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Synthesis, part of a Special Feature on Pathways to Resilient Salmon Ecosystems

Institutions for Managing Resilient Salmon (*Oncorhynchus* Spp.) Ecosystems: the Role of Incentives and Transaction Costs

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ABSTRACT. Institutions are the mechanisms that integrate the human and ecological spheres. This paper discusses the institutional challenge of integrating salmon (*Oncorhynchus* spp.) ecosystems and human systems in ways that effectively promote resilience. Salmon recovery in the Columbia River Basin demonstrates the challenge. Despite the comprehensive scope of Basin salmon management, it has a number of problems that illustrate the difficulties of designing institutions for ecosystem and human system resilience. The critical elements of salmon ecosystem management are incentives and transaction costs, and these comprise a large piece of missing institutional infrastructure. Once the focus is placed on incentives and costs, a number of different management strategies emerge as options for salmon ecosystems, including refugia, property rights to ecosystem goods and services, co-management, and markets in ecosystem services.

Key Words: *Columbia River Basin; ecosystems; human systems; incentives; institutions; resilience; salmon; transaction costs*

INTRODUCTION

> *Resilience is the amount of disturbance that an ecosystem can accommodate without shifting to a different regime characterized by a fundamentally different structure, function, and feedback mechanisms* (Walker et al. (2004); paraphrased in D. L. Bottom et al. 2008)

> *Resilience is the magnitude of disturbance that can be tolerated before a socioecological system moves to a different region of state space controlled by a different set of processes* (Carpenter et al. (2001)).

The two definitions of resilience cited above guide us toward the institutional attributes needed for ecosystem management. In the first definition, the existence of disturbance events is an acknowledgement of the natural variability and the specific contexts within which ecosystems exist. This variability generates uncertainty about a system’s state and trajectory that requires flexibility in action, monitoring of the results of actions, and learning from those results. These components and implications of ecosystem resilience are paralleled by those in human systems, where variability requires adaptability, diversification, and connectivity. The second definition acknowledges this human–ecological connection.

Institutions are the mechanisms that integrate the human and ecological spheres in ways that contribute to, or detract from, these resilience attributes. This paper discusses the institutional challenge of integrating salmon ecosystems and human systems in ways that effectively promote resilience, and the role that incentives and transaction costs play in that integration.

The word “institutions” is used in many ways in the natural resource literature, perhaps most commonly in reference to public agencies or organizations. However, institutions and the institutional environment are broader than organizations, and the breadth of their scope captures many of the complexities of salmon (*Oncorhynchus* spp.) ecosystem resilience. Institutions in their broadest meaning are the rights, rules, and responsibilities of

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organizations and individuals (Eggertsson 1990, North 1990). They include the laws, organizations, and procedures that shape the way people interact with each other and with their environment, determining who makes decisions, how those decisions are made, how regulations are implemented, and how adaptation takes place. They integrate networks of economic, legal, social, and ecological systems in formal and informal ways.

People make decisions about salmon ecosystems as individuals, members of tribes, members of watershed councils, agency scientists, and elected representatives. They follow the procedures of municipal, county, state, federal, and tribal organizations that exist under various enabling legislation. Ideally, institutions for salmon ecosystems should coordinate decisions over different scales, reconciling actions taken at one level with those in other "nested" levels. They should accommodate diverse objectives of multiple resource use and develop processes for assessing trade-offs among alternatives. They should address the uneven distribution of the costs of taking actions and the benefits received from those actions. And finally, institutions should be flexible enough to respond to changing conditions and to evolve in ways that allow their benefits to outweigh their costs (Hanna 2000).

The institutional ideal faces a number of challenges in practice. Institutions often reflect the diverse conceptual foundations—belief systems, assumptions, and principles—of the people who interact through them. Internal communication can be made difficult through the phenomenon of "towering," when subgroups act on the basis of different conceptual foundations (Norton 2005). The often ineffective communication among proponents of hatchery programs, harvest regulations, and habitat protection illustrates the problem of towering in salmon management institutions.

The ideal of institutional flexibility can directly conflict with the need for a stable decision environment and consistent expectations (Hanna 1998). The flexibility of adaptive management that allows managers to experiment and learn also allows any management action to be called "adaptive" (Volkman and McConnaha 1993). Learning through monitoring and evaluation requires a reconciliation of the relatively short time scales of resource management with the longer time scales of ecosystem change (Lichatowich 1997).

Williams (2006) recommends changing the conceptual foundation of salmon restoration to one based on ecological principles that quantifies social, economic, and biological trade-offs, establishes learning opportunities, and coordinates planning and implementation of mitigation measures. But changing a conceptual foundation, or creating a single conceptual foundation out of many, goes against the patterns of habit and expectations and is, therefore, a difficult task. It works against incentives to maintain the existing conceptual foundation, and it generates transaction costs associated with change.

This paper examines the role of incentives and transaction costs in promoting resilience in the salmon ecosystems and human systems of the Columbia River Basin. It places incentives and transactions costs within the institutional context of salmon management to address the integration of ecosystems and human communities.

The Columbia River Basin exemplifies the institutional challenges of managing for salmon ecosystem resilience. Once supporting the world's largest runs of Chinook (*Oncorhynchus tsawytsacha*) and large runs of coho (*O. kisutch*), sockeye (*O. nerka*), and steelhead trout (*O. mykiss*) (Williams 2006), the Basin now contains 13 salmon "evolutionarily significant units" (ESUs) and steelhead "distinct population segments" (DPSs) listed for protection under the Endangered Species Act (ESA) (Federal Caucus 2007). The operation of the federal Columbia River power system (FCRPS) is under continuing litigation for compliance with the ESA. In addition to power production, many competing interests depend on the use of the river: navigation, irrigation, transportation, recreation, tribal subsistence, ceremonial and commercial fisheries, recreational fisheries, and lower river commercial gillnet fisheries. The number of entities involved in the management of Pacific salmon fisheries and the number of overarching legal mandates require a high degree of coordination and cooperation among parties to control harvest impacts across jurisdictions. This coordination is evidenced in an extensive and detailed system of scientific advice and management decision making (Hanna 2000; Independent Scientific Advisory Board (ISAB) 2005).

Columbia River salmon management has evolved in response to changing biological, oceanic, legal, social, and economic conditions. The evolution has included a greater spatial distancing of people and actions, as, for example, in-river hatcheries serving as production systems for distant at-sea harvest. At the same time, the physical effect of river and coastal uses on salmon, estuaries, and the coastal zone, and laws enacted to protect salmon from extinction have forced a greater connectivity to fishery issues achieved through increasingly complex consultations and coordination. As such, they represent regional institutional adaptations to ecosystem-level and political requirements. Climate change and population growth are emerging as new and large-scale drivers of change (ISAB 2007a, 2007b).

THE INSTITUTIONAL PROBLEM

Several problems facing salmon management in the Columbia River Basin illustrate the difficulties of designing institutions for salmon ecosystem resilience. The first problem is one of disparity in the location of the causes of problems and the remediation for those problems. For example, pollution that degrades stream quality is usually of non-point source. Forest practices upstream or land development practices in the larger region, may take place outside the boundaries of a watershed but have effects realized within the boundaries of a watershed. Remediation actions taken only within the boundaries of the watershed will then fail to address the problems at the larger scale (Hanna 2000).

Second, salmon ecosystem resilience represents a classic problem of externalities in costs and benefits, in which those who pay for improvements in salmon ecosystems are not necessarily those who will benefit. Management is more effective when the costs and benefits of decisions are internalized, when those who invest in ecosystem health and those who benefit from that investment are the same. But the costs and benefits of actions for ecosystem resilience are usually unevenly distributed, with costs incurred by those in proximity to the ecosystem and benefits realized over much larger areas. Similarly, the costs of restricting fish harvests to protect wild stocks are borne by fishery managers, commercial fishermen, and anglers, but the benefits of wild stock protection are widely dispersed among the human population at large (Hanna 2000).

Third, competing interests for the goods and services of ecosystems exist that involve trade-offs. It is tempting, but unrealistic, to imagine that salmon ecosystem resilience is a priority objective shared by all. In practice, the number of interests in the Columbia River system and the intensity of river use means, as with ecosystems elsewhere, that competing interests and high-valued trade-offs create winners and losers (Hanna 2000).

Fourth, agencies and organizations make resource decisions affecting salmon ecosystems across fragmented jurisdictions. Decisions about marine salmon harvests, in-river harvests, power sales, dam operations, irrigation withdrawals, fish passage, hatchery production, and habitat protection are the responsibility of entities with overlapping boundaries, competing objectives, and incomplete authorities to accommodate the full scale of causes or effects. The conceptual foundation of Columbia River salmon management, comprising artificial propagation and technical fixes creates a perspective that enables and continues the institutional fragmentation.

Salmon managers can produce hatchery fish and regulate harvest of those fish without having to address other aspects of the ecosystem (Williams et al. 1999).

The decision landscape of the Columbia River is balkanized across two national governments, fourteen tribes, nine federal agencies, five states, and many municipal entities. A directory of organizations with an interest in Columbia River salmon posted on the Northwest Power and Conservation Council website is 83 pages long (www.nwcouncil.org). No overarching coordination mechanism exists. Land ownership is federal, state, tribal, and private. It has been estimated that a northern Idaho Chinook salmon passes through 17 separate management jurisdictions—international, federal, state, and tribal—during the course of its life migrations (Wilkinson 1992, ISAB 2005).

Fifth, and finally, significant levels of scientific uncertainty remain about salmon ecosystems and the range of conditions they experience, despite the sizeable research investment in various aspects of the salmon resilience problem. This uncertainty creates confusion about which actions should be taken to promote resilience, and so complicates the development of incentives to promote those actions (Hanna 2000).

INSTITUTIONAL DESIGN: INCENTIVES AND TRANSACTION COSTS

It is within the context of these problems that institutions promoting salmon ecosystem resilience must be developed. The institutional design problem for the Columbia River is to establish structures and procedures that contribute to achieving salmon ecosystem resilience and through it, the system-wide objectives of salmon recovery and habitat rehabilitation. The additional problem is to promote the resilience of human communities that depend on salmon. The critical elements of this design problem are incentives and transaction costs, and these comprise a large piece of missing institutional infrastructure.

The issue of "institutional fit" linking ecosystems to human systems is of central and continuing importance (Folke et al. 2007). Traditional institutions developed in stable isolated communities have been successful in sustaining resources in the past but have been vulnerable to rapid change and globalization. As Dietz et al. (2003) note, the ideal conditions for governance are increasingly rare.

Some have recommended a new conceptual foundation for salmon management that would replace the production paradigm of the established institutional structure with an ecological paradigm. While recognizing the importance of placing priority on ecosystem considerations, it is also important to recognize that salmon ecosystems have a long history of providing value in consumptive use, and management will continue to be directed toward production. The necessary change will be to find ways to redirect human behavior toward long-term production approaches that also support the non-consumptive values of ecosystems.

The institutional support needed to take a long-term perspective and manage for ecosystem and human system resilience rests on both structure and processes. Part of the institutional structure is a system of well-specified property rights over the goods and services of ecosystems that define the set of stakeholders and specify the conditions of their tenure (Barzel 1997). Systems of property rights over ecosystem components are generally weak. This weakness creates an uncertainty about tenure and an incentive to emphasize short-term over long-term goals. The existence of property rights would allow the focus to shift toward performance-based regulation, where the right to fish depends on certification of meeting specified conditions (Hanna 2002).

Institutional processes that promote consistent expectations and learning must also be in place. These processes must provide for full and transparent information and must accommodate adaptive management by promoting experimentation, supporting monitoring and evaluation. Experiential learning is where the rules are modified on the basis of "learning by doing" (Tirole 1995.)

The key considerations for resilience-promoting institutions will be how they address scale, uncertainty, incentives, and transaction costs. The nature of the scale and uncertainty problems is relatively well understood. This understanding is expressed in the ecosystem approach to fisheries, which recognizes the interactions between ecosystems and the people who use them and the fact that both are affected by natural long-term variability as well as by external factors (Food and Agriculture Organization (FAO) 2003). Management is slowly experimenting with ways to reconcile differences between ecological and political scales. In addition, programs are emerging to monitor and learn about ecosystem properties in order to reduce uncertainty (Boldt 2006, Marasco et al. 2005), although investment in research to learn about critical human system properties remains at very low levels. Social science has not been funded at levels or with a consistency that would provide in-depth description and prediction on an ongoing basis (National Academy of Public Administration 2002.)

With some, if slow, progress on uncertainty and scale in ecosystem management, the critical missing pieces are considerations of incentives and transaction costs.

Incentives

Incentive problems make it difficult for managers to take the long-term view and take action to reduce uncertainty. The literature on organizational economics offers insight into a number of important incentive problems that need to be addressed in order to promote resilience in ecosystem and human systems.

Power ambiguity

Power ambiguity exists when there is uncertainty about relative positions on a hierarchy that can lead to questioning and undermining of authorities (Arrow 1974). Although the relative roles and responsibilities at different levels of the federal and state fishery management hierarchy are detailed in law and implementing regulations, confusion among management participants about who has the authority to make which decisions is common, and broadening the scope of consideration to ecosystems will add further confusion.

Low incentives

Low-intensive incentives exist when there are weak connections between a person's decisions, and the appropriation of the consequences of those decisions (Williamson 1985). Accountability is missing. To provide incentives for accountability, ecosystem managers would need to be held to a set of resilience-based performance standards supported by a program of monitoring and evaluation.

Moral hazard

Moral hazard exists when hidden actions of some are unobservable to others—whether because it is too costly to fully observe or for other reasons—creating the potential for shirking (Eggertsson 1990). Compliance is an ongoing problem in fishery management that is only likely to expand with a broader scope of ecosystem considerations.

Bounded rationality

Bounded rationality is behavior that intends to be rational, but is limited by uncertainty and inconsistency. It is shaped by the conceptual foundation and is vulnerable to opportunism (Williamson 1985). High levels of uncertainty limit the degree to which fishery managers can be rationally foresighted, and prevents the completion of actions to simplify and stabilize management. Instead, continual bargaining can be the norm (Young 1991).

Failure to make credible commitments

Credible commitments exist when what is promised is reliably delivered (Williamson 1985). The ability to make credible commitments—or their inverse, credible threats—will rest on the ability to enter into contracts with various ecosystem interests, which rests in turn on well-specified property rights to ecosystem components.

Truncated learning

Learning-by-doing can be a way for organizations to increase proficiency, adapt to changing circumstances, and reduce costs (Tirole 1995.) Opportunities for this method of learning depend on management environments that have the flexibility to promote experimentation and the free flow of information.

These incentive problems will create problems for resilience if left unaddressed. All complicate the application of knowledge and prevent the private incentives of people with interests in ecosystems from being fully aligned with public objectives for resilient ecosystems.

Many of these incentive problems can be corrected through appropriately specified property rights to ecosystem goods and services. Without property rights of some form the incentives are wrong for sustainability (Hanna 2002, 2004, Hilborn 2007). One of the functions of property rights is to resolve the problem of externalities, in which one action affects another. When property rights to resources do not exist or are incomplete, people do not take full account of the costs of their actions because there is no corresponding owner to defend against harm. Development and pollution of estuaries harms habitat important to juvenile salmon, but because ownership over the early production stages of populations is not clearly specified, these ecosystem functions often remain unprotected. In some cases, property rights may be defined but unenforceable, and the lack of enforcement then becomes equivalent to removing the right. For example, if dumping silt into tributaries is prohibited but the rules are unenforced, the right of spawning areas to protection is invalid. If fishing rights are expressed in terms of areas, and others are not excluded from those areas, their encroachment will render the right meaningless.

Property rights to water offer a good example of how incomplete specification of property rights can hinder the allocation of resources to desirable ends. The system of rights to water in the Columbia River Basin reflects a history of value placed on agricultural consumptive use of water. Until recently, rights were specified only for consumptive use, and the use of water in-stream to benefit salmonid ecosystems was not represented as a right. As a result, tributary habitat was often dewatered by consumptive withdrawals. Actions by several states to broaden the specification of water rights to include an "instream flow" category has allowed the lease and purchase of consumptive water rights for the purpose of keeping water in streams (Columbia Basin Water Transactions Program 2007).

Transaction Costs

Transaction costs include costs of gathering information, coordinating users, organizing decision making, and enforcing rules (Eggertsson 1990). Some transaction costs remain fixed regardless of the type of process used to make decisions. Others vary with the way decisions are made—the amount of data collected, analyses done, and the process used to make decisions. The importance of transaction costs lies in their potential to overload an institutional structure to the point that their costs exceed the benefits they produce. This cost effect has a particular likelihood of being a problem in addressing the complicated questions of ecosystem resilience.

The early days of fishery management were simpler and, therefore, had a lower cost. Managers needed to know something about the biology of the fish, the general properties of simple regulations, and a little about the economics of the fishery. The emphasis was on maintaining conservation limits while intruding as little as possible into the operations of fishery user groups. However, the type and quantity of knowledge needed to effectively manage fisheries has changed over time as conditions in fisheries have changed. Broadening the scope of management to ecosystems will further add to transaction costs.

The salmon management task is to understand and accommodate the full range and distribution of public values within the constraints of the law. All this takes place in a context of changing public expectations and a broadening constituent base. Fishery interests are no longer just commercial harvesters and processors. They are increasingly heterogeneous, representing a wide range of commercial, recreational, and environmental interests (Smith et al. 1997). Additionally, the public is taking a much stronger role in demanding that salmon populations and their ecosystems be sustained. Non-market values of fish stocks—values placed on existence and future options—are taking on greater importance in management. The ecosystem management portfolio requires a wide range of skills to effectively coordinate, negotiate, think strategically, interpret science, understand risks, design regulations, implement regulations, monitor, and enforce. All of these carry costs. Transaction costs are also influenced by ecosystem condition and the extent of its institutional fragmentation. As an ecosystem becomes less resilient it generates an increasing number of externalities that add to the costs of program design and enforcement.

The containment of transaction costs requires an institutional setting that reflects the properties of both the salmon ecosystem and human systems. Because institutions link people and their decisions to the biophysical systems in which they live, institutional properties are instrumental to the incentives that are created and the magnitude and distribution of transaction costs. These in turn are germane to the resilience of ecosystems and human systems.

INSTITUTIONAL PROPERTIES FOR RESILIENCE

The structure and function of institutions can promote or degrade resilience. The resilience of ecosystems and human systems shares certain attributes and is strongly influenced by the incentives and transaction costs that institutions create.

Attributes of Resilient Ecosystems

Several authors in this issue have addressed the question of what salmon ecosystems need to be resilient. They note several key attributes of salmon ecosystems that center around variability (Bisson et al. 2008; Waples et al. 2008). Salmon ecosystems have a natural range of variation in system condition that may also be subject to episodic change. They experience structural shifts from large-scale drivers like climate change, human population pressure, and invasive species that can be mitigated by biocomplexity (Hilborn et al. 2003). They exist at varying scales and depend on habitat diversity and connectivity (Bottom et al. 2005). They express variability over both short and long terms.

Maintaining salmon ecosystem resilience in the face of these sources of variability carries a bundle of management requirements that generate transaction costs. Management must proceed with acknowledgment of uncertainty about system state and processes. It must accommodate the normal range of conditions, but also be able to adjust to episodic change. Management for a range of conditions means moving away from the stability-focused harvest management frames that were developed to promote stability in business planning horizons and for the benefits of consistent expectations. Stability-based approaches have been shown to be unsustainable, especially when expectations are formed at the high end of the range of natural variation.

Management must also include monitoring and evaluation to learn about current system conditions as well as to anticipate the effects of large-scale drivers of change. Ecosystem scale and boundaries must be defined with management actions targeted to that scale. Management must be based on a set of measurable objectives that include indicators of ecosystem resilience based on rates rather than absolute values. Maintaining diversity of species, life histories, and habitats should be at the core (M. Healey, unpublished manuscript). The development of objectives requires discussion of ecosystem components and trade-offs among them. Management planning horizons should be congruent with ecological time horizons. The knowledge base of management should be broad, including both scientific and experiential knowledge. Institutions must be matched to the scale of ecosystem processes that sustain salmon.

Attributes of Resilient Human Systems

People are a key but often overlooked component of ecosystems. Human and ecological resilience are linked, particularly in resource-dependent contexts (Adger 2000). Because the condition of human systems has a direct bearing on salmon ecosystems, institutions that promote ecosystem resilience will include elements to promote resilient human systems. The elements of human resilience are the incentives to which people respond and the transaction costs of that response.

At both the individual and community levels, many of the same types of influences affect resilience in human systems as in ecosystems. Variability in weather, salmon productivity, markets, regulations, and social conditions create uncertainty. Episodic changes, such as El Niño events or oil spills, can happen unexpectedly. Fragmentation exists in the regulatory landscape, as well as within interest groups and communities. Changes at larger scales, for example population growth or international markets for farmed salmon, may limit options at smaller regional scales. The uncertainty generated by these factors creates incentives for short-term decision making (Ludwig et al. 1993).

Fabricius et al. (2007) identify three categories of community adaptation to change. The first they call "powerless spectator" communities, which have a low adaptive capacity and weak capacity to govern, few options, and inadequate skill sets. The second is "coping actor" communities, which have the capacity to adapt, but lack the capacity for governance. The third is "adaptive manager" communities, which have both adaptive capacity and governance capacity. This type of community invests in the long-term management of ecosystem services. The complexity of the salmon management context is such that it includes communities of all three types and so contains mixed incentives.

People who depend on salmon need to be able to absorb and adapt to physical, biological, economic, and social changes in ways that promote their long-term resilience. They need to be able to manage the risk that salmon population variability creates. One path to risk reduction is to decrease dependence on salmon by diversifying harvest over more fisheries —a traditional portfolio approach that has become less available because of limited access regulations —or by diversifying economic activity beyond fisheries (Martin 2008). People need to be able to adapt to change through innovation and adoption of new technologies, and to have mobility to exploit different habitats. Economic well-being provides people the luxury of choice, and so provides a critical incentive for promoting resilience. Social and economic connectivity within communities is the human analog of habitat connectivity, preventing fragmentation and promoting cohesion.

Also promoting cohesion are management rules that make sense locally. The rules do not necessarily have to be developed and implemented locally, but they do have to have stakeholder input, feedback, and acceptance that provide the incentives to comply. In a recent report the Government Accountability Office (GAO) summarized the state of knowledge about rules for effective stakeholder participation (GAO 2006). The GAO recommended a set of core principles to guide stakeholder participation in quota-share programs, which was subsequently modified by NOAA Fisheries to reflect principles embodied in statutes governing fishery management council proceedings. These rules have general applicability for effective stakeholder participation and for containing transaction costs in the long run:

- Use an open and clearly defined decision-making process;
- Make key information readily available and understandable;
- Actively conduct outreach and solicit stakeholder input;
- Involve stakeholders early and throughout the decision-making process;
- Foster responsive, interactive communication between stakeholders and decision makers;
- Use formal and informal participation methods; and
- Include all stakeholder interests (NOAA Fisheries 2008).

The need to promote human resilience is often forgotten in discussions of ecosystem management. We may assume that the rules for ecosystem protection will be followed without thinking critically about how to elicit the desired human behaviors. The desired behavioral outcome is critically shaped by the institutional environment through the incentives and transaction costs it creates.

CONCLUSIONS: INTEGRATING RESILIENCIES

Institutions that promote resilience in salmon ecosystems must reflect the attributes of both ecological and human systems, and in doing so, must address incentives and transaction costs. Salmon are inherently resilient as are people. The question in the Columbia River Basin and elsewhere is how to promote and integrate these natural advantages in ways that will protect their respective ecosystems and communities while containing the costs of doing so.

The integration of ecological and human systems is a matter of reflecting the full range of ecosystem values—nonmarket as well as market. As Lichatowich (1999) phrases it, this integration represents a transformation from an industrial economy to a natural economy in which the disturbance of natural variability is anticipated and incorporated through management that addresses uncertainty, diversification, and connectivity. Being able to accomplish this integration will depend critically on the design of institutions and the extent to which these institutions account for incentives and transaction costs.

Once the focus is placed on incentives and costs, a number of different management strategies emerge as options for salmon ecosystems in the Columbia River Basin and beyond. These strategies include salmon refugia that set aside space as a low-cost protection against uncertainty and variability (Williams 1991, Li et al. 1995, Williams 2006). They establish property rights to ecosystem goods and services that provide incentives to fully account for ecosystem components. They incorporate co-management—power sharing between government and user groups—to reduce transaction costs and introduce incentives for stewardship (Hanna 2003, Olsson et al. 2004). Strategies also include the exploration of emerging markets in ecosystem services, such as water temperature or habitat for listed species. These markets provide an incentive to fully account for the services an ecosystem provides and offer the potential for recovering some of the costs of full ecosystem protection (Bayon 2002, Malloch 2005).

None of these strategies is right in all cases, and none is a sufficient condition for resilience. Salmon ecosystem resilience will depend on the full integration of human and ecological systems through an institutional structure that takes incentives and transaction costs into account. The challenge for resilience is how to make the transition from where institutions are to where they need to be.

Responses to this article can be read online at:
http://www.ecologyandsociety.org/vol13/iss2/art35/responses/

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