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EXPLORING THE ROLE OF OSPREYS IN EDUCATION

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Recent research in childhood education has demonstrated that experiences in nature are important in shap-

ing early environmental consciousness (Hinds and Sparks 2008, Hussar and Horvath 2011, Cheng and Monroe 2012) and ultimately the expression of pro-environmental attitudes and behaviors during adulthood (Wells and Lekies 2006, Chawla and Cushing 2007, Collado et al. 2013). Increasingly, those experiences happen via written and electronic media (e.g., textbooks, computer screens) or in very anthropogenic environments (e.g., in parks and zoos) and less through direct contact with nature, a concept Louv (2005) referred to as “nature deficit disorder.” Even in schools where environmental education is prioritized, the extent of access to outdoor classroom activities or experiential learning opportunities can limit the degree to which children can observe, explore, and directly experience the natural world (Hudson 2001, Louv 2005, Ernst 2009). Interestingly, the same information technologies that might serve to limit contact with nature also have the potential to enhance and encourage interest and concern for the natural world (Blewitt 2011, Pearson et al. 2011). We believe this is an important paradox that warrants much further exploration and evaluation within educational and scientific communities.

Although many environmental education programs have been based in the classroom, experiential and service-learning opportunities often supplement or replace these traditional classroom-based learning programs to provide “real-world” experiences to students (Zelezny 1999, Duerden and Witt 2010). Experiential learning opportunities in natural settings can be effective in producing positive environmental attitudes and behaviors in students (Dettmann-Easler and Pease 1999, Schneller 2008, Ballantyne and Packer 2009). Research involving effective pedagogies for increasing environmental awareness and pro-environmental attitudes often includes contact with the natural world (e.g., animals, animal artifacts; Sherwood et al. 1989, Bixby and Church 2010). At the secondary and postsecondary levels, such experiential learning deepens the students’ understanding of theoretical concepts by integrating them with practical situations (Millenbah and Millspaugh 2003, Johnson 2004, Shockley Robinette and Noblet 2009).

Osprey (*Pandion haliaetus*) life-history characteristics and conservation efforts on their behalf provide diverse opportunities for environmental stewardship and education. This species is a highly visible member of coastal and riverine ecosystems worldwide, facilitating opportunities to engage students of all ages in learning about the natural world. In North America, humans contributed to the Osprey’s dramatic decline in the 1950s and 1960s (Poole 1989, Poole et al. 2002) and then played a key role in their recovery during and after the 1970s (e.g., banning pesticides; constructing nest platforms; Henny et al. 2010). A conservation success story, Ospreys have population numbers equaling or exceeding those in the historical records in many regions (Haughton and Rymon 1997, Henny et al. 2010).

Osprey, due to their often highly visible nest sites (Fig. 1) and ability to live near humans (Ewins 1996,



Figure 1. Ospreys commonly nest on human-made structures, such as this light pole at a community baseball field. All photos were taken by the authors.

Henny and Kaiser 1996), provide abundant opportunities for observation and learning, and thus, direct contact and personal experiences with nature, even in urban areas. Furthermore, the Osprey’s role within an ecosystem can provide an example for teaching ecological ideas, such as interactions among trophic levels, animal migration, and effects of environmental contaminants.

With recent advances in technologies (e.g., satellite telemetry, webcams), our understanding of the life history of Ospreys, in particular during the migration and wintering periods, has increased dramatically (Martell et al. 2001, Elliott et al. 2007, Washburn et al. 2014). These newer technologies (e.g., GPS-accurate satellite telemetry) provide extensive datasets that could be used in a variety of secondary and postsecondary courses, including: ornithology, geography, wildlife management, geographic information systems, and statistics. Furthermore, the data that these technologies have generated could be used to promote geographic literacy and encourage students to think about Osprey ecology and habitat needs along migratory routes and on wintering grounds (Hudson 2001). Beyond uses in formal education, these new technologies can be utilized to provide a greater understanding of Ospreys for the general public and citizen scientists.

EXISTING EDUCATIONAL PROGRAMS USING OSPREYS

Ospreys can have an important role as an ecological model within primary education curriculums. For example, in Westport, Massachusetts, the local Massachusetts Audubon Sanctuary and the Westport River Watershed Alliance (WRWA) currently help maintain more than 70 nesting platforms, and facilitate environmental education activities in the region, including a classroom-based “Os-



Figure 2. Westport Elementary students (in Westport, MA) follow the fall migration of locally-nesting Osprey using a large migration route map.

preys are Special” curriculum for third graders (S. Costa pers. comm.). During 2009 and 2010, teachers and students at Westport Elementary School followed six satellite-tagged Osprey via the Westport Osprey website (www.westportosprey.org) and a large map of the migration displayed in the school library (Fig. 2). Students updated the map to track the birds’ movement to Venezuela, Colombia, Cuba, and the Bahamas. A survey on the website challenged students to predict which Osprey would reach its wintering area first (i.e., “The Great Osprey Race”). Field trips allowed the students to directly observe feeding Ospreys and to learn about their foraging patterns (at locations <2 km from the school) throughout river areas near Westport and Dartmouth, Massachusetts. WRWA educators used standard learning protocols (i.e., pre- and post-program testing) to measure the students’ understanding prior to and after they participated in the program.

The Conanicut Island Raptor Project (CIRP) in Jamestown, Rhode Island, follows a similar model (www.conanicutraptors.com) and provides another example of how Osprey ecology can be integrated into the science curriculum

at a primary school. Community members, including local elementary students at the Jamestown School, followed the movements of satellite-tagged Osprey via a website; this website also provided access to an Osprey webcam, a “how to” guide for using webcams near nests, and classroom activities for teachers. The CIRP webcam offered an intimate view into the breeding season behaviors of a locally nesting pair of Osprey. Students observed parental care behaviors (e.g., incubation, brooding, feeding, etc.) and gained knowledge of factors that could limit reproduction (e.g., weather, predators).

An Osprey curriculum, developed by the Public Service Company of New Hampshire, Audubon Society of New Hampshire, and the New Hampshire Fish and Game Department, entitled “The Return of the Fish Hawk” illustrates another way that environmental educators have adapted the broader environmental curriculum to pertain specifically to a locally breeding bird species. During a visit to a local Osprey nest, elementary school students can directly observe the Osprey behaviors (e.g., nesting, feeding young) they discussed in the classroom, offering an experiential learning opportunity within the natural world (Schneller 2008, Ballantyne and Packer 2009) and, perhaps more importantly, a personal experience with the species of interest. Such experiences can have important benefits for increased environmental awareness and pro-conservation attitudes and actions for the conservation of raptors (e.g., Curti and Valdez 2009) and other wildlife (e.g., Kleiman 1989).

In the United Kingdom (U.K.), the Rutland Water Osprey Project (www.ospreys.org.uk) provides an excellent example of how Ospreys and satellite tracking technology can be used to connect schools and communities on a global scale. In 2011, the Rutland Water Nature Reserve piloted a project to link schools in Rutland, U.K., with schools in The Gambia, West Africa, where many U.K. Ospreys winter. Students from the participating schools (i.e., 8- to 15-yr olds) exchanged letters, photos, and videos throughout the academic year as a way to study Osprey migration, the Eurasian-African flyway, and to learn about other human societies and cultures. Local guides in the U.K. and The Gambia organized field trips to allow the students to observe and study Ospreys in their natural habitats.

A consortium of Osprey researchers and educators, including The International Centre for Bird Migration (located at the University of Tel Aviv, Israel), the Highland Foundation for Wildlife in Scotland, and other organizations, plan to extend this project (geographically) and incorporate more schools through an interactive website. Schools throughout the world will be able to register with the project and create their own webpage. International collaborations such as this provide a variety of benefits to the schools and students involved, including an enhanced learning environment, a communication platform for the exchange of ideas and information, and supplements to traditional classroom teaching (Jhurree 2005).

Table 1. Examples of popular literature (i.e., books for children and adults) that contain information or stories about Ospreys.

TITLE	AUTHOR(S)	AGE GROUP
Why Did the Osprey Poop on My Head?	Helene Clark	4 and up
Mother Osprey: Nursery Rhymes for Buoy & Gulls Osprey Adventure	Lucy A. Nolan	4 and up
Awesome Ospreys: Fishing Birds of the World	Jennifer Keats Curtis	8 and up
Meeri Meets the Ospreys	Donna Love	8 and up
Oscar and Olive Osprey: A Family Takes Flight	Steve Costello	9 and up
Osprey: The Fish Hawk	Janie Suss	9 and up
Avian Ecology and Conservation in an Urbanizing World	Stephen D. Carpenteri	Adults
Soaring with Fidel: An Osprey Odyssey from Cape Cod to Cuba and Beyond	John Marzluff, Reed Bowman, Roarke Donnelly	Adults
Return of the Osprey: A Season of Flight and Wonder	David Gessner	Adults
Lady of the Loch: The Incredible Story of Britain's Oldest Osprey	Helen Armitage	Adults
Life of Ospreys	Roy Dennis	Adults
Ospreys: A Natural and Unnatural History	Alan Poole	Adults

POTENTIAL ROLES AND OPPORTUNITIES FOR OSPREY IN EDUCATION

Educational Resources. Numerous Osprey education materials are currently available to support curricular activities for varying ages and skill levels. In the popular literature, books for children and adults share themes ranging from hard-fought conservation successes to migratory adventures. Other books communicate natural history for a general audience or condense peer-reviewed science into a format understandable to nonscientists (Table 1).

In the last decade, conservation and education organizations have developed World Wide Web-based (hereafter web-based) and electronic media to support Osprey education and outreach efforts. Many Osprey websites focus on local or regional Osprey populations and provide opportunities for remote participation through webcams (Table 2) or satellite tracking maps (e.g., www.ospreytrax.com). Many organizations effectively use new social media outlets (e.g., Facebook, Twitter, YouTube) as alternative or additional means of sharing Osprey information (e.g., providing status updates through a variety of text, maps, photos, and videos), connecting with citizen scientists, and obtaining financial and logistical support for future efforts.

Technology in Secondary and Postsecondary Education. Although web-based efforts have already engaged hundreds of thousands of people (primarily from the general public) in environmental education and stewardship activities, few web-based efforts have effectively engaged high school and college students. The current populations of collegiate undergraduate students (and arguably those in high school) are part of the Millennial generation (Millenbah and Wolter 2009) for whom the use of electronic media has good potential for enhancing learning (Lee 2011). The Millennial generation of natural resource stu-

dents is already comfortable with web-based platforms such as Google Earth, blogs, webcams, and various forms of social media (Kaplan and Haenlein 2010, Millenbah and Wolter 2009, Evans and Forbes 2012, Kaplan 2012). Through the use of these technologies, undergraduate students could be introduced to, and challenged to think about, large-scale wildlife management issues that cross ecological, geographic, economic, and cultural boundaries (e.g., birds such as Ospreys that breed and winter on different continents).

Integrating Osprey research with experiential secondary or postsecondary education has great potential for increasing critical thinking, problem-solving, and quantitative skills. These skills are essential for the development of effective natural resource managers and professionals who exhibit pro-environmental attitudes and conservation-focused behaviors (Caro et al. 1994, Christie et al. 2013). Undergraduate wildlife students could gain exposure and experience with new technologies, such as satellite telemetry and spatial data analysis, within wildlife techniques classes (Millenbah and Millspaugh 2003, Millspaugh and Millenbah 2004). Ecological concepts, such as migration ecology or habitat selection, could be explored using Osprey data and examples. Focusing on satellite transmitter data from Ospreys during the fall and spring migration periods, students could analyze these location and movement data to better understand the timing and routes used by migrating Ospreys. Stopover locations and important habitats could be identified, allowing the students to understand how this biological information could be used to set conservation priorities for land preservation.

Osprey foraging behaviors and predictable patterns of habitat selection (e.g., repeated foraging in productive aquatic environments) provide students with the opportunity for direct observation and consequent discussion of

Table 2. List of (example) websites that host live webcams at Osprey nests throughout North America and the United Kingdom.

SPONSOR(S)	LOCATION	URL
Maine Audubon	Bremen, ME	http://explore.org/live-cams/player/live-osprey-cam
Massachusetts Audubon	Westport, MA	http://blogs.massaudubon.org/westportosprey/
New York Wild The Wetlands Institute	Seneca Falls, NY Stone Harbor, NJ	http://newyorkwild.org/osprey/osprey.htm http://wetlandsinstitute.org/education/osprey-camera
Friends of Blackwater	Cambridge, MD	http://www.friendsofblackwater.org/camhtm.html
Atlantic Security, Inc. American Electric Power Alcoa Power Generating Inc. Palmetto Electric Cooperative	Chesterfield, MD Smith Mountain, VA Badin, NC Hilton Head, SC	http://osprey.atlanticsecurityinc.com/ http://is.gd/smosprey http://www.alcoa.com/osprey/cam http://palmetto.coop/community/osprey/env_osprey.asp
Ocean's Reach Resort Progress Energy, CSX, and Clearwater Audubon Society	Sanibel Island, FL Dunedin, FL	http://www.oceansreach.com/osprey-cam.cfm http://dunedineospreycam.org
Central Lakes College Dunrovin Guest Ranch	Brainerd, MN Lolo, MT	http://ospreycam.clcmn.edu/ http://www.allaboutbirds.org/page.aspx?pid=2445
Hellsgate Canyon City of Sandpoint and Keokee Publishing Okanogan County Public Utility District and Oroville School District	Missoula, MT Sandpoint, ID Oroville, WA	http://www.allaboutbirds.org/mtosprey http://www.sandpointonline.com/ospreys https://www.okanoganpub.org/news/pud-partners-school-install-live-osprey-nest-webcam
Boulder County Colorado	Longmont, CO	http://www.bouldercounty.org/os/openspace/pages/ospreycamera.aspx
The Royal Society for the Protection of Birds Forestry Commission England, Lake District National Park, and The Royal Society for the Protection of Birds	Loch Garten, Scotland, U.K. Lake District National Park, England, U.K.	http://www.rspb.org.uk/reserves/guide/1/lochgarten/blog.aspx http://www.ospreywatch.co.uk/webcam.html
Montgomeryshire Wildlife Trust	Cors Dyfi Nature Reserve, Wales, U.K.	http://www.dyfiospreyproject.com/

ecological processes, such as predator-prey interactions. For example, students could analyze digital media (e.g., video and/or still images) from archives of webcams placed at Osprey nests to examine diet, food delivery rates at nests, and a variety of behaviors of adult and nestling Ospreys (e.g., courtship, incubation, brooding, aggression among nestmates). Combined with satellite telemetry data, such information could enhance student abilities to gain an understanding of factors influencing the foraging and breeding ecology of Ospreys.

Making International Connections. During the last decade, improvements to technologies used in raptor research and conservation, in particular satellite telemetry and webcams, have provided new scientific insights regarding long-distance migrants, such as Ospreys. These new technologies, which allow data to be collected remotely, also provide cutting edge opportunities to integrate Os-

prey research with education initiatives. Education experts encourage experiential learning opportunities as a foundation for problem solving and skill building, particularly for natural resource students (Hudson 2001, Ballantyne and Packer 2009).

Osprey education could be expanded by increasing communication and collaboration between schools and communities on an international scale. For example, the Rutland Water Nature Reserve project facilitated communication between schools that shared a growing interest and understanding of their local Osprey. In this case, each school had support from Rutland Water Nature Reserve professionals to help local teachers and bird guides develop activities to view and learn about the Osprey. Local Osprey education activities provided the foundation on which to build effective long-distance communication between schools and communities. Attempts to establish communication be-

Table 3. Prerequisite requirements to allow for successful international collaboration among primary and/or secondary schools for environmental education and outreach efforts involving Ospreys.

REQUIREMENT	DESCRIPTION
Planning	<ul style="list-style-type: none"> • Osprey curriculum is easily adaptable to different school locations • Curriculums are designed outside of classroom teacher preparation time (many teachers do not have the resources or background to develop new curricula) • Curriculum should be aligned with state-specific or other established science standards
Expertise	<ul style="list-style-type: none"> • Teachers need support of researchers or educators with Osprey expertise
Technology	<ul style="list-style-type: none"> • Schools must have the technological tools for Osprey tracking and collaboration (e.g., computers, internet access)
Communication	<ul style="list-style-type: none"> • A central online tool (e.g., social media) is needed to serve as a location to post Osprey information (e.g., migratory pathways) and a medium for interschool communication

tween schools are unlikely to succeed in situations where one or both lack local curricular support, technology, and communication infrastructure. This suggests several prerequisites are required to allow for successful international collaboration among schools (Table 3).

Integration of Research and Education. An unexplored area of environmental education and outreach with great potential involves the integration of Osprey research into secondary and postsecondary learning. Recent advances in Osprey tracking technology have contributed to the growth of datasets beyond the initial research questions. Furthermore, there may be opportunities to collect individual datasets into a central location (e.g., Movebank; www.movebank.org). Creating a central repository for Osprey tracking data is an essential first step in this process. Such a repository would enable researchers to conduct analyses on a global scale and provide a single location for educators to access Osprey data. Secondary and postsecondary students could use raw data in course activities or independent research with the help of a “suggested activities” resource or a list of unanswered research questions from which to build. Web-based social media could provide opportunities for students to “publish” or share their findings with colleagues and offer feedback to one another.

Citizen Science—Crowd-sourcing Data. Recent advances in technology, social media, and web-based data sharing presents new opportunities for large-scale citizen science endeavors and projects (Dickinson et al. 2010, Devictor et al. 2010, Catlin-Groves 2012). An example of citizen science involving Ospreys is Osprey Watch (www.osprey-watch.org), a new initiative by the College of William and Mary’s Center for Conservation Biology. This project is an effort to engage citizen scientists in the reporting and monitoring of Osprey nests worldwide. To date, nearly 1700 “nest watchers” have reported on more than 4700 Osprey nests. This growing effort provides abundant opportunities to engage primary and secondary school students in nest locating and monitoring activities (e.g., recording the number of eggs, hatching dates). One interesting and notable challenge will be to integrate long-established locally based nest monitoring programs into the global efforts of Osprey Watch.

POTENTIAL CHALLENGES

The integration of Osprey scientific research, environmental education (at the primary, secondary, and postsecondary education levels), and public outreach can provide mutual benefits to all involved. Curriculums for multiple age groups and skill levels must be developed; however, this requires efforts by individuals with expertise in both education and a strong understanding of current Osprey research. Several collaborative web-based environmental education projects that use social media have been recently developed and are demonstrating the value of this approach. Ultimately, however, their long-term success will depend on a clear vision for websites and online database management, including essential financial and logistical support.

Another challenge with integrating technology and education will be to provide the necessary technological resources to elementary schools, particularly in developing countries. Access to the internet is very limited in many developing countries and schools in economically poor and rural areas often do not have the needed equipment (e.g., computers), internet access, or computer literacy required for such efforts (Brooks et al. 2005, Gulati 2008). Consequently, to overcome these issues, exchange of information among students and teachers might be done more effectively by using written materials (e.g., paper) and broadcast media (e.g., video). Mobile technologies (e.g., tablets) represent another opportunity for overcoming the lack of internet access in developing countries, as these tools are more widely available relative to internet access (Ally and Samaka 2013). Ultimately, the continuation of such programs will rely on the creativity and resourcefulness of those involved.

Perhaps the greatest challenge, and arguably the most important, regarding these programs is the ability to accurately measure the success of a program for influencing long-term changes in behavior or cognitive skills. The development and implementation of accurate measures of program success is an important need.

SUMMARY

Osprey (and other migratory raptors) provide excellent opportunities for experiential and service-learning oppor-

tunities in environmental education programs for grade school students, secondary students, and communities as a whole. Written literature, electronic media materials, and information from modern technologies are available to enhance learning and influence attitudes about raptor conservation and the environment overall. Although there are challenges, we believe there is great potential for using Ospreys in education through a variety of means.

EXPLORANDO EL ROL DE *PANDION HALIAETUS* EN LA EDUCACIÓN

RESUMEN.—*Pandion haliaetus*, una carismática especie de ave rapaz con una distribución casi mundial, es altamente visible y adaptada a ambientes antrópicos. En consecuencia, esta especie ha sido ampliamente estudiada a lo largo de la mayoría de su área de distribución y proporciona un excelente foco de atención para el aprendizaje de estudiantes de educación primaria y secundaria. Avances recientes en tecnologías (e.g., telemetría satelital, cámaras web) utilizadas para estudiar a *P. haliaetus* han producido grandes bases de datos que pueden ser utilizadas en una variedad de cursos de secundaria y pos-secundaria para facilitar el desarrollo del pensamiento crítico, resolución de problemas y habilidades cuantitativas a lo largo de un amplio rango de límites geográficos y políticos. El uso eficaz de medios sociales podría mejorar las oportunidades de integrar la investigación científica de *P. haliaetus* con la educación ambiental, los alcances y los proyectos de ciencia ciudadanos. Este informe describe el uso de *P. haliaetus* en programas educativos, particularmente en el marco de la educación primaria. Además, sugerimos el modo en que las nuevas tecnologías y actividades de investigación con *P. haliaetus* (y otras aves migratorias) pueden ser integradas en programas educativos en distintos niveles para mejorar el aprendizaje a partir de la experiencia e incrementar potencialmente las actitudes y actividades en pro de la conservación.

[Traducción del equipo editorial]

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