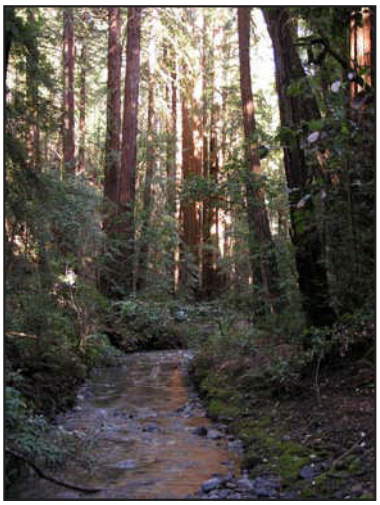
National Park Service
U.S. Department of the Interior
Inventory and Monitoring Program
Research Project Summary December 2008

Assessing the Ecological Health of Muir Woods and Redwood Creek

Importance: *Muir Woods National Monument preserves more than 560 acres of primeval redwood forest within the San Francisco Bay Area and hosts a variety of other significant natural resources such as the threatened northern spotted owl and the endangered coho salmon.*



Redwood Creek flows through Muir Woods National Monument.

Northern spotted owls make the old-growth redwoods their home, and Muir Woods and the rest of Marin County represent the southern limit of their range. Coho salmon use Redwood Creek throughout their life cycle, from migrating and laying eggs as adults to living in the stream as juveniles. These park resources as well as the experiences of nearly 800,000 visitors a year are shaped by important ecological parameters such as freshwater quality and quantity in Redwood Creek and by stressors such as invasive species.

Freshwater quality data provide key support for management and monitoring of aquatic or amphibian threatened and endangered species, wetlands, and riparian habitat. Certain ranges of water quality are required for different stream uses including fish habitat, migration, and spawning, and noncontact water recreation like bird watching. Long-term water quality monitoring can provide an important tool for detecting, assessing, and mitigating the impacts of climate and other types of change.

Streamflow, or the volume of water moving downgradient in a stream at any given time, reflects vegetation type, human use, weather and climate conditions, and soil characteristics. Streamflow controls critical habitat conditions in the river channel and floodplain. Invasive plant species alter landscapes and fire regimes, reduce native habitat, block views, and increase trail maintenance needs.

Inventory and Monitoring Programs: *Much like a doctor measures blood pressure and body temperature to assess health, the National Park Service tracks ecological indicators to measure the health of Muir Woods and other parks.*

For each ecological indicator, scientists collect a variety of measurements. For example, water quality is measured by collecting data on water temperature, dissolved oxygen, pH, conductivity, and discharge; the pathogen parameter coliform bacteria (total coliform and *E. coli*); and the nutrient parameters nitrate, ammonia, and total Kjeldahl nitrogen.

Coho salmon and northern spotted owls live in Muir Woods.

In some cases different measures are collected during different seasons. Fish biologists, for example, collect information on the number of adult coho salmon spawning and the number of redds (fish nests) during the winter. During the summer, the numbers of juvenile fish are counted. Some measurements are made continuously (e.g. stream flow) or at pre-determined intervals (e.g. monthly water quality sampling). Spotted owls are monitored during the breeding season when nests can be found and the number of fledglings counted.

Overall Health: *Muir Woods, Redwood Creek, and their resources appear to be relatively healthy, although coho salmon have been declining in recent years.*

Coho salmon comprise three "year classes" based on their three-year life cycles. The trends within one year class may be completely unrelated to those of another year class. The most startling recent monitoring finding was that no spawning coho were observed in Redwood Creek during the entire 2007-2008 winter monitoring period. At least one pair must have actually spawned because a small number of coho fry were observed the next spring. While a portion of this decline can be attributed to a regional oceanic phenomenon, local conditions that have not yet been pinpointed may also have been a factor.

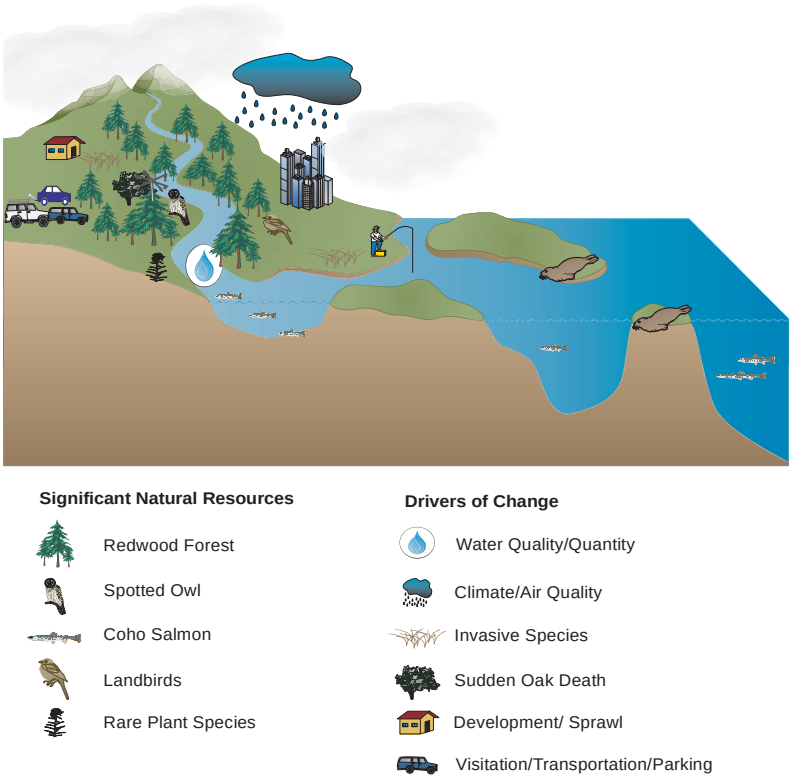
The number of known spotted owl territories in the region has remained stable. The Muir Woods pair did not nest successfully from 2004 to 2007, but they recovered in 2008. However, one breeding pair of invasive barred owls was found, which threatens the spotted owl population.

Surveys of invasive plants found one highly invasive species - cape ivy - in 23 patches in the Monument. Sudden Oak Death is also pervasive in the understory.

Streamflow is measured near the mouth of Redwood Creek where it enters the Pacific Ocean. The amount of flow in the stream varies monthly but generally peaks during winter rain events. The monitoring program has not existed long enough to determine flow trends.

Water quality samples were collected in Muir Woods in 2004 and 2005. The pH met the general objectives for aquatic life protection, as did dissolved oxygen. Total coliform, an indicator bacteria, was well below the limit for contact recreation. However, the water temperature was sometimes over the 12°C limit for salmonids, ranging from 11.0 to 12.6°C. Nutrients were also present at elevated levels. A consistent water quality sampling program for Redwood Creek began in 2008.

Conceptual Diagram
Muir Woods National Monument



Symbols courtesy of the Integration and Application Network (ian.umces.edu/symbols/), University of Maryland Center for Environmental Science.

Significant resources at Muir Woods include the redwood forest, Redwood Creek, spotted owls, and coho salmon. These are affected by a variety of drivers such as water quantity, water quality, and invasive species including Sudden Oak Death pathogens, barred owls, and exotic plants.

How do all these pieces fit together? Invasive weeds such as cape ivy can alter natural habitats, choking the vegetation where dusky-footed woodrats live. This is the spotted owl's favorite prey. Invasive species such as the Sudden Oak Death pathogen may change streamside vegetation and affect the shading of pools coho frequent in the summer. Invasive plants also may affect the nutrient and sediment levels in the stream. Coho are also heavily dependent upon streamflow. Rivers that dry can leave coho stranded or may cause redds to dry out. In contrast, overly strong currents can wash redds away. Fish are also very sensitive to water temperature, which is why the 12°C limit exists. The monument has been very active in restoring streamside habitat, removing invasives, and reducing visitor disturbances to protect these and other resources.

Additional Resources:

Summary written by Alison Williams. Find the executive briefings for individual vital signs including spotted owls and coho salmon at http://science.nature.nps.gov/im/units/sfan/ExecutiveBriefings.cfm. For more information contact Marcus Koenen, I&M Coordinator, San Francisco Bay Area Network Inventory and Monitoring Program, 415-331-5734.