Natural Resource Challenges in Parks Assessed by NPCA's Center for State of the Parks

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In establishing the National Park Service (NPS), the Organic Act of 1916 stated that national parks have a fundamental purpose "to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations." However, in the first 100 years of the NPS, there have been limited efforts to address the significant task of determining whether or not the NPS is able to meet that goal; not until the last decade have programs been put in place in a systematic way to address how successful the conservation of natural objects and the wildlife therein has been within national parks. Through the Natural Resources Challenge, funded in 1999, NPS has received a portion of the funding needed to evaluate, first, what resources exist at individual national park units; second, what condition they are in; and third, what natural resources will be continually monitored as indicators of the overall condition of natural systems and how will this be done. Parks covered by the National Park Service's Inventory and Monitoring Networks and Vital Signs Program have, for the most part, completed the first step in this process. Determining conditions of resources is requiring more extensive efforts, and in many cases the second and third steps are being worked on concurrently. Certain parks have received an evaluation of natural resource conditions through NPS national programs (e.g., Inventory and Monitoring, Coastal Watershed Assessment/Watershed Condition Assessment/Natural Resource Condition Assessment), while many others await their turn. In addition, understanding the condition of natural resources across the national park system as a whole is not easily done because the resources that have been selected for evaluation may differ among parks.

In 2000, the Center for State of the Parks (CSOTP) was initiated by the National Parks Conservation Association, partly because of the shortfall of information on the success of conservation efforts within the national park system. CSOTP has the goal of developing a complete, comprehensive, and informed understanding of resource conditions in America's national parks, using standardized methodologies to collect needed information. The center conducts both cultural and natural resource assessments in individual park units, seeking to identify and understand both park-specific and systemwide issues and threats that challenge

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the immediate and long-term integrity of park resources. The center completed its first park assessment in 2002 (an assessment of Adams National Historical Park), and since then has completed research on natural resources at 54 national park units that cross a range of geographic areas, ecoregions, cultural themes, and NPS designations. Publications and other products resulting from this research detail the state of natural resources at a given park. Assessments identify conditions at a park based on information available at the point in time when the assessment was conducted. Researchers from CSOTP evaluate habitat condition, fragmentation, non-native species, air quality, water quality, and disturbance regimes (focusing for this document on fire, grazing, and climate change), gathering information on up to 124 separate measurements of park resources and assigning a score indicating level of impairment of the resource (none, limited, widespread, complete, or insufficient data available). CSOTP has also noted where data are consistently lacking on natural resources.

Overall, CSOTP research at this subsample of parks has found natural systems to be degraded to some degree at the vast majority of parks. Because of both the history of land use in and around parks, such as grazing, logging, and farming, and contemporary activities on lands adjacent to parks, including transportation corridors, energy extraction, urban and industrial development, and agriculture, many national parks are internally fragmented as well as isolated from each other and other natural areas. Privately owned lands within park boundaries are also increasingly targeted for residential and commercial development.

A number of native species are declining or being lost entirely from parks, often resulting in a significant change in the structure of natural systems (e.g., hemlock loss due to the hemlock wooly adelgid greatly alters the structure of eastern forests in a number of eastern parks). The almost ubiquitous spread of non-native plants and animals, which have been introduced either intentionally or accidentally or have spread from adjacent lands, contributes to native species declines and also can alter natural processes. Continuing declines in water and air quality and changes in the amount of water and the timing of its availability add to the stresses on natural systems. Most national parks will also soon feel the effects of climate change. As evidenced above, human activities are resulting in many of the deleterious impacts on national parks. As such activities increase and spread, further declines will be seen if practices continue as they currently are. Further details on the findings are presented below.

Habitat loss and degradation

A habitat is defined as an environment where a plant or animal naturally lives and grows. Habitat loss or degradation is often associated with a decline in or loss of native species, and may also result in the loss of ecosystem functions, such as water or nutrient cycling. For the parks evaluated by CSOTP, 96% suffered loss or degradation of habitat; for 41% of all parks, the events were considered widespread. Agents of these changes are multiple, and are illustrated through the following examples:

- At Fort Union Trading Post National Historic Site, loss of the shortgrass prairie, which was the historic ecosystem in the park, was due to the loss of bison, the introduction of agriculture and its associated invasive grass species, and the suppression of fire.

- Hawaii Volcanoes National Park experienced extensive grazing and the invasion of numerous non-native plant species, which has severely impacted canopy and understory plant species.
- The pronounced loss of coral species at Virgin Islands Coral Reef National Monument has been attributed to disease (linked to climate change) and subsequent hurricane impacts.
- Big Bend National Park experiences significant flow reductions (to the point where the channel may run dry) and degraded water quality in the Rio Grande because of the demand for water from increasing human populations.

Other metrics for habitat condition that CSOTP investigates show similar patterns. Cover loss or bare soil increase was noted at 80% of the assessed parks. However, this percentage is likely to be artificially low, because issues in freshwater and marine systems are not often reported under this metric, and it also does not consider change in cover species (be they trees, shrubs, or something else) to be detrimental. When considering changes to the canopy or to the understory, both of which can alter habitat characteristics, 90% of parks assessed were affected, with 30% of the total considered to have pronounced impacts. Parks such as Lewis and Clark National Historical Park and Pictured Rocks National Lakeshore have forests that are still recovering from intensive logging activities that occurred decades ago. Chickamauga and Chattanooga National Military Park battles widespread invasions of Chinese privet that infest the understory of the park's forests. And a number of the islands at Apostle Islands National Seashore are experiencing concentrated deer browsing that is decimating Canada yew and starting to affect other understory species.

A summary of habitat conditions at parks assessed indicates numerous impacts with no shortage of pervasive problems. When all data on habitat condition were considered, parks that most consistently were rated as unimpaired were found in Alaska and Montana. Further analysis below highlights many of the specific reasons underlying habitat loss and degradation.

Fragmentation

Habitat fragmentation occurs when a large area of habitat is transformed, through various activities, into smaller patches that add up to a smaller total area. The areas surrounding these smaller patches often are not only no longer suitable habitat but also present barriers to movement of species. Issues with habitat fragmentation were found in many evaluated parks. Lack of connection among habitats and species isolation were not considered to be issues in 32% of parks, but 20% of parks had widespread problems. Certain parks were initially fragmented in their creation, for example:

- Indiana Dunes National Lakeshore is made up of two larger parcels and numerous noncontiguous satellite sites.
- Nez Perce National Historical Park consists of 38 sites, only seven of which are controlled or influenced by NPS management.

- Harpers Ferry National Historical Park is made up of more than ten individually acquired land parcels.
- Big Thicket National Preserve is composed of nine land units and six river and stream corridors distributed over 1,885 square miles of southeastern Texas.

Fragmentation has been exacerbated at these sites by roads, rights-of-way, and urban and industrial development. In addition, Harpers Ferry National Historical Park, Indiana Dunes National Lakeshore, and a number of other park units contain inholdings (privately held parcels within park boundaries), which also contribute to the loss of natural conditions if incompatible development occurs on them. Fragmentation within a park may also be the result of past land use. For example, at Channel Islands National Park, historic grazing resulted in the isolation of native plant species in areas that were inaccessible to grazers, and often far from each other. Also, aquatic systems within parks can be disconnected. A vivid example is the two units of the Missouri National Recreational River, which are isolated from each other, and the rest of the river, by dams.

Analysis of data collected on dispersal and recolonization barriers, which tended to consider whether the parks were isolated from their external environment a bit more than the previous metrics discussed, found that 72% of parks have barriers. In some units, barriers were inherent in the creation of the park. For example, the small size of Cabrillo National Monument and its location on a peninsula, next to U.S. Navy property, naturally resulted in barriers to certain species. Other parks, such as Fort Union Trading Post National Historic Site and Knife River Indian Villages National Historic Site, which exist in what historically was a shortgrass prairie ecosystem, contain native species that are isolated from recolonization sources by invasive and cultivated species whose presence has altered an entire region. Roads and development are mentioned above as causes of fragmentation, and in the case of Santa Monica Mountains National Recreation Area, an extensive research program is showing their effects on the movements of animals such as mountain lions.

Adjacent land development contributes to the disconnection of a park unit from its natural, surrounding environment, and it also has impacts on environmental quality at the park (see below for more on air and water quality). In evaluating both current impacts and future threats of adjacent land use on park units, 91% were considered impacted or threatened by development activities that included roads, agriculture, urbanization, and industrial development.

Non-native species

Non-native species damage park ecosystems by eliminating native plants and animals, often changing soil and microclimate conditions in ways that fundamentally alter physical habitat as well as system functions. Ninety-four percent of parks had non-native species issues. Lake Clark National Park and Preserve and Denali National Park and Preserve, both in Alaska, are the only two parks assessed by CSOTP, to date, that did not exhibit any net loss or degradation attributed to exotic species at the time of their assessments. Ninety-three percent of parks suffered impacts from non-native plant species; non-native animals were a concern at

72% of parks. Whereas non-native animal species were rated as having widespread impacts at only 9% of parks, non-native plants were considered a significant problem at 41% of parks. Non-native animals have significant impacts at parks such as:

- Assateague Island National Seashore, where feral horses and sika deer graze and trample native plant communities.
- Big Bend National Park, where feral hogs have overgrazed grasslands and exotic fish have contributed greatly to the decline of native fish in the Rio Grande.
- Sleeping Bear Dunes National Lakeshore, where the many invasive aquatic species in Lake Michigan have altered communities of native aquatic species, and the introduction of deer onto North Manitou Island has scarred the understory community.
- Exotic plants have altered or come to dominate systems in a number of parks, with examples including.
- The invasion of tamarisk along riparian corridors in parks such as Big Bend National Park and Canyonlands National Park.
- The almost complete replacement of native prairie systems by non-native grasses at Fort Union Trading Post National Historic Site, Knife River Indian Villages National Historic Site, and Nez Perce National Historical Park;
- The invasion of annual grasses and the retreat of most native Mediterranean vegetation communities at Channel Islands National Park.
- The invasion of faya tree, a nitrogen-fixing species that can colonize barren lava before native species, at Hawaii Volcanoes National Park.

Both land-use history (e.g., historic grazing, farming, and homesteading) and adjacent land use contribute to the current issues with non-native species. A lack of resources to adequately combat invasive, non-native species seems to be a pervasive problem among parks assessed. In addition, better education about non-native species and actions visitors can take (such as washing plant material from boots) could decrease the spread of non-native species.

Air quality

Air pollution can cause damage to species and ecosystems, and can also be detrimental to the visitor experience, particularly when it results in declining visibility in national parks. Nitrogen and sulfur compounds, which can be carried by winds and deposited on park lands, are linked to acid rain and to excess nitrogen effects in aquatic and terrestrial systems (including imbalances in available plant nutrients that can lead to changes in plant composition and loss of biodiversity). These chemicals were considered to be a limited but notable threat in approximately 50% of the evaluated parks, while 9% of parks reported concentrations considered to be very detrimental. Three parks, Shenandoah National Park, Indiana Dunes National Lakeshore, and Great Smoky Mountains National Park, had high deposition of both nitrogen and sulfur compounds. Great Smoky Mountains and Shenandoah National Parks are very sensitive to acidification from deposition of nitrogen and sulfur compounds, whereas Indiana Dunes is likely less sensitive because of the buffering capacity of local waterways and soils, including Lake Michigan. High concentrations are primarily attributed to the parks'

proximity to significant pollution sources such as coal-fired power plants. Concerns about excess nitrogen focus on ecosystems with short growing seasons, thin soils, or sparse vegetation that are less likely to have the capacity to assimilate excess nitrogen. Fifteen to 18% of parks lacked data on these two pollutants.

Fifty percent of parks experienced ozone levels that could impact resources, although work on identifying impacts was limited; in a number of cases, for example, ozone-sensitive plants resident in a park were identified but not monitored for ozone damage.

Increasing levels of particulates are one factor in declining visibility, and evaluation of these two metrics (particulates and visibility) was relatively similar across parks. Twenty-four percent of parks were not considered to be impacted by particulates and 20% were not considered to have impaired visibility. Data were insufficient to evaluate particulates at 26% of parks and visibility at 20% of parks. In most cases, parks that had pronounced problems with particulates were also rated as having a significant decline in visibility. Joshua Tree National Park, Great Smoky Mountains National Park, Shenandoah National Park, and Big Bend National Park were all in this category.

Elevated atmospheric deposition of mercury is a concern not only because of mercury's toxic qualities but also because mercury that lands in waterways can be converted into methylmercury by microbes. Methylmercury can then accumulate in aquatic animals at levels that may harm them or the animals that eat them. Human sources of atmospheric mercury include coal-fired power plants, incinerators, and mining. A relatively limited monitoring network exists for this element, and thus, no information was provided for 74% of the parks assessed. Mercury was a concern in 12 of the remaining 14 parks. Biscayne National Park, Great Smoky Mountains National Park, and Indiana Dunes National Lakeshore, which are all in a region of heavy industry and/or power generation, were most affected.

Water quality and quantity

The increasing demand for water and impacts on water quality that come with increases in human populations affect national parks. CSOTP attempts to gather information on 25 water quality measurements; ten of those are discussed here. Data are often available only for a limited number of waterways in a park; therefore, this summary is based on best available information but should not be considered to portray comprehensive water quality data for each park assessed. Acid deposition and pH alterations were found to affect less than 25% of parks assessed. Over 90% of parks had some measurement of pH; however, 32% did not have information on acid deposition in waterways. Shenandoah National Park, Great Smoky Mountains National Park, and Indiana Dunes National Lakeshore were all considered at high risk for acid deposition, but only Shenandoah was also rated as having significant alteration of pH in waterways.

Other factors resulting in deteriorating water quality include metals (61% of assessed parks), nutrients (59% of assessed parks), and organic wastes, primarily fecal coliform bacteria, which indicate sewage contamination and possibly the presence of disease-causing organisms in the water (74% of assessed parks). Metal concentrations in parks that are considered high or pervasive enough to have a pronounced impact on resources arrive from a variety of sources: long-range atmospheric deposition (Isle Royale National Park), non-point

source pollution of upstream waterways (Big Hole National Battlefield, Nez Perce National Historical Park), dumping into and concentration of industrial pollutants in major water bodies (Cabrillo National Monument), and a combination of the above (Gateway National Recreation Area, Indiana Dunes National Lakeshore, Shenandoah National Park, Mojave National Preserve). Elevated nutrient concentrations are mostly due to atmospheric deposition of nitrogen and agricultural practices carried out both inside and outside parks; these elevations can lead to increased turbidity and algal growth, fouling waterways and putting aquatic species at risk from elevated temperatures and decreased oxygen and flows. Organic wastes are entering park waters primarily from grazing animals, feral animals, improperly maintained septic systems, municipal sewage treatment plants, and untreated human waste (for example, boaters discharging waste). Organic compounds also impact water quality, but analysis for such compounds (i.e., PAHs, PCBs, certain pesticides) is sporadic. Only 43% of parks assessed had any data on them, and the majority suffered some impairment of water quality. Sedimentation was not considered a concern in 13% of the parks; 24% did not have information on this metric. Reasons for increased sedimentation in the other 63% of parks included logging, roads, and agricultural and ranching practices.

Finally, water quantity metrics were also evaluated for the parks. Information on diversion and flow were not available for approximately 21% of the parks; 42% of parks had diversions of waterways that impacted park resources, including in-channel flows. Alterations were most notable at parks such as Big Bend National Park (where upstream diversions have resulted in the Rio Grande channel running dry), Missouri National Recreational River (both units are bounded by power-producing dams), Biscayne National Park (water no longer reaches the Biscayne Bay from the Everglades), and Lewis and Clark National Historical Park (the Lewis and Clark River is altered by dams, municipal withdrawals, levees, and dikes).

Disturbance regimes (fire, grazing, climate)

Disturbance regimes refer to processes, many of which are natural but have components influenced by humans, which disturb biological communities. Sometimes disturbances have minimal impact if the community is resistant to the events and recovers easily (e.g., seasonal flooding in wetland communities), and sometimes they have more devastating results (e.g., crown fires due to high fuel loads). Fire is an inherent feature of almost all ecosystems. However, alterations in the fire regimes of most systems, including those within parks, have come with human habitation and resource extraction. They have also occurred because of practices and policies designed to manage natural resources on public lands. Seventy-four percent of parks have altered fire regimes. The majority of these parks have a history or a current policy of fire suppression. Although the value of fire is now better understood, and prescribed burns are conducted at some parks to mimic natural fire regimes, suppression may still be the norm, even when prescribed burns are considered a better ecological alternative, for historical, logistical, regulatory, and public safety reasons. In many cases, suppression results in unwanted side effects, such as high fuel loads, with the possible outcome of intense blazes, and the presence of non-native plant species. At Chickamauga and Chattanooga National Military Park, fires have been suppressed for 150 years, and a large-scale return to the

historic fire regime is unlikely given the proximity of the park to urban areas. However, this lack of fire has resulted in a dense understory layer in the forests and has allowed woody species to encroach upon rare glade habitats. Human-caused fires that occur at a much higher frequency than historical cycles are another alteration seen at some parks. While fire is a natural component of the ecosystem at Santa Monica Mountains National Recreation Area, the number of human-ignited fires has fundamentally changed the fire regime. There is a direct correlation between increased human population, increased fire frequency, and increased area burned annually. Increased fire frequency has caused the loss of some native plant communities (valley oak savannah, native grasslands, and coastal sage scrub) with conversion of these communities to invasive grassland species that are more tolerant of frequent fire.

In many cases, both native and domesticated grazing species occupied park lands before the national parks were created, and left their mark on plant communities; at some parks, evidence of grazing is still obvious. Grazing or browsing impacts on resources, including plant communities and water quality, have been noted at 69% of parks; these are considered pronounced at 22% of all parks. Examples of parks with widespread grazing impacts include:

- Cumberland Island National Seashore and Assateague Island National Seashore (ongoing grazing of feral animals);
- Channel Islands National Park and Hawaii Volcanoes National Park (historic grazing by domestic stock); and
- Apostle Islands National Lakeshore (overbrowsing by deer with few natural predators).

Changes in global temperature have been recorded over the past century along with a rise in carbon dioxide concentrations. Other aspects of climate, such as precipitation, are expected to or have already begun to change. For 56% of parks, climate change is currently having a limited impact or is viewed as a tangible future threat given prediction models. Thirty-two percent of parks had insufficient data to determine a level of current or future impairment. Parks along coastlines and in alpine areas may have the most immediate need to respond to climate change. It is expected that resource degradation from changes in climate will increase across the park system as time progresses.

Other data gaps

Specific gaps in information were identified in the sections above on air and water quality. But there were a number of sections in the CSOTP natural resources methodology with metrics that consistently were scored as having insufficient data to determine condition. The most telling were sections on community structure and function and on biotic interactions. Data to address metrics under both of these sections come from studies on higher-order biological interactions, such as those seen between species (e.g., predation, competition) and among species (e.g., food web dynamics), and on community structure (e.g., age class structure of species) and ecosystem function (e.g., nutrient cycling). Researching such processes requires current techniques, long-term commitment, and stable funding. Such programs do exist in certain parks, such as the studies of wolves and moose at Isle Royale National Park,

but they are not the norm at NPS units for a variety of reasons. Information on climate change and its impacts, another subject that will require knowledge of multiple levels of organization, is also lacking for many parks. For approximately one-third of the parks, predictions of climate change impacts were not clear.

A summary of metrics for environmental quality (air, water, soils) also indicated the need for more information. The primary deficiencies with air quality are mentioned above; insufficient data for more obscure compounds that are not monitored by a national network, including chlorinated compounds and volatile organic compounds, were noted at over 70% of parks. A lack of water quality data is also noted above, but even basic water quality monitoring data, such as temperature, dissolved oxygen, and conductivity, were not found at 25–30% of parks. In order to sufficiently track water quantity, flow and diversion information are necessary, as discussed above, but it would also be helpful to understand other aspects of waterways such as discharge, drawdown, and, particularly for groundwater, recharge. Insufficient data were cited for these three metrics at 30–48% of parks. Finally, data on condition of soils were sparse, with the exception of information on erosion, compaction, and infiltration. Data on soil characteristics such as chemical and biological makeup were not available for 55–87% of parks.

Addendum (September 2010)

Since this paper was submitted in early 2009 to the National Parks Second Century Commission's Science and Natural Resource Committee for the preparation of its committee report, CSOTP has completed assessments of additional parks, bringing the total number of units assessed and scored for natural resources to 62. The Center for State of the Parks is currently bringing the data from all of its assessments together in a publication with the working title *The State of America's National Parks*, which will include analyses similar to those above along with further discussion of the issues faced by the park system and the efforts that are being made to address them. This publication will be released in the first half of 2011.

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