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Unexpected co-benefits: Forest connectivity and property tax incentives

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ABSTRACT

Forest property tax incentives were developed in the early 1900s to enhance onsite forest management and ensure predictable timber supplies, but their ongoing contributions to landscape connectivity between public and private forests are not well understood. We measured spatial connectivity between public forests and private forests enrolled in forest tax programs. We also analyzed tax program laws and agency policies to determine whether the design or implementation of the programs considered connections to public lands. We focused on one of the largest forest tax incentive programs in the United States: Wisconsin's Managed Forest Law and Forest Crop Law, which enrolled 1.1 million ha of the state's privately owned forests. We quantified patch density, mean patch size, and area-weighted mean patch size of enrolled forests in three ecologically distinct regions. A neutral landscape model analysis showed that actual enrollments were more likely to cluster near public lands than enrollments randomly distributed across the forested landscape. Yet the tax programs' statutes and policies revealed no consideration of public lands in the programs' planning or implementation. Although they are a voluntary, untargeted policy tool, forest tax programs provide the unintended but important benefit of connectivity with public lands. If states and stakeholders recognize forest tax programs as a means to achieve landscape planning goals, they could coordinate cross-boundary management efforts and target areas of particular conservation interest. Forest tax programs deserve greater attention as a private land conservation strategy.

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1. Introduction

Planners and managers deploy a broad array of policy tools to produce and maintain public goods on private forestlands (Bengston, Fletcher, & Nelson, 2004). These policy approaches are of increasing importance as forest loss and fragmentation worldwide raise serious challenges for ecosystem management (Laurance et al., 2002; Radeloff, Hammer, & Stewart, 2005). One long-established but underexamined approach to private forest management is through the property tax system (Jacobson & McDill, 2003). Forest tax incentive programs have been established for nearly one century in the United States, but their implications for forest fragmentation and connectivity with public lands are relatively unknown. Forest connectivity is an important consideration for managers and planners in landscapes with a mosaic of public and private lands. The size and configuration of forest patches determine the provision of goods and services such as water quality, wildlife habitat, outdoor recreation, and timber production (Fischer, Lindenmayer, & Manning, 2006; Harrison, Herbohn, & Herbohn, 2000).

Private lands are crucial for achieving landscape-scale conservation goals like ecosystem management and forest connectivity. Fifty-six percent of US forest land is privately owned, of which 67% is non-industrial private forest (NIPF) and 33% is owned by industrial timber and other corporations (USFS, 2010). Private lands are critical for natural resource conservation, providing habitat for 85% of endangered species (US General Accounting Office, 1994) and buffering nature reserves (Wright, 1998). High rates of development adjacent to protected area boundaries limit effective core habitat area for species and disrupt ecological flows (Radeloff et al., 2010). Increasingly, public agencies realize the need for coordination with private land managers within and near public reserve boundaries to sustain ecological, social, and economic goods and services (Knight & Landres, 1998; Schonewald-Cox, Buechner, Sauvajot, & Wilcox, 1992). Policy approaches for private land management and conservation include direct incentives (tax programs, cost-sharing, or technical assistance), acquisition of land or conservation easements, education, regulation, and market creation (ecotourism, carbon markets, or forest certification). These approaches can be combined to achieve conservation goals more efficiently and effectively (Doremus, 2003). Since the failure of early US Forest Service efforts to regulate private forests, most US private

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forest programs have focused on incentives and assistance rather than regulation (Dana & Fairfax, 1980).

A primary approach to private forest policy is through the property tax system. Starting with Massachusetts in 1914, all 50 states have passed legislation to lessen the property tax burden for forest owners in order to prevent premature timber harvests and timber shortages (Hibbard, Kilgore, & Ellefson, 2003; Rozman, 1942). Some state forest tax programs have evolved from a singular focus on timber to adopt common NIPF owner objectives including recreation, wildlife habitat, watershed protection, and aesthetics (Egan, 1997). Implicitly or explicitly, numerous forest tax programs adopt the values of sustainability, ecosystem health, and adaptive management (Clendenning & Stier, 2002). Some programs promote landowner participation in emerging opportunities such as forest certification and carbon markets. While not all forest tax incentive programs explicitly promote the stewardship of forest resources beyond timber management, we consider those that require detailed management plans and best management practices, prohibit development, and enforce term-length minimums to be working forest conservation programs that operate on a property-by-property basis.

However, no forest tax program explicitly addresses forest fragmentation, connectivity or cross-boundary management (Clendenning & Stier, 2002) despite their ecological, economic, and social importance to forest management. Fragmentation can compromise surface water runoff, soil erosion, and nutrient cycling (Saunders, Hobbs, & Margules, 1991). Large forest patches often support higher species richness than small, isolated forest patches (Dramstad, Olson, & Forman, 1996; Laurance et al., 2002). Forest species unable to migrate or transfer seeds between isolated patches may be extirpated with climate change (Dyer, 1994; Scheller & Mladenoff, 2008). Forest patch size determines the economic return and feasibility of timber harvests as well as opportunities for recreation and scenic enjoyment (Gobster & Rickenbach, 2004; Kittredge, 2005; Row, 1978). Forty percent of NIPF owners own parcels of 10–50 acres (4–20 ha), a size considered "too large to ignore and too small to manage as a sustainable unit with most traditional methods" (Sampson & DeCoster, 2000). Meanwhile, it is increasingly common for industrial forestland to change hands from forest product companies to financial companies, with the most valuable lands sold for development (Gustafson & Loehle, 2008). From 1993 to 2003, the number of private forest owners in the US increased by 11% to 10.3 million while total forest area remained stable (Butler & Leatherberry, 2004). Managing forests as complete ecosystems requires cross-boundary coordination among a patchwork of owners (Schulte, Rickenbach, & Merrick, 2008).

Connectivity is an often-prescribed but ill-defined concept in natural resource management (Calabrese & Fagan, 2004). *Structural connectivity*, here referring to the physical connections between conserved forest patches, is defined by the size, number and configuration of patches (Leitão, 2006). Conserved private forests adjacent to public forests provide structural connectivity. Structural connectivity has important implications for *functional connectivity*, which refers to the ability of energy, materials, and organisms to flow through a landscape (Leitão, 2006). Functional connectivity can also refer to social processes including the flow of information and coordination of ecosystem management across ownership boundaries (Janssen et al., 2006; Wondolleck & Yaffee, 2000).

This study investigates three primary questions: (1) Do forest tax programs contribute to the structural connectivity of conserved forests? We use landscape metrics to quantify this contribution, comparing industrial and non-industrial forest enrollments across a gradient of forest cover. (2) Are forest tax programs contributing to public forest connectivity more than would be expected by chance? We employ a neutral landscape model (Gardner, Milne, Turner, & O'Neill, 1987) to compare the distribution of lands enrolled in forest tax programs with a test landscape of randomly selected forests for enrollment. Finally we ask, (3) Has the planning or administration of forest tax programs prioritized connectivity with public lands? We analyze statutes and policies for the integration of public and private land forestry programs. We expect private forest tax program enrollments to increase the connectivity of public forests, with greater contributions than what would be expected by chance. Natural areas often offer amenities that attract development and increase property values (Tarrant & Cordell, 2002), so the financial incentive to enroll in tax programs may increase with proximity to public forests (Garrod & Willis, 1992). However, we do not expect tax program policy and administration to prioritize public land connectivity because landscape-scale management is a relatively new idea compared to forest tax law (Liu & Taylor, 2002). To examine these relationships, we focus on one of the largest forest tax incentive programs in the United States, Wisconsin's Managed Forest Law (MFL) and Forest Crop Law (FCL), across a gradient of forest cover.

1.1. Study area

Over two-thirds of Wisconsin's forests are owned by private individuals and corporations (Best & Wayburn, 2001), so maintenance of the state's forest products industry relies on sustainably managed private forests. Wisconsin has ranked first in the nation in paper manufacturing for over 50 years (WPC, 2000). Hunting, fishing, hiking, and birdwatching are important outdoor activities requiring the preservation of forestlands, wildlife habitat, and watershed health. This range of activities demands that Wisconsin forests be managed to ensure multiple use while sustaining ecological integrity and water quality.

For this study, we divide the state into three regions by grouping ecological landscapes defined by the Wisconsin Department of Natural Resources (WDNR, 2006). These three regions vary markedly in forest cover and ownership (Fig. 1). The northern region is heavily forested (79%), the central region is 43% forested, and the southeastern region is only 14% forested. Nearly half of the forestland in the northern region is publicly owned, much of which was acquired after widespread private land abandonment in the early 1900s. In comparison, the hilly central region is characterized by cropped hillsides and forested uplands. The central region forests are largely private, except for a large area of public land in the ecologically unique Central Sands area. The southeastern region contains the state's largest urban centers, highest percentage of agriculture, and lowest percentages of forest and public lands.

1.2. Managed forest law and forest crop law tax programs

MFL and FCL are voluntary tax incentive programs encouraging sound forestry practices on private lands, administered by the Wisconsin Department of Natural Resources (WDNR). FCL, a program for industrial landowners established in 1927, is being replaced by the MFL program, which was established in 1985 and is the only program accepting new enrollments. Most FCL enrollments have been transferred to the MFL; therefore the MFL and FCL programs are grouped in our analyses.

The changing goals of Wisconsin's forest tax programs are evident when comparing the language in FCL and MFL governing legislation. The purpose of FCL is:

> . . .to encourage a policy of protecting from destructive or premature cutting the forest growth. . . .so that such lands shall continue to furnish recurring forest crops for commercial use with public hunting and fishing as extra public benefits, all in

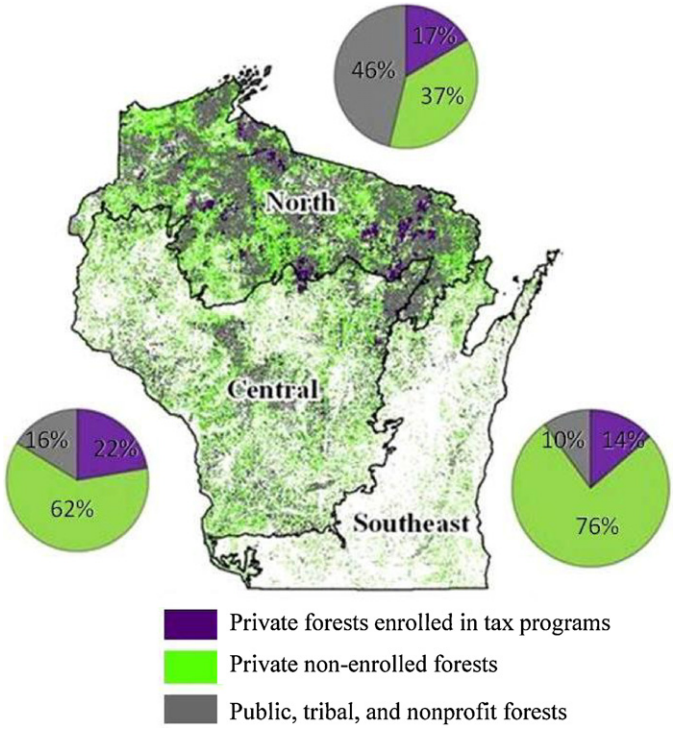

Fig. 1. Three regions of Wisconsin (USA) differ in forest cover and forest ownership, with public, tribal and nonprofit forests concentrated in the north. Pie charts show percent of region's forestland in each ownership category.

> a manner which shall not hamper the towns. . . .from receiving their just tax revenue from such lands. Wis. Stats. § 77.01 (2010)

In comparison, the purpose of MFL is:

> . . .to encourage the management of private forest lands for the production of future forest crops for commercial use through sound forestry practices, recognizing the objectives of individual property owners, compatible recreational uses, watershed protection, development of wildlife habitat and accessibility of private property to the public for recreational purposes. Wis. Stats. § 77.80 (2010)

Both FCL and MFL emphasize a primary objective of commercial timber production, but the broader objectives of the MFL program illustrate a growing recognition of non-timber public benefits. For example, MFL legislation offers a lower tax rate to landowners who open their enrolled land for public recreation. Statewide, 38% of MFL-enrolled land is publicly accessible (WDNR, unpublished data).

Wisconsin's forest tax programs are considered hybrid programs, combining a fixed property tax rate with a yield or severance tax. Enrollment is open to any private landowner, industrial or non-industrial, with at least 4 ha of forested land. To enroll, a landowner agrees to the conditions of a 25 or 50 year permit in exchange for a substantially reduced property tax rate. The permit is then attached to the property's deed and runs with the land even if ownership changes. Each non-industrial property is inspected by a forester who prescribes a management plan that is signed by the landowner and approved by the WDNR. Agreements between the WDNR and industrial enrollees do not require management plans, but all enrollees are subject to the same forestry guidelines. The penalty for breaching the mandatory practices outlined in the program, or for voluntarily withdrawing from the program, is payment of all back-taxes on the enrolled land plus penalties and fees. Less than 1% of enrolled acres are withdrawn from the program each year, voluntarily or involuntarily.

Mandatory practices include adhering to the harvesting schedule, ensuring tree regeneration, following best management practices for water quality, and providing public recreation access if enrolled under the "open" category (WDNR, 2008). Residences are not allowed on enrolled lands. Foresters are required to indicate the presence of endangered species in the management plans of non-industrial properties. Since 2008, non-industrial property enrolled in MFL is automatically certified by the American Tree Farm System and the Forest Stewardship Council, unless the property owner declines group certification in writing. These certification programs require forest owners to conform to standards not addressed by the MFL program itself, such as pesticide and GMO regulations.

2. Methods

2.1. Study design and data preparation

We evaluated forests enrolled in MFL and FCL (hereafter "tax programs") in relation to public and other conserved forests from both spatial and administrative perspectives. For the spatial analysis, we created a dataset that included fee simple acquisitions and conservation easements held by governments, public agencies, and The Nature Conservancy (TNC), as well as sustainably managed tribal forests. This dataset is hereafter referred to as public, tribal, and nonprofit (PTN) forests. Our first task was to quantify the contribution of forest tax programs to conserved forest connectivity. We compared connectivity of PTN forests only to PTN + tax program forest connectivity. We then evaluated the statistical significance of this contribution using a neutral model to compare connectivity of PTN + tax program enrollments to that of PTN + random "enrollments."

The PTN dataset included forested land owned by federal, state, county, and tribal governments, as well as conservation easements held by governmental organizations. These data were taken from the 2005 USGS GAP Stewardship dataset, except for the state data which was compiled from the 2008 WDNR managed lands dataset. Spatial data for TNC acquisitions and easements were acquired from TNC in 2009. The dataset did not include conservation easements held by the numerous local land trusts in WI, for which spatial data was largely unavailable. Spatial data for private lands enrolled in the tax programs in 2009 were provided by the WDNR at quarter–quarter section resolution (equal to 16.2 ha or 40 acres), based on the US Public Land Survey System. Parcel divisions were not included in the spatial analysis; we aggregated adjacent enrolled parcels using the "dissolve" tool in ArcGIS. Because MFL and FCL enrollments could be as small as 4 ha, the course-resolution data overestimated total tax program enrollment (WDNR, unpublished data), particularly when quarter-quarters contained non-forested land ineligible for enrollment in the programs. We used the National Land Cover Dataset (NLCD) 2001 product to identify and remove non-forested area from the aggregated quarter-quarter data. The revised dataset reduced the overestimate of area enrolled in the tax programs from 32% to 0.6%.

2.2. Adjacency of forest tax program enrollments to public, tribal, and nonprofit lands

To quantify the contribution of forest tax programs to connectivity of conserved forests, we compared PTN forest connectivity to PTN + tax program forest connectivity in each of the three study regions. In a secondary analysis, we separated the effects of tax program enrollments by enrollment type, to reveal the relative contributions of industrial versus non-industrial enrollments to forest connectivity in each region. Tax program enrollments non-adjacent to PTN forests were removed for these analyses.

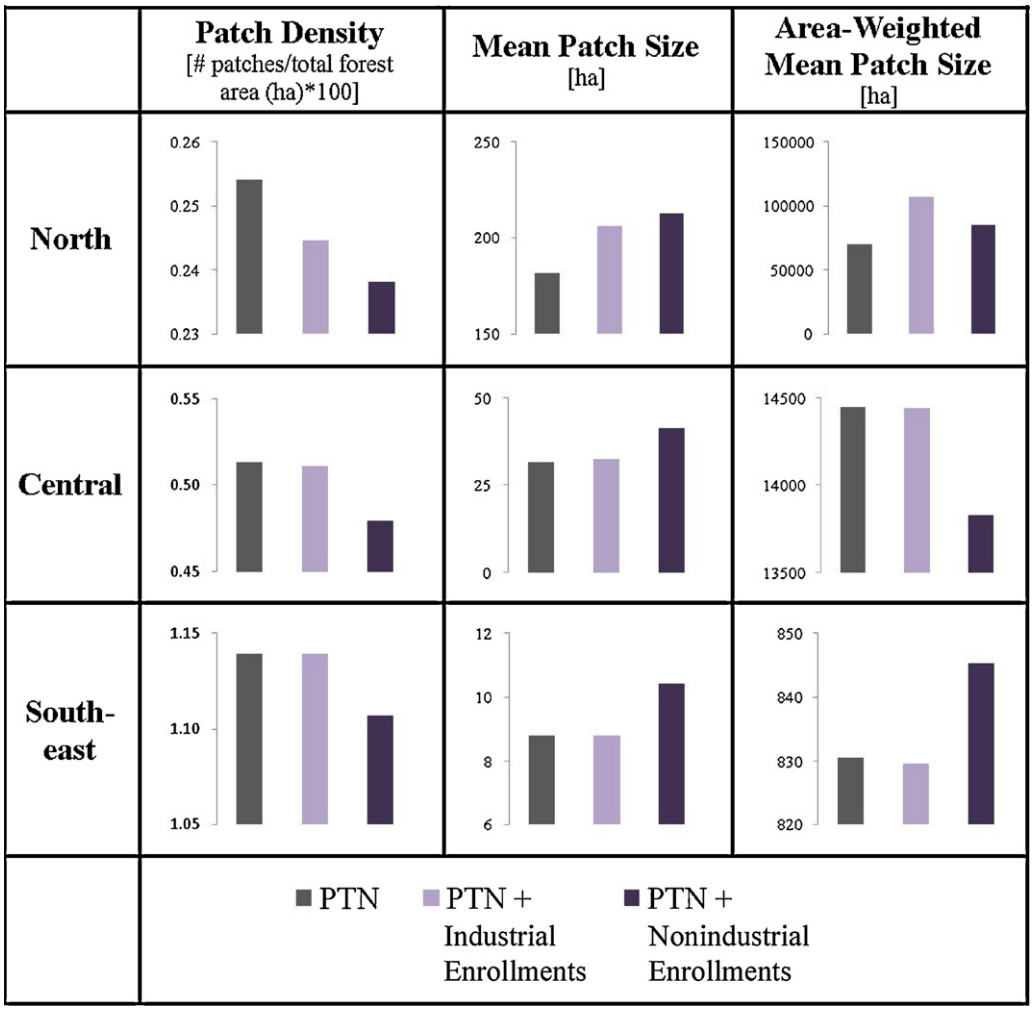

Fig. 2. Industrial enrollments had a larger effect on area-weighted mean patch size than did non-industrial enrollments in the north region only. In the other regions, industrial enrollments had almost no effect on PTN connectivity.

2.3. Neutral model

We compared the distribution of tax program enrollments to a neutral model to evaluate the statistical significance of the programs' contribution to conserved forest connectivity. Because landscapes cannot be replicated, hypothesis testing relies on neutral landscape models to provide null scenarios or "test" landscapes from which to compare actual landscapes (Gardner & Urban, 2007; Gardner et al., 1987). If enrollment were random, enrollment pattern could be predicted by a neutral landscape model. The degree to which landscapes behave or do not behave like a test landscape informs interpretations of landscape structure and the development of new models (With & King, 1997).

Our test landscape was created by removing all non-forested areas, all forested patches under 4 ha, and all PTN forests from the study area. In other words, the test landscape included privately owned forest patches over 4 ha where enrollments *could* occur based on the minimum requirements of the tax programs. We found the area enrolled in tax programs within these forested patches for each region, and then randomly distributed this area across each region's test landscape using ArcMap 9.3. We created 12 random iterations (Gardner & Urban, 2007) per region, and for each of three cell sizes: 64 m (0.4 ha), 201 m (4 ha) and 402 m (16 ha). We did two comparisons using the neutral model, the first comparing connectivity of the actual tax program enrollments to that of the randomly distributed "enrollments," and the second comparing forest connectivity of PTN + adjacent tax program enrollments to that of PTN + adjacent random "enrollments". All of the spatial data layers were aggregated before making connectivity measurements; they did not contain parcel divisions or property boundaries. Results of the first comparison were not affected by cell size, so in the second analysis we used the 201 m cell size only.

2.4. Landscape metrics for forest connectivity

We chose an intuitive approach to quantify forest connectivity: an area with few, large forest patches has higher connectivity than an area with many, small forest patches (Leitão, 2006). We measured connectivity using three metrics: patch density (PD, number of patches per unit area), mean patch size (AREA_MN), and area-weighted mean patch size (AREA_AM), as defined by McGarigal, Cushman, Neel, and Ene (2002). Area-weighted mean patch size is biased towards larger patches which are generally of greater economic and ecological importance. Additionally, we used the coefficient of variance metric to measure patch size variability and to clarify trends in the data. Measurements were made with FRAGSTATS (McGarigal et al., 2002) using the 8-neighbor rule to define patches; diagonal neighbors were considered adjacent.

2.5. Policy analysis of forest tax program

We analyzed tax program enabling statutes and WDNR policies, along with statewide forest plans, to determine if public land management was considered in the planning and implementation of Wisconsin's forest tax programs. The tax program administrative documents we analyzed were the Forest Tax Law Handbook ("Handbook") and MFL application materials. The Handbook is an internal WDNR document (WDNR, 2008), and the application materials are used by landowners applying for enrollment in the forest tax program (WDNR, 2009). We searched tax program documents for the following terms: county forest, state forest, national forest, public forest, public land, coordination, connectivity, fragmentation, and parcelization. We coded each mention of these terms as either "pertaining to public–private coordinated forest management", "within a context that refers to both public and private lands", or "no mention of relation between public and private lands".

Statewide forest planning documents included the Statewide Forest Strategy 2010 ("Strategy") and the Statewide Forest Plan 2004 ("Plan"). The Strategy presents current issues facing the state's public and private forests and proposes actions for future management (WDNR, 2004), while the Plan presents a "common vision" for the state's forests and a "framework for achieving that vision" (WDNR, 2010). Both documents are products of a collaborative effort by the WDNR and its private and public sector partners, and include citizen input. We searched the Strategy and Plan for the following terms: private land, private forest, private landowner, property tax, tax program, managed forest law, forest crop law, FCL, and MFL. We coded each mention of these terms as either "pertaining to public–private coordinated forest management", "within a context that refers to both public and private lands", or "no mention of relation between public and private lands".

We supplemented the document analysis by conducting a small number of informational interviews with foresters ($n = 2$) and tax program administrators ($n = 2$). One of the forester interviews was a day-long observation in which we visited timber sale stands and viewed online record systems for the tax programs and public forests.

3. Results

3.1. Adjacency of forest tax program enrollments to public, tribal, and nonprofit lands

Tax program enrollments contributed to connectivity among PTN forest patches in all regions, but prevalence of connections and distribution of enrollments in relation to PTN forests varied regionally. Tax program enrollments decreased patch density and increased mean patch size when combined with PTN forests in all regions, with the most drastic increase in mean patch size in the north. Area-weighted mean patch size showed a strong increase in the north when enrolled forests were combined with PTN forests, compared with a slight increase in the southeast and a decrease in the central region. The patch size coefficient of variance was 18% higher in the north and 20% lower in the central region for PTN + tax program forests versus PTN forests alone. Tax program enrollments clustered with large PTN patches in the north but with small PTN patches in the central region.

Non-industrial enrollments were important drivers of connectivity in all regions, but industrial enrollments were important drivers only in the north (Fig. 2). PTN + non-industrial tax program enrollments had lower patch density and higher mean patch size than PTN + industrial tax program enrollments in all regions. Area-weighted mean patch size was higher for PTN + industrial enrollments than PTN + non-industrial enrollments in the north and central regions, but lower in the southeast region.

3.2. Neutral model

Tax program enrollments were more clustered with each other and with PTN forests than would be expected due to chance. Forests enrolled in tax programs had significantly lower patch density, higher mean patch size and higher area-weighted mean patch size than the random enrollments in all regions, and for all cell sizes (Table 1). In the second analysis which included PTN lands, the contribution of tax program enrollments to mean patch size and area-weighted mean patch size was significantly higher than would be expected from the random distributions in all regions. PTN + tax program enrollments showed significantly lower patch density than did PTN + random enrollments in the central and southeast regions, but there was no significant difference in the north. This result indicated that PTN forest connectivity was so high in the north that adding tax program enrollments did not affect patch number.

3.3. Policy analysis of forest tax program

As expected, tax program documents revealed that the programs were focused on property-specific enrollment and management rather than regional coordination. We found no mention of coordination between public and private land management in MFL and FCL statutes, MFL application materials, or the Forest Tax Law Handbook. A review of application materials made clear that enrollments were based on meeting eligibility requirements for forest productivity rather than on proximity to conserved lands or ecological importance (WDNR, 2009). The latter point was emphasized in the Statewide Strategy, which made reference to oak savanna as an example of a declining natural community excluded from the tax programs due to its low tree density (WDNR, 2010). Although the WDNR identified landscape-scale sustainable management and forest connectivity as important statewide objectives (WDNR, 2010), the MFL program focused on individual property owners and did not address connectivity or coordinated management.

The Statewide Forest Plan hinted at future efforts to consider private forest management within a context of public–private ownership, but stopped short of suggesting public–private partnerships regarding management plans or practices (WDNR, 2004). The "vision" of the Plan was "to work in partnership to protect and sustainably manage Wisconsin's public and private forest lands and to ensure the ecological, economic, and social benefits of forests for the citizens of Wisconsin now and into the future" (WDNR, 2004). Although the importance of private forests to numerous public benefits was a common theme throughout the document, there was no mention of public–private coordinated management. Instead, tensions between private forest management and public use were emphasized. In all four instances where private lands were mentioned within a context of mixed public and private ownerships, private lands were presented as problematic for achieving public objectives and conservation goals, especially in the face of increasing parcelization of private forests. One example presented the difficulty in maintaining motorized trails for public use because trails rely on agreements that cross many ownership boundaries. Two of the four instances encouraged the purchase of land or development rights from private landowners in order to address such issues.

The Statewide Forest Strategy mentioned private lands within a context of public–private ownerships twice. One instance addressed recreation and the other called for a scoring system of sustainably managed forests based on several criteria,

Table 1
Neutral landscape model results comparing forestland enrolled in forest tax programs to randomly distributed enrollments in three regions of Wisconsin, USA.

Analysis	Region	Cell size [m]	Patch density	Mean patch size	Area-weighted mean patch size	Coefficient of variance
Tax program enrollments alone	North	201	(−)***	(+)***	(+)***	(+)***
	Central	201	(−)***	(+)***	(+)***	(+)***
	Southeast	201	(−)***	(+)***	(+)***	(+)***
PTN forests + adjacent tax program enrollments	North	201	0	(+)***	(+)***	(+)***
	Central	201	(−)***	(+)***	(+)***	(−)***
	Southeast	201	(−)*	(+)***	(+)***	(+)**

(−) Actual enrollment mean is lower than mean of 12 random iterations. (+) Actual enrollment mean is greater than mean of 12 random iterations. 0: no significant difference.
* $p < 0.5$.
** $p < 0.01$.
*** $p < 0.0001$.

including forest patch size and proximity to protected land. The latter effort was included in the Strategy as part of a Farm Bill requirement to identify "priority landscapes and issues" within the state. In addition, the Strategy contained one reference to public–private coordinated management. The "Fragmentation and Parcelization" section of the Strategy listed a "possible action" to address the issue of increasing numbers of forest patches too small to manage sustainably: "Encourage that plans for private and public lands incorporate. . .the management plans of adjacent and nearby public lands and lands enrolled in conservation programs." The "possible actions" listed in the document were ideas and suggestions from the WDNR and its collaborators for consideration; they do not necessitate future action.

Interviews revealed that landowners, loggers, and foresters have initiated public–private coordination as opportunities have arisen. According to a WDNR forester who worked on public and private forests in northern Wisconsin, private landowners have contacted the WDNR to have their properties included in timber sales on adjacent public lands. Also, loggers have combined jobs after noticing timber opportunities on adjacent or nearby properties. WDNR foresters were sometimes able to identify coincident 'due practices' on adjacent public and private properties. Lack of integration between public and private spatial data restricted this, but there were plans for integrated digital mapping in the future. A forester in southwestern Wisconsin thought that the cultural divide between private landowner and state government land management preferences would present challenges for formal timber sale coordination. WDNR administrative staff suggested that coordination occurred through individual initiative and relationships, but that administrative silos were clearly defined for public and private lands.

4. Discussion

Planning for forest-based goods and amenities in the context of landscape change requires the mobilization of private landowners. Forest property tax incentive programs represent one of the fundamental policy instruments for achieving sustainable forest management on private lands. Although they do not have explicit landscape-scale goals, forest tax programs may help maintain or increase forest connectivity by disproportionately enrolling high-value lands. As shown in a neutral model analysis, land enrolled in Wisconsin's forest tax programs was more clustered around public, tribal and nonprofit forests than would be expected due to chance. However, a document analysis revealed that public and private land policies within the state administrative agency were not integrated. Public and private conserved forests were connected spatially but not administratively.

Neutral landscape models allow us to compare landscape patterns with a randomized test landscape, but such models alone cannot identify which mechanisms drive the pattern (With & King, 1997). Future research should investigate the mix of landowner characteristics, property tax rates, property values, and market drivers that may influence landowner behavior (Beach, Pattanayak, Yang, Murray, & Abt, 2005), including decisions to enroll in tax programs at higher rates adjacent to public forests. Tax programs enroll industrial and non-industrial forest owners with diverse characteristics and motives. In the north, industrial enrollments were important in driving the connectivity trend between forest tax enrollments and PTN forests. In other regions, public land was scarce and tax programs were the major forest policy. Non-industrial forests drove the connectivity trend in these regions. NIPF landowners have greater incentive to enroll in forest tax programs where property taxes are higher, so the enrollment pattern we observed may be linked to high development pressure driving up land values adjacent to public reserves (Radeloff et al., 2010). Some evidence suggests that new landowners settling near public reserves, particularly ex-urbanites without forestry experience, are more likely to enroll in conservation programs and seek technical assistance in management planning (Healy & Short, 1979). However, more recent literature shows that many of these owners are wary of timber harvest requirements in tax programs like MFL (Rickenbach, Zeuli, & Sturgess-Cleek, 2005).

Whatever the mechanism driving enrollments to cluster near public lands, the high connectivity between PTN forests and forest tax enrollments was not due to planning on the part of the WDNR. Forest planning documents referred to the importance of forest tax programs in preventing forest conversion and providing public benefits like recreation, but tax programs were generally not mentioned in conjunction with public land conservation. However, supplemental interviews revealed informal, ad hoc efforts to coordinate management practices across property boundaries. Surveys of NIPF owners show broad interest in coordinated management (Bourke & Luloff, 1994; Jacobson, 2002; Rickenbach, Kittredge, Dennis, & Stevens, 1998). In a survey of central Wisconsin foresters, Rickenbach and Jahnke (2006) found that most foresters had worked with NIPF owners to coordinate multi-property timber harvests, and some had facilitated multi-property management planning. One step tax programs could take would be to incorporate management plans of nearby forests into private and public management plans, as noted in the "possible actions" section of the WI Statewide Strategy (WDNR, 2010). This would formalize a practice that is already done in an ad hoc manner (Rickenbach & Jahnke, 2006). In addition, a group enrollment option for NIPF owners with adjacent properties would encourage larger enrollment clusters and coordinated management practices across property boundaries.

Our results reflect four primary challenges facing tax programs in achieving forest connectivity and ecosystem management: spatial targeting of enrollments, temporal limits of enrollment, organizational capacity, and political feasibility. The property tax system is a blunt tool for land use policy without an efficient mechanism for spatial targeting. Still, voluntary tax programs have a

statewide reach and may enroll lands of high conservation value that narrower policy approaches miss. Because tax incentives appeal to landowners facing high property taxes, tax programs may disproportionately enroll lands facing higher development pressures. In contrast, public agencies and NGOs disproportionately target less-threatened lands for acquisition because these lands are less expensive per acre (Newburn, Reed, Berck, & Merenlender, 2005). Some voluntary forest tax programs have statutory authority to incentivize one enrollment type over another (e.g. enrollments that are open to public recreation), but none prioritize enrollments based on location. To make voluntary forest tax programs a more precise tool, non-enrolled private forests important for forest connectivity could be targeted with outreach or supplemental incentives.

The limited duration of tax program enrollments can impede their effectiveness in achieving lasting forest conservation. Limited and voluntary enrollment terms pose a particular challenge for preventing parcelization and development of private lands. Management activities can be influenced by property taxes (Bliss & Martin, 1989), but tax incentives alone do not discourage land conversion (Brown, Phillips, & Roberts, 1981; Wyatt, 1994). Forest tax programs do not attempt to govern management activities in perpetuity, as is common with perpetual land acquisition and conservation easements (Merenlender, Huntsinger, Guthey, & Fairfax, 2004). States can, however, require that a management plan be tied to the deed of each enrolled property. This measure makes property enrollment robust to landowner turnover – a major driver of parcelization – within the term-length minimum. Wisconsin's 25 or 50-year enrollment terms and significant penalties for withdrawal could serve as an example for other states with no term minimum or penalty for withdrawal. The success of forest tax programs will also depend on zoning regulations and other regional land use policies that direct growth.

Organizational capacity is a necessary condition for tax incentive programs to function as conservation programs (Bengston et al., 2004). In the US, only 24% of state forest tax programs require management plans, and 29% implement penalties for noncompliance (Hibbard et al., 2003). Even when management plans are required, not all states provide effective oversight to ensure management plans exist or are followed (Williams, Gottfried, Brockett, & Evans, 2004). Hiring or contracting foresters and monitoring management plans require stable funding sources, but these programs rely on state budgets that can change with political climate. Mayer and Tikka (2006) found that budget constraints limited the ability of European programs to enroll willing landowners and meet goals, and limited the ability of US programs to reimburse local governments for lost tax revenue. Increased capacity for monitoring and implementation is necessary as program enrollments increase over time.

Finally, a primary challenge lies in garnering political support to incentivize landscape connectivity. Legislative changes to private land programs are often controversial, especially where relations between private landowners and government agencies are contentious. A move away from traditional stand-level timber policies towards landscape-scale policies raises questions about private property rights and collective benefits. Americans often favor decentralized land management approaches (Mason, 2008), but local-level policies working in isolation cannot fully address ecosystem management goals like forest connectivity, fire management, and endangered species habitat protection. Administrative discretion in balancing stand management with landscape goals could provide incremental change within the bounds of existing laws. Broadening the conservation goals of tax programs would require heightened political support for landscape connectivity and ecosystem management.

5. Conclusions

Forest tax programs deserve greater attention as a private land conservation strategy. Although they are a voluntary, untargeted policy tool, forest tax programs provide the unintended but important benefit of connectivity with public lands. Effective planning and implementation of natural resource conservation requires planners and managers to consider regional differences in landscapes and landowners. If states and stakeholders recognize forest tax programs as a means to achieve broad landscape planning goals, they could create cross-boundary coordinated management efforts and target areas of particular conservation interest for outreach or additional incentives. Tax incentives can be combined with other policy tools to prevent forest conversion to development. Because connectivity between public reserves requires private land, addressing widespread issues like climate change adaptation and regional planning requires the mobilization of private landowners. Although they face significant barriers in addressing landscape-scale goals, tax incentive programs provide a framework for private land management at a time of increasing concern about rapid environmental change.

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