DESIGNING SCIENCE-BASED MONITORING PROGRAMS FOR REGIONAL MULTISPECIES CONSERVATION PLANS

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Long after I submitted the title for this talk on the "State of the Science" of monitoring to be given at the 2006 Annual Conference of the Western Section of The Wildlife Society, I realized that the "state" is much in flux with considerable lively, ongoing discussion surrounding the topic. Therefore, I've tried to interject a bit more honesty here, recognizing that our approaches to designing landscape-scale, long-term monitoring programs are often quite "cutting edge," and, as a result, admittedly uncomfortable for us to adopt without some angst. We fly by the seat of our pants more often than not in planning for monitoring, but we also have incredible freedom to proceed in "artful" ways that will help us fulfill our scientific responsibilities in the long run.

What we're doing in the realm of designing regional monitoring programs sometimes seems more art than science. Definitions of "art" from "The Concise Oxford Dictionary" (Sykes 1982:60) include: (1) skill, cunning, imitative or imaginative skill applied to design; (2) practical application of any science, industrial pursuit, craft; and (3) knack, stratagem. Additional definitions from WordNet 2.0 (Princeton University 2003) are: (1) a superior skill that you can learn by study and practice and observation; (2) the products of human creativity; and (3) the creation of beautiful or significant things. All of these definitions seem surprisingly relevant when we realize what goes into the design of these science-based programs.

All of us can probably also agree with the following quote from a study commissioned by Defenders of Wildlife last year: "Monitoring is important, it is difficult, and it is often avoided or overlooked" (Schoonmaker and Luscombe 2005:3). In addition to its importance, extreme difficulty, and often being forgotten, monitoring cannot be avoided by us because it is mandated by 2 laws for regional multispecies conservation plans in California.

The legal statutes that govern the development and implementation of regional conservation plans in California are: (1) the State of California's Natural Community Conservation Planning (NCCP) Act, which was amended in 2003 to require that NCCPs include monitoring and adaptive management programs (California Fish and Game Code, Chapter 10, Sections 2800-2835); and (2) the Federal Endangered Species Act of 1973. In 2000, a Final Addendum to the Federal Habitat Conservation Plan (HCP) Handbook was published (U.S. Department of Interior 2000) that gives specific guidance on adaptive management and monitoring for larger habitat conservation plans (pursuant to ESA Section 10[a], 1982).

These 2 laws are very complementary; each NCCP in California is also an HCP (but not vice versa). For the rest of this paper, I'll refer to these joint efforts as regional conservation plans, and I use the terms NCCP/HCP or NCCP interchangeably.

The primary goals of regional conservation plans in California are to: (1) protect and recover native biological diversity, including component ecosystems, natural communities (or habitats), and species; (2) prevent additional species from being listed as threatened or endangered and prevent risk to natural communities; and (3) allow compatible and appropriate human use of land for economic purposes, usually wild land conversion to urban development. The main characteristics of such plans are that they: (1) involve locally driven

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collaborative partnerships among the private sector, nonprofit organizations, local government, and state and federal wildlife agencies; (2) encompass a broad geographic scope, such as a county or a portion of adjacent counties; and (3) provide conservation and management of multiple species and multiple habitats on a landscape or ecosystem scale that includes ecological processes. Although reserve network assembly and dedication of conservation areas typically take place over a number of decades, adaptive management and monitoring is required in perpetuity. Adjacent plans share administrative and sometimes ecological boundaries, and may also have common suites of species and stressors.

There are 2 types of monitoring in regional conservation plans: compliance or implementation monitoring; and effectiveness monitoring. Compliance monitoring involves tracking the process. With compliance monitoring, for example, we ascertain whether the people leading implementation of the plan are doing what they promised. Through effectiveness monitoring, we attempt to get an indication that the conservation strategy, which includes reserve system configuration and management actions, achieves our objectives. Success, then, is a function of the measurable biological goals and objectives that were defined by the plan.

Some unique requirements and attributes of regional conservation plans pose special challenges for effectiveness monitoring. Although monitoring status and trends of only the covered species might satisfy the federal ESA, it will not satisfy the requirements of the NCCP Act for analysis of impacts on the natural community and at landscape scales. Therefore, we must integrate monitoring at multiple spatial scales that link our knowledge of the status of species, habitats, and ecological systems in a hierarchical way. The large spatial scope of these plans dictates the need to scale up and integrate across the landscape from specific reserves up to ecosystems that span different planning areas. In addition, we need to monitor at the appropriate geographic scales. Essentially immobile species can be monitored on single reserves, while large-scale issues and wide-ranging species must be assessed at larger scales, which requires coordinated sampling across multiple reserves and, possibly, on non-reserve lands.

Rarely do we have sufficient information to design a long-term monitoring program with confidence when developing documents for regional conservation plans. We need to acknowledge our high degree of uncertainty in the input data and the ecosystem's response. To accommodate this uncertainty, monitoring programs must contain mechanisms by which to reduce critical knowledge gaps while still fulfilling monitoring requirements. It's the "chicken and egg dilemma" (or "cart before the horse"). How do we artfully design a monitoring program when there is insufficient information about the ecological system or the species we are monitoring to begin to measure these species or their surrogates? We must build scientific capacity into the monitoring program by hiring high-level, dedicated core staff, and we must be willing to pay the right people to get the job done. We should provide the appropriate level of resources needed, and provide sufficient time and funding to develop the program. Uncertainty requires an institutional structure and process for adaptive management that is flexible, yet committed, to scientific rigor and quality results.

Because we are learning as we go, we need to phase in the development of the monitoring program. Transitions from 1 phase to another should be data driven because they rely on hypothesis testing and our increasing understanding of the system. To further complicate this, different parts of the monitoring program may simultaneously be in different phases. For example, there may be no monitoring information about some species, while there may be established, long-term monitoring for others. Because of inadequate source data, before the monitoring program can be developed, an inventory of species is often initiated right after plan approval. Phase 1, in which resources are inventoried and relationships among ecological components are identified, is very useful because it documents, to some degree, baseline conditions of the system. It includes filling information gaps, creating basic spatially explicit data layers, and developing descriptive conceptual models. Phase 2, which includes pilot tests of monitoring and resolution of critical uncertainties, is used to test field protocols and sampling designs, and to compare multiple methods at various spatial and temporal scales. Phase 3 involves long-term monitoring and adaptive management, and it occurs when we implement long-term protocols, conduct periodic evaluations of the effects of management and extreme natural events, and refine the monitoring program. Lastly, implementation of regional conservation plans, including monitoring, is necessarily staged in spatial increments because of the gradual assembly of reserve systems. Acquisition, management, and monitoring do not usually happen in parallel and are often asynchronous. Time lags are common, and we must plan for this.

To address these monitoring challenges, in 2004 we published a guidance document entitled *Designing Monitoring Programs in an Adaptive Management Context for Regional Multiple Species Conservation Plans* (Atkinson et al. 2004). This publication was a collaboration between the U.S. Geological Survey Western Ecological Research Center, California Department of Fish and Game's Habitat Conservation Division, and the Carlsbad Field Office of the U.S. Fish and Wildlife Service. There were many contributors and sources of inspiration for this work including other staff, primary and gray scientific literature, and regional monitoring projects around the world. Eight of us wrote the document; Andrea Atkinson and I were the primary authors.

The document outlines 9 steps to designing monitoring programs for regional multiple species conservation plans. Briefly, the steps are: (1) identify conservation goals and plan objectives; (2) identify the scope of monitoring; (3) compile relevant information; (4) strategically divide the ecosystem and prioritize monitoring needs; (5) develop simple conceptual models; (6) identify what to monitor and any critical uncertainties; (7) determine a monitoring strategy; (8) define data management, analysis, and reporting responsibilities; and (9) ensure effective feedback to decision makers. A full discussion of the steps is provided by Atkinson et al. (2004).

Given the challenges posed by regional conservation plans, below are my prescriptions for developing adequate monitoring programs for them. These recommendations also reflect how the previously mentioned 9 steps can become actions.

1. Think before monitoring by considering monitoring needs early in the planning process.
2. The plan should be a "grand vision document."
3. Embrace complexity; it cannot be avoided because ecological systems are complicated.
4. Use many brains, including uninvested and independent scientists and statisticians.
5. Get all these players together to brainstorm.
6. Be strategic.
7. Prioritize monitoring efforts using a bull's eye approach (Schoonmaker and Luscombe 2005) by articulating what monitoring is absolutely essential, highly desirable, and optional.
8. Have fun with uncertainty because where else can land managers treat actions as experiments?
9. Analyze data and results early and often, including annually if not more frequently.
10. Regularly communicate progress so that the public and other partners will know the results of your monitoring program.

Based on real-world lessons from the 4 NCCPs that currently implement effectiveness monitoring, below are some things we have learned about putting these programs together.

1. It hurts to think (P. Kareiva, University of California, Santa Barbara, personal communication). What exactly are the questions we are trying to answer by monitoring? It is critical to articulate these questions in words and then write them down, but this task is very difficult. Sometimes, this process reveals that the biological goals and objectives in the plan are nonsensical and must be revised.
2. Too many cooks can spoil the broth, especially if they are observers and not participants. Monitoring programs require engagement, dedication, and commitment from all responsible entities. The monitoring program is not optional. To make progress, periodic and regular interaction among all the partners is mandatory.
3. It is expensive. These programs need assured, long-term funding. Targeted studies to clarify critical uncertainties are especially expensive. Efficiency can be gained by highly focused monitoring, resource sharing, and engaging and training citizen volunteers for field crews. Additional costs for revising the monitoring program itself are inevitable and need to be anticipated.

4. There are tradeoffs between specific and narrow, and extensive and broad monitoring approaches; between utilization of professional scientific staff and citizen scientists; between front-loading monitoring during plan development and back-filling monitoring after plan approval or later in the permit period; and between having many independent monitors and an integrated approach led by 1 entity.
5. This is not the ivory tower. There are usually many partners and stakeholders, all of whom need to be educated about all aspects of monitoring. The local public must become sold on the monitoring program and they need to be fed results that they can understand so that they will support it in perpetuity. However, the program must also have credibility and intellectual accountability outside the group of local partners.
6. Each monitoring program is unique because it reflects the specific "personality" of the conservation plan for which it has been designed.

Implementers of high-profile, multispecies monitoring programs of this scale throughout other parts of the world are, as we, experimenting with the process of creating monitoring programs in an adaptive management framework. Our regional conservation plans are still in their infancies, but monitoring data collected from them thus far are goldmines of information that are helping us learn that designing and implementing these programs is a science and an art.

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