

An Environmental Science Curriculum Utilizing GIS and Satellite-Based Wildlife Tracking

Michelle Frankel, M. Blake Henke, Jack Cibor, and William S. Seegar

Abstract

The “Eye of the Falcon” is an interdisciplinary environmental science curriculum for middle school students that utilizes GIS to help students map and analyze the movements of satellite-tracked wildlife around the globe. Students use ArcView and ArcIMS GIS to map near real-time satellite tracking data and to analyze the relationships between the animals’ movements and various landscape variables. The curriculum draws from a wide range of fields, including ecology, behavior, social studies, and geography, and raises awareness about local and global environmental issues. Students learn how technology, such as GIS, remote sensing, and satellite biotelemetry, is used to study and conserve wildlife. The program also brings diverse and even conflicted cultures together, as sister schools in different countries exchange information about their cultures, environments, and the migrating animals that know no political boundaries. The program is being developed by Earthspan, a non-profit organization dedicated to wildlife conservation research and education.

Introduction

Geographic Information Systems (GIS), satellite telemetry, and remote sensing technologies are vital to the cultural, economic, and political development of this country, and to the management and conservation of our natural resources. In the conservation of biodiversity, these powerful tools are being used to study, manage and protect threatened species and habitats. Satellite tracking of wildlife is unlocking the mysteries of many species’ natural histories, such as the timing of migration events, how species navigate, where they go, and what types of habitats they need to survive (Fuller et al. 1995; Seeger et al. 1996; Marzluff et al. 2001). Research results can thus play an ever-increasing role in understanding wildlife and managing their populations and related habitats. The *Eye of the Falcon*, a new, supplementary environmental science curriculum for secondary schools, brings these powerful tools to the classroom, allowing students to discover, alongside with scientists, the behaviors and habitat preferences of wildlife around the globe.

Eye of the Falcon is an inquiry-based curriculum that involves secondary school students in authentic, technology-based ecological and conservation research, such as studies utilizing near real-time satellite tracking of migratory animals, remote sensing data, and GIS. The focus on global phenomena and wildlife conservation research around the world, as well as on locally-based research projects, engages and excites students about science and makes it feel relevant to their own lives. *Eye of the Falcon* brings environmental science to life as students are engaged in



Using satellite tracking data and GIS, scientists – and students – may discover the habitat needs of threatened wildlife around the globe.

authentic, ongoing research projects and are challenged to use their research results to solve real-life conservation issues. The curriculum includes concepts from a wide range of fields such as ecology, evolution, animal behavior, social studies, and geography, and meets many of the National Science Education Standards.

The *Eye of the Falcon* curriculum was developed by Earthspan, Inc. (<http://www.earthspan.org/>), a non-profit environmental organization dedicated to the development and application of advanced technologies for wildlife conservation research. In 2001, Earthspan began to develop an educational program that could take advantage of the scientific and technical expertise contained within the organization and apply it in an exciting way to help educate students about wildlife research and conservation. The *Eye of the Falcon* educational program was developed to meet the growing need for authentic environmental science and technology curricula in the school system.

Student and Teacher Outcomes

As a result of using the *Eye of the Falcon* curriculum, we anticipate the following outcomes for students and teachers:

Students will: (1) Develop inquiry skills as evidenced by their ability to design and conduct experiments, analyze data, and interpret and communicate results; (2) Learn and integrate core concepts in the life and earth sciences; (3) Understand the relationship between societal choices and environmental impacts; (4) Understand the relationships between local and global environmental phenomena; (5) Increase their proficiency in technology use and learn how to utilize advanced technological tools for research and problem solving; (6) Utilize technology communication tools to exchange information with peers and communicate with scientists; (7) Apply concepts in mathematics throughout the curriculum; (8) Conduct cooperative research projects effectively; (9) Feel engaged by the material regardless of background and skill level; (10) Develop mapping and geography skills and be able to analyze the relationships between people, places, and environments.

Teachers will: (1) Track student growth by using comprehensive assessment tools; (2) Increase their application of inquiry techniques to teaching science; (3) Increase their use of instructional technologies in the classroom.

Structure and Content of the *Eye of the Falcon* Curriculum

The *Eye of the Falcon* is a supplementary environmental science curriculum for secondary schools that integrates technology-based ecological and conservation research with core concepts in the life and earth sciences. A list of units and lessons, as well as a table showing the alignment of units with National Science Education Standards, may be found in Appendix A. *Eye of the Falcon* is distinguished from other curricula that are web-based and utilize “real-time” data in that it is a regionally-based program that focuses on local environmental issues and scientific research. In each region, we work closely with the schools as well as with local researchers to develop a program that caters to the needs of the schools and features the work of local scientists. Furthermore, students do not simply visit a web site and view the latest locations of tracked animals, but rather are able to conduct meaningful research projects using the tracking data. Students may access web-based GIS map projects (www.earthspan.org/EOF/maps.htm),

created using ArcIMS, that allow students to utilize our large data sets involving both historical and real-time tracking studies and analyze the relationships between animal locations and a wide range of landscape variables. By using ArcIMS, schools around the country, and even around the globe, may access the GIS map projects without installing or purchasing any GIS software. Finally, *Eye of the Falcon* is not simply a “web-based” program. Teachers are provided with comprehensive instructional materials and assessment tools and the instructional technologies are seamlessly integrated into a standards-based curriculum that involves experiential classroom activities, field experiments, and project-based learning.

Eye of the Falcon Teacher’s Guides: Comprehensive Teacher’s Guides with student worksheets have been developed that include theme-based units and extensions with opportunities for more in-depth exploration. The complete *Eye of the Falcon* Teacher’s Guide consists of five units focusing on core topics in environmental science. In addition, stand-alone 4-week units have been developed for each region that focus on local environmental issues and real-time tracking projects. This structure provides teachers with a wide range of options for implementation of the program: they may choose one unit to teach over a short period of time or they may choose a number of units to teach as a semester-long course. Each unit consists of:

- a. Easy to follow, 3-step lesson plans: Think-About-It, Activity, and Review/Assessment;
- b. Lists of learning objectives, vocabulary words, and materials needed;
- c. References to national standards;
- d. Experiential learning activities that introduce a topic or concept;
- e. A field-based research project that focuses on local ecosystems, wildlife and natural resources;
- f. A computer-based activity using the EOF web site that focuses on both local projects and research projects around the world;
- g. Student guides and worksheets for each lesson;
- h. Background information for teachers

EOF Web Site and Software: The EOF web site (www.earthspan.org/EOF/EOF.htm) is designed to be used in conjunction with the curriculum to aid students in conducting background research, performing analyses using GIS and remote sensing data, and creating dynamic maps using both real-time and historic satellite-tracking data. The EOF software contains everything that is on the web site except for the real-time tracking data, and is available for schools with no or slow access to the Internet. The EOF software uses ArcVIEW GIS in place of ArcIMS (which is the web-based version). The web site features information pages containing detailed background information on taxonomy, evolution, migration, ecosystems and biomes, natural history descriptions of featured species, research project descriptions, the technology scientists have developed to study animal movements, and much more.

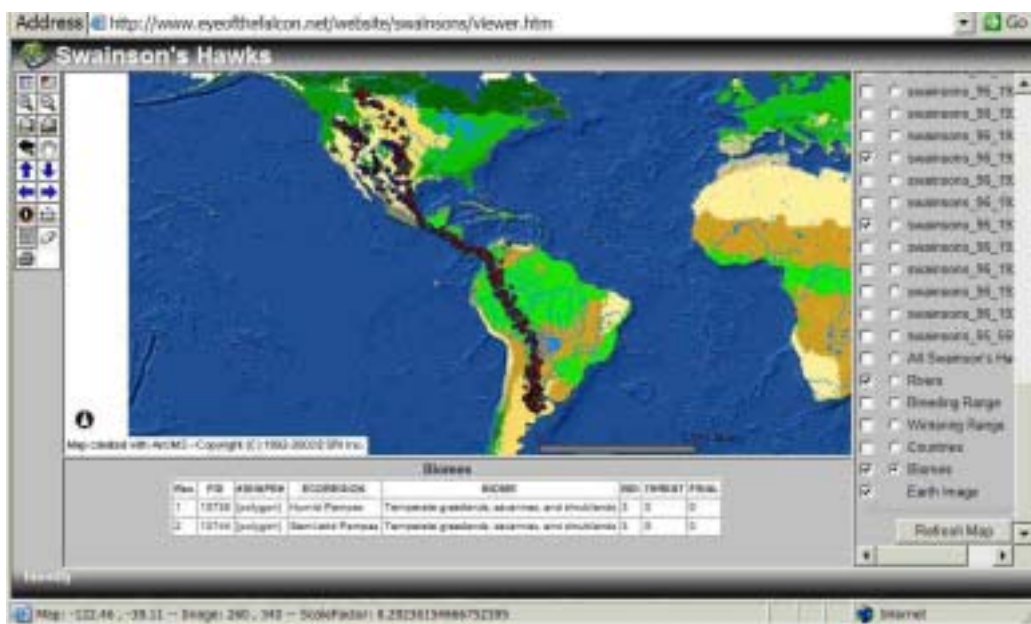
The "Maps" page on the web site allows students to choose from a variety of GIS-based projects, (tracking projects as well as other ecology projects using spatial data), and

selecting one of them opens up ArcIMS, a web-based version of GIS. Student worksheets guide students step-by-step through the use of GIS.

Research Projects Using Satellite Telemetry and GIS: *Eye of the Falcon* engages students in a wide range of real-time tracking and other research projects from around the world that have important implications for wildlife conservation, public health, and sustainable resource use, and students are able to make connections between the research projects and issues in their own lives. In addition, each research project introduces students to a different geographic region and biome, allowing students to investigate the relationships between humans, place and the environment. Examples of research investigations include:

- How does coastal development in the Chesapeake Bay impact Bald Eagle nesting success?
- How is the fishing industry in Alaska impacting the endangered Steller Sea Lion?
- Are the foraging patterns of Pink-footed Shearwaters that breed off the coast of Chile correlated with oceanographic variables?
- Do Shearwater foraging locations overlap with fishing vessel activity off the Chilean coast, making these threatened birds vulnerable to the impacts of fisheries bycatch?

Students may address these research questions by using GIS to overlay the satellite tracking data or other spatial data (such as Bald Eagle nesting success data) on other geographic variables such as human population density, land use data, chlorophyll a concentrations, sea surface temperature, topography, bathymetry, etc. The graphic below shows an example of a GIS map that students can create, showing the migration path of Swainson's Hawks overlaid on a biomes and ecoregions layer. Students use this particular data set to solve the “Mystery of the Disappearing Hawks” – they investigate the birds’ breeding and wintering habitat preferences to help them determine the cause of the rapid population decline for this species in the 1990’s (which turned out to be due to the use of a new pesticide by farmers in the Pampas region of Argentina).



The research projects are made available to *Eye of the Falcon* through research conducted by Earthspan, through collaborations with other scientists, and through the North Star Science and Technology, LLC, annual grant program which offers 6-10 free satellite transmitters to qualified projects willing to share their data for use in the *Eye of the Falcon* program. To date, featured real-time tracking projects include Bald Eagles, Peregrine Falcons, Sandhill Cranes, White Pelicans, and Pink-footed Shearwaters. Planned tracking projects for the 2004-5 school year include northern fur seals, loggerhead turtles, Andean flamingos, and Golden Eagles.

Field-Tested Curriculum

The Eye of the Falcon was first piloted in four Baltimore City public schools in 2002 through a grant from the Abell Foundation in Baltimore, MD. Earthspan developed and piloted the first unit by joining forces with Baltimore City school teachers, as well as with curriculum coordinators and teachers from the Ingenuity Project, a program that provides an accelerated and enriched curriculum in science, math, and research for Baltimore city public school students. Additional units were developed since then with funding from the American Honda Foundation, the William G. Baker Memorial Fund, Lockheed Martin, and ESRI. The curriculum is now being used in schools in Maryland, New York, Washington, and Montana.

In addition to piloting the program in the U.S., the Eye of the Falcon is also being introduced to schools in other countries around the world. Animal migration is an awe-inspiring phenomenon that may serve to connect students across the globe, as they exchange information about the wildlife they share. The protection of migrating animals often depends upon cooperation across international borders, and provides opportunities for scientists, educators and students to work together to learn about and protect these precious natural resources. One of the units was translated into Spanish and is being used by a small school on the Juan Fernandez Islands, Chile, where we are collaborating with scientists who are tracking Pink-footed Shearwaters. Students from Tacoma, WA (where the Shearwaters migrate to), are communicating by e-mail with the Chilean students with the help of their Spanish teacher. The collaborating scientist gave presentations to the students in Chile and in Tacoma, WA, and sent regular e-mails to the students with "stories from the field". In 2003, a three-way e-pal exchange was established between a school in New Jersey and a Palestinian and an Israeli school that were doing a parallel program to *Eye of the Falcon* in Israel (<http://www.birds.org.il/>). Plans are underway to establish similar sister school programs involving other countries where satellite tracking studies are taking place, allowing students from around the globe to exchange information about themselves, their cultures, and the migrating animals they share.

Resources for Teachers

Resources available for teachers utilizing the Eye of the Falcon curriculum include professional development workshops, the Teacher's Guide with student worksheets, access to the *Eye of the Falcon* web site and real-time tracking data, and a variety of audio-visual materials such as PowerPoint presentations and large wall maps that allow

students to map the latest locations of animals by hand. Teachers are also provided with free technical assistance as well as consultations with Earthspan's education director.

References

- Fuller, M.R., W.S. Seegar, J.M. Marzluff and B.A. Hoover. (1995). Raptors, technological tools, and conservation. Trans. 60th North Am. Wildl. and Nat. Res. Conf. 131-141.
- Marzluff, J.M., S.T. Knick and J.J. Millspaugh. (2001). High-tech behavioral ecology: modeling the distribution of animal activities to better understand wildlife space use and resource selection, *in* J.J. Millspaugh and J.M. Marzluff, eds. Radio Tracking and Wildlife Populations (pp 309-326). Academic Press, San Diego, Calif.
- Seegar, W.S., P.N. Cutchis, M.R. Fuller, J.H. Suter, V. Bhatnagar and J.G. Wall. (1996). Fifteen years of satellite tracking, development and application to wildlife research and conservation. Johns Hopkins APL Technical Digest, 17:401-411.

Author Information

Michelle Frankel, Education Director, Earthspan, 1450 S. Rolling Rd. Baltimore, MD, 21227. Phone: (215) 772-0774, e-mail: michellefrankel@earthlink.net

M. Blake Henke, Program Manager, Earthspan, 1450 S. Rolling Rd. Baltimore, MD 21227. Phone: (410) 455-5987, e-mail: blakehenke@msn.com

Jack Cibor, GIS Specialist, Earthspan, 1450 S. Rolling Rd. Baltimore, MD 21227. Phone: (410) 455-8046, e-mail: jcibor1@gl.umbc.edu

William S. Seegar, U.S. Army, US Army Edgewood Engineering Center, Aberdeen Proving Ground, MD 21010. Phone: (410) 436-2586, wsseegar@aol.com

Appendix A

The following is a list of units and lessons in the Eye of the Falcon curriculum. Lessons marked with an asterisk are still under development.

Unit 1: The Application of Geospatial Technologies to Wildlife Conservation

- Lesson 1: What do Maps Say?
- Lesson 2: A Sketch Map of Your Classroom
- Lesson 3: Neighborhood Map
- Lesson 4: Introduction to GIS
- Lesson 5: Mapping Your Neighborhood Using GIS*
- Lesson 6: Interpreting Remote Sensing Data*
- Lesson 7: Tracking Wildlife With Satellites

Unit 2: Exploring Biomes

- Lesson 1: Physical and Chemical Factors Influence Life in the Biosphere*
- Lesson 2: Exploring Your Local Biome
- Lesson 3: GIS Project: Climate and Biomes
- Lesson 4: Biome Research Projects
- Lesson 5: Earth's Waters*
- Lesson 6: Exploring Oceanographic Data Using GIS*

Unit 3: Organisms in their Environments

- Lesson 1: Adaptations to the Environment*
- Lesson 2: Identifying Niches in a Schoolyard Ecosystem*
- Lesson 3: Research Project: Amazing Animal Adaptations*
- Lesson 4: Why Do Animals Migrate?
- Lesson 5: Travelers in Danger*
- Lesson 6: Backyard Census of Robin Migration
- Lesson 7: GIS Project: Habitat Selection in Swainson's Hawks

Unit 4: Population Dynamics

- Lesson 1: Introduction to Population Dynamics
- Lesson 2: Squirrels and Hawks in an Oak Forest Ecosystem
- Lesson 3: Calculating Carrying Capacity in a Local Ecosystem*
- Lesson 4: Human Population Growth on a Stressed Planet*
- Lesson 5: GIS Project: Changes in Human Population and Land Use Practices in Your Local Region*

Unit 5: Communities and Ecosystems

- Lesson 1: Introduction to Communities and Ecosystems
- Lesson 2: Schoolyard Ecosystem Research Project
- Lesson 3: Introduction to Watersheds
- Lesson 4: Tracking Tributaries Using GIS
- Lesson 5: Who Uses the Bay?
- Lesson 6: Humans and the Bay
- Lesson 7: Measuring Water Quality
- Lesson 8: GIS Project: Bald Eagle Nesting Success and Coastal Development in the Chesapeake Bay

Regionally-Based Real-Time Tracking Units

Unit 1: Dispersal Patterns of Juvenile Bald Eagles in the Chesapeake Bay

Unit 2: Migration of Tundra Peregrine Falcons

Unit 3: Pink-footed Shearwater Foraging Behavior and Interaction with Fisheries off the Chilean Coast

Unit 4: American White Pelican Migration and Interaction with Fish Farms in Southeastern U.S.

Unit 5: Steller Sea Lions and Interactions with Alaskan Fisheries*

Unit 6: Andean Flamingos and Wetland Conservation in Argentina*

Unit 7: Migratory Dynamics of Golden Eagles in Wyoming*

Table 1. Alignment of units with National Science Education Standards

National Science Education Content Standards, Grades 5-8		Unit 1:	Unit 2:	Unit 3:	Unit 4:	Unit 5:
		The Application of Geospatial Technologies to Wildlife Conservation	Earth's Diverse Environments	Organisms in their Environments	Population Dynamics	Communities & Ecosystems
Unifying Concepts and Processes	Systems, Order & Organization		X	X	X	X
	Evidence, Models & Explanation	X	X	X	X	X
	Change, Constancy & Measurement	X	X	X	X	X
	Evolution & Equilibrium			X	X	X
	Form & Function			X	X	X
Science as Inquiry	Abilities necessary to do inquiry	X	X	X	X	X
	Understandings about inquiry	X	X	X	X	X
Life Science	Structure & Function			X	X	X
	Reproduction & Heredity					
	Regulation & Behavior			X	X	X
	Populations & Ecosystems		X	X	X	X
	Diversity & Adaptations		X	X	X	X
Earth & Space Science	Structure of the Earth System	X	X	X	X	X
Science & Technology	Abilities of technological design	X				
	Understandings about science & technology	X	X	X	X	X
Science in Personal & Social Perspectives	Populations, Resources & Environments		X	X	X	X
	Natural Hazards		X	X	X	X
	Science & Technology in Society			X	X	X