Complexity, Community, and the Interaction of Indigenous Knowledge with Landscape-level Research and Conservation.

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Abstract:

Collaborative landscape level research programs in the Mexico/US Borderlands demonstrate the utility of coupling local and science based knowledge systems in the adaptive management of natural resources. Hierarchical models guide monitoring and research with collaboration between communities and scientists expanding the scale and scope of research programs. This rescaling of monitoring, research, and management systems provides insights into the interaction of human and natural systems and the viability of community-based resource management as a conservation strategy. Landscape level studies of climate, fire, and grazing and the interaction of cattle and prairie dogs are the direct result of partnerships between diverse individuals and organizations illustrating the power of non-traditional approaches to science and their implications for land management.

Introduction:

Communities, scientists, and resource managers frequently recognize the need for synthesis between the biological and social systems (1, 2, 3) and the need to expand the scale and scope of ecological studies (4, 5, 6). Increasingly sophisticated research protocols address the role of scale and replication to increase the utility of ecological field experiments but ignore the socio-economic context within which experimental systems are imbedded (Figure 1). This paper illustrates how revising institutional frameworks through public-private partnerships between resource users, scientists, and resource managers can rescale research to make it more effective in addressing basic science and resource management.

Integrated conservation and research programs in the Mexico/US borderlands are demonstrating how non-traditional partnerships between pastoral communities and researchers can benefit the local community and expand the scale and scope of science (7, 8). External pressures on the ranching community including unprecedented climatically-driven vegetation change (9, 10, 11) coupled with external development pressures and changes in resource economies (12) lead the ranching community to seek collaborative approaches to landscape conservation. These approaches included the development of collaborative partnerships between agency land managers, conservationists, and researchers through formation of the Malpai Borderlands Group (7). Non-traditional partnerships between ranchers and researchers result in the organization of complex interactions into a hierarchical context, providing an organizational framework for guiding adaptive management of natural resources (13,14, 15).

Complexity and Conservation: Developing Dynamic Landscape Level Models:

The problem facing the conservation and research community in the borderlands was how to distill a nearly million-acre ecosystem with a vast number of variables into a coherent framework. Discussions between ranchers and researchers resulted in a hierarchical framework for understanding the driving variables and measurable constraints on the ecology of the borderlands. Key variables included climate, fire, geology, grazing, economics, land-tenure systems, and vegetation composition (11, 12, 13). Though all these processes are important in structuring ecosystems only two are readily measured or manipulated and therefore directly relevant to adaptive management: fire and grazing (11). Therefore these two factors become the major emphasis of collaborative monitoring, research, and restoration programs (7, 8).

Based on the preliminary hierarchical analysis a model of ecosystem structure and function was assembled incorporating the minimum number of measurable variables needed to describe the system. Using a Whittaker Diagram (18) a simple model of the Borderlands Ecosystem was assembled illustrating the connection between the two measurable/manipulable variables (grazing and fire) and the one variable of overwhelming importance in structuring the system (rainfall)(Figure 2). The landscape model was validated through a literature review and discussions with the ranching and research communities. This depiction of system processes has implications for prioritizing monitoring, research, and restoration efforts. While monitoring should be distributed between and within ecosystems, more intensive research and restoration efforts should be focused near ecotonal boundaries where systems are most responsive to change (19). Restoration efforts are likely to be more effective near system boundaries then at core areas where the system is less resilient. This organizational structure allows conservationists, land managers, and researchers to select and prioritize their efforts, or determine whether restoration and research efforts are optimally situated on the landscape. In addition to depicting the system in dynamic, but simple terms the state-spaces (habitats) depicted in the model relate to physical places on the ground allowing determination of how close a give spot is to the boundary between systems and the potential consequences of management action or inaction.

Applications and Implications:

Two landscape level experiments examine the interaction of response variables in ecotones between major vegetation communities. At 1,687 m (5,400 ft) the Mckinney Flats Project on the Gray Ranch in Southwestern New Mexico examines the effects of disturbance on a grassland-shrub transition (Figure 2). At 1,812 m (5,800) on the Cascabel Ranch 50km (32mi) northwest of Mckinney Flats at the savanna-woodland transition watershed studies examine the role of fire in woodland restoration (7, 8). Both these studies focus on the interactions of the driving variables outlined in the hierarchical analysis and landscape model. Initial results of the McKinney Flats Project illustrate how the application of landscape level research can be key to both sustaining community-based conservation efforts, and in advancing basic and applied science (Figure 3). For more than a century conservationists, land managers, and scientists have debated the role of livestock grazing (21, 22, 23, 24). While this debate is rooted in fundamentally different perceptions of the land (12), it continues largely because of a lack of consistent monitoring data or well-designed long-term large-scale studies (23, 24). Though prairie dogs have been widely perceived to be fundamentally in conflict with grazing and other pastoral land-uses (25, 26, 27), observations by local ranchers of prairie dog colonies in Mexico and recent literature (28, 29) suggested that the reintroduction of prairie dogs can be used as a restoration tool. The experimental landscape level studies yield results indicating that the reintroduction of cattle can increase biodiversity with the reintroduction of prairie dogs have benefits for cattle ranching at least as tangible as they are for conservation. The results illustrate how the development of effective biological experimental systems at scales relevant to conservation and management often rests with developing effective social systems. Without collaborative partnerships between agency land stewards and the local ranching community development of fencing and water systems, access to a large ungrazed landscape, and access and management of hundreds of cattle and prairie dogs would have been difficult or impossible.

The primary importance of the hierarchical approach to environmental problem solving presented above is that it provides an empirically based conceptual tool for distilling complex landscapes down into their fundamental components. The capturing of the bare essence of a system is invaluable for developing a shared vision of landscape processes to establish common ground between parties with diverse interests and expectations. The process described emerged from the intersection of local and scientific knowledge demonstrating the compatibility of these different knowledge systems as frameworks for understanding environmental change. When research is conducted at scales consistent with management the outcomes are often different from conventional academic or agency-based approaches with collaboration between local communities and scientists leading to a level of science frequently unobtainable through conventional approaches. In the example here the cost of purchasing and managing hundreds of head of cattle and the associated fencing and water systems would be prohibitive under most conventional grant programs, while access to private lands allows a flexibility of management hard to obtain on public lands. Collaborative science empowers the community and aids in their ability to retain local control of natural resources by providing credibility for local land conservation and management efforts, while providing scientists access to vast landscapes containing experimental systems well suited to addressing both basic science and applied questions.

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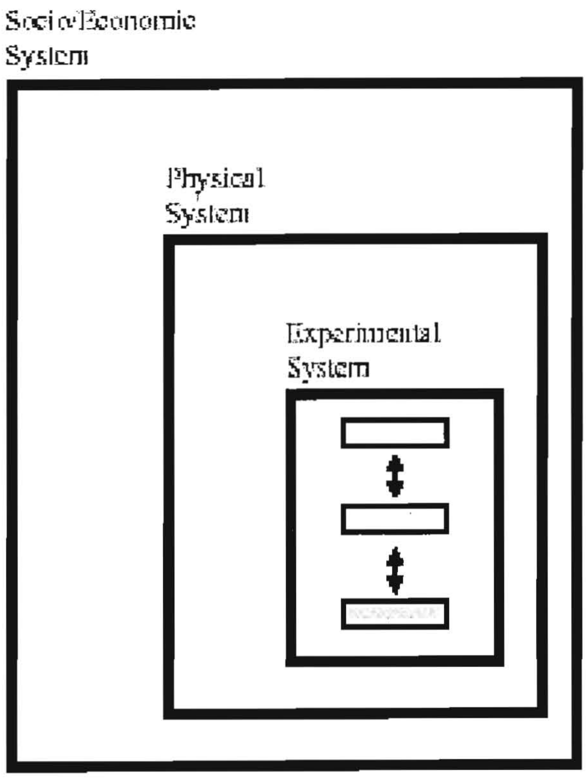
Figure 1. Though the biological literature has focused on issues of scale and physical context over the last several decades (13), the primary constraints on ecological research are often socio-economic rather than physical. This includes not just access to land, but also access to capital. In addition to making the research more applicable to resource management issues, collaborative partnerships allow access to none traditional avenues of funding frequently essential for sustaining long-term large-scale projects.

Figure 2. Through interaction between traditional resource users, land managers, and researchers a simple model of the basic factors structuring landscape composition is developed (A). The conceptual model in turn guides monitoring at the landscape level, and experimental research programs incorporating the driving variables (B). In the schematic diagram of the a 3667 ha (8,880 ac) McKinney Flats Project experimental treatments of (a) Ungrazed/Unburned, (b) Grazed/Unburned, (c) Grazed/Burned, (d) Ungrazed/Burned coupled with a 40% rainfall gradient examine the interaction of the variables depicted in the landscape model. The results of the experimental studies, coupled with over 200 monitoring plots distributed across the landscape, in turn feedback to the adaptive management of the landscape. The process illustrates how traditional knowledge systems and science can be integrated to sustain both ecological and social systems. Though variations on this approach are widely used in the developing world (14, 15, 16, 17), the results presented here illustrate how such locally based collaborations have much to contribute to conservation and science in industrialized countries.

Figure 3. Reintroduction of cattle and prairie dogs to an ungrazed landscape illustrate how two components of the landscape model interact to structure vegetation at the grassland/shrubland boundary. Comparisons of grazed (G) and ungrazed (UG) treatments illustrate how reintroduction of cattle can contribute to or sustain biodiversity. Areas with prairie dogs and grazing (G/PD) and without prairie dogs (G) did not exhibited minimal differences at the scale of meters, while at the landscape level at the scale of hectares reintroduction of prairie dogs lead to the colonization of a number of rare species including burrowing owls (Anthene cunicularia) and Ferruginous hawks (Buteo regalis). The results not only provide information important for basic science and resource management, but also establish the credibility essential for sustaining all facets of community-based conservation programs in the borderlands.

Figure 1.



Socio/Economic
System
Physical
System
Experimental
System

Figure 2.

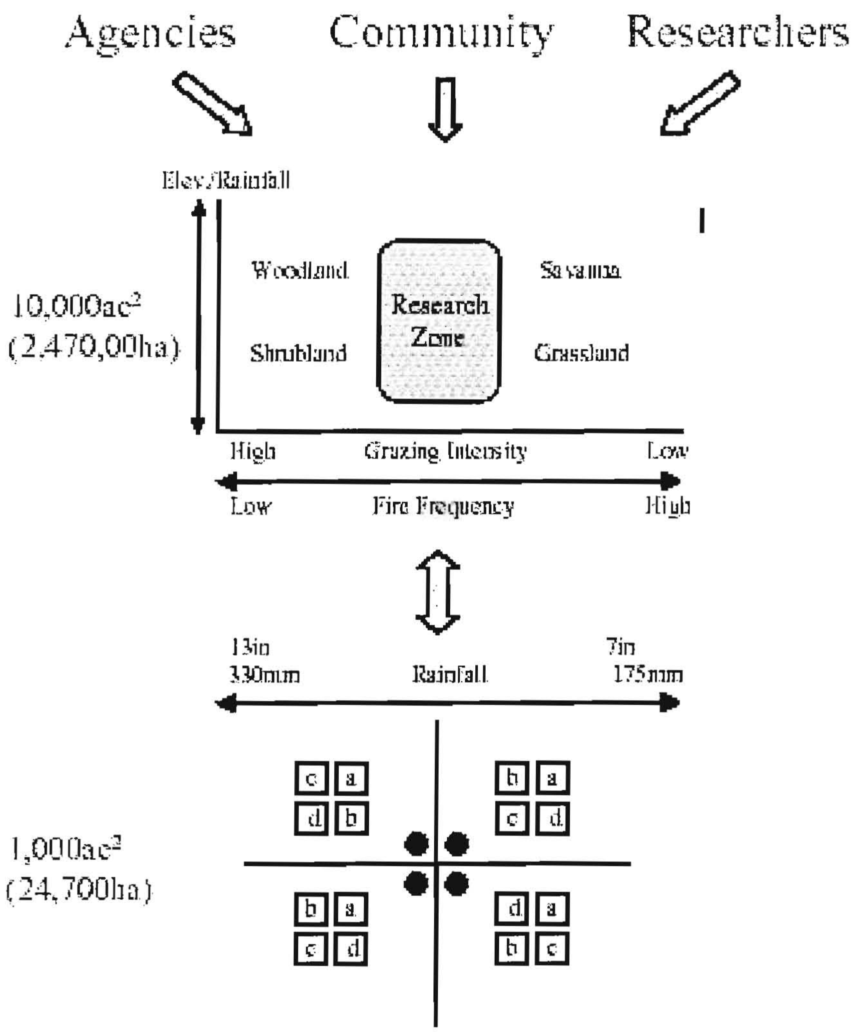

Agencies
Community
Researchers
Elev./Rainfall
10,000ac²
(2,470,00ha)
Woodland
Shrubland
Research Zone
Savanna
Grassland
High
Grazing Intensity
Low
Low
Fire Frequency
High
13in
330mm
Rainfall
7in
175mm
c a d b
b a c d
b a c d
d a b c
1,000ac²
(24,700ha)

Figure 3.

Reintroduction of Cattle

	G	UG	P-Value
Plant Biomass	-	+	0.04
Plant Diversity	+	-	0.03
Mam. Biomass	+	-	0.01
Mam. Diversity	+	-	0.02
Lizard Biomass	-	+	NS.
Lizard Diversity	+	-	NS.

Reintroduction of Prairie Dog

	G/PD	G	P Value
Plant Biomass	+	-	0.0001
Plant Diversity	-	+	0.001
Mam. Biomass	-	+	NS.
Mam. Diversity	-	+	0.01
Lizard Biomass	+	-	0.0002
Lizard Diversity	+	-	0.03

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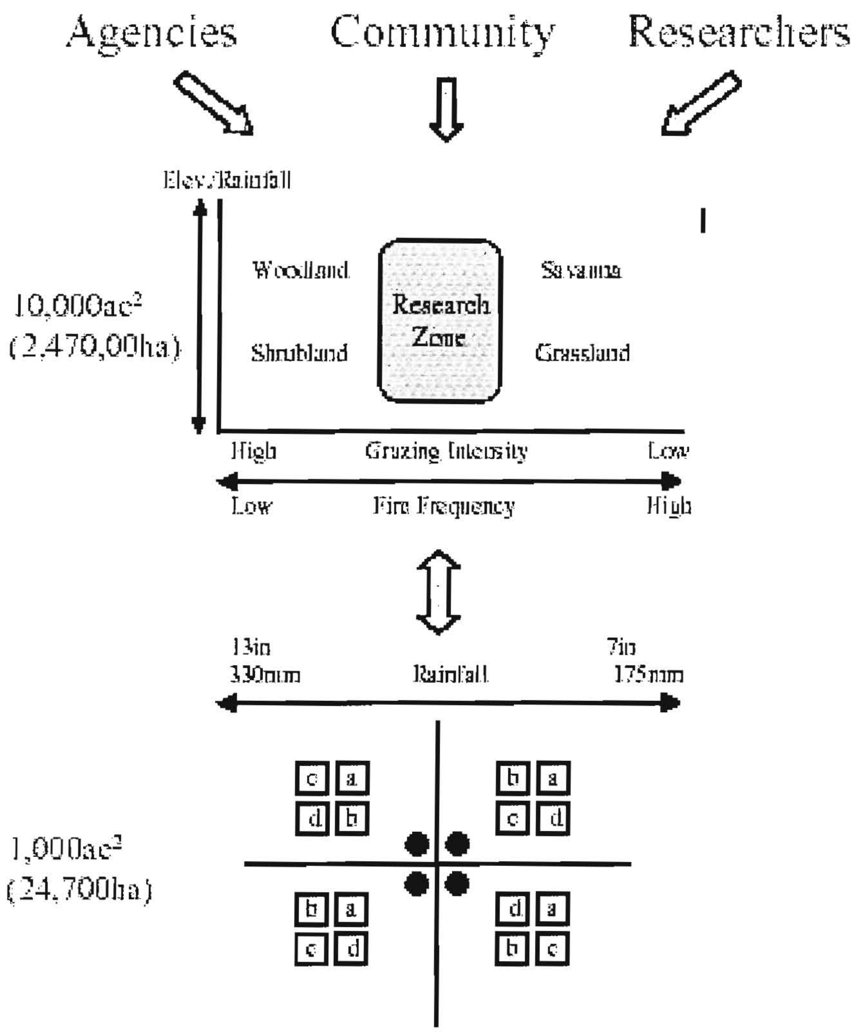
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