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National Parks and Hydraulic Fracturing

Balancing Energy Needs, Nature,
and America's National Heritage





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and America's National Heritage**



A special note of appreciation goes to the
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SINCE 1919, NPCA has been the leading voice of the American people in protecting and enhancing our National Park System. NPCA, its members, and partners work together with the National Park Service to protect the park system and preserve our nation's natural, historical, and cultural heritage for generations to come.

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**CENTER FOR
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777 6th Street, NW • Suite 700
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Cover/top photo: Boaters take a curve on the Middle Delaware River, inside Delaware Water Gap National Recreation Area (PA). ©Thomas Kelly **Lower left:** Road construction for hydraulic fracturing operations can fragment natural areas and cultural landscapes on lands that adjoin national parks, negatively impacting wildlife and other resources inside the national park itself. ©Nina Berman/NOOR **Lower right:** Traffic generated by the fracking oil boom passes through Watford City, North Dakota, on the highway leading to Theodore Roosevelt National Park (ND). ©Matthew Staver/Bloomberg via Getty Images **Inside cover:** Pronghorn in Wyoming. ©Morgan Heim **TOC:** Sunset highlights the Big South Fork National River and Recreation Area located in Tennessee and Kentucky. ©Willard Clay





Executive Summary

Hydraulic fracturing (or “fracking”) has the potential to rewrite America’s energy future, presenting the possibility of an energy-independent nation. This relatively new extraction method is now responsible for 90 percent of domestic oil and gas production, with thousands of wells peppering the countryside. The number of wells is expected to skyrocket during the next two decades. The Energy Information Administration estimates that the United States has 2,119 trillion cubic feet of natural gas and 25.2 billion barrels of crude oil recoverable through fracking. What will history say about this innovation? What will the impacts be on America’s public lands—especially our cherished national parks?

No one knows for sure. Most Americans aren’t witness to fracking operations, which typically take place in remote, rural locations inhabited (and visited) by few people. Most North Dakotans, for example, live within eight miles of the Minnesota border, so they’ve never laid eyes on the fracking wells that are springing up in the western part of the state, near Theodore Roosevelt National Park. Other national parks in relatively undeveloped regions have also seen fracking arrive at their doorstep: From Glacier National Park’s eastern boundary, visitors can throw a stone and hit any of 16 exploratory wells and their associated holding tanks, pump jacks, and machinery that is capable of forcing millions of gallons of pressurized fluids into energy deposits hiding thousands of feet beneath the earth.

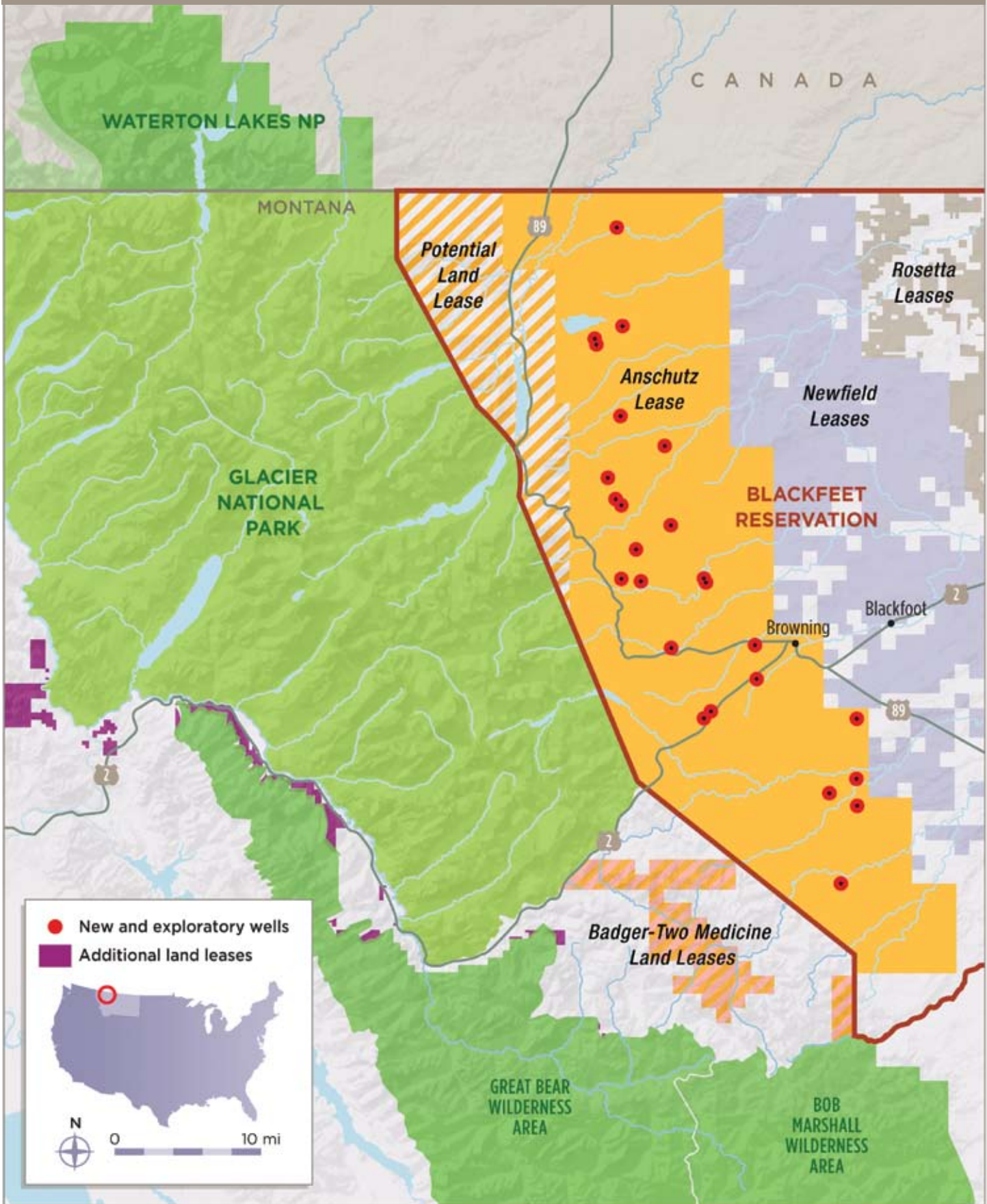
Yet even the experts can’t predict fracking’s impacts. Will it contaminate the air we breathe in national parks? Will it harm native wildlife and the water and forests they depend on for survival? Will it damage the resources we value in our national parks? The answers are just beginning to emerge.

Consequently, the National Parks Conservation Association recommends that policymakers require a measured, thoughtful approach to fracking, especially near national parks and in their surrounding landscapes. We must make every effort to understand and anticipate potential consequences—before they become irreversible.

Some impacts of fracking are already obvious. A web of new roads is expanding across the lands that lie above key oil and gas deposits. A proposed bridge and a new road to service a planned fracking field would dominate the view from Elkhorn Ranch, where

Left: Little Missouri River, Theodore Roosevelt National Park, North Dakota. ©Eric Foltz/ISTOCKPHOTO

Fracking Near Glacier National Park (MT)



Sources: BIA; BLM

President Roosevelt conceived his influential conservation theories. Astronomers at Theodore Roosevelt National Park—which once offered some of the nation’s darkest, most pristine night skies—also see a new constellation of flares from nearby fracking wells. Visitors heading east from Glacier National Park encounter road signs urging caution against the poisonous gases that fracking operations emit.



Other impacts from fracking are more obscure. The vast quantities of water required for hydraulic fracturing—millions of gallons per well—may deplete key waterways, including those within our national parks. Fracking’s expanding infrastructure may disrupt wildlife migrations into and out of our parks. The industry’s waste products may pollute air, land, and streams.

Some fracking projects appear to have resulted in groundwater contamination. Although the specific causes aren’t fully understood, a Duke University research group (Warner et al. 2012) proposed that geologic fissures between the deep shales and shallow layers of groundwater may provide conduits for toxic fluids to rise to the surface, where they may threaten people and wildlife. In fact, mounting evidence suggests that surface waters contaminated by fracking can harm domestic animals—and those consequences seem likely to impact national park wildlife as well.

These are warning signs, not conclusive proof, of fracking’s impacts. Yet these early indications of harm to America’s natural resources and national parks suggest the wisdom of a careful, considered approach to hydraulic fracturing, rather than blind complicity and a zealous rush toward monetary riches. National parks are managed under a precautionary principle designed to err on the conservative side of any potentially negative impacts. The same principle should be applied to fracking activities on lands adjacent to our national parks.

At the National Parks Conservation Association, our goal is to prevent an unexamined embrace of an oil and gas extraction method that can have far-reaching consequences for America’s most cherished landscapes.

Now is the time to investigate the impacts of fracking on America’s national parks. With the first wave of fracking wells yielding evidence for study—but before fracking has become a juggernaut producing a wake of irreversible damage—policymakers should examine the industry’s corollary impacts and steer a wise course for the benefit of all Americans and their national parks. We must understand fracking’s impacts on the nation’s waters, air, wildlife, and cultural landscapes—splendors that are preserved in our national parks and that are unmatched anywhere else in the United States. In this pivotal moment, we can protect, or imperil, America’s greatest legacy.

The National Parks Conservation Association does not oppose oil and gas development, and it acknowledges that hydraulic fracturing provides real value to an energy-dependent nation. Our goal is to prevent an unexamined embrace of an oil and gas extraction method that can have far-reaching consequences for America’s most cherished landscapes.

Above: In this satellite image of North America at night, natural gas flares illuminate fracking fields near Theodore Roosevelt National Park (ND). These flares diminish dark night skies that once brought visitors to the park for stargazing. Courtesy of NASA, Illustration by NPR



Key Findings

Hydraulic Fracturing Has Widespread Existing and Potential Impacts

Without smart planning, comprehensive pollution monitoring, and the best available environmental protections, oil and gas development near national parks will diminish America's natural and cultural heritage one park at a time. Only through sound decision-making can policy-makers protect these important cultural and natural resources.

Habitat Fragmentation and Wildlife Impacts

■ The oil and gas development boom across the country will require clearing substantial amounts of land and developing new or improved roads to support well sites. Important wildlife resources will be destroyed, and habitat that remains will be broken into smaller pieces by roads and development. Because national park wildlife do not recognize park boundaries—they move in and out of parks as food and shelter require—changes in landscapes that surround national parks will lead to the loss of park biodiversity, and fragmentation will increase the intrusion of non-native, invasive species.

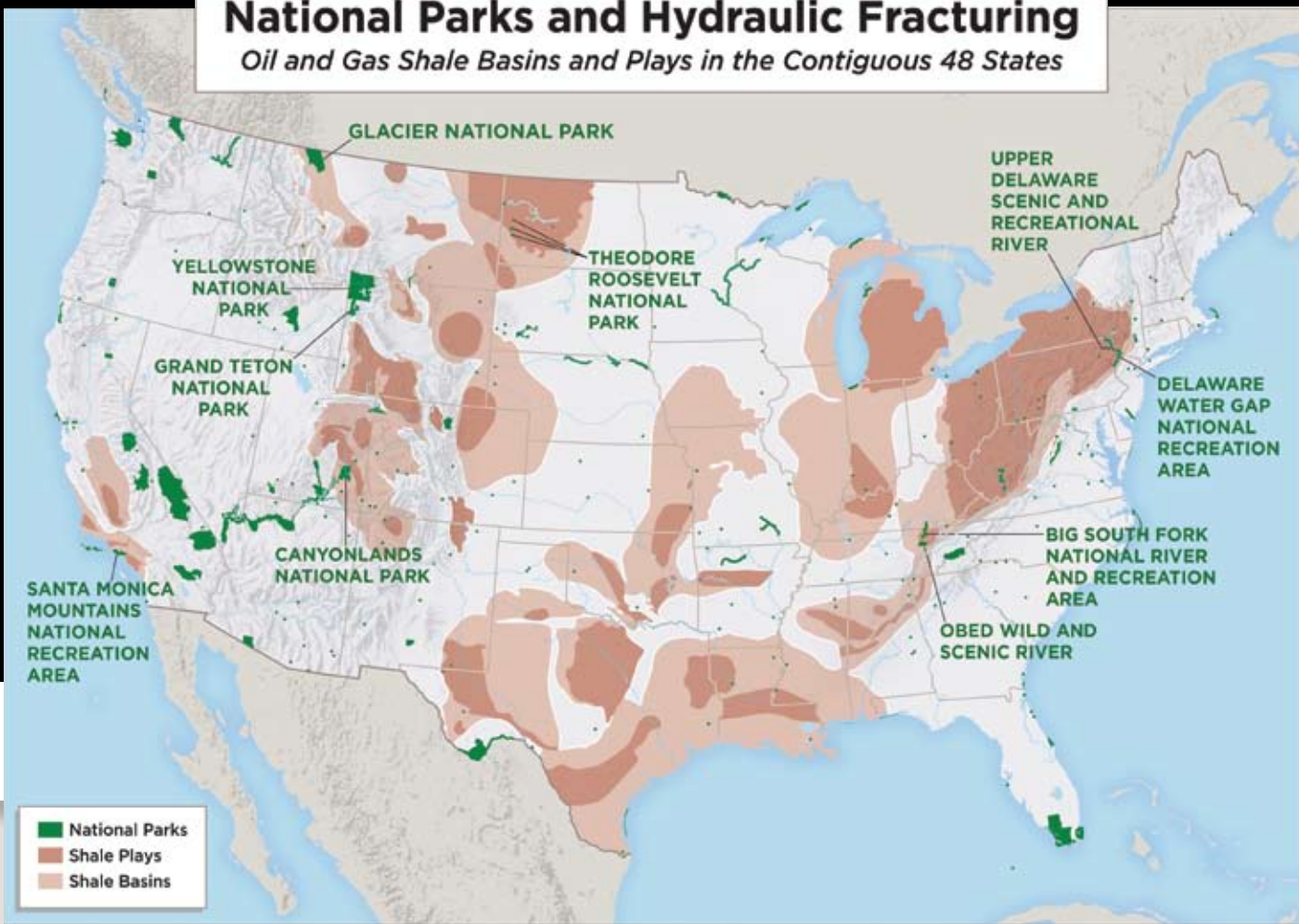
- Increased use of heavy machinery and increased truck traffic have the potential to crush vegetation, as well as increase the number of collisions with wildlife such as deer, elk, bears, and small mammals that move freely in and out of national parks. Additionally, these vehicles can transport invasive plant species across the landscape and into parks.
- Western wildlife species such as elk, mule deer, and sage-grouse tend to avoid areas near active oil and gas wells, while a loss of intact Eastern forests could affect Neo-Tropical migrant bird species—all impacts that could affect nearby national park resources.

National Park Scenic Views, Natural Sounds, and Night Skies

- Air compressors and traffic are just two of the sources of noise associated with fracking activities. These intrusions can alter the behavior of wildlife and infringe on people's enjoyment of nature's natural sounds—an effect of particular concern when fracking occurs near national parks.
- Fracking operations also present visual intrusions on the landscape, with drilling rigs that can extend vertically 100 feet. Lighting of drill pads and gas flaring at night can detract from the dark night skies and stargazing opportunities that draw thousands of visitors to our national parks. In North Dakota's Bakken shale region, at least a third of the natural gas that emerges with the exploited oil is flared off into the atmosphere.
- A 2009 National Park Service publication identified potential impacts to viewsheds (scenic views) as one of the factors that would force the Park Service, because of its mandate to

National Parks and Hydraulic Fracturing

Oil and Gas Shale Basins and Plays in the Contiguous 48 States



protect such resources, to delve into the oil and gas permitting process in the Marcellus shale region. The systematic mapping of park scenic views can provide relevant information to state agencies when they consider oil and gas permits, and some parks have staff working on this.

Water Quantity

- Fracking a single gas or oil well can require millions of gallons of water. Many thousands of wells have already been drilled, and trends indicate that oil and gas fracking will continue to expand in coming years, resulting in a growing need for more water. Water drawdowns for fracking have the potential to affect important water supplies for native plants and animals, including both surface and groundwater within national parks.

Water Quality

- The wastewater that results from fracking operations is polluted with chemicals, brines, and other pollutants that are difficult or impossible to remove from the spent water. Fracking wastewater cannot be reused for other purposes, except other fracturing jobs, and the available disposal options (e.g., dumping on the landscape, reinjecting into deep wells, transporting to water treatment facilities) create risks of contamination for affected landscapes, groundwater, and surface waters.

Air Pollution

- Hydraulic fracturing activities emit more pollutants than traditional oil and gas extraction methods, and some national parks are already experiencing

air quality impacts associated with fracking. These pollutants include a lengthy list of hydrocarbons, methyl mercaptan, carbon monoxide, nitrogen dioxide, and ozone.

- A long-term research project in Colorado concluded that exposure to air pollutants from natural gas fracturing could cause subchronic and chronic health problems such as neurological or respiratory ailments and cancer, conditions that could impact visitors to national parks and residents in nearby communities.
- Pollution coming from large gas fields has been connected to high regional ozone levels. Ozone negatively impacts park visitors and park flora and fauna. It is imperative that national parks be protected from the dangers of ozone pollution.

Above/Left: The Middle Delaware River graces Delaware Water Gap National Recreation Area (PA).
©Songquan Deng/Dreamstime.com



Recommendations

The National Park Service should be engaged as a formal cooperating agency, and comprehensive environmental reviews should be required when oil and gas drilling is proposed in the airshed, watershed, or connected landscapes that surround a national park. The Park Service should be a full partner with other agencies and with industry in determining where to avoid energy development that may impact national park wildlife, national park visitors' experience, or park visitors' health.

Habitat Fragmentation and Wildlife Impacts

■ The oil and gas industry should work with state and federal agencies, including the National Park Service, to develop and implement best practices or declare off-limit areas to protect wildlife traveling through oil and gas fields near national parks. State and federal agencies must work collaboratively to understand the condition of wildlife species and their movement before drilling begins near national parks. Thoughtful planning and comprehensive environmental analysis will reduce the impacts of oil and gas development on national park wildlife.

■ Bureau of Land Management (BLM) leasing reforms are a step in the right direction. However, where national park resources are at risk, BLM needs to go further than simply advising National Park Service of potential impacts and going on to develop mitigation measures unilaterally. Instead, BLM should designate National Park Service as a formal "cooperating agency" under the National Environmental Protection Act when there is a reasonable likelihood that national park air, water, wildlife, or other resources will be affected by oil and gas activities on BLM land. As a cooperating agency, National Park Service would be able to participate in preparing environmental impact statements to ensure that park

resources are taken into consideration from the outset of leasing decisions.

Scenic Views, Soundscapes, and Night Skies

■ Scenic views, soundscapes, and night skies should be included in environmental impact analyses before gas and oil fracking is permitted within national park view sheds and soundscapes.

Water Quantity

■ The amount of water required for fracking is enormous. It is imperative that statutory mandates to protect national park resources be met where water may be reduced or contaminated upstream or downstream from national parks. Federal partners and state agencies should work collaboratively with the National Park Service to ensure that stream flows and groundwater levels in parks are maintained at historic or mandated levels. Doing this will require enhanced water quantity monitoring inside parks when large scale fracking operations expand upstream from national park units.



Water Quality

- National Park Service water resources must be protected from the impacts of oil and gas development. Americans expect water resources in national parks to support healthy fish and wildlife populations and to offer opportunities for swimming and recreational fishing. Therefore, any pollutant input that would have a measurable negative impact on national park water should be prohibited or mitigated.
- If drilling is permitted near or upstream from a national park, the identity of chemicals used in the process should be disclosed to the public, and the industry should provide (and pay for) a comprehensive water quality monitoring plan for all park waters that might potentially be impacted.
- The Bureau of Land Management (BLM) has proposed a rule for fracking on land where BLM is the permitting agency: BLM, Tribal, U.S. Fish and Wildlife Service, and Forest Service Lands (a total of more than 750 million acres). Many of these areas are adjacent to units of the National Park System. BLM has proposed public disclosure

of the chemicals used in the drilling process 30 days after drilling has been completed, well integrity testing to prevent groundwater pollution, and planning for managing flowback waters (post-fracking sludge that is sometimes stored in open-pit holding ponds). While BLM's proposal is generally positive, the agency should also require that chemicals be disclosed to the public before drilling begins, that all flowback waters be stored in closed-loop containers and treated before they are allowed to reenter public waters, and that the National Park Service be fully engaged as a cooperating agency in the permitting process.

Air Pollution

- The Clean Air Act sets high standards for the protection and improvement of national park air quality, so that units of the National Park System can support the health of park ecosystems and visitors. The Environmental Protection Agency recently announced implementation of a regulation to target emissions from compressors, oil storage tanks, and other oil and gas equipment in order to cut 95

percent of ozone and toxic emissions from natural gas wells developed through fracking. However, the rule does not take effect until 2015. Instead, it should be implemented today and expanded to cover existing and future wells.

- A Federal Memorandum of Understanding on air quality analysis and mitigation exists between the Environmental Protection Agency, Department of Agriculture, and Department of the Interior. The agreement requires a complete environmental review of the impacts of oil and gas development on air quality before drilling occurs on federal lands. The agencies that signed this memo should work collaboratively to ensure the requirements of the memo are met and national park air quality is protected.
- Comprehensive air quality monitoring and the best available control technology for emissions should be required when oil and gas development takes place in national park airsheds. The cost of in-park monitoring and associated impacts should be covered by industry.

Above/Left: A male sage-grouse performs for potential female mates. Grouse are especially sensitive to fracking operations. ©Images in the Wild/ISTOCKPHOTO **Middle:** Visitors canoeing on the Middle Delaware River in Delaware Water Gap National Recreation Area (PA) bring sustainable economic benefits to neighboring human communities. ©Christian Heeb **Right:** Waterfall at Van Campens Glen, Delaware Water Gap National Recreation Area (NJ) ©Steve Greer Photography





National Parks and Fracking

Introduction

National parks are America's heritage made visible on the land—the places and events that formed us as a people and as a democratic nation. The majestic landscapes of Grand Teton, Glacier, Arches, and Canyonlands National Parks include some of the nation's most important ecosystems. Our national parks' historic structures include the places where America's freedom and creative spirit came to life.

Cherished, enjoyed, and celebrated, our national parks nonetheless have been buffeted at times by challenges from competing interests and intermittent lack of care. In the past, pressures of the moment have prompted demands to transform the parks' forests into timber, their landscapes into minerals, and their rivers into reservoirs. More recently, insufficient federal funding has led to crumbling historic buildings, the loss of vital park staff, and missed opportunities to teach and inspire our children.

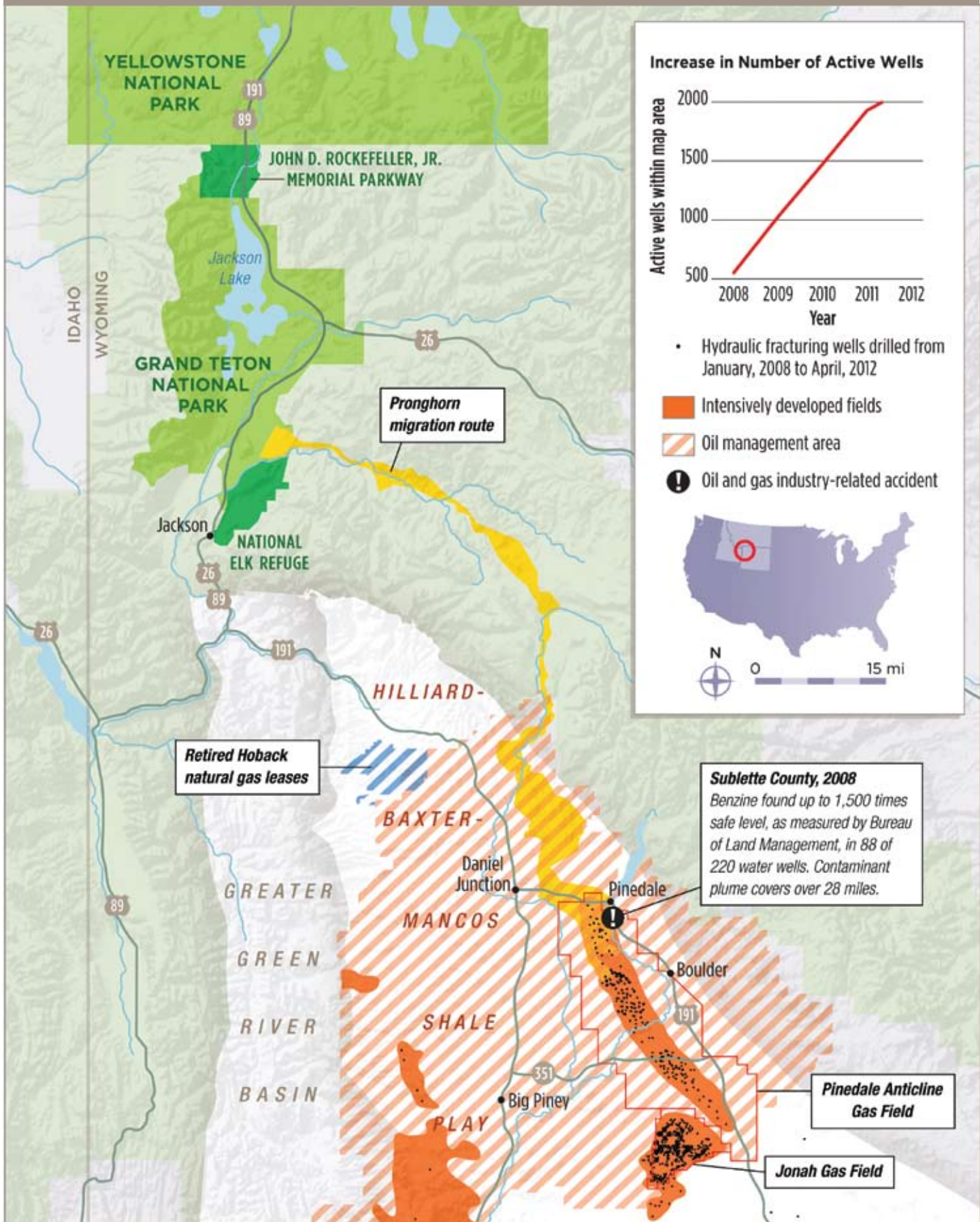
As America's national parks approach their centennial year in 2016, a new challenge is emerging: the rapid expansion of gas and oil development using hydraulic fracturing, better known as "fracking." Because the health of our national parks—air, water, wildlife, and forests—is a direct function of the health of their surrounding landscapes, the growth of fracking operations near national parks is especially alarming.

Industry representatives and government officials point out that fracking promises a steady flow of domestically produced natural gas and oil for U.S. consumption and export, prompting visions of energy independence. Despite its economic and political benefits, though, fracking could cause serious repercussions in America's national parks. The road construction and bulldozed well sites that come with fracking can fragment native forests that surround our national parks, disrupting wildlife habitat and migration routes that cross national park boundaries.

The millions of gallons of water that are drawn from surface waters and underground aquifers to make fracking possible can diminish the quantity of water that nourishes park wildlife and vegetation. The portion of the chemical-laced liquids used in fracking that belches back to the surface of the land can filter into streams and rivers that feed

Left: An aerial view of Big South Fork National Recreation Area. ©Willard Clay

Fracking Near Grand Teton National Park (WY)



Sources: BLM; EIA; NPS; WY Oil and Gas Conservation Commission

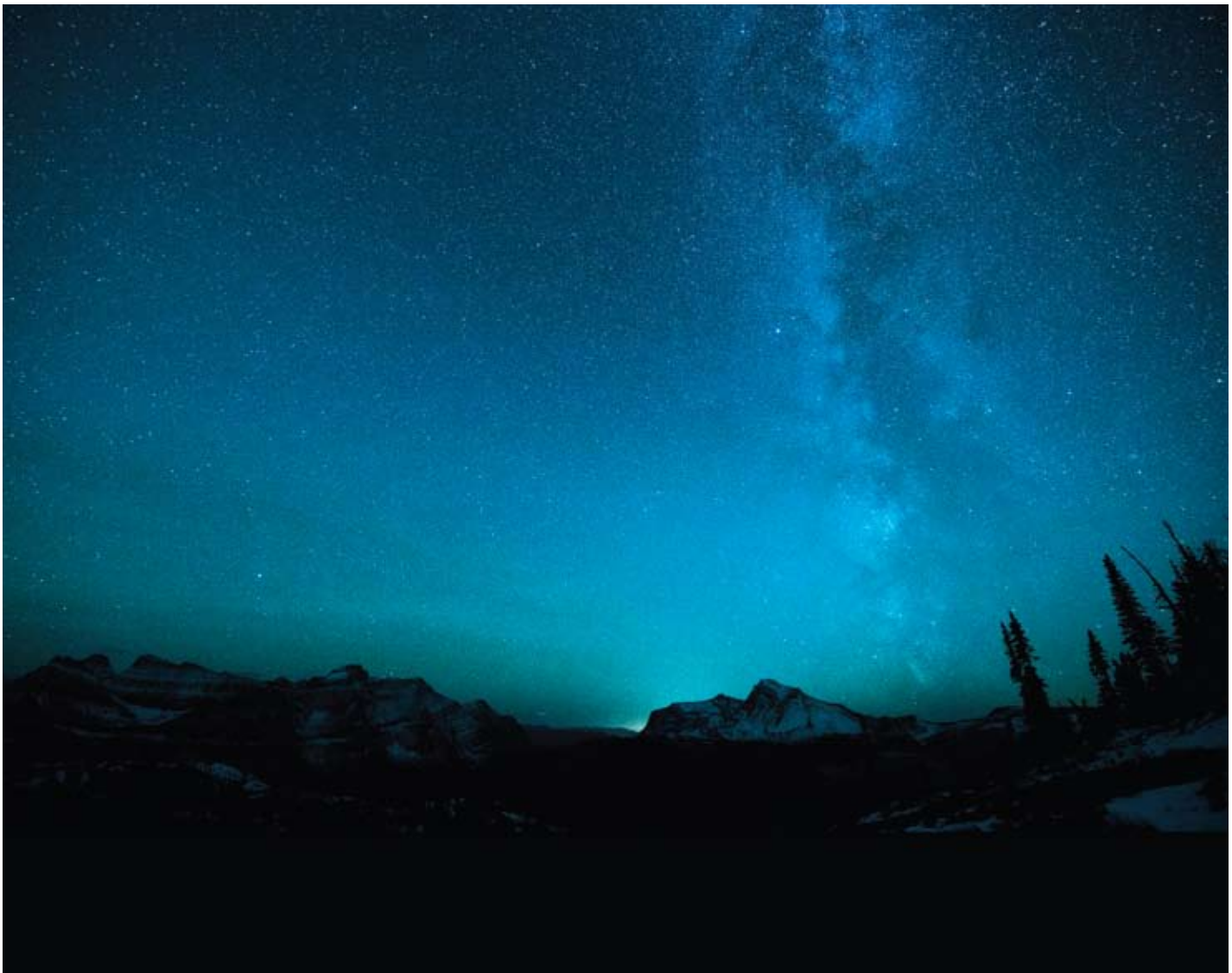
some national parks. Air pollution from oil and gas production wafts over surrounding landscapes, negatively impacting national park plant life and visiting families alike. The industrial noise of drilling, pumps, and traffic roaring past on newly constructed roads interrupts park visitors' experiences. And when night falls, bright flares of excess gases punctuate the dark night sky, illuminating a landscape of energy development and erasing the Milky Way.

Shale basins with potential for gas and oil development underlie an ominous number of our national parks. Of today's 401 national park units, 131 lie either directly above or fewer than 25 surface miles from these underground deposits. More than 33 percent of America's national parks could be impacted by fracking.

Despite the rapid growth of the fracking industry, we still know little about the impacts it will have on our nation's natural resources. But if we value healthy air to breathe, unimpaired outdoor recreation, and landscapes that support diverse communities of plants and wildlife, we need to ask the questions and find the answers. As fracking technology moves physically closer to the borders of our national parks, we must determine what is known and what needs be done.

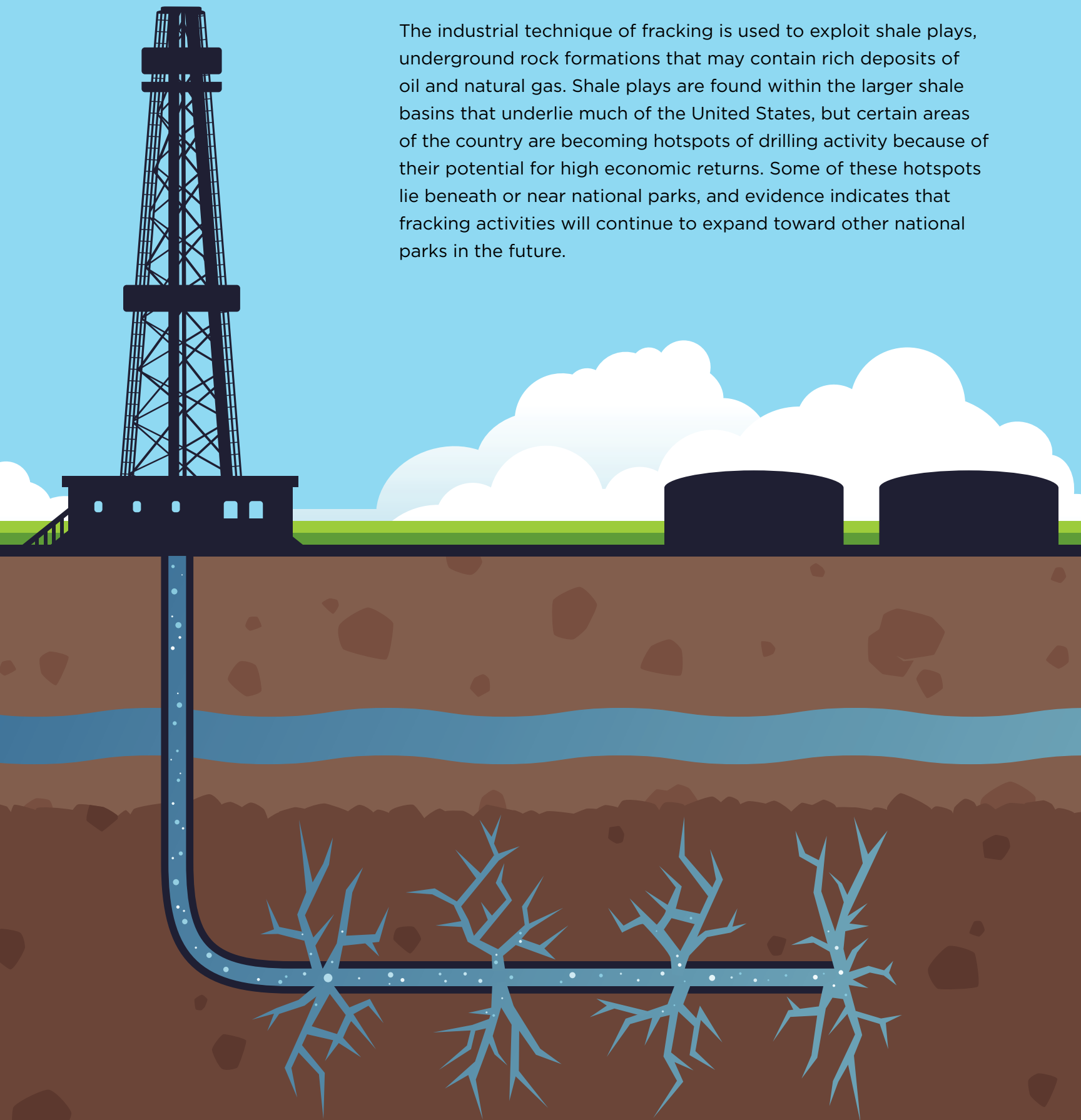
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Below: The Milky Way traces across the winter night sky above Glacier National Park (MT). ©Steven Gnam/TandemStock.com



Hydraulic Fracturing: The Basics

The industrial technique of fracking is used to exploit shale plays, underground rock formations that may contain rich deposits of oil and natural gas. Shale plays are found within the larger shale basins that underlie much of the United States, but certain areas of the country are becoming hotspots of drilling activity because of their potential for high economic returns. Some of these hotspots lie beneath or near national parks, and evidence indicates that fracking activities will continue to expand toward other national parks in the future.



Fracking technology has existed since 1947, but it mushroomed in the late 1980s when companies began to combine it with horizontal drilling to magnify productivity. To produce natural gas or oil through hydraulic fracturing, companies clear a well site, drill a bore hole, and drive a drill bit thousands of feet through the earth to reach layers of shale rock. Once they reach the strata of shale rock, they rotate the drill bit by 90 degrees and bore a horizontal cavity laterally through the shale seam to access a longer stretch of the deposit— from 1,000 feet to more than 10,000 feet. From the well head, they insert explosive charges down the bore hole and into the horizontal opening, and then set them off to perforate the well pipe and burst fissures in the rock. The drillers then pump millions of gallons of highly pressurized water, sand, ceramic beads, and chemical slurry into the hole to expand the fissures and hold them open. As natural gas or oil begins to flow upward to the wellhead on the surface, the sand and beads prevent the fissures from closing. Wastewater and drilling fluids that rise to the surface with the gas or oil are stored in ponds or tanks, or trucked away in heavy tank trucks.

The Energy Information Administration estimates that the United States has 2,119 trillion cubic feet of recoverable natural gas and 25.2 billion barrels of crude oil (<http://www.eia.gov/naturalgas/crudeoilreserves/>). Fracking is now being used in 90 percent of the nation's domestic oil and gas production, and its use is not tapering off, but expanding.



Left: Hydraulic fracturing (fracking) for natural gas and oil utilizes horizontal drilling to extract natural gas and oil from strata of shale rock beneath the earth's surface. ©filo/ISTOCK-PHOTO **Right/Top:** A Google Earth image of the oil fracking region near Pinedale, WY, illustrates the visual impacts fracking can have on the surface of the land. ©2013 Google and Tele Atlas **Second from top:** A crew constructs a 10-inch gas pipeline outside Watford City, ND, 2011. The U.S. Geological Survey estimates that shale formations in North Dakota may hold 4.3 billion barrels of oil. ©Matthew Staver/Bloomberg via Getty Images **Third from top:** Tanker truck servicing the fracking industry near Theodore Roosevelt National Park (ND). ©Kurt Repanshek **Bottom:** Fracking operations in Bradford County, PA. ©Les Stone/Corbis/AP Images



In 2010 there were approximately 1,000 drilled well pads in Pennsylvania's Marcellus shale region; that number is projected to increase over the next two decades to a total of 7,000 to 15,000 well pads.

Landscape Changes From Gas and Oil Fracking Intensive Energy Development Fragments Habitat

A single oil or gas well pad does not require much territory: About 1 hectare of land (10,000 m²; 2.5 acres) can support a drill pad, one or more wells, and a water retention pond. Add in a road, and possibly a pipeline to transport the gas or oil, and the land requirements for this one well pad are still relatively small.

But the intensive efforts underway to extract oil and gas are resulting in the development of an increasing number of larger well pads with numerous wells on each. Johnson (2011) reported that in 2010 there were approximately 1,000 drilled well pads in Pennsylvania's Marcellus shale region; that number is projected to increase over the next two decades to a total of 7,000 to 15,000 well pads. During the past four years, oil and gas companies have leased more than six million acres of public lands (Babbitt 2013). On this scale, energy exploration will alter the regional landscape and cause extensive habitat loss and fragmentation.

Where gas and oil development is taking place close to national parks, this situation is an especially serious cause for concern. National parks are physically and ecologically connected to the lands that surround them. Habitat loss and fragmentation in the larger landscape threaten the integrity of wildlife and vegetation inside the parks themselves.

The energy development boom across the country will require the clearing of large quantities of land and the development of new roads to support the emerging well sites. Where energy development is intensive, intact habitats will be fragmented into smaller units, which carries implications for the natural resources that remain. Direct changes to habitats (clearing forest for well pad construction), as well as indirect changes to habitats (increased species loss and drying out of forests), negatively impact native plant and wildlife populations. Because national park animals don't always remain within park boundaries, these impacts directly affect wildlife communities inside the parks themselves.



Research done in the Marcellus shale region of Pennsylvania is offering early glimpses into the fragmentation and habitat loss resulting from shale development (Johnson 2011, Fisher 2012). One GIS analysis showed that a single well pad and road built in Greene County, Pennsylvania, reduced an intact forest patch from 193 acres to 150 acres—a decrease of 22 percent (Johnson 2011).

The type of habitat loss is of particular concern. For example, slightly more than half of the drilling pads in Pennsylvania are located on agricultural lands, while many of the others are on forested lands (Drohan et al. 2012). Many of the sites targeted for wells are relatively large, unbroken tracts of Pennsylvania forest. In fact, more than 25 percent of existing or permitted pads in the Susquehanna River basin (the major tributary flowing into the Chesapeake Bay) are located within these core forest tracts. In addition, up to 145 miles of new roads may be built in this part of the basin, further fragmenting habitat and increasing edge effects. The likely outcome from the proliferation of edge habitat will be increases in the populations of less desirable edge species, including invasive weeds (Fisher 2012), as well as the loss of native plants and animals that thrive in intact ecosystems.

The situation has been carefully documented. In northern West Virginia, researchers monitored the impacts from a single gas well in the Fernow Experimental Forest (Adams et al. 2011, Adams 2011). The well (and its associated pipeline and road) was installed in the experimental forest in 2008. (This is the same experimental forest discussed in “Fracking Creates Dangerous Waste That Could Contaminate Surface Waters” on page 24.) Because the site is an experimental forest, reams of historical data exist to quantify the impacts of the gas well. What researchers found was that direct habitat impacts were predictable (cleared vegetation, soil erosion, road damage), and indirect impacts were consistent with the increase in edge habitat normally associated with pad and road development.

West of the Mississippi River, oil and gas development has added to the reduction of the once-widespread sagebrush steppe habitat, an ecosystem that once covered more than 63 million hectares (243,244 square miles) of the western United States (Knick et al. 2003, Halloran 2005). After the cumulative impacts of human activities such as agriculture, cattle grazing, mining, urbanization, and energy development, only 14 percent of the ecosystem remains (Knick et al. 2003). This once-dominant habitat provides food and shelter for many bird species and other wildlife. In Wyoming alone, some 100 bird species and 70 mammal species depend on sagebrush at some particular point in their life. Many of these are animals that national park visitors hope to see during their travels (Halloran 2005). Today, these degraded or eradicated sagebrush steppe lands have been urbanized, industrialized, or invaded by non-native grasses. None of these land uses provides high quality habitat for wildlife. Scientists in these Western states fear that the recent oil and gas boom brought on by hydraulic fracturing technologies will expand the destruction of this important ecosystem.

Habitat Fragmentation from Energy Development Has Consequences for Wildlife and Plants

Recent studies demonstrate how certain native wildlife species react to the intrusion of oil and gas developments. A study of greater sage-grouse (a candidate species for Endangered Species Act protection) in Montana and Wyoming showed that female birds avoid areas with coal-bed methane wells; another study in Wyoming found that males' breeding displays were less frequent in areas close to well fields and the roads that service them. While coal-bed methane extraction (the focus of the first study) differs from hydraulic fracturing, the impact to this iconic species is clear: Altering the landscape for energy development negatively impacts sage-grouse populations.

Elk, mule deer, and pronghorn antelope (wildlife species that characterize many national parks in the West) also depend on sagebrush habitats during winter (Halloran



Left: A new road piercing the forest in Susquehanna County, PA, paves the way for fracking operations. ©Nina Berman/NOOR
Above: Pronghorn that reside part of the year in Grand Teton National Park (WY) also move through corridors on adjoining lands that are increasingly being used for oil and gas fracking. ©Angela Cable/ISTOCKPHOTO

Fracking outside the boundaries of national parks produces effects inside the parks themselves.

2005). Studies in Wyoming showed that mule deer fled from drilling pads and did not acclimate to them during the three-year study period (Sawyer et al. 2005, 2006, 2009). Mule deer were less likely to use land with energy development as far away as 4 kilometers (2.4 miles). The effects of this shift on regional wildlife populations, particularly populations that use national park lands, remain unclear. But observers state that oil extraction in North Dakota continues to insulate and isolate the wildlife of Theodore Roosevelt National Park, and biologists expect that wildlife populations in the park may decline in number and variety as a result.

A similar concern is that habitat loss and alteration from energy development in Pennsylvania will affect forest wildlife, including Neotropical migrant bird species such as warblers, thrushes, and tanagers (Fisher 2012). As an example, approximately 20 percent of the world's scarlet tanager population breeds in the intact forests of Pennsylvania. In some cases, evidence suggests that impacts to native wildlife, particularly birds, will trickle down to plant communities that rely on birds for pollination. A study on lands near natural gas wells in New Mexico (Francis et al. 2012) revealed that persistent noise from compressors altered mice and bird communities and hampered the dispersal of piñon pine seeds.

In some cases, habitat loss and fragmentation might disrupt vegetation and wildlife populations close to or inside national park boundaries. Because wildlife, plant seeds, air, and water move freely across park borders, the condition of natural resources in our national parks is tied to the condition and character of the larger landscape that surrounds them. Fracking outside the boundaries of national parks produces effects inside the parks themselves.

Proposed oil and gas development in Pennsylvania's Marcellus shale region, for example, would fragment and destroy pristine forest adjacent to Upper Delaware Scenic and Recreational River. Downstream, at Delaware Water Gap National Recreation Area, there are proposals to build natural gas pipelines across the park, an action that would fragment park wildlife habitat and interfere with black bear migrations across the landscape.

Activities associated with fracturing, like sand mining, have also had an effect on national parks. The upper Midwest provides the sand commonly used in the fracturing process, and mining activities for this commodity have already caused sedimentation in the St. Croix National Scenic River. The long-term impacts of erosion and sedimentation to park resources are currently unknown.

How Can We Mitigate Habitat Loss and Fragmentation from Fracking?

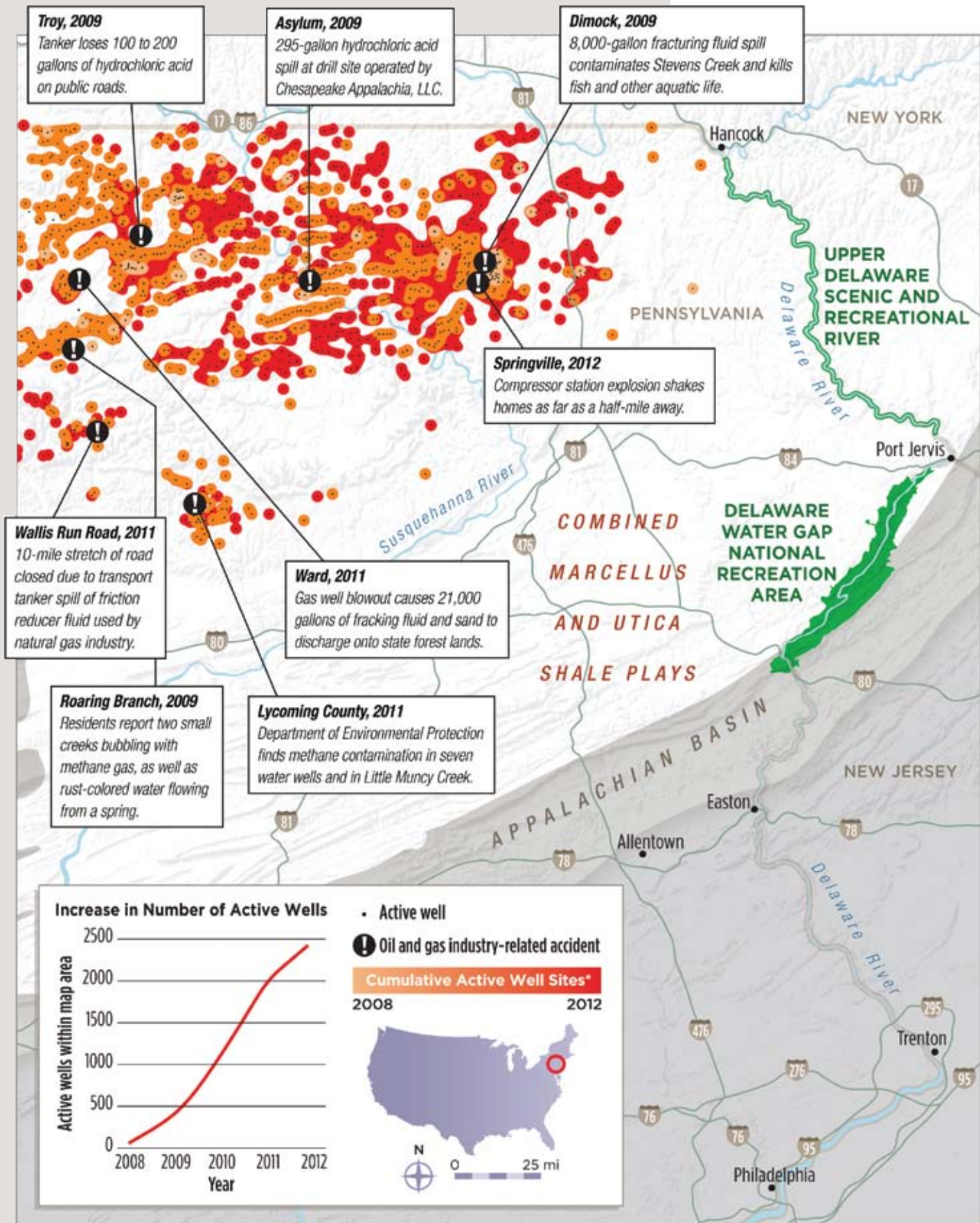
Loss of habitat is inevitable in energy development, but proper planning and research can mitigate some of the impacts. Researchers focused on landscape connectivity (sometimes called conservation connectivity) are addressing such questions as: What do we know about the landscape, its wildlife and plant life, and the flow of energy and organisms across it? What are the impacts of habitat disturbance, and what can be done to mitigate them?

A more complete understanding of landscapes and the importance of national parks within them will improve the conservation of the nation's ecosystems

as energy development expands in North America. But many practical obstacles remain. The permitting process for energy production that is standard practice in

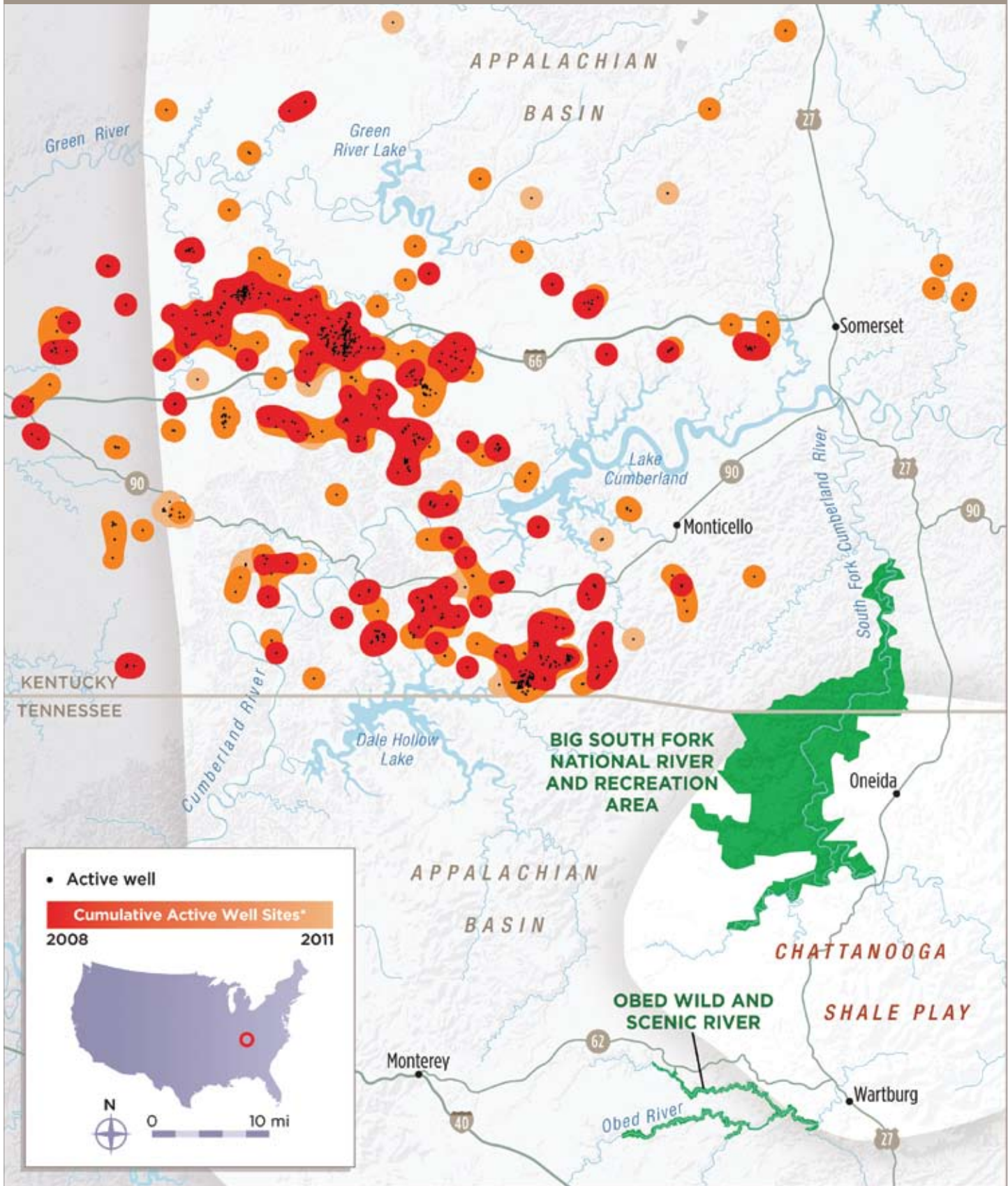
many states may not provide sufficient opportunity for proactive, comprehensive management. Even more, surface lands and subsurface mineral rights are often owned by different parties. Finally, many of the lands currently being exploited for oil and gas fracturing are privately owned. In fact, 90 percent of Pennsylvania's current gas drilling is taking place on privately owned properties (Fisher 2012). These factors make managing lands across a larger landscape even more difficult.

Fracking Near the Delaware River Basin



Sources: NPCA; EIA; www.fracktracker.org

Fracking Near Big South Fork NRA and Obed Wild & Scenic River (KY/TN)



Sources: EIA; KY Geological Survey; NPS

Oil and Gas Development Can Negatively Impact Park Visitors: Industrial Noise, Park Views, and Park Skies at Night

Noise accompanies oil and gas development, from the blast of air compressors pumping fracturing fluids into the ground to the roar of heavy trucks moving water and equipment to and from the drill pads. Adding a visual dimension to this din, drill rigs project up to 100 feet into the air and can sometimes be seen from great distances. At night, gas flaring—igniting excess gas to burn off gas pressure buildup and maintain safe conditions at the drill site—disrupts people’s appreciation of the beauty of dark night skies.

Where these impacts from oil and gas development occur near national parks—Theodore Roosevelt National Park in North Dakota is an example—they mar the natural and cultural resources the parks are designed to protect, and park visitors may turn away, disappointed by the outside intrusions. If fracking expands closer to Big South Fork National River and Recreation Area in Tennessee, for example, visitors listening and watching for endangered warblers may instead hear the hammering of industrial air compressors and see drill rigs ten-stories tall on the horizon. Although water and air contamination from oil and gas fracking receives a lot of media attention, the impacts on scenic views and natural sounds—especially in national parks—are also obvious and immediate.

National parks preserve the sound of rustling winds, bird songs, waterfalls, and perhaps most important of all, natural silence. Hearing birds and the river on the front porch of President Theodore Roosevelt’s Elkhorn Ranch in North Dakota or the bugling of elk on the eastern edge of Glacier National Park in Montana are also important resources protected in our national parks. Oil and gas development can threaten the enjoyment of these park resources.

Researchers have shown that oil and gas operations can produce noise pollution and impact parks’ natural soundscapes—affecting visitor experiences, wildlife, and cultural resources (see sidebar on page 20). A series of studies has documented how noise—from over flights, personal watercraft, and even other visitors—diminishes visitors’ park experiences.

Researchers have also examined the effects of noise on marine mammals, birds, and bats. In northwestern New Mexico, a research team has been evaluating how noise pollution from drilling sites’ air compressors affects birds, and how those effects translate to the surrounding landscape (Francis et al. 2009). The research found less species diversity within bird communities in noisy areas than in quiet control areas nearby. On the other hand, another recent study found that hummingbird pollination actually increased in noisy areas (Francis et al. 2012). This research indicates that the effects of noise on wildlife are not well understood.

Yet some effects are plain. Would Theodore Roosevelt have developed such a strong conservation ethic during his time at Elkhorn Ranch if he had been subjected to the noise now being generated by North Dakota’s oil fracking boom, currently taking place along the borders of his namesake national park?



Right: Constellations illuminate Grand Teton National Park (WY). Gas flares from fracking are beginning to threaten dark night skies in some national parks. ©Marc Adamus/Aurora Photos



Noise Intrudes on National Parks

Oil and gas extraction generates low-frequency noise, which travels farther than high-frequency sounds (Barber et al. 2011). A recent study modeled the impacts that compressors from oil and gas operations might have on Mesa Verde National Park in Colorado. The study found that the sound of 64 compressors outside Mesa Verde *elevated* the sound level within the park by 34.8 decibels on average, and by 56.8 decibels on the eastern side of the park (which sits closest to the compressors). For comparison, the U.S. Environmental Protection Agency recommends a “safe noise level” of no more than 55 decibels total to avoid damage to the human ear.

The same study also examined the potential for road noise to impact national park soundscapes, specifically modeling the effects of automobiles on the Going-to-the-Sun Road in Glacier National Park. Here the researchers found that modest traffic levels (e.g., 3,700 vehicle trips per day) produced a 42-decibel increase in noise within 500 meters of the road, and a 38-decibel increase within 1,000 meters. More vehicle trips and heavier vehicles (trucks carrying water, heavy drilling equipment) mean more noise pollution and more potential noise pollution. Some writers estimate that as many as 2,000 truck trips are required during the first year of a well’s operation, not including the removal of the fossil fuel itself (Dobb 2013).

In addition to the noise fracking makes, there are visual impacts to consider. Fracking operations are accelerating in northeastern Pennsylvania, and allowing them to approach Upper Delaware Scenic and Recreational River would compromise the pastoral quality that visitors so appreciate there. Indeed, the once-pristine badlands of western North Dakota have already been pockmarked by fracking projects that have produced a less appealing landscape. Surveys of visitors at other national parks have shown that natural quiet and unmarred views rank high in importance in their park experiences (Joshua Tree National Park Visitor Study, Fall 2010, www.nps.gov/jotr/parkmgmt/upload/2010VSPrept.pdf).

A 2009 National Park Service publication identified potential impacts to viewsheds (scenic views) as one of the factors that would force the Park Service, because of its mandate to protect such resources, to delve into the oil and gas permitting process in the Marcellus shale region. Mapping park scenic views using geographic information systems technology can provide relevant information to state agencies as oil and gas permits are considered. Some parks have staff working on this. Increased collaboration has the potential to prevent conflicts over scenic views.

Nested within the issue of scenic views is the potential impact to night skies. Some national parks around the country offer superlative opportunities to enjoy dark night skies and the kind of stargazing that’s simply not available near developed, urban areas. Oil and gas development can disrupt night skies through extensive lighting of drilling sites during the initial construction phase and through flaring, which burns off surplus gases. In areas where high concentrations of wells exist, flaring obscures night sky viewing opportunities.

Above: Traffic generated by the fracking oil boom passes through Watford City, ND, on the highway leading to Theodore Roosevelt National Park. ©Matthew Staver/Bloomberg via Getty Images

Water Quantity

Fracking's Enormous Demand for Water Could Threaten Our National Parks

Water means life for national parks. A sustainable supply of clean water supports healthy plant life, and plants are the foundation for wildlife and ecosystem diversity. Additionally, park waters provide visitors with recreation opportunities and provide sources of clean, municipal water. Given the narrowing physical distance between national parks and fracking sites, we have to ask whether or not fracking could threaten water resources in national parks.

To carry out hydraulic fracturing, companies inject millions of gallons of water, chemicals, and sand into the ground at extremely high pressures to crack and hold open gas- and oil-bearing shale. The quantity of water required for a specific fracking well depends on the depth of the target shale and its geological properties. In North Dakota's Bakken shale, which lies under lands adjacent to Theodore Roosevelt National Park, the operation may require 1 million gallons to fracture the rock and release oil. By contrast, a well in the Marcellus shale of the mid-Atlantic region, near Delaware Water Gap National Recreation Area, may require 5.5 million gallons to release the formation's natural gas. A single fracking well in the productive Eagle Ford shale play in Texas requires more than 6 million gallons of water (Rubin 2013).

These volumes reflect only the amount of water initially injected into the well. As production drops, wells can be re-fractured in hopes of stimulating additional oil or gas production, and this requires more water. Where the water comes from is a function of what's available in the area of operation. Rivers, streams, lakes, and underground aquifers are all being used by the industry. Some of this water is recycled as fracking fluid in other wells, but much of it is lost to the water cycle, denying future use by people or wildlife.

When water is pumped into a fracking well, 20 to 40 percent of it regurgitates back up the bore hole. In some places, companies have collected this "flowback" water and transported it for use in other fracturing jobs. In many other cases, the flowback is disposed of as waste. Much of the water used for fracturing is fully consumed—meaning it is too contaminated with chemicals and underground brines to be used again—at least until technology is developed to adequately treat it.

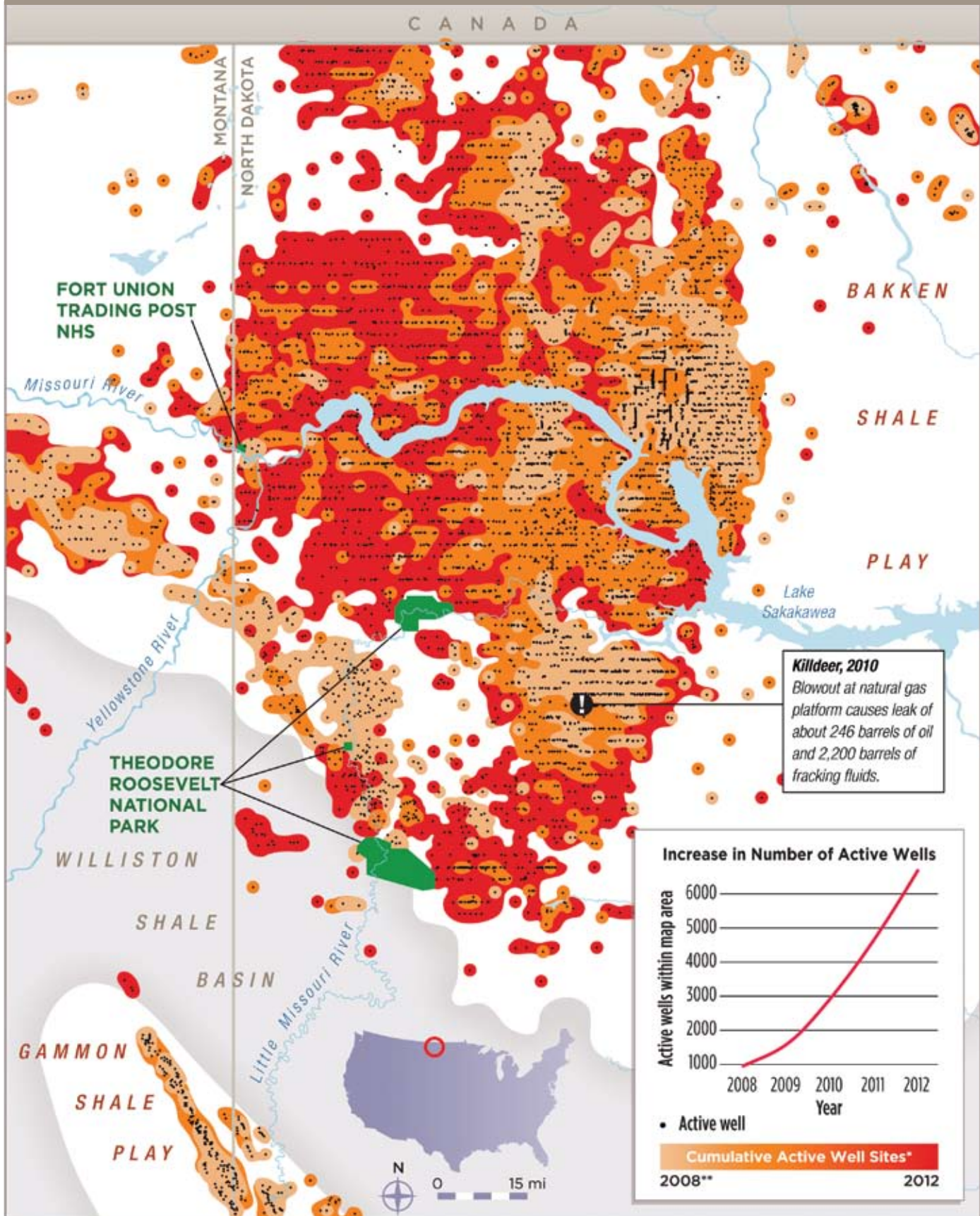
Because water availability is a contentious topic in both the Eastern and Western United States, the quantity of water used in fracking operations is coming under close scrutiny. Examining the issue in the Western states, a 2012 report by Western Resource Advocates, citing data from the Colorado Oil and Gas Association, indicated that the amount of water required to fracture the nearly 3,000 new wells drilled in Colorado in 2011 was between 22,000 and 40,000 acre-feet annually (an acre-foot is 325,851 gallons of water, thus, 7 to 13 billion gallons of water per year). That's equivalent to the water used by 79,000 families during the course of a year (WRA 2012). And in Colorado, as in many places across the country, water is scarce and already highly allocated.

In some areas of the country, municipalities have sold part of their water holdings to the oil and gas industry. In 2011, the northern Colorado town of Greeley sold more than 1,500 acre-feet (4.8 million gallons) of water to oil and gas companies for \$1.6 million (Hurst 2012). If continued, this sort of sale could be detrimental to regional water supplies, because water used to irrigate crops normally returns to area waterways or percolates through the soil to directly replenish underground aquifers. In contrast, much of the water used for fracking becomes unavailable for human beings and, in some places, for national park fish, wildlife, and vegetation.



Left: Autumn in Big South Fork National River and Recreation Area (TN/KY).
©David Muench/Muench Photography Inc.

Fracking Near Theodore Roosevelt National Park (ND)



** some active well sites displayed in Elkhorn Ranch Unit area may have pre-2008 ground-breaking dates

Sources: EIA; ND Department of Mineral Resources; NPS

On the arid Colorado Plateau, water is a life source for seven states, two countries, and 30 million people. The region's water resources are already over-allocated, producing a gap between water supplies and growing annual demands. Water seeps and springs are an especially critical link for park resources. They provide life-sustaining water for wildlife, waterfalls, and plant habitats in side canyons like those of Grand Canyon National Park. Because oil and gas activities can significantly impact overall water availability in the arid Southwest, the potential exists that seeps and springs could be negatively affected. The high demand for water from oil and gas fracking has the potential to impact national park resources, as well as harm visitor recreation and tourism economies near the national parks of the Colorado River basin and other regions of the country.

Less Water for National Parks?

The increasing quantities of water used for fracking may lead to less surface water in major river basins. Companies working the Bakken shale deposits of North Dakota, including those that lie beneath Theodore Roosevelt National Park, already are competing for access to reservoirs that feed the Missouri River. The companies need the water for fracking, but other interests would prefer to use it to offset the drought-induced, diminished flow of the Mississippi River, which receives the flow of the Missouri near St. Louis.

In the Western states, water extracted for fracking may affect the Colorado River and Rio Grande basins, home to a dozen iconic national parks. In the Colorado River basin, water quantity is a perennial issue for national parks—among them, Dinosaur National Monument, Canyonlands National Park, Glen Canyon National Recreation Area, and Grand Canyon National Park. More pressure on this resource, either through direct removal from surface tributaries or through the drawdown of groundwater that replenishes the river, will further exacerbate resource problems in the region's parks.

NPCA's Center for Park Research provides a detailed analysis of the impacts of reduced water flows on native fishes, natural river processes, and riverine cultural resources in national parks along the Colorado River in the 2011 report *National Parks of the Colorado River Basin: Water Management, Resource Threats, and Economics* (available online at www.npca.org/cpr). These impacts include declines in native fish populations, changes in stream bank plant communities, and alteration of sediment that produces impacts on recreational rafting and cultural resources such as archaeological sites. Meanwhile, shale development in southern Colorado, northern New Mexico, and Western Texas could reduce the amount of water that makes its way into the Rio Grande, where water flows are a perennial resource concern.

In other parts of the United States, including the Eastern seaboard, vital aquatic habitats in national parks could suffer from reduced water supplies wrought by fracking. Using surface or groundwater for hydraulic fracturing in Pennsylvania, New York, or New Jersey could reduce the amount of water flowing through Upper Delaware Scenic and Recreational River and Delaware Water Gap National Recreation Area, harming federally protected freshwater mussels in the river. As with many river parks in the National Park System, the benefits of the parks' clean water are well recognized far beyond their borders. The Delaware River supplies drinking water for 5 percent of the U.S. population—more than 15 million people.

The development of the Marcellus shale that underlies this region could also have consequences for the Susquehanna River, the area's largest river and the major tributary to the nationally significant Chesapeake Bay estuary. Currently, the natural gas industry in the region gets more than 65 percent of its water from surface water withdrawals (Richenderfer 2012). In the future, that could surge to 30 million gallons per day (Richenderfer 2012). The potential impacts of these withdrawals are uncertain—but at stake are drinking water, recreational opportunities, and the economic vitality the Chesapeake provides to the region's 54 national park units and 17 million human residents.



Above: Drilling rig for fracking operations in the Bakken shale formation (ND). ©David Gaylor/ Dreamstime.com

Water Quality

Fracking Creates Waste That Could Contaminate Surface Waters

Concerns about the impacts of fracking on national parks increase when we look at the potential for water contamination. The 20 to 40 percent of injected fracking water that flows back to the surface during drilling and production contains chemicals and lubricants added during the fracking process, as well as natural pollutants such as salts, radium, and barium that have been held in the geological strata for millions of years (Haluszczak et al. 2012).

As a result, wastewater generated by hydraulic fracturing remains a dangerous brew with few effective options for disposal or treatment (Biello 2012). In some production areas, wastewater has been trucked off-site to a treatment facility, or pumped into deep water injection wells. In a few cases, waste has been dumped (intentionally or accidentally) into surface waters or dispersed on the landscape. All of these disposal scenarios have negative consequences. In some cases, they may threaten resources inside national parks.

Modern wastewater facilities are designed primarily to process organic sewage, not to remove salts, radioactive materials, or hydrocarbons found in flowback water from fracking wells. In particular, material collectively known as Total Dissolved Solids (TDS), which is common in fracking flowback water, is difficult to remove from wastewater. TDS commonly includes ions (calcium, potassium, chloride) and compounds such as nitrate and phosphate. Although all natural waters contain these dissolved solids, the levels found in flowback waste can be much higher than typical freshwater sources. For example, one study reported that fracking flowback waste had a concentration of 7,500 milligrams per liter of chloride (Adams 2011), whereas a typical headwater stream in the Delaware River Basin might have 20-50 milligrams per liter of chloride.

Worse yet, a 2012 Penn State University study of the composition of flowback liquids from fracked gas wells of Marcellus shale in Pennsylvania and northern Virginia revealed that some of the elements returning to the surface appear to be barium and radium deposited hundreds of millions of years ago. Reporting in the scientific journal *Applied Geochemistry*, the study's authors note that while much attention has focused on the flowback of chemicals injected into the well during the fracking process, the release of toxic elements that have been held in the ground for millions of years is also a concern (Haluszczak, et al. 2012).

Because wastewater treatment facilities don't have methods to remove certain pollutants, the water they discharge into the environment remains high in compounds known to kill fish, corrode metal, and contribute to the excessive growth of certain algae (leading to more fish kills caused by depleted oxygen levels produced when the algae die and decompose). In some places, contaminated wastewater is discharged from facilities located great distances from well sites, a situation that makes fracking's environmental consequences far-reaching.

Even more relevant to fracking's potential threats to national parks is evidence indicating that contamination of surface waters from hydraulic fracturing can affect the health of domestic animals. In one study, researchers tabulated cases where surface water or shallow groundwater contamination was associated with domestic animal health problems (Bamberger and Oswald 2012).

Such studies can't always quantify potential or future risks to domestic animals, but the authors argue that animal health is an important research topic when considering the impacts of gas drilling. And if fracking poses consequences for domestic animals, could it not impact national parks wildlife as well? This threat is especially relevant as oil and gas development expands into the grizzly bear recovery zone established in and around Glacier National Park in Montana.



Above: American shad have long been a valuable resource in the Chesapeake Bay watershed, the largest estuary in North America and home to 17 million people. ©Dave Harp **Right:** Cold, clear water characterizes Kintla Lake, Glacier National Park (MT). ©Jason P Ross/Dreamstime.com



Because wastewater treatment facilities don't have methods to remove certain pollutants, the water they discharge into the environment remains high in compounds known to kill fish, corrode metal, and contribute to the excessive growth of certain algae.

On December 31, 2011, a minor earthquake near Youngstown, Ohio, appears to have been associated with well injections of fracturing fluid wastes from Pennsylvania.

The Fayetteville shale region of Arkansas has also experienced an increase in seismic frequency from the reinjection of fracking wastes.

Just as releasing fracking wastewater—even after treatment—degrades rivers and streams, broadcasting the wastewater over the landscape is not a viable solution, either. In a 2011 study that mimicked the effects of an accidental spill, nearly 80,000 gallons of wastewater were applied to a half-acre area of forest to document the impacts of fracturing wastewater on vegetation (Adams et al. 2011 and Adams 2011). The wastewater contained chloride levels that were within state standards for disposal on the landscape; however, the large quantities applied to a small area resulted in an estimated 4,500 kilograms of chloride per acre. The experiment resulted in damaged leaves and dead plants, likely as a result of the high concentration of TDS.

The study underscores concerns about accidental spills of fracking wastewater that could occur as trucks transport flowback water from drill sites to disposal or treatment facilities. Such accidents have the potential to contaminate lands and waters far removed from drill sites, including those of nearby national parks. Potential cases in Theodore Roosevelt National Park, in North Dakota, and Delaware Water Gap National Recreation Area, in Pennsylvania, come to mind.

Another practice currently used to deal with fracking wastewater is re-injecting it into deep wells that are otherwise unused resources (Clark et al. 2011). But several studies associate that practice with increased seismic activity, which may or may not have an impact on people and national parks. On December 31, 2011, a minor earthquake near Youngstown, Ohio, appears to have been associated with well injections of fracturing fluid wastes from Pennsylvania. Other areas of the country, including the Fayetteville shale region of Arkansas, have also experienced an increase in seismic frequency from the reinjection of fracking wastes. A recent peer-reviewed study indicated a correlation between deep-well injections of fracturing waste and small earthquakes in eastern Texas (Frohlich 2012).

These studies underscore the concern that injecting large amounts of wastewater into areas of tectonic activity may result in corollary problems. Changing the underlying geology of a region through fracking could increase the chances of groundwater contamination. Several recent studies revealed that contaminated fracking water can seep through fissures created by fracking into naturally occurring cracks in underground rock formations, gradually working its way to the surface through natural seepage and springs, some of which may be located inside national parks. As fracking wells are drilled ever closer to national park boundaries, this new research provides yet another reason to monitor potential impacts of the industry.





The Bureau of Land Management's Leasing Reforms: What do They Mean for National Parks?

In May 2010, the Department of the Interior issued a binding instructional memorandum (IM 2010-117) to improve oil and gas leasing on lands managed by the Bureau of Land Management (BLM). If implemented effectively, these leasing reforms could better protect national parks from the impacts of oil and gas development on BLM lands, including those adjacent to national parks.

The leasing reforms outlined in the instructional memo have two main components:

1. BLM must complete a National Environmental Policy Act (NEPA) review that provides the public with an opportunity to comment prior to each lease sale. As part of the review, BLM must determine whether “leasing would result in unacceptable impacts to the resources or values of any unit of the National Park System” and “coordinate and/or consult on parcel review” with the National Park Service in order to “achieve greater coordination and communication in managing shared landscapes, such as airsheds, viewsheds, watersheds, and soundscapes...” Simply put, BLM must now bring the public and the Park Service to the table to review and comment on proposed oil and gas development

when it might impact national parks.

2. BLM must conduct a pre-leasing planning process known as a “Master Leasing Plan” or MLP. This planning process was established to resolve sometimes longstanding conflicts between oil and gas leasing and the protection of lands such as national parks. Through MLPs, the BLM must identify and evaluate potential resource conflicts, including conflicts with “nearby...federal lands, including National Park Service and Fish and Wildlife Service lands, that could be adversely affected by BLM-authorized oil and gas development” and then adopt new measures to resolve those conflicts.

To date, BLM has agreed to prepare full MLPs in Montana, Utah, and Wyoming. The Utah MLPs are focused, in part, on

addressing impacts on Arches National Park and Canyonlands National Park.

The BLM leasing reforms are a step in the right direction. However, where national park resources are at risk, BLM needs to go further than simply advising the National Park Service of potential impacts and going on to develop mitigation measures unilaterally. Instead, BLM should designate the Park Service as a formal “cooperating agency” under NEPA when there is a reasonable likelihood that national park air, water, wildlife, or other resources will be affected by oil and gas activities on BLM land. As a cooperating agency, the Park Service would be able to participate in preparing environmental impact statements to ensure that park resources are taken into consideration from the outset of leasing decisions

Left: Elk feeding in Rocky Mountain National Park (CO). ©Sergio Ballivian/TandemStock.com **Above:** A containment pond at a fracking site in the Marcellus shale region, eastern United States. Ponds such as this hold flowback (fresh water mixed with chemicals, sand, and lubricants) that gushes up the wellbore to the surface during a fracked well's production phases. ©Dwight Nadig/ISTOCKPHOTO

An EPA study indicates that oil and gas development around the town of Pavillion resulted in localized groundwater contamination and, by extension, impaired drinking water. One notable finding: The water wells in closer proximity to gas production wells had higher concentrations of methane.

Some Studies Link Fracking and Groundwater Contamination

One of the most emotionally charged concerns specific to hydraulic fracturing revolves around groundwater contamination. The image of water engulfed in flames because of methane contamination has been burned into the public consciousness. Although this is a major concern, documented research on hydraulic fracturing's potential to contaminate groundwater is still sparse. Between 2009 and 2011, the U.S. Environmental Protection Agency conducted an extensive investigation to uncover why domestic water users in Pavillion, Wyoming, were complaining of bad tastes and odors in their household water supplies. Pavillion is a rural area near the Pavillion gas field, where hydraulic fracturing has been used to stimulate relatively shallow (around 1,000 feet deep) wells. Early findings from the EPA's study indicate that oil and gas development around the town of Pavillion resulted in localized groundwater contamination and, by extension, impaired drinking water. One notable finding: The water wells in closer proximity to gas production wells had higher concentrations of methane.

The Pavillion study uncovered some important information related to drinking water contamination, but it didn't identify what went wrong: Was the cement casing around the well bores insufficient, or did contaminants migrate upward through the geological layers? What was the initial baseline condition for the drinking water wells? What are the short-term and long-term consequences of this water contamination for human and animal health? These questions may never be answered, but Pavillion's cautionary tale is this: A connection exists between hydraulic fracturing and the contamination of domestic drinking water. For national parks in urban and exurban areas and for parks surrounded by human settlements, the potential for groundwater contamination should not be dismissed.

In northeastern Pennsylvania and southern New York—regions that overlie the Marcellus and Utica shales—another study also found a potential link between hydraulic fracturing and methane contamination in groundwater pumped for domestic use (Osborn et al. 2011). In domestic water supplies that were within 1,000 meters of "active extraction areas," concentrations of methane were much higher than water supplies at greater distances from active wells. The methane found in these samples matched the gas produced by the nearby wells. Unlike the Pavillion, Wyoming, study, however, the research provided no evidence of other fracking chemicals or brines in the drinking water. This was the first peer-reviewed paper to link oil and gas hydraulic fracturing to groundwater contamination.

Another recent study by Duke University scientists (Warner et al. 2012) suggests that Pennsylvania's geology might have higher connectivity than initially thought: Despite the depth of the Marcellus shale, there may be natural hydraulic links between the deep shales and shallow groundwater that could result in the transport of shale brines or even fracturing fluids to the surface.





Surface and Ground Water Contamination: Could National Parks Be Affected?

Pressure to develop the Marcellus shale in northeastern Pennsylvania and southern New York could degrade the Delaware River through the streams that feed into it. A spill in the upper Delaware watershed could quickly degrade water quality and high-value wildlife habitat of Upper Delaware Scenic and Recreational River and flow downstream to Delaware Water Gap National Recreation Area. For example, a fracturing wastewater spill near the Upper Delaware River or any of its many tributary streams or creeks could cause fish kills that harm the recreationally important American shad (*Alosa sapidissima*), or result in losses to wildlife species in the park, including the endangered dwarf wedgemussel (*Alasmidonta heterodon*).

Similar damage could occur at any number of national parks around the nation. A spill or discharge of improperly treated wastewater into surface waters would harm aquatic wildlife, as well as species that rely on those waterways. It could also translate into reduced recreational opportunities and negative

public perception of the parks' safety for swimming.

Should parks' drinking water become contaminated by nearby fracking, visitors wouldn't be the only ones impacted. In many national parks around the country, seeps fed by

groundwater create hanging gardens, and springs provide critical watering holes for a variety of terrestrial wildlife. One recent study (Bamberger and Oswald 2012) summarizes some of the suspected and potential impacts to livestock from well-water contamination: Cattle exposed to fracturing fluids (either from spills or leaky impoundments of wastewater) suffered serious reproductive effects (e.g., difficulty breeding, abnormalities in offspring) and in some cases, death. Similar water contamination impacts on wildlife seem plausible.

Left: Fly fishing is a popular activity in many national parks, including Upper Delaware Scenic and Recreational River (PA). ©Bob Krist/National Geographic Stock **Above:** Looking down from Devil's Jump Overlook at canoers and kayakers in Big South Fork National River and Recreation Area near Stearns, KY. ©Pat & Chuck Blackley

Pollution from concentrated oil and gas development could further increase existing park air quality problems or create air quality problems where they have not existed in the past.

In northeastern Utah's Uintah Basin, near Dinosaur National Monument, 10,000 oil and gas wells created ozone levels that were worse than those of New York City (Jaffe 2012).



Air Quality

How Fracking Affects Air Quality

National park visitors look forward to hiking through forests, breathing fresh air, or climbing to the top of a craggy peak to see a view of blue skies and mountain tops that seem to go on forever. In reality, air quality in some of our national parks is frequently contaminated with pollutants blown into the park from the smokestacks of coal-fired power plants or vehicle traffic in neighboring cities. Pollution from concentrated oil and gas development could further increase existing park air quality problems or create air quality problems where they have not existed in the past.

Air pollutants associated with natural gas development include a long list of hydrocarbons, some of which are known carcinogens. Some of these pollutants come from exploited underground deposits; others are emitted during the production process. People living near fracking wells have complained about “bad odors” or “funny smells,” prompting state offices to test air samples for pollutants. Several studies carried out by the Pennsylvania Department of Environmental Protection (DEP) have focused specifically on these complaints.

Although these short-term studies suggest that air pollutants, while present, do not reach levels expected to cause significant human health problems, a long-term research project in Garfield County, Colorado, concluded the opposite. Researchers there found that extended exposure to air pollutants from natural gas fracturing could, in fact, cause subchronic and chronic health problems such as neurological or respiratory ailments and cancer.

This Colorado-based study (McKenzie et al. 2012), the first of its kind to be published, collected samples every six days over an almost three-year period, and across distances up to 500 feet from an active well pad. The researchers detected two to three dozen kinds of airborne hydrocarbons during both the “well completion” phase (the phase that includes both high-pressure fracturing and flowback) and the “resource development” phase (when natural gas emerges from the well). Activities associated with fracturing technology typically resulted in higher pollutant discharges than those of traditional oil and gas development.

The authors of the study concluded that the air emissions observed in Garfield County will result in significant human health risks based on long-term exposures, particularly for those living within a half-mile of drilling sites. Further, repeated exposures among people visiting these places may also result in health problems. As a result of air quality concerns posed by fracking, individuals in communities near fracking wells are beginning to insist on real-time, publicly available air quality data from the gas and oil industry.

Recent reports from Wyoming and Utah suggest that the regional effects of extensive oil and gas development do add up. Because extraction efforts focus on the most viable shale plays, fracturing operations tend to be very intensive. Pollution emanating from large oil and gas fields has been connected to high regional ozone levels, particularly during winter, because winter inversions can trap pollutants close to the ground.

In northeastern Utah’s Uintah Basin, near Dinosaur National Monument, 10,000 oil and gas wells created ozone levels that were worse than those of New York City (Jaffe 2012). The final report of the 2012 Uintah Basin Winter Ozone and Air Quality Study found that oil and gas development contributes 98-99 percent of volatile organic compounds and 57-61 percent of nitrogen oxides, which combine to form ozone pollution (http://rd.usu.edu/files/uploads/ubos_2011-12_final_report.pdf). Studies for the winter of 2013 have found ozone levels as high as 130 parts per billion compared to EPA’s standard of 75 parts per billion (<http://www.deq.utah.gov/Issues/topics/ozone/>). While it is unclear what percent of Utah’s Uintah Basin wells utilize



Left: An elk silhouetted against the horizon in Theodore Roosevelt National Park (ND). ©Marc Muench **Above/Top:** Bald eagles, America’s national bird, are residents or visitors in many U.S. national parks. NPS **Bottom:** Views such as this one near Wind Canyon in Theodore Roosevelt National Park (ND) provided inspiration for Roosevelt’s later success in creating and protecting national parks. ©Marc Muench

hydraulic fracturing, the potential exists to add 25,000 more wells to the existing 10,000. In addition, in northwestern Colorado (south of Dinosaur National Monument), the BLM is considering a management plan to add up to 21,000 new oil and gas wells.

The general implication is clear: Intensive oil and gas development may produce regional air quality impacts, and fracturing technology (as it's currently practiced) may only make those issues worse. Federal and state agencies continue to monitor and study the connection between oil and gas field development and regional air quality issues. In addition, the U.S. Department of Agriculture, Department of the Interior, and Environmental Protection Agency have signed a Memorandum of Understanding (MOU) to create a collaborative and standardized approach to protect air quality and air quality-related values to facilitate responsible development of oil and gas resources on federal lands. This MOU will need to be broadly implemented early in the oil and gas planning process, and prior to leasing, if impacts to national park air resources are to be adequately analyzed and mitigated. As fracking wells are drilled ever closer to national parks such as Glacier in Montana, Dinosaur National Monument in Colorado, and around Theodore Roosevelt in North Dakota, park protection efforts will need to include adequate analysis of the impacts of oil and gas development on regional air quality, as well as implementation of strategies to reduce emissions.

As fracking wells are drilled ever closer to national parks, park protection efforts will need to include adequate analysis of the impacts of oil and gas development on regional air quality, as well as implementation of strategies to reduce emissions.





Working to Clear the Air in National Parks

Clean, clear air is an integral part of the national park experience. Visitors expect to see scenic vistas unmarred by ugly brown haze, to walk among majestic trees and wildlife undamaged by pollution, and to enjoy healthy outdoor activities like hiking, biking, and paddling without having to worry about hurting their lungs. While many national parks have a legacy of air pollution, conditions have steadily improved thanks to the Clean Air Act.

Unfortunately, oil and gas development adjacent to national parks threatens to reverse the trend toward cleaner air and return some parks to “code red” air quality conditions. Ozone—an odorless, colorless gas created when certain air pollutants from vehicles and industries, including oil and gas, react with sunlight in the lower atmosphere—is a particular concern. As highlighted in this report’s Grand Teton case study, ground-level ozone pollution in the park is on the rise, and its increase is linked to the rapid expansion of oil and gas drilling outside the park.

Ozone is a significant public health concern. It is linked to asthma attacks, respiratory ailments, and even premature death from long-term exposure. Ozone also damages and can even kill some plants. Despite the significant public health and environmental threat from

ozone, monitoring for ozone is extremely limited or entirely lacking near many oil and gas fields. Available emission control technology that could cut ozone levels is rarely used.

The Clean Air Act requires that the Environmental Protection Agency (EPA) set National Ambient Air Quality Standards (NAAQS) for ozone in order to protect public health and the environment. It also requires that EPA and states take steps to keep ozone within healthy limits. However, because oil and gas drilling has expanded so rapidly in so many areas, ozone monitoring has not kept pace. As a result, EPA and the states lack the data they need to put the necessary control measures in place.

At the same time, common sense and readily available ways to limit ozone

pollution from oil and gas drilling do exist, but these steps are not being implemented. For these reasons, NPCA has joined other concerned organizations in requesting that EPA take two steps that will help protect national parks from ozone pollution brought by oil and gas drilling:

1. EPA should require broad deployment of ozone air quality monitors in oil and natural gas development areas, in particular near national parks. Monitoring data will provide EPA, states, and national park managers with the information they need to implement targeted and effective ozone control measures.
2. EPA should issue technology guidelines for oil and gas equipment. These clean air measures can be some of the single most cost-effective methods for reducing ozone-forming pollution. Requiring the best technology at oil and gas drilling sites can help protect both national parks and public health.

Left: A cyclist stops to admire Buttermilk Falls in Delaware Water Gap National Recreation Area (NJ). ©Steve Greer Photography **Above:** Fog blankets the Upper Delaware Scenic and Recreation River (PA). ©Sam Abell/National Geographic Stock





Conclusion

Hydraulic fracturing for natural gas and oil holds great promise for the nation's goal of becoming an energy-independent nation. Domestic gas and oil production can bring wealth to American businesses and American families, and it can provide an opening for improving relations with other regions of the globe. All of these would be positive developments.

Simultaneously, though, it is crucial that America's economy and progress be based on our heritage of democratic process and cautious stewardship of our resources. The energy boom generated by hydraulic fracturing should be viewed with this same understanding.

At a minimum, the amount of natural gas and oil within U.S. borders makes it clear that we do not need to sacrifice our nation's most treasured places, our national parks, to produce vast quantities of fossil fuels through hydraulic fracturing. We can be judicious about where and how we harvest this emerging resource.

By working together, we can simultaneously promote our national economy and protect our national heritage, benefiting both from a new bounty of energy and from the protection of our nation's historic treasures, scenic landscapes, and ecological wonders. By moving forward cautiously and wisely, we can guard America's priceless national parks while we build a solid foundation for its energy future.

Left: Water seeps such as this one on the Flatbrook River in Delaware Water Gap National Recreation Area (NJ) could be threatened by water pollution from fracking wells on lands upstream. ©Steve Greer Photography



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Left: The Delaware River draws a wide range of recreationalists, including this runner in Bucks County, PA. ©Vince M. Camiolo/Tandem-Stock.com **Above:** A kayaker navigates rapids on the Flatbrook River at Delaware Water Gap, NJ. ©Steve Greer Photography



Top: Anglers enjoy the beauty and serenity of the northernmost reaches of the Upper Delaware River. NPS **Bottom:** Grizzly bears in Grand Teton National Park could be negatively affected by fracking operations. ©Ken Caning/ISTOCKPHOTO **Right:** Rugged beauty characterizes the landscape of Theodore Roosevelt National Park. NPS

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Hydraulic fracturing (or “fracking”) has the potential to rewrite America’s energy future, presenting the possibility of an energy-independent nation. This relatively new extraction method is now responsible for 90 percent of domestic oil and gas production, with thousands of wells peppering the countryside. The number of wells is expected to skyrocket during the next two decades.



Above: Delaware Water Gap's most stunning waterscapes are threatened by fracking operations. ©Christian Heeb **Inside Back Cover:** Bison stand sentinel over the badlands of Theodore Roosevelt National Park (ND). ©Marc Muench



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