News & Notes

Citizen Scientists in the Molecular-All-Taxa-Biodiversity Inventory of Yellowstone Lake

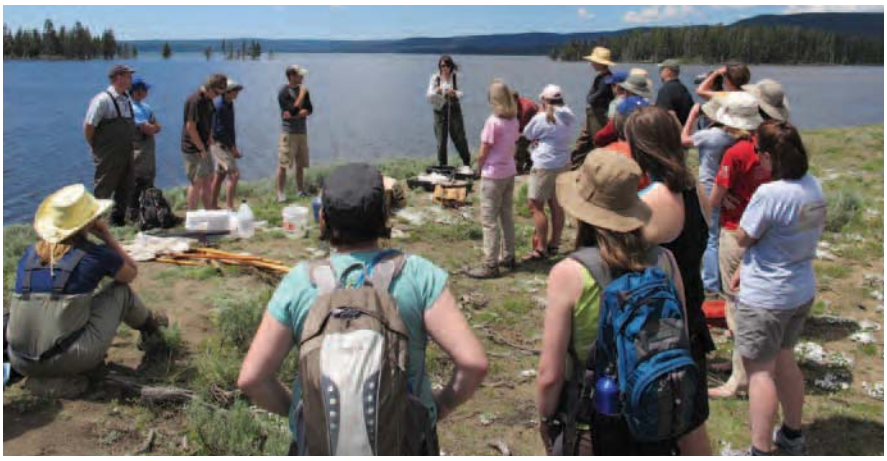
Since the pilot study conducted in 2004, the Molecular-All-Taxa-Biodiversity Inventory (MATBI) project on Yellowstone Lake has shown that the biodiversity of the lake is much richer and broader than early studies concluded. New species to Yellowstone National Park, and possibly to science, have been detected in all three domains of life (Bacteria, Archaea, and Eukarya), challenging the notion that high-altitude lakes are simple ecosystems.

A major emphasis of the MATBI survey has been to provide in-depth characterization of eukaryotic lake species, focusing on the plankton of Yellowstone Lake. Consequently, lake habitats such as lagoons and deltas were not explored by the formal study. In an expansion of the project's partnership with Montana State University (MSU), citizen scientists were invited to supplement that research.

In July 2011, for the second consecutive summer, teachers from across the nation participated in a week-long field course, Yellowstone Lake Geology and Ecology, offered through the Master's in Science of Science Education program at MSU. Teachers took part in several field geology and lake ecology sessions and collected lake organisms in a mini-bioblitz. Data and samples collected by the teachers helped supplement the data for the MATBI project. Teachers taxonomically identified organisms using microscopes in a field lab and then returned to MSU to start the molecular genetics analyses.

Many specimens collected during the field campaigns are fairly common to the lake and park, but their genetic information will be new to science. To date, the science teachers who looked in the lagoons and deltas have discovered at least one Cladoceran (*Eurycercus lamellatus)*, two Copepoda (*Macrocyclops* and *Diaptomus nudus*), and the first Ostracod crustacean (*Cypridae*) from Yellowstone Lake. In other categories, they found the first Collembola (springtails) in the lake and numerous insects that have yet to be analyzed and added to the MATBI.

The Yellowstone Lake Geology and Ecology course was developed by John Varley, Tim McDermott, Stephanie McGinnis, and Susan Kelly with the Institute of the Environment at MSU. The larger MATBI study has been funded through MSU, the Yellowstone Park Foundation, the Gordon & Betty Moore Foundation, and the National Park Service. The project's technical partners include Eastern Oceanics LLC, the J. Craig Venter Institute, and the US Geological Survey.



SUSAN KELLY

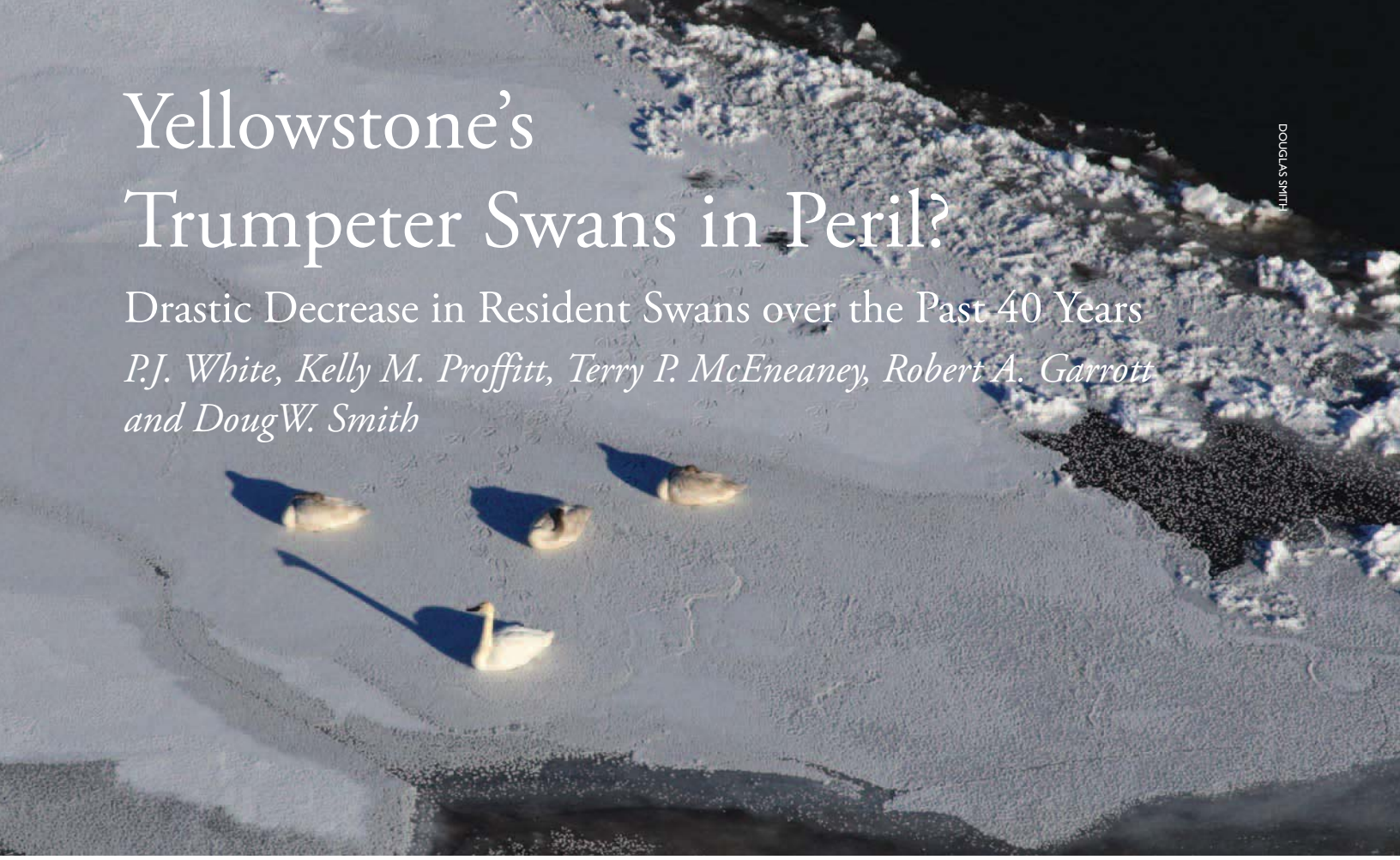
SUSAN KELLY

In July 2011, teachers collected organisms from Yellowstone Lake and analyzed data for the MATBI project.

Yellowstone's Trumpeter Swans in Peril?

Drastic Decrease in Resident Swans over the Past 40 Years

P.J. White, Kelly M. Proffitt, Terry P. McEneaney, Robert A. Garrott and DougW. Smith



DOUGLAS SMITH

During winter, Yellowstone National Park supports migrant trumpeter swans from throughout the greater Yellowstone area and Canada in addition to year-round resident swans.

Trumpeter swans *(Cygnus buccinator)* were nearly extirpated in the lower 48 states and throughout much of North America by 1900. In addition to providing food for early Euro-American explorers and pioneers, swan populations were reduced through commercial harvesting and habitat destruction (Banko 1960). However, national harvest regulations and habitat protection and acquisition helped facilitate recovery of the species, including the proliferation of small groups of swans that survived by remaining year-round in the vast wilderness of the greater Yellowstone area. Red Rock Lakes National Wildlife Refuge and Yellowstone National Park (YNP) played key roles in the conservation of the trumpeter swan (Banko 1960; McEneaney 1995). Today there are approximately 30,000 trumpeter swans in North America (US Fish and Wildlife Service 2006).

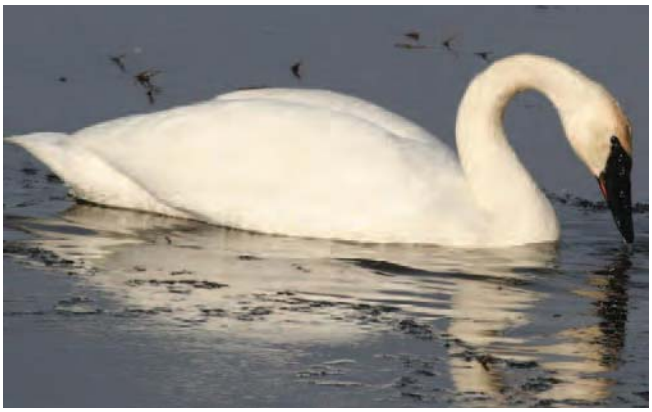
Trumpeter swans in YNP are part of the Rocky Mountain population, which includes genetically similar subpopulations that breed in the greater Yellowstone area of Idaho, Montana, and Wyoming, or in western Canada from the southeastern Yukon territories to eastern Alberta (Oyler-McCance et al. 2007). Many swans from both breeding areas use common wintering sites in the greater Yellowstone area. YNP supports year-round resident swans (essentially non-migratory) and, during winter, migrants from throughout the greater Yellowstone area and Canada (McEneaney and Sjostrom 1983). However, habitat used by trumpeter swans in YNP during spring and summer is considered marginal because nesting lakes are limited and generally small, feeding and nesting habitat is often discontinuous, feeding centers are restricted primarily to limited shallow water areas of lakes, and numerous predators are present (Banko 1960; Gale et al. 1987). Winter aggregations of trumpeter swans in YNP mainly congregate on ice-free waters on the north shore of Yellowstone Lake, along the Yellowstone, Madison, and Firehole rivers, and in smaller areas where tepid warm springs create ice-free feeding areas. However, these limited sections of ice-free water diminish as winter progresses (McEneaney 2006).

The abundance of resident trumpeter swans that nest in YNP has decreased steadily over the past 40 years, from 60 to 87 swans in the 1950s to fewer than 10 swans each year since 2007 (McEneaney 2006; Proffitt et al. 2009; Baril et al. 2010). Thus, there are concerns that trumpeter swan presence in the park may soon be limited to ephemeral residents and wintering aggregations of migrants from outside the park. In 2007, we initiated a collaborative effort between the National Park Service and Montana State University to investigate possible explanations for the decreasing trend in

the park's resident trumpeter swans from 1967 to 2007. We also monitored the clutch sizes and fledging success of trumpeter swans nesting in YNP from 1987 to 2007 to assess the effects of environmental conditions, swan density, and habitat characteristics.

Swan dispersal from elsewhere in the greater Yellowstone area may be an important factor in maintaining resident swans in YNP by filling vacant territories or providing mates for single adult birds (McEneaney 2006). Banko (1960) suggested that trumpeter swans from the Red Rock Lakes National Wildlife Refuge in the Centennial Valley of Montana, about 120 kilometers west of the park, moved into the park when numbers were high. Likewise, Gale et al. (1987) speculated and McEneaney (1995) presented evidence that the presence of nesting residents in the park in recent decades depended on immigration, most likely birds dispersing from the Centennial Valley. Thus, we evaluated if the decrease in the park's resident swans could be partly attributed to changes in swan management and the termination of the supplemental winter feeding that occurred at the Red Rock Lakes National Wildlife Refuge from 1936 to 1992 (McEneaney and Madsen 1983; McEneaney 1986a). Also, during the late 1980s and early 1990s trumpeter swans at the refuge were physically relocated to other regions during both winter and summer to encourage migration, and when birds returned or refused to leave the refuge, wintering ponds were drained. In addition, swans at the refuge and elsewhere in the greater Yellowstone area were hazed to reduce winter concentrations of migrants that could deplete forage for resident flocks and to encourage the establishment of new swan populations further south (US Fish and Wildlife Service 2003).

We also evaluated whether competition with migratory swans or changes in environmental conditions (e.g., drought, predation) in YNP had contributed to the decrease in resident swans. The increasing number of Canadian winter migrants to the park over the last several decades suggested they may have reduced food resources for resident trumpeter swans during breeding (US Fish and Wildlife Service 1998), though the evidence was inconclusive. Resident swans in YNP are also susceptible to random, naturally occurring events operating at local and regional scales such as severe winter weather, droughts, and predation. Drought conditions since 1995 have been the most severe recorded in northwestern Wyoming since monitoring began in 1895, resulting in an extensive reduction in the abundance and size of wetlands for nesting, molting, and feeding. Also, the abundance of predators such as grizzly bears (*Ursus arctos*), coyotes (*Canis latrans*), ravens (*Corvus corax*), eagles (*Haliaeetus leucocephalus, Aquila chrysaetos*), and wolves (*Canis lupus*) has increased substantially over the past 40 years (Stahler et al. 2002; Smith 2005; McEneaney 2006; Schwartz et al. 2006), potentially leading to lower reproductive success and increased trumpeter swan mortality (McEneaney 2006).


CALEB SLEMMONS/UNIVERSITY OF MAINE

Trumpeter swans congregate on ice-free waters and in smaller areas where tepid warm springs create ice-free feeding areas.

Causes of decreased abundance

The abundance of resident trumpeter swans in YNP began to decrease as the numbers of swans in the Centennial Valley decreased by 50% during 1978–1986 (McEneaney and Madsen 1983; Gale et al. 1987). However, analyses indicated that the decrease in the park's resident swans was more rapid following the cessation of the feeding program and draining of winter ponds at Red Rock Lakes National Wildlife Refuge in 1992–1993 (Proffitt et al. 2009). These findings suggest that the dynamics of resident trumpeter swans in YNP may be influenced by larger subpopulations and agency management actions in the greater Yellowstone area and elsewhere. There are sparse records of trumpeter swans banded in the Centennial Valley nesting in the park (McEneaney and Sjostrom 1983, 1986; McEneaney 1986), but only a few immigrants would be needed to affect the abundance of resident swans given their low numbers. Analyses also indicated that the abundance of migrant trumpeter swans that spent winters in the park increased from near zero in 1967 to more than 150 by 1993, but leveled off following the cessation of the feeding program and draining of the wintering ponds at the refuge, and termination of hazing operations at the refuge and Henry's Fork of the Snake River (Proffitt et al. 2009). Despite this stabilization in numbers of migrant swans during winter, the resident flock continued to decrease (McEneaney 2006), suggesting that the decrease was not primarily attributable to competition with the migrant swans.

Low productivity and fledging success may partially explain the decrease. Trumpeter swan productivity in YNP was consistently low from 1987 to 2007, with an average of only 2.7 cygnets per year surviving until their first autumn (Proffitt et al. 2010). Average clutch size in the park (4.2) was lower than in other parts of the greater Yellowstone area and Canadian breeding territories (Gale et al. 1987; Proffitt et al. 2010). Also, only about 0.5 cygnets per pair fledged in the

park during 1977–2007 (Shea 1979; Proffitt et al. 2010), which is low compared to other Rocky Mountain subpopulations (0.7–2.4 cygnets per pair; Gale et al. 1987). The reproductive success of resident trumpeter swans in the park is strongly influenced by annual variations in environmental conditions and naturally occurring events such as severe winter weather and droughts. Fifty-three percent of egg failures during 1987–2007 were due to nest flooding (Proffitt et al. 2010). Clutch sizes and fledging success were higher in years with lower April precipitation, and the abundance of resident trumpeter swans increased following drier springs that reduced flooding and increased the availability of pre-nesting food resources (Proffitt et al. 2009, 2010). Also, there is some evidence that a lower portion of adult swans attempted to nest during colder springs (May–June). Conversely, cooler summers created favorable conditions in wetlands used for foraging and nesting by preventing them from drying until later in the season and increasing aquatic plant production (Proffitt et al. 2009, 2010). Molting adult trumpeter swans and cygnets are flightless during a good portion of the summer and rely on ponds for protection from predators.


DOUGLAS SMITH

Swan dispersal from elsewhere in the Greater Yellowstone area may be an important factor in maintaining resident swans in YNP by providing mates for single adult birds.

In addition, long-term changes or reductions in wetland habitat due to a warmer, drier climate over the past 40 years (McEneaney 2006; Wilmers and Getz 2005) reduced the amount of suitable nesting habitat for trumpeter swans in the park and led to decreased reproductive success. Nesting habitats for trumpeter swans in the park are disjunct and differ substantially in physical characteristics (e.g., size, depth, elevation) and fledging success. Since 1931, trumpeter swans in YNP have nested in at least 94 wetlands in 18 different wetland complexes. However, less than 20% of the wetland sites used by swans for nesting contribute more than 60% of all fledged offspring. The two most frequently occupied nesting sites (Riddle Lake and East Tern Lake) during 1987–2007 produced 43% of all cygnets. We found that the number of years an individual wetland had previously been occupied was the best predictor of fledging success, suggesting that swans were able to assess nesting site quality and select sites that increased the chances of successful reproduction (Proffitt et al. 2010). Older, more experienced swans may have selected these high-quality nesting areas, further increasing reproductive success.

We also found that clutch sizes and fledging success were higher at nesting sites located within larger wetland complexes (Proffitt et al. 2010). Wetland complexes in the park ranged in size from 0.05 to 1.94 square kilometers during 1987–2007. Larger wetland complexes may have more abundant food resources, which could increase the ability of females to accrue food resources prior to egg laying and, in turn, increase clutch size. More abundant food resources would also reduce a female's search time for food resources during nesting and her time away from the nest (Henson and Cooper 1993). Increased incubation, nest tending, and years of site occupancy may increase hatching probability and confer a survival advantage to newly hatched cygnets by reducing predation (Gale et al. 1987).

The recovery of predator populations in YNP may have resulted in long-term decreases in egg or cygnet survival and contributed to the long-term population decrease (McEneaney 2006). Fifty-four percent of trumpeter swan nests hatched at least one cygnet during 1977–78, with only one of 26 nests failing due to predation by a grizzly bear (Shea 1979). However, nesting success during 1987–2007 was only 32%, with 41% of all egg failures attributed to predation: ravens (9%), coyotes (9%), grizzly bears (4%), and undetermined predators (19%) (Proffitt et al. 2010). Also, 18 detected incidents of pre-fledging cygnet mortality were due to predation by coyotes (6), bald eagle (1), and undetermined predators (11) (Proffitt et al. 2010). These results suggest that increases in predation have reduced nesting and fledging success, and it is plausible that increased predation coupled with weather events may be closely linked to the decreased abundance of resident trumpeter swans in the park (McEneaney 2006).

Conservation implications

The National Park Service is committed to the conservation of resident trumpeter swans and preserving habitat for winter migrants in YNP because trumpeter swans are part of the natural biota and a symbolic species with considerable historical significance. Thus, YNP managers have identified the trumpeter swan as a "Native Species of Special Concern" and

Trumpeter swans are part of the natural biota and a symbolic species with considerable historical significance. Thus, YNP managers have identified the trumpeter swan as a "Native Species of Special Concern."

taken actions to improve our knowledge and stabilize their status, including: (1) implementation of monitoring protocol that increased survey frequency, (2) identification of the most productive nesting areas, (3) management of human access at wetland areas frequently used by trumpeter swans in the past, (4) prohibition of the use of leaded split-shot sinkers, weighted jigs, and soft lead-weighted ribbon (Blus et al. 1989), and (5) participation in efforts to establish a flock of trumpeter swans in the nearby Paradise Valley of Montana (McEneaney 1995, 2006). In addition, the National Park Service is currently collaborating with Eastern Kentucky University to examine factors influencing territory occupancy and nesting success by producing a model of potential habitat for trumpeter swans in and around YNP using Landsat satellite imagery, geographic information systems, and field measurements of habitat quality.

The variability in trumpeter swan clutch sizes and fledging success across wetland complexes of different quality and size in the park underscores the importance of identifying high-quality nesting sites and responding with targeted management closures or protections. Human presence in or near high-quality nesting sites could influence occupancy or deter swans from using them. Thus, closures near high-quality nesting sites may be effective in encouraging swans to settle in high-quality habitats, improving fledging success. It is also important to maintain and protect large tracts of wetlands around important nesting sites because swans likely rely on surrounding wetlands for food resources and refuge from predators (Proffitt et al. 2009, 2010). In addition, the low productivity of YNP trumpeter swans highlights the importance of adult and sub-adult survival because wild swans are a long-lived species with a low reproductive rate and require years of productivity to replace themselves (Proffitt et al. 2009, 2010). Additional studies quantifying the relative contributions of adult survival rates and productivity on population abundance would be useful in prioritizing management actions aimed at protecting and conserving resident trumpeter swans in YNP.

The best available scientific evidence suggests that YNP provides marginal conditions for nesting and acts as a sink for swans dispersing from more productive areas within the greater Yellowstone area. This effect has been compounded over the last several decades by natural changes in habitat (e.g., decreased wetlands due to long-term drought or chronic warming) and community dynamics (e.g., recovery of predator populations). Thus, barring aggressive interventions (e.g., predator-proof fencing of wetlands, manipulations of hydrology) that would be inconsistent with National Park Service guidelines to minimize human interference, trumpeter swan presence in the park may be primarily limited to occasional residents and wintering aggregations of migrants from outside the park (Proffitt et al. 2009, 2010). We recommend that the National Park Service pursue a vision and agenda that centers on the challenges of a changing landscape, especially for the cooperative, integrated management of trumpeter swans with agencies controlling more productive areas within the Greater Yellowstone area.

YS

R.G. JOHNSON

Trumpeter swan pair with two immatures. Molting adults and cygnets are flightless during much of the summer and rely on ponds for protection from predators.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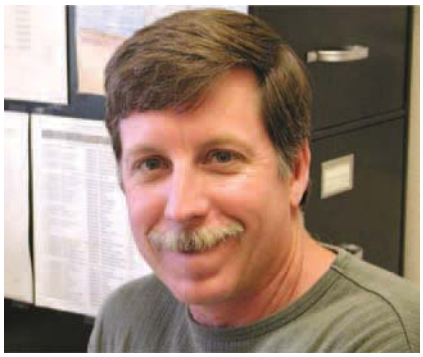
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Literature Cited

Banko, W.E. 1960. *The trumpeter swan: Its history, habits, and population in the United States.* North American Fauna series, 63. Washington, D.C.: US Fish and Wildlife Service.

Baril, L.M., L. Henry, and D.W. Smith. 2010. Yellowstone bird program 2009 annual report. Yellowstone National Park, WY: National Park Service, Yellowstone Center for Resources, YCR-2010-04.

Blus, L., R. Strand, B. Reiswig, and T. McEneaney. 1989. Lead poisoning and other mortality factors in trumpeter swans. *Environmental Toxicology and Chemistry* 8:263–271.

Gale, R.S., E.O. Garton, and I.J. Ball. 1987. The history, ecology and management of the Rocky Mountain population of trumpeter swans. Missoula, MT: US Fish and Wildlife Service, Montana Cooperative Wildlife Research Unit.

Henson, P., and J.A. Cooper. 1993. Trumpeter swan incubation in areas of differing food quality. *Journal of Wildlife Management* 57:709–716.

McEneaney, T. 1986. Movements and habitat use patterns of the Centennial Valley trumpeter swan population (Montana) as determined by radio telemetry data. Lima, MT: Red Rocks National Wildlife Refuge.

McEneaney, T. 1986a. An analysis of the Red Rock Lakes National Wildlife Refuge winter feeding program. Lima, MT: Red Rocks National Wildlife Refuge.

McEneaney, T. 1996. Trumpeter swan management within and beyond park boundaries. In *Trumpeter swans—a vision for the 21st century*, Proceedings and papers of the Fifteenth Trumpeter Swan Society Conference. February 1-4, 1995, Mount Vernon, Washington. Madeleine H. Linck, and Donna Compton eds. 151–155. Maple Plain, MN: Trumpeter Swan Society.

McEneaney, T. 2006. Yellowstone bird program 2005 annual report. Yellowstone National Park, WY: National Park Service, Yellowstone Center for Resources, YCR-2006-02.

McEneaney, T. and R. Madsen. 1983. The Red Rock Lakes NWR—Egg and live-swan giveaway program. A three year moratorium proposal. Lima, MT: Red Rocks National Wildlife Refuge.

McEneaney, T., and R. Sjostrom. 1983. Migration and movement of the tri-state trumpeter swan population—an analysis of neck-banding data. Wildlife Management Study No. 9. Lima, MT: Red Rocks National Wildlife Refuge.

McEneaney, T., and R. Sjostrom. 1986. Trumpeter swan movements and seasonal use, Centennial Valley (Montana): An analysis of neck-banding data. Lima, MT: Red Rocks National Wildlife Refuge.

Oyler-McCance, S.J., F.A. Ransler, L.K. Berkman, and T.W. Quinn. 2007. A rangewide population genetic study of trumpeter swans. *Conservation Genetics* 8:1339–1353.

Proffitt, K.M., T.P. McEneaney, P.J. White, and R.A. Garrott. 2009. Trumpeter swan abundance and growth rates in Yellowstone National Park. *Journal of Wildlife Management* 73:728–736.

Proffitt, K.M., T.P. McEneaney, P.J. White, and R.A. Garrott. 2010. Productivity and fledging success of trumpeter swans in Yellowstone National Park, 1987–2007. *Waterbirds* 33:341–348.

Schwartz, C.C., M.A. Haroldson, G.C. White, R.B. Harris, S. Cherry, K.A. Keating, D. Moody, and C. Servheen. 2006. Temporal, spatial, and environmental influences on the demographics of grizzly bears in the Greater Yellowstone Ecosystem. *Wildlife Monographs* 161:1–68.

Shea, R. 1979. The ecology of the trumpeter swan in Yellowstone National Park and vicinity. Thesis, University of Montana, Missoula.

Smith, D.W. 2005. Ten years of Yellowstone wolves. *Yellowstone Science* 13:7–33.

Stahler, D., B. Heinrich, and D. Smith. 2002. Common ravens (*Corvus corax*) preferentially associate with grey wolves (*Canis lupus*) as a foraging strategy in winter. *Animal Behaviour* 64:283–290.

US Fish and Wildlife Service. 1998. Pacific flyway management plan for the Rocky Mountain population of trumpeter swans. Subcommittee on Rocky Mountain trumpeter swans. Portland, OR: Pacific flyway study committee.

US Fish and Wildlife Service. 2003. Trumpeter swan survey of the Rocky Mountain Population, Winter 2003. Denver, CO: Division of Migratory Birds and State Programs.

US Fish and Wildlife Service. 2006. The 2005 Denver, CO: Division of Migratory Birds and State Programs.

Wilmers, C.C., and W.M. Getz. 2005. Gray wolves as climate change buffers in Yellowstone. *PLoS Biology* 3:571–576.

From the Archives

NPS/YELL 29013

A park ranger photographs two trumpeter swans in Lamar Valley, ca. 1941.

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