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A REPORT FROM LAKE TAHOE: OBSERVATIONS FROM AN IDEAL PLATFORM FOR ADAPTIVE MANAGEMENT

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INTRODUCTION

The Lake Tahoe basin is in environmental distress. The lake is still one of the world's most transparent bodies of water, but its fabled clarity has declined by half since discovery of the high-mountain lake basin by explorers a century and a half ago. At that time, incredibly, objects could be observed on the lake's bottom a hundred feet down. Two-thirds of the lake's transparency has been lost in just the past 30 years. The forests that surround 200-square mile Lake Tahoe were ravaged more than a century ago to feed expanding mining efforts in adjacent Nevada. Stands of yellow pines, once dominated by huge, widely spaced old-growth trees, were replaced after clear cutting by thickets of fir and shrubs. Subsequent fire suppression served to produce an especially fire-prone forest at great risk of severe and expansive wildfire events. A blaze two years ago destroyed hundreds of homes and nearly 3,000 acres of mature forest and wildlife habitat. Indeed, wildlife populations and the lake's fishes have not fared well over the past century. One of nature's most productive fisheries, which once sustained uncounted generations of Native Americans at Lake Tahoe, has completely vanished owing to decades of overharvest followed by invasion by non-native species and collapse of the benthic food web.

The Lake Tahoe basin seemingly is a perfect candidate for the implementation of adaptive management. The planning landscape of the basin is well defined. The lake is ensconced in a circumscribed watershed of just 400 square miles. The terrestrial and aquatic ecosystems within it are well studied. Time-series data on many environmental variables are available, and a number of reliable studies that link environmental stressors and system responses have been carried out. Many of the management actions necessary to arrest or to reverse declines in the basin's favored resources have been identified. Perhaps most important of all, "saving" Lake Tahoe has enjoyed a unique commitment from government. Every year since 1997, when President Clinton and Vice President Gore elevated Lake Tahoe to national prominence with a mid-summer visit, California's and Nevada's senators, several congressional representatives, the states governors, state legislators, the Secretary of the Interior, and agency heads at federal, state, and local levels have reassembled to reaffirm their commitment to restoring Lake Tahoe to its presettlement grandeur. They bring with them the funds to do so, nearly \$40 million in each of the past five years, with more on the way. An environmental planning milieu that is friendlier to integrated resource and land management informed by reliable scientific information – adaptive management – is hard to conjure up.

Against the background of ecological decline, the acknowledged management and restoration goal in the

Lake Tahoe basin has been unambiguous for more than 50 years and recognized by land and resource managers, policy makers, scientists, and the general public – a clearer lake surrounded by healthier forests sustained by natural ecosystem processes. Toward that goal, an inter-agency collaboration nearly two decades ago produced an Environmental Improvement Program, identifying more than 200 restoration projects, ranging from road armoring and reduction of impervious surfaces, to forest thinning and stream-course rehabilitation. And, while more than 70 percent of the Lake Tahoe basin, from lakeshore to alpine summits, is under the purview of the U.S. Forest Service, no fewer than 20 federal, state, and local jurisdictions and institutional entities were expected to contribute to implementation of the omnibus program, including associated longer-term monitoring and resource management needs.

Environmental monitoring has been an in-house enterprise, and the data are typically managed and archived by the agency that gathered or funded collection of the data

A Lake Tahoe Watershed Assessment (USDA Forest Service General Technical Report GTR-PSW-[175]) was prompted by the presidential visit 12 years ago, with the purpose of bringing better-informed management to the lake basin by compiling available information in one document to be used to "develop a comprehensive conservation plan for the lake and its watershed." Among synthesis treatments of the lake's environmental history and status, including air quality, upland water quality, lake clarity, biodiversity, and forest health, the assessment called for adaptive management and described a strategy for bringing together policy, management, and science. The proposed adaptive management approach described the complementary roles of monitoring, modeling, and research in acquiring and assessing the information needed to steer management actions; and identified the need for prioritization and allocation of resources to these activities, and a process of evaluation of information in decision-making to apply emerging knowledge to policy and management activities. The call for an adaptive management framework in the watershed assessment has been slow to realization, but measurable progress has been made.

The environmental challenge posed to policy makers and resource managers at Lake Tahoe has all the ingredients necessary to make the costs of adaptive management worth the beneficial ecosystem outcomes. Twelve conditions are required to foster adaptive management, allow for its institutional adoption, and facilitate its success (Table 1). The primary conditions that predicate the need for adaptive management are few, yet commanding: existence of a credible environmental crisis, options for

intervention to alleviate the crisis, and substantial uncertainties about how best to respond. The Lake Tahoe basin has these three ingredients in abundance. Lake Tahoe as a globally unique, renowned, and valued natural resource makes the prospect of its famous blue waters turning green simply unacceptable. The environmental crisis in the Lake Tahoe basin is a function of a myriad of causal factors, none of which is simple to reverse, and all of which have been generated by human activities. Atmospheric deposition of nitrogen and bio-available phosphorous entering the lake from the watershed, both causing algae growth, along with suspended sediments are the key contributors to the loss of lake transparency. The proliferation of dense, fire-prone forests that have high rates of tree mortality has created a forest health crisis. Invasive plants and animals have confounded ecosystem function and scrambled the lake's food web. The composite of these known factors results in rather high uncertainty as to feasible and effective solutions. The cornucopia of jurisdictions at Lake Tahoe demands serviceable inter-institutional relationships to meet the challenge of managing the identified environmental stressors in order to arrest or, better, reverse trends in the decline in the condition of the lake basin's terrestrial and aquatic resources.

The essential fuel for adaptive management is the availability of information that can guide management decisions. Lake Tahoe benefits today from decades-long concern over its declining clarity – it encouraged the establishment of an information baseline that grew into time-series data and provided the basis for focused scientific studies. Initial studies by Charles Goldman and his colleagues in the late 1960s documented the decline of Lake Tahoe's clarity, and brought public attention and resources to bear on its plight. That work provided scientific credibility to the crisis, which in turn served as a magnet for additional funding to further scientific investigations and begin restoration efforts. Since its passage,

the Lake Tahoe Restoration Act of 2000 has directed funding at both implementation of restoration activities and improvement of the information base that is necessary to make those restoration efforts more effective. Research institutions have rallied to form alliances in order to enhance the production and delivery of useful and reliable information to the management agencies. And, in turn, management has increased its support to and recognition of research as an essential element in management and restoration efforts. Although important knowledge gaps still exist, it is clear that information is not now a limiting factor in the implementation of adaptive management in the Lake Tahoe basin.

Institutional collaboration is the necessary vehicle for adaptive management to proceed. Slow progress toward implementation of adaptive management in many Lake Tahoe planning venues has been due, not to a lack of information, funding, or capacity, but rather due to predictable (and understandable) resistance by the land and resources management institutions. Agency staff and leadership are likely to find their traditional roles and prerogatives difficult to relinquish as is requisite for information-driven approaches to cooperative planning and action. Adaptive management is a collaborative process; that collaboration necessitates shared decision making, and shared decision making almost always entails compromise. The costs associated with compromises made in service of collaboration need to be balanced by (at least) the perception of counter-balancing benefits. In the Lake Tahoe basin, incentive for collaboration is high owing to the complexity of the challenge, the unusually large funding commitment, and the unyielding necessity for a successful ecosystem restoration outcome.

Institutional impediments to adaptive management in the Lake Tahoe basin have diminished and forward momentum has grown over time. Diverse stakeholder committees and cross-agency working groups have

Table 1. Primary Ingredients for Adaptive Management to Succeed.

Preconditions that necessitate an adaptive management approach ... the context for adaptive management

- 1 A credible, widely recognized environmental crisis exists.
- 2 Documented causal linkages between management actions and environmental responses.
- 3 Moderate to high levels of uncertainty regarding the most effective and lowest risk actions.

Fuel for adaptive management ... information needs for effective management action

- 4 Reasonable foundation of useful data exists upon which to build a management strategy.
- 5 Accepted ecological performance metrics have been identified and are recognized as appropriate.
- 6 Measurable triggers have been identified and decision points have been agreed upon.
- 7 A robust data collection design exists and analyses are proposed.
- 8 The required management actions can be accomplished at a feasible cost.

Institutional commitments ... A necessity where jurisdictions are shared

- 9 Jurisdictional relevance exists – with institutional participants sharing interests in meeting the environmental challenge.
- 10 Uncertainty and risk are equitably spread among participants and other stakeholders.
- 11 There is a shared commitment to pre-negotiated management responses to environmental status and trends.
- 12 The costs and benefits of likely outcomes are understood by participants.

formed over four decades of focused attention to address Lake Tahoe's environmental decline. These include formal government-sponsored groups, such as a committee of community interests and stakeholders that was formed under the Federal Advisory Committee Act to provide input and feedback to the federal agencies in the basin. Also, stakeholders have formed less formal, *ad hoc* groups to respond to short-term challenges, such as resource-specific agency planning efforts. Importantly, institutional collaboration is evidenced in coordinated databases that have been created and maintained for critical resources in the Lake Tahoe basin. Cross-agency collaboration is common in the support and management of core basin-wide data layers, including remotely sensed data and data layers that inform administrative responsibilities. But a similar level of coordination and collaboration generally does not yet extend to field-based data obtained through monitoring or agency-generated research. Environmental monitoring has been an in-house enterprise, and the data are typically managed and archived by the agency that gathered or funded collection of the data. The Lake Tahoe Restoration Act has sped progress in adaptive management activities and collaborations in the basin in a circuitous manner. Increased funding to agencies and research institutions made it possible to pursue larger-scale projects, which required the involvement of multiple agencies. The increase of management activities funded under the act has created an increased need for accountability, which in many cases has resulted in peer-review or research involvement to ensure that project design and implementation are scientifically credible. Similarly, distribution of funding for research has increasingly become guided by project relevance and the information needs of the resource managers. These emerging conditions compelled the formation of a Tahoe Science Consortium in 2005, comprised of five research institution signatories to a memorandum of understanding that was supported by the state and federal agencies in the basin. The establishment of the consortium represents a substantive step toward a functional adaptive management system at Lake Tahoe. In its brief three years, it has facilitated the development of a science plan for the Lake Tahoe basin, sponsored scientific literature reviews, implemented a scientific peer-review process that has been used to evaluate research proposals for annual awards of research funding, and provided science-consistency reviews for agency-led planning and assessment efforts, which have linked science and management as never before.

Progress toward increased collaboration and adaptive management propelled by the Lake Tahoe Restoration Act also has had direct and positive impacts on recent efforts to accomplish the first revision of long-term (10-year to 20-year) planning documents governing the U.S. Forest Service Lake Tahoe Basin Management Unit and the Tahoe Regional Planning Agency (TRPA), a bi-state regulatory agency. Cross-agency teams that consisted of both scientists and managers were formed early in the planning process with the intention of forming a shared perspective on the status of natural resources in the basin, desired future conditions, and how best to

measure resource status and progress toward management objectives. With that stage of planning completed, the management agencies have returned to their individual planning processes, which are governed by their own distinct regulations. The dominant land manager, the Forest Service, guided by land management directives in the National Forest Management Act, is producing a plan that is more general in its objectives and methods, with little emphasis on monitoring. Thus it is not apparent that its approaches to management actions will be particularly adaptive. In contrast, the TRPA is operating under the mandate to identify specific targeted ecological conditions toward which regulations, management, and monitoring are directed. Its planning process is clearly adaptive. TRPA is taking a lead role in developing a scientifically credible process to update these target conditions based on new scientific information; developing conceptual models that illustrate and describe the factors affecting environmental targets; developing indicator measures that will reliably reflect target conditions and key ecosystem drivers; and designing coordinated monitoring approaches to track the status of the indicators.

The hard work of adaptive management may be motivated by reward or fear of failure, but most often it is by both. Risk and uncertainty have encouraged a number of unique collaborations in a variety of contexts that have emerged from the institutional medley and the stew of environmental crises in the Lake Tahoe basin. But, it is clear from listening to the adaptive management dialog over the past decade, against the background of inevitable changes in key positions of leadership in the agencies, that it is the ability of those individuals to form open, trusting, and collegial relationships with one another that has the greatest impact on progress toward adaptive management. Collaboration in the form of partnerships has its own reward, and in turn it can overcome significant logistical barriers posed by funding or information gaps, mismatches in regulatory directives, and jurisdictional boundaries. If, indeed, the Lake Tahoe basin is an adaptive management milieu that may be "as good as it gets," then we might conclude that progress toward adaptive management, even in the best of circumstances, will be incremental, hindered only by the ability of everyone to just get along.

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