

COMMONS FORUM *Commentary*

A Research Plan for the Study of Rapid Change, Resilience and Vulnerability in Social-Ecological Systems of the Arctic

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How can research best address the challenges of Arctic sustainability in a world of rapid change? What determines the limitations of adaptation when a system is approaching a critical threshold? What are the social-ecological consequences when critical thresholds are crossed and new conditions emerge? How best do we frame the analysis of vulnerabilities? How can we best structure human institutions and social organization to build resilience and facilitate adaptation in conditions of rapid change? And how should Arctic residents engage in this research?

These questions reflect a broad set of issues that motivated our group to gather in Vancouver, Canada this past April, 2005, and begin developing an international research plan to explore issues of rapid change and sustainability through an analysis of resilience and vulnerability of Arctic social-ecological systems. We are one of several working groups preparing for the upcoming Second International Conference on Arctic Research Planning (ICARP-2), scheduled to take place in Copenhagen in November 2005. Our draft research plan, modified for this issue of *The Digest*, is intended to stimulate discussion among the northern researcher community and arctic residents about the key themes worthy of study.

Our definition of the Arctic is aimed at capturing the social, economic, political, and ecological processes that are critical properties for the functioning of the Arctic System. Thus, we do not limit the definition of Arctic to more restrictive definitions, such as that region north of the Arctic Circle or north of tree line, but view it as a region integrated within the Global System.

A Rapidly Changing Arctic

Our concern for rapid change in the Arctic is hardly novel. Indeed, change has been a central theme in Arctic research for decades. Much of the research in the North during the post WWII era focused on social and environmental change, and was related to the impacts on northern society. In retrospect we note how centralized institutions controlled by governments to the South and with policies of colonialism, promoted an open access view of the Northern Commons, putting Arctic resources and people at risk. In many respects, these colonialist views contributed to the dramatic transformation of northern indigenous cultures and modified the Arctic environment during the last five decades. Ironically, early social anthropology of the Arctic of this era (and before) highlighted the highly adaptable characteristics of traditional indigenous Arctic cultures, through their geographic mobility, opportunistic forms of subsistence hunting and gathering, and flexible forms of social organization. Today the characterization of Arctic Indigenous Peoples as exceptionally resilient persists, yet the forces for change and overall conditions in the North of today suggest the need to move beyond the focus on people as adaptive, and focus on the co-evolution of social systems and ecosystems to understand the implications of rapid change.

Today in most regions of the North, permanent human settlements have replaced hunter-gather nomadism, rigid political boundaries delineate jurisdictions where soft borders were once the tradition, local mix cash subsistence economies are well integrated and highly dependant upon central government transfer payments, and processes of economic globalization extend to the most remote settlements. These conditions are also coupled with a suite of relatively new regional- to international-level institutions that in some cases convey coastal regions both on the sea and the land, and create new risks (e.g., oil spills) and a potential need for Arctic marine protected areas. Such areas would likely lead to internationally contested claims for property and struggles to assert local harvesting rights. And while the impacts of a rapidly warming Arctic are important to the North, they also have implications to the Global System, by modifying ocean salinity and currents and reducing current rates of uptake in global greenhouse gases, significant local control in governance, a voice in international affairs, and a strong and growing sense of indigenous identity. What is novel in the current situation is a suite of unprecedented and mostly external drivers of change currently observed throughout the Arctic. These include climate change, extensive changes in human land use, as well as political, cultural, and economic change. In spite of these changes, most Arctic rural residents retain a close relationship with land and resources and remain highly dependant on them for food resources.

Three recent international summary reports highlight the extent of change in the Arctic, each developed as projects of the Arctic Council, an international body that coordinates Arctic initiatives and makes policy recommendations on key northern issues. Of these reports, The Arctic Climate Impact Assessment (ACIA) was based on the contributions of 178 scientists, and focused on the accentuated effects of climate change and increased ultraviolet radiation in the more northern latitudes (see <http://www.acia.uaf.edu/>). Climate trends in the North show a dramatic increase in mean annual temperature from 3 to 4 degrees centigrade in some regions, which is nearly twice that of other regions of the world. Gross-level landscape responses include the melting of permafrost and glaciers and changes in hydrological processes that are affecting ground cover vegetation, humans' exploration for hydrocarbons, and some regional economies. In several cases, climate change has shifted the distribution of some keystone species (e.g., moose and some fish), making hunter access to traditionally used resources more risky and Climate change has also been shown to extend the life cycle and geographic range of certain parasites affecting wildlife, and more importantly, has caused some species, such as polar bear and Peary caribou to be at serous risk.

A warmer and dryer North is also associated with an overall increase in the number of wildfires with implications to ecosystem services to those dependent on the northern forest, and increased storm surges in coastal areas. The current rate of coastal erosion has already forced some Alaskan residents to begin assessing options for costly village relocation. The most dramatic issues raised in ACIA come from model projections of an ice free Arctic for the coming decades. An ice-free Arctic would open new northern shipping trade routes (e.g., The Northwest Passage), bring significant economic activity to A second report The Arctic Human Development Report (AHDR) complemented ACIA by examining conditions of human well being throughout the Circumpolar North and providing a review of the region's diverse and complex geopolitical and social economic dimensions (see <http://www.svs.is/AHDR/index.htm>). Overall, the Arctic remains a region of sparse population (~4 million people total), with relatively strong indigenous cultures, pristine ecosystems, and a narrowly based economy. As noted in AHDR , the continued interest in exploitation of northern resources is bringing an increase in human infrastructure, an expansion of the human footprint; and in many cases, this comes with inadequate environmental policies for assessing impacts and land- and sea-use planning. Human in and out migration trends show a modest overall increase in population of the North and a greater urbanization, with an increase in outflow of residents and shift in several regions from the tundra dwelling to cities. If the current trend of urbanization continues, it is likely to lead to an increased demand for harvested fish and wildlife resources and thus, future challenges to rural and indigenous subsistence

harvesting rights. The trends also show an ongoing loss of indigenous language and an overall transformation of former traditional ways of living.

In Russia where about 15,000 people continue to live a nomadic way of life, the problems of rapid change are striking. The collapse of the Soviet Union highly centralized political system reduced and in some cases eliminated support for residents in northern hinterland regions, leaving many residents in dire conditions with limited opportunities for improvement. In many parts of Arctic Russia and other regions, northern people struggle with poor living conditions, limited political rights for self determination, and problems associated with general social dysfunction, such as alcoholism and suicide. However, the Arctic also provides a multitude of examples of institutional innovation through devolution and community-state power sharing, such as the many longstanding co-management regimes for Marine Mammals in Alaska, the newly implemented system of governance for difficult, while making other species more available. Nunavut in Canada, and the implementation of Home Rule in Greenland. In spite of these innovations, AHDR recommends the need to study more carefully the effectiveness of these institutions in the face of rapid change. Perhaps one of the most striking statements of AHDR is its attention on global-to local level processes, and its concern that global environmental and social changes may overwhelm efforts to implement regional initiatives successfully.

A third report, Reindeer Herding and Hunting Economies, and the Status and Management of Wild Reindeer/Caribou Populations, presents a summary on social-ecological change and its feedback effects as related to a particular resource (see <http://www.sami.uit.no/srh/>). The report shows that the collapse of the Soviet Union eliminated many of the government maintained markets for reindeer meat, which reduced traditional herding activities, and later led to an increase in wild reindeer populations. These conditions contrast with Alaska where an increase in the Western Arctic Caribou herd led to an expansion of the herd's range, which overwhelmed domestic reindeer on the Seward Peninsula and dramatically affected the viability of commercial herding. What is noteworthy about both of these cases is how social and ecological feedbacks contributed to the crossing of critical thresholds, which in turn, dramatically transformed the system and led to a new set of problems.

What emerges from all three of these reports is an image of the Arctic as highly dynamic and closely coupled to the external (non-Arctic) environment. Moreover, we suggest that the current rate and direction of change raise questions about how various forces for change will interact and affect the capacity for human adaptation. These conditions also point up questions regarding which variables ultimately govern the fundamental properties of the Arctic System and what is the potential of humans and or climate change to modify those processes in an environment of low biological diversity, limited human and material resources, and limited political and economic autonomy.

Social-Ecological Systems as Units of Analysis

Addressing these questions clearly requires that ecological, economic, and social dimensions be considered in an integrated fashion. The IASCP has for years been on the forefront in developing interdisciplinary approaches in the study of common property systems and sustainability, yet the challenges of doing research in conditions of rapid change in the Arctic (and in other regions) make for special analytical problems and a rethinking of several commonly held assumptions, such as conditions of equilibrium, linearity of change, immediate systemic response.

In our effort to achieve sufficient holism in the analysis of rapid arctic change, we considered how the idea of coupled "social-ecological systems" may serve as our primary unit of analysis, and an interdisciplinary program of northern research can be initiated that builds on recent theoretical development in resilience theory. Here, the focus on social-ecological systems is an effort to make

explicit the linkages between human societies and ecosystems. Using these ideas, we argue the need to identify the feedbacks among social and ecological aspects of the system, understand the complex properties that govern these processes, anticipate possible surprises, and appreciate better the implications of rapid change and its novel conditions to human well-being.

We also embark on this enterprise with the assumption that sustainability is a dynamic normative construct that is inextricably tied to human purposefulness and human-defined targets. Recent research in North American Arctic communities identified five sustainability goals including: 1) Use of, and respect for, the land and animals in their homelands; 2) A cash economy that is compatible with, and supports, continued local use of the land, sea, and animals; 3) Local control and responsibility for what is done in village homelands and what happens to resources used by the community; 4) Education of younger people in both traditional knowledge and western science, and education of the outside world about community goals and ways of living; 5) A thriving culture that has a clear identity, is based on time on the land and respect of elders. Similarly, interviews conducted by the Russian Association of Indigenous Peoples of the North (RAIPON) of 400 indigenous residents throughout the Russian North, Siberia, and Far East identified five dimensions of sustainability, including spiritual, social, economic, environmental, and legal elements. While the underlying values and targets of sustainability may differ among individuals and culture groups, and may change through time, Arctic residents are highly dependent upon ecosystem services, which in turn are critical to human development. For this reason, it is important to clarify human values and to ascertain the interrelated links between sustainable ecosystems services, human development, and social institutions that foster resilience. While focusing on social-ecological systems and their relationships to resilience may provide insights for successful adaptation, we must also break new theoretical and methodological ground to understand better the processes of social learning, the limits to mitigation, and the time scales and rates of change that are critical.

Key Concepts in the Study of Resilience and Vulnerability of Arctic Social-Ecological Systems

The focus of our working group on resilience, vulnerability, and adaptation follows from recent contributions by interdisciplinary scholars who approach questions of sustainability with the assumption that systems have inherently complex and on-going dynamic processes (see The Resilience Alliance, http://www.resalliance.org/ev_en.php). Resilience is defined here as the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity and feedbacks. A resilient social-ecological system can withstand shocks and rebuild itself, and may undergo those changes incrementally and or through dramatic modifications. Thus, the concept of resilience provides a way of studying how systems persist, transform themselves, or collapse. While several studies have applied resilience theory to northern case studies, a systematic and comprehensive application in Arctic research has not been undertaken.

The boundaries of coupled social-ecological systems are defined by the specific problems and subsystems being addressed in research. For example, the analysis on the effects of rapid change on subsistence in local communities would include global climate trends and their effects on ecosystems, those ecosystems from which subsistence resources flow, hunting and herding patterns and access to resources, the community's wage economy and its contribution to the support of hunting along with its impacts of ecosystems, a group's sense of identity as hunters and herders, their local knowledge of resources, institutions that support the tradition of sharing, the protection of species, and the communities' interactions with state agencies charged with jurisdiction over shared resources. Social-ecological systems represent an interaction of processes occurring at multiple scales and within and across scales to manifest a unique complex of emergent conditions. In this respect, this approach to resilience is distinct from that of engineering applications, which assume a rebounding to previous conditions. Whiteman et al 2004

provides illustrations of some of the key factors to be considered in any social-ecological system. Future theoretical development will require that the system in consideration make the links between the Arctic and other global components more explicit. A focus on resilience also suggests that a social-ecological system has a set of properties that determine a *domain of attraction* in which the system remains constant in its functionality. Thus, a social-ecological system may have multiple states with critical thresholds that can modify governing properties, be transformed, and result in the emergence of a new state.

The concepts of *adaptability* and *transformability* are helpful in this discussion as well, with adaptability being the capacity of actors to influence resilience and transformability being the capacity to create a fundamentally new system (Walker et al 2004). Another key idea of resilience theory is the *adaptive cycle*, which describes sequential patterns of growth or exploitation (r), conservation (K), collapse or release (omega), reorganization (alpha). Critical in the assessment of social-ecological systems and their transformation is the identification of “control variables,” which are typically slow to change and which regulate key systemic properties (e.g., building of trust relations among social groups, nitrogen levels in soil, permafrost, rate of lichen growth). How well do the ideas of resilience as presented above work when considering the sustainability of the Northern Commons? The adaptive cycle model is probably best applied with closed systems, and may need to be further modified to address the Arctic as a recipient of more global forces for change. For example, the Arctic ecosystem is a global sink in the long-range transport of contaminants, its population is highly transient in and out of the Arctic, and many Arctic residents depend on migratory species. In this way, the current ideas of resilience may need to accommodate better the “Waves of Arctic exploitation” model, presented by Sugden and others.

We suggest that the concept of vulnerability is complementary to resilience considerations, by forcing clarity in a system’s sensitivity to various types of change and their consequence while concurrently accounting for the system’s capacity to buffer against change. Vulnerability is therefore a function of the exposure to effects of change on a social-ecological system plus the capacity of that system to deal with that exposure. In this respect vulnerability is measured not only by exposure to hazards alone, but also resides in the resilience of the system experiencing the hazard. The literatures of resilience and vulnerability have for the most part been segregated. Several researchers have developed frameworks for the analysis of Arctic vulnerability, with Chapter 11 of ACIA being one example. A focus on vulnerability, especially when approached using scenario analysis, provides an excellent basis for assessing the likelihood and implications of change and possible surprise. But the considerations of vulnerability here raise the question of whether resilience and vulnerability can be considered an inverse relationship, whereby an increase in resilience results in a decrease in vulnerability. We believe that an integration of these two streams of analysis represents an area ripe for intellectual development.

Linking Resilience and Vulnerability with Policy

Since many of the key control variables that determine the properties of high-latitude ecosystems are undergoing rapid directional change, it is virtually certain that the current properties of these systems will continue to change and that efforts to keep the Arctic in its current state are doomed to failure. Given the directional change already underway, policies aimed only at preserving the system, such as reducing greenhouse emissions, are by themselves less likely to be successful if they are not related to enhancing resilience and adaptive capacity. To address this issue, we suggest the examination of human strategies and their effectiveness in dealing with the potential effects of rapid change. Here is where members of the IASCP can best contribute.

Formal and informal institutions for governance have been framed in functionalist terms to explore if and how “rules of the game” serve social collectives to economize transaction costs, monitor environments (including humans), resolve conflicts, network parties, and allow for local self organization while

coordinating decision making at greater scales (e.g., local-decision making bodies to regional and national level processes of governance). In the past, many studies of institutions of the Arctic have included a strong emphasis on periphery-core power relations, the effectiveness of power-sharing or co management arrangements, and the socio-cultural and psycho-social benefits of self determination. The current conditions of rapid change suggest the need to explore more carefully adaptive systems of Arctic governance that promote social learning and build resilience by providing adequate responsiveness between local groups who are close to resources and regional, national, and international level entities.

One of the overarching hypotheses explored in the discussions of Working Group 10 is that vulnerability can be reduced by maintaining a focus on local communities, with attention to complex systems phenomena such as levels and linkages. An additional hypothesis is that communities with the capacity to slow key elements of change are more likely to cope and maintain the ecosystems on which they depend. Much evidence indicates that institutions that are close to the resources, flexible, diverse, and receptive to feedback from the environment stand a better chance of success in responding to change than top-down, centralized management systems. A community-based focus helps build grounded theory and practice, and at the same time, helps develop a more sophisticated understanding of how cross-scale linkages and external drivers shape interactions. “Adaptive co-management,” in which social learning is explored in the context of well-integrated decision-making is clearly worthy of more study in the North.

It should be pointed out that although the strengths of a resilience approach is in addressing issues of scale, nonlinear effects, surprise, and complexity, it generally does not adequately address issues of equity. Like the study of sustainability, any study of social-ecological change must include explicit mention of the questions, “Resilient for whom and to what?” Yet as suggested above, a balance in the distribution of power in decision making potentially enhances the resilience. The diversity of arrangements of common property arrangements in the Arctic and the prominent role of Indigenous Peoples of the North will provide a strong basis for this research. But this work can not be passive in its approach. To make meaningful links between research and policy will require inclusive methods of involving stakeholders and decision makers in all phases of the research process. Given idealized notions of adaptive management in which policy decisions serve as experiments, such partnerships are critical to the success of the program.

Key Questions and Research Themes

To help focus our research, Working Group 10 identified a general set of research questions. They include:

- 1) How do we best characterize patterns of rapid social-ecological change in the Arctic?
- 2) What are the attributes of social-ecological sub-systems and their linkages to the Arctic System that are vulnerable or resilient to rapid change?
- 3) What are the critical thresholds of change, domains of attraction, recurring patterns?
- 4) What are the factors that account for variance in systems and subsystems?
- 5) How, if at all, should the study of resilience and vulnerability inform public policy?

1) Characterizing the patterns of rapid change: Descriptions of rapid change in the Arctic are often presented with little specificity regarding the temporal and spatial pan arctic scales. Rapid change measured at a regional scale may be revealed as a mosaic of heterogeneity with high variability. Rapid annual change may be determined to be insignificant when portrayed at a decadal or multi-decadal scale. As well, change is experienced and perceived by different people in different ways. Indigenous perspectives on rapid social-ecological change in the Arctic are often based on long-term relationships with land and animistic views of nature. Such perspectives are likely to be in tension with those deriving from short-term and quantitatively based data and western science.

Therefore, we encourage systematic studies of the characterization of forces for rapid change in the Arctic that include quantitatively based analyses of trends coupled with cultural perspectives and psycho-social considerations. Excellent work has been initiated in this area but more is needed. Climate studies show how trajectories of rapid warming are accompanied by increased variability and extreme weather events. Other studies suggest the possibility of abrupt changes due to climate. How do we compare rates of change of urbanization, climate, and land use? How do they interact and how do rates of their change affect those interactions? At what point do we move from modest to rapid rates of change? How should we portray multiple and interacting forces for change in research, and thus begin the analysis of cumulative effects? To what extent is rapid change in the Arctic internally and or externally driven? To what extent is rapid change the result of individual choice or collective action?

2) Identifying attributes of resilience and vulnerability: What are the vulnerabilities of Arctic communities to the onset of a cash economy, large-scale resource development, external boycotts of marine mammal products, shifts in national policies relating to transfer payments, and other forces for change? What are local communities' sources of resilience? Working Group 10 suggests that social-ecological systems are typically endowed with assets that contribute to their resilience while also being vulnerable, depending on their context and forces for change. For example, a social-ecological system may have high landscape diversity fostering ecological adjustment, while having low species diversity that can lead to large shifts in biological communities. Its residents may have jack-of-all-trades skills that allow for adjustment to a range of employment opportunities, while being relatively unskilled and thus unable to capture high end salaries.

How are the attributes of resilience modified in conditions of rapid versus more gradual change? Rapid change generates a unique type of stress because of the constraints it places on a system(s) response time, learning, and adaptation. It is suggested by some that resource management systems that operate at maximum levels of production, such as those currently employed in some "rationalized" fisheries programs, leave less room for adjustment, while precautionary approaches allow more error. The relationship between resilience and vulnerability attributes considered across social, ecological, economic, legal, and even spiritual dimensions is worthy of exploration. Given these complexities, we propose a line of research that identifies the attributes of various social-ecological subsystems, elaborating on the conditions in which they are resilient and or vulnerable. This work needs to be explicit about how to quantify and recognize resilience and vulnerability. For example, research could analyze patterns of change to determine which response variables changed to a greater extent (vulnerable) or lesser extent (resilient) than the rates of changes in drivers. Empirical research is also needed to test the hypothesis that slow variables of the Arctic are the most critical in the assessment of resilience. Similar analyses could be done with response to multiple stressors, to look for potential interactions.

We further propose that extensive work be undertaken to identify key indicators of resilience and vulnerability. This work can be undertaken in the development of on-going observation systems, currently proposed for the Arctic and should be initiated at various scales of analysis. It will also require extensive comparative analysis to tease out the extent to which indicators are context specific and are transferable across several social-ecological systems.

3) Understanding thresholds, domains, and patterns: This area is perhaps the most challenging because it requires the identification of key drivers and development of simulation models that identify tipping points at which systems are transformed into a new domain of attraction. To date, much of the resilience theory has been metaphorical in its approach (e.g., the adaptive cycle). To make such theories operational, we propose an extensive retrospective analysis of cases (e.g., resilience of small fishing communities of the north, vulnerabilities of subsistence-based communities that face rapid industrial development in their village homelands) that is coupled with simulation modeling. This line of inquiry would include an assessment of irreversibility-- those conditions in which points-of-no-return emerge and pass (e.g., the

loss of keystone species, loss of indigenous language). The study of critical thresholds should also include an analysis of unanticipated incidents and their outcomes (i.e. “the study of surprise”).

4) Accounting for variance in social-ecological systems: Why do some local communities develop strategies that lead them to successfully negotiate problems and/or learn from experience while others repeatedly fail? Why have some regions prospered economically and maintained their natural capital while others flounder and repeatedly fail to engage in commercial activities? What are the strategies for mitigating the negative impacts of rapid change? To what extent are differences related to the drivers of change, the rates of change, or the properties of the systems undergoing change? The great diversity of conditions found across the Arctic would serve this research program as a set of natural experiments and thus, facilitate comparative studies that lead to more generalized principles.

5) Informing Policy: Working Group 10 identified the need for research to break with past traditions that separate science and decision making, and to work more directly with policy makers and local stakeholders in the formulation, implementation, and evaluation of public policy. The members of Working Group 10 suggest this objective with great humility and considerable caution, recognizing the history of problems of past efforts by science to shape public policy. That being said, this approach differs from past efforts by promoting local stakeholder involvement in all phases of research and viewing studies as part of an adaptive co-management process. Thus, we believe that research can contribute to the policy process without prescribing specific policy choices (helping to create a program in which policy outcomes are examined later as experiments). Moreover, given current rapid rates of change, it is prudent to incorporate improvements in understanding into policy as expeditiously as possible.

Conclusion

The study of rapid change in the Arctic is critical given the extent to which various stressors may transform the Arctic System and how changes in the Arctic may in turn affect the Global System. In spite of these issues, resilience as a frame for understanding the sustainability of social-ecological systems seems to offer several analytical advantages.

First, resilience helps provide an integrated approach consistent with trends in the vulnerability and hazards literature to evaluate holistically the impacts of all the shocks and stresses that act on the system. Resilience as an organizing concept provides an approach to carry out a comprehensive analysis by avoiding the artificial divide between biophysical vs. social systems. Second, resilience puts the emphasis on the ability of a system to deal with change. It allows for the multiple ways in which a response may occur, including the ability of the system to absorb the disturbance, or to learn from it and to adapt to it, or to reorganize following the impact. Resilience thinking is in many ways consistent with a worldview of constant change and evolution, and is also consistent with indigenous conceptualizations of the universe. By emphasizing uncertainty and constant change, and by looking at change as an opportunity, resilience thinking challenges widely held notions about stability and incentives that originate outside the Arctic, at higher levels of political and economic organization. Third, because resilience deals with the dynamics of response to change, resilience is forward-looking and helps explore policy options for dealing with uncertainty and change. As Tompkins and Adger (2004) note, building resilience into human-environment systems is an effective way to cope with change characterized by future surprises or unknowable risks. Resilience provides a way of thinking about policies for future environmental change, an important consideration in a world characterized by unprecedented hazards and transformations.

A focus on resilience may also contribute to the long debates on whether or not Northern ecosystems are “fragile” and/or robust in their response to human activity (e.g., oil and gas development.) To date, many of these debates have been primarily rhetorical. A social-ecological systems approach with a focus on resilience applied to the study of rapid change promises better analytical precision and depth.

The ideas expressed in this research plan will be presented at the Second International Arctic Science Conference (ICARP-2) this November. Those interested in commenting on the plan are invited to visit the ICARP-2 web site (<http://www.icarp.dk>) or contact the chair of this working group, Gary Kofinas. E-mail: ffgpk@uaf.edu

Further reading:

Walker, B., C.S. Holling, S.R. Carpenter, and A. Kinzig. 2004. "Resilience, adaptability, and transformability in social-ecological systems." *Ecology and Society* 9(2):5. URL: <http://www.ecologyandsociety.org/vol9/iss2/art5/>

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