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Landowner conservation awareness across rural-to-urban gradients in Massachusetts

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ABSTRACT

In many parts of the eastern US, the provision of ecosystem services depends on private land. In these regions, decisions about land management and conservation made by private landowners can have significant effects on habitat and other ecosystem services. Advancing permanent conservation of land can be particularly challenging in dynamic rural-to-urban landscapes facing development pressures. We estimated private landowner "conservation awareness" using a mail survey instrument to assess relative familiarity, knowledge, and experience with various conservation and land management options. Conservation awareness differed significantly by town, implying hotspots and troughs of awareness, potentially leading to significant geographical variation in landowner decision-making and long-term conservation futures. We were surprised to find that conservation awareness did not necessarily diminish in more suburbanized environments of our study area. Higher conservation awareness was related to enhanced conservation social capital at the town level as well as relative affluence. We suggest that low conservation awareness could represent a precursor to or symptom of eventual land use change and hence loss of habitat. As a result, conservation efforts should focus not only on biophysical aspects such as habitat connectivity and rarity, but also on the conservation awareness of owners of private land.

1. Introduction

Non-industrial private landowners own more than one-half of the forestland in the United States (Stein et al., 2009) and up to 75% of the forestland in much of the eastern US (Smith et al., 2009). On unprotected, privately owned lands, the cumulative effects of land use and management decisions (e.g., subdivision, timber harvest) shape the regional landscape. Subdivision and conversion of forestland is one of the leading threats to private forests and the ecosystem services they provide (Stein et al., 2009). There are several resources to help landowners make informed decisions about management and conservation options for their land. While factors shaping the use of these options have been studied in rural areas (e.g., Kilgore et al., 2008; Ma et al., 2012a,b; Rickenbach et al., 2011; Van Fleet et al., 2012), little is known about forest landowners' knowledge and behavior in more quickly developing areas with higher real estate values. The future and success of conservation in these rural-to-suburban transition zones depends on a strong understanding of this disturbance regime and potentially relevant mediating interventions across the urban-to-rural gradient.

2. Threats to private forests and landowner decision-making

The continued provision ecosystem services from private lands is challenged by development pressures and the dynamic nature of ownership (Stein et al., 2009; Knight, 1999). For example, the average tenure in Massachusetts is approximately 25 years (Butler, 2008). As land tenure changes, parcels tend to be subdivided into ever-smaller physical pieces or into the possession of multiple family members, both of which complicate future land use decisions and opportunities for coordinated cross-boundary management (Rickenbach et al., 2011; Finley et al., 2006; Kittredge, 2005).

These landscapes are characteristic for the northeastern United States (Butler, 2008) and are also typical of the so-called urban–rural interface that surrounds major metropolitan areas. These areas experience sprawl and often unplanned suburban and exurban growth (Stein et al., 2005). Social (demographics), political

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(local zoning), and economic (real estate values) factors combine to strongly influence the land use change trajectory in these areas from rural and undeveloped towards suburban or urban.

In response to this threat, Foster et al. (2010) call for the permanent protection of 70% of the remaining forest in the New England region (i.e., six northeastern states that vary widely in their degree of development) primarily through the use of conservation easements or restrictions on private land. Rissman et al. (2007) also describe ways that biodiversity could be protected on private lands through easements, and provide some cautionary notes on their use, and Meyer et al. (2014) describes the use of easements for conservation in northern New England states (Maine, New Hampshire and Vermont), in contrast to the three southern New England states (i.e., Massachusetts, Connecticut, and Rhode Island) with much higher degrees of development, and proximity to significant urban areas (Boston, New York City).

In addition to conservation easements, several other policy and legal tools exist to help prevent subdivision and promote voluntary forest conservation on private land (Kamal et al., 2014). For example, many U.S. states have property tax programs that provide financial incentives for protecting land; estate planning can facilitate the passage of land to future generations and avoid sell-off for tax purposes; and sustainable timber harvest can provide income to support ownership expenses.

Forest landowners are a diverse group with management practices linked to a variety of socioeconomic, demographic, and lifestyle characteristics (e.g., Erickson et al., 2002; Kendra and Hull, 2005; Kilgore et al., 2008; Raymond and Brown, 2011; Stevens et al., 2002). According to the theory of planned behavior, knowledge and training can influence beliefs and behavior (Ajzen, 1991). Thus, knowledge and awareness of these 'conservation tools' is necessary (though not sufficient) for the utilization of these options. It follows that the likelihood of decisions and actions that keep forest parcels (and ecosystems) intact is higher when landowners are aware of their conservation options and make informed decisions.

Recent studies of landowner attitudes and behaviors indicate that other peer landowners and local social connections can influence landowners' knowledge and decision-making about their land. Rickenbach et al. (2011) discussed the need for informed "spanners" to connect landowners with needed information. Butler (2008) showed evidence of landowners relying on social sources of information (e.g., other landowners) rather than static written or electronic information. Landowner associations have been proven to be another effective way to disseminate information, both to members and non-members (Rickenbach, 2009). In some cases, landowners have shown a reluctance to work with trained professionals due to perceived arrogance, dissimilar management goals or philosophies, or matters of trust (Gootee et al., 2010) thus making more informal, social means of information gathering preferable. However, it can be challenging for landowners to find opportunities for information through informal, non–official, word-of-mouth channels. Opportunities for landowners to meet and exchange information and experiences with one another have been shown to be effective arenas to overcome these obstacles of trust and informal channels (Ma et al., 2012a,b). Informal landowner social networks have been documented as effective means by which conservation information is transferred (e.g., Kittredge et al., 2013; Sagor and Becker, 2014).

Areas that have strong formal and/or informal networks for transferring information about conservation can be viewed as having strong conservation social capital. Lin (2001) defines the concept of social capital as "resources embedded in social networks accessed and used by actors for actions." Social capital is said to "enhance the outcome of actions" (Lin, 2001) by facilitating the flow of information and Putnam (2000) provides a wealth of examples of how the quality of life is higher in communities where such social capital is abundant. Beyond the flow of information itself, social ties may lend credence or emphasis to the information, reinforcing its value or relevance. Social connections through capital also reinforce the information by seeing it or hearing it in different ways and contexts.

To better understand how the potential for conservation varies in areas with different patterns of development, we assessed forest landowners' familiarity, knowledge, and experience with conservation tools and examined how this knowledge varies across rural to urban areas. Given the importance of social capital in decision-making, we also examined the extent to which towns in our study region have conservation social capital and the relationship between landowners' awareness of conservation options and the conservation social capital in their town.

3. Study region and context: forests and forest owners in urban, suburban, and rural Massachusetts

Our study system includes 19 towns located along two 100 km transects that stretch westward from Boston, Massachusetts (Fig. 1). The transects were originally established as part of an earlier study of urban land use change and corresponding biophysical effects (e.g., Hutyra et al., 2011; Raciti et al., 2012). Development patterns, land uses, and human communities vary along the transects, providing an excellent opportunity to investigate the differences in conservation awareness among towns of varying densities, land uses, and degrees of development.

3.1. Forests and forest owners in Massachusetts

Massachusetts is the third most densely populated state in the United States, and is at the northern end of the largely urban corridor that extends from Boston to Washington, DC. It is estimated that approximately 63% of the Massachusetts landscape is covered by forest (Smith et al., 2009), and 70% of it is owned by private families and individuals (Kittredge et al., 2008). Periodic analysis of land cover data shows that in Massachusetts as a whole, between 1981 and 1987, 21 hectares/day of open space were lost to development (MAS, 2014). By 1999, this had slowed to an estimated 18 hectares/day, and more recently in 2009 that conversion was estimated to be 9 hectares/day.

For ownerships of 1.2 or more hectares, mean size ranges from 4.7 ha (SE = 0.08) in the eastern third of the state, to 8.2 ha (SE = 0.17) in the central, and 9.9 ha (SE = 0.15) in the western portion of the state (Kittredge et al., 2008). This shift in ownership size from the more suburban east (i.e., near Boston) to the more rural western part of the state is coincident with lower population densities and a less developed landscape. For purposes of our study, we consider conservation on private lands in ownerships of 4 hectares (10 acres) or greater. Smaller ownerships are ineligible for some state and federal conservation programs, and 4 hectares is thought of, conventionally in forestry, as being the minimum viable unit of management. The average size for ownerships of 4 or more hectares in Massachusetts is 15.5 hectares.

Forest owners in Massachusetts show a consistently strong interest in appreciative, non-consumptive benefits from their land. Repeated studies show they place a high priority on privacy, aesthetics, recreation, wildlife, and nature protection over timber harvest and management (Belin et al., 2005; Finley and Kittredge, 2006; Finley et al., 2006; Rickenbach et al., 1998). In spite of professing little interest in harvesting or timber income, data indicate that some owners have timber harvested from their land (McDonald et al., 2006). Likewise, though they profess interest in wildlife and nature, private land is lost to development each year.

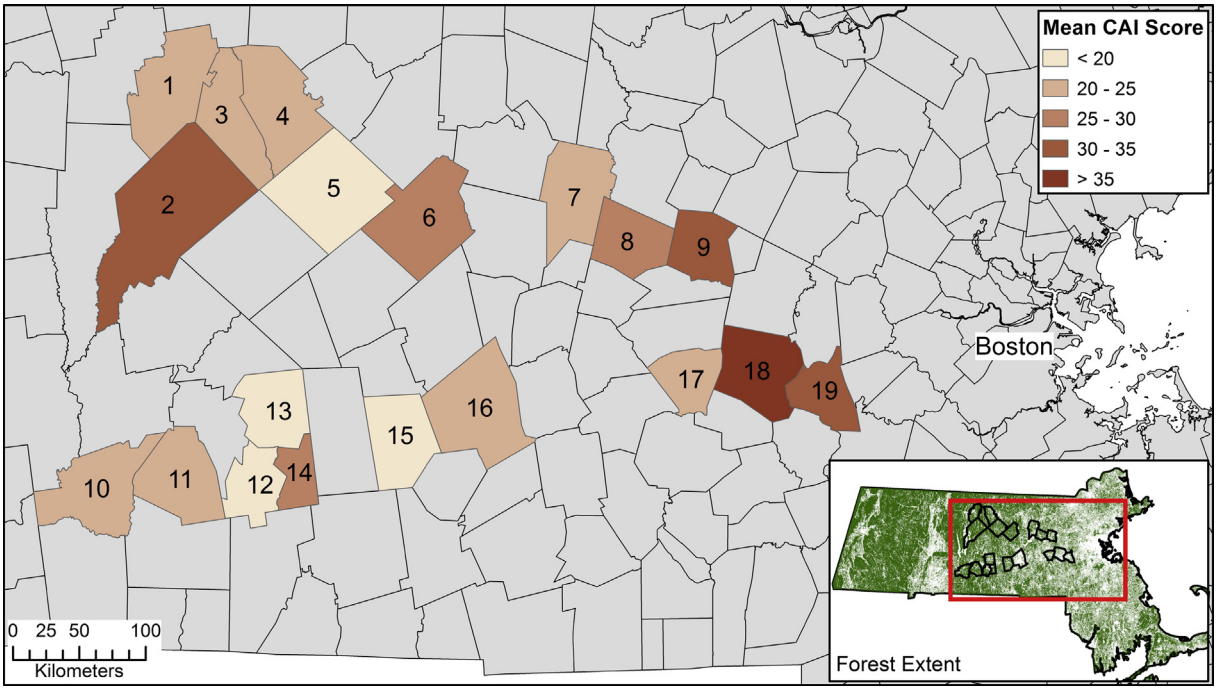

Fig. 1. Map showing location and mean CAI score of sampled towns along the study transects (1 = Athol; 2 = Petersham, 3 = Phillipston, 4 = Templeton, 5 = Hubbardston, 6 = Princeton, 7 = Lancaster, 8 = Bolton, 9 = Stow, 10 = Palmer, 11 = Warren, 12 = Brookfield, 13 = North Brookfield, 14 = East Brookfield, 15 = Leicester, 16 = Worcester, 17 = Southborough, 18 = Framingham, 19 = Natick). The inset map shows the forest coverage across the state (MassGIS Land Use, 2005).

Due to their passive use and appreciation of their land, most landowners do not have professionally prepared forest management plans (Kittredge, 2004), because they do not see a reason for a plan when their land is providing the values and beauty they seek. This is not unique to Massachusetts. Nationwide, it is estimated that as few as 3% of private woodland owners have a professionally prepared plan for their land (Butler, 2008).

3.2. Land use/land cover and social context along study transects

In the more rural parts of the study region, forest comprises as much as 78% of the land cover of towns, and this declines dramatically to as little as 29% in the more urban and suburban towns (Raciti et al., 2012). Timber harvest practices and forest conservation also vary across urban and rural regions. An analysis of MA timber harvest data from 1983 to 2003 showed great variation in harvesting patterns with limited harvest in areas with higher road densities and median household income (McDonald et al., 2006). The percent of forest formally protected ranges across the study towns with a low of 3.6% of forests protected in Warren, MA to a high of 54.5% of forest protected in Petersham, MA. In general, the protection of forests is higher in rural areas along the study transects.

The social context also varies in our study region. Population density in our study towns ranges from 7.0 to 997.3 people per km^2. In our study towns, the median income ranges from $42,422 to $140,439 and the level of educational attainment varies from 14.1% to 65% by town for residents who have attained a bachelor's degree or higher.

4. Methods

To examine awareness about conservation options in the study area, we administered a survey to landowners and analyzed how the level of awareness varied across different levels of development, patterns of land use and land cover, urban categories, and other social characteristics.

4.1. Conservation Awareness Index (CAI) survey

We utilized an existing survey instrument that provides a rapid means of estimating landowner's awareness of conservation options for their land (Van Fleet et al., 2012). The survey assesses awareness and knowledge of, and experience and familiarity with four tools that can promote conservation on private land: timber harvest, property tax programs, conservation easements, and estate planning. While there are many other management practices (e.g., removal of invasive plants, permitting or prohibiting hunting on land) and social factors (e.g., memory, emotion, values, beliefs; Lyons et al., in preparation) that can shape land use decisions and the resultant landscape, the four tools included in CAI were identified by conservation professionals, foresters, and landowners as having the most relevance for shaping decisions that could alter or remove forest cover (Van Fleet et al., 2012). The survey instrument was tested in six rural towns in western Massachusetts (Van Fleet et al., 2012) and also administered in six rural towns in New York (Schnur et al., 2013).

Returned CAI surveys were scored using a predetermined heuristic to assess relative conservation awareness. For each of the 4 conservation tools included in CAI, the instrument poses questions to assess: relative familiarity with the concept (i.e., "how familiar are you with ___, on a scale of 1–5?"); demonstrated knowledge of the concept (e.g., several true/false/I-do not-know questions); experience with or consideration of the concept (e.g., "Have you ever done ___, or considered it? Do you know someone who has done ___, or considered it?"); and ability to identify sources of information about the concept (e.g., "Where would you go to find more information about ___?"). The maximum possible score for each conservation tool (i.e., current use property taxation, conservation easements, estate planning, timber harvesting) was 16, resulting in a total maximum score of 64 (Fig. 2). The survey instru-

SECTION 2: Conservation Restrictions

5. How much would you say you know about Conservation Restrictions? Circle a number from the scale below:

Not heard of	*Nothing at all*	*Some*	*Quite a lot*	*A great deal*
1	2	3	4	5

6. Please indicate whether the following statements are true or false by circling *T* or *F*. If you do not know, circle *Don't know*:

A. Conservation Restrictions permanently limit development on my land.	*T*	*F*	*Don't know*
B. Conservation Restrictions must apply to my entire property.	*T*	*F*	*Don't know*
C. Conservation Restrictions require public access to my land.	*T*	*F*	*Don't know*
D. Land trusts hold Conservation Restrictions on private land.	*T*	*F*	*Don't know*

7. Have you or someone you know had experience with Conservation Restrictions? Circle *Yes* or *No* in the boxes below. If you do not know, circle *Don't know*:

A. I have considered a Conservation Restriction for my land.	*Yes*	*No*	*Don't know*
B. I have a Conservation Restriction on my land.	*Yes*	*No*	*Don't know*
C. Someone I know has considered a Conservation Restriction for their land.	*Yes*	*No*	*Don't know*
D. Someone I know has a Conservation Restriction on their land.	*Yes*	*No*	*Don't know*

8. Do you know a local land trust? Check *Yes* or *No* and provide any additional information that you can:

___ *Yes*: Specify their name(s):_____

_____

___ *No*: How would you find out about one:_____

_____

Fig. 2. Example section of the CAI instrument, covering awareness of conservation restrictions. An analogous set of questions was included for each of the four conservation tools. The maximum CAI score for each tool is 16 points, which were assigned as follows: Question 5: points ranged from 0 for "not heard of" to 4, for "a great deal. Question 6: 1 point for each correct answer, 0 for "don't know", and -1 for an incorrect answer. Question 7: 1 point for "yes", 0 for "no" and "don't know". Question 8: 4 points for "yes" and the correct name; 3 points for "yes" and the approximate name; 2 points for "Yes", but a correct place to find information; 1 point for "No" but a correct place to find information, and 0 for no response.

ment also includes several demographic questions as well as an open-ended question about land ownership objectives. More information on the development of CAI, types of questions, and scoring is available in Van Fleet et al. (2012).

4.2. Survey sample and administration

We acquired property tax ownership records from 19 towns located along our transects (Fig. 1). Some towns were excluded from the study due to the lack of usable ownership data. Because our goal was to understand private forest landowners' conservation awareness, we used land use codes to exclude parcels used for agricultural, industrial, or commercial purposes as well as those with condominiums or apartment buildings. We also excluded ownerships under four hectares because the Massachusetts current-use property tax program (one of the four tools considered in CAI) requires a minimum of four hectares for enrollment.

Where possible, 80 landowners were randomly selected for each town in the survey population. For towns that had fewer than 80 landowners who met the study inclusion criteria (parcel size and land-use), all eligible landowners were included. A total of 1201 surveys were mailed using a modified Tailored Design Method (Dillman, 2000). Recipients were sent an introductory post-card followed by a survey mailing containing a cover letter, the two-page CAI survey instrument, and postage paid return envelope. A reminder post-card, second-wave of surveys, and a final reminder letter were also mailed. Standard human subject protocols were followed to protect the anonymity of respondents.

Of the 1201 mailed surveys, 84 were returned undeliverable or disqualified because the recipient was deceased or did not own qualifying property, leaving an effective sample size of 1117 surveys presumed to be delivered and valid. Of those surveys, 434 were returned and usable giving an effective response rate of 38.9%. While the response rate varied significantly between the 19 towns studied (Table 1; Cramer's $V = 0.172$; $p = 0.002$; Vaske, 2008), we found no significant differences in response rate along any of the measures of development, land use or social characteristics we analyzed (e.g., development patterns, forest land cover, population density).

4.3. Town level data sets

We created a set of categorical variables to explore how CAI scores varied with the urban, suburban, and rural conditions of the towns; the demographic patterns in the towns; and the degree of conservation activity within towns. Because there is no single classification system that defines urban, suburban, and rural conditions, we used a variety of measures of land use and land cover, development trends, and urban-ness.

4.3.1. Land use and land cover metrics

Land use data for each town (including the percent of land used for residential purposes and forested land uses) was acquired from the 2005 Massachusetts Land Cover data layer available from the Massachusetts state GIS repository (MassGIS). Impervious surface area (ISA) for each town was derived from the MassGIS impervious surface data layer. Impervious surface areas include all constructed areas such as buildings, roads, and parking lots. Non-impervious surface areas include all vegetated areas, wetlands and water bodies, and naturally occurring barren areas.

4.3.2. Development patterns

We utilized data compiled by Mass Audubon to provide four measures of development patterns and trends: (1) *Developed land*:

Table 1
Survey response rate, ownership characteristics, and mean CAI score by town.

Town	Town ID	Response rate (%)	Mean respondent ownership area ± SE (ha)	Median respondent ownership area (ha)	Mean CAI score + SE	*n*
Athol	1	35.5	24.2 ± 7.9	8.1	24.7 + 2.5	25
Petersham	2	50.7	33.9 ± 11.6	9.1	30.9 + 2.6	36
Phillipston	3	36.7	21.3 ± 5.2	14.2	23.6 + 2.7	29
Templeton	4	43.2	30.0 ± 18.7	7.7	20.9 + 2.5	31
Hubbardston	5	30.8	10.9 ± 2.0	6.1	18.0 + 2.2	23
Princeton	6	38.5	11.2 ± 2.0	7.3	27.0 + 2.9	27
Lancaster	7	40.3	12.1 ± 3.4	6.1	24.7 + 2.2	21
Bolton	8	44.6	19.1 ± 7.0	10.9	27.0 + 2.7	29
Stow	9	36.4	14.6 ± 4.9	7.7	31.9 + 4.4	14
Palmer	10	33.3	20.8 ± 4.2	15	20.4 + 2.5	25
Warren	11	42.1	23.6 ± 4.6	14.2	23.1 + 1.9	31
Brookfield	12	39	13.6 ± 4.6	6.1	19.8 + 2.3	26
North Brookfield	13	60.5	12.9 ± 2.0	8.1	17.4 + 1.6	42
East Brookfield	14	31.5	44.7 ± 18.7	17	25.7 + 3.5	17
Leicester	15	38.3	10.6 ± 1.7	8.5	17.1 + 2.2	27
Worcester	16	21.4	18.9 ± 10.8	8.1	23.7 + 4.7	3
Southborough	17	33.3	7.5 ± 0.8	6.9	24.5 + 2.4	8
Framingham	18	40	24.4 ± 7.5	19.8	38.3 + 8.2	6
Natick	19	63.6	19.6 ± 6.5	17.8	31.7 + 6.4	6
Mean	–	40.2	20.8 ± 2.1	9.3	23.5 + 0.7	426

acres of developed land in 2005 as a percentage of the total land area; (2) *Recent development:* acres of new development from 1999 to 2005 per square mile; (3) *New housing development:* number of homes constructed between 1999 and 2005 as a percentage of existing housing units in 2000; and (4) *Development impact zone:* based on development trends and ecological characteristics, the development impact zone classifies towns as (a) at or close to build-out, (b) in the sprawl frontier where large lot development has been occurring, (c) in the sprawl danger zone where an initial wave of new construction could threaten the ecological integrity of ecosystems, and (d) in a limited development zone where there has not been significant new construction. Additional details about these metrics can be obtained from Mass Audubon (2009).

4.3.3. Urban-ness

Population density was calculated using population data from the 2010 census. Urban classification codes were derived from the MassGIS DOT urban boundaries data GIS layer, which delineates census blocks as urban areas, urban clusters, or non-urban. For any town where >75% of the land area is a single urban code, we assigned that code to the entire town. In other cases where a single town had multiple codes, we assigned a mixed-code to the town.

A metric for the landowner perception of the urban-ness of their town was derived from the results of a related survey deployed along the study transects (Short et al., unpublished survey data). Survey recipients were asked to describe the area in which they live as "urban," "suburban," or "rural." Responses were aggregated at the town level and towns were classified in the following categories: (a) rural: all respondents selected rural; (b) mostly rural: respondents selected a mix of rural and suburban with more than 50% of town respondents selecting rural; (c) suburban–rural: respondents selected a mix of suburban and rural with more than 50% of town respondents selecting suburban; or (d) suburban/urban: respondents selected either suburban or urban.

4.3.4. Other social characteristics

Town level affluence was derived from the median family income reported in the 2010 census data for each town. An index of conservation social capital was calculated for each town using data on a variety of characteristics linked to conservation in Massachusetts. While assessing social connections through social network analysis would provide a fine-grained picture of social capital among the study population, it is laborious (e.g., Rickenbach, 2009) and beyond the scope of this preliminary investigation. We thus elected to develop a simple index of social capital that could be calculated from publicly available data for each town.[1] Points were awarded based on (a) the activity and resources of the Local Conservation Commission in the town;[2] (b) the level of land trust activity in the town;[3] (c) the presence of Keystone Project volunteers in the town;[4] and (d) the town's commitment to the Community Preservation Act.[5] Scores for estimated conservation social capital ranged from 6.5 (East Brookfield) to 23.4 (Stow), with a mean of 13.9 for the 19 towns.

4.4. Analysis

We used descriptive statistics to analyze respondent demographics and to characterize CAI by town and in aggregate for all respondents. Responses to the open-ended question regarding the primary motivations for owning land were coded and sorted into categories of similar response. We used ANOVA to test for dif-

[1] Three of the four elements of this index are specific to Massachusetts (e.g., Conservation Commission, Keystone Project, the Community Preservation Act). While this limits the direct application of this tool to other states, similar metrics can be developed to estimate the extent of local conservation social capital in regions.

[2] By law, every town in Massachusetts is required to have a Conservation Commission. Commission members are generally volunteers appointed by the Mayor or Selectboard. Some towns also have paid positions to support the work of the Conservation Commission. Points were awarded based on the staffing, membership, and activity level of the Conservation Commission. Towns received: one point if they have a paid, professional conservation agent on staff and 0.5 points if they have an administrative assistant; one point for every two members on the Commission; and one point for each meeting scheduled per month.

[3] Points were awarded based on coverage of a land trust in the town: three points if a town had its own land trust and one point for every two regional land trusts serving the town.

[4] The Keystone Project (https://masskeystone.net/) is a UMass Extension program in operation since 1988. The program holds an annual 3-day workshop that trains local residents in conservation tools and practices. In-return workshop participants serve as conservation spokespersons or advocates in their respective towns. To estimate the potential influence of Keystone, points were awarded according to the number of Keystone Project volunteers in the town multiplied by the number of years since their training.

[5] The 2000 MA Community Preservation Act (http://www.communitypreservation.org) provides a source of funds for conservation, historic preservation and affordable housing. To be eligible, a town must vote to adopt the program and agree to increase property taxes by 1–3%. Towns earned 1 point for each percentage by which they increased property taxes.

ferences in CAI scores by town (continuous variable) and by the categorical variables describing land use, development patterns, urban-ness, and social characteristics, following methods described by Vaske (2008). We also ran a stepwise algorithm for model selection based on AIC scores with the suite of independent variables to identify the best predictors of conservation awareness. Given that these dependent variables were significantly correlated, interaction terms were included in the stepwise regression.

5. Results

5.1. Respondent demographics

Survey respondents were typical of Massachusetts landowners described by previous studies (e.g., Ma and Kittredge, 2011; Belin et al., 2005; Finley et al., 2006; Rickenbach et al., 1998; Rickenbach and Kittredge, 2009). The dominant reasons for land ownership are non-consumptive or appreciative (e.g., part of home, residence, privacy, family inheritance, legacy) rather than income or investment. Only 12.7% of respondents cited income/investment as the "main reason for ownership." The vast majority of respondents live on their ownership (70.9%) or less than 10 miles away (11.9%), and only 4.2% live more than 100 miles from their land. Respondents are well educated – 27.1% report having attained a minimum of a college degree, and 35.5% report an additional degree beyond a college degree, implying 62.6% with a minimum of a 4-year college degree. This level of educational attainment is higher than the overall education characteristics of our study towns where 37% of the population has a minimum of a 4-year college degree and Massachusetts in general where 39% with a minimum of a 4-year college degree (U.S. Census Bureau). Our respondents tend to be older (e.g., 35.1% are older than 66; 43.9% are between 51 and 65 years of age), and predominantly male (66.8%). Respondents have on average owned their land for 23.2 years (SE = 0.7 years). Size of respondent ownership varies considerably, with a mean of 20.9 ha (median = 9.3 ha; SE = 2.2 ha) and a range from 4 to 607 ha.

5.2. Overall CAI overall and subscores for conservation tools: timber harvest, property taxation, easements, estate planning

The mean Conservation Awareness Index (CAI) score for all respondents was 23.49 (SE = 0.66), with a wide range of 0.0–60.0 out of the potential maximum score of 64.0. There were significant differences in mean CAI by town ($F = 3.147$, $p \approx 0$, $df = 18$), with a high of 38.3 (Framingham) and a low of 17.1 (Leicester; Table 1).

The four components of CAI, each with a maximum score of 16.0 had mean scores as follows: conservation restriction (5.6), timber harvest (6.6), current use property taxes (5.9), and estate planning (5.2). At least one respondent attained this maximum score for each section, implying that the instrument assessed an attainable level of knowledge and experience, and respondents could achieve "maximum awareness." The results also imply that the state of landowner awareness of all of these four aspects of conservation is relatively low. We explored the correlation between the four components of CAI and several continuous variables that describe the biophysical and social circumstances of our sample towns (Table 2). In particular, there was significant correlation between the estate planning subscore of CAI and town median family income (2010), the percent land use of forest, percent land use of development, and population density. Similarly, the conservation easement subscore was significantly correlated with these attributes. The timber harvest subscore was only correlated in a limited way to land use, and the current use property taxation subscore was not significantly correlated to any of these attributes.

Respondent CAI and length of ownership were poorly related ($r = 0.024$). Similarly, there was no significant difference between respondent ownership tenure by town ($F = 0.852$, $p = 0.644$). It is not likely that owners with longer tenure have higher conservation awareness, nor that ownership tenure explains significant CAI differences by town.

5.3. Variation in CAI between towns by categorical variables

Mean conservation awareness as estimated by CAI varied significantly between 19 sample towns, and we found significant differences in respondent CAI depending on recent development trends (e.g., recent development acres and new housing development, population density, and impervious surface area; Table 3). Other measures of urban-ness including the urban code and landowners' perception of urban-ness proved to not be significant and several static measures of land use such as the percent of developed land, residential land, and forestland in towns were poorly related to the variation in CAI scores. In addition, the development impact zone, which provides a measure of the threat development poses to ecological systems, was poorly related to the variation in CAI scores.

The relationships between individual respondent CAI and development trends, ISA, and population density varied in different ways (Table 3). In all cases, we saw the most stable (e.g., lowest levels of recent development) and most rural conditions (e.g., lowest ISA, lowest population density) were related to the highest CAI scores. Depending on the specific measure, high CAI scores were also identified in areas with high or medium–high levels of recent development and medium high population density. The lowest scores were in areas of medium–low and medium levels of recent development and ISA.

We also found significant differences in CAI scores depending on conservation social capital and affluence (Table 3; Fig. 3). The relationship for these categories was more linear with high CAI scores related to high levels of affluence and conservation social capital, and low CAI scores related to lower levels of affluence and conservation social capital.

5.4. Findings of the model estimating CAI based on physical and social landscape characteristics

We also explored the relationship between CAI and fourteen continuous variables on land cover, population social characteristics, recent development, and development density using a multivariate stepwise linear regression. Models were evaluated based on the AIC score; the final model adjusted R-squared value was 0.6531 with $p = 0.0006$. Table 4 summarizes the best fit model with the form

$$\mathrm{CAI} = \beta_0 + \beta_1 \mathrm{FOR} + \beta_2 \mathrm{DEV} + \beta_3 \mathrm{ACRE} + \beta_4 \mathrm{CONSO} \quad (1)$$

where FOR is the percent forest land use by town, DEV is the recent development between 2005 and 2013 (mi^{-2}), ACRE is the respondent parcel size (acres), and CONSO is the conservation social capital score.

6. Discussion

6.1. Overall CAI

The overall mean CAI score from this study (23.49, SE = 0.66; 19 communities, $n = 426$) is similar to the mean CAI score reported by Van Fleet et al. (2012; 20.4, $n = 267$ from 6 rural Massachusetts communities), as well as another study of 19 Massachusetts communities (mean CAI = 23.4, $n = 409$, Losey, in preparation). In a study of landowners in 6 rural New York communities, Schnur

Table 2
Conservation Awareness Index conservation tool subscores and correlation with biophysical and social attributes of sample towns.

CAI conservation tool subscores	Mean	SE	Correlation coefficients[a]			
			Median family income (2010)	% Forest land use	% Developed land use	Population density (km^{-2})
Use taxation subscore	5.9	0.2	0.045	0.036	−0.006	0.011
Conservation easement subscore	5.6	0.2	0.191**	−0.144**	0.113*	−0.144**
Timber harvest subscore	6.5	0.2	−0.061	0.120*	−0.105*	−0.068
Estate planning subscore	5.2	0.2	0.265**	−0.213**	0.173**	0.154**
Total CAI score	23.3	0.6	0.136**	−0.062	0.055	0.075

[a] ** = Significant at the .01 level. * = Significant at the .05 level.

Table 3
Mean CAI score by various relative categorical metrics (with ANOVA results of *F* and *p* values).

Variable	Categories	*n*	Mean CAI[A]	Std error
Impervious surface area (% by town)	[1] Low: <2.90	92	27.41 a	1.58
$F = 3.671$, $p = 0.006$	[2] Medium low: 2.91–4.20	80	20.56 b	1.23
	[3] Medium: 4.21–6.02	84	21.24 b	1.37
	[4] Medium high: 6.03–7.10	101	23.16 ab	1.45
	[5] High: >7.10	69	24.87 ab	1.57
Recent development (acres of new development/$mile^2$)	[1] High: 10.4–17.0	8	24.50 a	2.35
$F = 5.798$, $p = 0.000$	[2] Medium high: 7.5–10.3	49	28.60 ab	2.15
	[3] Medium: 5.5–7.4	156	20.35 ac	1.01
	[4] Medium low: 3.1–5.4	148	23.13 a	1.05
	[5] Low: 0.2–3.0	65	27.60 ab	1.92
New housing development (% of existing housing units constructed between 1999 and 2005)	[1] High: 15.1–34%	50	26.02 a	1.81
$F = 3.550$, $p = 0.007$	[2] Medium high: 10.1–15.0%	198	23.89 a	0.98
	[3] Medium: 5.1–10%	121	22.76 a	1.23
	[4] Medium low: 2.6–5.0%	51	19.43 a	1.68
	[5] Low:<2.5%	6	38.33 a	8.17
Population density (people per km^2)	[1] Low: <36.78	92	27.41 a	1.58
$F = 3.418$, $p = 0.009$	[2] Medium low: 36.79–79.02	80	20.57 b	1.23
	[3] Medium: 79.03–94.54	88	22.16 ab	1.43
	[4] Medium high: 94.55–140.51	91	24.51 ab	1.41
	[5] High: >140.52	75	22.12 ab	1.58
Affluence (2010 Median household income; $)	[1] Low: <71,413	126	20.99 a	1.04
$F = 3.472$, $p = 0.008$	[2] Medium low: 71,414–73,082	60	22.20 ab	1.84
	[3] Medium: 73,083–76,932	89	23.46 ab	1.54
	[4] Medium high: 76,933–100,307	67	23.87 ab	1.65
	[5] High: >100,308	84	27.89 b	1.57
Conservation social capital	[1] Low: <8.00	116	20.68 a	1.09
$F = 7.815$, $p = 0.000$	[2] Medium low: 8.01–12.70	77	20.64 a	1.42
	[3] Medium: 12.71–12.90	65	27.60 b	1.92
	[4] Medium high: 12.91–16.50	86	21.49 ab	1.24
	[5] High: >16.50	82	28.99 b	1.7

[A] Mean CAI scores with different letters are significantly different at the 0.05 level.

et al. (2013) determined a mean CAI score of 14.5 ($n = 271$). In a recent study of 10 communities in central Massachusetts and northern Connecticut (Kittredge et al. unpublished survey data), the mean CAI score was 22.9 ($n = 283$). One respondent in this study achieved a score of 60 out of 64, indicating that high conservation awareness is possible among the landowner population. However, the overall results from the repeated assessment of landowner conservation awareness using the CAI appear relatively consistent and suggest rather low awareness of conservation options and alternatives, and lack of knowledge about where to go for additional information. This suggests that landowners are not prepared to make use of conservation tools when making decisions about the future of their land.

6.2. Understanding the similarities and variation in CAI in rural and suburban contexts

Our over-arching hypothesis was that conservation awareness would be highest in rural areas and decline with suburban and urban conditions where the landscape is more developed and fragmented and where the number of parcels qualifying for traditional of conservation and land management tools (e.g., timber harvest, forest management property tax programs) wanes. Our results show that CAI varies with land use and development context but not in the ways that we expected. We did not see consistent patterns across measures of land use, development trends, or urban-ness. Where we did find significant differences across these measures, two observations stand out. First, the most stable landscapes (i.e., those with the lowest rates of recent development measures by acres developed or housing) and the most rural conditions (i.e., low population density and low ISA) had the highest levels of CAI. Second, high levels of CAI were also found in areas that are changing relatively rapidly as well as towns that are on the more suburban or urban side of the development and land-use spectrum.

The relationship between CAI scores and other social characteristics aligned better with our expected results. A town's affluence, estimated by median family income, is related to conservation awareness, but significant differences only appear at the extreme levels (i.e., between towns with median family income lower than

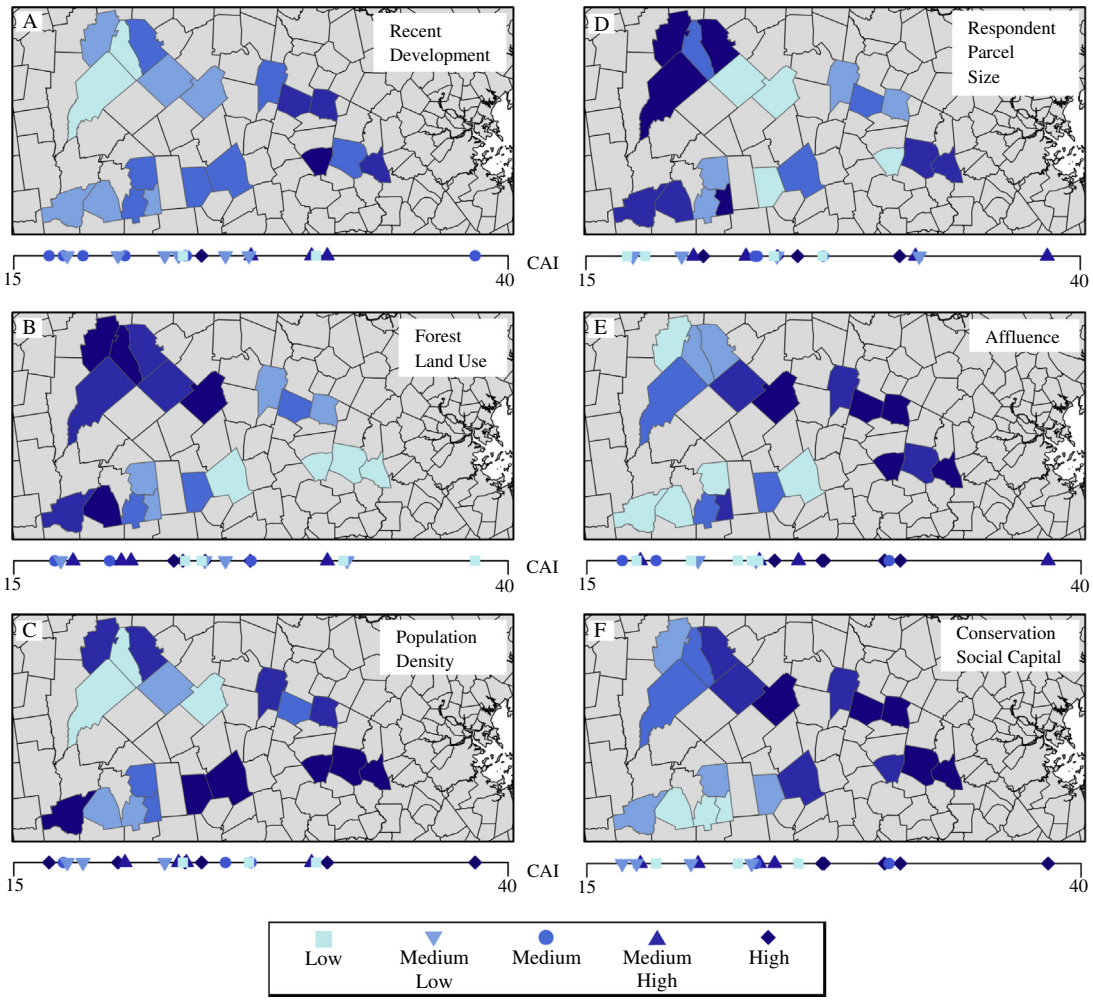

Fig. 3. Maps showing town values for the categorical variables with differences in CAI scores (see Table 2): (A) recent development, (B) forest land use, (C) population density, (D) respondent parcel size, (E) affluence, and (F) conservation social capital. The scale bar below each map denotes the distribution of CAI values based on town categorization for that variable with the color ramp corresponding to the values described in Table 3.

Table 4
Multivariable model results for CAI town-level analysis.

Parameter	β Estimate	*p*-Value[a]
Intercept	22.23	0.001**
FOR	−0.19	0.006**
DEV	−1.67	0.03*
ACRE	0.035	0.0005**
CONSO	0.81	0.0006**

[a] ** = Significant at the .01 level. * = Significant at the .05 level.

$71,143 and those greater than $100,300; Table 3). Thus affluence appears related to awareness, but not closely, or outside of other mediating factors. Our expression of relative conservation social capital in communities was also significantly related to a town's average conservation awareness (Table 3). The results of the stepwise regression further reinforce these results (Table 4). Conservation social capital is a highly significant variable in the model, relative to other continuous variables such as the percent of forestland in a town, the amount of recent development, or size of a respondent's ownership.

These results lead us to pose two questions that motivate future research. The first concerns the surprising results in urban and suburban areas: Why do we find high conservation awareness in what could otherwise be thought of as developed, built out, or heavily suburbanized towns? One possible explanation is the 'survivor hypothesis,' which suggests that landowners may need to have knowledge of all tools that promote the preservation of large parcels in order to 'survive' as an owner of 4 or more hectares in a suburban context. Landowners with low conservation awareness may have already sold and developed their property. The remaining larger landowners have high CAI and are capable of withstanding the pressures of high real estate values, zoning, and local attitudes (and local bylaws) against timber management. Their land may already be protected from development through easement, and they may have experience with conservation oriented estate planning and property tax programs, in light of the high monetary value of the land. Additional research is needed to uncover the motivations of these larger suburban landowners and to understand the role conservation knowledge and tools play in helping them to keep their parcels intact.

The second question concerns the variation in CAI scores among towns in the rural context: Why is there so much variation with the results from towns on the rural end of the spectrum (e.g., high scores for the towns with the lowest population density and ISA and low scores for the towns with medium–low population density and ISA)? Differences in the level of affluence and cultural characteristics may play a role in creating these distinctions.

The rural town with the highest CAI score, Petersham, is somewhat unique in its affluence and level of conservation activity. The

median household income in Petersham is approximately $71,000 while the median income in other towns perceived as rural ranges from $42,422 to $75,625 (U.S. Census Bureau). Petersham has been home, for over 100 years, to Harvard Forest, which hosts outreach programming and a world class natural history museum. Conservation organizations such as the Massachusetts Audubon Society and The Trustees of Reservations also have property in Petersham, and likely contribute to overall enhanced awareness. Petersham is at the epicenter of two regional land trusts and one of the most heavily conserved landscapes in southern New England (Golodetz and Foster, 1997). Logic and experience tell us that more affluent towns have the resources to invest in conservation that would manifest in higher levels of conservation social capital.

Additional research is needed to identify barriers to increased CAI in other rural contexts. In less affluent rural areas, there are few resources to devote to conservation and landowner education. In addition, there may be no awareness or belief in the necessity of these tools. Where land values are low, conservation tools that lower taxes (e.g., conservation easements and property tax programs) may not be perceived as necessary. Lastly there may be cultural barriers to participation in conservation activities, which may reduce landowners' interest in more information or to become involved in conservation initiatives.

Our study was exploratory in nature – at the onset, we had little knowledge about the relationship between conservation awareness and urban or rural-ness. Because there are a wide range of subjective and objective means by which urban and rural character can be defined, our analysis explored several categorical and continued variables. We found that some categorical variables were not distributed evenly across our transects because urban and rural characteristics sometimes do not lend themselves to gradual or orderly arrangement through a landscape. As noted above, we also found that several measures were correlated with one another (e.g., population density, impervious surface area, percent developed land use). This was to be expected as we selected an array of variables meant to measure relative urban-ness. Our model highlights the importance of percent forest cover, recent development, and parcel size as key measures of the urban and rural character. Future research on landowner conservation in dynamic rural-to-urban landscapes should focus these key variables. More explicit experimental design could be applied to balance sample sizes and reduce redundancy and correlation effects.

6.3. Implications for conservation planning and outreach

Identifying the attributes of towns with low conservation awareness can meaningfully assist outreach efforts to engage private landowners. Especially in dynamic, transitional rural-to-suburban landscapes, targeted outreach and investment resulting in elevated conservation social capital could translate to significantly higher conservation awareness of landowners and ideally alter the typical trajectory of sprawl and corresponding loss of habitat and other ecosystem services. This is particularly important in light of our finding of relatively low CAI scores in the so-called 'sprawl danger zone' where an initial wave of development is occurring in ecologically sensitive areas.

We find hope in the result that CAI scores are higher in areas with higher conservation social capital as this provides an initial avenue for addressing low CAI in key regions. Conservation social capital can manifest itself in many different ways. Labich et al. (2013) describe the role of Regional Conservation Partnerships in New England, where land trusts, watershed associations, state agencies, and others collaborate on land protection. These partnerships can be very effective at elevating local conservation capacity and reaching local woodland owners with information to assist with conservation decisions. They can convene meetings of owners where they can exchange experience and learn from one another (e.g., Ma et al., 2012a,b), and otherwise increase the chances for owners to encounter one another informally through social networks (e.g., Rickenbach, 2009; Sagor and Becker, 2014; Kittredge et al., 2013; Knoot and Rickenbach, 2011; Korhonen et al., 2012). These kinds of investments in local conservation social capital are not expensive, and our results suggest they could result in elevated conservation awareness of owners.

Many conservation planning activities focus on the identification of ecologically significant areas and traditional conservation metrics such as the extent of protected land, core habitat, habitat connectivity, rarity, and other biophysical features. Our results suggest that in landscapes dominated by small, private ownerships, it is also important to consider the relative conservation awareness of landowners, and the probability of them making a conservation-oriented decision about their land. Investments in conservation social capital to elevate landowner conservation awareness could be helpful in changing the trajectory of random, reactive, and unplanned development.

We thus recommend that habitat conservation efforts link biological and social assessments and focus efforts on building conservation social capital and landowner conservation awareness in high priority areas. The identification of areas with low conservation awareness (either through direct application of the CAI instrument or a locally appropriate variant) can be combined with existing ecological assessments to identify social and ecological priority areas. Woolsey et al. (2010) provide an example of an existing ecological assessment. Their "biomap" analysis of Massachusetts "combines hundreds of individual pieces of geospatial data about the state's species, ecosystems, and landscapes." Likewise, the Massachusetts State Wildlife Action Plan "uses a habitat-based approach, linking types of wildlife in greatest need of conservation to critical habitats that are essential for the survival of the species." (MA Division of Fisheries and Wildlife, 2005). Organizations can target education and outreach in areas of ecological importance and with low conservation awareness. The significant remaining challenge, however, is to have the education coincide with landowners poised and willing to make conservation-oriented decisions. More generic investment in local conservation social capital may have more enduring positive effect on conservation awareness than an individual series of workshops or education. As Raymond and Brown (2011) observe, "Environmental managers therefore cannot assume areas of high conservation priority will be areas of high conservation opportunity," unless more is known about the conservation awareness and interest of private owners (p. 2519).

The linkage of biological and social assessments raises challenging questions in terms of implementation and specific resource allocation. How should the level of conservation awareness shape conservation planning? Should only those places with high conservation awareness be targeted for additional resources? Alternatively, should effort be focused on areas where landowners are not already familiar with the tools? We recommend using information about conservation awareness along with the relative biological importance of a town to inform strategic decisions about resource allocation. Rather than making blanket investments in conservation social capital equally in all towns, a knowledge of conservation awareness allows for strategic investment, targeting, and marketing to enhance acquisition outcomes.

A more complete strategy for integrating social and biological assessments is contingent on understanding the relationship between conservation awareness and actual utilization of conservation tools. While this study is motivated by the theory of planned behavior (Ajzen, 1991) and the associated claim that conservation awareness is a necessary precursor for utilization of conservation tools, assessing the degree to which conservation awareness is

related to actual behaviors was beyond the scope of this study. Future research that directly explores the mechanisms that link conservation awareness to behavior would be useful for further defining conservation strategies.

7. Conclusions and implications

In regions where small private ownerships dominate the landscape, landowner conservation awareness is important as the cumulative effect of their decisions influence ecosystem structure, function, and ecosystem services. Elevated conservation awareness is not a guarantee of the utilization of conservation tools (e.g., it is possible for someone with an excellent understanding of their options, as estimated through CAI, to nonetheless behave in a non-conservation oriented manner due to other exogenous factors, such as fiscal need or family disagreement), but it is a necessary precursor to conservation-minded behaviors. At a fine scale this could be considered an expression estimating bounds on the likelihood of landowner conservation behavior and future landscape conditions.

We found high CAI scores to be possible on both ends of the suburban-to-rural spectrum and to be related to high levels of conservation social capital and town-level affluence. The presence of high CAI in suburban areas supports the notion that conservation tools may provide important support for landowners who aim to keep their parcels intact despite development pressure. We also found significant troughs of CAI in the rural-to-urban region we studied.

Being able to evaluate landowner conservation awareness enables targeting of social capital investment and attention. Broad, generic statewide programs and policies to educate landowners across all towns might not be as effective as strategic, targeted investments in local conservation social capital in places of identified need. The Conservation Awareness Index can be used as a rapid awareness assessment tool among landowners in a particular landscape to identify areas of need. The same way rapid ecological assessments can be made of landscapes to prioritize conservation efforts, landowner awareness can be rapidly assessed using a simple mail survey approach (e.g., Dillman, 2000). Alternatively, in light of the positive relationship between landowner awareness and conservation social capital, the latter can be even more easily assessed. Combining the results of spatial biological assessments (e.g., biomap in Massachusetts; Woolsey et al., 2010) with assessments of landowner conservation awareness may improve the net effect of conservation efforts where they are most needed.

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