National Park Service
U.S. Department of the Interior

CLIMATE *Friendly* PARKS

Mount Rainier National Park Action Plan

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MOUNT RAINIER NATIONAL PARK BECOMES A CLIMATE FRIENDLY PARK

As a participant in the Climate Friendly Parks program, Mount Rainier National Park belongs to a network of parks that are putting climate friendly behavior at the forefront of sustainability planning in national parks. 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, Mount Rainier National Park is serving as a model for climate friendly behavior within the park service.

Mount Rainier National Park, as a member of the Pacific West Region, is involved in the first regional effort within the National Park Service to become carbon neutral. The Region has developed a vision of having its park operations be carbon neutral by 2016 and of having all of its parks be Member Climate Friendly Parks by 2010. It is within the context of this larger vision that Mount Rainier National Park has developed the following emission reduction and adaptation goals.

Mount Rainier National Park has committed to reducing greenhouse gas (GHG) emissions from its Park Operations[1] by 30% below 2006 levels by 2016 and has committed to developing and implementing an adaptation plan to preserve the Park's natural and cultural resources and infrastructure from the impacts of climate change. Park Operations refers to the facilities, vehicles, equipment, etc. that are under the operational control of the park.

The Park's concession operations for lodging, food, beverage and retail are conducted by Mount Rainier Guest Services Inc. The guided mountaineering concessions are conducted by Alpine Ascents International, International Mountain Guides and Rainier Mountaineering Inc. These authorized park concessioners are committed to continued reduction of GHG emissions from their operations. Through a variety of contract requirements and voluntary measures, these operators continually seek out best business practices for reducing waste and implementing energy-efficient business practices. A summary of actions currently underway by concessions at Mount Rainier National Park to reduce GHG emissions is included in Appendix 1.

This Action Plan lays out the measures the park will take to meet this goal. In addition to implementing these measures, Mount Rainier National Park will:

- Monitor progress with respect to reducing emissions to preserve natural and cultural resources and infrastructure.
- Identify additional actions to reduce GHG emissions to preserve natural and cultural resources and infrastructure.
- Revise and update this Action Plan at least every five years, to strengthen existing actions and include additional actions.

THE CHALLENGE OF CLIMATE CHANGE

Climate change presents significant risks and challenges to the National Park Service. At Mount Rainier National Park, increased temperatures and changing precipitation patterns will likely alter the natural ecosystems, and change both the habitats available for species and resources available for visitors to enjoy the park. Appendix 2 and 3 provides specific details on climate change impacts to park ecosystems.

Scientists cannot predict with certainty the general severity of climate change nor its impacts. However, the current warming trend suggests that the problem is real and should be taken seriously. Average global temperatures on the Earth's surface

[1] Park Operations refers to the facilities, vehicles, equipment, etc. that are under the operational control of the park.

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. The single leading cause of this warming 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.

The continued addition of CO_2 and other GHGs to the atmosphere will raise the Earth's average temperature more rapidly in the next century; a global average warming of 4-7°F by the year 2100 is considered likely.[2] Rising global temperatures will further raise sea levels and 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.

GOALS AND OBJECTIVES

The objective of this Action Plan is to identify actions that Mount Rainier National Park can undertake to reduce GHG emissions and to adapt to current and future impacts of climate change. This plan presents the park's emission reduction goals, associated reduction actions, and adaptation strategies designed to achieve the park's goals. In addition to the GHG reduction actions identified in this plan, Mount Rainier National Park has already implemented air quality emission reduction actions parkwide. A summary of actions already implemented by Mount Rainier National Park that has resulted in a reduction in GHG emissions is included in Appendix 4.

The plan does not provide detailed instructions on how to carry out each of the proposed measures; rather, it provides the framework needed to meet Mount Rainier National Park's emission reduction and adaptation goals. The plan presents an opportunity for the park to devote resources for climate action through a mandate from the park's superintendent. This mandate gives park staff the resources and authority to pursue the mitigation actions contained in this plan.

Mount Rainier National Park aims to:

Reduce GHG emissions from Park Operations to 30% below 2006 levels by the year 2016 by implementing emission mitigation actions identified by the park.

Preserve to the highest degree possible the Park's natural and cultural resources and infrastructure from the impacts of climate change.

In order to meet or surpass this goal, the park will implement strategies proposed in this plan that build from the park's current and future emission inventories. Specifically, the plan recommends four strategies:

Strategy 1: Reduce GHG emissions from park operated facilities by identifying and implementing emission mitigation actions.

Strategy 2: Develop and implement a plan to adapt to current and future impacts of climate change

Strategy 3: Increase climate change education and outreach efforts.

Strategy 4: Evaluate progress and identify areas for improvement.

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[1]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>

GREENHOUSE GAS EMISSION INVENTORY AT MOUNT RAINIER NATIONAL PARK

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 energy (e.g., boilers, electricity generation) and transportation purposes, the decomposition of waste and other organic matter, and the volatilization or release of gases from various other sources (e.g., fertilizers and refrigerants).

In 2006, Mount Rainier National Park's GHG emissions totaled 12,710 metric tons of carbon dioxide equivalent ($MTCO_2E$). This total includes emissions calculated from Park Operations, Visitors, and Concessioner operations. As Figure 1 and Table 1 demonstrate, the largest emission sector for Mount Rainier National Park is Transportation - totaling 9,238 $MTCO_2E$. The majority of these emissions result from visitor vehicle travel within park boundaries. Figure 2 and Table 2 present emission inventory results for Park Operations, which excludes emissions from visitors and concessioners. These emissions totaled 3,100 $MTCO_2E$, resulting from Energy (66 percent), Transportation (24 percent), Waste (9 percent), and Other (<1 percent) activities.

FIGURE 1

Mount Rainier National Park's 2006 Greenhouse Gas Emissions by Sector ($MTCO_2E$) including park operations, concession operations and park visitor's contributions

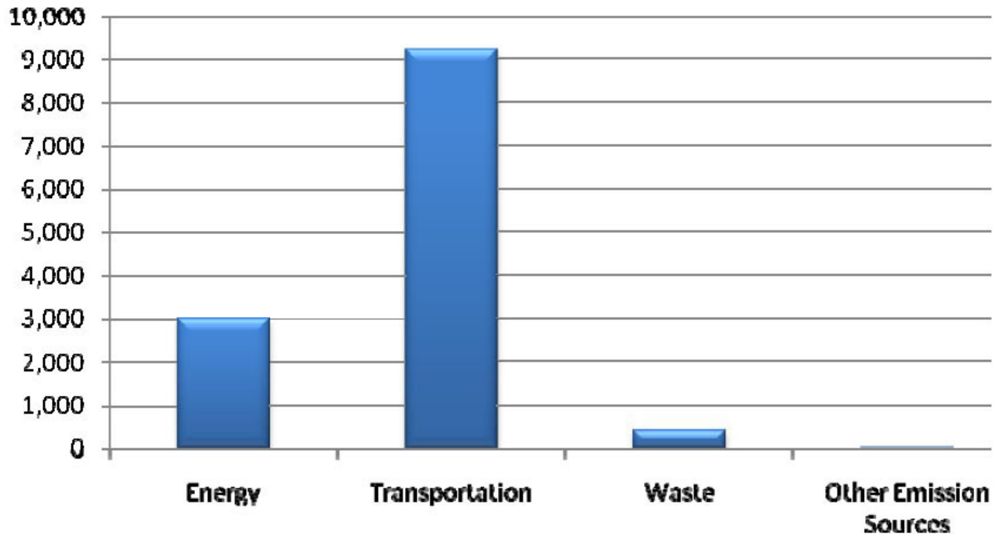

TABLE 1

Mount Rainier National Park's 2006 Greenhouse Gas Emissions by Sector and Source including park operations, concession operations and park visitor's contributions

	Emissions ($MTCO_2E$)	% of Total
Energy	3,006	23.7%
Stationary Combustion	1,551	12.2%
Purchased Electricity	1,455	11.4%
Transportation	9,238	72.7%
Mobile Combustion	9,238	72.7%
Waste	441	3.5%
Solid Waste Disposal	439	3.5%
Wastewater Treatment	2	0.0%
Other Emission Sources	25	0.2%
Refrigeration	25	0.2%
Total Emissions	12,710	

FIGURE 2

Mount Rainier National Park's 2006 Park Operations[3] Greenhouse Gas Emissions by Sector ($MTCO_2E$)

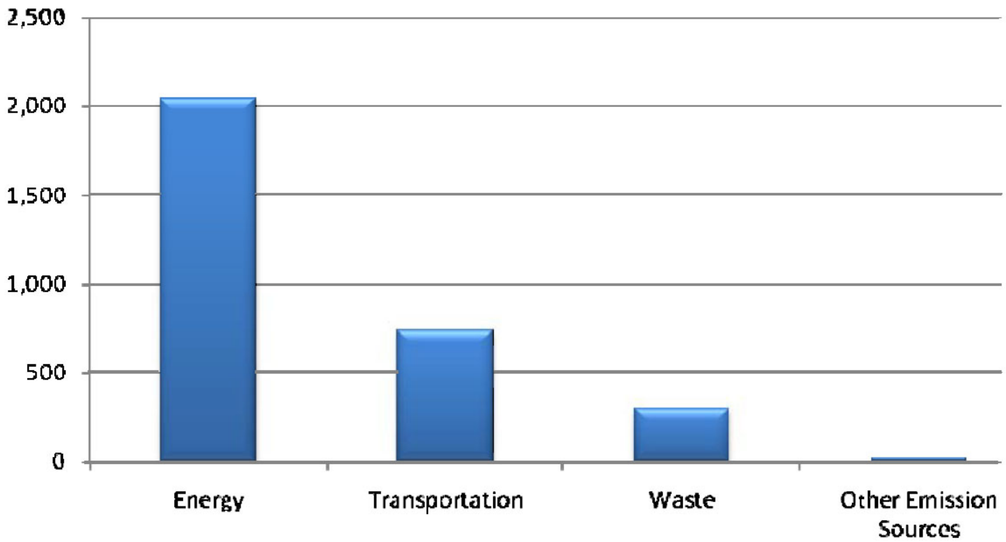

TABLE 2

Mount Rainier National Park's 2006 Park Operations Greenhouse Gas Emissions by Sector and Source

	Emissions ($MTCO_2E$)	% of Total
Energy	2,041	65.8%
Stationary Combustion	979	31.6%
Purchased Electricity	1,061	34.2%
Transportation	740	23.9%
Mobile Combustion	740	23.9%
Waste	297	9.6%
Solid Waste Disposal	296	9.5%
Wastewater Treatment	2	0.1%
Other Emission Sources	22	0.7%
Refrigeration	22	0.7%
Total Emissions	3,100	

[3] Park Operations refers to the facilities, vehicles, equipment, etc. that are under the operational control of the park.

How Mount Rainier National Park is Responding to Climate Change

The following actions were developed during the CFP workshop hosted by Mount Rainier National Park on February 18th and 19th, 2009 in order to meet the park's climate change mitigation and adaptation goals.

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

Energy Use Management

Park Operations

Emission Reduction Goal: Reduce Park Operations energy use emissions to 35% below 2006 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. As the inventory results indicate, 66 percent (2,041 $MTCO_2E$) of the park's GHG emissions from Park Operations result from energy consumption. Consequently, Mount Rainier National Park will take the following actions to reduce energy-related emissions. In implementing these actions, Mount Rainier will work to prioritize the actions according to their costs and benefits as well as their educational potential, and use the best available technologies and procedures.

1 Promote energy efficiency and energy conservation in park-operated facilities

- Implement conservation measures first before seeking technological improvements. Educate park staff to change behavior on energy use in both their work habits and residential living. Develop incentives and awards program to promote behavior changes.
- Initiate Standard Operating Procedures (SOP) for computer use and energy efficiency.
- Renew Government SOP for thermostat settings in offices.
- Explore opportunities to install solar hot water heaters on the Emergency Operation Center at Longmire.
- Purchase a kill-o-watt meter to identify inefficient appliances and use the information to inform the replacement schedule.
- Coordinate with Support Office to improve sustainability of L134 and Utility/Carpenter House remodel.
- Review contract for the Paradise Inn Annex rehab to make sure energy efficiency measures are included.
- Identify a partner for building energy audits (energy utility if free or contractor if needed).
- Review office space use to consider consolidation of office spaces on a seasonal basis. Currently several locations are occupied by single individuals during the winter season.
- Track Bonneville Power Association (BPA) grant proposal for energy star retrofits in quarters and process.
- Initiate planning with support office to improve sustainability of Maintenance Shop remodels.
- Initiate Conservation project for Roads Shop rehabilitation.
- Investigate replacement of Greenhouse temperature controls.

- Initiate conservation project for Tahoma Woods buildings.
- Expand Project Management Information System (PMIS) project for photovoltaics and submit in recovery package.
- Document building energy use profiles for occupant education.
- Continue to install energy efficient lighting fixtures and bulbs and educate residents on appropriate bulb wattage.
- Conduct a comprehensive inventory of lighting in all Park public buildings to create a baseline which will be used to document replacement of all non-energy efficient fixtures. This includes buildings occupied by the concession, in cooperation with park concessioners.
- Keep up with latest energy efficiency technology.

2 Produce clean energy or purchase electricity from a renewable energy provider

- Increase use of solar energy
  - Install solar system at Ohanapecosh.
  - Install solar panels on Emergency Operation Center at Longmire, Greenhouse at Tahoma Woods, and continue exploring solar options for other facilities throughout the park.
- Explore opportunities for using existing waterline at Ohanapecosh for hydropower purposes. Include assessment of legalities.
- Investigate purchasing “green power” with Lewis County Public Utility District.

3 Other

- Work with mandatory codes and traditional specifications to establish design standards for rehabs and new buildings that promote energy efficiency. Build a checklist that ensures these standards are met. Include language in the design specifications that requires contractors, etc. to estimate the potential GHG reductions associated with the project.
- Evaluate alternatives for increasing energy savings for office space at Longmire. This includes analyzing energy consumption of current office use at Longmire, feasibility of increasing energy efficiency of Longmire office buildings, and comparisons with moving staff out of Longmire to Tahoma Woods.
- Replace all Cathode Ray Tube (CRT) monitors with flat screens.
- Purchase only thin-clients for computers unless there is a justified need for a standard computer.
- Investigate alternative sources of heat to replace existing wood stoves in the park.

Transportation Management

Park Operations

Emission Reduction Goal: Reduce Park Operations transportation emissions to 30 % below 2006 levels by 2016.

Reducing vehicle miles traveled, improving vehicle efficiency and using alternative fuels can significantly reduce Mount Rainier National Park's emissions. As the inventory results indicate, 24 percent (740 $MTCO_2E$) of the park's GHG emissions from Park Operations are a result of transportation. The following strategies were developed to meet the park's transportation emission reduction goal:

1 Reduce fuel consumed by NPS vehicles.

- Develop and implement policies and technology to limit intrapark travel for staff/network (e.g., through the use webinars, telecommuting, flexplace, and video or teleconferencing during meetings).
- Lower fuel consumption in the park by 10% (reducing size of fleet, high fuel efficiency car, etc.).
- Renew policy on vehicle idling and continue to reduce amount of vehicle idling.
- Develop a plan for vehicle optimization including planned use, potential opportunities for sharing with other staff, and ensuring that vehicles required for the job utilize the most climate friendly vehicle type and fuels available.
- Develop opportunity for employee shuttle service through Pierce County Transit and implement a transportation subsidy program to increase ridership.

2 Use alternative fuels and oils in Park Operated vehicles and equipment

- Expand use of alternative fuel vehicles.

3 Other

- Consider integration of green road specs into road design and construction. [4] Utilize a consultant to assist park develop a plan for integration.
- Replace two-stroke engines with more efficient four-stroke engines for snowmobiles and other equipment.
- Purchase an electric leaf blower to test for parkwide application.
- Design appropriate building storage capacity during the building and facility planning process to ensure that vehicle delivery trips do not increase due to a lack of storage space.
- Perform a Fleet Management Program review.

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[4] Greenroads is a rating system that distinguishes high-performance more sustainable new, reconstructed or rehabilitated roads. It awards credits for approved sustainable choices/practices and can be used to certify projects based on total point value. Projects can be certified at the standard, silver, gold or evergreen level depending upon their level of sustainability. The ultimate intent is for Greenroads to be used as a nationwide standard (voluntary or otherwise) for the design and construction of more sustainable roads.

Visitor Transportation

As the inventory results indicate, the largest GHG emissions for Mount Rainier National Park result from visitor vehicle travel within park boundaries totaling 8,409 $MTCO_2E$. While an emissions reduction goal was not specifically set for private visitor vehicles, the park recognizes the need to pursue actions to reduce the GHG emission resulting from visitor transportation. The following actions were identified:

- Investigate ways to expand opportunities for alternative public access to park locations (e.g., public transportation, alternative transportation such as shuttle buses)
- Utilize shuttles to achieve a 15% reduction in the number of visitor vehicles parked at Paradise and Sunrise during peak visitor use days.
- Provide incentives to encourage alternative transportation assessment in upcoming transportation study.
- Evaluate potential to create a sliding fee scale and additional incentives to promote alternative public access and fuel-efficient vehicles.
- Consider implementing incentives to encourage visitors to take alternative transportation (shuttles) during peak periods
- Expand idling reduction program to include all vehicles and all areas. Increase traffic flow at entrance stations. Focus on education/signage
- Expand shuttle services during construction periods to reduce traffic and transport visitors from parking areas to popular park destinations.
- Research funding opportunities for community transportation plans (e.g. scenic byway funds and Forest Service enhancement funds, Indian Reservation Road funds, Federal Transit Administration funds).
- Partner with surrounding communities on alternative transportation initiatives (e.g., undertake feasibility study to expand shuttle systems to surrounding communities) with a focus on Ashford to Paradise route and highway 410 (Enumclaw to Sunrise) and perhaps the Carbon/Mowich corridor.

Waste Management

Emission Reduction Goal: Reduce Park Operations waste emissions to 15% below 2006 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 reduction and solid waste reduction—can dramatically reduce GHG emissions. The less we consume in terms of products and packaging, the less energy is used and fewer GHGs are emitted. Additionally, reducing the amount of waste sent to landfills reduces CH_4 emissions caused by decomposition.

Diverting or reducing the park's waste stream through increased recycling efforts and waste management procedures will reduce the amount of waste sent to landfills, which are the largest human-generated source of CH_4 emissions in the United States. Mount Rainier National Park's Park Operation activities emitted 297 $MTCO_2E$, or 8%, from waste management in 2006. The following strategies were developed to meet the park's waste emission reduction goal:

1 Manage waste through source reduction, composting, recycling, and combustion

- Continue to use bio-based lubricants in equipment, recycle anti-freeze, use green seal materials, and use 100 percent recycled content trash bags.
- Reuse or recycle material used during building and grounds remodeling.
- Explore opportunities for composting at the park or through Cedar Grove. Compostable waste is generated by the Park exotic plan reduction efforts. Research technologies that handle compost to ensure the system peak temperatures are high enough to kill invasive species. Consider bringing in contractor to identify the best process.
- Experiment with removing trash cans at White River Overlook and other locations where visitors are likely to use receptacles to simply empty car trash.
- Consider installing up-to-date electric hand dryers (e.g., accelerator, dyson blade dryer) to reduce paper towel use.

2 Other

- Update Integrated Solid Waste Alternative Program (ISWAP). Re-evaluate waste stream, recycling locations and signage throughout the park.
- Conduct an audit (through ISWAP) to characterize waste. Evaluate contents of dumpsters to assess amount of waste vs. what can be recycled (e.g., dumpster dive).
- Continue to work towards eliminating personal printers, and purchase machines that complete multiple tasks (e.g., fax, printer, scanner). Set all printers to print on black and white and to print double-sided. Encourage green meetings (teleconferencing, low/no paper).
- Explore opportunities to install grinders to transfer organic waste to wastewater treatment system. Work with wastewater treatment plant to make sure they can handle additions of organic material.
- Educate and train park staff and concessioners in new waste management practices such as recycling and composting (e.g., prepare an orientation packet and provide information on policies and practices on recycling).

- Reduce the amount of paper educational materials by including climate-friendly messaging into radio messages.
- Increase signage that identifies where recycling receptacles are located.
- Reevaluate system for recycling partnership between GSI and NPS to determine if it needs improvement.
- Develop employee orientation materials for sustainable messaging (i.e., recycling procedures). Consider use of volunteers, student interns, etc. to develop this educational material.
- Continue to install low flow toilets and faucets and investigate improved technology and application to park facilities

STRATEGY 2: DEVELOP AND IMPLEMENT A PLAN TO ADAPT TO CURRENT AND FUTURE IMPACTS OF CLIMATE CHANGE

While every effort must be made to curb future impacts of climate change through greenhouse gas reduction actions such as those proposed in Strategy 1, the impacts of climate change are being seen around the globe now. As such, it is important to develop and implement strategies to adapt to the changing environment in order to protect the natural and cultural resources, and infrastructure contained in our National Parks.

When developing strategies for adaptation, it is important to recognize that the planning processes and methods for addressing adaptation is in its early stages, and that the bodies of both scientific and planning knowledge on this subject are rapidly evolving. In general, the body of knowledge is currently coalescing around several key aspects of adaptation planning. These steps include: 1) establishing a baseline that is informed by science and measureable, 2) developing key partnerships both between entities (National Park Service, Forest Service, NGO's, etc.) and individuals (managers, policy makers, and scientists) which will be affected by any actions taken, 3) developing a plan, 4) implementing adaptive management through predictive modeling and scenario planning and finally, 5) revisiting and revising plan based on experience and updated science.

Climate change will result in widespread transformation of snowmelt and transient watersheds to rain dominant watersheds. As discussed during Mount Rainier's two day workshop, impacts of climate change on the park include increased warming that potentially results in loss of glaciers and snowpack, changes in precipitation patterns which in turn will likely alter physical, chemical and biological characteristics and processes of aquatic communities; increase flooding and debris flows with changes in surface water hydrology; and alter forest, subalpine and alpine environments including species migration or loss, increases in exotic species and fire frequency, changes in animal population and community dynamics. For a more detailed description of climate change effects on park resources refer to Appendix 2 and 3.

Many of these impacts are interrelated, making adaptation planning a complicated task. For example, increased temperatures and changes in precipitation can spur flooding and debris flows, which degrade stream habitats for fish and other species as well as threaten any infrastructure that surround affected rivers. This type of degradation of natural and cultural resources and infrastructure was seen during the Park's flood in 2006, which highlights the need for proper adaptation strategy planning and implementation. The actions discussed below represent the beginning of this process for Mount Rainier National Park.

The highest priorities to address that were associated with adaptation to climate change at Mount Rainier National Park were as follows with specific actions associated with Natural Resources, Cultural Resources, and Infrastructure detailed below:

1. Increasing our understanding of climate change impacts to ecosystems through inventory and monitoring efforts and modeling potential ecosystem and disturbance impacts;
2. Increasing education to managers and the public on climate change effects;
3. Planning for emergency management and response, addressing potential access issues such as the vulnerability of the existing park road structures;
4. Encouraging alternative transportation systems to reduce the number of vehicles on park roads;
5. Developing a better understanding and increasing education of the how management actions to protect areas from climate disturbances affect park natural and cultural resources;
6. Increasing coordination with other agencies on regional fish and wildlife issues, emergency planning, invasive species, and adjacent land management concerns.

Natural Resources

Parks throughout the U.S. contain, and have preserved for decades, various ecological landscapes and representative species of the much of the nation's biological diversity. The species that comprise these ecosystems and the landscapes they inhabit will respond to climate change. The actions below were developed in an effort to preserve and protect Mount Rainier National Park's natural resources to the greatest extent possible.

Improve our understanding of Climate change effects on aquatic and terrestrial resources on a landscape scale through the following actions:

- Conduct a review of MORA Vital Signs Plan[5] for climate sensitive resources (including invertebrates and non-vascular plants).
  - Conducting inventories to assess fish populations and track distribution
  - Conducting inventories of sensitive animal species where baseline data is lacking (e.g., pika)
  - Re-inventorying wetlands and tracking changes to representative climate sensitive wetland systems.
  - Monitoring trends in subalpine vegetation communities
  - Developing early detection and rapid response protocols and implementation actions for invasive non-native species.
  - Monitoring changes in forest communities response to climate change
  - Monitoring trends in lake and stream temperatures and species sensitive to temperature changes (e.g., bull trout spawning, amphibian breeding).
  - Monitoring snowpack and park lakes and streams for contaminants
  - Monitoring the aerial extent, ice surface elevations, and terminus positions of park glaciers.
- Research
  - Study the effects of glacier retreat on stream temperatures
  - Identify species in MORA that are sensitive to climate change effects and initiate monitoring program and develop modeling to track trends.
  - Identify key pollinators and develop research or monitoring protocols
  - Conduct research on species such as pikas and marmots looking at demography, meta-population dynamics and others that help predict how rapidly we expect to see changes to these species.
  - Increase our knowledge of climate change effects on forest functions.
- Research and develop predictive models that address spatial and temporal scale changes likely to occur with climate change in MORA through integration of research and monitoring efforts and coordination with adjacent agencies and academic institutions
  - Model how wildlife species are changing in population and distribution and use the model to identify research questions and potential management strategies.
  - Model how fragmentation is going to affect wildlife distribution.

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[5] Vital Signs Plan is a document that describes the inventory needs, selection of indicators of ecosystem health, and development of long-term monitoring programs to monitor the status and trends in park ecosystem components, functions and processes.

- Map avalanche chutes, monitor their activity and synthesize the research data to develop more predictive models.
- Use current data on sediment disturbance events to develop zones where we anticipate future events, develop predictions, and incorporate information into management planning. Develop more frequent monitoring or research to study linkages between storm events and slide events.
- Incorporate information from emerging models into fire management planning and fire management strategies. If conditions change the fire risk in different areas, change expectations for fire activity and what happens on the landscape post-fire event. Develop better correlations/analysis between fire management and exotic plant species.

- Develop projections for where known native and non-native insects and diseases are predicted to occur, evaluate effects on the function of the system, and develop management strategies.
  - Assess fish and amphibian disease and aquatic non-native invasives.
  - Develop early detection and rapid response protocols and implementation actions for invasive non-native plant and animal species.
- Increase our knowledge of linkages between climate and water resource patterns by monitoring high elevation streamflow, synthesizing available climate data
- Increase our knowledge of infrastructure effects on park natural resources (e.g., flood recovery effects on aquatic and riparian resources)
- Incorporate inventory and research findings in to park's curatorial management program.
- Interagency Coordination
  - Work with interagency groups across larger regions for addressing climate change issues at a landscape scale (e.g., Puget Sound consortium, wildlife agencies addressing large mammals such as bears and cougars to track their distribution; fish management agencies to address fish migration issues; agencies addressing regional invasive non-native species and disease, etc).

Other Actions

- Explore alternative to reduce campfire smoke in the park by:
  - increasing public education about the campfire smoke problem in the park,
  - establishing non-burn days in the park,
  - exploring alternative fueled campfires,
  - limiting campfires to one in each camp-ground loop or one centralized campfire and,
  - banning campfires during inversions and other adverse weather conditions
- Incorporate greenhouse gas as an impact topic in all environmental planning documents

Cultural Resources

In many instances, national parks were created to preserve a particularly special American cultural resource; or, since their inception, have discovered that they contain significant archaeological, historical, ethnographic, architectural, and designed landscape resources. The integrity of cultural resources such as these can be affected by physical landscape changes such as riverbank and sheetwash erosion, landslides, fire, and other sources of deterioration ultimately linked to altered climate patterns. Cultural resources within the park include some of the park infrastructure discussed below. This includes the major roads and several developed areas, the Wonderland and Northern Loop trails, and historic structures.

Mount Rainier National Park has developed the following actions to preserve as many of the cultural resources within the park boundaries as possible:

- Strive to document the full range of cultural resources preserved within the park.
- Assess vulnerability of these resources to various climate change scenarios.
- Determine management actions – protection, preservation, rehabilitation, etc.
- Implement mitigative actions in priority order based on susceptibility to climate-related damage.

Infrastructure

To enable visitors to experience all resources within each park, every park has a physical infrastructure that may include roads, trails, bridges, culverts, buildings, and utilities. This physical infrastructure represents a significant investment and can be impacted to varying degrees by climate change. Mount Rainier National Park recognizes the potential for its infrastructure to be impacted and has developed the following actions to understand and plan for the impacts of climate change to better protect its physical resources.

- Increase our knowledge of hydrologic effects on park infrastructure
  - Model available resource data to identify specific adaptive management actions to protect natural and physical resources (e.g. fish, bridges, infrastructure)
  - Obtain a better understanding of glacier status and trends, debris flow occurrence/frequency, and stream aggradation where infrastructure is threatened.
- Increase our knowledge of infrastructure effects on park natural resources (e.g., flood recovery effects on aquatic resources)
  - Conduct course woody debris surveys for the Nisqually, White and Carbon Rivers to obtain a full understanding of how removing wood to build shoreline protection structures (e.g., engineered log jams), affects natural ecosystem components, functions and processes.
  - Increase our knowledge of how infrastructure protection practices (e.g., constructing and maintaining shoreline protection structures; dredging, etc.) affect natural ecosystem components, functions and processes.
- Address current flooding and infrastructure issues by developing a road and trail management plan for flooding and sediment transport.
- Identify potential alternatives to primary road accesses threatened by flooding (e.g., Skate Creek road). Address drought impacts to visitor water supply.

  - Implement conservation efforts parkwide to conserve water during summer season when warmer temperatures result in reduction in surface water supplies and increase impacts on dependent natural resources.
  - Develop and present public and employee education on water conservation efforts.
- Implement new adaptation technology and showcase adaptation efforts through public education efforts.

In addition to the resource specific actions listed above, Mount Rainier National Park has developed a number of high level planning oriented actions designed to enable park staff to most effectively address the impacts of adaptation. These actions are listed below:

- Incorporate climate change concerns into visitor use capacity planning (e.g., future access issues).
- Update or develop Emergency Action Plans to address park management response to avalanches, geohazards, and fires. Increase coordination with regional emergency management agencies and adjacent landowners.
- Initiate planning and action to maintain access on Hwy 410.
- Initiate planning and action to address river aggradation and flooding issues on the Nisqually to Paradise road and Carbon River area.
- Address long-term access issues on West Side Road given future climate change effects on existing infrastructure
- Explore transportation alternatives to provide access to flood prone frontcountry areas of the park and to reduce use of private vehicles parkwide.
- Work with Federal Highways Administration and FEMA in addressing the existing constraints associated with emergency road repairs (e.g., prohibition of betterments to prevent future flood damage)

STRATEGY 3: INCREASE CLIMATE CHANGE EDUCATION AND OUTREACH

Mount Rainier is a perfect place to educate the public about the complex issue of climate change. Receding glaciers are an easily understood manifestation of climate change and provide a suitable backdrop for exploring the issue as it relates to park resources. A better understanding of the problem and the benefits of reducing GHG emissions can motivate staff, visitors, and community members to incorporate climate friendly actions into their own lives. Mount Rainier National Park 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 a crucial component of any climate initiative. From increasing the efficiency of public transportation to developing a green purchasing program, the actions Mount Rainier National Park takes to address climate change serve as opportunities for increasing the public's awareness of climate change.

Park Staff

Developing a climate change education program for park staff is vital to increasing awareness about climate change among park visitors. By incorporating climate change education into staff-development programs and creating new opportunities for staff to learn about climate change, Mount Rainier National Park will reduce park emissions and provide visitors with the tools and resources they need to reduce GHG emissions at home and in their own communities.

Incorporate climate change into park staff training and performance plans

In an effort to provide Mount Rainier National Park staff with the knowledge and tools to educate visitors, the park will:

- Place a form in park residences that identifies the climate-friendly actions residents should take. The form should include a line for residents to sign to commit to the actions. Include posting of previous year's energy consumption to build competition among year-to-year residents.
- Organize a park Green Team made up of representatives from all divisions and locations within the park, and include park concessioners.
- Have an annual energy-efficiency day that encourages park staff to identify inefficiencies in their workplace and report to Green Team for prioritization and mitigation.
- Work the message of sustainability into the park culture. Include sustainability messages in materials for park staff, concession employees, and commercial use permitees.
- Incorporate education on the science and impacts of climate change into concessioner training.
- Develop a sustainability web page on the park intranet and make materials available to the park concession operators.
- Institute periodic status checks on progress in sustainability in staff meetings.
- Incorporate education on the science and impacts of climate change into employee education tools (e.g., seasonal staff handbook, all park meetings, etc.)

Visitors

Understanding climate change and its consequences is essential to initiating individual behavioral change. Mount Rainier National Park 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, Mount Rainier National Park can play an important role in educating the public about climate change.

Incorporate climate change awareness into visitor and environmental education programs

Park interpretive staff has the opportunity to introduce the issue of climate change to many visitors. Mount Rainier National Park encourages staff to include messages about climate change in their visitor talks. The park will:

- Include messaging about climate change and what the park is doing in formal interpretive programs.
- Place interpreter on shuttles to educate visitors on climate change and the importance of reducing emissions.
- Include climate friendly action messaging on park shuttle fleet, concession facilities, and park facilities (including restrooms).

Develop park-specific interpretive materials for visitors

Educating visitors about the tangible effects of climate change is a powerful way to encourage visitors to reduce GHG emissions. The park will use existing climate change interpretive resources, and promote the development of climate change materials specific to impacts in Mount Rainier National Park. The park will:

- Continue showing visitors the Climate Change Power Point program at the Jackson Visitor Center.
- Include climate change message in park field trips and other education programs
- Develop a section of the Sister Mountain Curriculum project focused on climate change and mountain ecosystems
- Include a sustainability message to reduce visitors' carbon footprint in every issue of the park newspaper (Tahoma).
- Add a sustainability page to the park website.
- Use the climate change exhibit at the Puyallup Fair.

Highlight what the park is doing to address climate change

Mount Rainier National Park has already taken many climate friendly actions. In an effort to lead by example and demonstrate climate friendly behavior for the public, the park will increase education and outreach efforts related to sharing the successes it has already achieved. The park will:

- Collaborate with partners on messaging (Washington Trails Association, National Parks Conservation Association, NorthWest Trek, etc.)
- Disseminate information about climate friendly actions the park is taking at conferences and regional workshops.

- Collaborate with local universities and SEATAC Airport to disseminate information about climate friendly actions in the park.

Encourage visitors to reduce greenhouse gas emissions
Perhaps the greatest potential for Mount Rainier National Park to help reduce GHGs is to increase visitors' awareness of how they can reduce their personal GHG emissions. The park will:

- Implement the Do Your Part program at Mount Rainier National Park.
- Incorporate Do Your Part! materials in the park newspaper (Tahoma), and park website.
- Distribute messaging about actions that visitors can take to reduce the impact of their visit through posters

DO YOUR PART FOR CLIMATE *Friendly* PARKS

The Do Your Part! for Climate Friendly Parks program provides easy actions people can take every month to reduce emissions in their everyday lives.

Local Community

The communities within and surrounding Mount Rainier National Park can play a significant role in supporting the parks GHG reduction goals. As such, when appropriate, Mount Rainier National 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. Park staff will use their knowledge of climate change resources to help local communities engage in climate friendly actions.

Encourage climate change awareness among the communities within both the park and region
Mount Rainier National Park realizes that the communities within the park and the region are one of the greatest assets in addressing climate change at Mount Rainier. The park will:
Develop media strategy on climate change to provide public information.

- Work with surrounding community leaders to inspire them to take action on climate change in conjunction with Mount Rainier.
- Collaborate with National Parks Conservation Association weekend table to get climate change message out and communicate what the Park is doing.
- Reach out to individuals in surrounding communities by talking about Mount Rainier's initiatives and how to get involved either in person or through Do Your Part! at farmer's markets and other events.
- Plan a community event for Earth Day. Showcase climate friendly actions (including special speakers) to targeted groups who could implement some of these ideas elsewhere.

STRATEGY 4: EVALUATE PROGRESS AND IDENTIFY AREAS FOR IMPROVEMENT

By taking the actions established in strategies 1, 2, and 3 above, Mount Rainier National Park plans to reduce its emissions to the specified goal and begin adapting to the impacts of climate change. Achieving these goals will require an ongoing commitment by the park, which may include subsequent emission inventories, monitoring of adaptation success, additional mitigation and adaptation actions, and revaluation of goals. As part of this strategy, Mount Rainier National Park will:

- Monitor progress with respect to reducing emissions and preserving natural, cultural and physical resources. This will include subsequent emission inventories to evaluate progress toward goals stated in this action plan.
- Develop additional emission mitigation and adaptation actions beyond those listed in this plan.
- Green Team to meet annually to review progress on this plan.
- Conduct an emissions inventory in Fiscal Year 2011 and 2016.
- Provide emissions criteria needs to Concessions to facilitate tracking and future emission inventories.

CONCLUSION

Mount Rainier National Park has a unique opportunity to serve as a model for approximately 1.1 million visitors annually.[6] 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, Mount Rainier National Park will help mitigate climate change far beyond the park's boundaries.

This Action Plan also serves as an important enhancement mechanism for the Park's Environmental Management System (EMS). Realistic environmental commitments created by Mount Rainier National Park staff and approved by the park's superintendent will significantly reduce the park's GHG emissions in the coming years. The mitigation and adaptation actions included in this plan have been developed in order to be directly transferable to the park's EMS Mount Rainier National Park's Action Plan thus provides an effective way to meet EMS goals.

The National Park Service faces an uncertain future due to the possible effects of climate change. However, by seriously addressing climate change impacts and reducing emissions, Mount Rainier National Park 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 Mount Rainier National Park to the forefront of Climate Friendly Parks.

[6] Mount Rainier National Park: Park Statistics. Available online at: http://www.nature.nps.gov/stats/viewReport.cfm

Glossary

Adaptation
Initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects.

Alternative-Fuel Vehicles (AFVs)
Vehicles that operate on fuels besides gasoline or diesel. Burning alternative fuels – which can be derived from ethyl or methyl alcohol, electricity, hydrogen, petroleum products, or various vegetable oils – generally result in fewer emissions than traditional fuels

Alternative Transportation
Transportation that operate on fuels besides gasoline or diesel. Burning alternative fuels – which can be derived from ethyl or methyl alcohol, electricity, hydrogen, petroleum products, or various vegetable oils – generally result in fewer emissions than traditional fuels.

Biodiesel
Fuel used in diesel engines derived from the fatty acids in vegetable and animal fats.

Boiler
A device used for heating or other processes that works by using a combustion source (usually a furnace) to create steam under pressure in an enclosed unit. There are two common types of boilers: water-tube boilers, and fire-tube boilers. Water-tube boilers work by passing water around a fire in many small tubes; fire-tube types directly use the hot gases from the fire without having tubes insulate.

Carbon Dioxide (CO2)
A colorless, tasteless, odorless gas that is the most significant greenhouse gas. Carbon dioxide makes up less than 1% of the atmosphere; however, its concentration has been increasing rapidly in recent years due to large increases in the combustion of fossil fuels, which releases CO2 into the atmosphere.

Carbon Dioxide Equivalent (CO2 Eq. or CO2E)
A metric measure used to compare the emissions from various greenhouse gases based upon their global warming potential (GWP). Carbon dioxide equivalents are commonly expressed as "million metric tons of carbon dioxide equivalents (MMTCDE)." The carbon dioxide equivalent for a gas is derived by multiplying the tons of the gas by the associated GWP.

Climate Change
The term "climate change" is sometimes used to refer to all forms of climatic inconsistency, but because the Earth's climate is never static, the term is more properly used to imply a significant change from one climatic condition to another. In some cases, climate change has been used synonymously with the term, global warming; scientists however, tend to use the term in the wider sense to also include natural changes in climate.

Diesel Fuel
A type of fuel generally distilled from petroleum, which can be used in diesel-powered automobiles and other diesel engines. Diesel fuel can also be made from vegetable oil and animal fats, called Biodiesel, as a fossil-fuel alternative, yielding lower emissions.

Emissions
The release of a substance (usually a gas when referring to the subject of climate change) into the atmosphere. Greenhouse gases are one type of emissions.

Ethanol (CH3-CH2OH)
Otherwise known as ethyl alcohol, alcohol, or grain spirit; a clear, colorless, flammable oxygenated hydrocarbon with a boiling point of 78.5 degrees Celsius in the anhydrous state. In transportation, ethanol is used as a vehicle fuel by itself (E100), blended with gasoline (E85), or as a gasoline octane enhancer and oxygenate (10 percent concentration).

Gasoline
A complex mixture of relatively volatile hydrocarbons, with or without small quantities of additives, obtained by blending appropriate refinery streams to form a fuel suitable for use in spark-ignition engines. Gasoline is most often used in the internal combustion engines of automobiles and airplanes.

Greenhouse Gas (GHG)
A GHG refers to any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases can include water vapor, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), halogenated fluorocarbons (HCFCs), ozone (O3), perfluorinated carbons (PFCs), and hydrofluorocarbons (HFCs).

Greenroads
A rating system that distinguishes high-performance more sustainable new, reconstructed or rehabilitated roads. It awards credits for approved sustainable choices/practices and can be used to certify projects based on total point value. Projects can be certified at the standard, silver, gold or evergreen level depending upon their level of sustainability. The ultimate intent is for Greenroads to be used as a nationwide standard (voluntary or otherwise) for the design and construction of more sustainable roads.

Metric tons of carbon dioxide equivalent ($MTCO_2E$)
Metric Tons of Carbon Dioxide Equivalent equates to 2204.62 pounds of CO2. This is a standard measure of amount of CO2 emissions reduced or sequestered. Carbon is not the same as Carbon Dioxide. Sequestering 3.67 tons of CO2 is equivalent to sequester one ton of carbon.

Mitigation
Mitigation includes measures taken to reduce the sources or enhance the sinks of greenhouse gases and reduce adverse effects on the environment.

Renewable Resource
Renewable sources of energy include wood, waste, geothermal, wind, photovoltaic, and solar thermal energy. Energy obtained from sources that are essentially inexhaustible, unlike, for example, the fossil fuels, of which there is a finite supply.

Sustainability
Sustainability can be defined as a characteristic of a process or state that can be maintained at a certain level indefinitely. The term, in its environmental usage, refers to the potential longevity of vital human ecological support systems, such as the planet's climatic system, systems of agriculture, industry, forestry, and fisheries, and human communities in general and the various systems on which they depend.

Appendix 1. Mount Rainier National Park Concessions Greenhouse Gas Emission Reduction Actions

Guest Services Incorporated

Guest Services Inc. (GSI), a concessioner at Mount Rainier National Park, has committed to continued reduction of GHG emissions from its operations. GSI is a U.S.-based hospitality management company with a long history of providing food and beverage, lodging, and retail to the visitors in national parks. GSI has established a Green Team to continually seek out best business practices and new technologies. They use the following guidelines in their environmental management program: implement the most ecological purchasing standards practicable, reduce waste by actively encouraging and engaging in recycling and reuse, use energy-efficient and cutting-edge technologies and procedures wherever possible to reduce energy consumption. Actions currently underway include:

- 99% of lighting has been replaced with LED and/or Compact Fluorescent.
- Computerized lighting was installed at Paradise Inn during remodel.
- Currently researching on demand water tanks in housing units and energy efficient appliances.
- Furnaces are annually cleaned at the Sunrise Lodge, National Park Inn, and Paradise Inn.
- Currently researching the use of alternative fuel vehicles for warehouse operations.
- An employee shuttle operates during summer months. Approximately 150-200 employees utilize the service.
- Planning to combine employee shuttle with products delivery to reduce number of trips.
- A partnership currently exists with Mount Rainier National Park and GSI to recycle GSI's glass, aluminum, and plastic recycling. GSI recycles all other items.
- An in-room recycling basket for guests at the National Park Inn and employee recycling is available for employee residents.
- The daily water use at the National Park Inn is currently monitored and shower saver heads have been installed in guest rooms at the National Park Inn.
- Currently investigating the possibility of composting through GSI operations.
- Currently researching the possibility of installation of dual-flush flushometers.
- Currently investigating the possibility of foot petals for kitchen sinks at the Jackson Visitor Center, Paradise Inn, National Park Inn, and Sunrise.

Mountaineering

Alpine Ascents International, International Mountain Guides and Rainier Mountaineering Inc.

The mountaineering concessions continually seek out best business practices for reducing waste and implementing energy-efficient business practices through a variety of measures including:

- Mountaineering concessioners provide shuttle services between their base of operations and their destinations within the Park boundary. All concessioner employees and clients participating in guided activities are transported to trailheads via Concessioner operated shuttle.
- All vehicles used to shuttle clients into and out of the Park are powered by propane or another alternative environmentally friendly fuel.
- Tracking vehicle miles traveled in the park and continuing to implement measures to reduce miles traveled by:
  - Handing keys from the ascending climbing group to the descending climbing group resulting in one round trip versus two round trips.
  - Parking vehicles overnight in the parking lot to reduce number of trips.
- Waste reduction includes recycling programs and using procurement strategies that reduce waste.
- Blue Bags and/or Restop Bags. Bags used to collect solid human waste and toilet paper. The blue bags are carried by climbers and deposited in specific waste collection barrels while Restop bags are disposed of in trash receptacles or removed from the Park entirely.
- Propane stoves are used for melting water to provide water.
- Mountaineering concessioners follow and teach Leave-No-Trace (LNT) principles and practices for hiking, climbing and camping. Lead guides are required to have attended a LNT trainer level course. At least one employee in the organization must have attended a LNT Master Educator course.
- The Concessioner ensures that its guides and clients remove all of their trash and litter from natural areas and that guides assist as much as possible in removing any other litter they encounter.

Appendix 2. Climate Change effects on Mount Rainier National Park

Climate directly influences all aspects of the ecosystems within the NCCN.

Glaciers, which are melting rapidly in response to recent climate changes, provide important functions in many mountainous areas of the world, including Mount Rainier glaciers. Glaciers represent the sole habitat for certain species (Hartzell 2003), and greatly influence the habitat and hydrologic characteristics of these regions. Many freshwater aquatic species in the park benefit from the buffering hydrological influences that glaciers provide to many mountainous stream and river systems, particularly during seasonal and inter-annual droughts (Meier 1969; Meier and Roots 1982).

Freshwater systems are an extremely important component of the park, providing habitat to support unique amphibians, invertebrates and many other wildlife species. Climate change may significantly alter the hydrologic cycles, temporal temperature patterns, productivity, and distributions and abundance of aquatic biota within these systems. In riparian areas of the park, climate change models predict increases in winter floods which may alter the frequency and magnitude of disturbance events that significantly reshape local channel characteristics and supply sediment and large woody debris to stream channels (Ziemer and Lisle 1998). This, in turn, would influence the rate and characteristics of changes to the physical, chemical and biotic features of streams (Bilby and Bisson 1998), in addition to significantly threatening park infrastructure that lies adjacent to these streams and rivers.

Water temperature, which is expected to rise due to increases in air temperature and declining snow packs, is as a primary control on ecological processes in rivers such as litter decomposition (Robinson and Jolidon 2005) and the structure and composition of benthic communities (Milner and Petts 1994). Native char such as bull trout (Salvelinus confluentus) are dependent upon cold headwater stream areas. Tailed frogs (Ascaphus truei) are also dependent on rock-strewn mountain streams that have cold fast-flowing water. Aquatic invertebrates are highly sensitive to temperature, so glacial melt water is important for maintaining the trophic structure of stream communities (Lowe and Hauer 1999).

Mount Rainier has over 400 lakes and ponds and over 400 rivers and streams. Lake and river ice phenology is expected to change with climate warming. Lake ice influences biogeochemical cycling, including gas exchange with the atmosphere, habitat availability (through changes in pH and dissolved oxygen), biodiversity, and seasonal succession (Arnell et al. 1995; Cushing 1997).

Climate change can have significant impacts on wetland (riverine, palustrine, open water, emergent, shrub, forested; vernal pools) structure and function, primarily through alterations in hydrology, especially water-table level (Clair et al. 1998; Clair and Ehrman 1998). Wetland flora and fauna respond very dynamically to small changes in water-table levels (Poiani et al. 1996; Schindler 1998). Sea-level rise will result in loss of coastal wetlands in many areas, with potentially important effects on ocean fisheries (Michener et al. 1997; Turner 1997) which in turn will affect anadromous fish in the park.

Climate can significantly affect the air quality of the park. Winds carry air pollutants from nearby metropolitan areas as well as from trans-Pacific sources. While the air quality of the Pacific Northwest is generally considered better than other areas of the U.S., there is potential for both long-term and short-term degradation that could affect human health, vegetation, aquatic resources, and biogeochemical processes. Temperature increases significantly affect the formation of tropospheric ozone so we would expect higher levels of ozone to occur within the park. Warmer temperatures that rapidly melt heavy snowpacks can result in episodic acidification of park lakes, which may increase the acidity of poorly buffered aquatic systems and soils over the long term, and in turn, affect fish, amphibians, and soil dependent organisms (Allan 2001, Clow and Campbell 2008). Higher concentrations of anthropogenic aerosols have been shown to alter cloud properties in mountainous regions causing a reduction in snowfall in certain areas (Borys et al. 2003).

Connections between temperature warming and terrestrial ecosystems include: (1) the seasonal timing of life-cycle events or phenology; (2) responses of plant growth or primary production and; (3) biogeographic distribution (Field et al. 2007). Direct impacts on organisms interact with indirect effects of ecological mechanisms (competition, herbivory, disease) and disturbance (wildfire, hurricanes, and human activities) (Field et al. 2007).

Impacts on ecosystem structure and function may be amplified by changes in extreme meteorological events and increased disturbance frequencies associated with climate change predictions. Ecosystem disturbances, caused either by humans or by natural events, accelerate both loss of native species and invasion of exotics (Sala et al. 2000).

In alpine environments, surface soils on slopes are expected to become drier as thaw depth increases (McKane et al. 1997; McGuire et al. 2000). The rise in upper treeline in response to past warming of climate is well-documented (Mote et al. 2003). The boundary between alpine tundra and subalpine forest is controlled by extremes of temperature, moisture, and wind. Vegetation in both ecosystems is long-lived, and changes will proceed slowly and in a manner that depends on whether total annual snowpack decreases or increases and whether melt occurs earlier; both factors control the growth of alpine and subalpine species. The eventual effect of upward movement of the treeline will be to shrink the extent of alpine tundra in the park, possibly causing species loss and ecosystem degradation through greater fragmentation.

Forests at upper (cold) and lower (dry and/or hot) timberlines are most likely to show strong direct effects of climatic variation on tree growth, since they are closer to their physiological limits and, therefore, more prone to stress at these locations (Case 2007; Peterson et al. 2001). Rapid establishment of trees in subalpine ecosystems during this century is increasing forest cover and reducing meadow cover at many subalpine locations in the western US, and precipitation (snow depth) is a critical variable regulating conifer expansion (Fagre et al. 2003). Changes in plant species composition in response to climate change can facilitate other disturbances, including fire (Smith et al., 2000) and biological invasion (Zavaleta et al., 2004). Increased temperature in the future will likely extend fire seasons throughout the western United States, with more fires occurring earlier and later than is currently typical. It will also increase the total area burned in some regions (Westerling et al. 2006). A warming climate encourages wildfires through a longer summer period that dries fuels, promoting easier ignition and faster spread. If climate change increases the amplitude and duration of extreme fire weather, we can expect significant changes in the distribution and abundance of dominant plant species in some ecosystems, which would thus affect habitat of some sensitive plant and animal species. Some species that are sensitive to fire may decline, whereas the distribution and abundance of species favored by fire may be enhanced (Westerling et al. 2006).

Population and community dynamics will also be affected by climate change. For many amphibians, whose production of eggs and migration to breeding ponds is intimately tied to temperature and moisture, mismatches between breeding phenology and pond drying can lead to reproductive failure (Beebee 1995). Differential responses among species in arrival or persistence in ponds will likely lead to changes in community composition and nutrient flow in ponds. Amphibians may be especially susceptible to climatic change because they have moist, permeable skin and eggs and often use more than one habitat type and food type in their lifetimes (Lips 1998). Many amphibious species appear to be declining, although the exact causes (e.g., climate change, fungus, UV radiation, or other stresses) are difficult to determine (Laurance 1996; Berger et al. 1998; Houlahan et al. 2000). Disappearance and decline of several amphibian species in the rainforests of Costa Rica appear to be linked to climate warming (Pounds and Crump 1994; Pounds et al. 1999).

Insect dispersal to favorable areas to make effective use of microclimatic differences is a common response to changing climate (e.g., Fielding et al. 1999). Warming and changed rainfall patterns also may alter host plant-insect relations, through community or physiological responses (e.g. host plant food quality) (Masters et al. 1998). Multiple factors, including climate change, have been implicated in driving outbreaks of Mountain Pine Beetle in North America (e.g., Romme et al. 2006; Logan and Powell 2001; Logan et al. 2003).

Movement of species in regions of North America in response to climate warming is expected to result in shifts of species ranges poleward, and upward along elevational gradients (Parmesan 2006). Bird ranges reportedly have moved poleward in

North America (Price 2000). Spring and elevational range of some species has changed in response to climate change (Prop et al. 1998; Pounds et al. 1999). The ranges of butterflies in Europe and North America have been found to shift poleward and upward in elevation as temperatures have increased (Pollard 1979; Ellis et al. 1997; Parmesan et al. 1999, Parmesan 2006). Changes in mammal abundance can occur through changes in food resources caused by climate-linked changes or changes in exposure to disease vectors (Hart et al., 1985). Species declines will increase the number of endangered and threatened species listed (the polar bear is on the federal list of Endangered and Threatened Species and the pika was petitioned for listing primarily due to climate change affects on these species).

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Appendix 3. Table of Potential Impacts to Natural Resources Following Climate Change at Mount Rainier National Park

Discipline	Potential Impacts
Hydrology & Water Resources	• Loss of glaciers and associated effects on the timing and quantity of buffering summer flows • More winter precipitation falling as rain instead of snow, earlier snow melts, and associated changes in river flow that includes relative increases in the spring and relative decreases in the summer months (Mote et al. 2005, Barnett et al. 2008). • Ecological impacts to floodplain and riparian areas with decrease in spring flooding on higher elevation and east-side snowmelt streams • Increases in frequency of heavy precipitation events; floods in western WA are expected to increase due to the combined effects of warming and increasingly intense winter storms (Hamlet 2009). • Changes in flood risks are likely to result in substantial changes in sediment transport and channel formation processes, and is likely to affect ecological processes that are sensitive to changes in the probability distributions of high flow events such as habitat stability, biodiversity, and trophic structure (Konrad and Booth 2005, Hamlet and Lettenmaier 2007). • Stream channel instability associated with adjustment to larger floods • Warmer drier summers result in depleted surface and groundwater resources and impacts to fish, wells, etc. • Changes in regional water supply
Aquatic Ecosystems	• Warming temperatures will increasingly stress coldwater fish (at several life history stages) in the warmest parts of our region (Hamlet, 2009) • Potential to affect most freshwater life history stages of trout and salmon. Increased frequency and severity of flood flows during winter can affect over-wintering juvenile fish and incubating eggs in the streambed. Eggs of fall and winter spawning fish, including Chinook, coho, chum and sockeye salmon and bull trout, may suffer higher levels of mortality when exposed to increased flood flows. Higher winter water temperatures could also accelerate embryo development and cause premature emergence of fry (ISAB 2007). • Nonnative fish species may increase in abundance or distribution due to warmer water temperatures. • Higher surface water temperatures exacerbate pollution issues • Loss of summer/drought based water flow with loss of glaciers • Shifting of aquatic habitat – elevation and latitude-changing species composition & habitats
Vegetation	• Species composition and distribution of subalpine and alpine areas will change. Forest line and treeline may rise in elevation due to higher temperatures and decreased snowpack Subalpine meadows will change due to increased tree establishment and changes in forb:grass ratios. • High-elevation atmospheric pollutants (ozone levels) increase • Increased invasive species • Warmer and drier climates may influence the frequency and location of pest species (mountain pine beetle attacks) in PNW forests. Climatic suitability for pests such as mountain pine beetle may increase at higher elevations • Species composition of forests may change in response to higher temperatures and drought

Discipline	Potential Impacts
	stress. • Higher temperatures may result in increased mortality in whitebark pine populations due to white pine blister rust and increased distribution of mountain pine beetles. • Riparian forests may change in extent and composition due to reduced stream flows and higher temperatures.
Wildlife	• Changes in geographic distribution of wildlife species (i.e. latitude and elevation). An analysis of potential climate change impacts on mammalian species in the U.S. national parks indicates that on average about 8% of current mammalian species diversity may be lost. The greatest losses across all parks occurred in rodent species, bats and carnivores (Burns et al. 2003). Reduced snowpack may result in species such as coyotes expanding their distribution • Fragmentation of large ecosystems may occur due to increased disturbance and vegetation changes, disrupting existing wildlife ranges (McCarty 2001) and decreasing species persistence. • Invasion by non-natives • Changes in timing of migration, reproduction, dormancy, and the resultant changes in productivity Pollinator populations utilizing the subalpine areas may be affected by increases in tree islands and changing phenology of flowering plant species.
Disturbance (fire, pests, pathogens, avalanche)	• Increase in debris flows. • Avalanches may increase or decrease depending upon temperatures and type of precipitation. • Avalanche tracks may decrease due to decreases in winter snow pack resulting in changes in forest complexity and associated wildlife habitat. • Fire frequency and intensity may increase due to higher temperatures, increased drought, and decreased snow pack. • Fire: Unknown increase or decrease in fires Increase in length of fire season, severity of fires, and number of acres burned; non-native invasive grasses provide continuous fuelbeds and increase wildfire severity. There is high likelihood that this outcome will prove to be true, but some uncertainty still exists. But with changes in the pattern of precipitation (more rain in extreme events) there may be variable response from non-native grasses that could limit the frequency and extent of fires. • Pest/Pathogen: increased winter temperatures facilitate pathogen/pest survival • Wind-fall • Flooding
Soil	• Changes in precipitation and snowpack may result in an increase in the frequency and magnitude of debris flows (landslides, mudslides and sediment loading (Hamlet, 2009)). • Loss of glaciers may mobilize large reservoirs of fine sediments stored beneath them • Less soil moisture during growing season (related to vegetation mortality and fire regimes in those two sections)

References Appendix 3

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Appendix 4. Mount Rainier National Park Greenhouse Gas Emission Reduction Actions Implemented as of 2008

Air quality

- An emissions inventory of in-park sources was conducted to determine ways to improve air quality since the park is a Class 1 under the clean air act, which requires the highest level of protection.

Solar

- The solar system at White River replaced a generator only system. It produces 85% of the electricity required for the area reducing the generator supplied energy to 15%. The system powers the White River entrance station, ranger station, seasonal housing units, trail crew office, and maintenance shop.
- Solar energy powers the Steven's Canyon entrance station, high camps at Camp Schurman and Camp Muir, and radio repeaters housed at lookouts.
- A 2.5 kW solar system powers the greenhouse.
- A feasibility study is underway to study the possibility of a photo voltaic (PV) system at Sunrise.

Heating/Electric

- All residential furnaces have been converted from diesel fuel to propane. Are furnaces are 88 plus efficient.
- The Sunrise generator has been down sized from 100 kW to 60 kW.
- The generator at Tahoma Woods has been converted from diesel fuel to propane.
- We have set-back thermostats in work areas.
- We shut down buildings in cold areas where possible.
- All light have been changed from T-12 to T-8 lights.

Water

- On demand water heaters have been installed during remodels of small residential houses.
- All of Sunrise has been converted to low flow devices with the exception of the lodge.
- Water less urinals have been installed at White River and Sunrise.
- Dual Flush and Flushometer toilets have been installed at White River, Ohanapecosh, and Education Center.
- A solar water heater is in operation at White River Dorm.
- Installation of low flow devices is ongoing throughout the park.

Fleet Management

Use of Alternative Fuels

- Ultra low sulfur – B20 bio-diesel blend is used for all mobile diesel equipment.
- LPG propane is used for the fork-lift and pavement crack sealer trailer.
- Electric carts and Utility truck are used for campground operations.

Hybrid Vehicles

- 3 sedans, 5 SUVs', 2 half-ton trucks are in operation by the Park.

Biodegradable Hydraulic Fluid

- 13 pieces of mobile construction and specialized equipment have been converted to a bio fluid.

Engine Oil

- All fleet including power generators and small engines are lubed with re-fining oil (Safety Kleen).
- Used oil is picked up by re-fining company.
- Used oil bottles and fuel filters are crushed and recycled.

Recycled Antifreeze

- Recycled coolant is used in all fleet generators.
- Used antifreeze is picked up and recycled.

Batteries

- An exchange program exists with Napa Parts Store for automotive and industrial batteries.

Retread Tires

- Approximately 60 heavy truck and equipment tires are on a recap tire program.

Biodegradable Cleaners

- Biodegradable parts and brake cleaners are used in repair operations.

Diesel Equipment

- 16 heavy equipment diesel engines were installed with electronic fuel management systems.
- 15 diesel engines are still in operations that are retrofitted with diesel oxidation catalyst (DOC) to reduce emissions (EPA grant).

Other

- Employees are encouraged to carpool in the van provided.
- Visitors are also encouraged to carpool to the park through fee-reduction incentives.
- A no idling regulation (buses) and in-park directive to all employees is in effect.
- Flexi-Workplace

New Construction

Jackson Visitor Center

The new Jackson Visitor Center was designed and built to meet Leadership in Energy and Environmental Design (LEED) standards which include the following:

Heating and Cooling

- Chilled water from snow melt used to cool auditorium.
- No mechanical air conditioning – an outside air economizer measures comfort level and circulates outside air accordingly.

Energy Conservation

- Energy conserved through super insulated building envelope, night setback temperature controls, and main heating coils equipped with three-way valves.
- Low emissivity glazing to control heat transfer – gain and loss – through the windows.
- High solar and natural light gain provide high levels of daylight throughout building.
- Demand controlled ventilation (operable windows) and carbon monoxide monitoring.
- Variable volume multi-zone air distribution system with baseboard heating.

Lighting

- High solar and natural light gain provide high levels of daylight throughout building.
- Lighting and audio-visual systems operated by zone "smart controls."

Storm water runoff will be treated prior to discharge to prevent soil contamination from oil and other residue on the parking lots.

Green design and interpretive exhibits integrated throughout project.

Park Education Center

The new Park education center was constructed with the following sustainable design elements and energy efficient components:

- Polystyrene block construction with an R50 insulation rating.
- In-floor radiant heat with multiple programmable thermostat control zones.
- Multiple large energy-efficient, low-e, dual-paned windows and skylights
- Dual-flush, low-flow toilets
- Recycled carpet tiles
- Low VOC paint
- EnergyStar applicances
- Benches, picnic tables, and recycling and trash receptacles are made from recycled plastics.
- Compact fluorescent light bulbs

Environmental Purchasing

- Paper, plastic and other products with a high recycled-content percentage are purchased.
- The Park reuses products such as packaging materials.
- Energy efficient computers, printers, and copiers are purchased.
- The Park purchased in bulk when possible
- Products are purchased with minimal packaging and made from recycled materials whenever possible.

Bio Toilet

- A bio toilet was installed in 2008 at the Cougar Rock Campground, which uses cedar and natural composting techniques to operate efficiently with very little water and with no odor.