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An evaluation of environmental, institutional and socio-economic factors explaining successful conservation plan implementation in the north-central United States

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ABSTRACT

Conservation plans are commonly used tools for prioritizing areas for protection, but plan implementation is often limited and rarely formally evaluated. Without evaluations of planning outcomes, it is difficult to justify expending resources to develop new plans and to adapt future plans so they are more likely to achieve desired conservation outcomes. We evaluated implementation of four conservation plans in Wisconsin, USA, by quantifying land protection within plan boundaries over time. We found that 44% of lands inside plans are currently protected, compared to 5% outside plans. We then asked which environmental, institutional, and socio-economic factors explained implementation of the most recent (2008) plan by the state natural resources agency. Institutional and environmental metrics related to agency policy and past actions explained 61% of implementation variability among individual priority areas within the plan: the agency having secured acquisition authority (a policy requirement) and subsequently successfully protected land in the priority area prior to the conservation plan being completed, and acquiring land near open water (a policy priority). Our findings suggest that implementation is possible under a wide variety of socio-economic settings and indicate that development of new conservation plans may not necessarily lead to action in new locations in the near term, but rather may facilitate action in locations where the institutional groundwork for action has already been laid. Considering institutional policies of active conservation partners in the development of future conservation plans can facilitate identification of priority areas that are more likely to correspond with on-the-ground implementation opportunities.

1. Introduction

Conservation plans (hereafter, plans) are commonly used tools by governmental agencies and non-governmental conservation organizations worldwide. Plans are intended to guide conservation actions, and to provide a framework for evaluating conservation achievements (Bottrill and Pressey, 2012). Unfortunately, relatively few plans are implemented, and in few cases are implemented actions considered highly effective, leading to what has been termed the planning–implementation gap (Knight et al., 2008). Formal evaluation of plan implementation is still rare (Bottrill and Pressey, 2012), making it difficult to justify continued resource expenditures for developing new plans (Groves et al., 2002) and impeding the adaptive management process (Grantham et al., 2010).

Biodiversity conservation can be achieved through a variety of actions, including species and habitat management, policy and legislation, education, training/capacity building, and research (Kapos et al., 2009). Land protection through acquisition or conservation easements continues to be the backbone of many conservation strategies (Bengston et al., 2004), and is one of the primary outcomes expected by staff and stakeholders developing conservation plans (Bottrill et al., 2012). Thus evaluating land protection within plan boundaries is one approach for quantifying implementation success (Bottrill and Pressey, 2012).

While conservation plans are often based primarily or solely on biological data (e.g., Lerner et al., 2006), social, economic, and political conditions at national, regional and local scales often shape opportunities for implementing plans (Knight et al., 2011a; Radeloff et al., 2013) and affect the ability and willingness of organizations to act on those opportunities (Cowling and Wilhelm-Rechmann, 2007; Ban et al., 2013). At national levels, social and political conditions can greatly influence when major conservation actions are likely to occur (Radeloff et al., 2013). Political affiliation, income, and education have all been shown to influence support for local conservation actions, including land protection (Bultena and Hoiberg, 1983; Kroetz et al., 2014; Moon et al., 2012). Social factors specific to the planning process, such as ineffective

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stakeholder involvement, can lead to low acceptance of plans and limited support for their implementation (Martin et al., 2012). Land ownership and tenure patterns may shape opportunities for land protection within a region (Knight et al., 2011b), and land value may determine where land protection is most likely (Scott et al., 2001).

Institutional factors may also play an important role in conservation plan implementation. A lack of human and financial resources within agencies and other participating organizations may limit implementation opportunities, particularly when proposed actions include land protection, which is staff- and funding-intensive (Knight et al., 2011a). Agency missions as well as broader societal concerns may stipulate that lands protected for biodiversity also serve additional purposes, such as supporting local economies, which can restrict viable implementation options (Sunderlin et al., 2005). Agency policies may also define priorities (e.g., US Fish and Wildlife Service, 2014) or impose limitations (e.g., Wis. Admin. Code NR §1.41) on where land can be protected at broad and local scales. Being aware of and explicitly accounting for these socio-economic and institutional factors in planning processes is critical for the success of conservation plans and programs (Ban et al., 2013; Faleiro and Loyola, 2013).

Our overarching goal was to understand the circumstances under which implementation of conservation plans may be most likely. Our objectives were to 1) evaluate to what extent past plans have been implemented, and 2) identify which environmental, institutional and socio-economic factors best explain where recent plan implementation efforts have been successful. We assessed implementation by quantifying land protection within plan boundaries for four plans established for the state of Wisconsin, USA, using more than a century of land protection records. We developed a conceptual model of the implementation process to facilitate identification of specific environmental, institutional and socio-economic metrics that may influence implementation of conservation plans. We then evaluated which metrics explained implementation success of the most recent (2008) plan, as this is the most relevant time period for informing future implementation efforts. Our analysis used existing spatial datasets that are available across most regions of the world to facilitate application of our approach in other locations.

2. Methods

2.1. Study area

Wisconsin is a biologically diverse state in the north-central United States covering approximately 145,000 km^2. Tallgrass prairies and oak savannas historically dominated southern Wisconsin; northern hardwood forests dominate northern Wisconsin. Current major threats to biodiversity include habitat loss, invasive species, and pollution (WDNR, 2005), and housing development is the major cause of habitat loss and fragmentation (Radeloff et al., 2005). Wisconsin's state natural resources management agency, the Wisconsin Department of Natural Resources (WDNR), has a long history of conservation planning and land protection, and continues to actively protect land (Carter et al., 2014a).

2.2. Evaluating implementation of conservation plans

Statewide, spatially-explicit conservation plans were completed for Wisconsin in 1939, 1964, 2004, and 2008 (Wisconsin State Planning Board and Conservation Commission, 1939; National Park Service, 1964; Pohlman et al., 2006; WDNR, 2008). All four plans were expert-based and developed by or in close collaboration with WDNR (Appendix S1). Plan goals were either conservation only (2008 plan) or a combination of conservation and recreation (1939, 1964, and 2004 plans, Appendix S1). Criteria used to identify priority areas within all four plans were similar and primarily biological (e.g., high quality natural areas, important populations of rare species); additional criteria considered in some plans included recreation, water quality, scenic, scientific, geologic, and historic value (Appendix S1). Plan boundaries were digitized from hard copy (1939 and 1964 plans), available as GIS data (2008 plan), or estimated based on the location, size, and detailed description of each priority area in the plan (2004 plan, see Appendix S1).

Implementation of conservation plans for which land protection is a major goal can be quantified in a number of ways, including institutional capital outcomes such as the area of land protected or the amount of funds expended for land protection, and natural capital outcomes such as the change in biodiversity representation within the protected areas network resulting from the protection of specific habitats (Bottrill and Pressey, 2012). We quantified plan implementation using the area of land protected because data on habitat composition across the state over the century long time period examined here were not available. We quantified plan implementation using land protection data (both acquired lands and lands with conservation easements) from three sources: 1) lands protected by WDNR between 1876 and 2013 (WDNR, 2013d), 2) additional lands protected by other agencies and conservation organizations (Conservation Biology Institute, 2012), and 3) conservation easements held by other agencies and conservation organizations (National Conservation Easement Database, 2012). We defined protected lands as the cumulative total area of land protected according to these three data sources, which includes lands that are publicly owned, lands with conservation easements, and lands within tribal reservations. We calculated the cumulative area of land protected annually by WDNR within each plan boundary. We also calculated the total area of land protected as of 2013 within and outside of each plan boundary by WDNR and by all agencies and conservation organizations combined (i.e., total protected lands documented in the three data sources listed above).

2.3. Identifying factors explaining plan implementation

Drawing on the most recent (2008) conservation plan for Wisconsin and the authors' more than four decades of collective experience in planning, land protection, and natural resources management, we first conceptualized steps in the decision-making process that lead to plan implementation via land protection. Our overarching question was, 'What conditions likely need to be met for implementation (via land protection) to occur within an individual priority area in an existing conservation plan?' We identified five main considerations that influence whether an agency (here, WDNR) is likely to be able to successfully protect land within a specific priority area in an existing conservation plan (Fig. 1). Our model builds upon prior work conceptualizing the overall conservation planning and implementation process in an agency context (Carter et al., 2014a) by focusing specifically on key considerations in the agency land protection process.

We present the five major considerations for protecting land within the boundary of an existing conservation plan as a set of questions. A negative response to any question decreases the likelihood (sometimes to zero) that the transaction will be successful (Fig. 1). First, is there land available to protect within the priority area? If all lands within an individual priority area are already protected or if no private (unprotected) land is available for sale or easement, no land protection can occur. Conservation plans may include priority areas that are already largely or completely protected because they are priorities for other reasons (e.g., land management, Carter et al., 2014b). Second, is the available land in the priority area a priority according to laws, administrative code, or formal policies governing agency land protection actions? While such laws and policies are subject to change, substantive changes are infrequent, leading to a much longer effective lifespan for acquisition policies (decades) compared to individual conservation plans (usually 10 years or less). Individual land parcels that do not rank highly according to the specific criteria listed in agency acquisition policies are unlikely to be protected (e.g., US Fish and Wildlife Service, 2014). Third, is the priority area included in a formal agency implementation plan? Conservation plans are often developed by multiple stakeholders

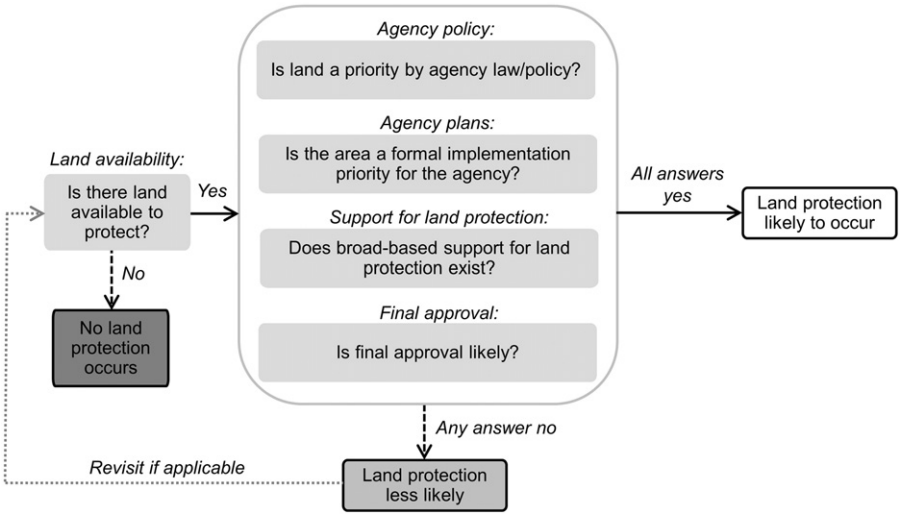

Fig. 1. Conceptualization of the process (and associated questions) that conservation agencies and organizations undertake when seeking to implement actions based on priorities identified in conservation plans. Here we focus specifically on land protection by an agency within the boundaries of an existing plan as the conservation action to be implemented.

for use by all conservation partners in a region. This was the case for many Wildlife Action Plans across the USA, including the 2008 plan studied here (AFWA, 2008). However, for a conservation plan developed by and for multiple partners to be most effective, individual conservation agencies and organizations ideally then commit to (and allocate resources for) implementing a specific subset of projects or priority areas identified in the broader plan within a specified time frame (Carter et al., 2014a; Edwards and Gibeau, 2013). These formal, organization-specific implementation plans provide clear direction on priority projects/areas in the near term, and a mechanism of public accountability for agencies. Fourth, does the agency, its partners, government, and the public (especially locally) support protecting land in the priority area? Broad-based stakeholder support increases the likelihood that conservation efforts will be successful (Stokes et al., 2010) and is generally necessary for successful plan implementation (Knight et al., 2011a). Opposition from local government, landowners, and other stakeholders can thwart an otherwise viable land protection opportunity (JP, *unpublished data*). Finally, do land parcels within the priority area meet economic and other criteria that government oversight boards or executives (e.g., state governors) consider when granting final approval for a land protection transaction? Such criteria are often undocumented, but may include land cost and the presence of a clear threat to the conservation value of the land (e.g., a proposed housing development).

We then quantified 20 environmental, institutional and socio-economic metrics (Table 1) corresponding to the five questions in our conceptual framework for each of the 231 priority areas in the 2008 plan. Environmental metrics included landcover (water, wetlands, and forests), endangered resources (a function of rarity), and proximity to major cities, all of which were directly referenced in agency policy. Institutional metrics included existing land use planning and zoning regulations, protected areas, and WDNR land protection projects (a metric of WDNR acquisition authority). Socio-economic metrics included land cost, threat from development, and population age, density, income, education, and political affiliation (Table 1). We relied on existing spatial datasets, most of which are available across the USA and other regions (e.g., landcover, protected areas, population density, and election statistics). Pairwise correlations for all explanatory metrics were ≤ |0.64|, indicating acceptable levels of collinearity for our analysis.

Finally, we evaluated which metrics were most strongly associated with implementation of the most recent (2008) plan. We considered plan implementation over a relatively short timeframe (six years). A similar (or shorter) timeframe has also been used to evaluate plan implementation in other studies (e.g., Bottrill et al., 2012; Knight et al., 2008). The six year timeframe was also short enough to help ensure that our explanatory environmental, institutional and socio-economic metrics were representative of on-the-ground conditions. We defined implementation as a binary response variable indicating whether or not land protection occurred in each of the 231 priority areas after plan completion. We limited our analysis to land protection efforts by WDNR, as transaction dates were only available for this subset of land protection transactions.

We modeled plan implementation as a function of the 20 explanatory metrics using boosted regression trees (BRT, Elith et al., 2008). Regression tree approaches are particularly powerful when the explanatory variables are not linear or normally distributed and may interact in complex ways (Olden et al., 2008), as was the case with our data. BRT combines a regression tree algorithm and a boosting algorithm to produce an ensemble of trees (Elith et al., 2008; Friedman et al., 2000). The boosting algorithm is a machine learning approach that adds a stochastic component to emphasize the most poorly-explained part of the data space (Elith et al., 2008; Friedman et al., 2000). We fit the BRT models using a learning rate of 0.005, a tree complexity of three, and a bag fraction of 0.75 using the gbm package in R (Ridgeway, 2013) and code written by Elith et al. (2008). The learning rate determines the contribution of each tree to the growing model. Tree complexity controls whether interactions are fitted in the model: a tree complexity of three fits a model with up to three-way interactions. We used ten-fold cross-validation to identify the optimal number of trees for the model (Elith et al., 2008). Variable importance was evaluated based on the contribution to model fit attributable to each explanatory variable, averaged across all trees; importance values for all metrics in the model sum to 100% (Friedman et al., 2000). We also modeled a more refined metric of agency support (i.e., land protected by WDNR only within the 20 years preceding the plan) and a broader metric of partner support (i.e., all lands owned or eased by partner organizations) to better understand how slight differences in the definition of metrics might influence our results (see Table 1 for primary definitions of each metric).

3. Results

3.1. Evaluating implementation of conservation plans

We found that WDNR protected 3% to 10% of lands inside plan boundaries prior to plan completion, and had protected a total of 10% to 12% of lands inside plan boundaries by 2013 (Table 2). Boundaries of newer plans overlapped substantially with previous plans (46%, 36%, and 52% of the area within the 1964, 2004, and 2008 plans,

Table 1
Predictive metrics identified for each component of the conceptual model in Fig. 1. These metrics were used to model implementation of priority areas in the 2008 conservation plan.

Metric	Description	Spatial resolution and source of data	Mean and range
Land availability: Is there land available to protect?			
Land not already protected	Proportion of each priority area not protected by the Wisconsin Department of Natural Resources (WDNR, the state natural resources agency) prior to plan completion, or in federal or tribal ownership.[a]	WDNR, 2013d	0.67 (0.001–1.0)
Age	Spatially-weighted average proportion of population over 65. We considered a greater proportion of the population near retirement age as an indicator of a greater likelihood of private (unprotected) lands becoming available for sale.	US Census block group, Minnesota Population Center (2011)	0.18 (0.07–0.41)
Agency policy: Is land a priority by agency law/policy governing land protection actions?[b]			
Population density	NR 1.40 (1) (see Appendix S2) specifies that WDNR shall place principal emphasis on lands in heavily populated areas. We computed the spatially averaged population density within the priority area.	US Census block group, Minnesota Population Center (2011)	25.3 individuals/km^2 (1.1–412.7)
Existing WNDR land protection projects	WDNR land protection is largely limited to lands within defined, local project boundaries where the agency has secured acquisition authority after completing an extensive, local project planning process (Wis. Admin. Code NR §1.41). NR 1.40 (2) (a) specifies that WDNR shall prioritize consolidation and completion of existing projects over the initiation of new projects (see Appendix S2). Typically, WDNR land protection projects are relatively small (90% are less than 25 km^2), and thus a single priority area in a statewide conservation plan may contain multiple WDNR land protection projects. WDNR land protection project boundaries were available as GIS data. We computed the proportion of each priority area that is both unprotected and inside current WDNR land protection project boundaries as an index of existing acquisition authority.	WDNR (2013c)	0.21 (0.0–1.0)
Endangered resources	NR 1.40 (2) (b) (1) specifies that WDNR shall next prioritize protection of rare and threatened natural resources (see Appendix S2). We used the ecological significance of each priority area (1 = statewide, 2 = Midwest region, 3 = continental, 4 = global) designated in the 2008 conservation plan. Ecological significance is based primarily on rarity of the species and natural communities in the priority area, as assessed by the Wisconsin Natural Heritage Inventory (WDNR, 2014).	WDNR (2008)	2.8 (1–4)
Landcover (water, wetlands, forests)	NR 1.40 (2) (b) (3) specifies that WDNR shall next prioritize protection of water-based resources (see Appendix S2). NR 1.40 (2) (c) (1,4) specifies that WDNR shall not prioritize protection of wetlands or forests that do not meet other criteria. We calculated the proportion of each priority area covered by open water, wetlands, and forests.	30 m x 30 m pixels, Fry et al. (2011)	Water: 0.05 (0.0–0.79), Wetlands: 0.20 (0.0–0.69), Forest: 0.41 (0.0–0.96)
Proximity to cities	NR 1.40 (2) (b) (5) specifies that WDNR shall next prioritize protection of lands within 40 miles of Wisconsin's 12 largest cities (see Appendix S2). We computed whether the edge of the priority area was within 64.4 km of the centroid of the 12 largest cities in Wisconsin using the near function in ArcGIS 10.1 (1 = yes, 0 = no).		0.43 (0–1)
Agency plans: Is the area a formal implementation priority for the agency?			
Identified implemen-tation priorities	WDNR has not committed to implementing any specific projects/priority areas in the 2008 conservation plan through a formal implementation plan.		0
Support for land protection: Does broad-based support (i.e., agency, partner, government, and public) for land protection exist?			
Agency/broad-based			
Extent protected by WDNR	Proportion of priority area protected by WDNR before plan completion (i.e., 2007 and before). We viewed previous successful land protection by WDNR as an indication of both agency and broad-based support, as land transactions must ultimately have both to be approved (JP, *unpublished data*). Successful land protection by WDNR, particularly after the mid 1940s, suggests a broader positive response to other components of our conceptual model as well.	WDNR (2013d)	0.11 (0.0–0.99)
Partner			
Partner conservation easements	Proportion of priority area currently under a conservation easement held by an entity other than WDNR. We considered enrollment of private lands in partner-held easements to be an indicator of active partner involvement and public willingness to work with conservation partners.	National Conservation Easement Database (2012)	0.007 (0.0–0.40)
Local government			
Land use planning	Proportion of priority area for which a comprehensive land use plan was adopted by November 2010 (the state deadline). Approved land use plans indicate general support from the community for land use planning, which includes protection of open space and conservation values (P. Herreid, *pers. comm.*).	city/village, township, or county; Herreid (2011)	0.74 (0.0–1.0)
Zoning regulations	Proportion of priority area for which zoning regulations are in place. Zoning regulations indicate a willingness of the community to designate specific areas on the landscape to meet specific purposes, including conservation and protection of open space (P. Herreid, *pers. comm.*).	city/village, township, or county; Herreid (2011)	0.38 (0.0–1.0)
Public			
Private lands conservation behavior	Proportion of priority area currently enrolled in the WDNR Managed Forest Law Program. We considered enrollment of private lands in this program to be an indicator of private landowner willingness to consider conservation in their land management actions and to work with WDNR.	0.16 km^2 (40 acre) blocks, WDNR (2013b)	0.11 (0.0–0.75)
Political affiliation	Spatially-weighted average proportion of population voting liberal (democratic, green party) in the 2006 gubernatorial election. Political affiliation has been shown to be related to support for conservation action (Kroetz et al., 2014).	Voting wards, Wisconsin Government Accountability Board (2006)	0.54 (0.25–0.85)
Income	Spatially-weighted average mean household income, which can be related to support for conservation action (Bultena and Hoiberg, 1983; Kroetz et al., 2014).	US Census block group, Minnesota Population Center (2011)	52,296 USD (30,539–90,427 USD)
Education	Spatially-weighted average proportion of population with a Bachelor's degree or higher, which can be related to support for conservation action (Bultena and Hoiberg, 1983; Kroetz et al., 2014; Moon et al., 2012).	US Census block group, Minnesota Population Center (2011)	0.25 (0.05–0.78)

Table 1 (*continued*)

Metric	Description	Spatial resolution and source of data	Mean and range
Final approval: Is the transaction likely to receive final approval?			
Land cost	Spatially-weighted average cost of forest (for northern Wisconsin) or agricultural (for southern Wisconsin) land for 2008–2012. Land cost per unit area is a key consideration of the agency oversight board in approving individual land protection transactions (JP, *unpublished data*).	County, US Department of Agriculture National Agricultural Statistics Service (2014)	3,264 USD (365–12,287 USD)
Threat (projected housing density, projected housing growth)	We computed two metrics of threat from projected housing development: proportion of priority area with 1) a housing density projected to exceed 1 house per 0.16 km^2 (40 acres) by 2030, and 2) a projected housing growth rate projected to exceed 50% between 2000 and 2030 (Carter et al., 2014b). Threat is a consideration of the agency oversight board in approving individual land protection transactions (JP, *unpublished data*), and housing development is currently the major threat to habitat in Wisconsin (Radeloff et al., 2005).	US Census partial block group, Radeloff et al. (2010)	Housing density: 0.10 (0.0–1.0), Housing growth: 0.05 (0.0–0.99)

[a] We do not have dates for land protected by local agencies or conservation organizations.
[b] Additional priorities in the policy were difficult to quantify (e.g., 'one-of-a-kind opportunities') and are not analyzed here.

respectively, was also included within the boundary of the preceding plan). Land protection began in the early l900s and continued through 2013 for all four plans, representing a total protection timeframe of more than a century (Fig. 2). Land protection to date by all agencies and organizations combined averaged 44% of lands inside plan boundaries (Table 2, Fig. 2). In comparison, 1.6% and 5.1% of lands outside of the boundaries of all plans have been protected to date by WDNR and by all agencies and organizations combined, respectively.

3.2. Identifying factors explaining plan implementation

Through 2013, WDNR protected land in 42% of the priority areas identified in the 2008 plan (Fig. 3). There was a substantial range of variability for all explanatory metrics among the 231 priority areas in the 2008 plan (Table 2, Fig. 3). For example, available land within priority areas ranged from 0.1% to 100%, population density ranged from 1.1 to 412.7 individuals/km^2, and the proportion of the population voting liberal ranged from 25% to 85% across priority areas in the plan.

Our model explained 61% of the variability in priority area implementation. The metrics most closely associated with implementation fell into two categories in our conceptual model: support for land protection and agency policy (Table 3). The top two metrics in the model were institutional factors related to agency policy and past actions: the percentage of each priority area protected by WDNR prior to plan completion (an indicator of agency and broad-based support for land protection, importance value 34%), and the percentage of the priority area within the boundary for which WDNR had acquisition authority (i.e., lands inside an approved WDNR land protection project, the second highest priority in agency policy, importance value 26%). The third most important metric in explaining implementation variability was an environmental metric also reflected in agency policy: the percentage of the priority area in open water (the fifth highest priority in agency policy, importance value 10%; Table 3, Fig. 3).

A second tier of metrics with lower importance values (~4%) related to support for land protection from the public, partners, and local government (Table 3). However, re-running the model excluding this second tier of metrics (and all other metrics with lower importance values) explained the same amount of variability in implementation as the full model (61%). Three environmental factors referenced in agency policy (wetlands, forests, and endangered resources) as well as the highest priority in agency policy, protecting lands in densely populated areas (Appendix S2), were not important in explaining implementation success (importance values ≤3%, Table 3). Re-running the model including slightly modified metrics for agency support (i.e., land protected by WDNR only during the 20 years preceding the plan) and partner support (i.e., all lands owned or eased by partner organizations) resulted in changes of less than 0.01 in the amount of variability explained by the model, and no changes in identity or order of importance of the top three metrics.

Fitted functions are useful for interpreting the characteristics of priority areas for which implementation is most likely. Fitted functions for the top three metrics in our model indicated that implementation was most strongly associated with priority areas in which roughly 10% or more of the area is 1) already protected by WDNR, 2) within the boundary of an approved WDNR local land protection project, and 3) open water (Fig. 4).

4. Discussion

The development of a new conservation plan for a state or region requires substantial staff and financial resources over multiple years, and involves many conversations with stakeholders (Bottrill and Pressey, 2012; Groves et al., 2002). There is an inherent expectation by stakeholders that a new plan will include new information, potentially leading to new activities in new locations. We examined implementation (via land protection) of four conservation plans developed for Wisconsin, USA, and found that land protection did indeed occur within plan boundaries: 10% and 44% of lands within plan boundaries are currently protected by WDNR and by all agencies and conservation organizations combined, respectively. However, our results also suggest that the expectation that new plans will lead to new actions in new locations may be unrealistic in the short term, as successful implementation of

Table 2
Conservation plan implementation via land protection in Wisconsin, USA.

Year plan completed	Area in plan (km^2, percent of state)	Total area protected by WDNR[a] within plan boundary (km^2, percent of plan area) prior to plan completion	Total area currently protected by WDNR[a] within plan boundary (km^2, percent of plan area)	Total area currently protected within plan boundary (km^2, percent of plan area)
1939	19,268 (13.3%)	577 (3.0%)	2,255 (11.7%)	11,226 (58.3%)
1964	30,842 (21.2%)	1,495 (4.8%)	3,130 (10.1%)	15,979 (51.8%)
2004	44,229 (30.4%)	3,113 (7.0%)	4,293 (9.7%)	12,754 (28.8%)
2008	37,034 (25.5%)	3,741 (10.1%)	4,469 (12.1%)	14,359 (38.8%)

[a] The Wisconsin Department of Natural Resources (WDNR) is the state natural resources management agency.

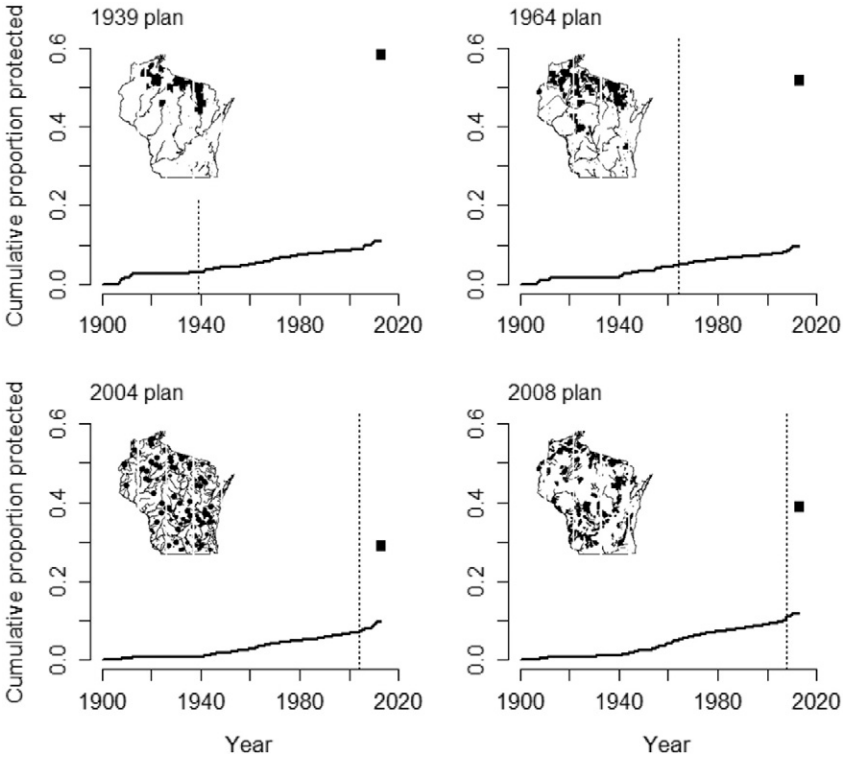

Fig. 2. Implementation over time of four conservation plans developed for the state of Wisconsin. Maps in the upper left corner of each plot show the priority areas (in black) for each plan. Solid chart lines represent the cumulative proportion of land inside each plan boundary that was protected by WDNR (the state natural resources management agency) over time. Black squares represent the proportion of the area inside each plan boundary currently protected by all agencies and conservation organizations combined. Dotted vertical lines indicate the year in which each plan was completed.

Wisconsin's 2008 Wildlife Action Plan within the first six years was best explained by actions already taken by the agency prior to the plan being developed. Specifically, we found that implementation was more likely to occur in individual priority areas within the plan where the agency had already successfully gone through their own agency-specific planning process at the local scale to secure acquisition authority, and further, had then successfully protected land, both prior to the broader conservation plan being completed. Below, we discuss the broader implications of our findings for conservation planning and implementation via land protection.

4.1. Evaluating implementation of conservation plans

Conservation agencies and organizations have protected nearly half of the land within the boundaries of conservation plans for the state of Wisconsin. Habitat loss and fragmentation from housing development and other causes of land use change are the major threats to biodiversity in Wisconsin (WDNR, 2005), and nearly all lands considered to be protected in this analysis prohibit development (development may occur on some tribal lands). Thus land protection within plan boundaries has substantially limited the area of high priority biological sites that is vulnerable to future land conversion. Further, land protection was substantially lower outside of plan boundaries (2% and 5% of the landscape outside the boundaries of all plans is currently protected by WDNR and by all partners combined, respectively). Thus, while broad-scale plans may not significantly influence overall land protection patterns in the short term (Carter et al., 2014a), over long time frames (multiple decades) plans do appear to focus action inside plan boundaries. Newer plans built on older plans (36–52% of the area within plan boundaries in Wisconsin was also included within the boundary of the previous plan), facilitating the focus of conservation action inside plan boundaries over long time frames, which is a fundamental goal of systematic conservation planning (Margules and Pressey, 2000).

However, the plans examined here lack specific, measurable conservation targets and goals, a common problem in conservation plans (Game et al., 2013). Thus, while substantial land protection has occurred within plan boundaries to date, it is unclear whether these focused efforts have achieved long-term conservation goals, or whether additional land protection is needed to protect against future habitat loss from ongoing land conversion (Radeloff et al., 2010). For example, current protected areas and land acquisition efforts occur primarily in forested regions of Wisconsin, with much lower representation and acquisition of grassland and savanna ecosystems that historically covered the southern half of the state (Carter et al., 2014a). We recommend that future plans and actions be informed by a comprehensive assessment of the representation of biodiversity elements within existing protected areas and existing plan priority areas, that future plans identify explicit conservation targets and goals for both the plan as a whole and for individual priority areas within the plan, and that plan implementation be evaluated by measuring progress toward achieving these specific goals. Similar efforts have recently been undertaken to evaluate biodiversity representation within the existing Natura 2000 protected area network of Europe, and to identify additional areas needed to ensure that the network adequately represents biodiversity (Hermoso et al., 2015).

The current level of land protection within plan boundaries took many years to achieve - up to 70 years for the earliest (1939) plan which has the highest percentage of land protected (58%). For all plans, land protection began before plans were completed, likely due in part to the substantial overlap in plan boundaries (e.g., 90% of priority areas in the 2008 plan were partially or entirely encompassed by a previous plan) and to WDNR's policy prioritizing the completion of existing projects over the initiation of new ones (Appendix S2). Land protection inside plan boundaries continues through the present, in contrast with some marine conservation planning efforts, where protection occurred almost immediately upon plan completion (Fernandes et al., 2005;

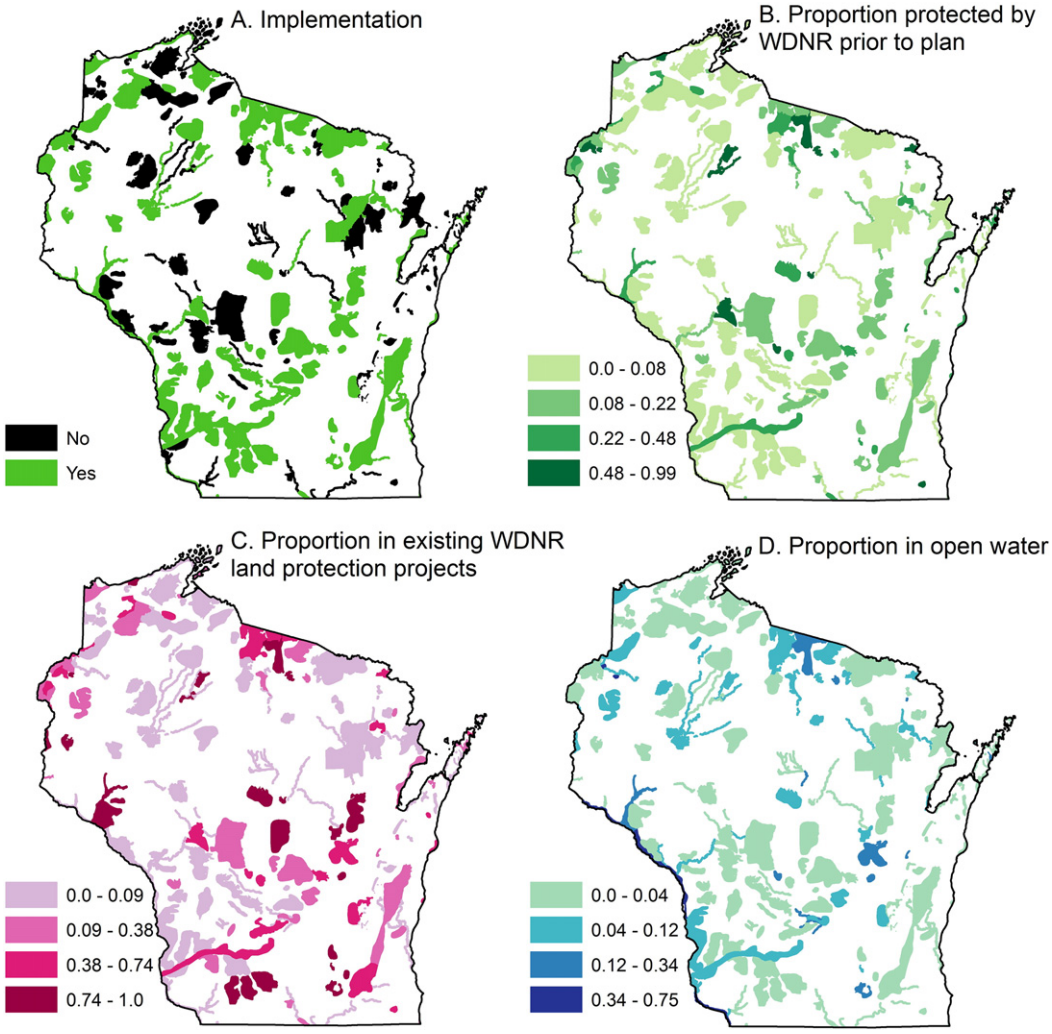

Fig. 3. A) Priority areas in the 2008 conservation plan for which implementation occurred (i.e., land was protected by WDNR within the priority area after plan completion). B) Proportion of each priority area protected by WDNR prior to plan completion. C) Proportion of each priority area within the boundary of existing WDNR local land protection projects and unprotected. D) Proportion of each priority area in open water. All explanatory variables are mapped into four classes using natural breakpoints in the data.

Gleason et al., 2010). Two common strategies for targeting conservation efforts are minimizing loss (targeting areas of high conservation value that are also highly threatened) and maximizing gain (targeting areas of high conservation value regardless of threat, Wilson et al., 2007). While the former is generally most effective, strategies that seek to maximize gain may be optimal when conservation action is delayed (Visconti et al., 2010). Given the pattern of gradual protection over long time frames observed here, we suggest that targeting land protection toward areas of high conservation value which are not yet highly threatened (i.e., land conversion is less likely in the near and medium term) may ultimately provide the best opportunity to achieve significant land protection and long term conservation goals when funding availability, land ownership patterns, and land protection processes indicate that land protection timeframes may be long.

4.2. Identifying factors explaining plan implementation

Conservation plans (including those studied here) often contain hundreds of priority areas (Cowling et al., 2003; Lerner et al., 2006). Effective action (especially land protection) in all or even a majority of these priority areas in the near term is unlikely given limited conservation resources and the costly nature of buying land. Our findings provide strong, quantitative evidence for the need to consider agency policy, processes, and past actions in the development of future plans, so that individuals and organizations involved in developing and implementing the plans will understand which of the many priority areas in plans are locations where high conservation values intersect with high implementation feasibility, and which priority areas may be more difficult to implement successfully in the near term because they do not align closely with institutional policies and processes.

We found that the two most important metrics explaining current implementation success were institutional factors related to agency policy and past actions: securing acquisition authority and successfully protecting land prior to the plan being completed. There are two important implications of these findings. The first is that our results demonstrate quantitatively what others have long suggested - that broad-based support from local governments, stakeholders, and the public is critical for successful plan implementation. Agency acquisitions in Wisconsin are largely limited to sites with defined (local) project boundaries where the agency has formal acquisition authority (Wis. Admin. Code NR §1.41). Initiation of a WDNR land protection project is most often preceded by identification of the area in a statewide conservation plan (JP, *unpublished data*). Securing acquisition authority requires undergoing a separate planning process at the local level that generally requires multiple years and extensive opportunities for public comment (WDNR, 2013a). Organization-specific, local project planning processes are also a relevant step in the land protection processes of federal agencies (e.g., US Fish and Wildlife Service National Wildlife Refuge System,

Table 3
Importance of metrics in explaining variability in implementation of priority areas within the current conservation plan for Wisconsin, USA. Importance values for all metrics in the model sum to 100%. Please see Fig. 1 for a schematic of the model, and Table 1 for descriptions of model components and metrics.

Metric	Model component	Importance
Extent protected by WDNR[a]	Support (agency and broad-based)	33.7%
Existing WDNR land protection projects	Agency policy	26.1%
Water	Agency policy	9.8%
Private lands conservation behavior	Support (public)	4.6%
Land use planning	Support (local government)	4.4%
Partner conservation easements	Support (partner)	4.0%
Wetlands	Agency policy	3.1%
Land cost	Final approval	2.5%
Projected housing density	Final approval	2.3%
Endangered resources	Agency policy	2.2%
Land not already protected	Land availability	1.9%
Projected housing growth	Final approval	1.1%
Education	Support (public)	1.0%
Zoning regulations	Support (local government)	0.8%
Political affiliation	Support (public)	0.7%
Forests	Agency policy	0.7%
Population density	Agency policy	0.5%
Income	Support (public)	0.4%
Age	Land availability	0.1%
Proximity to cities	Agency policy	0.0%

[a] The Wisconsin Department of Natural Resources (WDNR) is the state natural resources management agency.

D. Granholm, *pers. comm.*) and non-governmental conservation organizations (e.g., The Nature Conservancy, Bottrill et al., 2012). As a result, gaining acquisition authority and subsequently acquiring land are unlikely for both public agencies and other conservation organizations without broad-based support from local governments, stakeholders, and the public. Conservation activities other than land protection (e.g., monitoring, management, outreach) are not subject to the same lengthy authorization process, and thus might exhibit different implementation patterns and opportunities.

The second implication is that without careful attention to systematic conservation planning principles, the tendency for future land protection to continue in the same places that it has occurred in the past may lead to actions that either do not fully protect all elements of biodiversity (i.e., a lack of representation) or do so inefficiently (i.e., a lack of complementarity, Margules and Pressey, 2000). Considering representation is particularly important if there is evidence that protection of natural community types may be biased by land cost, availability, or other factors (e.g., Aycrigg et al., 2013; Joppa and Pfaff, 2009; Scott et al., 2001). In Wisconsin, forests and wetlands may be cheaper and easier to acquire than grasslands and savannas due to differences in land cost, regulatory protections, and federal funding programs (Carter et al., 2014a). Potential inefficiencies (from a conservation perspective) are likely whenever conservation priorities do not align exactly with other institutional priorities (e.g., providing recreation opportunities, supporting local economies). The challenge for agencies and other organizations is to understand clearly which goals (conservation or otherwise) are being achieved through a specific land protection action, and which are not. Such an understanding is facilitated when the representation of biodiversity elements within existing protected areas has been assessed, when clear and explicit conservation targets and goals are identified in plans, and when progress toward meeting those conservation goals is evaluated and shared on a regular basis (e.g., Bottrill and Pressey, 2012; Game et al., 2013; Margules and Pressey, 2000).

Environmental factors such as land productivity, altitude, and distance from cities are strongly reflected in protected areas in the USA and worldwide (Joppa and Pfaff, 2009; Scott et al., 2001). We found only one environmental factor (of five tested) that helped to explain conservation plan implementation in Wisconsin. The importance of open water in explaining implementation success reinforces the importance of considering agency policy during the planning process, as acquiring lands near open water is a priority in the agency's land acquisition policy (Appendix S2). The potential for water-based recreation associated with protection of parcels near water may also bring additional stakeholder groups to the table (e.g., anglers, kayakers), providing a broader base of support for land protection, and suggests a role for greater consideration of areas where recreational and conservation interests align (Thomas, 2010). Rarity of species and natural communities, a criteria for identifying priority areas and actions in this and many other conservation plans (e.g., Myers et al., 2000), was not important in explaining implementation success.

Political, economic, and social factors known to influence conservation support and actions in other locations and contexts (e.g., political affiliation, income, and education of local residents; Bultena and Hoiberg, 1983; Kroetz et al., 2014; Moon et al., 2012) did not explain successful conservation plan implementation in Wisconsin, nor did local land use regulations, land availability, or the level of threat presented by current and projected future housing density. Political affiliation and income do correspond with adoption of land use regulations in the neighboring state of Michigan (Locke and Rissman, 2015). Clearly the human context of conservation influences the feasibility of land protection and other conservation actions identified in plans (Bottrill et al., 2012; Knight et al., 2008, 2011a), but our findings suggest that successful plan implementation via land protection is possible under a wide range of political and socio-economic settings at the local level.

Notably, neither the top priority in agency policy, protection of land in densely populated areas, nor a related policy priority (protecting land near large cities, Appendix S2), were important in our model. Both findings illustrate conflicts between different steps of the land protection process. While the agency's acquisition policy prioritizes protection of land that provides nearby recreational opportunities for people living in cities, land near cities also tends to be more costly, which decreases the likelihood of the land protection transaction receiving final approval (Table 1). Using alternative metrics that reflect policy priorities (e.g., expected annual recreational user visits per dollar rather than acres per dollar) to evaluate whether final approval of the transaction will be granted might facilitate protection of parcels meeting the agency's policy priorities.

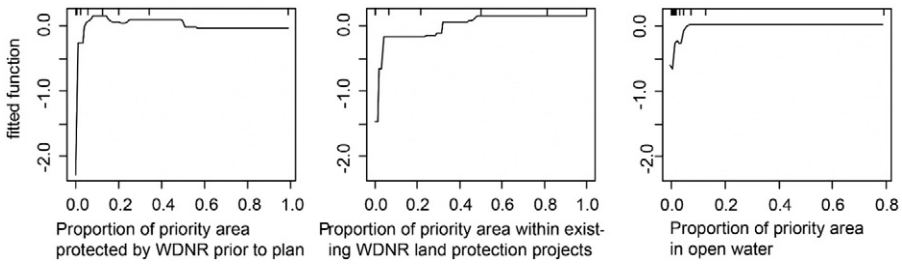

Fig. 4. Partial dependence plots for the top three most important variables in the final boosted regression tree model explaining in which priority areas land protection occurred after the plan was completed. Tick marks along the top of the plots indicate the distribution of values in the dataset.

5. Conclusion

We suggest that plans may be most feasible to implement in the short term when they build on past conservation plans, actions, evaluations, and bases of support; consider existing land protection policies of key conservation actors; and take into account available conservation funding and programs. Given limited funds, it may be helpful to focus initial implementation efforts on a subset of previously identified priority areas which align well with land protection policies of key conservation actors and with funding availability (funding programs are often limited to specific locations, species, or natural community types), in which targeted land protection would facilitate the greatest increases in biodiversity representation, in which conservation actions are likely to be achievable before threats diminish the conservation value of the land, and for which there is demonstrated, agency, partner, and public support.

When these institutional, socio-economic, and environmental factors align, plan implementation can begin quickly. For example, the 2004 and 2008 conservation plans for Wisconsin identified a small number of prairie, savanna, and stream priority areas in southwestern Wisconsin with limited land protection to date (Pohlman et al., 2006; WDNR, 2008). Prairies and savannas are underrepresented in Wisconsin's protected areas (Carter et al., 2014a). The priority areas face relatively low threat from development (Carter et al., 2014b) and contain water and endangered resources that are priorities in WDNR's land acquisition policy (Appendix S2). Local, state, and federal agencies and non-governmental organizations were already actively working with local residents to protect the priority areas in conjunction with federal programs that provide funding and technical support for prairie, grassland, and savanna conservation (WDNR, 2009). In 2009, WDNR approved a land protection project authorizing funding and staff for conservation actions within a large (1,917 km^2) boundary, including a goal of permanently protecting 49 km^2 over the next 15 years (WDNR, 2009). Establishment of a WDNR land protection project often coincides with substantial land protection activity (Carter et al., 2014a). In this case, WDNR funded a new permanent staff position to work with landowners in the project area to promote prairie, grassland, and savanna protection on private lands, and has also permanently protected 3 km^2, with additional lands protected by partners and through federal programs (JP, *unpublished data*).

Conservation biology has been criticized as an academic endeavor that has had little impact on real world activities (Whitten et al., 2001). Given the small proportion of plans effectively implemented to date (Knight et al., 2008), the same might be said of conservation planning. Our study has provided a quantitative assessment of plan implementation and of factors associated with implementation success. Planners can use this information to help identify where conservation practitioners are most likely to be able to protect areas identified as being of high biological importance in current conservation plans in the short term, recognize where effective protection is likely to require additional efforts (e.g., building broad-based support, encouraging policy changes) over longer time frames, and develop future plans which consider (in addition to biology) key institutional factors likely to correspond positively with on-the-ground implementation opportunities.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.biocon.2015.09.013.

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