Extending the design principles for common-pool resource governance to conservation easements on private lands

Tatyana Ruseva (Appalachian State University- Boone, NC)

James Farmer (Indiana University- Bloomington, IN)

Michael Drescher (University of Waterloo- Waterloor, Ontario)

Abstract

Private land conservation mechanisms, such as conservation easements (CE) by nonprofit land trusts, create increasingly complex and potentially resilient regimes for securing and maintaining conservation benefits from private lands. Questions remain about how well eased lands can sustain social, economic, and environmental changes shaping resource use on private lands, and to what extent CE regimes may remain institutionally and ecologically robust. We conceptualize CE-protected lands, stewarded by land trusts, as quasi-common pool resource systems that produce shared resources and public goods in the form of ecosystem services. Linking the PLC literature with common-pool resource theory, we extend Ostrom's institutional design principles for common-pool resource governance to PLC with a focus on CE regimes. While we find most of the principles to be applicable to CEs, three principles appear problematic, namely: clearly-defined social boundaries; perceptions of fair match between appropriation and provision rules by second generation CE property owners; and, ecological monitoring. Overall, this paper advances the notion that Ostrom's design principles may offer land trusts and other participants in the private land conservation field a tool for planning and assessing the resilience and institutional viability of CE regimes as complex and evolving social-ecological systems.

INTRODUCTION

Recognition of the degradation and loss of ecologically valuable private lands, coupled with a heightened sensitivity to the limitations of government conservation and local land-use regulations, have inspired the growth of land trusts and conservation easements (CEs) in the United States, Canada, and elsewhere (Wright and Hilts 1993, Gustanski and Squires 2000, Fishburn et al. 2009, Owley and Rissman 2016). Land trusts are nonprofit, charitable organizations that purchase land for permanent protection or accept donations of land, funds, and CEs, which limit development and protect private land for its conservation, historical, and public values. Private lands in the United States represent roughly 61% of all land, 87% of farmland, and more than 50% of rangelands and forestlands (Nickerson et al. 2011, USDA 2013, Butler et al. 2016), and serve as habitats for over half of federally threatened and endangered species (Morrisette 2001). Since the early 1980s, increased application of CEs and other negotiated contracts between landowners and land trusts has enabled the protection of over 19 million hectares of private lands and associated ecosystem services in the United States (LTA 2011).

A CE is "a legal agreement between a landowner and a land trust or government agency that permanently limits uses of the land in order to protect its conservation values" (LTA 2011). CEs are common and increasingly complex means employed by land trusts to conserve socially and ecologically important private lands. Compared to CEs before 2000, CEs today include more clauses and purposes, and are more likely to permit residential development and working land uses (e.g. timber harvest) than earlier, more restrictive CEs (Owley and Rissman 2016). But concerns exist that CEs do not offer flexibility in the face of environmental, socioeconomic, and demographic changes shaping resource use on private lands (Rissman 2010, Owley and Rissman 2016). These evolving complexities raise questions about how resilient to change CE protected lands are (Rissman et al. 2007), how responsive nonprofit land trusts are to economic conditions (Larson et al. 2014), and to what extent CEs can remain institutionally robust (McLaughlin 2005, Rissman and Butsic 2011). Given lack of reliable information across time and space, insufficient monitoring, and experimental designs that credibly establish counterfactual outcomes, it has been difficult to rigorously assess the performance of CE regimes (Curzon and Kontoleon 2016, Wallace et al. 2008). Questions, thus, remain about the effectiveness and endurance of private land conservation regimes (Merelender et al. 2004, Hardy et al. 2016).

In this paper, we argue that under certain conditions CEs may remain viable institutional arrangements for ecosystem service provision from private lands. These conditions are embodied in eight design principles found essential to common-pool resource (CPR) governance (Ostrom 1990). A CPR perspective is useful in the context of CE regimes because of the shared and public good nature of ecosystem services produced by CE-protected lands (e.g., clean water, soil conservation, carbon sequestration, wildlife habitat). As negotiated mechanisms, CEs enable organizations and individuals to create rules about how resources on private lands are to be managed, who may use them, and what resources can be appropriated. Here, we conceptualize these mechanisms as governance arrangements or regimes for quasi-CPR management and ecosystem service provisioning, and examine them through the lens of Ostrom's institutional design principles.

Based on extensive case studies, Ostrom (1990) proposed eight design principles that characterize successful long-lasting institutions for CPR governance, often under common-property arrangements (Ostrom 1990, Cox et al. 2010). We extend the application of these principles to land trust conservation easement (CE) holdings that are largely seen as private-property arrangements, but which, in actuality, constitute a basket of negotiated rights over the use, access, and management of ecosystem services (Schlager and Ostrom 1992). This paper integrates elements of the private land conservation literature with Ostrom's design principles – two sets of literature that have currently remained in isolation of one another – in order to better understand the extent to which Ostrom's design principles apply to CE practice and policy. We present a case for why a CE regime can be considered a social-ecological system comprised of different users (landowners, neighbors), rules (CE terms), resource systems (eased properties), and units (ecosystem services) that embody CPR and public good characteristics, and to which Ostrom's institutional design principles might be extendable (Fig. 1). In addition to linking the institutional and private lands conservation literature, this review draws on key informant interviews to illustrate how the design principles relate to private CE regimes.

[Fig. 1 here]

From a policy perspective, we expect insights from this paper to provide a useful diagnostic tool for assessing the institutional robustness of CE regimes and resilience of conservation lands in the face of socioeconomic and ecological changes (e.g., climate variability, generational transfer, new markets, technologies) (Lindsay 2008, Rissman et al. 2014). From a practical standpoint, our insights can inform new ways of formulating, implementing, and enforcing easement contracts. Emerging scholarship has examined the application of Ostrom's design principles to contexts beyond the local commons, including large-scale social-ecological systems, carbon policy, ozone regulation, and atmospheric pollutants (Epstein et al. 2014, Lacroix and Richards 2015). Arguably, the design principles can be used as a guide for understanding the efficacy of groups, beyond CPR settings, where people need to cooperate to achieve shared goals (Wilson et al. 2013). This paper contributes to this growing interest in the usefulness and generality of the design principles (Cox et al. 2010).

PRIVATE CONSERVATION LANDS AS QUASI-COMMON POOL RESOURCES

Conservation easements by nonprofit land trusts constitute an evolving model of environmental governance, integrating diverse participants across a variety of resource systems (water, forests, farmland) and levels of rules (local, state, federal), in order to conserve ecologically important private lands. These lands produce environmental services, representing a mix of private goods (food, timber), public goods (carbon storage, water purification), club goods (hunting), and CPRs (wildlife, water, aesthetics). The two attributes that distinguish types of goods are exclusion (access) and joint use/consumption (rivalry) (see Supporting Information for classification of ecosystem services by types of goods). In the case of widely-shared CPRs, limiting access to the resource is costly or infeasible, and resource use by some reduces the availability of resource units (e.g., deer, water) to others. Excluding users from public goods (e.g., carbon storage) is also difficult, but in contrast to CPRs, public goods can be jointly used without affecting resource availability (Ostrom 1990, Lant et al. 2008). Conserved lands are also quasi-CPR systems that: (a) can make it difficult to exclude others from benefiting from resource units produced by these

lands, and (b) can create consequences for linked resource systems (e.g., adjacent parcels or related ecosystems) (Ostrom et al. 1999).

Often, the natural resource status on one parcel is dependent on the state of natural resources on other parcels, regardless of ownership regime. For example, exploiting resource units (e.g., timber) can negatively affect the resource system, diminishing the parcel's supply of ecosystem services (e.g., carbon sequestration) and those CPRs that cross the parcel's boundaries (e.g., wildlife, water). The fact that the consequences of management practices do not end at a parcel's boundary, but can materialize across spatial and temporal scales (Huntsinger and Oviedo 2014), potentially involving multiple parcels, imparts quasi-CPR characteristics on the system of private land ownership. These landscape-scale interdependences – across different ownership parcels, land uses, and management practices – suggest that collective action among multiple owners (users) is necessary in order to protect ecologically valuable private lands. Absent market institutions or government rules stipulating what owners can or cannot do with their land and resources, private lands may be subject to degradation, fragmentation or development. We suggest that these deficiencies in the private land ownership system may be partially mitigated by a governance system stewarded by land trusts and guided by Ostrom's institutional design principles.

In CPR theory, the "presence of a leader or entrepreneur, who articulates different ways of organizing to improve joint outcomes" is an important impetus for successful collective action (Ostrom 2010:244). To the degree that collective action among multiple users (i.e., landowners, land trusts, community members) is required to protect resource systems (i.e., quasi-CPRs) and units (i.e. environmental services) on private land, we argue that land trusts serve as key entrepreneurs (Fig. 1). They bridge sectors and bring diverse participants around common goals and shared values (e.g., trust, reciprocity) that facilitate community-based conservation. The likelihood of successful collective action – investing in and maintaining CE regimes over the long term – may be improved if owners and users of quasi-CPRs follow a set of principles: "Successful self-organized resource regimes can initially draw upon locally evolved norms of reciprocity and trustworthiness and the likely presence of local leaders in most community settings. More important, however, for explaining their long-term survival and comparative effectiveness, resource regimes that have flourished over multiple generations tend to be characterized by a set of design principles." (Ostrom 2010:244).

Central to Ostrom's design principles is the idea that groups that are successful at sustaining resource use in small-scale local CPR settings (e.g., game, fish, pasture) possess common attributes or practices pertaining to: who can access and use the resource, the extent to which they can appropriate resource units; how and by whom rules for resource use are created and modified; and, how and by whom resource use is monitored or penalized (Ostrom 1990, 2005, Poteete et al. 2010). These practices have been proposed as conditions necessary for solving collective action problems in CPR management. The presence of all principles is neither necessary, nor sufficient for successful CPR management (Poteete et al. 2010), and we do not expect every principle to be present in CE regimes. However, given complex and uncertain environments, we believe adherence to the design principles may help ensure sustainability of CE governance arrangements, for example in the context of generational land transfer currently taking place in the United States and Canada (Butler et al. 2016).

EXTENDING THE DESIGN PRINCIPLES TO CE REGIMES

Our discussion of the applicability of the design principles focuses on CEs as a common, perpetual mechanism for PLC. Drawing on real-world cases, interviews with seven land trusts in the upper Midwest US and Canada (Supporting Information), and peer-reviewed literature, we illustrate the extent to which the design principles are present in CE governance arrangements. We also discuss how the design principles interplay, positively and negatively, with CEs, and note limitations in the extension of the design principles to CE regimes.

Principle 1: Collective action in CPR management is facilitated by clearly defined user (1A) and resource (1B) boundaries (Table 1). Users (e.g., landowners) who have the right to withdraw resource units from the CPR system must be clearly identified, and so must be the boundaries of the resource system (Ostrom 1990). This is illustrated in both the rules proposed in a CE, the geographic boundaries of a land trust's working area, and the CE property boundaries itself. For example, CEs outline strict rules and terms as to who has access to the resource system (i.e., eased property), and what the boundaries of the protected area are. Complications may arise, however, when delineating the users/beneficiaries of ecosystem services provided by CE-protected lands.

It is important to distinguish between direct users (i.e., appropriators/providers of ecosystem services, such as landowners of CE properties), indirect users (i.e., neighbors, residents), and non-users (i.e., outsiders) of CE lands and related ecosystem services (Cox et al. 2010). Ecosystem services are heterogeneous in space and time and imply fluid boundaries with regard to direct, indirect users and nonusers of ecosystem benefits (Fischer at el. 2009). While soil formation is an in-situ service with an in-situ benefit to the property owner (e.g., agricultural cultivation), water regulation services occurring in one place (e.g., mountain top/slope), can benefit users in another place. Another consideration is that some resource systems (e.g., forests) harbor clusters of ecosystem services (e.g., regulating water cycle, carbon sequestration) occurring over different time spans, with different rates of uncertainty, frequency of use, and implications for current and future user generations (Fischer et al. 2009). The relevance of principle 1A (i.e., user boundaries) is, thus, conditional on the type of ecosystem services supplied by CE-protected lands, type of users, the spatial and temporal scales, and joint production and interactions among different types of ecosystem services. These dimensions can possibly guide future negotiations of CE terms, with a focused attention on the current and future users of conservation benefits.

Principle 2: Congruence between appropriation and provision rules and local conditions is normally expressed in the negotiated CE contract. CE terms often specify appropriation and provision activities within the resource system, such as timber harvesting, resource extraction, or residential development. Rules may require maintenance of the parcel's land cover type (e.g., forest, meadow) and/or allowance of activities deemed suitable to an area (e.g., farming, tourism, timber harvesting, natural gas extraction). Local land trusts are uniquely positioned to ensure correspondence between local conditions and land use/management on CE protected parcels, i.e. a socio-ecological fit (Principle 2A, Table 1). For instance, a land trust may be able to negotiate the protection of a critical watershed element, a rare geophysical feature, or a cultural heritage

feature. The negotiated balance between productive use for private benefit and the conservation value of the property is illustrated by the outline of a subset of prohibited activities for a real parcel held under a CE:

> "The Protected Property shall be used for agricultural, forestry, educational, non-commercial (or commercial if, in Grantee's opinion, there is no effect on conservation or preservation values), recreational, and/or open space purposes only. Examples of commercial undertakings which could be conducted in a way not harmful to the conservation or preservation values include, but are not limited to, a bed and breakfast, horse stable, youth hostel, truck garden, historic farm open to the public, production and sales of handicrafts of some kind, as well as general or specialized agricultural production."

If CE terms do not match the attributes of the resource system and users, sustaining conservation values may be challenging. If the initial rules established by landowners and land trusts are not congruent with local conditions (e.g. biophysical characteristics, local customs, culture, livelihoods), the long-term success of CPR governance systems (i.e., CE regimes) may be questionable (Cox et al. 2010). Possible complications may arise when land is transferred to succeeding owners who are unaware of all easement stipulations, or who may not perceive the CE restrictions vis-à-vis benefits as fair (Morrisette 2001). In this regard, fair distribution of costs and benefits (Principle 2B) reflects an equity consideration among participants in CE governance regimes (Table 1). Ostrom (2005:263) describes this dimension as follows: "When the rules related to the distribution of benefits are made broadly consistent (and fair) with the distribution of costs, participants are more willing to pitch in to keep a resource well-maintained and sustainable."

CE arrangements provide both private (e.g., tax deduction) and public benefits (e.g., ecosystem services), and necessitate private (e.g., land trust resources, landowner fees) and public resources (e.g., government funding). Tax incentives, in particular, have been critical to the growth of CEs across the United States and Canada, and suggest the presence of this principle for current owners of CE lands; however, questions remain about the principle's relevance to future owners. The inability to predict the land use intentions and objectives of future owners of CE lands, illustrates conditions under which CE rules can fail to live up to local conditions (ecological, economic, social or technological), and ultimately diminish the prospects for long-term survival of CE regimes. We surmise that the degree to which users perceive benefits and costs to be fairly distributed (Principle 2B) can be problematic in the context of future owners of CE-protected lands, who may hold different preferences, values, and management objectives (Table 1).

[Table 1 here]

Principle 3: Collective-choice arrangements ensure that users have the right to participate in the formulation of rules governing resource use. CEs are negotiated contracts that enable the property owners and CE holders to influence the formulation of CE terms. Participation in rule-making is key for ensuring compliance with easement rules (Ostrom 1990). Members of a land trust, too, have access to mechanisms shaping the mission of a land trust, its strategic goals, and conservation values and objectives. Additionally, resource owners and users have a constitutional right that guarantees participation in political processes (e.g., elections) and in

local, state, and federal government decision-making (e.g., public comment, petitions, lobbying). The latter are important mechanisms that ensure users have a say in policy decisions regarding conservation tax incentives (e.g., deductions for charitable donations), the availability of state funds for land conservation, or local land-use regulations. For example, in 2015, the Enhanced Federal Tax Incentive for Conservation Easement Donations in the US became permanent – a decision long advocated by the land trust movement and an outcome illustrating the applicability of this design principle to CE regimes.

Principle 4: Monitoring is an essential component of CEs and a key condition for sustainable CPR governance. Studies of fisheries, forests, and irrigation systems around the world have found monitoring to be critical for sustainable CPR management (Ostrom 1990). Monitoring the biophysical conditions of the eased property (e.g., ecological monitoring) represents one part of this principle (Principle 4A). Many land trusts may not have the legal right or capacity to monitor ecological conditions beyond the requisite compliance with CE terms (Rissman et al. 2013). Kiesecker et al. (2007) examined 119 CEs held by The Nature Conservancy, spanning 8 states and 20 years (1984-2004). They found that 92% of eased properties had been monitored for legal compliance in the past 3 years, but only 20% of biological targets had been monitored quantitatively. This can be a potential weakness to CE regimes, particularly because understanding ecological processes and outcomes is essential to the adaptive governance of conservation lands.

The second component of the monitoring principle (Principle 4B) relates to compliance monitoring. Monitoring the terms of the CE helps meet the legal requirements of preserving the conservation values for which the land is being protected. The easement holder is obligated to routinely monitor and enforce the agreed-upon CE rules (Merenlender et al. 2004). Additional practical benefits include that monitoring can help instill trust in CE holders, improve the knowledge base for land management, and help guide future management plans (Ringold et al. 1996). Different land trusts monitor in different ways: on-site annual visits and meetings, telephone calls, drive-byes, or analysis of aerial photography. While the latter options may suffice in many cases, violations to CEs can easily occur without thoroughly performed site visits. In-person meetings and on-site monitoring visits help foster better communication and stronger relationships between land trusts and landowners, educate and engage landowners in land stewardship, and detect and mitigate potential CE violations. Compliance monitoring is also important for sustainable CPR governance (Neugarten et al. 2011), such that fewer easement violations occur on land that is monitored annually. To sum, while compliance monitoring is clearly applicable to CE regimes, ecological monitoring is a potential weakness that participants in these regimes may need to address to ensure the future resilience of CE lands.

Principle 5: A graduated system of sanctions is essential to the long-term sustainability of CE lands. Formal letters, in-person meetings, and telephone conversations are frequently used as initial sanction communication strategies for landowners found in violations of CE terms. It is common that once informed about a violation, most landowners remedy the violation to the satisfaction of the land trust. As expected, sanctions increase with the frequency and/or severity of the violation, and may include reimbursement of ecological restoration costs or financial penalties. While a violation such as mowing a trail wider than agreed can easily be remedied by letting it grow back, other violations necessitate payments for specific restoration activities, such

as replanting an area illegally cleared of all vegetation. Considerable variability has been found in adherence to CE rules, specifically when lands transition from the original owner (i.e., easement grantor) to succeeding landowners. Richman and Loza (2011:4) state that "[CE holders] have found that stewardship demands increase after land ownership changes from the landowner that initially established the easement. Holders are likely to spend more time answering questions and dealing with potential and actual easement violations with subsequent landowners. Future landowners are more likely to be hostile towards provisions of the easement." Furthermore, Danskin (2000) found that among 15 CE violations requiring litigation, all were committed by second-generation landowners. Our interviews revealed a similar trend showing greater occurrence of violations of CE terms and the need to seek resolution among second-generation owners. Consequently, we believe Principle 5 is applicable to CE regimes (Table 1).

Principle 6: Participants in CE regimes must have access to financially attainable conflict resolution mechanisms that are perceived as fair (Ostrom 1990). Generally, landowners and land trusts have access to local, low-cost means for resolving CE violations or other conflicts, including direct communication or mediation (Table 1). They typically prefer out-of-court resolution and will pursue these avenues before turning to legal recourse. However, expensive resolution of resource use conflicts can be sought through the court system. To make court resolution financially attainable for land trusts, the US Land Trust Alliance established in 2011 a shared conservation defense service for land trusts. This service provides a legal defense fund for addressing potential conflicts related to the permanence of conservation regimes. It is owned by member land trusts and aims "to insure the costs of upholding CEs and fee lands held for conservation purposes when they have been violated or are under legal attack, and to provide information on risk management to those land trusts" (Terrafirma 2016).

Principle 7: Minimal recognition of rights to organize is a principle reflected in the presence of the rule of law. The sustainability of local CPR governance arrangements can be influenced by the degree to which government agencies recognize, or alternatively challenge, the rules of CEs. Research on local CPR systems, such as fisheries, irrigation systems, and community forests, has found that incongruence between local community rules and higher-level external rules may diminish the prospects for long-term resource sustainability (Ostrom 1990). In contrast, when users have tenure rights to the resource and these rights are externally recognized, the prospects for successful CPR governance increase. The legal defense fund created to ensure that CE rights are properly represented and defended in a court of law is a good illustration of this principle. Given the existence of rule of law and enforceable property rights regimes in the US and Canada, we expect this principle to be present in CE regimes.

Principle 8: A nested enterprise suggests that CE regimes are part of larger social and economic systems (Fig. 1) and that linkages exist among participants in CE regimes (i.e., landowners, land trusts) and other groups at local (i.e., horizontal), state and federal (i.e., vertical) levels (Cox et al. 2010). Nesting refers to "appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities" that may occur at different scales (Ostrom 2005:259). The provision of ecosystem services from CE lands is a fitting example, illustrating the confluence of different rules shaping resource use on eased properties. In particular, local land-use ordinances, state regulations for resource use on private lands (e.g., timber harvesting permits, hunting

permits), and federal statutes (e.g., Endangered Species Act, Section 404 of the Clean Water Act for wetlands protection) can constrain or enable actions on private lands that ultimately impact the health of the system and flow of ecosystem services.

CE regimes are part of a fragmented, federal system, where monitoring, enforcement and governance activities are spread throughout multiple state (provincial) and federal agencies with varying degrees of authority, illustrating the presence of institutional nesting for private conservation lands. In addition, land trusts are embedded in multiple organizational memberships at different levels, including: (1) regional groups, such as Blue Ridge Forever, a collective campaign of 10 land conservancies to protect land and water in the Southern Blue Ridge region (United States); (2) state or provincial associations like Virginia's United Land Trusts, the North Carolina Land Trust Council, and the Ontario and British Columbia Land Trust Alliances that aid land conservancies in their fundraising and advocacy efforts; (3) national alliances, such as the Land Trust Alliance (LTA) Accreditation Program; and (4) even international links such as the American Friends of Canadian Land Trusts. This multi-level governance system has implications for learning, the sustainability of CE governance regimes (e.g., monitoring and enforcement), and for the long-term success of community conservation efforts.

PROSPECTS FOR SOCIAL AND ECOLOGICAL RESILIENCE OF CE REGIMES

We have argued that Ostrom's institutional design principles reflect essential conditions necessary for successful collective action in the governance of CE regimes. In particular, clear boundaries, monitoring, graduated sanctions, and conflict resolution are foundational to CE stewardship as practiced today. While most of the principles are applicable in the context of CE regimes, three appear problematic: clearly-defined social boundaries (1A); perceptions of a fair match between appropriation and provision rules among future owners (2B); and, ecological monitoring (4A) (Table 1). Here, we discuss what this means for the use of the design principles as a diagnostic tool in analyzing the social robustness and ecological resilience of CE regimes.

We believe CE regimes may remain institutionally robust and resilient, to the degree that they are able to meet the following conditions: provision of information with regard to property boundaries (Principle 1B); conservation management and use restrictions that are in line with local conditions (Principle 2); compliance monitoring (Principle 4B) based on graduated sanctions (Principle 5); financially attainable conflict resolution mechanisms (Principle 6); minimal recognition of rights to organize (Principle 7); and embeddedness of CE regimes within and beyond local communities (Principle 8). Critics have argued that the inflexibility of CEs, coupled with increased levels of CE restrictiveness (Owley and Rissman 2016) and novelty in ecosystems (Radeloff et al. 2015) may require greater contingencies and/or creativity in crafting future conservation practices. Keeping CE regimes flexible may require periodic revisions of CE terms in a way that enables the balancing of resource production for private gain with conservation restrictions for public benefit (Owley and Rissman 2016). Given competing human needs, development priorities, and demand for working lands, land trusts need guidelines for managing and conserving ecologically valuable private lands. We believe these guidelines are largely reflected in Ostrom's institutional design principles.

The design principles can offer a diagnostic framework as well as a planning tool for translating values into conservation practices. Practitioners may find these principles useful in understanding: how to better define the boundaries of the resource system, resource units, and the individuals that use or rely on them; how to clarify the relationships between benefits received from conserved properties and the cumulative costs needed to sustain these properties; as well as, how to encourage the participation of future stewards and owners of CE lands. These questions could offer land trusts and other participants in CE regimes a checklist for planning and assessing the resilience of conservation landscapes, and the institutional robustness of CE regimes as complex and evolving social-ecological systems.

Compliance and biophysical monitoring that inform adaptive governance are essential conditions for the institutional and ecological viability of CE regimes. It is important for participants in the PLC arena to remain open to institutional adaptation and be supportive of maintaining the fit between CE rules and local ecological conditions. Where ecological uncertainty is high, greater flexibility in CE terms may be needed (Quinn et al. 2007, McLaughlin 2005). Potential hindrances to future conservation efforts may include conflicts among land trusts (e.g., competition over resources and external funding), stagnation (e.g.. land trusts' staff or board members), missing or limited use of scientific information, failure to adapt to changing political and economic conditions (e.g., state budget cuts for conservation work may threaten the financial viability of some land trusts), and stipulations limiting landowner ability to adaptively manage their land (Stroman and Kreuter 2016).

Demographic changes among private landowners, generational transfer of land, and the diversity of values and objectives for owning land are some of the social dynamics shaping conservation stewardship today. In parallel, climate change, invasive species, and other natural disturbances will impact the spatial and temporal distribution of environmental services produced by CE areas. Emerging markets for ecosystem services, renewable energy sources, and climate mitigation (e.g., carbon offsets), too, will shape the decisions of CE regime participants, their perceptions of benefits, costs, and demand for resources. Adaptability to these conditions, while maintaining the set of good practices embodied by Ostrom's design principles, may mean greater likelihood of long-term survival for this PLC regime.

Future research could consider developing a taxonomy of PLC that classifies conservation regimes by the degree of institutional robustness or success in sustainably managing quasi-CPR systems. Case studies or comparative case research may be one strategy for addressing this objective. Such a taxonomy may help support decisions regarding the best-suited conservation approach given certain constellations of institutional practices, actors/users, and local conditions. Additionally, the biophysical dimensions of the resource system may serve to guide the choice of conservation tools. Finally, studying the spatial variation in the use of different conservation tools throughout the US and Canada, but also in other countries where PLC practices are common (e.g., Australia, Brazil, UK), can help us better understand the breadth and depth of experiences in the private land conservation arena.

SUPPORTING INFORMATION

A classification of ecosystem services by types of goods (Appendix S1) and our interview questions (Appendix S2) are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

LITERATURE CITED

Butler, B. J., J. Hewes, B. Dickinson, K. Andrejczyk, S. Butler, and M. Markowski-Lindsay. 2016. Family forest ownerships of the United States, 2013: findings from the USDA Forest Service's National Woodland Owner Survey. Journal of Forestry 114:000-000.

Cox, M., G. Arnold, and S. V. Tomas. 2010. A review of design principles for community-based natural resource management. Ecology and Society 15(4):38.

Cumming, G. S., C. R. Allen, N. C. Ban, D. Biggs, and H. C. Biggs. 2015. Understanding protected area resilience: a multi-scale, social-ecological approach. Ecological Applications, 25(2): 299–319.

Curzon, H. F., and A. Kontoleon. 2016. From ignorance to evidence? The use of program evaluation in conservation: evidence from a Delphi survey of conservation experts. Journal of Environmental Management 180:466-475.

Danskin, M. 2000. Conservation easement violations: results from a study of land trusts. Land Trust Alliance Exchange Winter 19(1): 5-9. Land Trust Alliance, Washington, D.C.

Epstein, G., I. Pérez, M. Schoon, and C. L. Meek. 2014. Governing the invisible commons: ozone regulation and the Montreal Protocol. International Journal of the Commons. 8(2):337–360.

Fishburn, I. S., P. Kareiva, K. J. Gaston, and P. R. Armsworth. 2009. The growth of easements as a conservation tool. PLoS ONE 4(3):e4996.

Gustanski, J. A., and R. H. Squires. 2000. Protecting the land: conservation easements past, present, and future. Island Press, Washington, D.C.

Hardy, M. J., J.A. Fitzsimons, S. A. Bekessy, and A. Gordon. 2017. Exploring the permanence of conservation covenants. Conservation Letters, March 2017, 10(2), 221–230

Huntsinger, L., and J. L. Oviedo. 2014. Ecosystem services are social–ecological services in a traditional pastoral system: the case of California's Mediterranean rangelands. Ecology and Society 19(1):8. http://dx.doi.org/10.5751/ES-06143-190108

Kiesecker, J. M., T. Comendant, T. Grandmason, E. Gray, C. Hall, R. Hilsenbeck, P. Kareiva, L. Lozier, P. Naehu, A.Rissman, M. R. Shaw, and M. Zankel. 2007. Conservation easements in context: a quantitative analysis of their use by The Nature Conservancy. Frontiers in Ecology and the Environment 5:125–130.

Lacroix, K., and G. Richards. 2015. An alternative policy evaluation of the British Columbia carbon tax: broadening the application of Elinor Ostrom's design principles for managing common-pool resources. Ecology and Society 20(2):38. http://dx.doi.org/10.5751/

Lant, C. L., J. B. Ruhl, and S. E. Kraft. 2008. The Tragedy of Ecosystem Services. *BioScience* 58(10).

Land Trust Alliance. 2011. 2010 National land trust census report: a look at voluntary land conservation in America. Land Trust Alliance, Washington, D.C.. Available from

http://www.landtrustalliance.org/land-trusts/land-trust-census/2010-final-report (accessed July 2016)
Larson, E. R., A. G. Boyer, and P. R. Armsworth. 2014. A lack of response of the financial behaviors of biodiversity conservation nonprofits to changing economic conditions. Ecology and Evolution 4(23):4429-4443.
Lindsay, B. 2016. Legal instruments in private land conservation: the nature and role of conservation contracts and conservation covenants. Restoration Ecology 24(5): 698:703.
McLaughlin, N. A. 2005. Rethinking the perpetual nature of conservation easements. Harvard Environmental Law Review 29:421–521.
Merenlender, A., M. L. Huntsinger, G. Guthey, and S. K. Fairfax. 2004. Land trusts and conservation easements: who is conserving what for whom? Conservation Biology 18(1):65–75.
Morrisette, P. M. 2001. Conservation easements and the public good: preserving the environment on private lands. Natural Resources Journal 41:373-426.
Neugarten, R. A., S. A. Wolf, R. C. Stedman, and T. H. Tear. 2011. Integrating ecological and socioeconomic monitoring of working forests. BioScience, 61(8):631-637.
Nickerson, C., R. Ebel, A. Borchers, and F. Carriazo. 2011. Major uses of land in the United States, 2007, EIB-89, U.S. Department of Agriculture. Available from http://www.ers.usda.gov/media/188404/eib89_2_.pdf (accessed July 2016).
Ostrom, E. 2010. Polycentric systems for coping with collective action and global environmental change. Global Environmental Change 20:550–557.
Ostrom, E. 2009. A general framework for analyzing sustainability of social-ecological systems. Science 325:419-422. doi: 10.1126/science.1172133
Ostrom, E. 2005. Understanding institutional diversity. Princeton University Press.
Ostrom, E., J. Burger, C. Field, R. Norgaard, and D. Policansky. 1999. Revisiting the commons: local lessons, global challenges. Science 284:278.
Ostrom, E. 1990. Governing the commons: the evolution of institutions for collective action. Cambridge University Press, Cambridge, United Kingdom.
Owley, J., A. Rissman. 2016. Trends in private land conservation: increasing complexity, shifting conservation purposes and allowable private land uses. Land Use Policy 51:76–84.
Richman, E., and A. Loza. 2011. Costs of conservation easement stewardship. Pennsylvania Land Trust Association. Available from http://www.na.fs.fed.us/legacy/resources/pdf/PLTA_Costs_of_CE_Stewardship_Guide_2011.pdf (accessed July 2016).
Poteete, A. R., M. A. Janssen, and E. Ostrom. 2010. Working together: collective action, the commons, and multiple methods in practice. Princeton University Press.
Quinn, C. H., M. Huby, K. Kiwasilac, and J. C. Lovett. 2007. Design principles and common pool resource management: an institutional approach to evaluating community management in semi-arid Tanzania. Journal of Environmental Management 84:100-113.
Radeloff, V. C., J. W. Williams, B. L. Bateman, and J. Usinowicz. 2015. The rise of novelty in ecosystems. Ecological Applications 25(8):2051–2068.
Ringold, P. L., J. Alegria, R. L Czaplewski, B. Mulder, T. Tolle, and K. Burnett. 1996. Adaptive monitoring for ecosystem management. Ecological Applications 6:745–747.
Rissman, A. R., J. Owley, M.R. Shaw, and B. Thompson. 2014. Adapting conservation easements to climate change. Conservation Letters 8(1):68-76.

Rissman, A.R., M. Bihari, C. Hamilton, L. Locke, D. Lowenstein, M. Motew, J. Price, and R. Smail. 2013. Land management restrictions and options for change in perpetual conservation easements. Environmental Management 52:277–288

Rissman, A.R., and V. Bustic. 2011. Land trust defense and enforcement of conserved areas. Conservation Letters 4:31–37.

Rissman, A. R. 2010. Designing perpetual conservation agreements for land management. Rangeland Ecology & Management 63:167–175.

Rissman, A.R., R. L. Lozier, T. Comendant, P. Kareiva, J. M. Kiesecker, M. R. Shaw, and A. M. Merenlender. 2007. Conservation easements: biodiversity protection and private use. Conservation Biology 21:709–718.

Schlager, E., and E. Ostrom. 1992. Property-rights regimes and natural resources: a conceptual analysis. Land Economics 68(3):249-262.

Stroman, D., and U. Kreuter. 2016. Landowner satisfaction with the wetland reserve program in Texas: a mixed-methods analysis. Environmental Management 57(1): 97-108.

Terrafirma RRG LLC. About Terrafirma. Available from http://terrafirma.org (accessed July 2016).

U.S. Department of Agriculture (USDA). 2013. Summary report: 2010 national resources inventory. Natural Resources Conservation Service, Washington, DC, and Center for Survey Statistics and Methodology, Iowa State University, Ames. Available from http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1167354.pdf (accessed June 2016).

Wallace, G. N., D. M. Theobald, T. Ernest, and K. King. 2008. Assessing the ecological and social benefits of private land conservation in Colorado. Conservation Biology 22(2): 284-296.

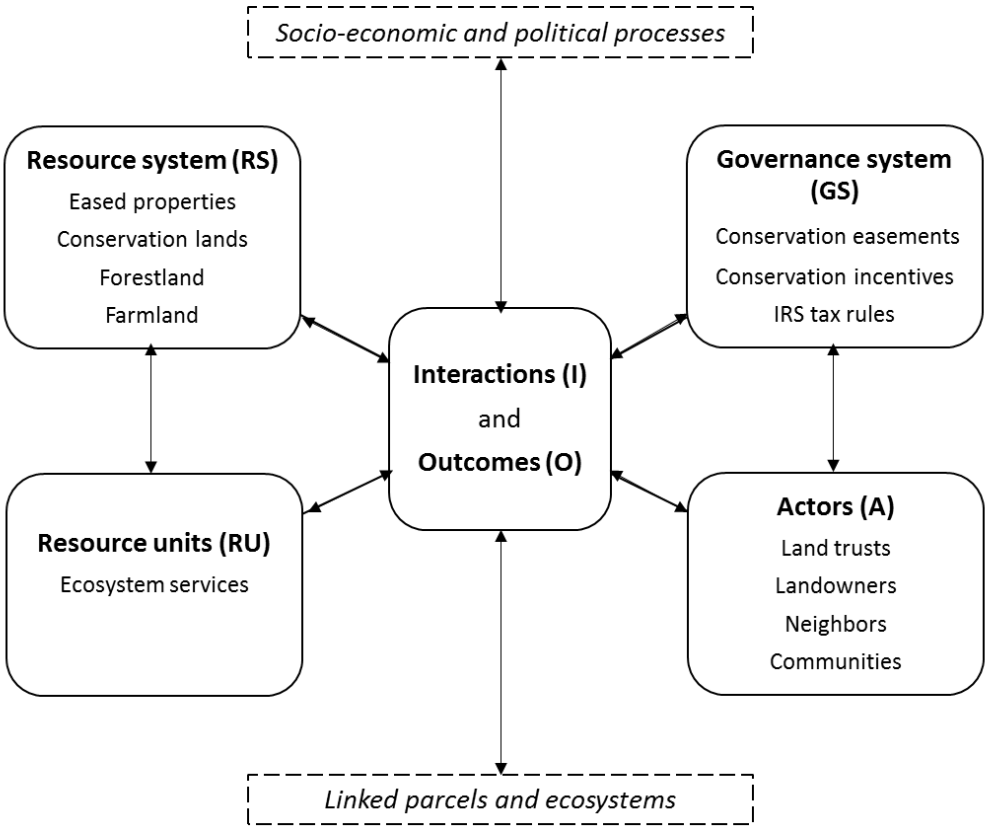
Wilson, D. S., E. Ostrom, and M. E. Cox. 2013. Generalizing the core design principles for the efficacy of groups. Journal of Economic Behavior & Organization 90S:S21-S32.

Wright, J. B., and S. G. Hilts. 1993. An overview of voluntary approaches to landscape conservation in the

Table 1: Presence of Ostrom's institutional design principles in the context of conservation easements on private lands

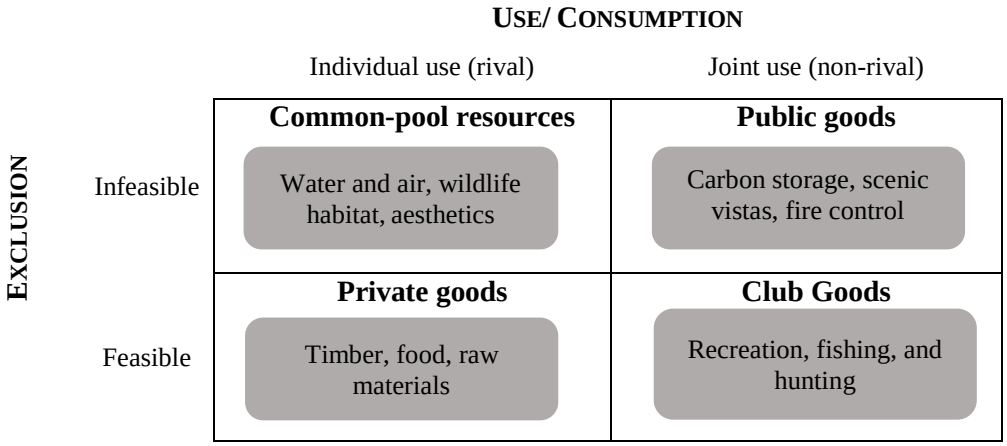
Design principle	Presence of the design principle
1A. Clearly-defined user boundaries	Conditional presence
1B. Clearly-defined resource boundaries	Present for resource system (protected property) Conditional presence for resource units (ecosystem services)
2A. Congruence between appropriation and provision rules and local conditions: Social-ecological fit	Present
2B. Congruence between appropriation and provision rules and local conditions: Fair distribution of costs and benefits	Present for current owners; Conditional presence for subsequent/future owners
3. Collective-choice arrangements: Participation in rule making	Present
4A. Ecological monitoring: Monitoring biophysical conditions	Largely absent
4B. Compliance monitoring: Monitoring user behavior, where monitors are accountable to the users and/or are the users themselves	Present
5. Graduated sanctions	Present
6. Conflict-resolution mechanisms	Present
7. Minimal recognition of rights to organize	Present
8. Nested enterprises	Present

Fig. 1 Conservation easement regimes as a social-ecological system (Adapted from: Cumming et al. 2015; Ostrom 2009)



Supporting Information

Appendix S1 - A classification of ecosystem services by types of goods produced from private conservation lands (Fisher et al. 2009; Ostrom and Ostrom 1999)



Appendix S2 – Open-ended interviews with key informants were guided by the following questions:

1. Is there any difference in first and second generation conservation easement holders and how conservation easements are respected or violated?
2. How might this change in the future as lands transfer to new owners?
3. Do you have any interesting example of conservation easement violations?
4. How did monitoring, conflict resolution, and/or sanctions play out in the process?
5. How did this process(es) evolve? What steps did you take?
6. How does your land trust do monitoring? Does it work well with minimizing conservation easement violations?

Literature Cited

Fisher B, Turner RK, Morling P. 2009. Defining and classifying ecosystem services for decision making. Ecological Economics **68**(3): 643-53.

Ostrom V, Ostrom E. 1999. Public goods and public choices. Pages 75-106 in McGinnis MD, editor. Polycentricity and local public economies: readings from the workshop in political theory and policy analysis. University of Michigan Press, Ann Arbor.