* of issues is an important component of problem definition. In his study of transportation policy in the U.S., Kingdon (2011) found that, "The category [transportation for people with disabilities as opposed to transportation generally] into which the issue was placed made a tremendous difference." That is, how an issue is conceptualized (for example, as a habitat issue or water quality issue) impacts how it is received.

The policy stream consists of policy actors who discuss, formulate, and combine potential policy solutions (Zahariadis, 2007). Potential policies must be consistent with accepted *values*, be technically *feasible*, and there must be *adequate resources* to implement them (Kingdon, 2011). Bipartisan environmental policies developed in the 1960s and 1970s reflected the broad consensus of lawmakers that environmental conditions were unacceptable and solutions feasible, but since that time there has been little such agreement among legislators at the federal level about environmental policies (Klyza and Sousa, 2008). Instead, policy discussions related to environmental protection have primarily focused on economic losses, and solutions are left unaddressed by Congress and instead taken up by the states and courts (Klyza and Sousa, 2008).

The politics stream is characterized by policy makers who take proposed solutions and act upon those that are acceptable. Policy solution acceptability is impacted by how policy makers perceive the problem's importance and how the solution will be

received among constituents and interest groups. Policy makers assess *public opinion* with regard to the problem and its solution and the degree to which proposed policies *balance the interests* of those impacted by decisions (Kingdon, 2011). Options elected officials are willing to consider are also constrained by *party ideology* that provides a set of norms for what solutions can be considered acceptable (Kingdon, 2011).

The problem, policy, and politics streams coexist separately and overlap during policy windows recognized by *policy entrepreneurs* as optimal times for policy shifts (Zahariadis, 2007; Kingdon, 2011), as was the case with environmental policies in the 1960s and 1970s. Policy windows may occur because of predictable events like *elections* or rare focusing events, and policy entrepreneurs take advantage of these events to link their preferred policy solutions together with the other streams in a process called *coupling* (Kingdon, 2011). The *decision style* of elected officials — their aversion to risk or willingness to take risk — also impacts how a policy solution is perceived.

Expert Information

A number of actors play roles in defining the problem, solutions, and political acceptability of alternatives. Kingdon (2011) describes "hidden participants" as academics, agency personnel, and others who impact policy through developing policy solutions. In this article, we focus on experts who provide information that impacts policy processes, even though such information rarely is incorporated in the discrete progression of stages from problem formulation to solution development described by the rational planning process (see, for example, Sabatier, 1987; Weible, 2008; Kingdon, 2011; Alexander, 2015). This rational use of expert, scientific information, what Weible (2008) terms "instrumental," is not the only or even the primary way expert information in used for policy purposes. There is also a learning use, where knowledge accumulates over time and impacts policy actors; and a political use, where information about a problem is used — sometimes selectively — to support policy decisions (see Table 2). Weible (2008) is careful to differentiate between expert and local information, as the former may be perceived as more legitimate. However, Weible's (2008) distinction does not take into account the role of citizen science in natural resource management, and how scientific information generated from these processes can potentially impact policy at various administrative scales.

Policy itself is often defined, if it is defined at all, as regulations that recognize an authority capable of enforcing regulations on regulated entities (termed "authority tools" by Schneider and Ingram, 1990), although other instruments (*e.g.*, capacity building, incentive) can achieve policy goals. Experts are discussed as generators of information that can be incorporated into decision making, with the primary focus on the role of the information generated (*e.g.*, Alexander, 2015) or how those developing regulations use or perceive expert information (*e.g.*, Jennings and Hall, 2012; Oliver *et al.* 2014). The converse — how disciplinary experts perceive policy approaches regardless of whether they directly participated in a process — is rarely considered.

The Current Study

This investigation was initially driven by the need of the Northeast Partners in Amphibian and Reptile Conservation to understand expert perceptions about technically feasible solutions for protecting vernal pools in the region and what might facilitate or constrain those solutions. The themes identified during the first stage of the iterative, inductive process of coding expert interviews revealed a number of significant similarities among their comments and the components of the multiple streams framework. A key strength of postpositivist, qualitative methods is the ability to adapt the research to patterns that emerge from data, rather than strictly adhering to a question formulated and investigated in a linear fashion. We therefore used the multiple streams framework as a lens through which we could better understand how vernal pool experts discussed the presence, absence, and extent of multiple streams components in their descriptions of existing and potential policy solutions, not as an *a priori* conceptual framework. This approach expands the current body of knowledge on vernal pools policy solutions in the Northeast by documenting expert opinions and placing them within the context of an established policy framework, providing insight for those interested in understanding this group and their views on approaches to vernal pool protection. It also allows for exploring the application of the multiple streams framework outside of a specific regulatory process but within the bounds of a defined problem. For instance, interviewing those involved in the policy processes associated with the Clean Water Rule would be a typical approach to examining a policy framework, but experts are rarely directly involved in such activities.

We also examine how participants discussed uses of science, and how their discussions related to multiple streams subcomponents. Because we consider "policy" to be the broad array of policy tools used to achieve goals, and we also consider citizen science as a method of generating scientific information, we do not limit the use of science only to information generated by experts alone. Rather, we broadly interpret use of science in policy processes as the ways in which scientific

information is generated and used instrumentally, politically, or for learning by any policy-relevant actors.

Our specific objectives were to (1) identify how expert discussions of policy approaches related to the subcomponents of the problem stream, policy stream, politics stream, and policy windows (see Table 2), and (2) identify how experts discussed the use and impact of science and expert information on policy development and implementation.

METHODS

Case Study Selection and Sampling

We conducted a single case study (Yin, 2009) of the northeastern U.S. in 2014. Comprised of 11 states (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont), all have established at least some additional regulatory protection for wetlands and 6 have policies that directly reference vernal pools (Figure 1, Table 3) (ELI, 2011; Kolozsvary *et al.*, 2014). These states are in a similar physiogeographic region: moving south or west, the physiogeographic region as well as the general climate and timing/seasonality of pools change substantially. Northeastern states are commonly grouped together when forming regional partnerships for conservation purposes (*e.g.*, North Atlantic Landscape Conservation Cooperative, Northeast Partners in Amphibian and Reptile Conservation).

We conducted semistructured interviews with vernal pool experts who had direct experience with vernal pool protection and were knowledgeable about the regulatory environment in their state using a snowball (a.k.a. personal network or chain) sampling strategy. Initial participants were identified through the Northeast Partners in Amphibian and Reptile Conservation vernal pools working group. Thirty-seven experts were ultimately contacted, and 32 who met the criterion of a current professional affiliation within the study area were interviewed and included in the analysis. Seventeen men and 15 women participated and were diverse in terms of occupations related to vernal pools, but were all within the broad categories of academics/researchers, consultants, managers, and nongovernmental organizations (Table 4).

Interview Guide

Interview questions focused on effectiveness of policies, approaches and barriers to protection, criteria for identifying vernal pools for protection, and threats to vernal pools (Table 5). Follow-up and probing questions were asked when appropriate. Interviews were recorded and transcribed for analysis.

Data Analysis

Transcripts from the 32 interviews were analyzed in NVivo 11 (QSR International Pty Ltd, 2016) software. The coding process described by Strauss and Corbin (1998) — open coding to thematically analyze text, axial coding to identify patterns in themes, and selective coding to identify central themes — was followed. Responses to each question were analyzed as a set in the open coding process based upon several *a priori* themes and additional themes and subthemes identified during coding. *A priori* themes included "approaches to vernal pool protection," "concerns," "stumbling blocks," "criteria," "effectiveness," and "states." One author and a research assistant coded the interviews during the open coding process, and intercoder reliability was established by sampling 5% of the answers to each question, coding the transcripts individually, and calculating agreement scores. Coding agreement ranged from 95 to 100%.

Similar to Jansujwicz *et al. (*2013) use of framing to understand how landowners conceptualize vernal pools, we applied multiple streams as a conceptual framework based upon initial results from open coding. Thus, after open coding, axial coding was completed whereby text within each open code was analyzed once again by the first author through the lens of the 13 multiple streams components and subcomponents and the three uses of expert information in policy (see Table 2).

Quotes could be assigned more than one code: for example, the following quote, "Maine, which has the strongest direct vernal pool regulations, it's still not working because it's so political. It depends on who the governor is — how the law's interpreted and enforced — and the mission of the regulatory agencies within the state changes," was coded as *political acceptability of issues*, *Maine*, and *policy effectiveness* during open coding. When coded for multiple streams components, it was coded as *party ideology* and *election/change in officials*.

Selective coding — the process of identifying patterns and a central theme or themes in the data (Strauss and Corbin, 1998) — was aided by examining coding similarity through complete linkage clustering and Jaccard's coefficient of similarity in NVivo 11 (QSR International Pty Ltd, 2016). Complete linkage clustering combines each unique code in sequential steps until all codes are in one cluster — if there were only a few codes, this process could be represented in a dendrogram. Coding similarity was

FIGURE 1. Map of Study Region.

TABLE 3. Northeastern State Level Policies Protecting Vernal Pools.

State	Laws or Rules	Vernal Pool Regulation Afforded by Policy
Connecticut	Inland Wetlands and Watercourses Act	Identify wetlands to be protected by soil drainage and landscape position; regulated by municipalities
Delaware	None	N/A
Maine*	Natural Resources Protection Act	Vernal pools that are "significant wildlife habitat," determined by abundant levels of at least one of four species or threatened or endangered species
Maryland*	Nontidal Wetland Protection Act	Nontidal wetlands falling within a number of criteria — with specific mention of vernal pools — are protected
Massachusetts*	Wetlands Protection Act	State certifies vernal pools; pools that meet jurisdictional requirements are regulated
New Hampshire*	Env-Wt 100, Env-Wt 301.01 and 302.04(a), RSA 482-A	Primary and secondary species as indicators of vernal pools; development permitting through Department of Environmental Services
New Jersey	Freshwater Wetlands Protection Act	Development of vernal pools meeting habitat, species presence/absence, and hydroperiod requirements permitted through Department of Environmental Protection
New York	Freshwater Wetlands Act	Wetlands smaller than 12.4 acres protected when they meet Class I criteria or are deemed to have "unusual local importance"
Pennsylvania	Dam Safety and Waterway Management	All wetland development is permitted through Department of Environmental Protection
Rhode Island	Rhode Island Freshwater Wetlands Act	All wetland development is permitted through either Department of Environmental Management or the Coastal Resources Management Council (which oversees freshwater wetlands near coast); regulated as "special aquatic sites"
Vermont*	Wetland Protection and Water Resource Management Rules; Act 250 Land Use Law	Vernal pools providing amphibian breeding habitat are considered significant and are protected. All significant wetland development permitted through Department of Environmental Conservation

*State has vernal pool specific policy.

examined for all multiple streams framework components along with the three uses of science in policy identified by Weible (2008). Jaccard's coefficient is the size of the union of each pairwise comparison of codes divided by the intersection of the two codes, where 0 indicates no coding similarity and 1 indicates complete coding similarity. In addition, comparisons of coding based upon whether a respondent's state had a vernal pool policy and their profession were also completed.

Technical feasibility and resource adequacy were merged into one code instead of being kept as separate subcomponents as participants tended to discuss them together: for example, the technical feasibility of achieving policy goals was related to having the resources to gather information. Because interviewees were asked about criteria that could be used to categorize vernal pools for protection, indicators and categories were also largely indistinguishable from each other as separate concepts and were merged.

Limitations and Trustworthiness

While the findings from this nonrandom sample are not generalizable to the population of all vernal pools experts in the Northeast, they are trustworthy representations of this pool of participants. Trustworthiness (Lincoln and Guba, 1985; in quantitative research, the corollary would be "rigor") of findings is supported by the following factors: Interviews were conducted until data saturation was achieved (*i.e.*, no new themes arose during interviews); there was a high level of intercoder agreement, indicating the constructs we present here were reliably found in the data; and, finally, the second author is continually immersed in the issue and among the types of experts interviewed for this study.

FINDINGS

The findings we present to fulfill our first objective focus on the relationships among multiple streams subcomponents that were most prominent in the data (Table 6). While participant comments were coded within 10 of the 13 subcomponents, three were central and highly interrelated: technical feasibility and resource adequacy, categories, and public opinion. Using feasibility as the central concept, we illustrate

TABLE 4. Composition of Interview Participants.

Gender	
Men	17
Women	15
Region	
New England	21
Mid-Atlantic	11
Profession	
Researchers	7
Consultants/contractors	8
State or federal manager/regulator	14
Nongovernmental organization	3
Vernal pool policy status	
Participant from state with policy	19
Participant from state without policy	13

TABLE 5. Interview Questions.

Q1	How would you rate the effectiveness of vernal pool protection or legislation at the state level across the Northeast?
Q2	Do you think there should be a blanket approach protecting all vernal pools or a threshold of importance by which only select vernal pools are protected by a state? Why?
Q3	Ideally, what criteria do you think should be used to identify vernal pools to be protected? Why?
Q4	In a realistic world when you consider politics, economics, *etc*., what do you think would be the best approach to developing effective statewide regulations for vernal pools?
Q5	Do you think any of the states' approaches to vernal pool regulations are good models to follow? What works for each and what does not?
Q6	What do you think is the biggest stumbling block to protecting vernal pools?
Q7	What are your feelings about an integrated approach that includes education or community-based citizen science?
Q8	What is your biggest concern about the future of vernal pools in the Northeast?

how participants discussed: categorizing vernal pools as separate from wetlands, difficulties associated with making policies based on different categories of vernal pool value, and how public opinion impacts whether policies that could achieve conservation goals are adopted. To fulfill our second objective, we follow these results with a description of how learning was discussed as the primary use of science in policy, and how the learning use of science was connected to feasibility and public opinion. We did not find major differences in the comparisons among participant responses based upon whether they were from a state with a vernal pool specific policy or upon their profession.

Feasibility, categories, and public opinion subcomponents had correlations ranging from 0.71 to 0.79 (Figure 2). We highlight the interplay among these multiple streams subcomponents in how participants discussed policy approaches for protecting vernal pools, particularly with regard to how vernal pools could be categorized for protection.

Objective 1: Policy Approaches in the Multiple Streams Framework

Categorization and Feasibility. The multiple streams framework defines technical feasibility as how well policies will achieve outcomes, and resource adequacy as the financial capacity to adopt and implement policies. To be feasible for achieving conservation goals, interviewees felt existing or potential policies must require adequate vernal pool buffers and take into account landscape level metrics and

TABLE 6. Results of Coding by Multiple Streams (MS) and Uses of Science.

MS Component/ Use of Science	MS Subcomponent	# of Interviewees Mentioning	Interview Questions with Any Text Coded within Each Component/Use*
Problem stream	Categories	31	Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8
	Feedback	11	Q1, Q3, Q4, Q7, Q8
	Focusing events	0	N/A
	Load	0	N/A
Policy stream	Network integration	4	Q4, Q7
	Feasibility	26	Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q8
	Values acceptability	9	Q1, Q2, Q5, Q6, Q7, Q8
Politics stream	Balance of interests	18	Q1, Q2, Q4, Q5, Q6, Q7, Q8
	Party ideology	4	Q1, Q4, Q5, Q6, Q8
	Public opinion	25	Q2, Q4, Q5, Q6, Q7, Q8
Policy window	Coupling/coupling logic	5	Q3, Q4, Q6
	Decision style	0	N/A
	Election/change in officials	6	Q1, Q4, Q5, Q6, Q8
Use of science	Instrumental	12	Q1, Q2, Q4, Q5, Q7, Q8
	Learning	16	Q2, Q4, Q5, Q6, Q7, Q8
	Political	2	Q4, Q8

*See Table 5 for questions.

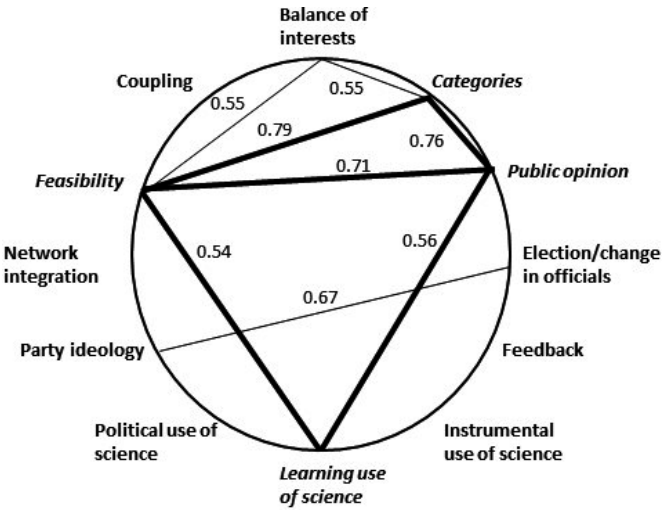

FIGURE 2. Correlations above 0.50 among Multiple Streams Subcomponents and Uses of Science.

meta-population goals. Participants who felt blanket protection was the best policy approach largely supported their opinions by discussing the resources necessary for categorizing more/less valuable vernal pools. "If you go with blanket protection, it certainly makes the task of protecting them easier from a delineator standpoint and management standpoint, because then you don't have to go in and assess every wetland."

Participants expressed concern that policies attempting to use a tiered approach to categorize pools would not adequately protect the function of vernal pools while also being very resource intensive. For example, one person said, "I feel like the thresholds that really protect what needs to be protected are far more complex than anything that could be put into an actual regulation. Because of the inter-relationships between vernal pools." Lack of resources to map and identify vernal pools was discussed, as was the technical feasibility of locating vernal pools at all. An interviewee said, for example, "I also think one of the biggest stumbling blocks is we don't know where they are. They're small, they're hard to find, so we don't really have a good understanding of where they are on the landscape."

The use of indicators for categorizing vernal pools and the impact on indicator choice in terms of feasibility was also discussed. Participants noted the difficulty associated with categorization based on species presence. While almost all participants mentioned the presence of specific species as a good criterion for protection, several also noted that variation in individual pools could lead to less protection than needed. "Vernal pools have high variability," one interviewee said, "Populations of many species, especially the amphibians, can vacillate widely from year to year. I think there's a lot of pools that may not have species in them for several years that might be really critical for keeping regional populations of vernal pool species alive." Further, the presence of a threatened or endangered species could also trigger protection, but may not be present in a pool if the pool is not observed at the right time.

Participants did not agree on whether current state policies effectively solve the problem, regardless of whether vernal pools were categorized as protected by general wetland or vernal pool specific legislation. Along with poor enforcement, inadequate buffers were noted as a critical issue. Categorization for protection is not, alone, enough if the protection strategy triggered is not effective. One interviewee said,

> *In Massachusetts there's a hundred foot buffer all around vernal pools, but that only counts if they fall in a wetland resource area. There's this [buffer] but biologically it doesn't really do all that much for you. If you develop everything but a hundred feet around a vernal pool, you've probably nuked all the salamander populations, and the wood frog populations, and you've transformed the hydrology, too. It's such a weak protection that it doesn't do you that much good, and then at the same time it ends up ticking off a lot of people. You have pools that probably aren't worth anything that you're spending political capital on.*

Public Opinion and Feasibility. The last quote illustrates a major issue participants discussed: while the feasibility of categorizing vernal pools on a tiered scale of protection value was viewed somewhat negatively from a technical and resource standpoint, many participants also saw it as the best solution when considering public opinion. A blanket approach to protecting wetlands including vernal pools is contrary to how participants perceive the current public mood focused on property rights, economic growth, and limited government interference. For example, one person said, "I think we won't make a lot of effective progress if we try to regulate everything. . .there's so much resistance to protection of the pools out there, that it seems to me prioritizing the higher value pools is a good idea. . .you get a better balance than you would if every single spot is protected." Another stated, "You need to identify through some kind of a rating system the vernal pools that are the most important in the landscape, and theirs would get some kind of special protection above and beyond anything else. And I think the public can buy that from a political standpoint." Others felt that even categorizing vernal pools as a resource separate from wetlands was difficult because of public opinion: "It is such a political hot potato. The outcry against wetland regulations, and then they're putting another layer of regulations for a resource that people feel like is in everybody's backyard."

Taken together, public opinion and widespread vernal pool protection across a state were seen as somewhat incompatible. Some interviewees, however, discussed the need for top-down and bottom-up policy tools. Maine, which requires municipalities to enforce regulations to protect vernal pools and allows alternative policy development, was discussed as more likely to successfully address challenges related to categorizing vernal pools appropriate for protection. Local approaches to developing these policies were thought to improve public opinion for vernal pool protection. Interviewees discussed more feasible policies as ones that incorporated stakeholder input either in the policy development process or through citizen science.

Public opinion at local and state levels was noted as being impacted by stakeholder involvement. Interviewees stated that people engaged in local policy development processes would take actions such as calling their legislators to support vernal pools protection, and communicating the value of vernal pools to others in their community. "It raised awareness, some of which created more opposition, but for the most part improved the visibility and importance of vernal pools and increased support for protection," one person said about citizen science. Others, however, saw the local development of regulations as inadequate. "I think when it boils down to local protection, I think you get less consistent control, less consistent protection," one person said.

Objective 2: Uses of Science in Policy Processes

The cluster analysis results show that the learning use of science, as adapted for this study, was highly related to several multiple streams components (see Figure 2). The two subcomponents with which learning was most highly correlated were public opinion and feasibility (Jaccard's coefficient = 0.56 and 0.54, respectively), though other components were also related. Here, we focus on how the learning use of science, feasibility, and public opinion were interrelated.

Learning was discussed as an outcome of citizen science that could impact public opinion and also as a means of shifting how affected interests — like developers — feel about vernal pool protection. Some viewed local approaches in states without significant vernal pool protections as necessary, and others noted how science learning at the local level impacted outcomes beyond the individual to a broader network of people. One said:

> *If we can get people more aware of the value of natural resources, and get them to make more informed, responsible choices in their own lives, that's really the hope we have. Ultimately you can do so much with regulations, but you really need the public engaged. We really do need that public engagement. . .The more people take ownership of their area, the more community pride, state pride, country pride that people have. The outcomes of that sort of pride that is generated from being part of a group can have really great effects on conservation.*

The role of activities that promote learning and data collection were also discussed in relationship to accomplishing on-the-ground actions and positively impacting feasibility. One participant discussed Massachusetts' approach, which engaged nongovernmental organizations and stakeholders to assist with data collection and mapping efforts. "That's where the real power of state regulations can be, because at the state level you can work toward what will be feasible in your state and you can provide the flexibility for different areas within the state to work toward conservation," they said. Another said, with regard to a voluntary certification program, "That program included massive amounts of education. . .and it is citizen science. It is people saying, 'I've got a vernal pool in my backyard and I want to document that.' I think that program combines the best of really solid environmental education and citizen science." However, the issues Weible (2008) identified with regard to perceived legitimacy was also discussed by a participant who connected learning and instrumental uses, stating,

> *As soon as you propose new wetlands regulations, there are more lawsuits and more attorneys involved than scientists. So, I would propose here that we collect more data on the science, whether it's citizen science [or otherwise], recognizing that [citizen science] has a value that can be challenged because it may not all be collected the same or be scientific research.*

One additional, important point about how participants framed the different uses of science needs to be made. If a less stringent requirement for identifying key categories (*i.e.*, coding correlation of 0.30 instead of 0.50) had been used in this study, the instrumental use of science would have appeared as connected to categorization, balance of interests, feasibility, and public opinion. Most notably, participants recognized the limitations of the instrumental use of science in policy formulation when it is balanced with other considerations by policy makers.

DISCUSSION AND CONCLUSIONS

What does a technically feasible, publicly supported policy to protect vernal pools look like?

Experts who participated in this research were not in full agreement about an answer to that question. They did, however, agree generally that adequate buffers and landscape scale metrics need to be considered. Their discussions of how or why categorizing vernal pools for protection were tied to public opinion and feasibility: the tiered approach to protection would be best for public opinion, but technically difficult to implement and very resource intensive. The multiple streams framework was useful for contextualizing the experts' perceptions with terms that are well-defined and applied across disciplines. It also illuminates conditions or roles potentially inappropriate for experts to address or fill — such as acting as policy entrepreneurs who advocate for particular policy solutions — that may not be currently adequate to couple the three policy streams for further protection of vernal pools. Kingdon's (2011) framework put forth that solutions need to be coupled with things the public values. For instance, public concerns about compromised drinking water quality, stormwater retention, and flood control could be used to frame wetlands protection as an economic gain rather than a loss.

Much of the research on multiple streams focuses on the three streams rather than the subcomponents that are the core of the framework (Jones *et al.*, 2016), and thus provides sparse literature to which we can compare our findings on the core subcomponents. However, we see a number of relationships between our research, the battle in the courts over defining waters of the U.S., and the studies of vernal pools policy development conducted in the Northeast.

Categorization has been at the core of vernal pools discussions. At the federal level, what can be considered waters of the U.S. and thus protected under the Clean Water Act, is still under consideration. Further, the federal level challenges of determining what constitutes a significant nexus have been experienced at lower administrative levels of government. The participants in our research felt that feasible policy solutions for vernal pools are difficult to develop because of public opinion and resources needed to categorize pools for protection. Citizen science and community-based conservation were seen by some of our participants as solutions for shaping policy and improving science through data collection and learning, and is evident in other work that has been done in the Northeast (*e.g.*, McGreavy *et al.*, 2012, 2016).

Our research was not originally framed using multiple streams. Only through the first stages of coding did the similarities between what participants were discussing and elements of multiple streams become apparent. Even so, only three of the thirteen multiple streams elements were never discussed (load, focusing events, decision style). Others were often discussed (*e.g.*, balance of interests), but were not highly related with other prominent themes. Politics and performing as policy entrepreneurs are likely not central foci of our participants' jobs: Like Weible (2008) describes, many may view themselves as having instrumental impacts on policy through their work on defining problems and informing policy feasibility. In our study, experts tended to recognize the limitations and potential uses of the information they generate and how such information is but one piece in a complex system of considerations impacting policy.

Participants did not discuss how science could be used for political purposes or how decisions and rules at the federal level could potentially provide opportunities (policy windows) for states to fill gaps in protections. The use of science was solely discussed as instrumental or learning. The learning use of science at the local level, which impacted the knowledge of local participants and thus had impacts on policy support, was highly related to feasibility and public opinion in participant discussions. The use of science — learning or otherwise — by policy makers at higher levels, though, was not a central theme in our data.

As evidenced from the literature on developing and studying citizen science programs (*e.g.*, McGreavy *et al.*, 2016; Levesque *et al.*, 2017), it seems at least some experts are taking on the role of leading or participating in local efforts to provide trustworthy information that can be incorporated into policy and program development. It may be that adaptive governance approaches at lower administrative scales that increase learning and trust at those levels (*e.g.*, McGreavy *et al.*, 2016; Levesque *et al.*, 2017) — what one interviewee termed "...a top-down and bottom-up, hybrid approach..." — are the primary, most feasible means to protect vernal pools in states with supporting legislation.

Future Research

As policy systems become more centralized, conflict increases (Weible, 2008). Is it feasible, then, for states to develop ecologically based guidelines to categorize vernal pools for protection, have resources adequate for identifying and categorizing pools, and implement programs to protect pools all while having public support for doing so? Our exploration in this article suggests such a solution is almost impossible, but deeper understanding of approaches — particularly in states with very little to no protection for vernal pools — is necessary and is currently a large gap in our understanding. If both top-down and bottom-up approaches are needed to protect vernal pools, what is happening in states with no top-down policy? One clear research

need is to examine the roles of scale and devolution of power to implement policies. How have bottom-up approaches emerged (or not) to fill potential gaps in protection at the federal and state levels as policy windows to do so open? Are collaborative approaches, citizen science, and other institutional designs most prevalent and successful only when there is strong state level legislation? Following similar approaches in watershed management (*e.g.,* Prokopy *et al.*, 2015), what types of events have focused attention on the problem? With regard to the role of expert opinion in policy development, are there characteristics of experts that tend to be associated with how they view their role in policy development? For instance, is age associated with an expert's opinion of their role or how that role can be carried out? Answering these questions will help those interested in protecting vernal pools and their functions in the landscape understand and more effectively participate in the policy process.

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