We exist in linked social and ecological systems. This should be a self-evident truth; however, it's not reflected in the manner in which we traditionally analyze and practice natural resource management. We have economists who model the economy, sociologists who explain how and why human communities behave as they do, and scientists who attempt to unravel the biophysical nature of ecosystems. They all generate powerful insights into how the world works; but these insights are partial. They are only one component of a system rather than the system as a whole. While there have been growing calls for greater integration of these various disciplines for years, it is only just starting to happen. (Holling and Meffe, 1996).

From Resilience Thinking: How Can Landscapes and Communities Absorb Disturbances and Maintain Function by Brian Walker and David Salt

resilience thinking:

What a resilient world might look like.

Brian Walker

"The most potent keystone species in the world may be the sea otter," wrote the biologist Edward O. Wilson.

These sleek, furry creatures that feed on sea urchins and shellfish once lived in coastal waters all the way from Baja, California, around the Pacific Rim, to the northern islands of Japan. Where they are present, the ecosystem tends to be characterized by dense kelp forests, which provide shelter for fish, and in turn provide food for harbor seals. In ecological terms, sea otters determine the regime that will govern the near-shore ecosystems that they inhabit.

Prized for their dense fur, they were hunted to near extinction in the eighteenth and nineteenth centuries. As otters disappeared, sea urchin populations grew unchecked. The urchins grazed heavily on kelp, leaving little food or shelter for fish. As fish populations declined so did the harbor seals.

This story of the otters and the urchins illustrates the ecological notion that there is a threshold between two different states. If a system changes too much, it crosses a threshold and begins behaving in a different way, with different feedbacks between its component parts—it takes on a different structure. It is then said to have undergone a regime shift. In the case of the otters, the near-shore waters that originally existed in one regime, crossed a threshold into another.

The role of people in the story of otters and sea urchins also illustrates another fundamental point. Ecological systems are inextricably linked with the social systems of people—in effect, all life exists within a social-ecological system. Changes in one domain of the system, either social or ecological, inevitably impact the other.

In thinking about systems and thresholds we might ask the following key questions about otters and urchins: If sea otter numbers were to begin rising, what density of otters would be required to shift the system back to the regime in which kelp, fish, and harbor seals were also abundant? And conversely, what density of sea urchins (otter food) could be sustained before the numbers of kelp, fish, and harbor seals decline?

These questions explore the concept of *resilience.* Resilience is the capacity of a system to undergo change and still retain its basic function and structure. In other words, it's the capacity to undergo some change without crossing a threshold into a different *system-regime.*

A Perennial Gale of Destruction

Resilience thinking presents an approach to observing and managing natural resources that embraces the complexity of human and natural systems. By studying ecosystems all around the world, researchers have learned that most systems of nature proceed through recurring cycles.

These systems continually adapt through cycles with four phases: rapid growth, conservation, release, and reorganization. The manner in which a system behaves is different from one phase to the next.

The easiest way to appreciate these *adaptive cycles* is to observe them. Think of a forest, going through a succession of species from pioneer to climax species. There is the front loop, which witnesses the forest resources (nutrients and biomass) slowly being accumulated and locked up in the trees and the various organisms they support. It's a long, reasonably predictable phase of increased growth. The longer this phase persists the more efficient it becomes in using resources, and in so doing, it eventually locks up available resources.

This locked up stage is the *conservation phase.* As it proceeds, the forest becomes less resilient and more vulnerable to shocks and disturbances. At some point, inevitably, the forest will experience a disturbance such as a fire, storm, or pest outbreak big enough to precipitate a collapse that releases the accumulated nutrients and biomass. The longer the forest has been in the late conservation phase, the smaller the disturbance required to send its resources into a short, chaotic phase of release. After the release, the forest reorganizes; some new and some of the existing species take hold, and a new growth phase of the next adaptive cycle begins.

Although ecologists have most thoroughly documented the adaptive cycle, it was an Austrian economist, Joseph Schumpeter, who sparked the original idea. Schumpeter analyzed the economy's boom and bust cycles, and in 1950 described capitalism as a "perennial gale of destruction." The term "creative destruction" is now used to describe the disturbances that periodically punctuate adaptive cycles in human systems and nature. In human systems, the breaking down of stability and predictability releases resources for innovation, new groups gain influence, and reorganization takes place. If we ignore or resist change, we increase our vulnerability and forgo opportunities.

Consider how adaptive cycles can operate in a human economic system. A new business that builds houses is innovative and keen to build up its market. It proves successful and starts growing. Over time it starts adapting to its own success by being more efficient at doing the things that it does well. Resources are optimized or locked up in doing things in the most efficient manner, such as buying equipment for building houses in a certain way. As a business concentrates the resources available, however, it becomes less resilient to change. The loss of flexibility increases vulnerability to an economic recession or the appearance of a competitor who builds different types of houses.

The rise of the just-in-time approach to manufacturing illustrates this tension between efficiency and resilience. In the traditional approach, manufacturers build up and then dispense with big stockpiles of materials. With the just-in-time approach, parts and supplies are delivered to a factory at the exact moment when they are needed. The system, deemed to be efficient and optimized, yields big savings in inventory expenses but is very sensitive to disruptions in any part of the supply chain.

Paradox of Optimization

In theory, an efficient economy optimally produces things people want and value. It leads to the elimination of redundancies. However, the *paradox of optimization* is that optimization is often applied too narrowly—redundancy (a large inventory) may be a safety valve. Such systems, as one that efficiently hunts down sea otters, are efficient in that they optimize resources for a narrow set of interests (otter pelts) and not for a wider range of values.

Such narrow goals lead to a loss of resilience in a business, an ecosystem, or the world economy (if it fills the air with pollution). More simply, a system that sustains timber yields but not the other benefits of a healthy forest does not really generate maximum value for society. This is the paradox of optimization.

Efficiency itself is not a bad thing, but when we apply efficiency principles to only a narrow range of values and a particular set of interests, we inevitably create unwanted outcomes. The history of ecology, economics, and sociology is full of examples such as the sea otters, showing that the systems around us, the systems we are part of, are much more complex than we often assume.

We are a long way from understanding how to create a resilient world. Nevertheless, keeping this fact in mind; it is possible to offer some visions for what a resilient world might look like.

- A resilient world would promote diversity (biological, landscape, social, and economic) that is a major source of future options in a system's capacity to respond to change.
- A resilient world would embrace and work with natural ecological cycles. A forest that is never allowed to burn loses its fire-resistant species and becomes very vulnerable to fire.
- A resilient world consists of modular components (such as a forest with discreet habitats). Any system that becomes too connected loses resilience. When over-connected, shocks rapidly transmit through a system as in a forest with discreet habitats that are more endangered by wild fires when connected by logging roads.
- A resilient world possesses tight feedbacks. Feedbacks allow us to detect thresholds before we cross them. Globalization is leading to delayed feedbacks that were once tighter. For example, people of the developed world receive weak feedback signals about the consequences of their consumption.
- A resilient world promotes trust, well developed social networks, and leadership. Individually, these attributes contribute to what is generally termed "social capital," but they need to act in concert to effect adaptability—the capacity to respond to change and disturbance.
- A resilient world places an emphasis on learning, experimentation, locally developed rules, and embracing change. When rigid connections and behaviors are broken, new opportunities open up and new resources are made available for growth.
- A resilient world has institutions that include redundancy in their governance structures and a mix of common and private property with overlapping access rights. Redundancy in institutions increases the diversity of responses and the flexibility of a system. Because access and property rights lie at the heart of many resource—use tragedies, overlapping rights and a mix of common and private property rights can enhance the resilience of linked social-ecological systems.
- A resilient world would consider all the un-priced (when users do not pay for the service or the damage to the system providing the service) ecosystem services (water filtration, etc) in development proposals and assessments. These services are often the ones that change in a regime shift and are only recognized and appreciated when they are lost.

Resilience thinking is not a panacea for all of the world's problems. It does, however, provide a foundation for achieving sustainable patterns of resource use. It encapsulates thinking that is significantly different than the ruling paradigm of maximizing returns via controlled optimal states in resource management—such as a forest that never burns, a rangeland that is never heavily grazed, or a business that never has to deal with financial or political adversity. It is only by probing the boundaries of resilience that resilience is maintained. The concept of resilience encourages us to ask a different set of questions about the way we manage our resources, and therefore ourselves.