National Park Service
U.S. Department of the Interior




CLIMATE*Friendly* PARKS

Oregon Caves National Monument Action Plan

TABLE OF CONTENTS

Oregon Caves National Monument Becomes a Climate Friendly Park 3
The Challenge of Climate Change 11
Greenhouse Gas Emission Inventory at Oregon Caves National Monument 25
STRATEGY 1: Reduce GHG Emissions Resulting from Activities within and by the Park 29
Energy Use Management 29
Transportation Management 33
Waste Management 35
STRATEGY 2: Increase Climate Change Education and Outreach 39
Park Staff 41
Visitor Outreach 43
Local Community Outreach 44
STRATEGY 3: Evaluate Progress and Identify Areas for Improvement 45
Conclusion 45
Citation Bibliography 46
Appendix A: List of Participants to Climate Friendly Workshop 52

OREGON CAVES NATIONAL MONUMENT BECOMES A CLIMATE FRIENDLY PARK

As a participant in the Climate Friendly Parks program, Oregon Caves National Monument belongs to a network of parks nationwide that are putting climate friendly behavior at the forefront of sustainability planning. By conducting an emission inventory, setting an emission reduction goal, developing this Action Plan, and committing to educate park staff, visitors, and community members about climate change, Oregon Caves National Monument is serving as a model for climate friendly behavior within the park service. To compare how the Monument's Action Plan compares to those of other park units, visit http://www.nps.gov/climatefriendlyparks/parks/applicant_parks.html.

The Monument's latest General Management Plan (GMP) lays out specific goals within its enabling legislation, and the mandates and policies of the National Park Service.

The 1909 proclamation established the purpose of Oregon Caves National Monument. The proclamation states:

> "Whereas, certain natural caves, known as the Oregon Caves, which are situated upon unsurveyed land within the Siskiyou National Forest in the State of Oregon, are of unusual scientific interest and importance, and it appears that the public interests will be promoted by reserving these caves with as much land as may be necessary for the proper protection thereof, as a National Monument; ..."
>
> Specifically, the primary purpose of the Monument is to protect the natural processes of Oregon Caves as well as any new caves found within the boundaries of the Monument. Protection includes management of old-growth forest and its associated species and natural processes within the watershed of the caves to assure that the chemistry of the water entering the cave is reflective of natural cycles associated with the region. Visitors to the Monument have an opportunity to tour through the cave and experience the twisted catacombs and cave formations created by water tables and aquifers of ancient watersheds while at the same time observe the behavior of water under the conditions of the current ecosystem above and surrounding the caves. The caves are managed to preserve the collection of Pleistocene fossil bones and footprints as well as its endemic, cave dwelling life that is found there (National Park Service 1999).
>
> Five buildings and their associated landscape features and public use areas are listed in the National Register of Historic Places as an historic district. The centerpiece of the historic district is the Chateau, a National Historic Landmark. This unique six-story, cedar bark-sided building was built in 1934 and still operates today providing lodging and food service to Monument visitors. Other buildings in the National Register historic district include the Chalet, Guide Dormitory, Ranger Residence, and Checking and Comfort Station.

Those features that will most need additional protections and mitigations of adverse effects in the face of climate change include old-growth forest (including meadows and riparian areas) and cave ecosystems, historic structures, and the positive experiences of physical or other visitors to the Monument. Since the very fact of rapid climate change changes the efficacy of various management strategies to accomplish the above goals, such strategies are addressed in the appropriate sections in this document.

This Action Plan identifies steps that Oregon Caves National Monument can undertake to reduce greenhouse gas (GHG) emissions in order to mitigate its impact on climate change. The plan presents the Park's emission reduction goals, and associated reduction actions to achieve the Park's goals. Strategies and action plan items were developed by working groups at the Klamath Climate Friendly Parks Workshop.[1] While the plan provides a framework needed to meet the park's emission reduction, it is not intended to provide detailed instructions on how to implement each of the proposed measures. The park's Environmental Management System will describe priorities and details to implement these actions.

Oregon Caves National Monument aims to mitigate or counter the climate-induced anthropogenic threats to the Monument's historical fidelity (especially to natural processes and historical features), its biodiversity, and the resilience of its ecosystems in the face of the cascading effects of rapid climate change. Oregon Caves National Monument has committed to reducing greenhouse gas (GHG) emissions from park operations to 80% below 2007 levels by the year 2012 by implementing emission mitigation actions, and to being carbon neutral by 2018.

To meet these goals, this Action Plan lays out the measures the Monument will implement as they relate to the Monument's current and future emission inventories. Specifically, the plan recommends three strategies within two phases:

STRATEGY 1: Reduce GHG Emissions Resulting from Activities within and by the Park.

STRATEGY 2: Increase Climate Change Education and Outreach.

STRATEGY 3: Evaluate Progress and Identify Areas for Improvement.

Division of actions under these strategies is listed further in the action plan.

Phase 1: Identify and implement mitigation actions that the park can, with the help of researchers and the visiting public, begin within a year to reduce GHG emissions resulting from activities within and by the park or to gain information as to how to do that in subsequent years.

Contractors

- Begin discussions with the present concessionaire and regional or other concession specialists in the next Request for Proposals for the concessions contract about how to incorporate incentives to reduce carbon emissions in the next concession contract slated to be signed in 2015. This could include in 2011, for example, hiring a hospitality expert to help the concession determine ways to reduce carbon-associated costs, such as at what limit the reduced rate for groups should be so as to ensure operations are more or equally profitable (thus sustaining concession operations) as well as encourage individual families to carpool together to the Monument.

[1] Original notes from these workshops, including detailed action items not presented in the final plan have been archived by Oregon Caves National Monument and are available upon request.

- Develop safe drop-off sites in town for small items from UPS, Fed-Ex, etc. that would otherwise necessitate traveling an additional 19 miles to the Monument.
- Continue planning and compliance for installing microhydro in culvert connecting different parts of Cave Creek to supply electrical needs for Chateau.
- Explore the possibility of providing economic incentives to allow the Oregon Caves Outfitters to better evaluate past food inventories so as to reduce food waste at end of operating season and to donate excess food to local or regional food banks.

Education

- Create sustainability exhibit & activities for the annual Earth Day event.
- Update the Monument's website with relevant information from this action plan as well as other pertinent information relating to reducing carbon emissions. Create web links to at least ten other pertinent web sites, including www.nps.gov that has a link to the brochure "Climate Change and Western National Parks."
- Explore the use of Park Service approved social networking media that will get the message out to more people concerning the most important aspects within this plan.
- Incorporate climate friendly topics into existing interpretive public, child, and school programs
- With the help of Judy Giddings or similar author, begin compiling a Park Service cookbook that combines, from potluck-intensive park staff and members of the public who have cooked in national parks, the best recipes that promote weight loss, tolerance of cultural diversity, and the unique "flavor" of certain parks or the regions in which they occur. This book would complement the *National Park Cookbook* by Judy Giddings which does not emphasize all of these foci. This book donates all profits to the NPS but the new book could specifically target donations that would help the parks reduce carbon emissions.

Other Governmental Stakeholders

- Initial collaboration with US Forest Service on developing of wayside exhibits, etc. on Caves Highway (State #46) to give it a more historic aspect and illustrate historic resources.
- Collaboration with US Forest Service to complete fuels reduction and enhancement of old-growth traits to offset likely effects from global warming and reduce the likelihood of crown fires emitting carbon.
- Continued collaboration with state on compliance requirements concerning installing a microhydro facility near the Chateau.

Monitoring

- Purchase scale for tracking waste amounts more accurately.

- Begin yearly emission inventories to monitor progress.

- In an understandable, non-threatening, and relevant way, monitor and make accessible to the public studies that help quantify how:

  1) mixed hardwood-conifer temperate forests act as carbon sinks or sources, including the effects of increased albedo on atmospheric carbon from increasing tree cover and declining snowpacks. Begin project proposals and compliance if sufficient science is available to determine whether actions such as increased fuels reduction will help reduce atmospheric carbon while at the same time complying with Park Service and Monument mandates to increase or sustain safety, health, and what is "natural" within the Monument.

  2) reducing health care emissions. A 2007 study by the Center for Disease Control determined that 75% ($1.7 trillion) of health care costs in the country could be prevented with changes in exercise and eating habits. That's a lot of carbon. Avoiding highly processed foods, eating more vegetable products, and buying fresh foods grown locally not only reduces medical emissions but also reduces emissions from processing, transportation, and converting crops into meat. Just one example suffices; anesthetic gases used in the United States in surgery each year have the same greenhouse effect as the yearly emissions from a million cars (Sulbaek Andersen, et al. 2010).

Begin conceptualizing an interpretive message about how being overweight leads to a lower quality of life, including a lower quality of life from the effects of carbon emissions as a result of increased health care.

Park

Electrical

- Complete cave diode project.
- Install small reminder signs at light switches to "Turn off Lights – Reduce Carbon Footprint" when room/area is not in use.
- Ensure that energy provider (Pacific Power) is maximizing renewable energy sources but a cost that does not exceed 10% of prior energy use.
- Begin compliance to use sun control film, etc. to reduce heating/cooling costs of windows of Visitor Center portion of the Chalet, a part of a National Historic District.
- Begin compliance in replacing historic incandescent street lighting in Historic District with appropriately colored diode lights.
- Increase weather stripping in Chalet.
- Ensure that all hot water heaters are adjusted to 120 F. or below.

Staff

- Communicate sustainability expectations in housing agreements for park residents.
- Develop a “Myth Busters” check list for all offices and reminders to turn things off with facts about sustainability to show benefits.
- Provide yearly training on climate friendly actions for park staff and incorporate climate friendly messages in orientation manuals accessed electronically by each new member.
- Advocate for a required yearly on-line DOI climate friendly course that is updated at least every two years to reflect the rapid increase in climate-related science and historical knowledge.

Phase 2: Identify areas for improvement or knowledge acquisition in pursuit of improvement that will take more than one year. Monitor progress with respect to reducing emissions and mitigating the effects of such emissions. Include additional actions and strengthen existing actions, to reduce CHG emissions in future Action Plans or other pertinent plans

Monitoring

- Continue subsequent emission inventories to monitor progress.
- Continue to monitor the effects of climate change on park resources. For the Monument this especially includes research on forest and cave resources, including implementation of peer-reviewed cave, aquatic, and bird monitoring protocols

Contractors and Concession Sites

- A completed concessions contract will require the operator to be even more environmentally friend and to educate visitors about those actions. This could include display signage such as asking hotel guests to forego daily cleaning of their rooms in order to reduce carbon emissions.
- Investigate feasibility of composting with the concession with a goal of composting 5% of baseline year waste amounts.
- Assuming the Life and Safety rehab of the Chateau is completed, winterize the Chateau by draining the fire protection system each year and shutting down the boiler before the onset of winter.
- Continue discussions as to how to introduce projects that would be done at the same time as the Chateaus rehabilitation (construction slated to start in 2016) which is only Life and Safety. This would not only save energy in the installation (like not having to remove walls twice) and integrate LEED certification but would also save energy in the long run and increase occupancy (reduced noise between rooms).
- Finish installation microhydro facility in culvert connecting different parts of Cave Creek to supply electrical needs for Chateau.

- If possible provide in the new concession contract economic incentives to allow the Oregon Caves Outfitters to better evaluate past food inventories so as to reduce food waste at end of operating season and to provide excess food to local or regional food banks.

- Raise the biodiesel percentage to the point that the Chateau boiler still performs well. This should require minor adjustments to fittings, etc.

- Explore the possibility of using cooking oil and grease wastes in the Chateau boiler instead of the current practice of recycling such wastes off the Monument.

Governmental Stakeholders

- Completion of US Forest Service funded wayside exhibits, etc. on Caves Highway (State #46).

- Completion of compliance with state requirements concerning installing a microhydro facility near the Chateau.

Education

- Increase climate change education and outreach efforts via media that will take more than one year to fully implement:

  Books:
  - "Oregon Caves and the Siskiyou Mountains: A Guide to the Region (110 pages (scheduled for publication by Natural History Association in 2012

  - "Natural History of the Klamath-Siskiyous" (255 pages: tentatively scheduled for publication in 2012)

  - Supply a computer and a digitized, self-administered junior ranger handbook that gives the child the option of foregoing acquiring a junior ranger badge in favor of some recognition that produces less carbon emissions, such as a posting of the child photograph in the visitor center or a written certificate.

  Chalet Visitor Center exhibits:
  - Scheduled for completion in 2012.

  - One exhibit on past (oxygen and carbon isotope proxies for temperature and precipitation in stalagmite), present (observed), and future (predicted based on past and present) climates.

  - One exhibit on how Monument species save on energy and how this relates to the visiting public.

Park

Electrical

- Install new water storage reservoirs of different sizes to reduce treated water storage during non-peak seasonal use. 6 months winter season peak daily use is 10,000 gallons, 6 months summer season peak daily use 25,000 gallons. Installation of these structures would save an estimated 50% energy consumption at the water treatment plant. This project (currently being funded with fee revenue) would involve changing the water delivery system so that water used for fires does not have to be chlorinated.

- The Park will construct a micro-hydro generator on site and provide a net metered constant generation of renewable hydro power. This facility is anticipated to produce an average of an average of 7 kW of continuous power, 63,500 kW-hr annually for a reduction of 11 tons in GHG emissions annually.
- Incandescent bulbs can now be directly replaced with LEDs, thus reducing both energy usage and the energy that goes into replacement bulbs.
- Install diodes and timers (for night-time use) in public bathrooms.
- Use solar panels in conjunction with diodes and where vandalism is not likely, such as on top of maintenance building.
- Consider purchasing carbon offsets (if available) to reach the goal of being carbon neutral by 2016
- Ensure that the Monuments main energy provider (Pacific Power) is maximizing renewable energy sources but a cost that does not exceed 20% of prior energy use.
- Explore the possibility of installing a lower tank volume hot water heater.
- Add, to the rehab the Chalet, work on water pipes to be able to winterize the building and shutting down the electrical heating at the end of the Chateau hotel occupancy each year.
- Subject to approval of compliance concerning replacement of Chalet windows with better insulated panes, complete the project.
- Use solar panels in conjunction with diodes and where vandalism is not likely, such as continuously illuminating flags.
- Subject to approval of compliance, replace historic incandescent street lighting in Historic District and interior lighting in Chateau with appropriately colored diode lights.

Staff

- Create a climate friendly pin made of recycled material to increase employees participation in the "Do Your Part" program – to be worn on uniforms.

Transportation

- Financially rewards parks that come substantially under their travel cost ceilings. Or, failing that, use monies from penalties incurred from exceeding travel limits to help parks reduce emissions.
- Upgrade the current two electric cars for employee use between work sites with either more sustainable batteries (a >three-year average life expectancy)
- Replace the oldest or selected existing 4-wheel drive vehicles with a more energy efficient vehicle, such as an electric car whose battery weight and tire width are such that it does not compromise safety or mission accomplishment
- Use appropriate-sized vehicles to match the job.

- Put in a Project Management Information System (PMIS) project that would install three electric car charging stations in the large parking lot.
- Encourage slower travel speed by park vehicles.
- Use video or audio conferencing instead of driving to meetings where face-to-face contact is not essential.
- Improve coordination of travel to airports and off-site meetings to maximize efficiency of official vehicle use by employees.
- Install bicycle racks in large parking lot.

Non-Road Equipment

- Buy a push mower for YCC to use in cutting the grass at the Cave Junction Visitor Center. It will help reduce both human weight (reduced medical carbon emission) and energy use.

Recreation

If the expansion of the Monument to about 4,000 acres is enacted by the US Congress or proclaimed by the US president, expand this action plan to include the expansion area. The expansion is expected to increase visitation but not necessarily carbon emissions. This is because the “staycation” phenomenon is likely to continue past the current downturn in the economy. The increase Oregon Caves would increase its prominence in attracting visitors already drawn to the recreational corridor between the coast and the Cascades. This likely would result in fewer trips just to the Monument. Greater efforts will be made to showcase the Monument to local and regional populations.
Promote climate-friendly recreation such as requiring more hiking (appropriate to the target age-group and parents) to qualify for a junior ranger badge.

By offering a reduced cave-fee that rewards separate families who would not otherwise carpool to the Monument, change the cave tour fee structure so as to reduce visitor vehicle miles driven.

Increase various types of interpretive media, such as books, films, park websites, visitor center exhibits, waysides, and social networking that deals with some of the park and regional specific material contained in this document in such a way to be scientifically accurate, relevant to human experience, and provocative in regards to inaccurate information currently regarded by many members of the public as factual about climate change.

Completion of wayside exhibits, etc. on Caves Highway (State #46). Compared to the proposed Monument expansion, the same situation would likely occur here in that visitation would increase but the miles traveled per person may decrease.

The Challenge of Climate Change

Climate change is any significant change in the climate lasting for decades or longer. Climate patterns (e.g., temperature, rain, snow, concentrations of atmospheric carbon dioxide) may vary naturally but modern climate changes are being driven at accelerated rates by human activity. Climate change presents significant risks and challenges to the National Park Service and specifically to Oregon Caves National Monument. Due to the complex feedback systems of climate itself and how people will respond to climate change, even the most sophisticated and up-to-date models designed by scientists cannot predict with certainty the general severity of climate change nor its impacts. However, to take just once example, much of the Pacific Northwest's greater yearly changes in precipitation about 20 years into the future arise from the effects of increasing greenhouse gases. (Meehl & Hu 2010).

The single leading cause of warming at Oregon Caves is the buildup of GHGs in the atmosphere—primarily carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) —which trap heat that otherwise would be released into space. However, one of the key challenges to all Park Service units is that around half of the adult population in the United States appears not to even understand what a greenhouse gas is and what affect on climate it has. Almost half the population believes that fossil fuels comes from dinosaurs. Such observations are part of a larger challenge, that large segments of the U.S. population not only don't believe that humans are largely responsible for non-cyclical climate change but that whatever the causes, climate change is not a serious threat either to their health or economic well-being.

The continued addition of CO_2 and other GHGs to the atmosphere will raise the Earth's average temperature most rapidly (so far) in this next century; a global average warming of 4-7°F by the year 2100 is considered likely.[2] Just a doubling of atmospheric carbon dioxide by itself is expected by 2100 to raise temperatures by about 3^0 F (Bounoua et al., 2010). Average global temperatures on the Earth's surface have increased about 1.1°F since the late 19th century, and the 10 warmest years of the 20th century all occurred in the last 15 years. 2010 is now the warmest year ever recorded. While the ratio of daily high maximum temperatures to low temperatures in the U.S. is already about two to one, it is expected to reach 20 to 1 by mid-century, with changes in temperature extremes likely due to human-caused greenhouse gases and the largest increase in heat waves expected in the Pacific Northwest (Meehl 2009; Meehl et al. 2007). As with Earth's hottest years, most of the hottest days on record in the Monument (up to 104^0 F. at 4,000' elev.) have only occurred in the last decade or so. Temperatures also appear to be increasing even faster at the higher elevations of Oregon Caves than at lower nearby areas such as the city of Medford.

Rising global temperatures will affect all aspects of the water cycle, including snow cover, mountain glaciers, spring runoff, water temperature, and aquatic life. Climate change is also expected to affect human health, crop production, animal and plant habitats, and many other features of our natural and managed environments.

---

[2] IPCC 2007. Climate Change 2007: The Physical Science Basis. Intergovernmental Panel on Climate Change, Geneva Switzerland. Available online at < http://ipcc-wg1.ucar.edu/wg1/wg1-report.html>

There is now a scientific consensus that atmospheric carbon dioxide is at a higher level at present than at any time in the past 15 million years (Tripati & Eagle 2009). Since the climate in this area 12,500 years ago appears to have been even hotter than at present and carbon dioxide is strongly correlated with temperatures over the long run, there likely are significant lag effects from that much carbon in the air (Briles, et al. 2008). However, over the scale of decades and centuries, the degree of global warming appears directly proportional to the cumulative amount of carbon emissions into the atmosphere (Matthews et al. 2010).

This document thus reflects much more than just “nice things to do,” energy efficient management, or concern about “what ifs” or what effects may occur in the future. By the end of 2010, Oregon Caves National Monument had already experienced increases in winter flooding, extreme yearly changes in snowpack, and rapidly increasing daily low temperatures throughout much of the year. A higher loss of soil water over decades is decreasing herb biodiversity and food for rare cave species. It is also degrading the experience and sometimes even the health and well-being of park visitors. Given the uneven and geographic specific nature of available science, this plan both generalizes about and documents some of these effects that are of the most concern in protecting the Monument and its visitors.

Climate change is likely to have major health effects. Although the average high daily temperatures at Oregon Caves do not seem to have increased significantly, extreme events appear to have become more common. Whereas temperature highs prior to the last decade rarely reached even the mid-nineties, the last decade has seen more extreme highs, including a record 102 degrees at 4,000 foot elevation. This suggests that the risk of both heat exhaustion and heat stroke are both increasing at the Monument. The incidence of tick-borne encephalitis has increased in Sweden as a result of decreased tick mortality and longer growing seasons (Lindgren & Gustafson 2001). Anecdotes suggest that increased ticks and mosquitoes in the Oregon Caves area have increased the potential for Lyme disease and West Nile virus in the last 20 years. Poison ivy is thought to have increased in leaf size, geographic and elevation range, and virulence of its oils as a result of air warming. Since both species contain the same oil irritant, similar changes may be happening to poison oak. In the last twenty years it has moved upslope and reached the lower elevations of Oregon Caves.

All park units are entrusted by Congress and the American people to manage them in such a way as to leave them “unimpaired for future generations,” as well as to contribute to what most interpret as the well-being and flourishing of the parks’ owners. “Unimpaired” is a term that for most of NPS history has meant that park managers should be preserving natural conditions. However, trying to follow such a managerial or even a judicial interpretation of this mandate has always been difficult due to 1) limited resources, 2) a continued focus on preserving scenic icons, and 3) whether actions by Native Americans, and in what time frame, should be considered “natural.”

Various climate projections for the Pacific Northwest agree that winters will continue to get wetter and warmer but disagree as to whether summer precipitation will change. Also uncertain is the effect of a PDO in its warm and dry (low or negative phase) cycle since 1977 although possibly with its weakening or transition to a wetter part (high or positive phase) of the cycle starting in the mid-1990s (Mote et al. 1999). The mid-1970s climate shift in the Pacific itself may have been delayed for a decade by the effects of global warming (Mehl & Hu 2009). Both phases of the PDO have precipitation effects in southern North America and in the Great Plains, Canadian Prairies and Great Lakes regions but its effect on the area covered by the three parks in this assessment is uncertain (Zhang, et al. 2010).

Even whether the PDO is an artifact of combining other cycles is debated. It may be the sum of direct forcing by El Niño–Southern Oscillation (ENSO), the “reemergence” of North Pacific sea surface temperature anomalies in subsequent winters, and white noise atmospheric forcing (Newman et al. 2003). In other words, compared to shorter cycles like ENSO, longer cycles like the PDO are less understood and harder to predict what will happen to them in a rapidly changing climate. This is in part because only a few cycles at most have been witnessed for long cycles. Consequently, whether the PDO is causative, a true oscillation, or an artifact is not clear.

The amount of decadal and multi-decadal variability in precipitation is higher in the Klamath-Siskiyous than in anywhere else in the U.S (Ault et al. 2010). This may be in part because of unusually intense orographic effects (high mountains near a western coast and extending far inland) in a climate in between Mediterranean and Pacific Northwest climates. This is also reflected in the start of past interglacials at Oregon Caves NM going back 380,000 years. Compared to other times in this period, the start of rapid warmings appears to result in greater fluctuations of both temperature and precipitation at all scales below the millennial and above the limit of Uranium-Thorium dating resolution (Ersek et al. 2009).

Rapid climate change is making it increasingly unlikely that even extensive cooperation between park managers and other stakeholders will be able to keep everything “unimpaired” at least in the sense of everything being as it was at some designated point in the past, what is known as historical fidelity. The result is that hard choices are already being made as to what are the most important goals entrusted to park managers to accomplish. Is it to maintain one type of biodiversity, that of major ecosystems, by keeping them resilient and resistant to abrupt change? Or is it to maintain only the species or genetic biodiversity of a charismatic or flagstone species that, at some point, climate change may no longer allow their existence in a park.

For example, the whitebark pine ecosystem appears to be going extinct, or will become so small in area coverage as to raise the local or regional extinction (extirpation) of dependent species, such as red squirrels, grizzlies, or Clark’s nutcracker. Likewise, an increasingly drier summer in much of the Western U.S. led to a shrinkage of wetland areas that resulted in the (regional extinction) of many tree species now only found in the Eastern U.S. with its more evenly distributed precipitation.

Meeting the “unimpaired” mandate has now become even more difficult due to an increase recognition of rapid and widespread ecosystem change both human-caused and otherwise (Joos & Spahni 2008). This change has decreased how certain we are of ecosystem pathways (including the effects of restoration or mitigation) and increased contradictions in what a single definition of "natural" implies (i.e., both a lack of human impact and control (such as restoration) and humans apart from nature). In other words, you are criticized if you do and criticized if you don’t actively manage. This is now true even of caves, ecosystems once thought to be largely removed, insulated, or buffered from most human impacts.

Therefore, the best that can be hoped for in most NPS mitigation/restoration efforts is to achieve the most positives for the most Americans" by maximizing, in a cost-effective manner, the highest sum of measurable objectives revolving around both widely accepted scientific, judicial, and managerial definitions of the term "natural." This means demonstrating that Oregon Caves is trying to 1) maximize a diversity of desirable outcomes for their lands, 2) partly restore historical fidelity of the Monument, 3) restore, balance, and/or preserve biodiversity at both the endemic species level and the cave ecosystem level, and 4) increase ecosystem resilience, the ability to prevent stresses from causing undesirable and irreversible changes, an aspect of ecosystem health.

A fully functioning ecosystem has what has been called ecological integrity but this is better labeled as biological integrity so as to include processes that occur over long periods of time. Most healthy and persistent ecosystems are biodiverse, ecologically broad (functionally redundant), and evolutionarily deep. Thus the four objectives listed above are linked yet also at times distinct, especially in this era of rapid change.

An ecosystem's persistence through time by way of its resilience is of course an aspect of its biodiversity. However, ecosystem diversity differs from species or finely divided diversity in that an ecosystem can still persist even if extirpated from one area, provided it is already at or can move to another location (due to climate change or other stressors), whereas the extinction (global extirpation) of a species or lesser genetic grouping is forever and constitutes impairment. Rapid change can radically alter an ecosystem but some good can came from this if managers can help change that ecosystem into something new that delivers at least some of the desired functions of the former ecosystem (Chapin et al. 2006). One approach to increase resilience is to identify land facets—recurring landscape units with uniform topographic and soil attributes—and designing reserves and linkages for diversity and other key elements of these units such as the degree of disturbance. This would help conserve the arenas of biological activity, rather than the temporary occupants of those arenas (Beier & Brost 2010).

Phenology is the scientific study of the relations between climate and periodic and cyclical biological events. Although the aggregate advance of spring events in the Northern Hemisphere averages about 2.3 days per decade (Parmesan & Yohe 2003), it is about 5 days/decade for those species that are changing (Rosenzweig, Casassa, et al. 2007: 113). The latter biological advance in spring is closer to that based on temperatures, which based on satellite data, has advanced by 10-14 days over the last 20 years (Lucht et al. 2002).

Plants

The Klamth-Siskikyou bioregion is also in between the effects of La Ninas and El Ninos (wetter or drier than the average to the south or north) and, to a lesser extent, the Pacific Decadal Oscillation. This means that even slight yearly strengthening or weakening of these weather patterns can increase precipitation variability in this region. This would help explain why there seems to be increased mortality from the current dry cycle which results in fuel loading from what appear to be even-aged trees in the lower parts of Oregon Caves NM. During decades of greater than normal precipitation, trees become established on dry south-facing slopes at low elevations and have a long enough time to grow roots deep enough to survive decades of more than average precipitation, only to succumb in the next dry cycle.

Mortality may mainly increase because sap, a tree's main defense against insects, is reduced during droughts and because some bark beetle species at the elevation of the Monument are now able to have two generations per year likely largely due to higher daily minimums in temperature. Leaf-eating insects are also expected to increase in diversity and abundance under all projected global warming scenarios (Currano, et al. 2010).

Rising concentrations of atmospheric carbon dioxide is making trees more efficient at saving water (Bounoua et al. 2010). However, based on observed mortality, this effect likely is being overwhelmed by higher evapo-transpiration rates and soil moisture losses. Concurrent tree mortality during severe droughts increases the likelihood of a crown fire from an ignition source, especially a lightning strike. Only more tree ring data will indicate whether this is likely the case at the Monument.

Fuels reduction around Oregon Caves National Historic District (including the Chateau) and by 2011 about 19% of the entire Monument. This is expected to help increase plant growth in the Monument. A doubling of carbon dioxide is thought increase plant growth due to lower water loss from earlier closure of leaf pores once enough carbon dioxide has been absorbed. This reduction in carbon dioxide may reduce a rise in global temperatures from 3.5^0 to 3^0 F. (Bounoua et al. 2010).

The average contribution of plants absorbing carbon dioxide as from land areas west of the Cascades, such as at the Monument, appears to be less. Productivity, measured by projected potential mean annual increment, is explained by the interaction of annual temperature, precipitation, and precipitation in excess of evapo-transpiration through the growing season. Under the three most likely socioeconomic scenarios (low growth, high development, and low energy usage) regional average temperature is expected to increase from 0.5 to 4.5 °C, while precipitation shows no clear trend over time. For the west side of the Cascade Mountains, respectively, productivity increases 7%, 8% and 5% under these three scenario scenarios, respectively (Alig, 2009).

Though this fuels reduction and thinning is a high percentage for even such a small federal or state unit of land, the frequency of lightning set fires in and adjacent to the Monument in the last 20 years suggests that the rate of fuels reduction is not keeping pace with the likelihood of a fire. In addition to fire suppression and higher evaporation rates, the increased daily lows of the last few decades decrease the number of dew points reached, thereby making it more likely that lightning caused fires will spread. A crown fire not only would destroy most cultural resources at the Monument but likely would endangered humans and many other species as well as put a great deal of carbon dioxide into the atmosphere.

Studies of forest fires in interior Alaska indicate that fires in the last decade have become larger, resulting in a loss of carbon into the atmosphere from carbon deeper in soils, and more frequent and larger fires due to late-season burning (Turetsky, et al. 2010). Since soils at the Monument generally have less carbon than in much of Alaska, there is likely not as great a response to this effect of globally warming but it likely is not insignificant. However, the greater variation in decadal precipitation in the Monument's bioregion is likely to add plant biomass during wet periods and then release that carbon in the hotter fires of drought decades. For example, the carbon released into the atmosphere from the nearby Biscuit Fire in 2002 was about 16 times the yearly carbon stored by the burned area (Campbell et al. 2007). However the fire history at Oregon Caves suggests that the ratio of ground fires versus crown fires was such that there was high carbon storage for most of the past five hundred years (Agee 1991).

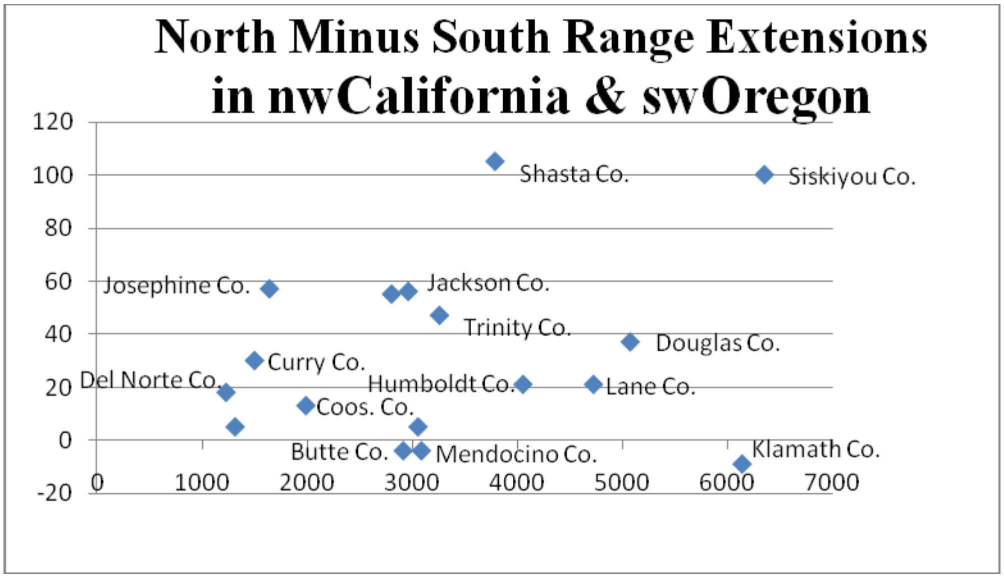
Fires less intense than most crown fires tends to store carbon as charcoal that can take up to hundreds of years for its carbon to transfer back to the atmosphere.

Another positive feedback may occur in soils like those that occur above Bigelow Lakes near the Monument. In such peatlands. with a vegetation cover, the increase decomposition may accelerate if the energy generated by the decomposition cannot escape fast enough into the atmosphere (Luke & Cox 2010).

The most obvious changes in Monument plants in the last two decade are the observed increase in upper elevation limit for a number of species, including Columbia lily (*Lilium columbiensis*), poison oak (*Toxicodendron diversilobum*), and rayless arnica (*Arnica venosa*). The scarlet monkeyflower (*Mimulus cardinalis*) was recorded from the Monument at about 4,000 feet elevation above sea level. It occurs at lower elevations nearby but it may be moving upslope due to less severe winter freezes than in the past (Angert et al. 2008).

Even with increased winter precipitation it is expected that madrone and tanoak forests at the lowest, south-facing forests will move upland to replaced much if not most of the upper elevation conifer forests because these trees are more drought resistant but less resistant to damage by deep winter frosts (Lenihan et al. 2003). These trees are already replacing what were dominant conifer forest areas on south-facing lower elevation slopes developed on marble-derived soils. These soils tend to be thinner (less insoluble residues of bedrock) than soils developed on other types of rock and thus hold less water in the spring. Many drought stressed plants also emit more methane, a potent greenhouse gas that is rising globally faster than carbon dioxide (Reid & Qaderi 2009).

Based on past studies, the effects on global warming in migration and extirpation in the Klamath Network has been ongoing for >60 years and is becoming increasingly threatening to park resources and ecosystems and other park resources. This is largely due to the acceleration of global warming and inputs of carbon dioxide and other greenhouse gases into the atmosphere. Subtracting southward migration rates reduced the "noise" of migration in all directions. This yielded a net average movement northward of 1.3 km/yr./taxa, more than double that estimated for north temperate species in other studies (Minckley et al 2008). This is likely due largely to a higher than usual habitat diversity.



Much of the Klamath-Siskiyous' high habitat diversity likely results from the many intersecting water access gradients and of fairly equal sized areas that have similar amounts of water access. The steep water access gradients in turn result from the intersection of winter-summer, east-west, north-south, up-down, diverse aspects, and soil-induced effects.

This likely is a major cause of the Klamath-Siskiyous' high number of endemic and total species in many plant, animal, and fungal groups. This high habitat diversity also reduced extirpations and increased successful migrants so as to net gain about 66 vascular plant taxa since Whittaker's study (Roth 2009).

With more rapid climate changes "poleward," it should be expected that areas especially with high habitat diversity should see in the short run such a "flattening out" of latitudinal biodiversity gradients. However, severe climate change itself in the long run is likely to decrease habitat diversity in the Monument and the bioregion by changing where environmental gradients intersect.

All ecology plots adjacent to Oregon Caves that were not altered by crown fires or clear-cut logging showed significant changes to an herbaceous community more indicative of drier and hotter conditions. This was true regardless of elevation, aspect, or substrate (Harrison, et al. 2010). However, there were only two time periods (1949-1950 and 2007-8), in which vegetation in the same plots (some in the proposed expansion area) were surveyed. The ~2^0 F. increase in averaged air temperatures in the region between those time periods also appear to have been mostly the result of higher daily lows throughout the year, times when evaporation from soils presumably was not significantly increased even in summer. So it may have been natural variation in climate, added to fire suppression (more competition for water), that reduced herbaceous biodiversity. However, observed wilting of late blooming species such as a certain aster (*Eucephalus brickellioides*) before seeding could result from earlier snowmelt and higher soil evaporation.

Not surprisingly, the greatest reduction in biodiversity on all or most of the plots was among those species at the southern limit of their range in the Klamath-Siskiyous bioregion, at least 32 such species recorded from the present-day Oregon Caves NM. Several species, such as *Eriogonum nudum, Platanthera unalascensis*, and *Galium bolanderi* have disappeared from south-facing mid-elevation slopes at Oregon Caves NM. in the last 21 years.

Although the average snowpack per decade at the Monument does not appear to have substantially changed when averaged over the last six decades, there appears to have been greater extremes of melting, land cover, and snow depth. Thus the nearest snowpack stations to the Monument on April 1 from 1950 to 2002 show many decreases of from 60% to 30% and two that show a 15% to 30% increase.

However, the earlier snowmelt (from one to four weeks) and lower snowpack at low and mid-elevations in the mountainous Western U.S. also likely has an effect on herbaceous composition and has been attributed to anthropogenic climate change (Bonfils et al. 2008). A related earlier increase in streamflow of from one to four weeks across western North America is in part controlled by Pacific Decadal Oscillation (PDO) phases but a significant part of rising temperatures spans PDO phases (Stewart et al. 2005).

The best data on flowering times is from Europe where 78% of species are advancing in flowering and leaf unfolding and only 22% are delayed. Spring and summer showed an advance by 2.5 days per decade. (Rosenzweig, Casassa, et al. 2007: 113). Near our latitude, Japan has recorded the bloom of a cherry tree species since 1400. The first statistical change to earlier blooming started in the early twentieth century with a steady advancement since 1952. Longitudinal studies in the U.S. tend to be shorter but one showed an increase in growing seasons in four areas at 42 to 45 degrees latitude (White et al. 1999), within the latitude of Oregon Caves.

Project Budburst is operated by the University Corporation for Atmospheric Research (UCAR) and a team of partners. It allows students, gardeners, and other citizen scientists in every state to enter their observations into an online database that will give researchers a detailed picture of our warming climate. As with flowering and seeding times, the opening of buds in Alberta and other parts of North America has also changed (Beaubien & Freeland 2000). The USA National Phenology Network (USA-PN) (www.usanp.org) is a new partnership among federal agencies, academics, citizen volunteers, etc. to monitor and understand the influence of seasonal cycles on the nation's biological resources.

In the U.S., the average flowering time is increasing by about 8 hours per year, mostly based on data from the Eastern U.S., and, to a lesser extent, areas to the north (Eugene) and south (Stanford, etc.) of the Monument (Parmesan & Yohe 2003). The flowering of lilacs (*Syringa vulgaris*) and honeysuckle (*Lonicera tatarica* & *L. korolkowii*) in the Western US is advancing by 1.5 and 3.5 days per decade, respectively (Cayan et al. 2001). The advancement in flowering is estimated to average between 2.5 and 6 days per degree Centigrade (Menzel et al. 2006). If previous relationships hold, at 8 hours per year advancement of spring, spring also should be advancing upslope at around 10 meters (33 feet) of altitude and northward by 5 minutes of latitude per year (Heidorn 2003), which at our latitude is about 20 miles per year.

In the 1990s, the park noted when most species here bloomed and compared their timing to climate and park herbarium records from the 1950s. If past collecting averaged around the peak of flowering for most species, then the advance of averaged flowering times was about ten days by the 1990s. The 1990s study also showed an averaged earlier flowering of non-woody compared to woody plants. This is likely because many woody plants tend to time their flowering by length of daylight, which isn't changing, rather than by temperatures, which are changing. Annual, wind-pollinated, and non-woody plants are also flowering earlier than wind-pollinated, perennial or woody plants in Britain (Fitter & Fitter 2002).

The result for at least some photoperiod plants is a mismatch in which insects are now emerging too early to pollinate these plants. Although different definitions and time periods may exaggerate such a difference, it may be that the transition in southern Oregon from a Pacific Northwest climate to a Mediterranean one may make it particularly sensitive to changes in snow cover as a result of warming and other climate change.

This is likely because woody plants tend to time their flowering by photoperiod that is not changing rather than by temperatures that are changing. If herbarium records from the 1940s and 1950s at and near the Monument recorded on the average the peak of flowering for most species, then the advance of averaged flowering times was about two weeks in the 1990s. This is higher in flowering time that was found in an orchid with both modern observations and herbarium records in snow-free areas The orchid flowered about three days earlier for every degree rise spring temperatures (Fahrenheit) (Robbirt, et al. 2010).

Snowpack is more important at higher elevations and so it may be playing a role. Flowering timing in high elevation habitats are those most likely to be affected by the amount of snowpack (Inouye et al. 2002). This also appears to be the case at elevations at and near the top of Oregon Caves National Monument. Compared to the previous fifty years, average snow depth of the last fifty years in Oregon decreased almost in half compared to the previous 50 year average. This is considerably higher than the 10% decrease of snow cover over the Northern Hemisphere since the 1960s (Hulme 2005).

Averaged temperatures and fires are increasing at the higher elevations faster than at lower elevations. with paleo-climate pollen and charcoal studies in the Monument and nearby indicating that this is may be the case in past warmings as well. The most likely explanation is that snowmelt at the higher elevations and latitudes is providing a faster feedback in which dark earth exposed by the snowmelt is absorbing solar energy and increasing air temperatures. The selective increase of high energy ultraviolet hitting the ground at the higher elevations may be partly responsible if indeed warming is taking place faster in the mountains.

The effect of higher temperatures has other positive feedback effects. Less snow on steep slopes means less avalanching. This tends to accelerate the encroachment of conifers in mountain meadows, an invasion that appears to be taking place in such meadows in the Monument. Such an invasion decreases the reflectivity (albedo), thus increasing warming and the length of the growing season. This allows for the survival of conifer seedlings. Trees around a meadow intercept snow such that snowpack under those trees in the spring tends to be less than in the adjacent meadow, resulting in further survival of conifer seedlings.

Phenology is the study of seasonal patterns in life. The 1990s flowering phenology at Oregon Caves also showed an averaged earlier flowering of non-woody compared to woody plants. This is likely because woody plants tend to time their flowering by photoperiod that is not changing rather than by temperatures that are changing. If herbarium records from the 1940s and 1950s at and near the Monument recorded on the average the peak of flowering for most species, then the advance of averaged flowering times was about two weeks in the 1990s. Aside from snails and flowering plants, the third highest number of endemics of any taxa at Oregon Caves is the micromoths, which in Europe are now emerging too early to feed on larval plants (Ellis et al. 1997). *Cypripedium fasciculatum* likely occurs in the proposed expansion area. It apparently is now flowering too late for its main pollinating gnats, which are now emerging too early to pollinate the plant.

Fungi and Microbes

Little is known how climate change will affect fungi and microbes in general and even less is known about how climate change will affect such species within the Monument. The best strategy at present is to continue documenting the distribution and biodiversity of such species. It is known, for example, that certain underground fungi only occur in rare substrates, such as three species in marble soils, at least in the Monument. However, it is unknown if climate change will change that distribution.

Maintaining a diversity of moisture and disturbance regimes seems critical to maintaining the diversity of such species, if not their abundance. Cave microbes, however, seem most common in both abundance and diversity in wet areas of the cave whereas microbes that "eat" minerals tend to occur where those metals occur (Fowler 2009). A range of nutrient levels also seems important for the diversity of both groups. This may mean allowing more human-caused organics to remain in the Monument's showcave as it may compensate for reduced organic input due to less water entering the cave.

Animals

The biggest concern about climate change is its affect on biodiversity, especially for a biodiverse place like the Monument and its region as there is so much more to lose. K-selected ("equilibrium") species are those that tend to live in late-succession habitats like old-growth forests and big caves, and comprise most of our biodiversity. Unlike "weedier" species, they are most at risk from climate change in part because most of these species are habitat specialists, have few offspring, and are slow migrants (Rodland & Bottjer 2001; Keller 2002; Foufopoulos 2011 et al.). Most such species simply cannot evolve or even migrate fast enough to keep up with current and anticipated climate change rates (Joos & Spahni 2008). This especially includes those animals that cannot just move uphill or downhill to find habitat suitable to it in a changed climate regime. Under middle range scenarios of climate warming in biodiverse areas like the Klamath-Siskiyous, it is estimated that up about a quarter of species will become at least regionally extinct by the end of the century (Thomas et al. 2004). More recent estimates that take into account conservation measures put the estimates at between 10 to 20 % (Pareira et al. 2010).

The study of fossils provides a deeper context of climate change and extinctions. Since warming began after the height of the last glacial period 21,000 years ago, climate-induced extinctions of both big and small mammals have been, compared to other continents, especially severe in North America (Nogués-Bravo et al. 2010). All three of the world's three biggest mass extinctions occurred during the warmest "greenhouse" periods when global biodiversity was low, compared to cooler "icehouse" phases when biodiversity was high and extinctions were low (Univ. of York 2007). Predicted climates by no later than 2100 will put the earth into such a greenhouse period, thus accelerating what most biologists believe is already a mass extinction in the present.

Records and predictions of the effects of climate change on animals have been similar to that of plants (Lawler et. al. 2009). Specific species moving northward include the meadow spittlebug on the California coast (Karban & Strauss 2004). It was fairly common at the lowest elevations of Oregon Caves about two decades ago is rarely seen there now, presumably because of fewer herbaceous plants with enough water for the bug to hide within the bubbles that it makes from plant fluids. Since that time spittlebugs have become more common mostly at elevations above the entire Monument.

70% of 23 species of butterfly in California have advanced their first flight date over 31 years, by an average of 24 days. Changes in climate explained 85% of these changes with warmer, drier summers being the most important (Forister & Shapiro 2003).

In recent years the field skipper or sachem (*Atalopedes campestris*) has seemingly reacted to a 2-4 degree C. winter warming by expanding its range from northern California to central Washington State and Idaho in just 35 years. It expanded its range northward by 75 miles just in 1998, one of the warmest years on record (Crozier 2003). Although still considered scarce in the Siskiyous, it was first recorded near Oregon Caves in 2001; a butterfly inventory in 1993 at the Monument had previously failed to detect it. It is also found in Humboldt County but has not yet been recorded from Redwood NP. It has been very responsive to higher spring temperatures, first appearing nearly a month earlier than it did near Sacramento 30 years ago (Shapiro n.d.). Like many butterflies, it also likely is limited by cool summer temperatures at the northern edge of its range (Dennis 1993). As a southern species the sachem stays active all year and so was formerly killed by even short periods of 18 degrees below freezing.

Likewise, the mean location of the Edith's checkerspot (*Euphydryas editha*) since 1860 has shifted 92 kilometers northward and upward in elevation 105 meters in response to air warming averaged at about 1.3^0 F. (Parmesan 2005). Unlike the weedier and presumably more adaptable sachem, warming associated with extreme droughts and low snowpack years, as well as emerging before nectar was available in their host plants (especially in 1989) has extirpated about 40% of lowland populations (0-2400 meters) but only 15% at higher elevations (2400-3500 meters). There have also been more extinctions of local populations in the southern end of the range than in the northern range (Singer & Thomas 1996).

Other changes in geographic distribution include the following in which sOR = southern Oregon, swOR = southwestern Oregon, SW = Southwestern U.S. and CA = California:

> ant(-)like flower beetle *Ischalia californica* (Oregon Caves) (sOR (range extension) to northern Calif. (Shasta Co.) to sCA
>
> weevil *Agronus cinerarius* (OR (range extension) to northern Calif. to sCA) and *Apion cribricolle* (OR (range extension) to sCA, e. to CO). It is found at snowfield edges at high elevations so it may be effected by declining snowpacks.
>
> click beetle *Athous limbatus* (sOR (range extension at Oregon Caves) to CA Sierras)

sap-feeding beetle *Colopterus truncatus* (Oregon Caves) (sOR (range extension) to cCA to sCA)

ironclad beetle *Megataphrus tenuicornis* (cOR (range extension) to Sierras to sCA)

Alydidae bug *Darmistus subvittatus* (OR (range extension) to CA, e. to AZ, CO, TX)

Sorhagenia daedala (midrib gall moth) (sOR (Josephine Co. (range extension) to northern Calif. (Siskiyou Co.) (endemic to Network)

geometrid moth *Mesothea incertata viridipennata* (swOR (range extension) to Trinity Co. to northern Calif. Sierras)

leaf blotch miner moth *Caloptilia nondeterminata* (Oregon Caves NM) (Josephine Co.) (range extension) to Marin Co. to sCA)

hesperid *Ochlodes agricola a.* (rural skipper) (swOR)(range extension) to northern Calif.)

lycaenid butterfly *Brephidium exile* (Western pygmy(-blue)(cOR (range extension)toSW)

nocutuid moth *Chlosyne hoffmani segregata* (sBC to cCASierras, extension to near coast in Klamaths) (Siskiyou Co.)

oecophorid moth *Exaeretia nechlys* (range extension in Siskiyou Co. to cCA to Baja)

The bizarre caddis fly *Desmona bethula* (WA (range extension) to CA)

In 1992 and 1993 dissolved organic carbon in Oregon Caves averaged to .4 milligrams per liter, less than the 1 milligram/liter in other caves (Simon et al. 2007). Some of the difference results from climate, elevation, and drainage size differences. However, some likely results from a drying trend started or accelerated in the last 60 years, based on changes in surface vegetation. Since the activity of microbes and macro-invertebrates decreases as the water and food content of the substrate decreases (Fowler 2009), this threatens cave endemics.

Within the single cave of Oregon Caves is a recorded 380 total species, and 8-9 arthropods only known from this cave, both more than most any other cave. Based on field data, lipid analysis, and dissolved carbon measurements most organics these species eat comes from diffuse seepage of dissolved organic carbon from overlying soils. (Rushdi et al. 2009). Paleoclimate studies and cave limestone growth rates suggest that human-induced increases in evapo-transpiration and decreases in snowpack may be slowing down this carbon influx beyond all or nearly all ranges of water infiltration in the past 380,000 years in an interglacial that started out as one of the driest in that period (Ersek et al. 2009). Therefore, assessing changes in this organic flow is critical to protect Oregon Caves' globally significant biota, which is certainly part of the "unusual science" cited as needing protection in the Monument's enabling legislation.

Rapid decreases in water and food flow to the caves' endemics makes this resource damage extensive, persistent, immediate and, by likely increasing extinction rates, irreversible. Both of the nearest snow gauges shows for 2009 less than 20% of thirty year averages for snow water equivalent and precipitation. Oregon snowpacks are more than 50% thinner compared to past twenty year averages. This decreases the dissolved organic surge that enters the cave near the end of snowmelt because the time that soils is frozen (thus preventing organic percolation) appears much less than just a few decades ago even with the insulation effects of snow much less than it was. This is in part because the heat energy produced by human activities since the Industrial corresponds to less than 7% of global warming, with the rest having gone into warming water or the ground (*Nordell* & *Gervet* 2009).

In the early 1990s, an organic carbon study and a biological use of oxygen study by a microbiologist found that the two main influxes of organic carbon into the cave occur at the end of snowmelt and ground thawing and with the first rains of fall. Global warming has moved these two influxes closer to each other or, as the ground is now mostly unfrozen most of the year, prevents the spring organic influx from occurring at all. This trends is likely to increase in the future as climate change is predicted to cause the effects of future El Niño events to increase precipitation and the number of frost days in the Pacific Northwest (Meehl et al. 2007).

Springtail grazing suggests microbes largely occur on wet cave surfaces. Since much of the cave has been observed to be bone dry for longer periods compared to just twenty years ago, this deprives cave species of food and suitably wet habitat both seasonally and in total area.

Higher carbon dioxide combined with higher evaporation rates may also increase root growth which will reduce organics entering caves. Elevated atmospheric carbon dioxide concentrations generally increase the carbon to nitrogen ratio of plant tissue. This, along with fire suppression, can lead to the accumulation of hard-to-break-down biomass in which nitrogen is sequestered (locked up). A Northwest study suggests that on nitrogen rich sites like Oregon Caves, carbon sequestration may increase about 25% over a 100 year period of elevated carbon dioxide and temperatures (McKane et al. 1997; Luo et al. 2004). This change would be detected in changes in the ratio of plant and microbial lipids and proteins best sampled in a cave.

Birds have also been affect by climate change. U.S. songbirds are also moving to the north as the northern end of their ranges generally appears to be limited by winter nighttime temperatures (Root 1988). Likely as a result of warmer fall temperatures, acorn woodpeckers have increased their fall nesting. This secondary nesting is something that ~16% of all North American birds do (Koenig & Stahl 2007). Tree swallows are also laying eggs about nine days earlier across North America (Dunn. & Winkler 1999). Birds wintering in the United States arrived on the average 13 days earlier than before (Butler 2003). Birds in North American and Europe are migrating in spring 1.3 to 4.4. days earlier each decade (Rosenzweig, Casassa, et al. 2007:100).

The first major chorusing of the Pacific treefrog or chorus frog (*Pseudacris regilla*) appears to have shifted near the lowest part of Oregon Caves (~1700' elevation) about two weeks in the last twenty years, from early to mid-March to late February. Another effect from climate change may be on chytrid fungus diseases. During the dry cycles of El Nino, the fungus may be spread in populations as frogs are forced to converge onto the few remaining wet areas.

Some wild fish and zooplankton copepods show phenological shifts as well (Gerten & Adrian 2002). Spring algal blooms in lakes are up to 4 weeks earlier in the last 45 years in Europe and North America. Spring phytoplankton bloom in a northwestern US lake had advanced 19 days from 1962 to 2002. However some species zooplankton have not responded similarly. Their populations are declining because their emergence no longer corresponds with high algal abundance (Winder & Schindler 2004a). Fish are migrating up to 6 weeks earlier in the last 20 to 50 years in North America (Cooke et al. 2004).

The timing of reproduction of red squirrels appears to be related to length of day. However some of their foods such as underground fungi respond more to climate influenced factors such as when the soil dries out in late spring (Berteaux et al. 2004). In summary, there is so much climate-response variation among species groups such as predators, pollinators, herbivores, etc. that mismatches are inevitable and likely frequent (Winder & Schindler 2004a).

Resources Management

Park managers often use knowledge of historical and prehistoric conditions to achieve historical fidelity, meaning a return to or retention of a type of naturalness in which post-Columbian human effects on an ecosystem are absent or minimal. However, in an era of rapid climate change, such a goal is rarely obtainable. For starters, it's rarely clear what time period, what percentage of land coverage by different ecosystems, and which part of an environmental cycle constitute historical fidelity. In other words, historical fidelity often is a moving target (Briles, et al. 2008; Walsh et al. 2010; Mohr et al. 2000; McKinley & Frank 1995).

More importantly, you can't mitigate the effects of past actions that have degraded ecosystems without human actions that are likely to move ecosystems even further away from historical fidelity. This includes intensive energy use, which adds to the problem of global warming. In particular with rapid climate change, a sole emphasis on historical fidelity as defining naturalness is neither possible nor desirable (Aplet & Cole 2009).

A more productive approach in management would be to sustain present biodiversity from genes to ecosystems but minus highly invasive species that threaten native diversity. This includes increasing resilience, especially three of its aspects. These include **increasing latitude** (the maximum amount a system can be changed before losing its ability to recover) and **resistance** (how difficult it is to change the ecosystem) and **decreasing precariousness** (how close the current state of ecosystem is to a limit or threshold in which it becomes a substantially different ecosystem. Efforts to increase resilience include avoiding landscape fragmentation and its converse, restoring connectivity, ensure that refuges are protected so that re-colonization is possible, protecting keystone species if possible, and removing introduced invasive species. Another way to sustain or increase biodiversity and resilience would be to ensure that major environments are more or less evenly distributed across the landscape in both time and space, such as in different stages of forest succession within entire watersheds.

GREENHOUSE GAS EMISSION INVENTORY AT OREGON CAVES NATIONAL MONUMENT

Naturally occurring GHGs include CO_2, CH_4, N_2O, and water vapor. Human activities (e.g., fuel combustion and waste generation) lead to increased concentrations of these gases (except water vapor) in the atmosphere.

Greenhouse Gas Emissions

GHG emissions result from the combustion of fossil fuels for transportation and energy (e.g., boilers, electricity generation), the decomposition of waste and other organic matter, and the volatilization or release of gases from various other sources (e.g., fertilizers and refrigerants). The majority of the emissions at the Monument result from food services and hotel housekeeping provided by the concession and waste and waste removal by the park. A smaller portion is largely the result of park maintenance and contractor actions to improve or sustain communication and other utility systems, restore historic features at the park, like road curbing, keep water from damaging structures in both historic and non-historic buildings, and performing more routine maintenance functions. Additional emissions result from transportation to the Monument.

In 2007, GHG emissions within Oregon Caves National Monument totaled 208 metric tons of carbon dioxide equivalent ($MTCO_2E$). This includes emissions from park and concessioner operations and visitor activities, including vehicle use within the park. For perspective, a typical single family home in the U.S. produces approximately 11 $MTCO_2$ per year.[3] Thus, the combined emissions from park and concessioner operation, and visitor activities within the park are roughly equivalent to the emissions from the electricity use of 19 households each year.

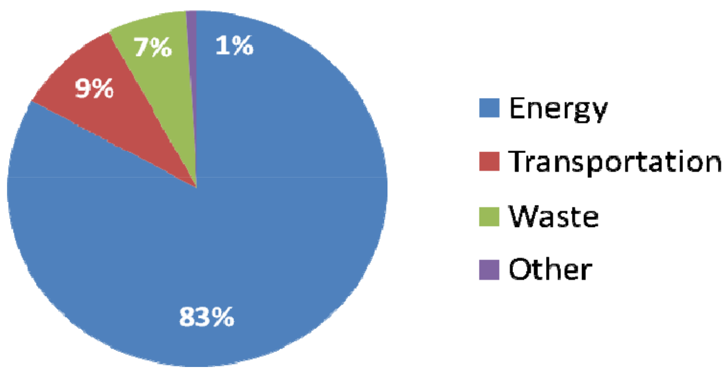
The largest emission sector for Oregon Caves National Monument is energy (mainly heating), totaling 173 $MTCO_2E$ (Fig 1 and Table 1). This high percentage is in part because the two largest buildings in the Monument, the Chalet and Chateau, are poorly insulated and presently cannot be winterized during the winter season due to plumbing that at present cannot be drained in the winter.

The next largest emission is from vehicles used to visit the Monument. Although visitor surveys indicate that there has been a substantial increase in regional versus extra-regional visitors since the late 1970s (~70% & 30% to ~35% & 65%), there are still many visitors from both areas that do not efficiently integrate an Oregon Caves visit with other attractions in the area.

[3] U.S. EPA, Greenhouse Gases Equivalencies Calculators – Calculations and References, Retrieved , Website: http://www.epa.gov/RDEE/energy-resources/calculator.html

FIGURE 1

Oregon Caves National Monument 2007 Total Greenhouse Gas Emissions by Sector



Visitor Vehicle Miles Traveled = 20,862

TABLE 1

Oregon Caves National Monument 2007 Total Greenhouse Gas Emissions by Sector and Source

Source	ORCA	
Building Fuel		
Propane	875	gallons
Electricity	184,990	kWh
Vehicle Fuel Use		
Gas Car	1,048	gallons
Waste	39	tons
Wastewater	NA	gallons

FIGURE 2

Oregon Caves National Monument 2007 Park Operations Emissions by Sector

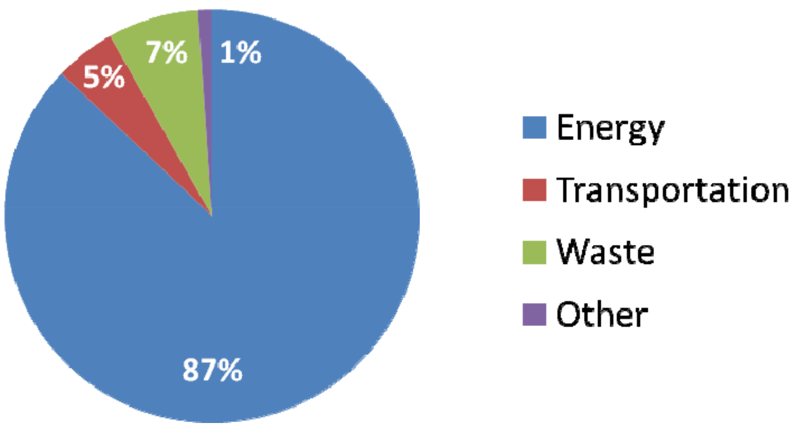


TABLE 2

Oregon Caves National Monument 2007 Park Operations Emissions by Sector

Source	ORCA	
Building Fuel		
Propane	875	gallons
Electricity	184,990	kWh
Vehicle Fuel Use		
Gas Car	1,048	gallons
Waste	39	tons
Wastewater	NA	gallons

Oregon Caves National Monument Responds to Climate Change

The following actions were developed during the Klamath Climate Friendly Parks Workshop on April 14th and 15th, 2010, in order to meet the park's climate change mitigation goals.

STRATEGY 1: REDUCE GHG EMISSIONS RESULTING FROM ACTIVITIES WITHIN AND BY THE PARK

Oregon Caves National Monument has developed a set of actions that the park is committed to taking in order to reduce emissions from activities within and by the park. These strategies have been prioritized based on a qualitative assessment of a set of criteria including: emission reduction potential, cost-effectiveness, feasibility, co-benefits, regional impact, and ability to rapidly implement. Actions that Oregon Caves National Monument will take have been presented below in order from highest to lowest priority within each sub-category.

Energy Use Management

Emission Reduction Goal: Reduce park operations' energy use emissions to 80 percent below 2007 levels by 2016.

Improving energy efficiency and implementing alternative energy sources reduces park-based fuel use, lowers GHG emissions, decreases electricity consumption, and offers monetary benefits for the park. Emissions inventory results indicate that 87 percent of the park's GHG emissions from Park Operations are from energy consumption. Consequently, Oregon Caves National Monument identified actions it will take to reduce energy-related emissions. Presented below are the actions that are currently under way and which comprise the park's progress to date, as well as those actions the park will pursue.

Progress to Date

Behavioral Changes

- The Park will continue to conserve first in regards to energy management.
- The Park maintenance staff has set the guidelines for thermostat settings to be 68 degrees in the winter time and 78 degrees in the summer when running an air conditioning units.
- In order to conserve energy the Park instituted a policy to close the visitor center and cave in mid-week during the shoulder seasons.
- Enforcement of no idling of vehicles.
- Renewed focus on Environmental Management Systems projects that will reduce carbon emissions.

Lighting

- Continuing to replace cave lighting with diodes. Explore the feasibility of directly converting some surface units to dioides now that they are available at relatively low prices from major distribution centers like Home Depot.
- Installed solar panel lighting on foot path to headquarters building on November, 2010.

Energy Efficient Electronics, Materials, and Devices

- Implemented a procurement policy that requires the Park to purchase energy efficient office equipment, appliances, and other equipment needs.
- Installed roof insulation to headquarters annex.
- New appliances upgraded to Energy Star.

Alternative Energy

- The Park purchases electric from hydroelectric sources.

Energy Use Management – Planned Actions

1 Promote energy efficiency and energy conservation in the park through behavioral change

- Encourage energy conservation in all park activities.
  - Apply insulation for walls, hot water pipes during remodeling of Chateau.
- Develop a mandatory energy-saving training program.
  - Park employees will continue to receive training on energy savings at the all employee meetings.
  - Initiate a program the will provide incentives of improvements in energy conservation via the spot awards.
  - Develop a "Myth Busters" check list for all offices and reminders to turn things off with facts about sustainability to show benefits.

2 Upgrade lighting options

- Upgrade all light fixtures and bulbs in park to energy efficient bulbs.
  - Replace all the lights in the cave with energy efficient LED's.
  - Check all of the lighting in the buildings and replace them to a more energy efficient lighting source if necessary.
- Install lighting controls.
  - Install motion sensors with timed controls in walkways and public bathrooms and street lighting in Historic District.

3 Heating, Ventilation, and Air Conditioning (HVAC)

- Develop an HVAC maintenance schedule.

    - Have the systems checked for efficiency and create a schedule to have them checked in the future.

- Recalibrate thermostats.
    - Continue to recalibrate the thermostat in the Headquarters building once a year as well as the monitoring of the system by computer.
- Ensure efficient use of building automation system (BAS)
    - The Park will start to use the installed timer on the system in July and August for the Chalet.

4 Switch to more efficient electronics and devices

- Default all computers to print double-sided.
    - Train all staff on the ways and means to have all the printing done from there stations to be double-sided printing by default.
- Install Smart Strip power strips.
    - The Park will purchase six new power strips with year-end funding.
- Replace park's existing boiler or furnace with an energy-efficient model.
    - Replace the old furnace in the Chateau with a newer energy-efficient propane model during the remodeling project in 2014.
- Install energy efficient water heaters.
    - Replace the old hot water heater in the Chateau with a newer energy-efficient propane model during the remodeling project in 2014.
- Make concession refrigeration equipment more efficient.
    - Evaluate the need for temperature-sensitive fans to increase energy efficiency.
- Make sure all transformer devices are managed so that they are only plugged in when in use.

5 Improve building structures and envelopes

- Replace old windows with new windows.
    - Install double pane windows in all of the Mission 66 buildings throughout the Park.

6 Utilize alternative energy sources

- Purchase electricity from a renewable energy provider.
    - Check for costs for additional percentage of renewable power from the current electrical provider.

- Install photovoltaic panels on park buildings, parking lots, open areas, etc.
  - Install photovoltaic panels on the back of the kiosk and on maintenance shop.
- Install clotheslines on side of Chalet adjacent to staff washing machines and on one side of the Chateau adjacent to hotel commercial driers to encourage use of solar power for drying.

7 Measure energy use throughout the park

- Partner with local universities on energy efficiency studies, audits and building audits.
  - Look in to partnership that Humboldt State University and Redwoods National Park has to see if there is some compatibility with Oregon Caves.
- Modify concessioner constructional language to include sustainable practice requirements.
  - The Park will look into adding more language in concessioner's contracts to include sustainable practice requirements for the contract renewal coming up in 2013.
- Conduct an energy audit for all park buildings.
  - Partner with Oregon Energy Trust to conduct a prioritized audit of the Chalet and Chateau.
- Install building-level utility meters in existing buildings and in new major construction and renovation projects to track and continuously optimize performance.
  - Investigate the most likely energy vampire usage outlet and install a smart power strip.

Transportation Management

Emission Reduction Goal: Reduce park operations transportation emissions to XX percent below 2007 levels by 2016.

Reducing vehicle miles traveled, improving vehicle efficiency, and using alternative fuels can significantly reduce Oregon Caves National Monument's emissions. As the inventory results indicate, GHG emissions from transportation comprise 5 percent of park operations emissions and 9 percent of the park's overall emissions (including visitors and concessionaires). Accordingly, in addition to the park operations emissions reduction goal, Oregon Caves National Monument set a goal to reduce overall transportation emissions by 10% percent below 2007 levels by 2016. Presented below are the actions that are currently under way and which comprise the park's progress to date, as well as those actions that the park will pursue.

Progress to Date

Behavioral changes

- The Park encourages its entire staff to carpool when commuting to work.
- The Park encourages its entire staff to use electric cars when traveling within park boundaries when possible.
- Increased checking to keep tires properly inflated.

Transportation Infrastructure

- Native plants were planted to reduce the amount of mowing needed for non-native grasses.
- Existing pavement is reground and reused for road construction projects.
- Where possible, the Monument's concessionaire is using local or regional fresh foods in its dining facilities.

Transportation Management – Planned Actions

1 Transportation-related Behavioral Changes

- Prohibit visitor vehicle idling.
    - Enforce policy for asking for no idling for busses and cars by outreach rangers.
    - Put message of no idling in to all group reservation forms.
- Encourage staff carpooling.

- Explore shuttle options between Cave Junction and Monument to determine how much cost/carbon savings would result.

- Reduce staff idling.
  - Install no idling stickers and incorporate into training to reduce staff idling. Explore whether any idling is needed for any vehicle.
- Reduce meeting travel.
  - Increase the use of Telnet (NPS teleconference system) to reduce the amount of travel done by park employees.

2 Reduce visitor vehicle fuel consumption

- Promote accessible front-country trails.
  - Continue to develop access to trails so people will be encouraged to get out of their car and hike the Park more.
- Expand shuttle services during construction.
  - Employee shuttle will be available during the life and safety rehab of the Chateau.
- Explore the use of biofuels in Park vehicles.

3 Reduce NPS vehicle and equipment net carbon emissions

- Exceed federal fleet performance requirements set by Energy Policy Act (EPAct), Executive Order 13423, and the Energy Independence and Security Act (EISA).
  - Continue to encourage the General Services Administration (GSA) to be more flexible in vehicle usage.

4 Replace NPS vehicles and equipment

- Use alternative fuel vehicles or hybrids.
  - Find more lasting batteries for electric cars or purchase mini-truck.

5 Vehicle maintenance

- Use bio-based lubricants and greases.
  - Purchase appropriate bio-based materials for the Park.

Waste Management

Emission Reduction Goal: Reduce park operations waste emissions to 10 percent below 2007 levels by 2016 through waste diversion and reduction.

The connection between waste and GHG emissions may not be obvious. However, waste management—in the form of source and solid waste reduction—can dramatically reduce GHG emissions. Landfills are the largest human-generated source of CH_4 emissions in the United States. Reducing the amount of waste sent to landfills reduces CH_4 emissions caused by decomposition as well as the GHGs emitted from the transportation of waste. The less the park and its visitors consume in terms of products and packaging, the less energy is used and fewer GHGs are emitted.

Oregon Caves National Monument's park operation activities emitted 14 $MTCO_2E$ from waste management in 2007. Diverting or reducing the park's waste stream through increased recycling efforts and waste management will reduce the amount of waste sent to landfills and resulting emissions. Presented below are the actions that are currently under way and which comprise the park's progress to date as well as those actions that the park will pursue.

Progress to Date

Waste Prevention

- All toner cartridges for copiers are recycled.
- Bear proof containers were purchased and are now currently in use.
- Reusable containers, plates and utensils are available for use at all employee functions.
- A replacement schedule, for existing materials, has been set up for the rehab on the Chateau.
- Encouraged the use of recycled content products and materials procurement, especially with copy paper and toner cartridges.
- Placed a drinking fountain in the visitor center to encourage the reduction of plastic bottles used by park visitors.

Green Procurement

- Concessioners have been purchasing locally produced materials whenever possible to lower the carbon footprint associated with transportation.
- Placed language in Environmental Management (EMS) Plan to encourage the increase of recycled content of purchased materials.
- The roof on the lodge was replaced with Forest Stewardship Council (FSC) certified wood.
- The Park does not use paints with any VOC content for interior projects.

- Instituted a policy to use carpets with a high recycled content.
- Established purchasing requirements for computers, fax machines, printers, scanners, and other electronic s.

Waste Management – Planned Actions

1 Decrease waste through behavior change

- Engage staff to reduce and manage waste at work.
  - Have training sessions once a year at start of summer season coving lowering the amount of trash that is sent to landfill.

2 Establish new plans and policies that promote waste reduction.

- Start a comprehensive waste reduction and recycling outreach campaign aimed at park visitors.
  - Purchase recycling canisters to replace trash cans at lower end of big parking lot.
  - Put signs on canisters that ask visitors to take recyclables home as, due to transportation costs, recycling at the Monument produces more carbon emissions than recycling at home.
- Choose hand dryers over paper towels.
  - Install high velocity hand dryers in Headquarters staff area.
- Pack-In and pack-out.
  - Make sure message is on more trail waysides about the Parks efforts to encourage packing out trash.
- Purchase products that minimize packaging.
  - Encourage Natural History Association to discontinue using Styrofoam cups.
- Ensure maximum recycling of paper waste.

3 Implement recycling and composting practices

- Partner with vendors to reuse and recycle park waste
  - Encourage/negotiate with concessioners to help in recycling/sorting waste from the hotel.
- Start a comprehensive recycling outreach campaign aimed at park visitors.
  - Encourage all visitors to recycle and post signage at more trail heads to educate visitors on their recycling options while at the park.

- Measure the baseline solid waste generation (tons) at the Park.
    - Measure waste stream more accurately by using weighing machine.
- Assign at least one full time person to act as a park recycling leader/manager.
    - Put in future job description or modify existing up to limit available to head the recycling program at Oregon Caves.

4 Reduce waste through green procurement

- Encourage contractors to practice green procurement practices.
    - Investigate possibility of changes in contract language to include the requirement of green procurement practices.
- Use post-consumer recycled paper in all park publications.
    - Check with materials paid for by cooperating associations to see if post-consumer materials are being used, especially in interpretive publications.
- Train staff on green procurement practices.
    - Establish and implement a green procurement practices training schedule.
- Adapt a list of pre-purchase questions for the Park.
    - Create a list of questions to be used as a guide when making purchases for the Park.
- Inventory and substitute all cleaning supplies with non-toxic products.
    - Continue to follow this practice.

5 Reduce Wastewater

- Install low-flow faucets
    - Install low-flow faucets during the Chateau remodeling project.
- Conserve water used in grounds maintenance.
    - Explore possibility of using waste from city of Cave Junction for the watering of plants
    - Replace sprinkler heads with low-flow models.
    - Explore using low water usage sod for landscaping.
    - Replace 50% of grass lawns with drought resistant shrubs.
- Monitor, manage and reduce point source wastewater.
    - Explore traps (filter drains) for parking lots.

6 Other Waste Management Actions

- Track and report landfill data to monitor reductions and success in diverting waste from the landfill.
  - Purchase scale for tracking waste amounts more accurately.
- Implement and enforce a construction waste management plan and job site recycling policy.
  - Make sure WMP and Job Site Recycling policy is in place and in contract language prior to Chateau and/or Chalet rehab.

STRATEGY 2: INCREASE CLIMATE CHANGE EDUCATION AND OUTREACH

Climate change is a complex and easily misunderstood issue. According to a 2008 Gallup Poll, only about 60 percent of the U.S. adult population believes that the effects of global warming has already begun. There has been a decline in that belief, as well as that most global warming is due to human activities, among some groups of Americans in the last decade. The belief that the seriousness of global warming is "exaggerated" rose from 31% in 1997 to 48% in 2010.

Mass media commentators have long challenged IPCC reports such as cited in this action plan as reflecting the "scientific consensus" on global warming by highlighting the views of a modest number of "skeptic" or "contrarian" scientists who question the IPCC conclusions. One result is that in their efforts to provide "balanced coverage," U.S. media have given disproportionate attention to the skeptics, creating the impression of less scientific consensus on global warming than exists within the mainstream scientific community. As a consequence, American newspapers' portrayal of global warming as a scientifically controversial issue differs significantly from the image presented by the media in other nations.

Still, there has nonetheless been a sizable increase over the past decade in the percentage of Americans who agree that "most scientists believe that global warming is occurring," up from 48% in 1997 to 65% in 2008. The belief that global warming will pose a serious threat to Americans and their way of life in their lifetimes has also increased from about 30%in 1998 to about 40% in 2008. 75 percent say that schools should teach children about climate change and 68 percent would welcome a national program to teach Americans more about the issue.

Emphasizing the dire consequences of climate change in an emotionally charged way tends to cause rejection of such messages in part because most people see their world as just, fair, and stable (Feinberg & Willer 2011). In contrast, emphasizing positive actions that Oregon Caves National Monument has and will take to reduce carbon emissions likely increases not only the belief in climate change but buttresses the belief that changing one's behavior and accepting the positive role of science in mitigating the effects of climate change can make a positive difference.

By using the best and most up-to-date science in ways that will educate and engage many different groups of stakeholders, Oregon Caves National Monument can play an integral role in communicating about climate change to a vast audience. A better understanding of the challenges and benefits of reducing GHG emissions can motivate staff, visitors, and community members to incorporate climate friendly actions into their own lives. Oregon Caves National Monument recognizes that the greatest potential impact the park can have on mitigating climate change is through public education. Thus, the park sees public education as an end goal of any climate initiative. From increasing the efficiency of public transportation to developing a green purchasing program, the actions Oregon Caves National Monument takes to address climate change serve as opportunities for increasing the public's awareness of climate change. Presented are the actions that are currently under way and which comprise the park's progress to date, and those actions and those described in this plan's introduction that the park will pursue.

Progress to Date

Climate Change Education

- New draft coffee table book on Oregon Caves National Monument has several climate messages.
- Developed climate change message into major interpretive theme for the Monument using park-specific examples.
- A Volunteer in Park (VIP) completed the effects of climate change on fuels reduction at Monument for college credit.

Climate Change Partnerships

- Hosted teacher workshops that had segments on climate change.

Other Education and Outreach Actions

- In order to create relationships with surrounding community the Monument partnered with the Siskiyou Field Institute. A one day program was given to members of the public on climate and weather.
- Climate change materials were presented at National Park Family Day.

Park Staff

Incorporate climate change into park staff training, events, and performance plans
Developing a climate change education program for park staff is vital to increasing awareness about climate change among park visitors and fostering a sense of collective responsibility among staff to help reduce park emissions. By incorporating climate change education into staff development programs, Oregon Caves National Monument will enable its staff to demonstrate their commitment through leading by example, and providing visitors with the tools and resources they need to reduce GHG emissions in the park and in their own communities. Potential actions include:

- Keep staff members that are part of the Green Team/Environmental Management Team informed about climate-related issues.
  - Post significant completed actions like the LED project for the cave.
  - Initiate better and more often notifications when webinars come up.
- Incorporate climate change issues into the employee handbook.
  - Incorporate language into the employee handbook outlining climate change issues and what the Park is doing to lower its carbon footprint.
- Include the science and impacts of climate change into park education tools.
  - Incorporate park-specific climate change research and themes into cave guide handbook.

- Incorporate sessions on climate change into staff training at least once a year.
  - Increase percentage of time devoted to research and mitigation when educating new staff about climate change.
- Develop a brown bag series for park staff including concessioners, partners, and occasionally visitors to educate about current climate change science, the park's efforts, and what they can do.
  - Create a brown bag series for employees to help educated and answer questions concerning climate change and the Park.
- Create visual reminders for park employees with climate change information and tips on how employees can help reduce emissions.
  - Give messages prominent positions and where most often seen, and post yearly estimates of emissions for the Park. Put in generic climate change exhibits in conjunction with park specific research.
- Create personal incentives for staff to reduce GHG emissions in park and at home.
  - Develop criteria for evaluating who to give awards or other forms to recognition to.
- Develop a oral history series for interviewing individuals with long term connections/visits to the Monument about changes that they have seen that appear likely due to climate change.
- Develop and leverage relationships with other agencies and entities to create opportunities for workshops on climate friendly activities.
  - Incorporate climate change messages in new revisions of cooperative agreement with the Siskiyou Field Institute
- Contribute park success stories to green voice biannual publication.
  - Send an article to the PWR office in Seattle on the LED lighting replacements for the cave and historic districts.
- Disseminate information about climate friendly actions the park is taking at conferences, meetings, and regional workshops.
  - Give staff reviews of climate presentations at Pacific Northwest Resource Management workshop in May.
- Additional Action
  - Seek funding from climate initiative, etc. to have park-specific research to interpret which makes interpretation more effective.
  - Buy two Kindles for park library and buy digital texts (those cited in the Library Acquisition Plan) when they are available.

Visitor Outreach

Understanding climate change and its consequences is essential to initiating individual behavioral change. Oregon Caves National Monument realizes that it has a unique opportunity to educate the public in a setting free from many of the distractions of daily life. By using existing materials, developing park-specific materials, highlighting what the park is currently doing about climate change, and encouraging visitors to reduce emissions, Oregon Caves National Monument can play an important role in educating the public about climate change.

Oregon Caves National Monument staff recognize the many different audiences that visit the Park, including recreational and non-recreational park visitors, "virtual visitors" who visit the park online, school-aged visitors, local and out of town visitors, local tribes, and external audiences. Reaching these various audiences with climate change information and engaging them in the park's efforts requires appropriately focused messaging. The park has developed a number of strategies to reach these various audiences effectively. These strategies include:

- Educate visitors about climate change.
  - Develop free brochure for visitors on Big Tree Trail wildflowers with flowering times and elevation map in which visitors can leave an insert on flowering times, species and elevation and keep brochure.
- Create and distribute previously produced information on climate change and its effects on National Parks in general and on your park in particular.
  - Distribute more general and Western parks brochures. Rotate short video segments into park video intro room. Have previous research on plant migrations and flowering times available to staff.
- Integrate climate change themes into interpretive programs.
  - Incorporate climate change messages in new revision of the two Junior Ranger handbooks.
  - Incorporate climate message in three new films about the Park.
  - Develop poster on flowers migrating due to climate change or blooming earlier, etc.
- Create signs promoting the park's efforts to curb emissions.
  - Incorporate into sign committee meetings\

    This would include combining some signs, determining the most efficient number and placement of signs, and using recycled materials for the signs.
- Host distance learning events on climate change.
  - Combine generic exhibit with homegrown exhibit on climate change research and mitigation going on in Oregon Caves.
  - Promote or encourage attendance of existing distance learning events.
- Incorporate climate change information into existing park brochures.

- Insert climate change language and information into the rack cards.

- Incorporate/create climate friendly information into interpreter programs and talks.
  - Develop off the shelf program outlines for new interpreters. Incorporate climate information in watershed curriculum development. Include recycling into outreach curriculum.

- Educate visitors about their recycling options at the park and at home.
  - Use as many appropriate media sources as possible to disseminate information about visitors recycling options.

- Communicate with local communities, park visitors, and local media about actions they can take to reduce GHG emissions.
  - Teach course on climate and climate change with Siskiyou Field Institute.
  - Discuss climate change initiatives with Siskiyou Field Institute and BLM.

- Develop and distribute Do Your Part! materials.
  - Put in webpage on park website on climate change and link to Network webpage and others on climate change.

- Create demonstration projects and exhibits to convey park sustainability message to visitors.
  - Develop exhibits that links paleoclimate study and other climate research to visitor behavior.

Local Community Outreach

The gateway communities, agencies, vendors, and volunteers surrounding Oregon Caves National Monument can play a significant role in supporting the park's climate change mitigation goals. As such, when appropriate, park staff will assist local communities with incorporating climate change messages into community events and find partners to promote climate change education at those events, and engage with surrounding agencies to coordinate effective outreach and education efforts. Potential actions include:

- Incorporate education on the science and impacts of climate change into concessioner training.
  - Develop joint training sessions with concession and natural history association staff.
  - Add yearly operating plan and make sure concession has brochures for distribution.

- Host climate change education workshops.
  - Explore whether teacher's workshop on climate change would be compatible with state curriculum.

STRATEGY 3: EVALUATE PROGRESS AND IDENTIFY AREAS FOR IMPROVEMENT

By taking the actions established in strategies 1 and 2 above, Oregon Caves National Monument plans to reduce its emissions to the specified goals. Achieving these goals will require an ongoing commitment by the park, which may include subsequent emission inventories, additional mitigation actions, and revaluation of goals. As part of this strategy, Oregon Caves National Monument will:

- Monitor progress with respect to reducing emissions. This will include subsequent emission inventories to evaluate progress toward goals stated in this action plan.
- Develop additional emission mitigation actions beyond those listed in this plan.
- Periodically review and update this plan.
- The park will track climate friendly actions through the environmental management system.

CONCLUSION

Oregon Caves National Monument has a unique opportunity to serve as a model for over 80,000 recreational visitors annually.[4] This report summarizes the operational actions the park commits to undertake to address climate change. Specifically, the park realizes its ability to educate the public and serve as a valuable model for citizens. By seriously addressing GHG emissions within the park and sharing its successes with visitors, Oregon Caves National Monument will help mitigate climate change far beyond the park’s boundaries.

The National Park Service faces an uncertain future due to both possible and likely effects of climate change that at present are difficult to predict. However, by seriously addressing climate change impacts and reducing emissions, Oregon Caves National Monument will reduce its contribution to the problem while setting an example for its visitors. The strategies presented in this Action Plan present an aggressive first step towards moving Oregon Caves National Monument to the forefront of Climate Friendly Parks.

[4] Oregon Caves National Monument: Park Statistics. Available online at: http://www.nature.nps.gov/stats/viewReport.cfm

CITATION BIBLIOGRAPHY

Agee, J. K. 1991. Fire history along an elevational gradient in the Siskiyou Mountains, Oregon. *Northwest Science 65*:188-199.

Alig, Ralph. 2009 (under review). Analysis of potential impacts of climate change on forests of the United States Pacific Northwest. Submitted to *Forest Ecology and Management* (November issue).

Angert AL, Bradshaw HD Jr, Schemske DW. 2008. Using experimental evolution to investigate geographic range limits in monkeyflowers. *Evolution* 62(10):2660-75.

Aplet, Gregory H. and David N. Cole. 2010. The trouble with naturalness: Rethinking park and wilderness goals. In *Beyond Naturalness: Rethinking Park and Wilderness Stewardness in an Era of Rapid Change*. Eds. David Cold and Laurie Yung. DC: Island Press., pp. 12-31.

Ault, T. R. and S. St. George. 2010. The prominence of decadal and multidecadal variability in North American precipitation. *Journal of Climate* 23: 842-50.

Beaubien, E. G. and HJ. J. Freeland. 2000. Spring phenology trends in Alberta, Canada: Links to ocean temperature. *International Jour. of Biometeorology* 44: 53-59.

Beier, P., and B. Brost. 2010. Use of land facets in planning for climate change: conserving the arenas not the actors. *Conservation Biology* 24(3): 701-10.

Betts, R. A. and H. H. Shugart. 2005. Dynamic ecosystem and earth system models. In *Climate change and Biodiversity*. Yale University Press. Haven & London, pp. 232-251.

Berteaux, D., et al. 2004. Keeping pace with fast climate change: Can arctic life count on evolution? *Integrated Comparative Biology* 44: 140.

Bonfils, Céline, and Coauthors. 2008: Detection and attribution of temperature changes in the mountainous Western United States. *J. Climate*, **21**, 6404–6424.

Bounoua, L. et al., 2010. Quantifying the negative feedback of vegetation to greenhouse warming: A modeling approach. *Geophysical Research Letters*, **37**, L23701.

Briles, C. E., C. Whitlock, P. J. Bartlein, and P. Higuera. 2008. Regional and local controls on postglacial vegetation and fire in the Siskiyou Mountains, northern California, USA. *Palaeogeography Palaeoclimatology Palaeoecology* 265(1-2), 159-169.

Campbell, J., D. Donato, D. Asuma and B. Law. 2007. Pyrogenic carbon emission from a large wildfire in Oregon, United States. *Jour. of Geophysical Research* 112.

Cayan, D. R. et al. 2001. Changes in the onset of spring in the Western United States. *Bull. of the American Meteorological Soc.* 82: 399-415.

Cooke, S. J. 2004. Abnormal migration timing and high en route mortality of sockeye salmon in the Fraser River, British Columbia. Fisheries 29: 22-3.

Crozier, Lisa. 2003. Winter warming facilitates range expansion: cold tolerance of the butterfly *Atalopedes campestris*. *Oecologia* 135(4): 1432-9.

Currano, Ellen D., Conrad C. Labandeira, and Peter Wilf. 2010. Fossil insect folivory tracks paleotemperature for six million years. *Ecological Monographs* 80:547–567.

Dennis, R. L. H. 1993. *Butterflies and Climate Change*. Manchester, UK: Manchester Univ. Press.

Dunn, P. O. & D. W. Winkler. 1999. Climate change has affected the breeding date of tree swallows throughout North America. Proc. Royal Society of London Series B 266: 2487-90.

Ellis, W. N., J. H. Donner, et al. (1997). Recent shifts in phenology of Microlepidoptera, related to climatic change (Lepidoptera). *Entomologische Berichten Amsterdam* **57**: 119-125.

Ersek, Vasile, et al. 2009. Environmental influences on speleothem growth in southwestern Oregon during the last 380,000 years. Earth and Planetary Science Letters 279: 316-25.

Feinberg, M. & Willer, R. 2011. Apocalypse Soon? Dire Messages Reduce Belief in Global Warming by Contradicting Just World Beliefs. *Psychological Science, 22.*

Fitter, A. H. and R. S. R. Fitter. 2002. Rapid changes in flowering time in British plants. *Science* 296: 1689

Forister, M. L. & A. M. Shapiro. 2003. Climatic trends and advancing spring flight of butterflies in lowland California. *Global Change Biology* 9: 1130-35.

Fowler, Richard. 2006. Environmental DNA analysis techniques for microbial studies at Oregon Caves National Monument. Contracts # 61-1358086.

Gerten, D. and R. Adrian. 2002. Climate-driven changes in the phenology and peak abundance of freshwater copepods in response to warm summers. *Freshwater Biology* 47: 2163-73.

Harrison, Susan, Ellen I. Damschen, and James B. Grace. 2010. Ecological contingency in the effects of climatic warming on forest herb communities. *Proceedings of the National Academy of Sciences.* 107 (45) 19362-19367.

Heidorn, Keith C. 2003. *The Weather Doctor's Weather Almanac:* Spring's Northward Migration, http://www.islandnet.com/~see/weather/almanac/arc2003/alm03mar.htm.

Hulme, Mike. Recent climate trends. 2005. Biodiversity and climate change in context. In *Climate Change and Biodiversity*. Eds. T. E. Lovejoy and L Hannah. New Haven: Yale Univ. Press., pp. 11-40.

Inouye, D. W. et al. 2000. Climate change in affecting altitudinal migrants and hibernating species. *Proceedings of the National Academy of Science, USA* 97: 1630.

Johannes Foufopoulos, A.. Marm Kilpatrick, and Anthony R. Ives. 2011. Climate Change and Elevated Extinction Rates of Reptiles from Mediterranean Islands. *American Naturalist* 177, pp. 119–129.

Joos, Fortunate and Renato Spahni 2008. Rates of change in natural and anthropogenic radiative forcing over the past 20,000 years. *Proc. of the National Academy of Sciences of the United States of America* 105(5): 1425-1430.

Karban, R. and S. Y. Strauss. 2004. Physiological tolerance, climate change and a northward range shift in the spittlebug, Philaenus spumarius. *Ecological Entomology* 29: 251-4.

Keller, G., et al. 2002. Paleoecology of the Cretaceous-Tertiary mass extinction in planktonic foraminfera. *Palaeogeography, Palaeoclimatology, Palaeoecology* 178(3): 257-97

Lawler, J. J., S. L. Shafer, D. White, P. Kareiva, E. P. Maurer, A. R. Blaustein, and P. J. Bartlein. 2009. Projected climate-induced faunal change in the Western Hemisphere. Ecology 90(3): 588-597

Lenihan, J. J., R. Drapek, D Bachelet, and R. P. Neilson. 2003. Climate change effects on vegetation distribution, carbon, and fire in California. *Ecological Applications* 13(6): 1167-81.

Lindgren, E.; Gustafson, R. 2001. Tick-borne encephalitis in Sweden and climate change. *The Lancet* 358(9275): 16-18.

Luke, C. M. and P. M. Cox. 2010. Soil carbon and climate change: from the Jenkinson effect to the compost-bomb instability. *European Jour. of Soil Science.* Nov. 4. Butler, C. J. 2003. The disproportionate effect of global warming on the arrival dates of short-distance migratory birds in North America. *Ibis* 145(3): 484.

Luo, Yiqi, et al. 2004. Progressive nitrogen limitation of ecosystem responses to rising atmospheric carbon dioxide. *BioScience* 54(8): 731-39.

Matthews, H. Damon, et al. 2010. The proportionality of global warming to cumulative carbon emissions. *Nature* **459**, 829-832

McKane, R. B., D. T. Tingley, and P. A. Beedlow. 1997. Spatial and temporal scaling of CO_2 and temperature effects on Pacific Northwest forest ecosystems. *American Association for Advances in Science, Pacific Division Abstracts* 16: 56.

McKinley, G. and D. Frank. 1995. *Stories on the land: An Environmental History of the Applegate and Upper Illinois Valleys.* BLM, Medford District.

Meehl, Gerald A. 2009. Relative increase of record high maximum temperatures compared to record low minimum temperatures in the U.S.. *Geophysical Research Letters* 36.

Meehl, Gerald A., Jule M. Arblaster, and Cluadia Tebaldi. 2007. Contributions of natural and anthropogenic forcing to changes in temperature extremes over the United States. *Geophysical Research Letters* 34, L19709.

Meehl, Gerald A., Aixue Hu, Benjamin D. Santer, 2009: The Mid-1970s Climate Shift in the Pacific and the Relative Roles of Forced versus Inherent Decadal Variability. *J. Climate*, **22**, 780–792.

Meehl, Gerald A. and Aixue Hu. 2010. Decadal prediction in the Pacific Region. *Jour. of Climate* 23: 2960-73.

Meehl, Gerald A., C. Tebaldi, H. Teng, and T. C. Peterson (2007), Current and future U.S. weather extremes and El Niño, *Geophysical Research Letters* 34, L20704.

Menzel, A. et al. 2006. European phonological response to climate change matches the warming pattern. *Global Change Biology* 12: 1969-76.

Minckley, T. A., P. J. Bartlein, C. Whitlock, B. N. Shuman, J. W. Williams, and O. K. Davis 2008. Associations among modern pollen, vegetation, and climate in western North America. Quaternary Science Reviews 27(21-22): 1962-1991.

Mohr, J.A., Whitlock, C., and C.N. Skinner. 2000. Postglacial vegetation and fire history, eastern Klamath Mountains, California. *The Holocene* 10, 587-601.

Mote, Philip, et al. 1999. Impacts of Climate Variability and Change in the Pacific Northwest: The JISAO Climate Impacts Group. Univ. of Washington.

National Park Service. 1999. Oregon Caves National Monument. August. Prepared by U.S. Department of the Interior, National Park Service.

Newman, Matthew, Gilbert P. Compo, Michael A. Alexander, 2003: ENSO-Forced Variability of the Pacific Decadal Oscillation. *J. Climate*, 16, 3853–3857.

Nogués-Bravo, D. R. Ohlemüller, P. Batra, M.B. Araújo. 2010. Climate predictors of Late Quaternary extinctions**.** *Evolution* 64(8): 3442-9.

Nordell, Bo, and Bruno Gervet. 2009. Global energy accumulation and net heat emission. *International Journal of Global Warming* 1, 378-391

Parmesan, C. 2005. Detection at multiple levels: *Euphydryas editha* and climate change. Case study. In Climate Change and Biodiversity. New Haven, CT.P Yale Univ. Press, pp. 56-60

Parmesan, C. and G. Yohe. 2003. A globally coherent fingerprint of climate change impacts across natural systems. *Nature* 421: 37-42.

Pereira, Henrique M. et al. 2010. Scenarios for Global Biodiversity in the 21st Century**.** *Science*: Vol. 330 (6010): 1496-1501

Robbirt, Karen M., Anthony J. Davy, Michael J. Hutchings and David L. Roberts. 2010. Validation of biological collections as a source of phenological data for use in climate change studies: a case study with the orchid *Ophrys sphegodes. Journal of Ecology* Sept. 21.

Rodland, D. L. and D. J. Bottjer. 2001. Biotic recovery from the End-Permian mass extinction: Behavior of the inarticulate brachiopod *Lingula* as a disaster taxon. *Palaios* 16(1): 95-101.

Root, T. L. 1988. Energy constraints on avian distributions and abundances. *Ecology* 69: 330-9.

Rosenzweig, C., G. Casassa, et al. 2007. Assessment of of observed changes and responses in natural and managed systems. In *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Eds. M. L. Parry et al. Cambridge, UK: Cambridge Univ. Press, pp. 79-131.

Reid, David M. and Mirwais M. Qaderi. 2009. Methane emissions from six crop species exposed to three components of global climate change: temperature, ultraviolet-B radiation and water stress**.** *Physiologica Plantarum*, July 14.

Roth, John E. 2009. Flying flowers: Vascular plant ranges move and contract northward in last 60 years. Paper presented at Third Conference on Klamath-Siskiyou Ecology Conference: Biodiversity in a Changing Environment. May 28th - 30th, 2009. Selma, Oregon.

Rushdi, A. I., Clark, P.U., Mix, A.C., Ersek, V., Simoneit, B.R.T., Cheng, H., and Edwards, R.L. (2009), Compositions and sources of lipid compounds in speleothem calcite and their potential for paleoenvironment studies, Quaternary Research, in review.

Shapiro, Art. N.d. Art Shapiro's Butterfly Site: *Atalopedes campestris*. http://butterfly.ucdavis.edu/butterfly/Atalopedes/campestris-

Simon, K. S., T. Pipan, and D.C. Culver. 2007. A conceptual model of the flow and distribution of organic carbon in caves. Journal of Cave and Karst Studies, v. 69, no. 2, p. 279–284.

Singer, M. C., & C. D. Thomas. 1996. Evolutionary responses of a butterfly metapopulation to human and climate-caused environmental variation. *American Naturalist* 148: S9-59.

Stewart, Iris T., Daniel R. Cayan, Michael D. Dettinger, 2005: Changes toward Earlier Streamflow Timing across Western North America. *J. Climate*, **18**, 1136–1155.

Sulbaek Andersen, M. P. et al. 2010. Inhalation anaesthetics and climate change. *British Jour. Of Anaesthesia* 105(6): 760-766.

Thomas, Chris D. 2004. Extinction risk from climate change *Nature* 427, 145-148

Tripati, A., C. Roberts, and R. Eagle. 2009. Coupling of CO2 and ice sheet stability over major climate transitions of the last 20 million years. *Science* 326: 1394-97.

Turetsky, Merritt et al. 2010. Recent acceleration of biomass burning and carbon losses in Alaskan forests and peatlands. *Nature Geoscience.* December 5.

University of York. 2007. Fossil Record Supports Evidence Of Impending Mass Extinction, Posted October 24.

Walsh, Megan K., C. A. Pearl., C. Whitlock, P. Barlein and M. Worona. 2010. An 11,000-year-long record of fire and vegetation history at Beaver Lake, Oregon, central Willamette Valley. *Quaternary Science Reviews* 29: 1093-1106.

Winder, M. & D. E. Schindler 2004b. Climate effects on the phenology of lake processes. *Global Change Biology* 10: 1844-56.

Zhang, Xuebin, Jiafeng Wang, Francis W. Zwiers, Pavel Ya Groisman, 2010: The Influence of Large-Scale Climate Variability on Winter Maximum Daily Precipitation over North America. *Jour. of Climate*, **23**, 2902–2915.

Ziska, L.H., Sicher Jr, R.C., George, K., Mohan, J.E. 2007. Rising carbon dioxide, plant biology, and public health: Potential impacts on the growth and toxicity of poison ivy (*Toxicodendron radicans*). *Weed Science* 55:288-292.

APPENDIX A: LIST OF WORK GROUP PARTICIPANTS

Vicki Snitzler, Superintendent of Oregon Caves National Monument

John Cavin, Chief of Maintenance at Oregon Caves National Monument

John E. Roth, Chief of Resources Management at Oregon Caves National Monument

Cynthia Hunter, Engineer for Klamath Network (Redwoods NP, Whiskeytown NRA, Crater Lake NP, Lassen Volcanic NP, Lava Beds National Monument.