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Incorporating biodiversity in municipal land-use planning: An assessment of technical assistance, policy capacity, and conservation outcomes in New York's Hudson Valley

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ABSTRACT

In the United States, municipal governments play an essential role in creating plans, policies, and procedures that consider biodiversity. However, municipal leaders do not always have the knowledge or capacity to integrate conservation into land-use planning effectively. Habitats and natural areas that occur outside of protected areas are vulnerable to incompatible land-use change and planning decisions made by local governments. Recent scientific evidence suggests that municipal actions are a critical dimension of biodiversity conservation. Yet adaptations are needed to foster municipal policy and practice that would yield more meaningful conservation outcomes, including increasing the capacity for conservation planning by local governments. Our research examines how biodiversity conservation measures are included in the planning and decision-making of local municipal officials who participated in a biodiversity outreach program in the Hudson River estuary watershed in New York State, as compared to a sample of non-participants. Our analysis of biodiversity program participants illuminates factors that support or hinder their consideration of biodiversity in land-use planning. Our findings demonstrate how both individual and municipal policy capacity significantly influence the adoption of plans, policies, and procedures that address the need for biodiversity conservation at the local level. Even where capacity is high, municipal officials experience political and other barriers that prevent them from pursuing effective biodiversity conservation measures in land-use planning.

1. Introduction

Globally, land-use change has been the primary driver of the decline in terrestrial and freshwater ecosystems since 1970 (IPBES et al., 2019). Therefore, the conservation of biodiversity depends, at least in part, on the myriad of land-use decisions (Brody et al., 2003; Haines-Young, 2009) made by municipal governments at village, city, town, and county levels (Aronson et al. 2017; Beatley, 2000; Dale et al., 2000; Wilhelm-Rechmann and Cowling, 2013). Whereas some areas of importance for biodiversity are protected as parks and preserves, most exist on private lands on different parcels in different jurisdictions, where uncoordinated, local planning decisions determine their fate. Ecosystems like forests and stream corridors cross municipal and parcel boundaries, and land-use decisions made by different municipalities can collectively degrade or support their value for biodiversity and the overall integrity of the broader ecological landscape. The land-use decision-making power of local governments has significant implications for biodiversity (Pierce et al. 2005; Soanes et al., 2019).

By integrating biodiversity information and conservation principles into land-use planning, decision-makers can help to reduce the negative impacts of development on biodiversity such as forest fragmentation, streamflow modification, and invasive species introductions. The term biological diversity (biodiversity) refers to the "variety of life on Earth at all its levels, from genes to [species and] ecosystems, and can encompass the evolutionary, ecological, and cultural processes that sustain life" (American Museum of Natural History, 2019). The complexity of natural systems and processes that sustain biodiversity do not readily integrate into the traditional framework of local planning, which often consists of parcel-scale decision-making, with little attention paid to biodiversity resources shared with neighboring communities or the larger ecological

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context. This mismatch can result in sprawling development patterns that use land inefficiently and have disproportionate impacts on biodiversity. In the upstate region of New York State, for example, the Brookings Institution reported that between 1982 and 1997, urbanized land increased by 30%, but the population only grew by 2.6% (Pendall, 2003). Rapid consumption of land and associated loss or degradation of habitat is a primary threat to imperiled species in the United States (Ewing et al., 2005). Incorporating biodiversity into land-use plans, policies, and procedures can be challenging (Azerrad and Nilon, 2006; Berke, 2008; Miller et al., 2009). For example, "many local land-use plans still only incorporate ecological principles and biodiversity considerations in a cursory way, if at all" (Berke, 2008, p. 408). Additionally, land-use planners may not know how to use the information, even when it is given (Berke, 2008).

In many communities, decisions about development are the responsibility of volunteers on planning and zoning boards, sometimes with input from volunteers on conservation commissions. These volunteers typically have minimal formal training (Kaplan et al., 2008), yet are expected to protect the health, safety, and welfare of their communities by making land-use decisions that consider drinking water, stormwater, climate change, traffic, parking, natural resources, viewsheds, lighting, street trees, economic impacts, as well as relevant local, state, and federal laws. While they may take advantage of educational opportunities, self-teach, and gain experience over time, this may not be adequate to fully understand the long term and far-reaching implications of their planning decisions (Kaplan et al., 2008).

The vital role of local land-use decision-makers in creating plans, policies, and procedures that conserve biodiversity is widely recognized (Beatley, 2000; Dale et al., 2000; Mason et al., 2007; Stokes et al., 2010). Accordingly, many conservationists and local government officials agree that biodiversity education in local, state, and federal government will help decision-makers integrate biodiversity conservation into their land-use planning efforts (Broussard et al., 2008; Miller et al., 2009; Rands et al., 2010; Stokes et al., 2010). While not a panacea, building policy capacity for biodiversity conservation at the municipal level is necessary to ensure local officials adequately address biodiversity in local plans, policies, and procedures.

By focusing on the unique opportunity to survey municipal officials trained in planning for biodiversity conservation, our research provides insights into how biodiversity is considered and acted upon in local planning processes. Focusing on those municipal officials that underwent biodiversity training, we investigate how biodiversity is represented in local plans, policies, and procedures that govern their community. For comparison, we also describe the municipal policy capacity of non-participants in the biodiversity training.

1.1. Land-use planning and biodiversity conservation

In many countries, local municipal governments have an essential role in determining how land is used and developed. New York State has given its counties, cities, towns, and villages the primary role in determining how land is used within their jurisdictions. The home rule provision in New York State's constitution provides authority for and delegates broad powers to regulate the quality of life and provide services for communities to local government (NYS Department of State Division of Local Government Services, 2018, p.33). Thus, local government institutions such as municipal boards, planning boards, and conservation commissions can play a crucial role in decision-making that impacts habitat protection (Brody, 2003a, 2003b, 2003c; Larson et al., 2017). In studies that identified factors that influence local government adoption of land-use plans, policies, and procedures that support biodiversity conservation, some found that biodiversity does not figure centrally into decisions (Miller et al., 2009; Stokes et al., 2009) and that it occurs in a reactionary, as opposed to a proactive, manner. For example, threats to biodiversity, not necessarily the presence of high-quality biodiversity, have been a significant driver of protection measures (Brody, 2003a, 2003b, 2003c; Hawkins, 2014; Locke and Rissman, 2015). Researchers also cited the values of the community and federal or state mandates as the most influential determinants of whether biodiversity conservation was integrated into land-use plans (Stokes et al., 2009). To more proactively protect biodiversity, researchers (Brody et al., 2003) recommended increasing awareness and action through monitoring activities, use of technical tools that assist in planning (such as geographic information systems or GIS), incentive-based policies, and public education and outreach programs.

1.2. Policy capacity

Policy capacity is comprised of the skills and competencies needed to perform policy functions such as formulation, decision-making, and implementation (Gleeson et al., 2009; Wu et al., 2015, 2018). Municipal decision-makers' knowledge, attitudes, and skills contribute to their capacity to produce preferred policy outcomes such as biodiversity conservation. Policy capacity translates into the government's ability to implement policy alternatives that provide public goods and services (Davis, 2000; Press, 1998). Research has not yet explored the role of policy capacity in how biodiversity measures are incorporated into land-use plans, policies, and procedures.

Municipal land-use planning decisions can be examined using policy capacity as an analytical lens. Analytical policy capacity is defined as the ability to access and apply technical and scientific knowledge and analytical techniques in policy (Howlett, 2009; Wu et al., 2015). In exercising their analytical policy capacity, policymakers effectively acquire and implement knowledge in the policy process (Adams, 2004; Leeuw, 1991; Lynn, 1978; MacRae, 1991; Radaelli, 1995). A high level of analytical policy capacity is a function of both supply and demand—access to a supply of useful information that can inform policy and demand on the part of policymakers for that information (Howlett, 2015).

Research highlights the need and demand for conservation-related training for land-use decision-makers (Wilhelm-Rechmann and Cowling, 2013). In examining the adoption of conservation assessment maps that support biological conservation by South African land-use planners, the authors found that planning capacity was inconsistent and highly varied across the land-use planners in their study. They noted the need for individualized training for land-use planners that links conservation-based planning with local needs (Wilhelm-Rechmann and Cowling, 2013). The corpus of studies demonstrates the value of building the capacity of land-use decision-makers through biodiversity training so that they can effectively apply knowledge in the planning process and realize policy outcomes.

Political dimensions of policy capacity pay close attention to the political aspects of policymaking, such as stakeholder engagement and policy advocacy, that can often dominate the process for undertaking policy actions (Fukuyama, 2013; Gleeson et al., 2009, 2011; Rotberg, 2014). The uptake of biodiversity information in the land-use planning process often depends on political support from the community and collaborators (Pierce et al., 2005; Theobald and Hobbs, 2002). Community values are crucial determinants of whether land-use officials will include biodiversity conservation measures in their comprehensive plans. Additionally, collaboration between and among jurisdictions is vital for incorporating biodiversity conservation into local planning (Stokes et al., 2010).

Political and analytical policy capacity are interlinked. For example, Pierce et al. (2005) created a comprehensive outreach and technical assistance program to build policy capacity for land-use decision-making in South Africa. Tools included conservation priority maps and guidelines, and training that covered the interconnectedness of biodiversity, sustainability, land reform, and environmental legislation. Post-training assessments showed that municipalities and consultants were using the program's handbooks. However, a few years later, almost no one was implementing the guidelines, despite the presence of

motivated trainees who were expected to keep the projects moving. This likely occurred due to a lack of support from the national government (Knight et al., 2011). While some successes were achieved, the authors cited the need for multi-disciplinary team members and engaged stakeholders, a comprehensive social context assessment, and sharing opportunities and actions (rather than identifying priorities only) as among the lessons learned. There was also a need for sustained training, technical assistance, and follow-up (Knight et al., 2011).

Financial and human resources are also critical dimensions of policy capacity as analytical policy capacity operates within the constraints of the organizational and socio-political systems within which policy-making occurs (Howlett, 2015; Wu et al., 2015). For example, financial resources in the form of increased funding opportunities were identified as a contributing factor in planners being able to perform conservation actions (Stokes et al., 2010). Concerning stakeholder engagement and staffing, in a study of Maine's "Beginning with Habitat" program, researchers found that greater stakeholder involvement was associated with more conservation actions (Kartez and Casto, 2008). However, they did not find that having a professional town planner in a facilitative role resulted in a statistically significant increase in the number of actions taken. This finding contrasts with other studies that found that having land-use planning staff and consultants specializing in biodiversity can increase capacity for local conservation activities (Hawkins, 2014; Miller et al., 2009). For example, Hawkins (2014) studied open space preservation through the use of residential subdivision ordinances that couple residential cluster development and open space protection via conservation subdivision design. Results showed that communities with professional planning staff had a significant and positive effect on the adoption of conservation-oriented subdivision bylaws and also had a positive impact on participation level (Hawkins, 2014).

2. Research questions and methodology

In this research, we empirically investigate policy capacity and its relation to how biodiversity is included in local land-use plans, policies, and procedures. We explore this question from the perspectives of municipal officials who participated in biodiversity conservation training. A sample of non-participants is incorporated into the study to illustrate how biodiversity-related capacity varies between participants and non-participants. Data collection entailed a quantitative, web-based survey of municipal officials in the Hudson River estuary watershed who participated in a biodiversity conservation program aimed at building

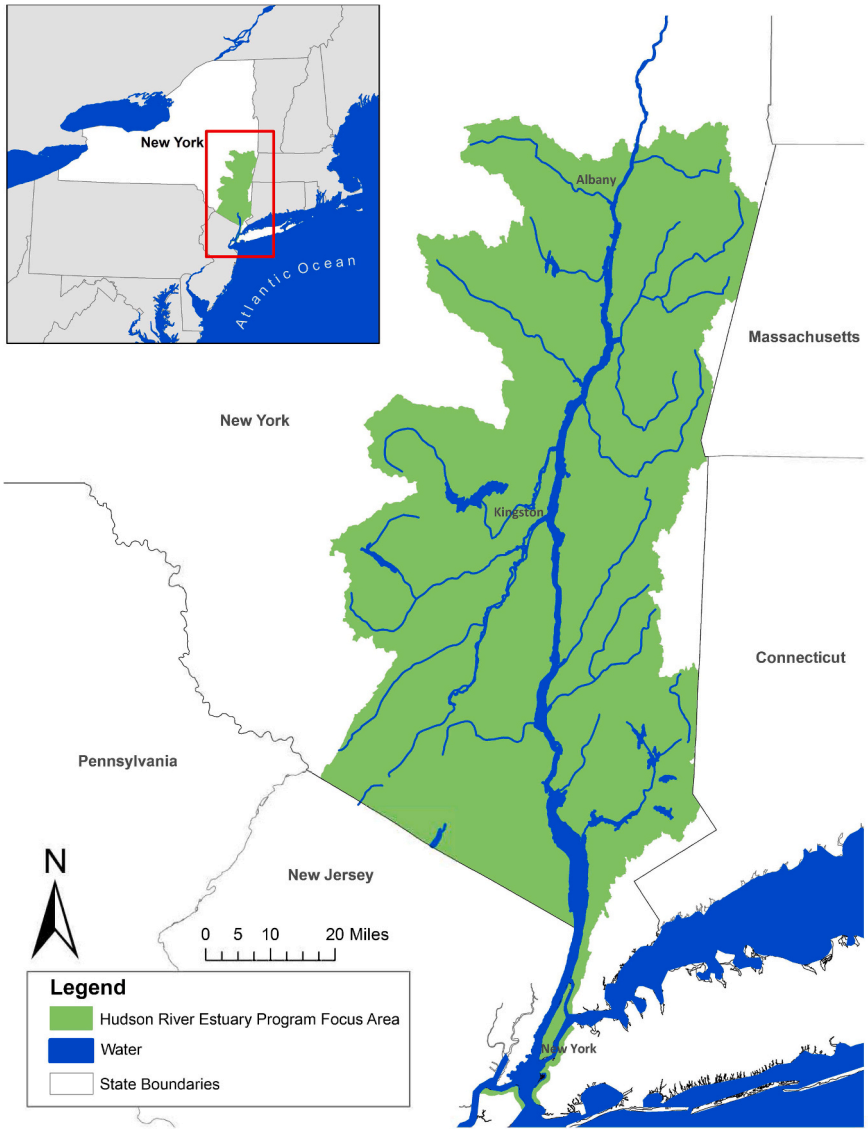

Fig. 1. The Hudson River Estuary Program provides conservation and land-use assistance to municipalities throughout the estuary watershed in southeastern New York State.

the capacity of local officials to incorporate biodiversity into municipal land-use planning. The unit of analysis in this study is the municipal decision-maker and, for Program participants, their self-report of whether they used Program information, assistance, and training to incorporate biodiversity in municipal plans, policies, and procedures in their city, village, or town.

2.1. Study area

The Hudson River begins at the highest elevation in New York State (U.S.) and runs 300 miles south to empty into the Atlantic Ocean at New York City, the largest U.S. city (Fig. 1). The Hudson River is a tidal estuary for about 150 miles from NYC (north to Troy, NY). The watershed of the Hudson River estuary (commonly known as the "Hudson Valley") contains a mix of shoreline cities, quaint villages, expanding suburbs, and pastoral towns with active farming communities. Situated between the State capital in Albany and New York City, its location makes it a popular place to live and visit and is prime for development. The watershed also contains biodiversity of national and global significance. Spanning more than 4 million acres, the Hudson Valley's varied geology and elevations set the stage for a diversity of habitats, such as pine barrens, grasslands, cliffs, mountain ranges, caves, streams, and wetlands, including globally rare freshwater tidal wetlands. Comprising only 13.5% of the land area of the state of New York, the region contains nearly 85% of the bird, mammal, reptile, and amphibian species that occur in the entire state. Approximately 150 species in the watershed are listed as threatened, endangered, or of special concern in New York State. Habitat loss and degradation are a threat to the biodiversity of the region. While land protection of large forested mountains and ridges has contributed to biodiversity conservation in the Hudson Valley, 90% or more of the suitable habitat for the region's birds, mammals, amphibians, and reptiles is found on private lands—where the individual planning decisions of 260 towns, villages, and cities can have significant and lasting impacts on biodiversity (Penhollow et al., 2006).

2.2. Background on the biodiversity conservation and land use program

The Conservation and Land Use Program (hereafter, "Program") is implemented by the NYSDEC Hudson River Estuary Program and Cornell University. The Program provides voluntary education and assistance to municipal decision-makers and regional conservation organizations (e.g., land trusts) to build capacity for biodiversity conservation in the estuary watershed (Strong et al., 2015). The Program works with partners to develop current, science-based regional conservation priorities, maps, and data sets. Program staff conduct outreach to raise awareness of the region's biodiversity priorities, create publications and tools to support local decision-makers, and provide technical assistance and grants to enhance the inclusion of conservation data, objectives, and principles into local plans, policies, and procedures. The Program engages directly with local government officials from villages, cities, and towns through presentations, workshops, roundtables, and customized assistance. Training focuses on how to use biological data and tools such as remote sensing (e.g., topographic, geologic, and soil maps), assessments in land-use planning (e.g., identifying important habitats and verifying in the field), and how to incorporate biological data in environmental reviews and land-use planning. Program engagement may be short-term (e.g., participation in a two-hour workshop) or longer duration (e.g., ongoing assistance). All municipal decision-makers in the Hudson Valley have the opportunity to engage, but participation is often the result of self-selected volunteers who choose to enroll or request assistance. The amount of assistance/outreach received was based on municipal/individual interest, not on geographic or biodiversity priorities.

2.3. Survey samples and survey methodology

We compared a sample of Program participants to a sample of non-participants to gain insights into the decision-making of biodiversity-trained municipal officials. By focusing on municipal officials that engaged in a program specifically aimed at providing tools, training, and support to bring biodiversity into land-use planning decisions, we can understand the impact and challenges in doing so. The Program participant sample was comprised of all past municipal official participants in the Conservation and Land Use Program, which is the leading biodiversity outreach program explicitly focused on land-use and conservation planning for municipal officials in this region. Local officials from 125 of 260 municipalities and other local and regional decision-makers and land-use planners in the Hudson Estuary watershed participated in the Program between 2001 and 2011.

We created a database of Program participants, which comprised individuals who attended Program workshops or received assistance sometime between 2000 and 2011. The database of approximately 700 individuals included municipal decision-makers such as members of planning boards, open space committees, comprehensive plan committees, zoning boards of appeals, or conservation advisory councils. These municipal positions capture the full range of roles and responsibilities in land-use planning at the local level, from the routine land-use decision-making of planning and zoning boards, to the environmental role of conservation commissions and land conservation responsibility of open space commissions, to the ad-hoc nature of comprehensive plan and zoning update committees. These roles can vary under different elected leadership and from one community to the next, and sometimes work collaboratively. People in these positions would all be capable of responding to questions regarding policy capacity.

The database was then edited to remove duplicate records and exclude those without a valid email address. The resulting database ($n = 592$) contained everyone's name, contact information, municipal information, programs attended, year of most recent program participation, and the total number of program hours. To identify non-program participants for the survey, we developed a list of conservation advisory council members, planning board chairs, and municipal planning staff for the municipalities that had not participated in the Program between 2000 and 2011. The final non-participant database included only individuals for whom we could find an email address ($n = 109$). The non-participant survey was administered to 109 municipal officials. While the comparative findings between participants and non-participants are useful in illustrating trends between the two cohorts, we are not attempting to attribute any causal relationships to the Estuary Program. The research was approved under Cornell University Institutional Review Board protocol # 1002001193.

In January 2013, Cornell University's Survey Research Institute implemented a web survey of participants and non-participants. The surveys and cover letters were sent to individuals from the participant sample lists via email. Up to four weekly reminders were sent to individuals who had not yet completed the survey. The survey remained open for approximately seven weeks. Of the 592 Program participants in the survey sample, 547 received surveys by email (45 email addresses were returned as undeliverable). Of the 109 non-participants in the survey sample, 104 received the survey (5 email addresses were returned as undeliverable). The survey measures and questions are detailed below.

2.4. Study variables

Study variables include measures of municipal capacity, individual capacity, influencing factors, and biodiversity measures in municipal plans, policies, and procedures. Gender, age, and educational attainment were also asked of both participants and non-participants (Table 1).

Table 1
Socio-demographic and individual characteristics of Program participants and non-participants.

	Participant *M*(S.D.) or %(n)	Non-participant *M*(S.D.) or %(n)	Chi-square (Phi) or Levene's independent samples T-test
Gender			
Male % (n)	50.2% (102)	54.8% (17)	$\phi = 0.074$, df = 1, p = 0.348
Female % (n)	49.8% (101)	45.2% (31)	
Mean age[a]	3.76 (202) n=202	3.71 (31) n=31	F = 2.026, df = 1, p = 0.848
Mean educational attainment[b]	3.48 (.734) n=202	3.16 (.860) n=31	F = 0.994, df = 1, p = 0.029
Mean years of experience in land-use[c]	3.32 (1.051) n=236	3.46 (1.144) n=39	F = 1.077, df = 1, p = 0.449
Self-efficacy[d]	3.89 (.862) n=210	4.11 (.796) n=35	F = 2.154, df = 1, p = 0.143
Municipal role in land-use[e]			
Town/village board or City Council			
Yes	7.3% (15)	4.8% (2)	$\phi^b = 0.038$, df = 1, p = 0.745
No	92.7% (190).	95.2% (40)	
Planning Board			
Yes	30.7% (63)	57.1% (24)	$\phi = 0.208$, df = 1, p = 0.001*
No	69.3% (142)	42.9 (18)	
Zoning Board of Appeals	3.4% (7)	9.5% (4)	$\phi = 0.111$, df = 1, p = 0.097
Yes	96.6% (198)	90.5% (38)	
No			
Conservation Advisory Council	43.4% (89)	9.5% (4)	$\phi = 0.263$, df = 1, p < 0.001*
Yes	56.6% (116)	90.5% (38)	
No			
Open Space Committee	15.1% (31)	0% (0)	$\phi = 0.171$, df = 1, p = 0.008*
Yes	84.9% (174)	100% (42)	
No			
Comprehensive Plan Committee	16.6% (34)	9.5% (4)	$\phi = 0.074$, df = 1, p = 0.348
Yes	83.4% (171)	90.5% (38)	
No			

[a] Age = 1 = under 35, 2 = 35–44, 3 = 45–54, 4 = 55–64, 5 = 65–74, 5 = 75 or older.
[b] Educational attainment = 1 = high school graduate, 2 = some college or technical school, 3 = bachelor's degree, 4 = graduate or professional degree.
[c] How long have you been involved in local land-use planning in a formal capacity? (1 = less than 1 year, 2 = 1–4 years, 3 = 5–9 years, 4 = 10–20 years, 5 = more than 20 years).
[d] I am confident my actions will make a difference (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree).
[e] What is your formal role in municipal land-use planning?
* $p < 0.05$.

2.4.1. Municipal capacity

We explored municipal capacity characteristics such as resources, staffing, and technical tools because of the stated importance of these attributes of policy capacity (Brody, 2003a, 2003b, 2003c; Broberg, 2003; Hawkins, 2014; Kartez and Casto, 2008; Miller et al., 2009; Wellstead and Stedman, 2010) (Table 2). The municipal capacity survey questions are detailed in footnotes of Tables 1, 2, 3 and 5.

For Program participants, municipal governance capacity was measured with a summative scale comprised of five questions: (a) My municipality has capable leadership, (b) my municipal elected officials work well together, (c) residents are engaged in municipal issues and decision-making, (d) my municipality will take steps within the next five years to conserve biodiversity and habitats, and (e) my municipality has adequate policies and procedures to conserve biodiversity (Response options were 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree). The municipal governance capacity scale had a Cronbach's alpha of 0.777% and 53.81% variance explained.

Stakeholder engagement is another vital dimension of policy capacity (Knight et al., 2011; Pierce et al., 2005; Stokes et al., 2010). Program participants and non-participants were asked to rate the degree of interaction with those internal and external to the board (Table 3). The survey question was asked, "*In the course of your land-use or conservation planning work, how often do you interact with the following*?" The survey question wording and response options are provided in Table 3.

2.4.2. Individual capacity

The seven measures of individual capacity included the extent to which the Program helped the participants' land-use positions, their motivation for participating in the Program (personal interest, leadership encouragement, or annual training requirement), and self-efficacy (confidence in actions) (Table 5). Total Program hours attended by participants were included along with whether they had held a leadership role in land-use planning (Table 5). The survey question wording and response options are provided in Table 5.

2.4.3. Biodiversity efforts in municipal land-use planning

The dependent variable measures whether and how municipal officials incorporate biodiversity conservation measures in the land-use planning process, such as using habitat maps in deciding where development should happen (and where it should be avoided), creating open space plans, and passing ordinances that protect biodiversity. While this is not a direct measure of biodiversity protection, these voluntary measures nevertheless provide insights into municipal decisions at the

Table 2
Municipal capacity characteristics (resources, staffing, tools) as reported by Program participant and non-participants.

	Participant *M* (S.D.) or % (n)	Non-participant *M* (S.D.) or % (n)	Chi-square (Phi) or Levene's independent samples T-test
Resources[a]			
Over the past 5 years, how have resources (e.g. budgets, volunteers, or information) available to your municipal board/ commission/committee or department changed?[a]	2.81 (0.962) n = 188	2.66 (0.865) n = 32	F = 0.036, df = 1, p = 0.402
Staffing			
Does your municipality staff the following positions (at least part time or more)?			
Planner: Yes	39.7% (54)	52.9% (18)	ϕ = 0.107, df = 1, p = 0.179
Planner: No	60.3% (82)	47.1% (16)	
Planner (consult as needed): Yes	89.2% (99)	94.1% (16)	ϕ = 0.055, df = 1, p = 0.531
Planner (consult as needed): No	10.8% (12)	5.9% (1)	
Wetland Inspector: Yes	13.6% (18)	10.0% (3)	ϕ = 0.042, df = 1, p = 0.768
Wetland Inspector: No	86.4% (114)	90.0% (27)	
Biologist/Ecologist: Yes	4.0% (5)	3.3% (1)	
Biologist/Ecologist: No	96.0% (119)	96.7% (29)	ϕ = 0.014, df = 1, p = 0.859
Technical tools			
Does your municipality use computer-based mapping (such as GIS) in land-use conservation planning review?			
Yes	71.1% (101)	50.0% (15)	ϕ = 0.171, df = 1, p = 0.025
No	28.9% (41)	50.0% (15)	

[a] Municipal resources scale: 1 = greatly decreased, 2 = decreased, 3 = no change, 4 = increased, 5 = greatly increased.

local level that have consequences on biodiversity by examining whether and how biodiversity is represented in municipal plans, policies, and procedures.

Three survey questions were asked of Program participants to measure their self-report of whether and how they helped to incorporate biodiversity in municipal plans, policies, and procedures in their city, village, or town (see Table 4 for survey questions). Program participant survey respondents were presented a list of common municipal *plans or inventories*, *policies and actions, and procedures* and asked to indicate whether they used the Program information and resources on which they could take action (Table 4). *Municipal procedures* are changes in practice that do not require approval by the municipal legislature and are usually conducted by the planning board (Strong et al., 2015) (Table 4). Municipal procedures that reduce negative impacts of development to habitats and natural areas include requesting wildlife and habitat information from applicants, having standardized procedures for reviewing habitat impacts of proposed projects, and using aerial photos, soil maps, N.Y. Natural Heritage Program data, National Wetland Inventory maps, and site visits to inform the review of proposed development projects.

Municipal plans create a vision and blueprint for the future of the municipality (Strong et al., 2015) (Table 4). Municipal plans include items such as developing an open space plan or inventory, conducting a natural resource inventory, and incorporating biodiversity into comprehensive plans. *Municipal policies* refer to local laws, subdivision regulations, creation of conservation advisory councils, and other actions requiring approval by the municipal legislature (Strong et al., 2015) (Table 4). Municipal policies include items such as adopting a local wetland ordinance, updating zoning that conserves natural areas through conservation subdivisions and purchasing development rights, or creating an open space fund. A full listing of municipal plan, policy, and procedure survey questions and response options are provided in Table 4. We created a summative scale by coding the responses (yes=1, 0 =no) and adding them to create a scale of the total number of municipal biodiversity measures in plans, policies, and procedures (hereafter, PPP).

2.4.4. Factors that influence biodiversity efforts

We explored internal and external influences of biodiversity efforts along with a threat perception question. We used Principal Components factor analysis (orthogonal solution with varimax rotation) to determine the underlying dimensions of influencing factors. Cronbach's alpha (α) was calculated to estimate the internal reliability of the scales produced by the factor analysis. Principal Components Analysis produced a three-factor solution, with factor loadings greater than.500 that accounted for 68% of the variance in influencing factors for land-use decision making for biodiversity. One component included two items about internal influences (interests of the chair and personal interest) (Cronbach's α = 0.551). The second component included four items regarding external political pressures (political pressure, state and federal regulations, vocal community groups, and vocal board member) (Cronbach's

Table 3
Internal and external board interactions as reported by Program participant and non-participants.

Question stem (participant *n*, non-participant *n*)	Participant Mean (S.D.)	Non-participant Mean (S.D.)	Levene's independent samples *t*-test
Town board, village board, or city council (n = 192, 34)	3.30 (1.029)	3.79* (0.880)	F = 1.409, df = 1, p = 0.009
Conservation advisory council, board or environmental commission (n = 181, 34)	3.40* (1.373)	2.79 (1.298)	F = 0.821, df = 1, p = 0.018
Planning board (n = 183, 32)	3.44 (1.256)	4.31* (0.965)	F = 6.315 df = 1, p < 0.001
Zoning board of appeals (n = 179, 34)	2.45 (1.102)	3.15* (1.132)	F = 0.181, df = 1, p = 0.001
Other municipal committees (e.g. comprehensive plan, trails, open space) (n = 180, 33)	2.84 (1.045)	2.94 (1.116)	F = 0.003, df = 1, p = 0.636
Neighboring municipal governments (n = 188, 34)	2.41 (0.929)	2.38 (0.888)	F = 0.309, df = 1, p = 0.874
New York State Department of Environmental Conservation (n = 188, 34)	2.92* (.981)	2.50 (0.896)	F = 0.025, df = 1, p = 0.021
Conservation organizations (e.g., watershed alliance, environmental group) (n = 187, 34)	3.03* (1.145)	2.32 (0.976)	F = 0.240, df = 1, p = 0.001
Land trusts (n = 182, 34)	2.87* (1.166)	1.88 (0.946)	F = 0.960, df = 1, p < 0.001
Universities and colleges (n = 176, 34)	2.24* (1.095)	1.76 (0.955)	F = 1.062, df = 1, p = 0.019

Survey question: In the course of your land-use or conservation planning work, how often do you interact with the following? [a]Scale: 1 = never, 2 = rarely, 3 = sometimes, 4 = often, 5 = very often

* p < 0.05.

Table 4
Reporting of biodiversity measures in municipal plans, policies, and procedures by Program participants (dependent variable).

Municipal plans (n = 228)[a]	**(n)**	**Yes (%)**
Have you used the biodiversity information, assistance, or training provided by the Estuary Program to help your municipality create, update, or provide recommendations to any of the following municipal plans or inventories?		(0 =no, 1 =yes)
Habitat map	74	33%
Comprehensive plan	72	32%
Open space plan or inventory	58	25%
Natural resource inventory	57	25%
Watershed plan	38	17%
Regional plan	11	5%
Municipal procedures *(n = 223)*[b]	**(n)**	**Yes (%)**
Have you used the biodiversity information, assistance, and training provided by the Estuary Program to help your municipality with any of the following municipal procedures to reduce negative impacts to habitats and natural areas? My municipality:		(0 =no, 1 =yes)
Uses publicly-available information (e.g., national wetland inventory maps, aerial photos, soil maps) to inform project review	96	43%
Is more likely to suggest changes in proposed projects	77	35%
Regularly conducts on-site visits and/or habitat assessments for proposed projects	73	33%
Uses existing habitat maps to inform project review	64	29%
Requests habitat and wildlife information at the beginning of any project review, including queries to the N.Y. Natural Heritage Program	56	25%
Uses conservation strategies to manage parks and other municipal lands (e.g., allowing deer hunting, restoring stream buffers, changing mowing regimes for grassland-breeding birds)	38	17%
Has standardized procedures for [requesting] wildlife and habitat information from applicants (e.g., habitat assessment guidelines, standards for environmental review)	30	14%
Municipal policies (n = 228)[c]	**(n)**	**Yes %**
Have you used the biodiversity information, assistance, and training provided by the Estuary Program to help your municipality with any of the following municipal policies or actions?		(0 =no, 1 =yes)
Update zoning that conserves natural areas (e.g., conservation or cluster subdivisions, overlay zoning)	43	19%
Adopt a local law that reduced impacts on natural areas (e.g., wetland or watercourse law, land clearing ordinance)	39	17%
Purchase property or development rights, create a dedicated open space fund, or a voter approved open space fund	31	14%
Create a new Conservation Advisory Council or Conservation Board	18	8%

[a] 77% of Program participants used information or assistance gained from the Program to implement a municipal plan.
[b] 76% of Program participants used information or assistance gained from the Program to implement a municipal procedure.
[c] 67%of Program participants used information or assistance gained from the Program to implement a municipal policy.

α = 0.767). The third factor was the conservation partnerships and plan priority factor scale, which was comprised of two items (priority in existing plan and strong partnerships) (Cronbach's α = 0.593). While the Cronbach's alpha was less than ideal for the internal influences and conservation priority scales, we decided to keep the variables in the analysis given the conceptual importance to the model and our desire to test the predictive validity. We discuss this further in the limitations and future research section. Perception of a threat to natural resources as an influencing factor was measured with the perception of worsening natural resource conditions: *"How has the condition of your community's natural resources (e.g. forests, wetlands, and streams) changed over the last ten years?"* Response options were 1 = much better, 2 = somewhat better, 3 = about the same, 4 = somewhat worse, 5 = much worse (Table 5).

2.5. Success stories in land-use planning and habitat conservation

Program participants were asked to share a story of how they brought biodiversity into the land use planning process. The stories illustrate how policy capacity is manifested and further elucidates how biodiversity-trained municipal officials helped to incorporate biodiversity into plans, policies, and procedures in their municipalities. We asked an open-ended question on the survey, *"Please briefly describe a personal 'success story' where you believe you made a significant contribution to habitat conservation and/or improved land-use planning in your community."* We wanted to provide Program participants with an opportunity to express, in their own words, what they believe to be significant contributions to habitat conservation and land-use planning in their community.

2.6. Data analysis

The analysis was conducted using SPSS Version 22. The dependent variable in the Program participant linear regression analysis was biodiversity efforts in municipal land-use planning, a summative index calculated based upon the number of municipal plans, policies, and procedures as reported by each Program participant. Linear regression was utilized to ascertain the relative influence of each of the predictor variables. To compare differences between Program participants and non-participants we used chi-square analysis for the categorical variables and an independent samples Levene's test to compare mean scores for the Likert-scaled variables. Levene's test was used to account for the small sample size of non-participants. For the nominal by nominal categorical variables of gender, municipal role, and municipal staffing, the Phi coefficient was used, which is a measure of association used for cross-tabulated 2 × 2 tables (Cohen, 2013).

We used U.S. Census data from 2010 to examine population of the municipalities where Program participant and non-participants serve in their land-use planning roles. We calculated Housing Density of the municipalities where Program participant and non-participants serve in their land-use planning roles by manipulating housing unit data in GIS. Housing unit counts come from the 2010 Census of Population and Housing count data (U.S. Census Bureau, 2012). We calculated densities at the municipal level (cities, towns, and villages) and removed protected lands (Theobald, 2001). We modified the densities in Theobald (2005) and Kretser et al. (2008) to identify land use types relevant to the Hudson Valley: urban = (0.00–0.60 acres per 24 ha), high density suburban =(0.61–1.70 acres per unit) (.25−0.68 ha), low density suburban = (1.71–5.00 acre per unit) (0.69–2.02 ha), exurban = (5.01–20.00 acres per unit) (2.02–8.09 ha), rural =(20.00+ acres per unit) (8.10+ hectares).

The p-value was set at $p < .05$. For factor analysis, we used principal components factor analysis (orthogonal solution with varimax rotation) to determine the underlying dimensions of the influencing factors survey questions. Cronbach's alpha (α) is a measure of internal consistency and was calculated to estimate the internal reliability of the scales produced by the factor analysis.

For the open-ended success story survey questions, qualitative responses were downloaded in full and entered into an excel spreadsheet, and each response was coded for themes and sub-themes. Themes, subthemes, and example success stories are reported along with the number of participants that were coded under each theme. In conducting the

Table 5
Descriptive statistics for dependent variable, individual policy capacity, municipal policy capacity, influencing factors, and socio-demographic independent variables for Program participants (survey questions denoted in footnotes).

	(n)	*M* (SD) or % (n)	Range
Biodiversity measures in municipal plans, policies, and procedures[a] (dependent variable; seeTable 4 for survey questions)	223	4.38 (3.73)	0–16
Individual characteristics and capacity			
Program helped in current land-use position[b]	225	3.92 (1.02)	1–5
Total Program hours attended	251	24.23 (18.568)	2–85
Personal interest in biodiversity as motivation[c]	214	4.50 (0.809)	1–5
Leadership encouraged me to attend as motivation[c]	163	2.08 (1.333)	1–5
Annual training requirement as motivation[c]	170	1.86 (1.231)	1–5
Confident actions will make a difference[d]	210	3.89 (0.862)	1–5
Past leadership role in land-use planning (% yes)	179	21.4% (63)	0–1
Municipal role (seeTable 1 for descriptive statistics)			
Municipal capacity			
Municipal governance capacity[e]	147	3.32 (0.793)	1–5
Staffing: Planner (% yes)	136	39.7% (54)	0–1
Staffing: Wetland Inspector (% yes)	132	12.4% (18)	0–1
Change in board resources (past 5 years)	188	2.81 (0.962)	1–5
Computer-based mapping used by municipality (% yes)	142	71.1 (101)	0–1
Influencing factors			
Internal influence scale	161	3.31 (0.927)	1–5
Political pressure scale	167	2.95 (0.956)	1–5
Conservation plan priority scale	163	3.19 (1.06)	1–5
Perceived threat to natural resource conditions[f]	177	3.11 (0.831)	1–5
Socio-demographics			
Age (age as of last birthday)	202	3.76 (1.32)	1–6
Gender (0 = female, 1 = male)	203	49.8% Female	0–1
Education (highest level of formal education)[g]	202	3.48 (0.734)	1–4

[a] Summative scale created from biodiversity measures in municipal plans, policies, and procedures from Table 4.

[b] How much has your participation in the Estuary Program helped you in your position in your community? (1 = not at all, 2 = slightly helpful, 3 = somewhat helpful, 4 = helpful, 5 = very helpful)

[c] PERSONAL INTEREST: I have a personal interest in the subject (biodiversity), LEADERSHIP: Leadership (e.g. town supervisor, committee chair) encouraged me to attend, REQUIREMENT: I needed to fulfill my annual training requirement (1 = not at all important, 2 = slightly important, 3 = somewhat important, 4 = important, 5 = very important)

[d] SELF-EFFICACY: I am more confident that my actions will make a difference (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = somewhat agree

[e] MUNICIPAL GOVERNANCE CAPACITY SCALE: (a) My municipality has capable leadership, (b) my municipal elected officials work well together, (c) residents are engaged in municipal issues and decision-making, (d) my municipality will take steps within the next 5 years to conserve biodiversity and habitats, (e) my municipality has adequate policies and procedures to conserve biodiversity. Cronbach's alpha = 0.777% and 53.81% variance explained.

[f] PERCEIVED THREAT TO NATURAL CONDITIONS: How has the condition of your community's natural resources (e.g. forests, wetlands, and streams) changed over the last 10 years? (1 = much better, 2 = somewhat better, 3 = about the same, 4 = somewhat worse, 5 = much worse)

[g] EDUCATION: what is the highest level of formal education you have attained? (1 = high school graduate, 2 = some college or technical school, 3 = bachelor's degree, 4 = graduate or professional degree). The variables of municipal role on a Zoning Board and Biologist/Ecologist municipal staffing were excluded from the regression model due to low frequencies for these variables (n was less than 10).

thematic analysis, we followed the process laid out by Braun and Clarke (2006). The first steps entailed reading the responses and familairlizing ourselves with the data, which was followed by generating initial codes and coding data. We then created and defined the themes based on the coded quotations, analyzing them in relation to one another and extracting example quotations and actions to report for each theme (Braun and Clarke, 2006). Details of those not reporting a success story are also provided.

2.7. Nonrespondent analysis

Because not all those sampled respond to surveys, it is recommended that a nonresponse bias analysis be conducted of survey nonrespondents (Dillman et al., 2014; Stedman et al. 2019). By understanding how survey respondents compare with nonrespondents on key demographic and research variables, researchers can generalize their findings more accurately and confidently, which is needed in an era of declining response rates to surveys (Stedman et al., 2019). We conducted a telephone survey of a random sample of nonrespondents (n = 66) and compared them to respondents on 11 key questions. Seven questions were asked regarding their role in municipal planning, one question on environmental attitudes, and three socio-demographic questions were included (age, education, gender). Results on these 11 questions were compared for statistical significance between respondents and nonrespondents using chi-square and independent samples *t*-test procedures.

3. Results

In total, 253 Program participants completed the participant survey (including partial responses), yielding a total participant response rate of 46% as calculated using AAPOR Response Rate 2 (American Association for Public Opinion Research AAPOR, 2011). For the non-participant survey, 42 municipal officials completed the survey yielding a non-participant survey response rate of 40%.

3.1. Nonrespondent analysis

In comparing those that responded to the survey (respondents) and those that did not (nonrespondents), only two of the 11 variables showed significant respondent/nonrespondent differences: organizational role and educational attainment. Nonrespondents were significantly less likely to have a role on a conservation advisory council (18%) than were respondents (43%) ($X^2 = 14.92$, df = 1, $p < .001$). Respondents were also slightly more educated ($M = 3.48$) than were nonrespondents (M=3.16) (t = 11.38, p = .001) where 3 =bachelor's degree and 4 =graduate or professional degree. The mean educational level of both respondents and nonrespondents was "bachelor's degree." We did not reweight the data to account for nonresponse because respondents and nonrespondents did not differ on our core variables of interest (those related to environmental concern and their role in the implementation of plans, policies, and procedures). Nonrespondents were similar in some ways to Program non-participants (see 3.2 below), which we account for in the results and come back to in the discussion.

3.2. Descriptive statistics for respondents (participants and non-participants)

For Program participants, the primary municipal land-use planning roles were serving on conservation advisory councils and planning boards, while non-participants were less likely to serve on conservation advisory councils and more like to serve on planning boards (Table 1). Nearly one-third of Program participants reported serving on the planning board while over half of non-participants did (Table 1). For conservation advisory councils, 1 in 10 non-participants served while nearly 50% of Program participants served in this role. Fewer Program

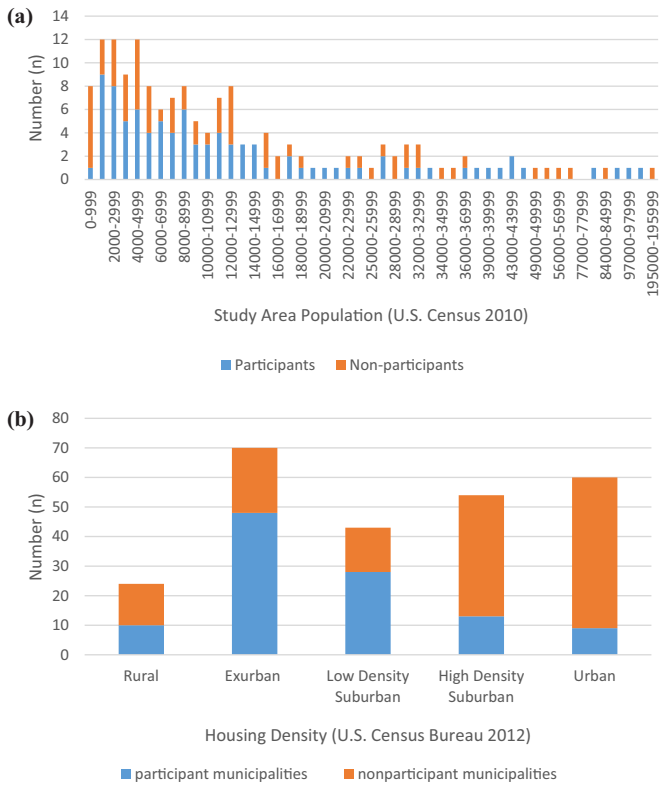

Fig. 2. Population and housing density of the municipality where participant/non-participant serve in their land-use planning role.

participants and non-participants served on open space committees, comprehensive plan committees, or town/village board or city council (Table 1). Participants were more likely to serve on conservation advisory councils and open space committees compared to non-Program participants, and non-Program participants were more likely to serve on a planning Board compared to Program participants. Program participants likely underrepresent planning boards and overrepresent those that serve on conservation advisory councils and open space committees.

Both participants and non-participants averaged 5–9 years of formal experience in land-use planning (Table 1). There were no significant participant/non-participant differences in gender nor age; half of the Program participants were female compared to 45% of non-participants (Table 1). In general, respondents were highly educated. Most had educational training beyond a Bachelor's degree, and participants/non-participants did not differ (Table 1). The mean age of respondents (both Program participants and non-participants) was between the ages of 45–54 years (Table 1).

Program participants mostly serve exurban and low-density suburban municipalities while non-participants serve mostly urban or high-density urban municipalities in their land-use planning role (Fig. 2). The Hudson River Valley is comprised of many small municipalities (Fig. 2), including 143 town, 92 villages, and 19 cities. Few Program participants come from low population municipalities (less than 1000 population) as compared to non-participants (Fig. 2).

3.3. Program participation characteristics

Most respondents participated in the Program offerings in 2009, 2010, or 2011 (76%, n = 191), with 24% participating in 2008 or prior (n = 62). The majority of respondents (76%) used Program information in *municipal procedures* (Table 4), most frequently using habitat maps and other databases to inform project review, suggesting changes to proposed projects, and conducting habitat assessments (Table 4). For *municipal plans*, respondents most frequently used the information from the Program to create habitat maps, comprehensive plans, open space inventories, and natural resource inventories (Table 4). They were least likely to use the information from the Program for regional plans or watershed plans. Only about one in four (23%) respondents did not utilize Estuary Program information to develop or inform municipal plans. For *municipal policies*, nearly 1 in 5 (19%) respondents utilized Estuary Program information to update zoning that conserves natural areas and adopt local laws that reduce impacts on natural areas (Table 4). Respondents were least likely (8%) to use the Estuary Program information to create a new conservation advisory council or conservation board.

3.4. Comparing municipal capacity between participants and non-participants

We compared Program participants and non-participants on several key dimensions of municipal capacity, including resources (e.g., budgets, volunteers), staffing, and technical tools necessary to integrate biodiversity into land-use planning. Both groups report that resources available to their municipality over the past five years have decreased (Table 2). For staffing, there were no significant differences between Program participants and non-participants (Table 2). The majority of respondents indicate that their municipality consults planners as needed, while some have a professional planner on staff (Table 2). Fewer

Table 6
Linear regression predicting biodiversity representation in municipal plans, policies, and procedures.

	B(S.E.)	β	p-value
Individual capacity			
Program helped in current land-use position	0.939 (0.332)	0.256	0.0067*
Total Program hours attended	0.049 (0.016)	0.245	0.003*
Confident actions will make a difference	0.737 (0.392)	0.170	0.064
Personal interest in biodiversity as motivation	0.797 (0.396)	0.173	0.048*
Leadership encouraged me to attend as motivation	0.523 (0.231)	0.187	0.027*
Annual training requirement as motivation	0.211 (0.272)	0.069	0.441
Past leadership role in land-use planning	2.355 (0.599)	0.302	<0.001*
Municipal role			
Town/village/board or city council	−2.008 (1.176)	−0.140	0.092
Planning board	1.088 (0.725)	0.135	0.138
Conservation advisory council	1.815 (0.606)	0.242	0.004*
Open space committee	−0.118 (0.802)	−0.011	0.884
Comprehensive plan committee	−1.335 (0.758)	−0.105	0.082
Municipal capacity			
Municipal governance capacity	0.497 (0.445)	0.106	0.269
Staffing: Planner	−0.353 (0.702)	−0.046	0.616
Staffing: Wetland Inspector	3.954 (0.923)	0.365	<0.001*
Change in board resources (past 5 years)	0.339 (0.302)	0.087	0.265
Computer-based mapping used by municipality	0.230 (0.687)	0.028	0.739
Influencing factors			
Internal influence scale	−1.497 (0.375)	−0.372	<0.001*
Political pressure scale	0.787 (0.340)	0.202	0.023*
Conservation plan priority scale	0.799 (0.320)	0.227	0.015*
Perceived threat to natural resource conditions	1.340 (0.376)	0.298	0.001*
Socio-demographics			
Age	0.305 (0.223)	0.108	0.175
Gender	0.677 (0.591)	0.091	0.256
Education	−0.423 (0.416)	−0.083	0.312
Model summary			
R^2=.643, Adj. R^2=.528, F=5.618, p<.001			

* p<0.05.

Table 7
Program participant responses to the open-ended question, *"Please briefly describe a personal 'success story' where you believe you made a significant contribution to habitat conservation and/or improved land-use planning in your community"* (n = 92).

Themes	Example reported actions	Example success story quotations
Helped to raise awareness of biodiversity (n = 14)	Included biodiversity in publications, increased others' awareness of habitat, increased others' awareness of the value of trees, increased others' awareness of the watershed concept, increased peers' awareness, influenced action in other community	"I have made many individuals in the community aware of amphibian migrations, and of the need to preserve woodland pools. I have tried to get people interested in the amphibian life cycle and discourage them from introducing fish into their private ponds. "
		"I requested the habitat survey for our town. The results were surprising to town officials and inhabitants. This information was presented at a public meeting and good comments were received. This has jumpstarted more attention to habitat and environmental factors in many areas."
Contributed to draft or final town policy (n = 12)	Wetland/watercourse law, zoning, conservation overlay district, conservation subdivision, floodplain law, Habitat Assessment Guidelines, ridge zoning *[but questioned effectiveness],* steep slope law, tree ordinance	"I supported the passage of a strengthened floodplain development law which has withstood court challenges. This law not only protects riparian habitat in the 100-year floodplain, but protects people from investing and risking their welfare in building new homes in the 100-year floodplain and floodway where they cannot be accessed by emergency vehicles during flood conditions."
		"Helped in developing the Habitat Assessment Guidelines. Wrote the Wetlands Ordinance.unfortunately neither being used [in our town]. satisfied that other municipalities are benefiting from them."
Site-scale planning outcome (n = 12)	Avoided sensitive areas (forests, stream buffer, wetland, wildlife corridor, wildlife habitat, erosion control, reduction in number of units	"I was instrumental in convincing my planning board to limit development on a 52 acre parcel that had 25 acres of active wetland. The lot count was reduced from 27 lots overall to 16 allowing space for animals to connect with a larger biodiversity corridor and preserving forest canopy to help retain the current populations of forest interior birds within the parcel. The parcel was part of a larger series of parcels that connected to a biodiversity corridor to the north and west, and to a large habitat sensitive land preserve to the south."
		"Seven large-scale subdivisions (more than 50 dwelling units proposed) were completely modified in design through sometimes arduous but collaborative dialogue with the project sponsors and based on the environmental particulars on each parcel. One, in particular, went from 150 multi-family units to seven [single family] homes, clustered."
Implemented stewardship actions or		

(*continued on next page*)

Table 7 (*continued*)

Themes	Example reported actions	Example success story quotations
plans (n = 11)	Buffer planting, deer management plan, forest management planning, easement monitoring, grassland habitat management for nesting birds, habitat management planning, pond management, volunteered for other program	"Our CAC requested that the board require that mowing of leased fields in a park be done later in the season to not interfere with ground-nesting birds. This was accepted."
		"The Open Space Committee has created a management plan for the newly acquired Preserve based on habitat analysis and is working to develop similar management plans for other larger municipal holdings."
Land-use planning advisory role (n = 11)	CAC/CB engaged in environmental review, created map overlay for important parcel, evaluate PDR parcels, formed CAC to collect detailed habitat information, providing input to environmental review to lessen impacts to habitat	"Our newly designated conservation board has become much more widely utilized by our planning board as a "planning partner" on site plans that have or might have any significant conservation conditions. Part of the reason is that some of my colleagues and I have taken the time to attend trainings like these and the gained expertise is now considered an asset by the town."
		"The Open Space Committee's training has enabled it to begin habitat mapping the entire town and to better discharge its newly enlarged powers to review proposals referred by the Planning Board. "
Land protection success (n = 11)	Municipal conservation easement or purchase, ongoing land trust work, State land protection	"I helped create a map overlay that was used by others to promote conservation of a large parcel that was purchased for open space."
		"Honestly, I did it on a regular basis for [my land trust job] in assessing biodiversity values on properties along the Hudson River corridor from Albany to New York City. Using the data created and maintained by the Estuary Program was instrumental in justifying the protection of many properties of with high ecological value."
Town-scale planning outcome (n = 7)	Biodiversity included in comprehensive plan, biodiversity protection included in open space plan, comprehensive plan and new zoning law passed, open space plan adopted, habitat map used for town planning, habitat map created or expanded to more acreage	"Town Comprehensive Plan has revised and updated chapter on Natural Resources including the most recent information on biodiversity."
		"Helped with organizing and continuing the municipal will to apply for grants to create a municipal wide habitat mapping project. The training I received encouraged me to actively proceed in bringing this tool to my town and its planning board. Also, when creating publications biodiversity was included along with other water related issues again due to the training received. Thank you."
Advocacy role (n = 5)		

(*continued on next page*)

Table 7 (*continued*)

Themes	Example reported actions	Example success story quotations
	Advocating for biodiversity in land trust processes, municipal processes, and environmental review in municipal processes	"All the members of the [our mapping] team are still heavily involved in these processes. All members are diligent advocates for biodiversity. Even ten years later our map has resurfaced and was recently reviewed at a municipal meeting."
		"I work as a kind of background ombudsman helping to forward habitat conservation and protection agendas (and in other areas), serving my town in supporting those who are doing these things more formally on the commission/committee/board levels. I "agitate" the questions when appropriate; challenge the premises and details when they are poorly or not properly presented; advocate with those in a decision-making role, try to popularize decisions, and try and save money for the town in doing all of this."
Brought attention to important location for biodiversity (n = 4)	Contributed to prioritization of open space, secured impaired water status designation, used skills to identify and assess important biodiversity connection, used skills to identify state-significant amphibian habitat	"Using municipal open space funds, my committee identified and evaluated a 7-acre tract that connected two 800-acre tracts of watershed lands identified as keys to biodiversity in [our county]. We then negotiated a deal with the land owners, and worked with the Town Board and the Planning Board to complete the purchase."
		"Ongoing amphibian surveys in an area exhibiting unusually high species diversity led, in part, to inclusion of a particular priority protection area in the State Open Space Conservation Plan."
Development of large-scale planning tools (beyond the individual municipality) (n = 3)	Development of watershed plans, established intermunicipal watershed council, updated county Natural Resources Inventory (NRI)	"Updating of the [county] NRI, one of the most comprehensive in the nation."
		"For me the most rewarding efforts have been the development of local water resource (wetland, stream, etc.) protection laws, and local watershed management plans."
Improving recreational access (n = 3)	Applying for AT Community designation, creating new fishing areas, planning a town nature preserve/trail	"We are planning a preserve/trail system near a unique bog pond within the town."
		"We are in the process of finalizing a mile long public fishing rights area."

report having a wetland inspector or ecologist on staff (Table 2). Program participants had a higher probability than non-participants of their municipality using GIS tools in land-use conservation planning and review (Table 2).

Participants have significantly higher mean interaction levels with conservation advisory councils and conservation boards (a), New York State Department of Environmental Conservation (g), conservation organizations (e.g., watershed alliance, environmental group) (h), land trusts (i), and universities and colleges (j), indicating that Program participants have a higher level of engagement with external organizations in their land-use planning role (Table 3). Program participants have a significantly lower mean interaction when compared to non-participants for town board, village board, or city council (a) and planning board (c), indicating a propensity for focus on internal interactions (Table 3).

3.5. Program participant reports of biodiversity measures in municipal land-use planning

A linear regression using the Program participant dataset predicted the number of municipal biodiversity measures in plans, policies, and procedures (PPP) based on policy capacity measures at the individual and municipal levels. The model predicted 53% of the variation in the dependent variable (adjusted R^2 =.528, F= 5.618, $p < .001$) (Table 6). The strongest municipal capacity predictor was having a wetland inspector on staff, which increased municipal PPP by nearly 4.00 (B=3.95), while internal municipality stressors reduced PPP by nearly 2.00 (B=1.50) (Table 6). Individual capacity and characteristics were key driving forces in PPP with having a past leadership role in land-use planning associated with a 2.35 increase in PPP. Serving on a conservation advisory council increased Program participant self-report of PPP by nearly 2.00 (B=1.81). The three socio-demographic variables of age, gender, and education were not significant predictors of conservation measures in municipal PPP (Table 6). Detailed regression model results for each model component are detailed below.

3.6. Policy capacity

Inclusion of conservation measures in municipal PPP increases with more hours of Program training attended and the extent to which the Program helped municipal officials apply what they learned in their current land-use position (Table 6). Personal interest and leadership encouragement as motivating factors for Program participation along with Program participant's past leadership role in land-use planning all positively and significantly predicted PPP (Table 6). Specifically, a belief that the Program helped them apply biodiversity knowledge in their current land-use position increased respondents' municipal PPP by 0.94, while more Program courses taken increased PPP by 0.49. Having a past leadership role in land-use planning was the most significant and positive predictor by far, which increased municipal PPP by 2.36. NYS's planning board training requirement (four hours of training per year) as a motivating factor for Program participation and self-efficacy were not significant predictors of PPP (Table 6). Of all the municipal roles held by Program participants, only serving on a conservation advisory council was a significant predictor of conservation measures in municipal PPP. Having a wetland inspector on staff was the strongest and only positive and significant municipal policy capacity predictor of incorporation of conservation measures in land-use PPP (Table 6). That is, having a planner on staff did not factor significantly into whether respondents were able to incorporate biodiversity measures into municipal PPP, but having a wetland inspector on staff did.

From a political policy capacity perspective, internal pressure (e.g., interests of the board chair) was a significant negative predictor, and external political pressure (e.g., vocal community groups) was a significant positive predictor of biodiversity in PPP. Internal pressure decreased conservation measures in municipal PPP by 1.44 while external pressure such as vocal stakeholders or state or federal regulations increased conservation measures in municipal PPP by 0.97. The conservation priority scale, which measured the facilitating role of conservation partnerships and biodiversity priority in existing plans, was also a significant positive predictor, increasing PPP by nearly 1.00 (B=0.80). Perception of a decline in natural resource conditions was also a significant and positive predictor of PPP (Table 6).

3.7. Success stories in land-use planning and habitat conservation

We asked Conservation and Land Use Program participants to describe a personal success story in land-use planning and received 92 responses to the question and coded them into 11 themes (Table 7). Some responses were cross-cutting and were coded across multiple themes. Many "success stories" demonstrated outcomes in municipal PPP (Table 7). Stories of conservation and planning outcomes included contributing to a draft or final town policy (12 respondents), such as a local wetland law; helping to revise site-scale plans (12 respondents) (e.g., to avoid sensitive areas or reduce the development footprint); or assisting with a town-scale planning outcome (10 respondents), such as habitat mapping. Additionally, eleven respondents reported on success in their role as advisors to the local land-use planning process, citing increased engagement in environmental review. Fourteen program participants reported positive outcomes in helping to raise awareness (e.g., by increasing others' awareness of habitat). Land protection and stewardship outcomes were each reported by 11 respondents, with contributions including municipal conservation easements or land purchases, stream buffer plantings, and forest management plans.

Ten respondents to the success story survey question indicated they did not have a story to report because their success was achieved before contact with the Program or because there had been no recent project applications needing review. Five respondents to the question reported on how other outcomes of their Program involvement had been achieved outside of their formal municipal role, such as peer networking, incorporating the biodiversity training into their professional work, or anti-fracking advocacy work.

3.8. Barriers to action

About one fifth (21%, n = 23) of respondents did *not* use Program information or tools for municipal plans or inventories; 33% of respondents did not use program information to inform municipal policies, while 24% did not use Program information to inform municipal procedures. Thus, it is useful to examine the obstacles faced by respondents. Respondents not taking action were asked to indicate the reasons why. The top reasons noted were: 35% were no longer on a municipal board or commission; 26% hadn't yet had the opportunity to use Program resources, and another 26% lacked support from their elected officials to do so. Almost 10% felt that the recommended actions would have resulted in too many restrictions for landowners or the community, while another 10% lacked support from colleagues/peers on their boards or commissions.

4. Discussion

Municipalities are under pressure to address a myriad of land-use planning issues, and their boards and committees want to address conservation despite the challenges. Building capacity through programming such as that offered by the Hudson River Estuary Conservation and Land Use Program can help mitigate limited funding resources and foster increased understanding and partnerships necessary for successful, locally-driven conservation planning.

Most participants applied knowledge and skills gained in the Program toward creating new PPP to improve the conservation of biodiversity through land-use planning. Municipal officials were more likely to have created procedures and plans than policies. This result is not

surprising because procedures are somewhat more straightforward to implement, and funding sources are available for the development of plans. At the same time, approval is needed from the municipal legislature for policies and the overall process is more complicated and fraught with opposition to increased regulation. Participants helped their municipalities create habitat maps, municipal plans, and open space plans or inventories. They drew on Program materials to update zoning that conserved natural areas, contributed to the adoption of local laws to reduce impacts on natural areas, purchased property/development rights, and created an open space fund. Respondents also used Program information to institute changes to municipal procedures to reduce negative impacts of development on habitats and natural areas such as using habitat maps to inform land-use project review.

We found many similarities as well as distinguishing characteristics between Program participants and non-participants. There were commonalities in age, gender, and education, years of experience, and self-confidence to impact land-use decisions. Both participants and non-participants report a decrease in resources (e.g. budgets, volunteers) in the municipality where they serve and also described similarities in staffing. However, Program participants were significantly more likely to report that their municipality uses GIS in land-use conservation planning. Also, we found that Program participants have a higher level of engagement with external organizations such as the NYS Dept. of Environmental Conservation, conservation organizations, land trusts, and universities and colleges in their land-use planning role. In contrast, non-participants were significantly less likely to report these types of external engagements in their land-use planning role. Program participants are likely overrepresented in exurban and low-density suburban municipalities as compared to urban or high-density urban municipalities where non-participants serve in their land-use planning role. Below we discuss our findings in light of the literature on policy capacity and conclude with a discussion of limitations and future research.

4.1. Policy capacity and influencing factors

Analytical capacity builds on the ability of individuals to acquire and process information and data necessary to perform policy functions (Wu et al., 2015). Analytical policy capacity is demonstrated by policymakers when they actively seek information to inform decisions (Howlett, 2015). Several studies raised the point that threats to natural resources and biodiversity can be a motivating factor for planning or protection (Brody, 2003a, 2003b, 2003c; Hawkins, 2014). We similarly found that perceptions of worsening natural resources conditions significantly predicted biodiversity measures in land-use planning. At the individual level, past leadership role, the extent of biodiversity-related courses taken, and the belief that the knowledge gained was helpful in one's current position significantly predicted increased biodiversity measures in municipal PPP while personal interest and leadership encouragement were also significant motivators.

Municipal policy capacity—based on effective leadership and relationships—was a significant and positive predictor of biodiversity measures in land-use PPP. Locke and Rissman (2015) and Stokes et al. (2009) also stressed the importance of governmental cooperation for biodiversity in local planning. Vocal stakeholders and political pressure held significant sway in biodiversity measures being incorporated into local land-use decisions as measured by PPP. Relatedly, Kartez and Casto (2008) found an association between implementation actions and stakeholder groups utilizing biodiversity data and habitat information in planning decisions. Our research similarly found that vocal stakeholders and federal and state mandates are also critical determinants of whether biodiversity conservation is integrated into land-use plans (Stokes et al., 2009). Additionally, Program participants whose municipalities participated in conservation partnerships and made biodiversity a priority in existing plans was predictive of biodiversity measures in land use PPP. At the municipal capacity level, staffing yielded the most significant positive influence, and internal influences yielded the most significant negative impact on biodiversity measures in municipal PPP. If a municipality is willing to prioritize its natural assets like wetlands by committing resources to a wetlands inspector staff person (which suggests they also likely have a local wetland law in place), we posit that the municipality may be more committed to environmental protection in general. Thus, having a wetland inspector on staff is not a surprising predictor of PPP success.

Participants reported fewer policies adopted than municipal procedures and plans. Local policies are a more complicated, politically challenging, and time-consuming endeavor, and change is often slow. Municipal procedures or recommendations in plans are often precursors to policy, and it may be years before a municipality may adopt a regulatory option such as a local law. We theorize that using habitat maps to inform project reviews for proposed development projects and including conservation principles and biodiversity priorities in an open space plan might eventually lead to updated zoning that conserves natural areas or local laws that reduce impacts to natural areas. Our study confirms Wilhelm-Rechmann and Cowling's (2013) assertion regarding the critical role of training and information in land-use planning. Knight et al. (2011) emphasized the importance of sustained and supportive leadership and direction. Thus, policy capacity is something to be maintained over time rather than achieved at one point in time (Wellstead et al., 2011).

Our research findings demonstrate that the tools, information, and assistance provided to municipal officials by the Program builds analytical and political policy capacity to enhance biodiversity measures in land-use planning—primarily for municipal plans and procedures but with evidence of action in municipal policies as well. The Program enables participants to be more effective in their decision-making roles in land-use, biodiversity, and conservation through the provision and use of biodiversity-related information and tools that can be utilized in decision-making. We infer that the Program enhances biodiversity measures in municipalities, in part, due to the Program's engagement of participants over the long-term. By providing continuous outreach, assistance, and funding opportunities, the structure of the Conservation and Land-Use Program sets it apart from more episodic training programs that may struggle with sustained levels of engagement (Knight et al., 2011).

The results of our study illustrate the critical role of individual policy capacity, as personal motivation was one of the strongest positive predictors of increasing biodiversity efforts in municipal land-use planning. The municipal level contexts in which local government officials operate are also relevant, but individual-level factors exerted some of the strongest influences on biodiversity incorporation in municipal PPP. Program staff have referred to individuals that serve as catalysts for municipal biodiversity action as "spark plugs," due to their ability to energize, lead, and reach successful outcomes. Given the strong role of individual capacity we believe that fostering interest in biodiversity among municipal leaders is as important as building analytical competencies to apply biodiversity knowledge and information in planning.

Of all the municipal roles held by Program participants, serving on a conservation advisory council was the most crucial role that in predicting conservation measures in municipal PPP. Conservation advisory councils were created specifically to work on conservation issues and municipalities, and among their decision-making peers, would be expected to have the greatest bandwidth to pursue biodiversity-related projects. Additionally, Program participant respondents likely underrepresent planning boards and overrepresent those that serve on conservation advisory councils and open space committee members. This is likely due to the salience of the survey topic to municipal officials serving in those roles and their associated mandates, as opposed to the myriad of issues that must be considered and reviewed by their planning board counterparts. It is also noteworthy that there are far more municipalities with planning boards in the Hudson Valley than there are conservation advisory councils. The critical role of conservation advisory councils in predicting PPP coupled with the revealing finding that

non-participants were less likely to come from conservation advisory councils presents a window of opportunity. There is strong evidence that non-participating municipalities would greatly benefit from developing conservation advisory councils and participating in the Program.

4.2. Success stories in land-use planning

The open-ended responses shared by Program participants illustrated more deeply their varying perceptions of success, and suggest the variability in policy capacity of respondents and their municipalities. Nearly all success stories did, in fact, describe a positive outcome; however, the respondent's decision-making role, individual capacity, municipal policy capacity, stressors, and other factors likely influenced the degree of that success. For example, success stories ranged from a single development plan being revised to reduce the impact of development to habitat, to adopting a local law that has larger-scale conservation implications for many development proposals. This range of actions by municipal boards, commissions, and committees is necessary to comprehensively address biodiversity conservation at all levels of local land-use planning, while also matching political will of the time. The open-ended responses enabled the survey to capture the nuances of the PPP being pursued and adopted by municipalities engaged in the Program. In some cases, stories provided context-setting and candid commentary. One respondent who offered no success story replied, "Those of us interested in conservation constitute a small and ignored minority in a town dominated by development-obsessed politicians. Unfortunately, we have long been voices crying in the wilderness. We persist in the hope of a better future."

4.3. Recommendations

There are further steps that municipalities can take to support conservation-oriented land-use actions. At the municipal scale, continuing to spark interest in biodiversity conservation among individual decision-makers is recommended. In addition, the creation and empowerment of conservation advisory councils could increase the likelihood and efficacy in addressing biodiversity conservation needs. Similarly, across multiple municipalities, leaders could pool resources by sharing a natural resources planner, for example, or by leveraging additional funding to build regional capacity. Such intermunicipal collaboration is an effective strategy for addressing issues that span municipal boundaries, including landscape connectivity, watershed protection, and climate change.

Ideally, practitioners of land-use and conservation planning programs would be able to offer ongoing outreach and assistance that continually evolves and expands to help municipal decision-makers progress in their capacity to conserve biodiversity. Local planning and conservation volunteers are given a great responsibility in shaping a community's future. Given that biodiversity conservation is not a universally embraced priority by local municipalities, and many aspects are not mandatory, those individuals willing to serve as biodiversity leaders deserve ongoing assistance and allies in supporting their efforts. Successful models should be shared to educate and inspire.

This study demonstrates that for outreach programs to yield long-term outcomes in the land use planning arena—especially in a region as large and diverse as the Hudson River estuary watershed—offering a variety of programs over a long time is beneficial. This approach considers the capacity and needs of different communities, and it can foster agility when opportunities arise. For example, following Program participation, a municipal official may propose to include habitat conservation recommendations in the town's comprehensive plan. There may be no movement on the recommendation for years, until a shifting priority opens the door for additional technical or funding assistance to advance the recommendation into an actionable policy with real conservation potential, such as a land protection fund. Providing outreach and assistance to municipal officials today positions them to seize the moment in the future when barriers to taking action are fewer, and the timing is right.

Land-use planning and policy changes happen slowly, differ by community, and are affected by many external factors. This research shows that programs like the Conservation and Land Use Program can be an active partner to municipal officials to help them achieve conservation goals through local land use.

4.4. Barriers

Most Program participants used biodiversity-related information or tools from the Program. Respondents who did not often reported they were no longer on a municipal board or commission, did not have the opportunity, or lacked support from elected officials in their municipalities. These barriers point to the fact that policy change can be slow to happen at the municipal level. Many plans and policies are not routine or mandatory actions, and the Program may be investing resources today for the opportunity that arises years late. Being nimble and ready to act also means creating new opportunities where they may not exist currently. It is also an intriguing finding that time and resources were not identified as significant barriers to taking action. Instead, inaction was due to not having an opportunity or the challenge of navigating the restrictions on land use that may come with protecting biodiversity. Perhaps resource limitations would become important in implementing actions at the municipal level but not necessarily in applying information from the Program.

5. Limitations and future research

The sample for this study included municipal officials who participated in a biodiversity outreach training program. We found that municipal officials came to the Program with high levels of both education and experience. These findings are consistent with data showing that residents serving on planning and other citizen advisory boards/committees tend to be older adults with professional backgrounds and may not represent the socio-economic and cultural diversity of their respective communities (Anderson and Eastman, 2014; Dougherty and Easton, 2011). This is not a weakness of the study, per se, but rather a systemic bias inherent in planning and other citizen advisory boards.

While a higher Cronbach's alpha is preferable, we retained two factor scales that were close to but below the recommended threshold of 0.60 (Cortina, 1993; Taber, 2018; van Griethuijsen et al., 2015) because of their importance to the concepts being measured. While the scales did have predictive validity, future research should attempt to refine these scales by incorporating additional dimensions such as other internal and external influences in land-use planning.

We encountered the issue of survey nonresponse consistent with the overall decreasing trend in natural resource-related surveys (Stedman et al., 2019). Despite our implementation of a rigorous nonresponse survey and subsequent nonresponse bias analysis, our results likely represent the conservation advisory council members when compared to nonrespondents and non-participants and fewer planning board members when compared to non-participants. We attempted to address this by including a municipal official sample that did not participate in the Program to provide a comparative context of those in non-participating municipalities.

We also acknowledge that building policy capacity is not the same as on-the-ground outcomes for biodiversity in terms of ecological metrics. While we believe there is a relationship between municipal PPP and biodiversity metrics, this was not measured in our study and is not currently measured by the Conservation and Land Use Program, which focuses on achieving land-use outcomes that support biodiversity. Here, our measurement similarly stops at the role of adoption of a municipal plan, policy, or procedure related to biodiversity as reported by survey participants. Future research could link the dimensions of municipal policy capacity with ecological outcomes for biodiversity, which would

help us understand which PPP are most effective in conserving biodiversity. Future research might also include the role of flagship species and development controversy in increasing policy capacity and driving outcomes for biodiversity in municipalities. Despite these limitations, there is value in this study's findings as very few biodiversity educational efforts have been examined for their impact on local land-use planning decisions (Bengston et al., 2004; Carleton-Hug and Hug, 2010; Ferraro and Pattanayak, 2006; Heimlich, 2010; Jenks et al., 2010)—making this an avenue ripe for continued research.

CRediT authorship contribution statement

Shorna Allred: Conceptualization, Methodology, Investigation, Formal analysis, Writing - original draft, Writing - review & editing, Supervision, Project administration, Funding acquisition. **Richard Stedman:** Conceptualization, Methodology, Investigation, Writing - review & editing, Project administration, Funding acquisition. **Laura Heady:** Conceptualization, Methodology, Investigation, Formal analysis, Writing - review & editing, Data curation, Validation, Project administration. **Karen Strong:** Conceptualization, Methodology, Investigation, Formal analysis, Writing - review & editing, Data curation, Validation, Project administration.

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