

FOCUS . . . Contaminants

Mercury Found in Songbirds in New England Salt Marshes

“I was surprised to find high mercury levels in wildlife on our refuge. We had always considered the salt marsh to be the most pristine of our habitats,” said Nancy Pau, wildlife biologist at Parker River National Wildlife Refuge in Massachusetts. Parker River Refuge is one of four national wildlife refuges on which the nonprofit BioDiversity Research Institute (BRI) (<http://www.briloon.org/>) tested saltmarsh sharp-tailed sparrows for mercury contamination.

BRI biologist Oksana Lane was also “surprised to find such elevated mercury in most of the birds we sampled in several national wildlife refuges set aside to protect birds.” The other refuges are Rachel Carson in Maine, Stewart B. McKinney in Connecticut and Rhode Island National Wildlife Refuge Complex. Testing is now underway at Long Island National Wildlife Refuge Complex in New York as well. The three-year sparrow survey was based on data from 220 individual birds.

Nearly all the mercury measured in the saltmarsh sharp-tailed sparrows blood was methyl mercury, which is a more toxic form. It had been thought that mercury contamination was primarily a problem in fish or fish-eating birds. Now BRI concludes that “airborne mercury is

pervasive and its impacts are no longer limited to surface waters and the wildlife that use them.”

Mercury contamination typically comes from industrial runoff or as a byproduct of burning fossil fuels. Mercury concentrates in salt marsh environments, accumulating in food chains. The salt-marsh sharp-tailed sparrows consume invertebrates, possibly species with high mercury levels. The biological reasons for the bioaccumulation in sparrows are not yet known, but it is likely that elevated levels may cause behavioral changes in birds and possibly lead to reduced productivity. More studies – and more funding – are required to establish if and how mercury affects the birds’ health and survival.

Much to Learn from Wetland Songbirds

The refuge biologists are most eager to learn more from the sparrows. All four of the New England refuges worked closely with BRI to select study sites, monitor nesting productivity, help capture sparrows for blood sampling and, as biologist Kate O’Brien at Rachel Carson Refuge put it, “have lively discussions on how to frame research questions and gather data on a shoestring budget.”

So far, the testing has raised more questions than answers. “It’s difficult



Researchers are investigating the risk of mercury contamination to waterbirds like the American avocet on the San Francisco Bay National Wildlife Refuge Complex. (USFWS)

Mercury Contamination in Waterbirds in San Francisco Bay

A large collaborative research project is investigating the risks of mercury to waterbirds breeding on the San Francisco Bay National Wildlife Refuge Complex. The goal is to determine the actual levels of mercury contamination

in the waterbirds and its effects on reproduction, typically the most sensitive manifestation of mercury toxicity.

The study covers five species – two terns (Forster’s and Caspian), two shorebirds (American avocet and black-necked



The BioDiversity Research Institute has found elevated methylmercury levels in salt marsh sharp-tailed sparrows tested on four national wildlife refuges in New England. (USFWS)

to draw statistically valid conclusions on results thus far,” says Pau, “but consistently high mercury levels at Parker River Refuge have prompted me to engage other agencies to investigate potential sources of mercury in the watershed.” Pau says Parker River Refuge is now working with BRI to trace the mercury through the food chain, ultimately to pinpoint potential sources. EPA is also running mercury samples on invertebrates from salt marsh sites in Rhode Island and Massachusetts.

“The early research results reinforced the importance of protecting water quality,” added Pau. “Parker River Refuge is

almost entirely wetlands and activities in adjacent uplands can have a tremendous impact on habitat quality on refuge lands. To ensure ecological integrity, we must work beyond our boundaries and with a diverse array of partners.”

Similarly, at Rachel Carson Refuge, O’Brien says “we need to ensure that water coming onto the refuge, from streams, rivers and stormwater runoff is clean enough to support our wildlife objectives.” Rachel Carson Refuge manages land in 12 towns.

In 2007, Suzanne Paton, biologist with the Rhode Island National Wildlife

Refuge Complex, started monitoring productivity and survival rates of sparrows that nest in refuge marshes. The saltmarsh sharp-tailed sparrows are one of the highest priority species for coastal refuges in New England, but Paton says there is little information on whether elevated mercury levels are having an impact on these birds.

“Our emphasis has been to conduct a more in-depth look at the life cycle of these birds,” explains Paton, “including the number of nest attempts and reasons for failure, number of chicks produced, estimates of survival and total population and habitat variables.”

“We established that birds are at risk,” said BRI’s Lane. “Now we need to determine how to protect them by reducing or eliminating contaminant exposure.” O’Brien called the research fascinating and a “reminder to all of us that Rachel Carson’s message about the consequences of environmental pollution are as relevant today as it was in the 1950s.”

“Methylmercury is a powerful neurotoxin, and it is bioaccumulating in our environment at some astonishing levels,” O’Brien continued. “Humans can modify our diets to avoid overconsumption of foods that carry large mercury burdens. Wildlife cannot.” ♦

stilt) and one diving duck (surf scoter). Birds are being tagged to mark their movements and habitat use. Blood samples and feathers are being collected.

Researchers are monitoring nest success and examining chick movements and survival. Toxic levels of mercury contamination usually show up in reduced breeding effort and egg production, impaired vision hearing or motor skills and reduced chick survival.

Research began in 2005, but the U.S. Geological Survey has already reported that mercury concentrations are high enough to be a cause for concern. Higher mercury levels in the northern and southern ends of the bay may be the result of sediment transported through the watershed from quicksilver and gold mining activities.

This West Coast mercury research is funded by the CalFed Ecosystem

Restoration program and involves biologists from USGS, the U.S. Fish and Wildlife Service, San Francisco Bay Bird Observatory and Point Reyes Bird Observatory. ♦

For more information see:

<http://soundwaves.usgs.gov/2007/10/research.html>

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Bombs Away: From Military Training Ground to National Wildlife Refuge



Frequent fires sparked by exploding ordnance helped maintain the mountain longleaf pine forests at Mountain Longleaf National Wildlife Refuge in Alabama. (Bill Garland)

by Aaron Ferster

It's the rugged ridge rising out of the Appalachian's Choccolocco Mountain on the outskirts of Anniston, Ala., that first caught the attention of the military. The topography offered an ideal background for shooting off

artillery, a place for soldiers to sharpen their skills while preparing for battle during the Spanish-American War. The War Department formally established Camp (later named a fort) McClellan on July 18, 1917.

Over the years, frequent fires sparked by exploding ordnance and other military activities at Fort McClellan helped sustain a rare natural habitat: mountain longleaf pine forests. Without fire to regularly clear out the understory of brush and kill off competing saplings, mountain longleaf pines are gradually overshadowed and displaced by hardwoods. Fires around Fort McClellan helped sustain extensive areas of longleaf, including stands of old growth more than 250 years old.

The old pines have outlasted the fort itself. The Department of Defense closed McClellan in 1999, part of a larger effort to consolidate military operations. A major part of the reuse and redevelopment plans for the site was sustaining its signature mountain longleaf pine forests. Studies by The Nature

Wetland Restoration to Improve Habitat and Reduce Pollution Impact

Settlement funds from an oil spill near Philadelphia, upstream from the Delaware River, were used to restore wetlands at one refuge in Pennsylvania, while wetland restoration on a North Carolina refuge is intended to sequester other pollutants.

Freshwater tidal wetlands at **John Heinz National Wildlife Refuge at Tinicum**, near Philadelphia, provide critical habitat for more than 300 species of birds along the Atlantic flyway. These wetlands

historically measured more than 5,700 acres, but diking, dredging and filling have reduced this to only 200 acres.

In February 2000, a subsurface oil pipeline ruptured, releasing 191,982 gallons of crude oil into a freshwater wetland impoundment within the refuge. Through the Natural Resources Damage Assessment and Restoration (NRDAR) process, a settlement for \$865,000 was reached with the responsible party. These funds, combined with a

Conservancy and Auburn University identified the habitat's importance to regional biological diversity.

The military and the McClellan Joint Powers Authority, an unincorporated, non-profit association created to help guide redevelop of former Fort property, transferred a combined 9,016 acres of land to the U.S. Fish and Wildlife Service to establish Mountain Longleaf National Wildlife Refuge. Dedication ceremonies were held June 30, 2003, and 3,000 acres of the refuge were opened to the public on December 20, 2004.

The transition from military training ground to national wildlife refuge has not been without challenges. The artillery fire that inadvertently helped sustain longleaf pine forest also created a safety hazard. While some shells fired into the surrounding hills exploded and sparked forest fires, others landed with a thud, leaving fuses and other volatile parts intact where years later they could catch the attention of an unsuspecting hunter or curious hiker. To make sure that never happens, large areas of the refuge will remain closed until unexploded ordnance is found and safely disposed of.

There has been progress. In August 2004, the Army Corps of Engineers announced government contractors had recovered and destroyed old target practice ordnance rounds along roads and firebreaks within the refuge. "To ensure complete safety, all of the items were destroyed. Whatever scrap remains is then inspected, characterized and disposed of in an appropriate manner in accordance with state and federal rules," explained Dan Coberly, a public affairs officer with the Corp's Huntsville Center. Another 2,400 acres of former practice artillery firing ranges, along with a 2,600-acre safety buffer, remain closed to the public. No specific timetable has been established for completing cleanup and opening those areas.

Another challenge confronting Mountain Longleaf Refuge is environmental contamination. "Fort McClellan had a long, rich history that included a lot of small arms fire," explains refuge manager Steve Miller. Lead, copper and other bullet constituents have led to areas of soil and water contamination. As a result, the Department of Defense, the state of Alabama, the Environmental Protection Agency and the Service

are negotiating to come up with an environmental cleanup plan that protects and restores refuge habitats and will provide for the safety of visitors within currently closed areas.

While only about one-third of the refuge is open to the public, Mountain Longleaf does have a lot to offer. In addition to perhaps the nation's most extensive fire-maintained mountain longleaf pine ecosystem, the refuge is home to Appalachian cottontail rabbits, wood frogs, scarlet tanagers, ovenbirds and the endangered gray bat. It also provides breeding habitat for many migratory birds and resident wildlife species.

"It might be another 20 years before the refuge is completely cleaned up and all areas are open to the public, but we still offer our visitors plenty of great wildlife-dependent recreational opportunities. We have hunting, wildlife photography and wildlife observation," says Miller. ♦

Aaron Ferster is a writer-editor in the Refuge System Branch of Communications.



Settlement funds from an oil spill are being used to restore 12 acres of wetlands at John Heinz National Wildlife Refuge at Tinicum in Pennsylvania. These wetlands provide critical habitat for migrating birds in the Atlantic flyway. (USFWS)

\$537,000 NRDAR settlement received from a nearby Superfund site, yielded approximately \$1.5 million for wetland restoration on the refuge.

Environmental Contaminants staff from the Pennsylvania Ecological Services Field Office worked with refuge staff to develop a restoration plan for 12 acres of freshwater tidal wetland. This area had been filled in the 1960s with dredge material from a federal navigation channel in the Delaware River.

Restoration work began in July 2007 and is slated to be completed this year. It is expected to restore the depth and

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Landfill Siting: Securing Protective Buffers for North Carolina's Refuges

by Sara Ward

A new law in North Carolina requires protective buffers when landfills are planned near national wildlife refuges and other environmentally sensitive areas. The state's Solid Waste Management Act of 2007 prohibits construction of landfills within five miles of national wildlife refuge boundaries, embracing the Service's recommendation for protection. The law also halted permit applications for two new solid waste landfills near refuges.

With rapid population growth in the eastern United States, the demand for landfill space is at a premium. In recent years, several new or expanded landfills have been proposed, many located close to North Carolina's national wildlife refuges. Of the 11 refuges in North Carolina, six are less than five miles from

active or closed landfills that pre-date the new law. Sediment contamination and water quality degradation have been documented at these refuges, prompting more robust pollutant monitoring and assessment of potential stormwater impacts to refuge resources.

Service environmental contaminants biologists became involved in 2005 when two new landfills were proposed near four refuges in the state, both with the potential to impact refuge resources and public enjoyment of refuge lands: a mega-landfill to be sited within one mile of Great Dismal Swamp National Wildlife Refuge and a recycling landfill less than five miles from Pocosin Lakes, Swanquarter, and Mattamuskeet National Wildlife Refuges.

The landfill proposed near Great Dismal Swamp Refuge would receive three million tons of waste each year from

Deep Fork National Wildlife Refuge Restoration after Sewage Release

by Karen Cathey

In the case of a spill, damage from contaminants can be instant. In the case of pollutants released over time into groundwater or rivers, the damage is long term. In any case, the settlement of damage claims is never instant.

In 2006, the Department of the Interior collected funds for restoration projects resulting from a sewage spill in Oklahoma six years earlier. Sewage released from a privately-owned facility killed fish, mussels and other aquatic species along almost 11 miles of the Deep Fork River. The sewage and sludge had been released into a tributary of the

Deep Fork River. The plume of sewage migrated slowly downstream into Deep Fork Refuge. The restoration funds came from settlement of a Natural Resource Damage Assessment and Restoration (NRDAR) claim.

The U.S. Fish and Wildlife Service Environmental Contaminants Program worked with the refuge staff to document injuries to trust resources. Both instream resources and their habitat were injured.

Deep River Refuge was established in 1993 to protect important bottomland hardwood forest and emergent wetland habitat along the Deep Fork River for the benefit of migratory birds, native fish and

“Of the 11 refuges in North Carolina, six are less than five miles from active or closed landfills.”



Service biologists collect contaminants data on mussels injured by a 2000 sewage release on the Deep Fork National Wildlife Refuge in Oklahoma. (USFWS)

as far away Michigan and Florida. At the end of its 27-year life, the 490-acre landfill would contain more than 100 million cubic yards of trash in a 280-foot high mound, making the site visible for up to 20 miles. Although much smaller in size, the landfill planned near the other three refuges was intended to store wastes in unlined landfill cells, creating concerns about groundwater and surface water quality.

Interagency Cooperation Leads to Protective Buffer Recommendation

Prompted by public concerns, the North Carolina General Assembly enacted a landfill moratorium in 2006 in order to study siting, design and operation of landfills in environmentally sensitive areas. With this open window for technical review and input, Service Environmental Contaminants biologists, together with refuge staff, worked with regulators from the North Carolina Division of Waste Management and a stakeholder group of the North Carolina legislature to recommend a

five-mile protective buffer around refuges in North Carolina. The recommended buffer was based on a review of technical literature on waste facility disposal siting and consideration of protective measures employed in other states, modified to meet the unique characteristics of eastern North Carolina. The buffer is essentially a five-mile zone around refuge boundaries where landfills are prohibited.

Protective buffers are important because landfill impacts to refuges can occur over large distances. Buffers can preserve the views and reduce noise and odor nuisances. Buffers also prevent alteration of wildlife foraging patterns as well as degradation of water and habitat quality.

The protective buffer is a key provision of the new North Carolina statute. The law also included provisions to compensate permit applicants for the two new landfill proposals, creating a mechanism to both protect the environmental quality of refuge lands as



Pollutant sources, like this burning landfill adjacent to Alligator River National Wildlife Refuge in North Carolina, can harm refuge plant, fish, and wildlife resources. (USFWS)

well as equitably increase the stringency of landfill siting requirements. The buffer protection provision in the new law secures tangible resource protection now and into the future. ♦

Sara Ward is in the Raleigh Ecological Services Field Office.

other wildlife species. Fifty-nine species of fish and several native mussel species are known to exist on the refuge.

Freshwater mussel species comprise a significant portion of the total biomass in freshwater benthic communities and are important in nutrient cycling. Freshwater mussels are also the most rapidly declining faunal group in the United States: 72 percent of the 297 species and subspecies are listed as endangered, threatened or of special concern. Over-harvesting, widespread habitat destruction, chronic pollution, land use changes and introduction of exotic species have caused many mussel populations to decline or disappear.

Restoring Contaminated Habitat to Give Wildlife a Future

To determine which restoration project would offer the greatest benefit to the

multiple natural resources injured by the sewage spill on the refuge, the Service evaluated projects that would benefit the river itself, including enhancement of bottomland hardwood forest within refuge boundaries. The health of the Deep Fork River is directly tied to the health of the adjacent bottomland hardwood forest ecosystem. Several tracts of bottomland forest located along the river corridor on the refuge need to be restored if they are to continue acting as a filter for contaminants, pesticides and livestock wastes.

The refuge focused on 440 acres of privately-owned land within the refuge's proposed acquisition boundary that had been cleared of their original bottomland hardwood habitat. The refuge partnered with The Conservation Fund, American Electric Power (as part of a carbon

sequestration partnership) and the Friends of Deep Fork Refuge to help secure these valuable tracts. Settlement funds were used to purchase some of this land; the purchase of one tract is still pending. This partnership involved a complex matrix of funding sources that enabled the Service to purchase land and implement reforestation of the parcels to meet common goals of all the partners.

Almost half of this cleared acreage will be replanted with hardwood seedlings this winter/spring. Enhancement of these tracts will improve water quality in the river, including that section affected by the spill, thus supporting mussel recolonization. In addition, the acquisition and protection of property will create a contiguous tract of habitat for wildlife to migrate, forage and breed.

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Oil Spill Response Carefully Coordinated



An oily surf scoter was one of 2,000 birds killed or oiled after a cargo ship hit the San Francisco Bay Bridge in heavy fog in November 2007. (Bill Beckon/USFWS)

More than 2,000 birds were killed or oiled in early November 2007 when the cargo ship Cosco Busan hit the San Francisco Bay Bridge in heavy fog. The impact ruptured the hull and spilled approximately 58,000 gallons of medium grade fuel oil. Most of the oil spread to central San Francisco Bay and the outer coastal areas on either side of the Golden Gate Bridge.

Oiled birds were found at several refuges in the San Francisco Bay National Wildlife Refuge Complex, including the Farallon Islands. Little shoreline was affected.

At least three marbled murrelets and two brown pelicans were found dead and several western snowy plovers were found oiled. All are threatened or endangered species. Because snowy plovers roost on the beach, they are not as much at risk as sea birds and may be able to recover if they are not too heavily oiled, explains Jim Haas, environmental

contaminants branch chief in the California-Nevada Region.

Haas coordinated about 30 U.S. Fish and Wildlife Service personnel who responded to the spill from area refuges and ecological services offices. Refuge staff also participated in Natural Resource Damage Assessment and restoration activities authorized by the Oil Pollution Act of 1990, passed after the Exxon Valdez oil spill. It authorizes the Service to respond to spills to protect trust resources and seek restoration of injured resources.

The lead oil spill response agency in California is the state Department of Fish and Game. California also sponsors an Oiled Wildlife Care Network at the University of California Davis, which has three treatment facilities along the coast as well as a network of volunteers.

Haas, until recently one of seven field spill response coordinators in Region 8, learns of spills from the state Office of Emergency Services, the Department

Oil Pits: More than Meets the Eye

More than 4,400 oil and gas wells are scattered across more than 100 national wildlife refuges. According to a Government Accountability Office report in 2003, 1,806 active wells on 36 refuges provided almost a billion dollars worth of oil and gas that year – about one percent of domestic oil production.

The GAO reported that drilling operations on refuges disrupt wildlife habitat, cause large-scale spills of oil and brine and contaminate soil and groundwater. As a result, the U.S. Fish and Wildlife Service has drafted a

handbook for refuges – currently under review – titled, *Management of Oil and Gas Activities on National Wildlife Refuge System Lands*.

The handbook provides an overview of the types of issues refuge managers should consider when dealing with oil and gas development, from noise and explosives to spills and garbage, abandoned equipment, cut, crushed or destroyed vegetation, hydrologic changes, environmental contaminants, invasive species, sensitive habitat disturbance and alteration of plant communities.

of the Interior Office of Environmental Policy and Compliance or directly from the U.S. Coast Guard. "In 95 percent of the cases," says Haas, "we just file the report because the spill has not affected Service resources. We do the triage to decide what our response will be."

The response depends on the size of the spill, the species involved, the type of product spilled, the time of year and the location. In this case, timing was critical. San Francisco Bay is a major wintering area for migratory waterfowl and there was a potential for oil spreading to marshes where endangered clapper rails forage. As it turned out, some marshes were indeed oiled but none on refuges.

Key to Effective Spill Response is Training

Effective response to oil spills requires an investment in training. Last July, a large multi-agency spill exercise was conducted on the Mississippi River. Participants included refuge managers from the Mark Twain National Wildlife Refuge Complex, biologists from the Service's Environmental Contaminants Program, the U.S. Coast Guard,

Environmental Protection Agency, Department of Homeland Security and local governments. During the intense, three-day exercise, Service personnel responded to oil and chemical product spills that had been caused by simulated earthquakes and tornadoes.

The lessons from this exercise will be used to update the Midwest Region's Spill Contingency Plan. Mike Coffey, an environmental contaminants biologist at the Rock Island, Illinois, Ecological Services Field Office, said the key lessons learned related to good response strategy planning, identifying who takes charge when response personnel are stretched thin and coordinating interstate and inter-regional resources along rivers that border multiple states and jurisdictions.

Haas says one lesson from the San Francisco spill is the need for more refuge staff to be trained in safely recovering oiled and dead birds in addition to finding them. Carcass recovery must meet three objectives, explains Catherine Berg, wildlife biologist in the Anchorage Fish and

Wildlife Field Office. It must prevent secondary contamination of resources (such as eagles or foxes feeding on oiled birds); it must satisfy law enforcement rules of evidence; and it must satisfy data protocols for natural resource damage assessments. Berg helped to outline many of these rules and responsibilities in the 2003 Service manual chapter, *Best Practices for Migratory Bird Care During Oil Spill Response*.

Chief of the Environmental Response and Restoration Branch Mark Huston notes that many Service personnel respond to spills, whether they are in the Contaminants Program, Refuges or Law Enforcement. He adds that continued training, both within the Service and on larger spill exercises, is necessary to ensure a smooth response and to protect and restore trust species. ♦

For more information see:

http://www.fws.gov/contaminants/OtherDocuments/best_practices.pdf and

http://alaska.fws.gov/fisheries/contaminants/pdf/spillresp_april.pdf

Oil waste or reserve pits are one of the many challenges confronting refuges. Oil or gas companies sometimes use reserve pits to store drilling fluids and drilling mud. A drilling company typically adds diesel, oils, detergents and other chemicals to drilling mud to improve performance. The fluids in these reserve pits are a major hazard to wildlife and birds.

Pedro Ramirez, an environmental contaminants specialist in the Mountain Prairie Region, says migratory birds often mistake an oil-covered pit for clear water. Reserve pits and production skim pits remain a significant source of mortality for birds in the United States.



Oil mixed with water in reserve pits like this one in North Dakota is toxic to birds and other wildlife. This reserve pit is lined but there is no netting to prevent wildlife access. (Pedro Ramirez/USFWS)

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Oil Pits: More than Meets the Eye — continued from pg 15

Production skim pits are used to separate oil from formation water produced along with the oil. A 2006 report from the Service's National Fish and Wildlife Forensic Laboratory says that 500,000 to one million birds are killed annually throughout the United States due to oil pits.

Progress is Being Made

Some progress is being made. The number of migratory birds killed in oil pits is about half what it was a decade ago. Help comes from both refuges and oil companies themselves.

Sabine National Wildlife Refuge in Louisiana began prohibiting new oil pits in 1983. Since then, Chevron-Texas has been closing and decontaminating all of the oil pits on the refuge. Chevron was expected to close the last of 25 pits in 2007, at a cost of \$1.5 million, according to *Bird Conservation* magazine (Fall 2007).

At Aransas National Wildlife Complex in Texas, project leader Charles Holbrook says the refuge now requires a "closed loop system" for drilling operations before a Special Use Permit is issued to an oil or gas company. Southwest Louisiana National Wildlife Refuge Complex also requires drilling operators to use a closed loop system. This is the safest method for avoiding environmental contamination because contaminated mud circulates within a closed shaft. The drilling mud is stored in tanks and hauled offsite for reuse at another drilling rig or for disposal when the drilling is completed.

Since 1985, national oil and gas coordinator Janine Van Norman says the



Environmental contaminants specialist Pedro Ramirez says this plastic flagging is not adequate to deter birds from landing on water contaminated by oil and drilling refuse. (Pedro Ramirez/USFWS)

Service has typically required a Special Use Permit for oil and gas operations when the Refuge System acquires land with privately owned subsurface mineral rights. That permitting process can then impose environmentally sound requirements on drilling practices. A Special Use Permit is automatically required when the federal government owns subsurface mineral rights.

For a number of years, Ramirez says oil operators have used strands of multi-colored plastic flagging suspended over oil pits to deter birds and fences to exclude larger mammals. Pointing out just how ineffective such flagging is, Ramirez now advises oil companies to net or cover a pit to effectively keep out birds and other wildlife.

The Service's upcoming handbook says refuges should "advise the oil company that, although economically cheaper, open reserve pits will probably result in a 'take' of migratory birds and, potentially, other protected species. This situation could lead to an enforcement action that may result in significant fines and penalties to the operator."

Refuges could well be faced with increased oil and gas exploration, drilling and production. Understanding the motivation, mechanics, process, effects and legal authorities governing oil and gas activity on refuge lands is critical for protecting trust resources, concludes the handbook. Successful communication with oil and gas operators and their contractors is vital so that the operators may exercise their mineral rights while the safety of refuge personnel, the public, wildlife and the refuge is vigilantly maintained. ♦