The Art and Science of Communicating Nature

It can take years to refine one’s photography, drawing, and writing skills. In a semester’s time I was able to confidently learn the basics of each skill so that I can now go and explore and practice these skills further on my own.

—Peter Frank, NRES 499 student

The term “interdisciplinary” appeared in the halls of higher education some years ago, but is still in some circles regarded as a departure from serious study, as if the world were naturally compartmentalized. What is often forgotten is that most disciplines we regard as discrete entities today once were not. The most striking example is that of art and science. Leonardo Da Vinci, Lewis and Clark, and Darwin all documented their discoveries using sketches and written observation, often with what we might now consider an “artistic” eye.

A new course at the University of Illinois this spring was created with the intention of bridging that modern art/science gap and teaching science students to depict their findings artistically for a lay audience.

NRES 499, “Communicating Nature,” was a collaborative effort by three Illinois Natural History Survey scientists: Dr. Michael Jeffords, Susan Post, and Carolyn Nixon. The course proposed that empirical methods are not always sufficient to describe the natural world, and can in fact be somewhat myopic. The lofty goal was to encourage students to “analyze with the mind of a scientist, see with the eyes of an artist, and speak with the words of a poet.”

The first step in communicating nature is truly to pay attention to it. Though the course was divided into the three disciplines of photography, writing, and drawing, all of the instructors focused on the fundamental skill of observation. Post, the writing instructor, insisted that students have a 3” x 5” notebook on hand at all times. They were to take weekly notes on anything that struck them, as well as the circumstances of the encounter: the date, season, weather, and location. These notes can provide the raw material for a completed piece, as shown by Post’s own book, “Hiking Illinois,” which began as two shoeboxes filled with these little notebooks.

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Possible Displacement Mechanisms in Non-native Crayfishes

The influx of exotic species into Illinois has been continual since European settlers first set foot in the state. Many exotic species do not become established or have minimal impacts on our natural resources; however, some can have significant detrimental effects on native flora and fauna once established. One exotic species that falls into that second category is the rusty crayfish (Orconectes rusticus). The rusty crayfish is native to Ohio, Indiana, and Kentucky and was first discovered in Illinois in 1973. Through its use as fishing bait, the rusty crayfish was introduced into approximately a dozen sites in northern Illinois over the next 12 years. Since then the species rapidly spread across northern Illinois and in the process has eliminated populations of the native northern clearwater crayfish (Orconectes propinquus) and reduced populations of the native virile crayfish (Orconectes virilis). In other states the rusty crayfish has been shown to also reduce populations of sport fishes by consuming those fishes’ eggs and by eating vegetation used by juvenile sport fish for refuge. Over the past 30 years, Illinois Natural History Survey (INHS) researchers have documented the slow spread of the rusty crayfish across Illinois’ river basins. However, equally important as documenting range expansions of exotic species is determining the mechanism or mechanisms by which exotic species are able to successfully displace native species. Once these mechanisms are understood, steps can be taken by resource managers to minimize or even stop the spread of exotic species. A new research effort by INHS staff is attempting to determine which mechanisms are at work in Illinois’ crayfishes.

Experimental evidence gathered by other researchers suggests that several processes may play a part in crayfish displacements. These include faster growth rates by invading crayfishes and a subsequent “upper hand” in competing for food and shelter, differing susceptibility to fish predation by native and non-native crayfishes, and the dilution and eventual extinction of native species genes by hybridization events with non-native species.

An additional possible displacement mechanism is simple resource competition, and INHS researchers are beginning to examine food resource use by non-native versus native crayfishes in Illinois streams. Crayfishes have been reported to eat a wide variety of food items such as algae, rooted aquatic plants, decaying leaf litter, insects, and even small fish. By measuring carbon (C) and nitrogen (N) isotope ratios in body tissue, one can determine what types of food resources an organism has been consuming over an extended period of time. For example, organisms with relatively high ratios of $^{13}$N to $^{15}$N are thought to reside higher on the food chain than those with lower ratios, and $^{13}$C to $^{14}$C ratios provide information on carbon sources (e.g., aquatic versus terrestrial plant material). Isotope ratios can thus give a clearer picture of the long-term diets of organisms since other methods of diet analysis, such as examining gut contents, are limited to what animals have eaten in the past 24 to 36 hours. Using museum records housed in the INHS Crustacean Collection, researchers have identified streams in Illinois where rusty crayfish have occurred for longer than 25 years, less than 5 years, and streams that are currently being invaded by that species. By taking tissue samples of crayfishes in these streams, in addition to those from streams not yet invaded by rusty crayfish, and analyzing isotope ratios in those tissues, INHS researchers are hoping to determine if food resources play a role in displacement. Specific questions to be addressed are what food items invading rusty crayfish and native crayfishes consume, is there any overlap in diet requirements, and if so, are species with greater dietary overlap more likely to be displaced. By examining sites where rusty crayfish have been established for several years, INHS researchers also hope to learn if the diets of these exotic invaders change once they become established and eliminate native crayfish.

The rusty crayfish is already well established in the northern half of the state and there is currently no known means to eradicate it. The continued education of anglers on the negative effects of rusty crayfish and the undesirability of dumping unused bait is one of the best ways to slow the spread of that species. However, INHS researchers hope to be able to determine if food use plays a role in invasion dynamics. Once the diet of invading rusty crayfish has been identified, stream sites more susceptible to invasion could potentially be identified and extra efforts taken to prevent the introduction of that species. The potential also exists for reducing or eliminating newly established populations of rusty crayfish by manipulating the availability of certain food resources.

Christopher A. Taylor, Center for Biodiversity and David J. Soucek, Center for Ecological Entomology
Nutrients in Illinois Streams

Anthropogenic eutrophication persists as a major problem for U.S. waters despite progress in reducing nutrient discharges from point sources over the last 30 years. Excessive levels of nutrients continue to be consistently identified as a reason why as much as half of U.S. waters fail to meet water quality objectives. Illinois waters are not exempt from the problem of eutrophication; a growing population, expanding suburbs, and intensive agricultural activities are responsible for substantial loadings of phosphorus and nitrogen into Illinois waters.

Cultural inputs of nutrients are responsible for excessive growths of microscopic and macroscopic plants, which then create a cascade of conditions detrimental to both aquatic ecosystems and their beneficial uses by humans. Uncontrolled algal growth can result in water bodies that are visually unattractive and odorous, and extensive growths of filamentous algae and macrophytes physically interfere with fishing and boating in affected water bodies. The unbalanced growth of algae caused by cultural eutrophication affects numerous ecosystem parameters as well. Large standing crops of algae cause large diurnal (24-hour) swings in dissolved oxygen and pH, which can have severe repercussions for sensitive fish and invertebrates. Even when dissolved oxygen levels are adequate, eutrophication affects higher trophic levels by skewing communities toward massive populations of grazers such as stoneroller minnows and midge larvae. Excessive algal growth can also alter fish and invertebrate communities by changing the nature of the benthic substrates.

The U.S. EPA is in the process of requiring Illinois and other states to establish nutrient criteria for streams and rivers. Under provisions of section 304(a) of the Clean Water Act, the EPA has produced a set of suggested nutrient standards that will protect aquatic ecosystems. The U.S. EPA has encouraged state agencies (e.g., Illinois EPA) to suggest alternative quantitative criteria that are based on scientific research. In response to Illinois’ need for a scientific underpinning for nutrient standards, the Illinois Council on Food and Agricultural Research (CFAR) funded a Water Quality Strategic Research Initiative (SRI) specifically addressed nutrients in Illinois streams. Scientists from the Illinois Natural History Survey (INHS), led by Dr. Walter Hill, are collaborating with researchers from the Illinois State Water Survey and the University of Illinois on CFAR-funded projects investigating the role of phosphorus in stream eutrophication. These researchers are attacking a number of poorly known aspects of stream eutrophication that hinder the development of nutrient criteria. INHS researchers are focusing on establishing a quantitative description of the relationship between phosphorus loading and algal growth in streams. Unlike the situation in lakes, it is currently impossible to predict what effect a given reduction in phosphorus will have on algal growth in streams. The levels of phosphorus needed to cause excessive algal growth are, at best, imprecisely known, and the effects of other algal-limiting factors (e.g., turbidity, floods, temperature, nitrogen, grazers, etc.) on the phosphorus relationship to algal growth are unclear. INHS researchers have established a three-pronged research attack to address these unknowns: (1) statewide surveys of algae, nutrients, and associated ecosystem parameters; (2) intensive research and monitoring in Little Kickapoo Creek to take advantage of the nutrient input by the new Bloomington sewage treatment plant; and (3) nutrient addition experiments in streamside channels and laboratory streams.

Other issues investigated by researchers funded by the CFAR Water Quality SRI include the role of phosphorus regeneration in stream sediments and conditions under which excessive phosphorus loading leads to dissolved oxygen problems.

Walter Hill, Center for Aquatic Ecology and Conservation
Suburbanization is the outward expansion (or movement) of development away from the main portion of a city into previously uninhabited areas, including farmland and wooded forest. Suburbanization is, in general, the result of people wanting to escape the city confines by living several miles (or more) away. The construction of housing developments and shopping malls or “strip malls” continues to increase at a rapid pace due to the demand for rural-type living. New subdivisions are typically built in semi-wooded habitats where a diversity of insects and animals have resided for years. However, encroaching into uninhabited environments puts humans into direct competition with wild animals and plants. Wildlife pests include skunks, termites, wasps, wood-boring insects, and mosquitoes. Some common insect pests include ants, or habitats for many insects and wildlife. New subdivisions are typically built in semi-wooded habitats where a diversity of insects and animals have resided for years. However, encroaching into uninhabited environments puts humans into direct competition with nature. In order to survive, insects and animals compete for food and space. As suburban sprawl encroaches into areas previously occupied by insects and wildlife, this leads to increased calls to pest control operators and lawn-care professionals by homeowners. In general, the people who live in subdivisions are well-to-do and don’t want to deal with insects and wildlife in their homes or landscapes.

New housing developments commonly have pest problems due to the installation of trees, shrubs, flowers, and turfgrass, which are watered and fertilized regularly—thus providing an abundance of food or habitats for many insects and wildlife. Some common insect pests include ants, termites, wasps, wood-boring insects, and mosquitoes. Wildlife pests include skunks, raccoons, and deer.

A combination of insects and wildlife can lead to major problems for homeowners. For example, many new housing developments have large expanses of highly-maintained turfgrass that are irrigated regularly, providing an ideal environment for Japanese beetle, *Popillia japonica*, females to lay eggs. The larvae or grubs that hatch are a viable food source for skunks and raccoons that destroy the lawn while searching for the larvae. Then the homeowner wants to know what can be done to alleviate the problem.

New subdivisions and businesses are being built on land that was once used in growing agriculture crops such as corn and soybean. Herbicides were most likely applied to these fields in order to reduce problems with weeds. However, what is the impact on landscape plants that are exposed to these soils that may contain herbicide residues? It is possible that herbicide residues may stress trees and shrubs enough to increase their susceptibility to wood-boring insects.

Landscapes containing a variety of plant material, especially trees, shrubs, or flowers in the rose family may experience problems with deer because these plants provide abundant food that is easily accessible to the animals. Building wooden homes in previously forested areas where termites or ants exist provides abundant food for these two insect pests. Termites will feed on the wood and ants, depending on the species, will enter homes in search of food or nesting sites. Suburbanization may also artificially create conditions that place undue stress on plants as well as influence natural control by predators and parasitoids. For example, construction activities near tree roots can result in soil compaction, a change in grade, and/or a change in soil pH. All these conditions can injure the root system of plants—increasing stress on pre-existing trees or shrubs. This kind of stress increases plant susceptibility to wood-boring insects.

Shopping mall plantings of trees, shrubs, and ground covers are typically located near buildings or in parking lot “islands.” These plants are surrounded by concrete or asphalt, which absorb and radiate heat, creating a microhabitat that may create stressful conditions, which increases susceptibility to insect pests including scales, aphids, and spider mites. In addition, these microhabitats, which are typically warmer than the surrounding areas, increase the reproductive potential of insect and mite pests. These microhabitats or “islands” are also inhospitable to natural enemies such as predators and parasitoids due to the extreme temperatures, volume of dust, or levels of automobile exhaust. The plants may be so isolated that natural enemies cannot locate the pests. This is referred to as “fragmentation.” For example, mugo pines planted in parking lot “islands” are typically heavily infested with pine needle scale, *Chionaspis pinifoliae*, because natural enemies are unable to locate the scale populations. The question then is: will this result in an increase in insecticide usage? The best way to avoid fragmented landscapes is through proper plant selection, that is, using resistant plant material and incorporating a diversity of plants into a landscape as opposed to pure monoculture plantings.

Suburbanization will continue to be a dominant factor as housing developments and shopping malls expand beyond the cores of cities. However, it is important for humans to understand that just because we inhabit a new area it doesn’t mean we will not have pest problems. We will never eradicate insect pests—they were here first and many are a vital part of the established ecosystem.

*Raymond A. Cloyd, Center for Ecological Entomology and the University of Illinois*
Are Small, Isolated Prairie Preserves Sustainable?

The tallgrass prairie with all its complex interactions among plant and animal species and environmental variables has nearly vanished from Illinois. Prairie remnants are disproportionately found on nutrient-poor sites or other lands with limitations to agricultural development. Remnants on the rich silt-loam soils are particularly scarce due to extensive conversion to agriculture. Prairie remnants persisting on these rich soil types mostly occur in railroad rights-of-way or on lands associated with pioneer cemeteries. Vehicle incursions, abundant weed infestations, fire absence, and continued losses due to agricultural expansions continue to threaten remnants in the railroad rights-of-way. The remnants associated with pioneer cemeteries tend to be small (< 5 acres), isolated, rectangular units, surrounded by agricultural and other land uses where prairie species are absent. However, these areas offer the greatest opportunities to preserve the floristic composition characteristic of the original silt-loam prairies, and many of the best remaining examples have been protected as Illinois Nature Preserves.

Important questions remain: are these small and isolated sites sustainable or is there attrition from the pool of prairie species? Will these species persist in the absence of interactions with many bird and mammal species or even some insect pollinators? Can these sites survive offsite influences such as herbicide drift and do they resist invasion of weedy species from surrounding lands? To answer these questions, a study begun in 2001 was designed to determine current patterns of plant species diversity and assess trends in three high-quality remnants of the rich silt-loam prairies of Illinois. These preserves, Prospect Cemetery Prairie, Loda Cemetery Prairie, and Weston Cemetery Prairie, range in size from three to four acres.

The vegetation was quantitatively surveyed using the standard quadrat sampling frame—50 cm on each side, placed along six parallel transects. The transects were placed in a stratified order across each preserve. Metal rebar posts mark the beginning and end points of each transect.

Based on these sample data, total richness of native plants ranged from 98 to 109 species with total richness of non-native species ranging from 13 to 30 (13% to 28%) at Loda, Weston, and Prospect, respectively. The average number of native species per quadrat (species density) was similar across sites ranging from 13.2 to 14.5/quadrat in the core interior portions of the prairies. Loda Cemetery Prairie, the only site with no grave markings in the preserve, had the greatest native species density and the lowest proportion of non-native species and appears to be the site with the fewest on-site disturbances.

The first signals that changes which could threaten these preserves may be underway would be differences in patterns of diversity and composition between external and internal portions.

The profile of native plant species richness across each site forms a consistent arching pattern with peak diversity in the internal portions. Analysis of the compositional differences between these zones indicates that the edge plots include a greater proportion of weedy species including many woody vines. Comparisons of native and non-native species richness between the “edge plots” in the external 10 m of each preserve and “interior plots” indicate the differences are more than expected from random chance, with native species diversity greater in the internal zones and non-native species greater in the external zones. In most cases (excepting patterns for non-native species at Loda), the contrasts are statistically significant.

These results provide a baseline estimate of species diversity and abundance patterns as a means to make future comparisons. Since such descriptions from this historically species-rich region of the tallgrass ecosystem are surprisingly scarce, these characterizations also provide comparative information for studies of other grasslands. Results from resampling efforts will indicate whether trends show an increase in edge-type vegetation at these preserves or whether on-site management is adequate to sustain these important relics of our natural heritage. If the trends indicate attrition from the pool of prairie species, there will be strong justification for attempting to acquire adjacent lands to augment the prairies with borders of reconstructed prairie to buffer them from some of the effects of edge.
Almost anyone who has ventured into an oldfield or even a garden in late summer has undoubtedly had a close encounter with an imposing yellow and black female garden spider. Her large size, bold colors, and habit of sitting rather menacingly in the center of a large web, nearly always built in open, sunny locations, make the garden spider easily recognizable. Such encounters are unforgettable, if not downright startling.

The black and yellow garden spider, *Argiope aurantia*, is one of two species of garden spider found in Illinois. *A. aurantia* are found from southern Canada, south through the lower 48 United States, Mexico, and Central America. They are found as far south as Costa Rica. These spiders have egg-shaped abdomens with yellow or orange markings on black backgrounds. Their legs are black with the upper portions orange. Like most spiders, the females are larger 19–28 mm, while the males are 5–8 mm.

Garden spider webs are of the classic orb design—a central hub with a geometric arrangement of spirals and strengthening threads radiating from the center like the spokes of a wheel. This design forms a strong, yet flexible structure up to two feet in diameter, making it a highly efficient interceptor of flying or jumping insects as large as grasshoppers. Adding to this efficiency is the unique zigzag pattern of shiny white silk extending from the center of the web. This was once thought to be a warning device to prevent birds or other animals, perhaps even the inattentive gardener, from blundering into the painstakingly constructed web. This was once thought to be a warning device to prevent birds or other animals, perhaps even the inattentive gardener, from blundering into the painstakingly constructed web. However, recent research suggests an even more ingenious purpose. Because it reflects ultraviolet light much like flowers that use these signals to attract insects for pollination, the structure may actually be sending an irresistible invitation to insects.

They may fly into the web thinking they are headed to a flower rather than onto a dinner table!

Once snared in the web, the insect’s struggles are sensed by the female, who has been lying in wait, with her head downward and legs outstretched to better detect even the faintest hint of a meal. She deftly moves to the source of vibration and quickly restrains the captured prey by wrapping it in silk before biting and injecting it with paralyzing venom. This ready-to-eat package is then moved to an out-of-the-way portion of the web so it will not interfere with later catches. The hapless insect can then be sucked dry at the spider’s leisure.

In spite of their impressive sizes and seemingly ruthless demeanor, garden spiders are harmless to humans and should be seen as allies in the garden, even when they cause us heart palpitations in the tomato patch! This Illinois resident will perish with the first hard freeze, leaving only a brown, fuzzy egg cocoon filled with tiny spiderlings that must await the coming spring.
Capture a Garden Spider’s Web

A spider web is a truly beautiful piece of natural art, and you can capture a garden spider’s web and preserve it on a piece of paper. You will need a can of quick drying spray paint, a piece of stiff paper such as poster board, a pair of scissors, and several newspapers. Use a dark-colored paint, such as black or brown, if you use white or light colored paper; use white paint with dark-colored paper.

Find a nicely formed spider web. It will work best if it is not wet from dew or rain. Cut your paper so that it is larger than the web. If the spider is present, shoo it from the web. You do not want to injure the spider as it is beneficial to the habitat. The spider will make a new web once its old one is gone.

Hold the can of paint about a foot from the web and spray it at an angle to the web. Spray paint on both sides. Have a partner hold up a piece of newspaper to catch the paint that misses the web. Quickly place your piece of stiff paper against the web, lifting the web onto it. Have your partner cut the long silk threads that hold the web to the supporting plants.

Lay your collected web on a flat surface for several minutes while the paint dries. Write the date and location where you collected the web on the paper, and the species of spider, if you know it. You can either spray the collected web with clear acrylic to protect it or place it in a picture frame with a piece of glass or plastic in front of it.
Communicating Nature

Much of the course was designed to help students see the natural world and their own capacities anew. A sample exercise consisted of drawing from an upside-down image. Nixon, the drawing instructor, feels that this activity forces the artist to examine the actual contours of a subject, freeing him or her of the mind’s preconceived notions of, say, a duck. Many of the students were shocked at how effective their drawings turned out, when viewed right side up.

Coupled with observation, of course, is the fundamental act of recording. Recording requires tools, and students spent a good deal of time practicing the basic skills in each genre. As the photography instructor, Jeffords emphasized the importance of precision. An image that is perfect in all other respects will still fail if it is blurry. He taught photography as a matter of levels, grounded in basic technical knowledge of the equipment, proceeding to artistic variables (depth of field, perspective, etc.) and finally to pure aesthetic tools (e.g., composition). He removed the mystery from creating striking images by breaking the process down and showing that the aim is to be thorough and thoughtful at every level.

Hands-on experience was an important part of the course. There were three field trips: to Matthiessen State Park and Lodge Park in Illinois and Turkey Run State Park in Indiana. Here students learned to distinguish between theory and practice. Birds aren’t cooperative drawing models, wind-blown plants are challenging to photograph, and it’s hard to make a description of a sunset cliché-free. Students realized that after learning the fundamentals of any art, the payback comes with practice.

NRES 499 involved near constant peer review, in class as well as through an on-line forum. The culmination of this process, and indeed of the entire course, will be a real-world exercise in communicating nature. Watch for the Fall 2005 issue of the Illinois Steward. Every article, drawing, and photograph in the issue will be the work of this pioneer group of NRES 499 students. The enthusiasm of the students as well as the quality of their work demonstrate that there is a need for courses such as this one. The idea is not so outlandish, in the end, since higher education was initially intended to provide just this—a truly well-rounded education.

Andrea Appleton, Office of the Chief