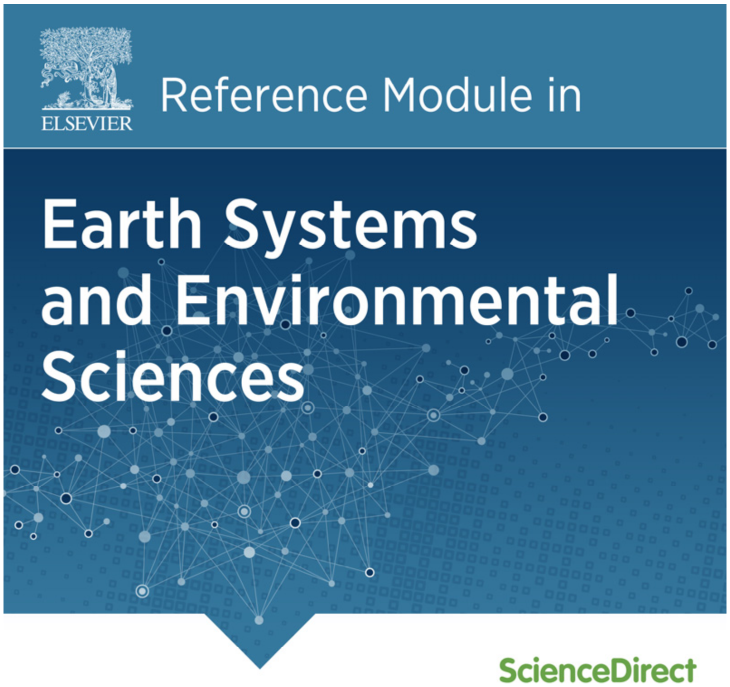

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Large Landscape Conservation: Addressing the Realities of Scale and Complexity

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Area Considerations in Conservation

Perhaps the most fundamental relationship in conservation and ecology is the species–area curve which demonstrates that species diversity, as well as population size, are largely a function of area (Rosenzweig, 1995). Therefore, much of conservation essentially boils down to issues of scale, and using conservation design, management, and captive rearing programs for at risk species to make a fragmented world as large and connected as possible (Curtin, 2015). The fundamental reality is that the integrity of ecosystems and species populations is largely a function of area. Large landscape conservation is essentially an effort to match the scale of conservation with the imperative to work at ever-larger scales to sustain ecological function and the processes that maintain natural and human systems over the long haul (**Figure 1**).

The Landscape Matrix

It is increasingly realized that it is not just the area, but also what lies outside the boundaries of protected areas that is key to the integrity of protect areas (Weins, 2009). In what ecologist Dan Janzen termed the 'eternal, external threat,' protected areas exist within the context of the surrounding landscapes where the protected area borders are usually porous. Thus, the context within which a protected area exists is key to its sustainability (**Figure 2**).

The integrity of what exists within reserves is also crucially important (Brown et al., 2003). This means preserving natural processes such as fire and herbivory that maintains ecological function (Watt, 1947). Especially important during periods of increasing climatic change is maintaining natural processes that are an important buffer to ecological change (**Figure 3**). Landscape-level initiatives that re-establish fire regimes, for example, are needed over hundreds of thousands of hectares with larger planning areas such in the US southwest or Central Rocky Mountains (Curtin, 2015). As disturbances are a part of the function of all natural systems, conservation has increasingly realized that sustaining ecosystem functions involves the participation of local communities and partnership with national resource managers and other stakeholders.

Corridors and Connectivity

While conservation historically focused largely on protecting reserve areas, conservation design has increasingly recognized that reserves alone (even very large ones) are not enough (Laliberte and Ripple, 2004). In the example below of Montana's Swan Valley and adjoining wilderness and park areas one can see that the Grizzly Bear (*Ursus arctos*) are using the private lands between the mountain ranges as much as park areas (**Figure 3**). This is also very much a reflection of the history of land tenure that the richest lands that were better watered, had richer soils, and that containing less harsh environments were settled first and stayed in private hands, whereas public lands tend to be those areas people could not effectively homestead. So there exists a gap in which the richest lands with the highest biodiversity tend to be private, whereas protection is primarily on public lands (Scott et al., 1993).

Because private lands areas are areas of conflict between humans and wildlife, there needs to be increased efforts and reducing these threats on private lands. An example of an effective effort to mitigate human–wildlife conflict is in Montana's Blackfoot Valley where the rancher-led Blackfoot Challenge has devised innovative strategies to reduce bear mortality, while improving wildlife habitat and rural incomes (http://www.blackfootchallenge.org).

A key facet of a large landscape approach is restoring and sustaining connectivity between protected areas (Ament et al., 2014). Migration patterns of the vast ungulate herds in the Serengeti, or mule deer and pronghorn in Wyoming need 'room to roam' or to connect crucial parts of their habitat, as it is increasingly recognized that mobility across vast areas is essential to species survival. For example, in East Africa where the ability to track rains across the landscape to derive an additional energetic benefit from fresh grasses is a key ingredient in maintaining the last herds of wildlife that still inhabit the region (McNaughton, 1985).

Figure 1 Large landscapes provide a range of ecosystem good and services that are key for sustain social, ecological, and economic function of human and natural systems.

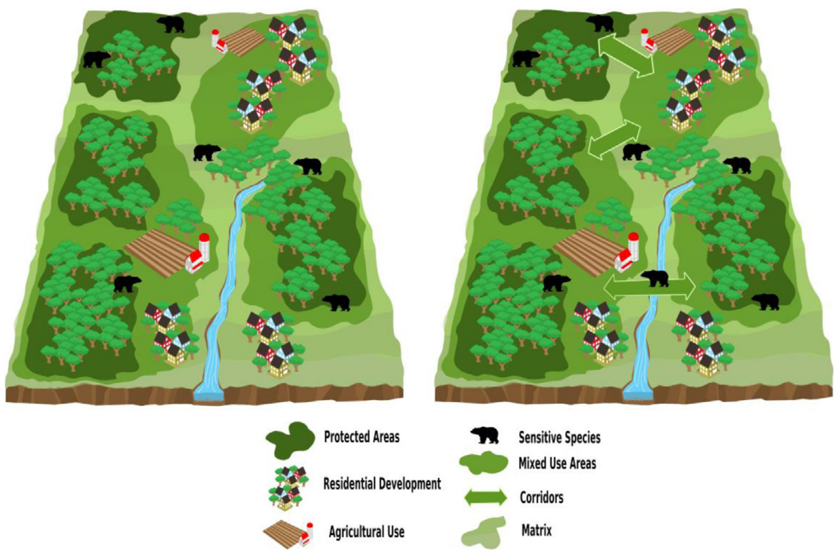

Figure 2 The image at left is typical of most conservation where protected areas are discrete entities. While the whole system conservation approach at right is indicative of large landscape conservation and focuses as much on linkages between protected areas, as the areas themselves. Viewing them as an integrated whole is key to sustainable large scale conservation. After Curtin and Tabor (unpublished).

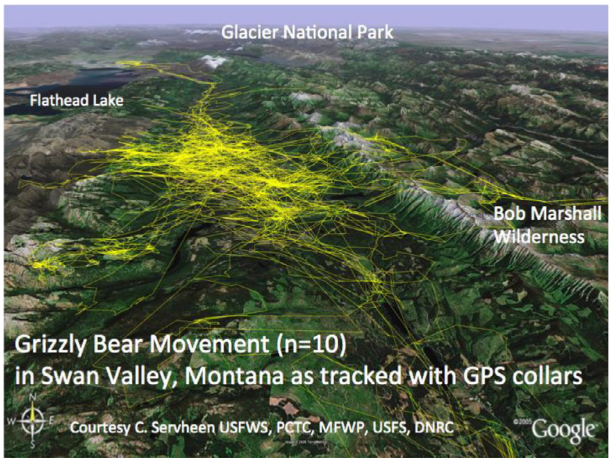

Figure 3 Radio tracing data from Grizzly Bears in Northern Montana illustrates that even in some of the most wild and remote parts of the US wildlife is still spending a disproportionate amount of time in private lands or moving between parks and wilderness areas.

Figure 4 This figure of Grizzly Bear populations in the Intermountain West illustrates the need for continental-scale connectivity among populations to conserve genetic viability in wide-ranging species. After Miller, C. R. and Waits, L. P. (2003). The history of effective population size and genetic diversity in the Yellowstone grizzly (*Ursus arctos*): Implications for conservation. *Proceedings of the National Academy of Sciences of the United States of America* 100, 4334–4339.

Genetic connectivity is also an essential ingredient in preserving species (**Figure 4**). Whether is to cod in the North Atlantic or Grizzly Bear in the central Rockies, connections within meta-populations are essential for maintaining the genetic diversity to sustain species fitness (McCullough, 1996).

An increasingly fragmented world means it is harder for meta-populations (i.e., small populations maintained by periodic genetic exchange) to maintain their historic connections. Thus maintaining meta-populations linkages is an integral part of any long-term and large-scale conservation strategy. Movement corridors are not just essential for animals, but also in allowing plants the ability to move in response to environmental change, particularly climate change (Peters and Darling, 1985).

Beyond Issues of Scale

Approaches to environmental problem solving too frequently represent small-scale, short-term solutions seeking to address large, long-term, and complex problems. Yet challenges such as climate change require ever-larger scales of adaptive problem solving, while the increasing scale and complexity of environmental challenges often thwarts simple, straightforward policy solutions. This means that there is not a simple scalar relationship between the component parts such as human communities and wildlife, but complex and dynamic outcomes that mean these systems are inherently unpredictable (Curtin, 2015).

The realities of an increasingly uncertain world requires devising conservation design that accepts and embraces uncertainty, where it is essential to devise governance designs that can learn from mistakes and that have the adaptive capacity to respond to change (Olsson et al., 2006). Conservation at large scales must almost by definition engage and involve people for in practice well designed institutions are essential pre-conditions for sustaining large landscapes (**Figure 5**; Curtin, 2015).

Local engagement and co-management is key to sustain social and ecological systems. Some of the very longest and largest examples of sustainable resource systems have emergent properties based on local norms or standards of practice including thousands of years of Maasai grazing in East Africa, harvest of Holm oak in Iberia, water distribution systems across the globe, and, most recently, co-management of the lobster fishery in the Gulf of Maine.

The crux of the challenge is in devising effective institution designs that maximize conservation and human benefits. Collaborative examples such as the rancher-led groups the Blackfoot Challenge and the Malpai Borderlands Group have for more than two decades demonstrated the effectiveness of collaborative partnerships in expanding the scale and scope of stewardship and science. However, it is equally possible that weak collaborative governance systems can result is policy that seeks the lowest common denominator and which may not help either people or the environment. The devil is in the details and designing effective process is essential for effective conservation design (Curtin, 2015). Successful examples tend to exhibit several shared themes, many of which have been identified in the literature on governing the commons, including systems of local trust, feedback loops, and accountability that profoundly impact the sustainability of governance systems and the associated science and conservation (**Table 1**).

Tilt et al. (2008) provide one of the clearest discussions of the importance of grounding conservation in trust and transparency. What they illustrate is that conservation and resource management are profoundly impacted by power arrangements, and a key role of effective governance is to counterbalance the intrinsic propensity of systems to degrade through social arrangements and provide

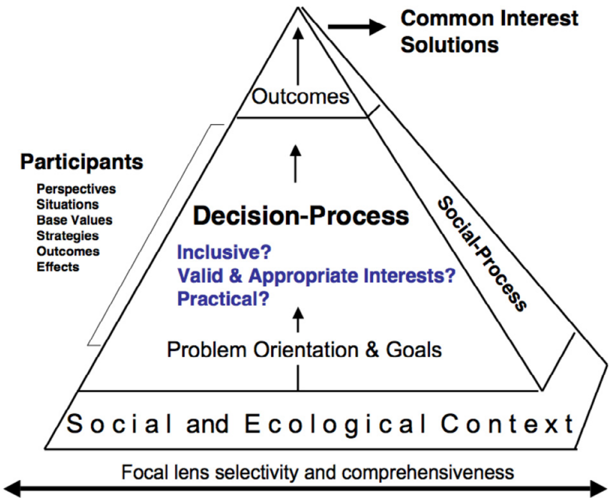

Figure 5 The sweat equity pyramid for conservation at large scales that rests heavily on building social capital, trust, and understanding between a diversity of individuals and institutions. Used by permission of Seth Wilson.

Table 1 Commons design principles

Define users and resource – Group and resource system boundaries and characteristics are well defined and commonly acknowledged
Rules make sense locally – The rules governing the use of collective goods are appropriate to the local context and conditions
Agreements among users define roles – Collective-choice arrangements exist, with the individuals affected by the rules able to participate in their modification
Monitoring and feedback learning essential – Monitoring systems are in place to generate feedback loops to promote learning by both the governing and the governed
Responsive regulation needed – A system of graduated sanctions that is responsive to the seriousness of the infraction. Often locally instituted or self-enforced by the community
Conflict resolution at the ready – Community-members have access to internal and external conflict resolution systems to addresses internal and external conflict between resource uses and other social actors
Affirmation by the powers that be – External authorities recognize the right of resource users to devise and implement their own institutions
Governance design essential – Governance is organized in nested levels that recognize slow and fast ecological and social variables and integrate them into the institutional design

the structure to hold them together despite their propensity to come apart. These pressures, or what we term organizational entropy, increase with the size and scope of projects, which is why large-scale science and conservation become exponentially more complex to undertake, but also why attention to local relationships also become more important with increases in scale (Curtin, 2015).

However, successful governance is rarely strictly locally based, but instead emergent, flowing from a large collection of individual efforts often coordinated at larger scales. The fundamental challenges, and paradox of large landscape approach is in devising institutional arrangements that are locally relevant, while networked across vast areas. Therefore large scale approaches are not just bigger versions of convention park-based approaches, or of the management of isolated reserves or land trusts, but present a complex interaction between social and ecological perspectives and paradigms.

Governance and Policy Design in Large Landscapes

The intrinsic disconnect between the scale of science and policy, and that of the systems they seek to influence are a fundamental source of failure in conservation and management (Curtin, 2015). Park and reserve are the cornerstone of protecting wildlife and other public resources, at the same time top-down 'command-and-control' approaches to governance that have typified much of large-scale conservation and resource management frequently lack the institutional capacity to be responsive to local conditions, build trust and social capital, or the ability for timely response to change. A good illustration of this tension between the need for public protection and the associated challenges is Yellowstone National Park that was the world's first park and is an international model of effective conservation. However, even with all its successes the many conflicts of resource use at Yellowstone over the years from bear management to fire suppression demonstrate many of the challenges of park-based approaches that are not always in

Figure 6 In the collective impact approach (Kania and Kramer, 2011) provide a framework, based on commonly recognized practices to generate alignment between a diversity of organizations and individuals. To link local action into a c hesive network to address large and complex environmental challenges.

step with ecological, or even political realities (Chase, 1987; Craighead, 1982; http://www.nps.gov/fire/wildland-fire/resources/documents/wildland-fire-history_ch7.pdf). Therefore a fundamental paradox exists in which there is a need for science and policy that is coordinated across large spatial and temporal scales, while also being responsive to local needs and flexible enough to address changing conditions.

Network governance provides the conceptual tools and institutional framework to address this paradox. The large-scale connectivity among individuals, organizations, and agencies al.e. governance networks is imperative for addressing large, complex environmental problems. The particular patterns and arrangements of relational ties result in the emergence of social structures that contribute to processes and outcomes in which the whole is greater than the sum-of-its parts. Examples of relevance to the governance of large landscapes and seascapes include the diffusion of innovative practices, knowledge exchange, and collaboration. Moreover, it is through these networks of actors that decisions are made and actions implemented concerning large landscape conservation and natural resource management.

One promising approach emerging from the field of organizational design is called collective impact (**Figure 6**), in which a 'back bone organization' serves in a coordinating function to integrate the efforts of a number of small entities into a larger coordinated program (Kania and Kramer, 2011).

Collective impact leverages local action and provides the networked governance to facilitate collaboration, rather than competition between a diversity of smaller individuals and organizations and represents a crucial step forward in permitting the kinds of networked approaches essential for sustaining social and ecological systems over the long haul.

Closing Remarks

Large landscape conservation reflects a paradigm shift in conservation away from park-based approaches to conservation to ones that consider the connectivity across a range of landscape and land-use types, and the need for adaptive governance frameworks, nested across a range of scales. While these realities are especially true in large systems, they are also relevant in any system where a range of cultural, ecological, and economic factors interact (i.e., most conservation and resource management). This imperative to conserve large or complex systems requires the social pre-conditions be established to develop trust and common ground to maintain conservation and science at scales directly relevant to the systems in question. A coupling of locally based approaches, in a networked framework across vast ecosystems, not only influence conservation, but also profoundly influences the relevance of science and monitoring, and improves the ability to sustain projects at the scales needed to successfully sustain species and ecosystems. These elements require flexible institutional designs that can respond to changing social and ecological conditions in order to expand conservation stewardship over time.

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