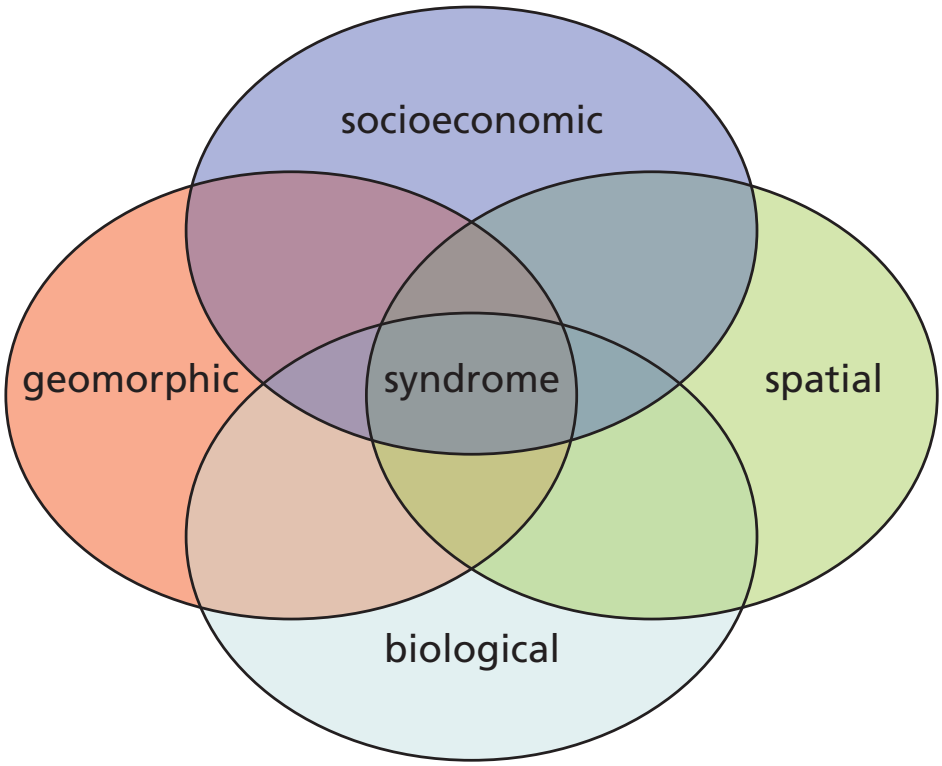
Science Features

Defining resource stressor syndromes in southwestern national parks

By Kristina Monroe Bishop, Lisa J. Graumlich, and William L. Halvorson

RESEARCHERS HAVE INCREASingly focused on the interactions and connections between ecosystems and humans. Through the greater use of resources, increases in pollution, and changes in land use, humans have changed the ecosystems around them. Human activities such as urbanization and intensification of agriculture lead to an increase in road and housing density, oil and gas usage, and necessary infrastructure such as utility transmission corridors. While it is clear that such shifts in land and resource use impact our environment, current research shows that linking the changing population to specific ecosystem change is not simple (Meyer 1996; Harte 2007). Measuring these impacts in protected areas provides an additional layer of complexity, as the source of the ecosystem stress is often found off-site. Although those who manage protected areas, such as the National Park Service (NPS), understand there is a link between encroaching human populations and a change in ecosystem health of the protected area, untangling specific causes of change has proven difficult. With this in mind we aimed to develop a conceptual framework for using available social, economic, and environmental indicators to give land managers new tools for understanding the potential ecological ramifications (effects) to park resources of adjacent socioeconomic stressors (causes). What emerged from this process was the "syndromes" approach. This is a new method for categorizing impacts to park ecosystems that moves away from trying to find one-to-one relationships between socioeconomic factors and ecosystem changes in protected areas. Establishing such relationships is extremely difficult and we therefore suggest this holistic approach to gaining insight into how socioeconomic factors effect park ecosystem changes. When one or more syndromes are found to be influencing a protected area, the protected area would benefit by monitoring the factors involved, such as encroaching development, mining, ranching, and public use.



The Syndromes concept

Syndromes approach

The National Park Service is charged with protecting national park lands and resources by such means as will leave them unimpaired for future generations. To achieve this goal, park managers need to understand not only the condition of their parks, but also the kinds of factors that may be contributing to that condition. Rather than being unique to each park, these stressors often share a common set of elements or characteristics that allow them to be broadly categorized. The syndromes approach to classifying those stressors involves examining a collection of biological, socioeconomic, geomorphic, and spatial elements that work together to create a larger ecological condition (see diagram, above). Because it is necessary to consider how ecological and social systems are working together in order to fully understand an ecological situation, taking this sort of holistic approach will help park managers make well-informed decisions. Schellnhuber et al. (1997) introduced the concept of using syndromes to examine the interconnection of ecological and social factors. Others have followed

up with this concept at global and local scales (Ludeke et al. 2004; Manuel-Navarrete et al. 2007).

In the national parks, biological stressors include changes in the range of certain species through habitat reduction or exotic species invasion. Socioeconomic stressors related to the national parks include nearby population growth, urban buildup, infrastructure, primary production (agriculture and mining), and land use change, as well as visitor use and other anthropogenic influences that can change the ecological system. Geomorphic stressors include changes in the land itself, such as local-scale erosion and alterations to fire and flood regimes, as well as shifts due to larger-scale factors, such as climate change. The spatial element of the syndromes approach identifies where stress is occurring (within the park, near the park, or far off-site), which is useful for understanding how managers might deal with the stressors and their effects.

The syndromes identified by the research team (table 1) came out of coding the Sonoran Desert Network (SODN) Vital Signs Monitoring Plan Stressor Survey Results (NPS 2005). When the researchers coded the stressed resources and their stressors, trends were uncovered, leading to the identification of eight syndromes. To fit a syndrome a park need not have all the symptoms, and it is possible for a park to exhibit more than one syndrome. The eight syndromes we identified are (1) Encroaching Urbanism, (2) Distant Degradation, (3) Intensive Extraction, (4) Extensive Consumption, (5) Excursionist Strain, (6) Desperado, (7) Shifting Terrain, and (8) Remote Bliss (see corresponding figures).

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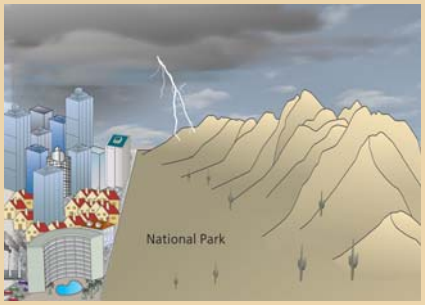

Figure 1: Encroaching Urbanism

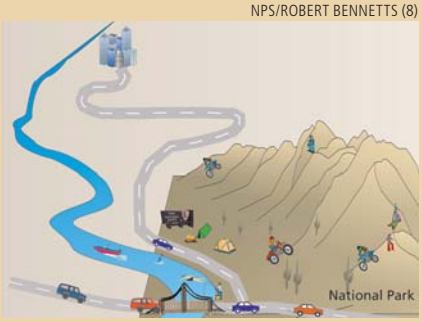

Figure 5: Excursionist Strain

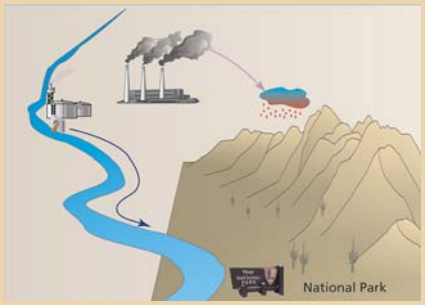

Figure 2: Distant Degradation

Figure 6: Desperado

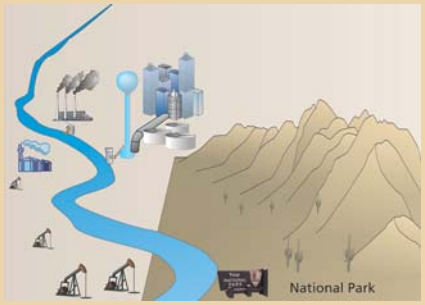

Figure 3: Intensive Extraction

Figure 7: Shifting Terrain

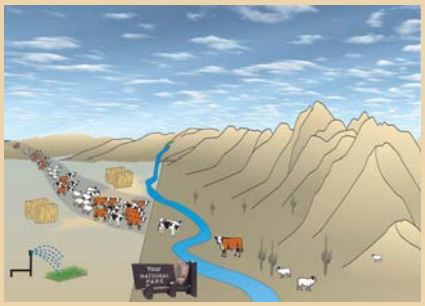
Figure 4: Extensive Consumption

Figure 8: Remote Bliss

Implications

The syndromes are intended to help managers identify the suite of effects that may result from the various stressor symptoms common to units of the National Park System. If managers detect the stressors of a syndrome whose origin is primarily outside the unit boundaries, they may seek to establish collaborative relationships with appropriate state, local, or federal governmental representatives and private landowners and entrepreneurs, with the goal of either curbing the presence or impact of the stressors or devising and implementing mitigation of their effects. If managers detect the stressors of a syndrome whose origin is primarily inside the unit boundaries, they may wish to reassess the types of uses permitted in the area with the goal of mitigating the undesired effects.

Table 1. The syndromes facing units of the National Park System

Syndrome	Description	Symptoms	Selected Examples of Possible Effects	Location
Encroaching Urbanism	A large urban population center is located very close to the park and is growing in either population size or area.	• Increase in population • Increase in nearby housing, industry, or retail development • Increase in construction of utility corridors and roads	• Increase in invasive species • Light and noise pollution • Groundwater depletion • Increase in human-animal interactions • Increase in dust and smog • Increase in roadkill • Habitat fragmentation/loss	Adjacent to park
Distant Degradation	There is an off-site, nonlocal source of stress, such as a pollution source upstream, that is brought in by a vector or transport line.	• Major highway nearby • Air traffic • Upstream or upwind factory, industry, utility plant, or mine	• Water/air/noise pollution • Soil toxicity • Vibration • Species loss • Dust and smog	Source far outside park with a "transport" line into or near the park
Intensive Extraction	There is intensive resource extraction or use very close to the park, such as a mine, wells, or agriculture.	• Nearby wells/mines • Nearby intensive agriculture • Chemical runoff	• Water depletion/pollution • Soil toxicity • Air pollution • Increase in invasive species • Habitat fragmentation/loss	Adjacent to park
Extensive Consumption	There is a large-scale, dispersed, extensive use of resources or source of disturbance.	• Cattle grazing near or in park • Extensive agriculture • Off-road vehicle use or horseback riding within buffer zone of park	• Trampling • Habitat degradation • Loss of habitat for native species • Erosion • Water pollution	Adjacent or in park
Excursionist Strain	There is overuse or abuse by the visitors in the park.	• Unusually high numbers of visitors over a sustained period • Established uses whose potential for resource impacts exceeds that of leave-no-trace activities • Extensive off-trail use • Overuse or abuse of park facilities or resources • Insufficient maintenance budget	• Trampling • Noise pollution • Litter • Habitat disturbance • Increase in direct take of resources by visitors • Damage to geological features • Increase in human-animal interactions • Decrease in visitor satisfaction	Adjacent or in park
Desperado	Numerous illegal activities, such as the trafficking of drugs or people are occurring in the park.	• Poaching • Proximity to international border • Known or possible drug farms • Human migration and smuggling through park	• Increase in direct take of resources • Danger to park personnel and visitors • Trash and human waste • Park infrastructure damage • Water drawdown and pollution from chemical runoff	Adjacent or in park
Shifting Terrain	There is a significant change in the disturbance regimes of the park, such as an increase or decrease in fires, floods, or drought.	• Dike or dam affecting waterways • Increase in impermeable surface in or near park (such as roads) • Increase in invasive species • Ineffective fire management regime • Climate change	• Increase in floods/fires • Species reduction • Change in water runoff pattern/erosion • Habitat fragmentation/loss • Smoke	Adjacent or in park
Remote Bliss	This park has few unwanted stressors.	• Low nearby population • Limited visitor disturbance • Limited intensive use of land outside park • Unaltered or minimally altered disturbance regimes	• Low pollution • Sustainable water supply • Visitor satisfaction • Healthy habitats	Adjacent or in park

One approach to dealing with the concerns of a particular syndrome may be to engage with NPS managers from other units with the same syndrome. These other units may not be geographically near each other, but may be facing many of the same issues. Such interaction, whether through informal conversation or formalized meetings and conferences, could lead to creative solutions. This may also hold true for managers of other types of protected areas (e.g., state parks, wildlife refuges, and Nature Conservancy lands).

In addition, the NPS I&M networks already have a Geographic Information System (GIS) for their units, including the NPScape program, which "provides landscape-level data, tools, and evaluations for natural resource management" (NPS 2011), yet it might be helpful for the networks to expand the GIS so that information about each of the symptoms listed in table 1 can be organized by syndrome. Programs that only detail GIS data on the interior of the park are no longer sufficient to understand the greater issues that protected natural areas are facing. Data such as surrounding land use, population density, and sources of pollution are also required. The networks' GIS will need to cover an area large enough for the symptoms included in distant degradation to be mapped for each natural area.

The networks could also explore a relationship with outside organizations, such as the Western Governors' Association, which is developing programs to address wildlife corridors and crucial habitat, or the Western Region Partnership (http://wrpinfo.org) and its committees on (1) Wildlife Corridors, Critical Habitat, Threatened and Endangered Species; (2) GIS/Mapping; and (3) Land Use. The National Park Service could work with these organizations on land management issues surrounding its units.

Next steps

We developed this as a holistic approach to conceptualizing social and environmental interactions. The issues facing all protected natural areas are complex, and it will take a comprehensive, integrated, landscape-scale strategy to manage them. Though this study was done specifically for the National Park Service, the results should be considered by managers of all protected natural areas.

The usefulness of this theoretical approach can only be known through its application to real-life situations in the field. We hope this article will help us locate natural area managers who are willing to work with us to develop such case studies. We believe that the syndromes approach is an additional tool for managers to assess factors in the condition of protected area resources and to anticipate what future changes are likely to occur. Our research shows that finding one-to-one relationships between external stressors and changes in internal ecosystem factors is a limited approach, as few one-to-one relationships likely exist and most ecosystem change is the result of numerous stresses. Thus, we propose this holistic approach and look forward to working with managers to test its usefulness in specific areas.

Acknowledgments

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About the authors

Kristina Monroe Bishop *(kmbishop@email.arizona.edu) is with the School of Geography and Development, University of Arizona, Tucson.* ***Lisa J. Graumlich*** *is dean, College of the Environment, University of Washington, Seattle.* ***William L. Halvorson*** *(sustainablesolutions@mindspring.com) is the director of Sustainable Solutions for Arid Lands, Tucson, Arizona.*

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