



# Redwood Currents

Resource Management and Science Division

Volume 37

February 2013

## On the Wild Side



Adult marbled murrelet in breeding plumage.

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## The Marbled Murrelet Fog Robin of the Ancient Redwood Forest

By Keith Bensen, Fish and Wildlife Biologist

Each of the 36 issues of *Redwood Currents* over the past thirteen years has featured an article dedicated to telling the stories of the parks' notable fish and wildlife. Amazingly, this is the first time that *On the Wild Side* has spotlighted the animal that best exemplifies the intimate link between the huge coastal redwoods and the Pacific Ocean—the marbled murrelet. Much like the hard-to-know murrelets themselves, sometimes stories in this newsletter can remain untold for a long time. Recent studies have uncovered much about these

extraordinary seabirds and a good proportion of that science has taken place right here in Redwood National and State Parks (RNSP).

In the early 1970s, the nesting site of the marbled murrelet along the Pacific Coast was one of the great remaining ornithological mysteries of North America.

**How could a bird that numbered in the thousands when seen out at sea not have an obvious nesting place?**

*(Continued on page 3)*



Old growth redwood tree, right of center, where first marbled murrelet nest was discovered in the early 1970's in Big Basin State Park, California.

NPS Photo



Photo by Steve Sillett

Marbled murrelet chick on a nest in an old growth redwood tree in Redwood National and State Parks.

The mystery wasn't solved until 1974 when a maintenance worker in Big Basin State Park near Santa Cruz in central California was climbing in an old growth redwood tree less than a half mile from the park's main visitor center. Near the tree top, he saw a fluffy spotted nestling about the size of a robin sitting on a very large branch. Strangely, the chick had webbed feet. He took a picture of it and showed it to bird experts. Lo and behold, the nesting habitat of marbled murrelets was finally discovered—coastal old growth coniferous forests of the Pacific Northwest.

With the discovery of a murrelet nest in a tree, a major evolutionary leap in seabird biology was revealed. Most animals stick to a life style similar to other closely related species. Murrelets belong to the auk family (Alcidae) of birds that includes puffins, murrelets, and guillemots. All other alcids nest on isolated rocky islets or cliffs. But somewhere in the far past, a few murrelets' ancestors decided that those giant woody green things just inland off the coast made pretty good nest platforms too. When that happened, a seabird became a forest bird.

To become forest birds, marbled murrelets had to develop adaptations not typical of seabirds. Coloration was one. Most seabirds are white on the bottom to blend

in with the surface of the ocean when seen from below and dark on the back to blend in with the surface of the ocean when seen from above. During the non-breeding season, murrelets hold to that pattern. But during the nesting season, they turn reddish brown all over with a marbling of white spots, perfectly blending in with the sun-dappled shadows of the redwood canopy. The chicks are similarly well camouflaged. Murrelet eggs are also perfectly suited to their canopy environs, colored jade green with dark speckles. Another adaptation from ocean to forest has to do with parental arrivals and departures from the nest. Murrelets only come inland from the sea during the low light hours just before sunrise or just after sunset. This lowers their chances of being seen by an avian predator

that hunts during daylight. Once at the nest, one adult either feeds the chick and leaves as quickly as possible or makes a quick exchange with its partner if an egg is being incubated. The adult won't return for a full 24 hours, leaving the incubating adult or nestling to sit on the nest in absolute stillness, trying to stay as hidden as possible. Researchers using remote video cameras to record nest behaviors here in Redwood National and State Parks



Photo by Steve Sillett.

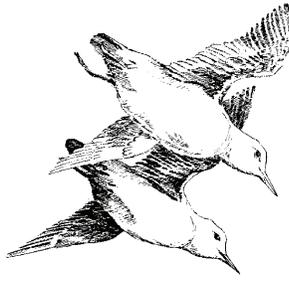
Close up of marbled murrelet egg and nest in Redwood National and State Parks.

*(Continued on page 4)*

have told me that watching hundreds of hours of a motionless bird takes the term *mind numbingly boring* to new heights. After a month of egg incubation and a month of feeding their rapidly growing chick, the murrelet parents abandon their chick to its fate. The chick, now half again heavier than its parents, needs every gram of that extra fat to undergo a simultaneous molt lasting just a few days. The chick loses all its spotted nestling down and replaces it with black-and-white subadult feathers in one fell swoop, a massively energetic process. The now boldly-patterned nestling stands out in a forest setting, but the soon-to-be fledgling is wonderfully cryptic for an ocean setting.

The fledgling leaps off the large branch that has been its only home and takes its first flight. Alone. On instinct only, the newly fledged bird must navigate up and out of the massive trees and westward to the ocean. If lucky, it will land just outside the surf zone, and dive beneath the sea where it will fly underwater like a penguin, chasing prey like sand lance, herring and anchovy. On rare occasions, fledglings don't make it all the way to the ocean. And on even rarer occasions, visitors and park staff sometimes find helpless fledglings on the forest floor (see inset box: If you find a marbled murrelet or murrelet eggshell on the ground).

After scientists learned that marbled murrelets nested in trees, they started to search for them up and down the



Pacific Northwest old growth coastal forests by looking up into the early morning sky and listening. Sometimes murrelets give out a robin-like “keer keer” call when flying over the forest.

Murrelets are fast fliers because their broad paddle-like wings require high speed to generate lift, so listening was as important as trying to see a small fast bird in the early dawn. It became immediately clear that murrelets were only found where there are large stands of old growth trees within a few tens of miles of the coast. In California, that meant that murrelets were only likely to be found in the redwood forests protected in California State Parks and Redwood National Park. Subsequent intensive at-sea population surveys have revealed that only 4,000 murrelets, give or take a thousand, exist off the coast of Redwood National and State Parks. Unfortunately, that population is by far the largest remaining in California. The only other large population of murrelets, numbering less than 100, is found off the Santa Cruz coast. These startlingly low numbers led to listing murrelets as threatened under the federal Endangered Species Act and endangered by the State of California. Oregon and Washington each have roughly the same number of murrelets as in California.

Almost all the old growth redwoods outside the parks are long gone. Even with the nesting habitat gone, conservation biologists hoped that at least the murrelet populations protected within the parks and forest reserves of the west coast would remain stable. Unfortunately, at-sea population monitoring surveys over the past ten years have indicated that the overall populations protected by listing has fallen by approximately 29%, despite little additional loss of nesting habitat over that same time period. Additional studies, including a key study conducted here in RNSP, discovered that one of the primary causes of the population decline is a high rate of nest predation, particularly by Steller’s jays and to a lesser extent common ravens, gray jays, and a few small forest



NPS Photo

Marbled murrelet fledgling ready for release after rehabilitation. The young bird was found by Redwood National and State Parks staff on the forest floor near a trail.

(Continued on page 6)

## What to Do If You Find a Live Marbled Murrelet on the Ground

Marbled murrelets are protected by the federal Endangered Species Act and the California Endangered Species Act and so normal state and national park policies to let nature take its course for injured wildlife is superseded. If you find a live marbled murrelet or a park visitor brings you one, the goal is to get the bird to a park staff biologist or ecologist quickly so that it may be given to a licensed, qualified wildlife rehabilitation center. Please do the following:

- ❖ Using gloves, if available, place the bird in a small (approximately 12"x12"), covered box or container with a towel on the bottom. Make sure the box has ample air holes. Cover the box with a towel. Keep all noises to a minimum to lower stress to the bird.
- ❖ Call a staff biologist or ecologist from either agency to arrange for a pick up or delivery as soon as possible. For the National Park Service (NPS), please call Keith Bensen, Kristin Schmidt or Terry Hines. For the California Department of Parks and Recreation (CDPR), please call Jay Harris or Amber Transou.

## What to Do If You Find a Marbled Murrelet Egg Shell

Over the past three years, 16 sets of marbled murrelet egg shells have been found on the ground beneath 14 different old growth redwood trees throughout Redwood National and State Parks by park staff and visitors. Tree climbing scientists climbed four of those trees in 2012 and found murrelet nests in three of them. Only a few dozen actual marbled murrelet nests have ever been found and so these recent discoveries have been very important for expanding our knowledge about where murrelets nest. If you find a marbled murrelet egg shell, please:



- ❖ Take a photo of the egg shell and tree it was found under, if possible. Also, map and discreetly identify, with a temporary mark, the tree that the egg shell was found under. Staff biologists and ecologist will return later to take more detailed measurements and map coordinates.
- ❖ Carefully package the egg shell, or fragments, in a non-crushable, padded container. Send the container, location information, and photos to either Keith Bensen or Amber Transou.



Scientists Luke George, Will Goldenburg and an assistant place color bands on a Steller's jay in Elk Prairie campground.

NPS Photo

mammals. Most troublesome have been the results of more studies and monitoring here in RNSP, and elsewhere, that have demonstrated that where there are high numbers of park visitors with food, like in campgrounds, there are very high numbers of Steller's jays. Due to the jays' systematic foraging patterns, this means that where you have more jays you have much higher chances of a murrelet nest becoming predated because there are more predatory eyes searching per unit area. The equation is simple: more human food available to jays in an area = more jays in that area = more murrelet eggs eaten and more dead chicks in or immediately adjacent to that area. Researchers in RNSP have shown that the area of effect extends up to one kilometer outside of the campgrounds.

Redwood National and State Parks and our conservation partners have gone all in to address this problem. Over a million dollars have been spent on marbled murrelet conservation in RNSP in the last 15 years. An adaptive management process was adopted to deal with an initial dearth of information. Scientists were brought in to study everything they could about how Steller's jays and common ravens live in the parks' campgrounds and old growth forests so that the parks can best tailor management options to preserve murrelets.

Campground infrastructure has been redesigned to limit the amount of food waste available to wildlife. A huge visitor education campaign has been launched to educate visitors to prevent the intentional and unintentional feeding of wildlife to cut off the supplemental food supply to the murrelets' predators. One principle of adaptive management is monitoring to see how well



NPS Photo

Steller's jay and common raven proof campground wash station drain grate.

actions work and if something else would work better. Social scientists evaluated the efficacy of the education campaign itself. The result has been a recent revamping of the campaign to best modify the behavior of park visitors in the most effective

*(Continued on page 7)*

manner. See Figure 1 for an example of the new logo and motto that resulted from the study. Park staff have been monitoring Steller's jay populations to see whether all the effort is resulting in any real change. The summer of 2012 was the first year of monitoring that showed any positive change (see Figure below). Monitoring in the upcoming few years will tell park managers whether this change was an actual move in a positive direction or simply natural variation in nest predator populations. In case these parks management actions aren't enough, additional researchers have been brought in to test even more potential management options. The weirdest option to some folks is conditioned taste aversion. A recent laboratory and field experiment in RNSP used emetic-laced dummy eggs painted to look like murrelet eggs to teach Steller's jays to not eat murrelet eggs; emetics are vomit-inducing chemicals that animals learn have unpleasant effects. The experiment was surprisingly successful and less expensive to implement than originally thought. Depending on what future

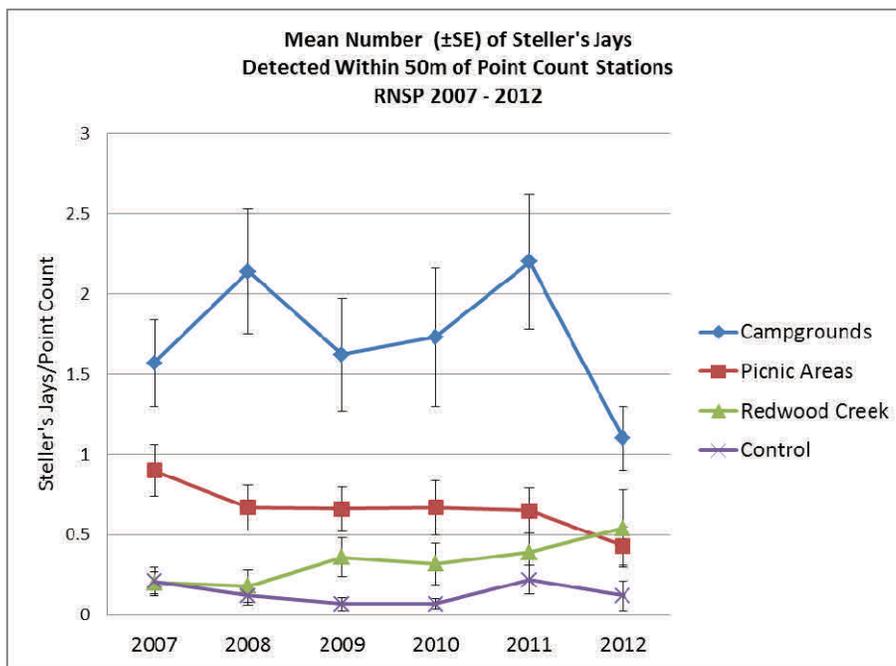
Steller's jay monitoring indicates, this new management technique may or may not be implemented as a management strategy.



Figure 1. New logo and graphics for Redwood National and State Parks Do-Not-Feed-the-Wildlife visitor education campaign.

The close association of the marbled murrelet and old growth coastal forests and the science done in RNSP make the murrelets truly an iconic bird in the parks. The Redwood Parks Association has even adopted murrelets as a kind of redwood wildlife mascot, festooning park memorabilia with their image. And about that arcane title: even though scientists didn't know that marbled murrelets lived up in the old redwood trees before the early 1970s, locals knew something lived

high in the canopy. In the early morning, they would hear something "keer keer'ing" over their heads in the often misty skies. They called them fog robins. Through science-informed management, RNSP should hopefully be a place that future generations can listen to the calls of the fog robins too.



Mean number (plus/minus standard error) of Steller's jays detected at monitoring stations located in Redwood National and State Parks from 2007 to 2012.

## Want to Know More?

Below are some recent publications and reports on marbled murrelet, Steller's jay and common raven research and monitoring done in Redwood National and State Parks.

Gabriel, P.O. and R.T. Golightly. 2011.

**Experimental Assessment of Taste Aversion Conditioning on Steller's Jays to Provide Potential Short-Term Improvement of Nest Survival of Marbled Murrelets in Northern California – Report to National Park Service.**

Humboldt State University, Dept. of Wildlife, Arcata, CA. Unpublished report on file at Redwood National and State Parks, South Operations Center, Orick, CA, 36 pp.

Goldenburg, W., J.T. Black, T.L. George. In Preparation. **Steller's Jay Space Use in Redwood National and State Parks.** Humboldt State University, Arcata, CA.

Hebert, P.N. and R.T. Golightly. 2006.

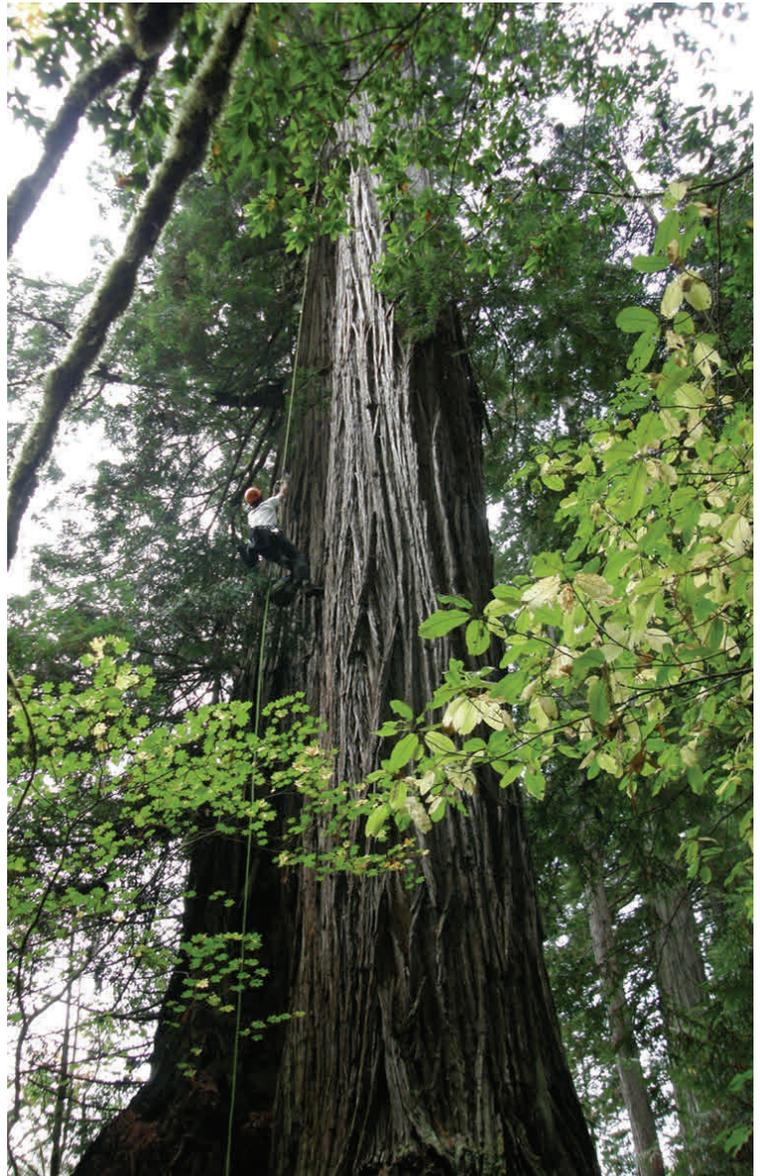
**Movements, Nesting, and Response to Anthropogenic Disturbance of Marbled Murrelets (*Brachyramphus marmoratus*) in Redwood National and State Parks, California.**

Unpublished report, Dept. of Wildlife, Humboldt State University, Arcata, California and California Department of Fish and Game Report 2006-02, Sacramento, California. Unpublished report on file at Redwood National and State Parks, South Operations Center, Orick, CA, 321 pp.

Redwood National and State Parks. 2013. **Forest and Beach Corvid Monitoring and Management and Backcountry Management Plan Implementation – 2012 Annual Progress Report.** Unpublished report on file at Redwood National and State Parks, South Operations Center, Orick, CA, 26 pp. Also available on the Redwood National and State Parks intranet at: <http://inpredwgis2/redw/office/parkoffice.cfm?office=corvid>.

Scarpignato, A.L. 2011. **Home Range and Habitat Use of Breeding Common Ravens in Redwood National and State Parks.** Master of Science Thesis, Humboldt State University, Arcata, CA. 43 pp.

Ward, C., J. Taylor, S. Martin. 2011. **Evaluation of Communication Strategies to Mitigate Visitor Use Impacts on Marbled Murrelets – Final Report** Submitted to Redwood National and State Parks. Humboldt State University, Arcata, CA. Unpublished report on file at Redwood National and State Parks, South Operations Center, Orick, CA, 129 pp.



NPS Photo

Scientist Jim Spickler climbing old growth redwood tree to search for marbled murrelet nests.

# Volunteers Support Resource Management in So Many Ways!

By Stassia Samuels, Plant Ecologist

**I**n FY12 the Resource Management and Science Division (RMS) hosted 82 volunteers, who contributed a total of 7,993 hours of their personal time to support Resource Management and Science activities. That is the equivalent of nearly four full-time employees!



All branches of RMS utilized volunteers and interns, who came from all over the country, and as far away as England. However, we also had great support from local volunteers—both community members and Humboldt State University students (HSU).

Some volunteer program profiles:

**Vegetation Management:** Vegetation Management volunteers and interns worked primarily in invasive plant control, with some significant volunteer time put into rare plant and phenology monitoring, forest restoration, and assistance with Amy Livingston's Bald Hills vegetation centered Master's thesis. For the first time, Student Conservation Association (SCA) interns worked a full 12 week season controlling Harding grass.

**Geology:** Devin Schwartz was a HSU student who developed a digital geologic map of RNSP for her Geology Capstone Project. She assessed the 1987 Weed Sheet digital geologic map and improved upon the map attributes with additional data. She also worked on integrating the digital geologic symbols and attributes from different agencies. Both of these products will be very useful to the Geology Branch for planning and interpretive purposes and they will also be provided to the California Geologic Survey.

**Cultural Resources:** Redwood National Park (REDW) Cultural Resources staff managed volunteers from Humboldt State University, University of Colorado at Boulder, and the National Council for Preservation Education interns to catalog museum objects and archives. This work resulted in the inventory or processing, re-housing, and cataloging of 358 linear feet of REDW archives and 38.5 linear feet of archival materials for Lassen Volcanic National Park. Our volunteers came from near Council Bluffs, Iowa; Tucson, Arizona; Lawrence, Kansas; New York, New York; and Humboldt County. To find out more about their work, see the Curator's Corner feature article *Economies of scale: WHIS, LAVO, RNSP share Redwood's Museum Expertise* in the July 2012 *Redwood Currents* edition.



Vegetation management Volunteer In the Parks (VIP) Amanda Mahaney (SCA), Brad Huffstedtler (SCA), Peter Ngyuen (HSU) and Damien Hawley-Jones (HSU)

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South Operations Center also hosted six job shadowing students from Arcata High School, four of which volunteered for half a day with Vegetation Management, Fire Management, and the Interpretive Division, learning about jobs in the NPS.

## FY13 Volunteer Highlights

Resource Management and Science is currently hosting six volunteers from afar. **Pascal Walther and Esther Aemisegger** are from a village in the Swiss Alps, and have volunteered three months of their time here. Pascal is a forester and Esther is a naturopath. They have primarily helped with forest restoration, invasive plant control and trail crew; have helped us enter years of historical rare plant data into our geodatabase; and of course, given us lessons in the fine art of fondue! Esther and Pascal's contributions have been huge and we are very thankful that they included REDW in their journey across North America.

**Amanda and Brandon Piper** have recently arrived from Ohio, and will be working primarily with Fish and Wildlife, with some vegetation management and hydrologic monitoring. Brandon worked in invasive plant control and Amber worked with a non-profit at Yosemite National Park (YOSE) and bring that experience, plus a great attitude here to REDW! If you see them, be sure to say hello!



International VIP's Pascal Walther and Esther Aemisegger

Vegetation Management will also welcome **Graham Sivak** as an intern with the Student Conservation Association from February–April. Graham comes with several seasons of paid vegetation experience and will be staying at the Williams house.

**Kendall Story** has been on board with the Geology Branch since the beginning of January. She is a GeoCorp intern and is helping out with the Hydrologic Monitoring program. Kendall is backfilling the vacant Hydrologic Technician position and she has been instrumental in keeping our gaging stations operational and helping monitoring flow and sediment in Prairie Creek as well as analyze water samples.



Amber Piper



Brandon Piper



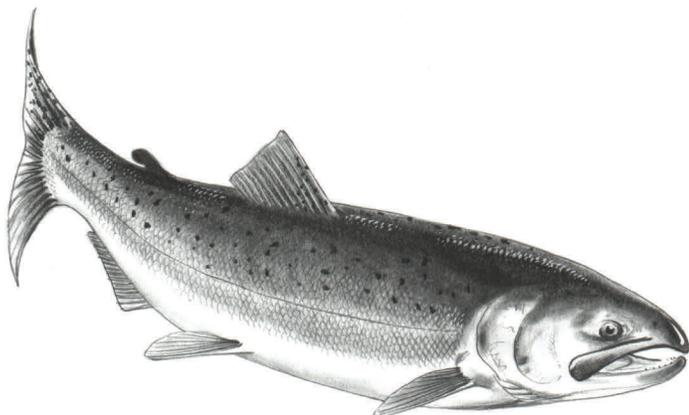
Kendall Story

# Linking Physical Monitoring to Coho and Chinook Salmon Populations in the Redwood Creek Watershed

By Mary Ann Madej, Research Geologist, Western Ecological Research Center, Arcata

U.S. Geological Survey scientists hosted a workshop at the RNSP Arcata office in May 2012 for researchers and resource managers working in RNSP to share data and expert opinions on salmon populations and habitat in the Redwood Creek watershed. The workshop focused on how best to synthesize physical and biological data related to the freshwater and estuarine phases of salmon life cycles to increase our understanding of constraints on salmon populations.

The health of salmonid populations is a major research topic for national park units with coastal streams that once supported abundant salmon runs. This workshop was a contribution to the research efforts of the U.S. Geological Survey (USGS) Status and Trends (S&T) Program National Park Monitoring Project (<http://www.fort.usgs.gov/brdscience/ParkMonitoring.htm>), which supports USGS research on priority topics (themes) identified by the National Park Service Inventory and Monitoring Program (I&M) and S&T.



## Workshop objectives were to:

- Provide RNSP natural resource managers with initial data compilations, analyses, and syntheses in forms relevant for decisions on issues of park concern, such as restoration of native habitats.
- Solicit expert opinions on conceptual models representing various synthesis approaches.
- Show an example of synthesis of data on salmonid populations and physical habitat conditions developed for the San Francisco Bay Area I&M network.
- Examine datasets from Prairie Creek, Redwood Creek, and the Redwood Creek estuary to develop conceptual models that synthesize the vital signs of Redwood National Park for park management use.
- Solicit input from the group to identify the synthesis approach that best fits the available data and the needs of park resource managers and specialists.
- Identify data gaps and action items to advance analyses.
- Engage workshop participants in the effort to fill data gaps by contributing their as-yet-unincorporated data into models or by deriving proxies for data gaps.

A summary of the workshop is available at:

<http://www.werc.usgs.gov/ProductDetails.aspx?ID=4834>

# Update: California Phenology Project

By Stassia Samuels, Plant Ecologist

Thanks to an amazing suite of volunteers, RNSP completed its first full season of phenology monitoring in 2012! Here are a few program highlights:

- ❖ In April the phenology team from UC Santa Barbara visited REDW. We hosted a series of four public workshops in Crescent City, Orick and Arcata to inspire community interest in the phenology project, including an article in the Times Standard. Over 75 people attended these workshops, including agency and tribal representatives as well as students and members of the general public.
- ❖ The interpretation division joined the fun and seasonal interpreter Steven Krause wrote a phenology feature article for the 2012 visitor guide and presented talks and walks featuring the phenology project.
- ❖ The core of the program is the phenology monitoring itself, which was championed by the following five extremely dedicated volunteers:

- **Hannah Waterhouse**, an Humboldt State University student using phenology for her senior biology project, made 737 individual plant observations at the Kuchel Visitor's Center (KVC) and Lady Bird Johnson Grove (LBJ), ranked 58<sup>th</sup> in the national list of top phenology observers ever and was our first dedicated volunteer.
- **Robert DiPaolo and Lily Pastel**, HSU botany students, made 716 observations between them at the KVC and LBJ sites, ranking 61<sup>st</sup> in the national list.
- **Patree Scheid** almost singlehandedly kept the Crescent Beach Overlook sites going, making a total of 1,245 observations and ranked 36<sup>th</sup> nationally.
- **April Shackleford** took on coordination duties, and also managed to make 1,446 observations earning her the rank of 25<sup>th</sup> top phenology observer in the nation!



NPS Photo



Phenology volunteer and coordinator April Shackleford

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In our second year, we faced several challenges, including:

- ❖ Finding enough volunteers to keep the observations coming in
- ❖ Locating our monitoring plants in places that are easily accessible/findable while also being safe from trailside maintenance activities and visitor wildflower picking
- ❖ Public vandalism of tagged plants
- ❖ Plants tagged in 2011 not coming up in 2012

As a pilot program, we welcome challenges as opportunities to refine the program and our experiences will inform the monitoring protocol/guides that the phenology team is developing for national distribution.

For more information on the California Phenology Project see *California Phenology Project: How Climate Change is Changing the Seasons* in the February 2012 *Redwood Currents* edition.



## Interested in learning more or helping out?

We are looking for back-up phenology observers for the north and south sites for times when our regular volunteer monitors are unavailable. Monitoring will start up again in the spring with the emergence of the trillium, and continues through the fall when the coyote brush finally fruit. If you are interested in learning more, or helping out, please contact Stassia Samuels, plant ecologist, X7784.

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## Acronym List

|                 |   |       |  |
|-----------------|---|-------|--|
| °C              | Degrees Celsius                               | m     | meters   |
| C               | Carbon  | Mg    | Mega-grams   |
| CASA            | Carnegie Ames Stanford Approach               | NASA  | National Aeronautics and Space Administration          |
| CNPS            | California Native Plant Society               | NCASI | National Council for Air and Stream Improvements, Inc. |
| CDFG            | California Department of Fish and Game        | NPS   | National Park Service                                  |
| CDPR            | California Department of Parks and Recreation | NRCS  | Natural Resources Conservation Service                 |
| cm              | centimeter                                    | REDW  | Redwood National Park                                  |
| CO <sub>2</sub> | Carbon Dioxide                                | RNSP  | Redwood National and State Parks                       |
| COLE            | Carbon On-Line Estimator                      | S&T   | Status and Trends                                      |
| CPP             | California Phenology Project                  | SCA   | Student Conservation Association                       |
| ESA             | Endangered Species Act                        | SOC   | South Operations Center                                |
| FIA             | Forest Inventory and Analysis                 | UC    | University of California                               |
| GIS             | Geographic Information System                 | UCSB  | University of California Santa Barbara                 |
| ha              | Hectare                                       | US    | United States  |
| HSU             | Humboldt State University                     | USFS  | United States Forest Service                           |
| in              | inches  | USFWS | United States Fish and Wildlife Service                |
| I&M             | Inventory and Monitoring                      | USGS  | United States Geological Service                       |
| IPCC            | Intergovernmental Panel on Climate Change     | VIP   | Volunteer in the Park                                  |
| KVC             | Kuchel Visitor's Center                       | YOSE  | Yosemite National Park                                 |
| LBJ             | Lady Bird Johnson Grove                       |       |  |

# Mapping Ecosystem Carbon Stocks at RNSP

By Phil van Mantgem, USGS Forest Ecologist, Joe Seney, RNSP Soil Scientist, and Mary Ann Madej, USGS Research Geologist

**R**apid climate change will require changes in stewardship of parks and protected areas. Release of greenhouse gasses (primarily CO<sub>2</sub>) into the atmosphere has led to increases in global temperatures of 0.6 °C over the past 50 years (IPCC 2007). Warming trends are expected to exacerbate the effects of other ecosystem stressors, such as air pollution and the spread of exotic species. Reducing greenhouse gas emissions in park operations is already a priority (e.g., Climate Friendly Parks Program), but managing ecosystem carbon stocks is a relatively new consideration. Terrestrial ecosystems store vast amounts of carbon, on the order of about 2205 to 2756 billion tons C (2000 to 2500 billion Mg) (Houghton 2007) (see inset box— What is a Megagram). Much of the terrestrial carbon is found in soil, but in forests a large proportion of ecosystem carbon can be stored in vegetation. In contrast, the atmosphere is estimated to contain approximately 882 billion tons C (800 billion Mg).

## *What is a Megagram?*

**1 megagram (Mg) = 1 million (10<sup>6</sup>) grams = 1 metric tonne = 2205 pounds = 1.1 tons**

A first step in the management of ecosystem carbon stocks is to create an inventory of what is to be managed. However, estimating carbon stocks at RNSP pose several challenges. First, RNSP span diverse geologic conditions underlying a variety of habitats including estuaries, riparian areas, grasslands, oak woodlands, and coniferous forests. Each of these habitats has varying ecosystem carbon stocks. Second, the massive size and the slow decomposition of old-growth redwood (*Sequoia sempervirens*) make it difficult to accurately estimate old-

growth forest carbon stocks. Last, the history of logging at RNSP has resulted in forest stands of different ages, each with typical carbon stocks. In this article we describe our efforts to map ecosystem carbon in soils and forests at RNSP.

## *Carbon Stored in Soils*

Fortunately at RNSP, we have relatively recent soil surveys that allow a reasonably precise estimate of soil carbon stocks (USDA-NRCS 2008). There are 87 soil map units and 442 soil components mapped in RNSP. Organic and inorganic carbon content, bulk density, percent rock fragments, thickness of horizons for each soil component, and the extent of soil components and map units were used to estimate soil carbon content to a depth of 1.5 to 2 m.

Average carbon content varied among soil map units and soil components, ranging from 5 tons per acre (11 Mg per ha) in floodplain soils with little vegetation cover to 209 tons per acre (468 Mg per ha) in moist redwood forests with a thick herbaceous understory. Overall there is approximately 13,531,422 tons (12,275,500 Mg) of carbon stored in soils of RNSP, or an average of 95 tons per acre (213 Mg per ha) (Figure 1). A comparison of the soil organic carbon stock values of different vegetation types in RNSP shows that the soil carbon stocks generally decrease with increasing landscape instability and distance from the ocean (related to decreasing plant productivity).

## *Carbon Stored in Vegetation*

We combined cover data from the RNSP vegetation map with estimates of carbon content for vegetation types from publically available online tools. Specifically, we used the US Forest Service's (USFS) Carbon On-Line

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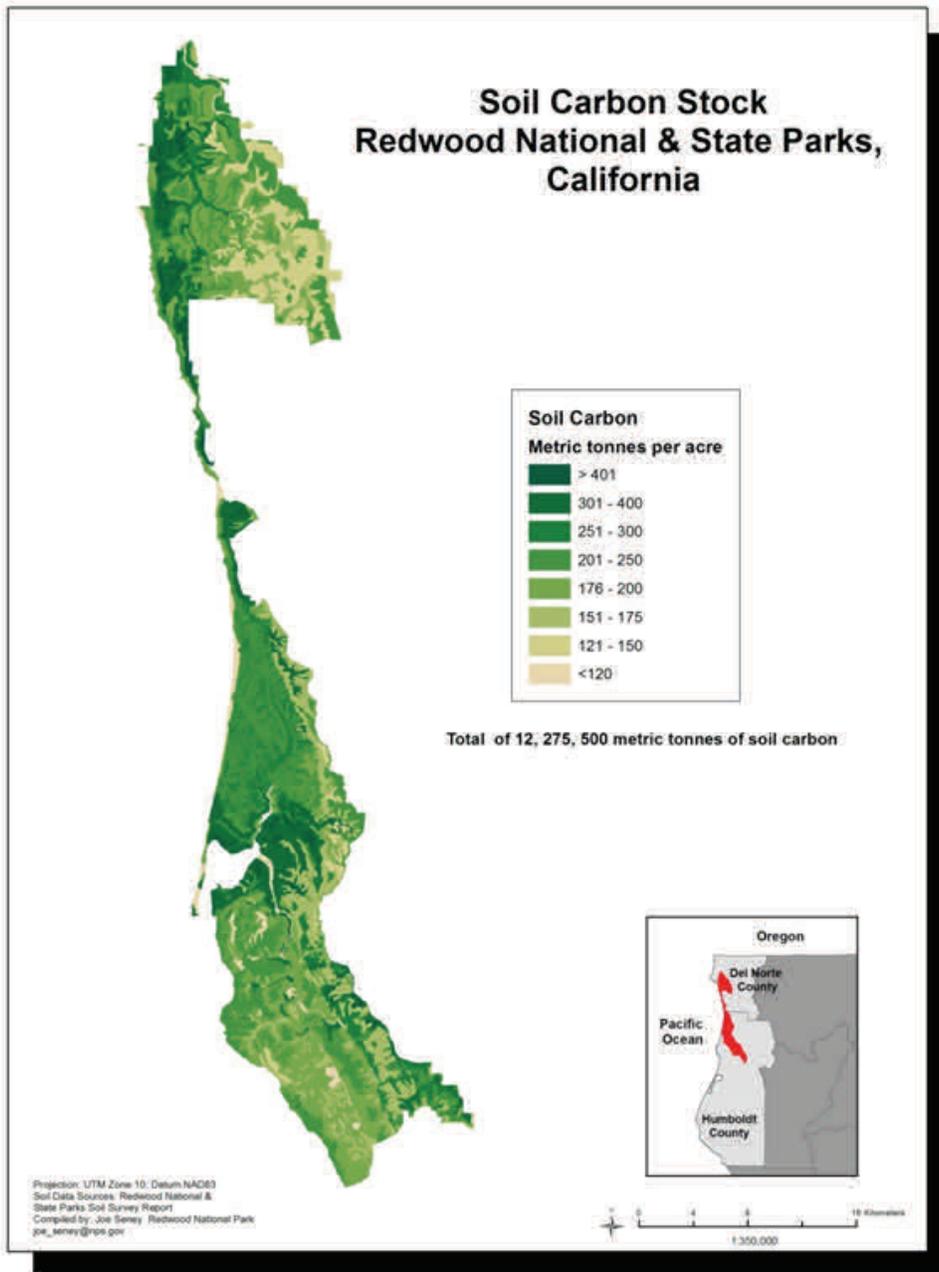


Figure 1. Map of soil carbon stocks at RNSP and the BLM property in the Park Protection Zone.

Estimator (COLE) (NCASI 2011) and NASA’s carbon modeling tool and estimates for live forest carbon provided by the NASA-Carnegie Ames Stanford Approach (CASA) (Potter et al. 2008). COLE uses USFS Forest Inventory and Analysis (FIA) data and known relationships between individual tree size and carbon content to estimate carbon by forest type (species composition and age class). Users can define the scope of the FIA data from local to national, although the number of FIA plots used by COLE may be very small for specific locales. We used data at the county level, representing a

trade-off between locally derived data and sample size (~20 FIA plots per major forest type). The CASA model uses remotely sensed vegetation cover data with FIA-derived estimates of carbon content per unit area of vegetation type throughout the continental United States.

From COLE, carbon held in vegetation at RNSP was estimated to be 18,987,482 tons (17,225,154 Mg), of which 71% was from standing wood (live and dead trees)

*(Continued on page 17)*

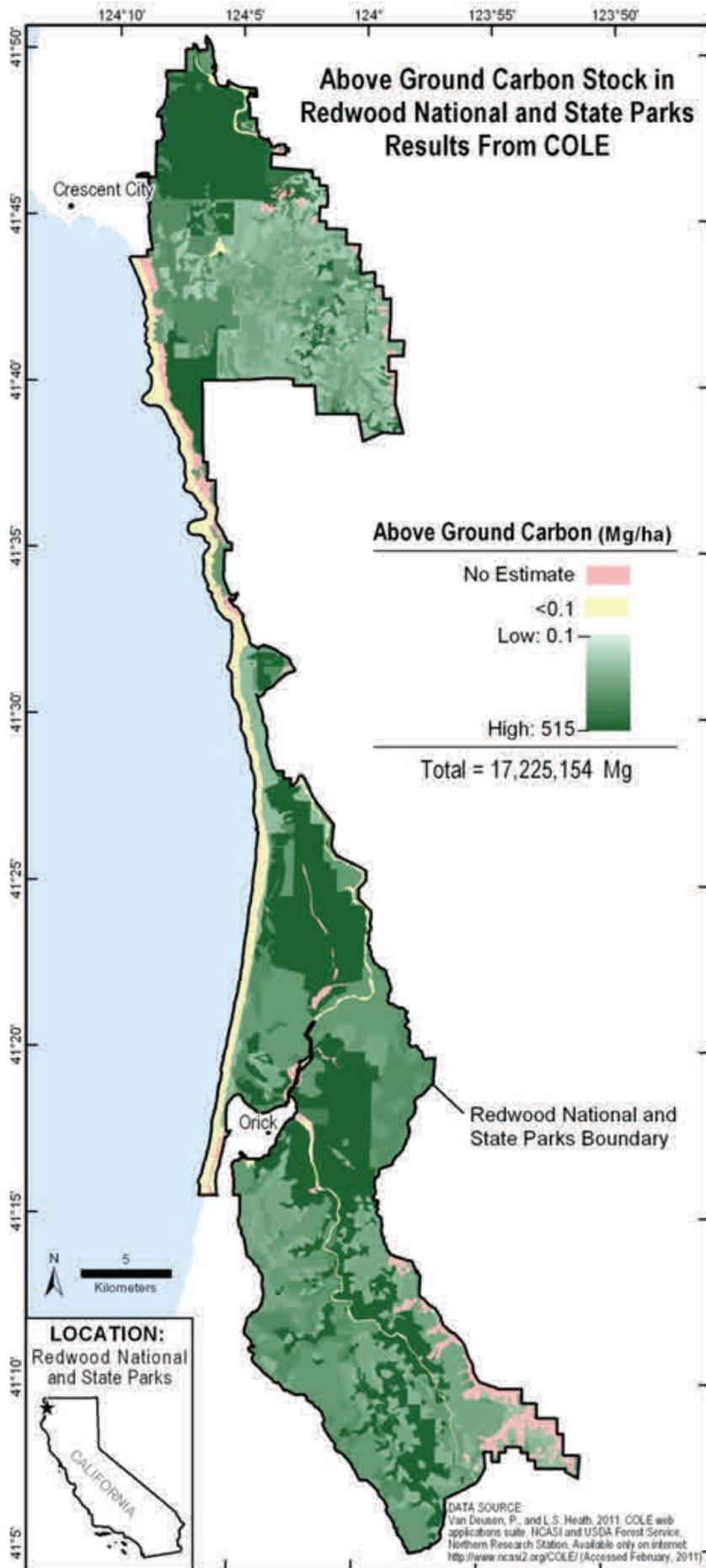


Figure 2. Above ground carbon stock estimates for RNSP and the BLM property in the Park Protection Zone. Estimates were derived from US Forest Service’s Carbon On-Line Estimator (COLE) (see text) and applied to the Park’s best available vegetation data as of January 2013.

(Figure 2). The CASA model gave a much higher estimate of live forest carbon, 65,422,604 tons C (59,350,388 Mg C), over five times the COLE estimate. The largest discrepancy between these models was for old-growth redwood forests. We do not know which estimate is more accurate.

### *What do these estimates mean for park management?*

Accounting for ecosystem carbon stocks is important as parks seek to become carbon neutral. Protecting existing ecosystem carbon stocks may be a primary consideration for managers in this context. Catastrophic ecosystem carbon losses from pathogen outbreaks or wildfires that destroy large swaths of forest could overwhelm any carbon savings from reduced fossil fuel use. Land management may also have substantial effects on carbon stocks. Our analyses of RNSP road removal projects suggest long-term carbon savings, particularly when removals occur in young forests (Madej et al. 2012)(see article *What Does Road Rehabilitation Have to do with Carbon Budgets* in this issue). Other studies are exploring the effects of second-growth thinning on forest carbon (van Mantgem and Das *In review*). With a diversity of physical and biological systems RNSP can be thought of as a microcosm for many other areas in the western US, making the approaches we present here potentially useful to other parks.



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# What Does Road Rehabilitation Have to Do with Carbon Budgets?

By Mary Ann Madej, USGS Research Geologist, Western Ecological Research Center, Arcata

**T**hrough the first major road decommissioning program in the United States, Redwood National Park has treated 425 kilometers (264 miles) of abandoned logging roads since 1978. While similar projects around the nation aim to reduce soil and habitat impacts from roads, the exact effects of forest road decommissioning on carbon emissions and sequestration are not yet clear. Mary Ann Madej and Phil van Mantgem of the USGS and Joe Seney of REDW recently assessed the carbon budget implications of the 30-year road removal program. They examined the carbon costs (= emissions) and carbon savings (= sequestration) of various road restoration techniques that evolved during the Redwood program.

Treatment of 425 km of logging roads from 1979 to 2009 saved 72,000 Mg of carbon through on-site soil erosion prevention, revegetation, and soil development on former roads. Carbon sequestration will increase in time as forests and soils develop more fully on the restored sites.

The carbon cost for this road decommissioning work, based on heavy equipment and vehicle fuel emissions, short-term soil loss, and clearing of vegetation, was 23,000 Mg of carbon. Mechanical vegetation removal was found to be a key carbon cost. Carbon costs of road decommissioning can be reduced by using fuel-efficient equipment and minimizing vegetation removal.

Overall, the project resulted in a net carbon savings of 49,000 Mg of carbon to date. The carbon costs associated with road removal are not trivial, but the carbon savings outweigh carbon costs in the coast redwood ecosystem.

Research continues to examine the soil organic carbon content of soils at various ages of removed roads. While the ratio of carbon costs to savings will differ by ecosystem and road removal technique, the procedure outlined here to assess carbon budgets on restoration sites should be transferable to other systems. The full report was published in "Restoration Ecology" and is available at: <http://www.werc.usgs.gov/ProductDetails.aspx?ID=4792>



NPS Photo

Example of recent road rehabilitation project in Redwood National and State Parks.

# Taking the Pulse of the Forest: Klamath Network Old Growth Forest Plots

By Phil van Mantgem, USGS Forest Ecologist, Western Ecological Research Center, Arcata

Old growth forests may appear timeless, but there are many recent examples showing how climate change may already be impacting these forests. How will old-growth forests and their associated biota respond to changing climates across the Klamath region? A joint venture between NPS, Bureau of Land Management (BLM) and USGS to measure changes in old-growth forest is attempting to answer this question.



To date this project has established 16 large (approximately 2 acre) monitoring plots in old growth forests at the Cascade-Siskiyou National Monument (NM), Oregon Caves NM, Crater Lark National Park (NP), Lassen Volcanic NP, Whiskeytown National Recreation Area, Lava Beds NM and Redwood NP. At each site forests are mapped and individual trees are measured, with repeated censuses allowing for estimates of tree growth, reproduction and mortality. The 2013 field season will see remeasurements occurring here at Redwood National Park.

Initially, we will describe how forests change across the steep marine to continental climatic gradient in the Klamath region. Continued monitoring at these will be critical if we want to understand how our forests function and how they might respond to changing climates and biological invasions.



USGS Photo

Measuring the big trees at Redwood National Park.



# Hot off the Press

## New Publication and Reports

Hodge, B. 2010. Life history variation in *Onchorhynchus mykiss* from the lower Klamath River basin. M.S. Thesis, Humboldt State Univ., Arcata , CA. 113 pp. [PDF](#)

Fritschle, J.A. 2011. Identification of old-growth forest reference ecosystems using historic land surveys, Redwood National Park, California. *Restoration Ecology*. Vol. 20. No. 6. Pp. 679-687.

Madej, Mary Ann, Torregrosa, Alicia, and Woodward, Andrea. 2012. Linking physical monitoring to coho and Chinook salmon populations in the Redwood Creek Watershed, California—Summary of May 3–4, 2012 Workshop: U.S. Geological Survey Open-File Report 2012-1245, 24 p.

The URL for this publication is <http://pubs.usgs.gov/of/2012/1245/>.

Madej, Mary Ann, Torregrosa, Alicia, and Woodward, Andrea. 2012. Vital Signs of Salmon Streams: North Coastal California National Park Units. (Redwood NP, Point Reyes NS, Muire Woods NM and Golden Gate NRA)

<http://www.werc.usgs.gov/ProjectSubWebPage.aspx?SubWebPageID=1&ProjectID=229>

McCraney, W. T., G. Goldsmith, D. K. Jacobs and A. P. Kinziger. 2010. Rampant drift in artificially fragmented populations of the endangered tidewater goby (*Eucyclogobius newberryi*). *Molecular Ecology* 19, 3315-3327. [PDF](#)

Metheny, M.D. 2012. Use of Dual Frequency Identification Sonar to Estimate Salmonid Escapement to Redwood Creek, Humboldt County, California. M.S. Thesis. Humboldt State University, Arcata, California. 90 pp.

Poxon, B. 2012. An investigation into the efficiency of observers to visually detect adult salmon spawning in the Prairie Creek watershed, Humboldt County, California. M.S. Thesis, Humboldt State University, Arcata, CA. 52 pp. [PDF](#)

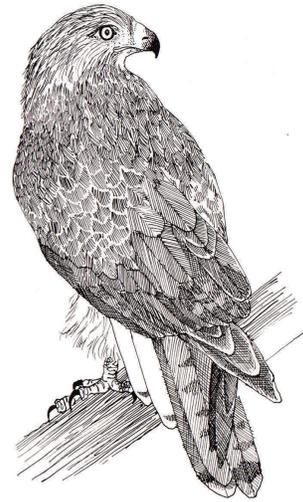
Scarpignato, A.L. 2011. Home Range and Habitat Use of Breeding Common Ravens in Redwood National and State Parks. Master of Science Thesis, Humboldt State University, Arcata, CA. 43 pp.

Ward, C., J. Taylor, S. Martin. 2011. Evaluation of Communication Strategies to Mitigate Visitor Use Impacts on Marbled Murrelets – Final Report Submitted to Redwood National and State Parks. Humboldt State University, Arcata, CA. Unpublished report on file at Redwood National and State Parks, South Operations Center, Orick, CA, 129 pp.

Wright, K. A. 2011. Escapement, migration timing, and spatial distribution of adult Chinook and coho salmon in Prairie Creek, California. M.S. Thesis, Humboldt State Univ., Arcata , CA . 127 pp. [PDF](#)

# Resource Management & Science Division

## Field Schedules February—June 2013



**Division Chief:** Dave Roemer x7700

**State Park Liaison:** Virginia Moran x7772

### **Cultural Resources:**

Karin Anderson, Branch Chief x7710

- **Information on archeology, historic barns and Bald Hills cultural sites, Tribal issues and ethnographic resources** – Karin Anderson, x7710
- **Museum and archive access, collecting, and research permits** – Bow O'Barr, Park Curator x7711

### **GIS:**

Dave Best, Branch Chief x5146

- **Geospatial data and supporting services (maps, databases, InsideREDW)** – Judy Wartella, GIS specialist x7721

### **Fire Management:**

Rick Young, Fire Management Officer x7730

- **Fire coordination and planning**—Rick Young, Fire Management Officer x7730
- **Prescribed fire** –John “Johnny Mac” McClelland x7732
- **Fire ecology studies**—Eamon Engber

### **Fish and Wildlife:**

Aida Parkinson, Branch Chief x7703

#### **Environmental planning**

Surveys take place throughout the year, with most wildlife surveys between March and September. Contact the biologists below for current and upcoming field opportunities.

#### **Aquatic**

- **Electrofishing to determine distribution of listed fishes**—August~October; David Anderson x7771
- **Salmonid population estimate and growth study**—June~October; David Anderson x7771
- **Steelhead snorkel survey**—late July~early August; David Anderson x7771
- **California Dept. of Fish and Wildlife, lower Redwood Creek**—contact David Anderson x7771 to visit CDFW's outmigrant trapping station near Orick

#### **Birds**

- **Bald eagle nest observations and potential nesting sites**—February~July; Keith Bensen, x7777
- **Corvid management surveys**—May~September; Keith Bensen, x7777
- **Raptor surveys in the Bald Hills**—once per month all year; Kristin Schmidt, x7741
- **Spotted owl night surveys**—March~July; Terry Hines, x7776 or Kristin Schmidt, x7741

- **Western snowy plover beach surveys**—February~September; Keith Bensen, x7777 or Amber Transou, California State Parks, 707-445-6547 x14

### **Butterflies**

- **Butterflies**—May~September; Terry Hines, x7776 or Kristin Schmidt, x7741

### **Marine and Beach**

- **Western snowy plover beach surveys**—February~September; Keith Bensen, x7777 or Amber Transou, California State Parks, 707-445-6547 x14
- **Marine mammal and seabird beach carcass survey**—monthly throughout the year; Keith Bensen, x7777
- **Seabird colonies on offshore rocks**—May~June; Keith Bensen, x7777

### **Mammals**

- **Elk**—September~January; Kristin Schmidt, x7741

### **Geology/Watershed Restoration:**

Joe Seney, Branch Chief, x7704

- **Maintain gaging stations and discharge measurements on Prairie Creek**—Kendall Story x7745, Carrie Jones x5141 and Vicki Ozaki 5142
- **Sediment lab analysis**—Carrie Jones x5141, Kendall Story x7745

- **Cross Section Surveys on Redwood Creek and Estuary**—Vicki Ozaki x5142

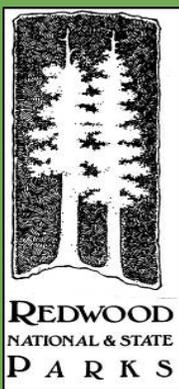
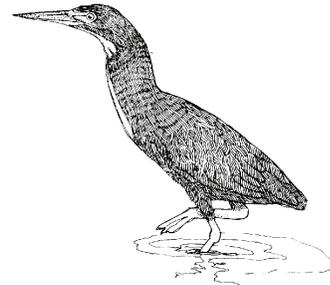
### **Vegetation Management:**

Leonel Arguello, Branch Chief, x7780

- **Forest Restoration:**
  - Middle Fork Lost Man thinning monitoring plot establishment
  - Middle Fork Lost Man project layout
  - Dolason Trail Head prescribed fire monitoring
  - A-972 Experimental thinning plot re-measurements

Projects will start during the spring season and end when winter rains come. Bulk of the work will occur from mid-May through August; Jason Teraoka x7783.

- **Invasive Plant Control**—Killing English ivy, Scotch broom and a host of other bad guys year round—Laura Julian x7787
- **Rare Plant Surveys**—April~September in a variety of locations around the park; Laura Julian x7787



Redwood Currents is a resource management newsletter published by the Division of Resource Management and Science. This publication is dedicated to the dissemination of cultural and natural resource information and critical issues relevant to the interpretation and resource management of Redwood and National State Parks. Information in this newsletter is for interpretive and educational purposes only.

Editor, Aida Parkinson

Coordinator/Design, Vicki Ozaki