Grassland for Prairie Chickens: How Much is Enough?

The first of scattered sanctuaries for prairie chickens were acquired with extremely limited funds in the early 1960s by the Prairie Chicken Foundation of Illinois and The Nature Conservancy. Little information was available on the amount of grassland that would be required to preserve the species in Illinois. Also, estimates of the number of individuals of a species that constitute a minimum viable population ranged from 50 to 500; the latter allowed for evolutionary processes to continue over the long term.

Initial goals called for 1,000 acres in each of two counties (Jasper and Marion) to develop and maintain two breeding populations of about 500 birds from extant remnant flocks. A sex ratio of approximately 50:50 was assumed. These goals were believed to be realistic because prairie chicken numbers soared from about 80 to 400 (40-206 cocks) between the mid-1960s and early 1970s in Jasper County. This dramatic response occurred with only 660 acres of sanctuary grassland available to the birds by spring 1972. Nevertheless, the sanctuary goals were raised to 1,500 acres in each of two counties in 1973 to allow for probable intensification in farming practices.

By spring 1982, a similar encouraging response occurred in Marion County with an increase to about 230 prairie chickens (116 cocks) with only 450 acres of sanctuary grassland. For 19-year periods, densities averaged 93 and 83 cocks per square mile of managed land for Jasper and Marion counties, respectively. Thus, for nearly two decades, 100 prairie chicken cocks per square mile of sanctuary grassland appeared to be a realistic density goal for Illinois. Two sanctuary systems, each with 1,500 acres, well-situated, properly managed, and well-used by the birds, appeared to be at least minimum goals with which to achieve long-term preservation of the species.

Unfortunately, land acquisition goals were not attained and the favorable responses did not continue into the current decade. By spring 1994 in Jasper County, the count of prairie chickens on booming grounds had declined to six Illinois cocks plus two translocated Minnesota cocks. This brink of extinction occurred despite a new record of nearly 1,000 acres of sanctuary grassland available in 1992 to the prairie chickens at Bogota. The situation was not much better in Marion County where the cock count ranged from 9 to 18 in the past five springs with approximately 500 acres of sanctuary grassland.

Continued on back page
Fish display enormous reproductive potential and highly variable survival rates during their juvenile year. Individual females of many species annually produce thousands or hundreds of thousands of larvae, most of which die during the first few weeks of life. However, if favorable conditions occur at critical times, larval fish survival may increase substantially, resulting in unusually abundant year classes. Consequently, the number of young fish that eventually reach maturity, or “recruit,” may depend to a large extent on the conditions during their early life history.

One idea that biologists have devised to explain the dynamics of early life history and variable fish recruitment is the Match-Mismatch Hypothesis. According to Match-Mismatch, adult animals should spawn when resources are plentiful, thereby enhancing the chance their offspring will recruit. Fish produce more offspring and enjoy greater fitness if they “match” spawning to the peak abundance of the zooplankton diet of their larvae. Individuals that spawn too late or early or during years with low zooplankton abundance “mismatch” and produce slow-growing offspring that either starve or are consumed by predators. Although this idea has been applied primarily to marine ecosystems, freshwater flood pulses also create discrete periods of high productivity similar to those assumed by the Match-Mismatch Hypothesis.

Analyses from Lake Shelbyville, Illinois, a flood-control reservoir built by the Corps of Engineers (COE), have sought to apply the principle of Match-Mismatch to a freshwater system. Each fall, the COE lowers Lake Shelbyville to a level below normal pool. The next year, a significant portion of the spring flood is impounded to inhibit flooding downstream. This flow regulation strategy results in a single, large flood peak within the reservoir that generates a burst of phytoplankton and zooplankton production. Field data from this system show that higher abundance and survival of larval fish occur during the period following floods.

Using seven years of electrofishing data collected in Lake Shelbyville by the INHS Kaskaskia Biological Laboratory, and lake-level data from the COE, we created a simple empirical model based on the principles of the Match-Mismatch Hypothesis to predict juvenile abundance of the omnivorous fish species gizzard shad (*Dorosoma cepedianum*). Assumptions of the model for Lake Shelbyville include 1) adult gizzard shad always produce larvae in excess of carrying capacity, 2) the height of the flood pulse determines the abundance of resources for larval fish, 3) the total number of surviving larval and therefore juvenile fish increases with the availability of flood-generated resources during the larval stage, and 4) larval survival increases as flood pulses near an optimal date that corresponds with a predictable annual peak of sexual maturity within the adult gizzard shad population. Model parameters include the height and the date of the flood peak. For the past two years, this model has produced successful a priori predictions of juvenile gizzard shad abundance, and now explains 83% of the variability in juvenile gizzard shad abundance over the last nine years.

Application of the Match-Mismatch Hypothesis in flood-prone waters may benefit researchers, managers, and resource users. For instance, predictions from the flood model could guide water-level manipulations to manage shad populations to the benefit of sportfish. If Match-Mismatch principles are sufficiently general in freshwater systems, knowledge of these interactions may facilitate conservation of economically important or endangered species, particularly in systems with managed flows. Current needs include an exploration of flood-driven recruitment in systems and with species that challenge or violate model assumptions to varying degrees.

Timothy B. Smith and David H. Wahl, Center for Aquatic Ecology

Predicting Juvenile Fish Abundance From Characteristics of the Spring Flood

**Gizzard shad from Lake Shelbyville.**
The European corn borer (ECB), *Ostrinia nubilalis*, is one of the most destructive insect pests of corn in the Midwest. ECB reduces corn yields by 5% annually (a loss of 540 million bushels) at an estimated farm value of $1.1 billion. Populations of ECB in recent years have increased because the trend for less tillage causes less disturbance of overwintering larvae, and early planting of long-season hybrids enhances both generations of ECB. Corn borers may attack any part of the plant above ground from the early whorl stage until corn is harvested. Borers injure plants by feeding on ears and tunneling in stalks and ear shanks. The holes and tunnels weaken the stalks and provide entry for pathogens that cause stalk rot, premature drying, broken plants, ear drop, and subsequent yield loss.

Growers have managed ECB with cultural practices like stalk destruction and fall plowing to reduce overwintering densities. During the growing season, they may apply chemical or microbial insecticides if scouting reveals that ECB densities have exceeded the economic threshold. Although applicators use microbial insecticides, like DiPel, that contain the delta endotoxin of the bacterium *Bacillus thuringiensis* (*Bt*) to control ECB in the Corn Belt, the effectiveness of these insecticides has been inconsistent. However, the use of *Bt* for control of ECB entered a new era in the spring of 1996 when Ciba Seeds and Mycogen Plant Sciences received approval from the Environmental Protection Agency to sell transgenic corn (*Bt*-corn) with “built-in” insect resistance. *Bt* is a bacterium that produces a crystalline protein (delta endotoxin) that is toxic to certain insects. When ingested by a susceptible insect, the protein breaks down in the insect’s midgut, causing gut paralysis. The affected insect stops feeding and dies within a couple of days. Modern gene transfer techniques have been used to develop corn plants that contain the endotoxin-producing gene [Cry1A(b)] taken from *Bt*. The endotoxin is expressed at high concentrations in the leaves and other green tissues throughout most or all of the growing season.

For the past three years, scientists at the Illinois Natural History Survey have worked with extension entomologists at the University of Illinois to examine the efficacy of *Bt*-corn against ECB. *Bt*-corn greatly reduces the amount of leaf and stalk feeding by ECB larvae, resulting in more erect plants, fewer dropped ears and broken stalks, and higher yields. One of the benefits of controlling ECB with *Bt*-corn is reduced use of chemical insecticides. *Bt*-corn is not hazardous to the environment and is not toxic to humans and other mammals, birds, fish, and beneficial insects.

The effectiveness of *Bt*-corn varies among hybrids. Because the level of expression of the endotoxin declines in some hybrids after pollination, second-generation borers may survive and tunnel in the stalks, shanks, and ears. Growers must be aware of these differences and adjust their expectations accordingly.

A major concern about the use of *Bt*-corn is the potential for ECB to develop resistance to the *Bt* endotoxin. Although field populations of ECB currently are not resistant to *Bt*, a laboratory colony exposed to selection pressure by *Bt* has developed resistance. Therefore, resistance management strategies for the deployment of *Bt*-corn are crucial.

Current studies at the Natural History Survey will help farmers make decisions about using *Bt*-corn. In the near future, transgenic technology likely will produce plants resistant to black cutworms and corn rootworms. These tools will be used in a completely integrated pest management program for long-term benefits to agriculture.

*John Shaw and Kevin Steffey, Center for Economic Entomology*
If you travel through the northern two-thirds of Illinois during late July and August, you may notice soybean leaves turning yellow prematurely. The yellowing of the leaves is due to interveinal necrosis of the leaf tissue. Longitudinally splitting these soybean stems will reveal a dark, reddish-brown discoloration. You are looking at an important soybean disease called brown stem rot. The disease was first reported in Illinois some 50 years ago, and it occurs in the north-central United States and Canada. Brown stem rot, which is caused by the fungus *Phialophora gregata*, is responsible for up to 25% yield loss in soybeans.

Brown stem rot is difficult to recognize because it often has no outward symptoms. The most common practice in identifying the disease is by looking at the browning of the soybean stem; however, stem browning is not exclusively associated with brown stem rot. Other fungi also cause browning of the stem but do not cause this disease. Therefore, conclusive identification of the disease involves isolation and identification of the pathogenic fungus from the diseased stem. The process of isolation and identification is time consuming, and a more efficient identification procedure is required for rapid diagnosis of the disease.

We are working to develop an alternative and efficient diagnosis technique of soybean brown stem rot. We collected more than 80 accessions of the pathogen from five north-central states and from Brazil and Japan. Accessions of the pathogen were compared among themselves and with other fungi that are also associated with soybean stems using molecular techniques, such as polymerase chain reaction (PCR) and DNA sequencing. PCR is a technique that allows amplification of a specific piece of DNA from a minute amount of DNA material. We have identified a piece of DNA that is uniquely shared by all the accessions of the pathogen and differentiates the pathogen from other fungi. Based on the sequence information of this unique piece of DNA, we designed oligonucleotides (primers) that allow sensitive detection of the genetic materials of the pathogen within infected soybean plants. By using the PCR technique with the specific DNA primers, we are able to unambiguously identify the brown stem rot disease within hours, whereas the traditional identification process of isolating the pathogen would take three weeks.

We are currently using this technique to study the mechanisms of soybean resistance and to identify new sources of resistance.

Weidong Chen, Center for Biodiversity, in cooperation with Lynn Gray, USDA-Agricultural Research Service at Urbana, and Craig Grau, University of Wisconsin at Madison.

Soybean plot with healthy plants and plants infected with brown stem rot (lighter area at center right).

Cross sections of stems infected with brown stem rot.
New Publications and Educational Materials

**Illinois Mussels**

A new color poster showing 30 of the 80 native freshwater mussels of Illinois and 2 exotic bivalves (the Asian clam and zebra mussel) has been published. The poster was produced by the Illinois Department of Natural Resources - Educational Services Section and was developed by Kevin Cummings of the Illinois Natural History Survey’s Center for Biodiversity and Robert Warren, archaeologist with the Illinois State Museum (ISM), in cooperation with the Education and Publications Sections of the ISM. Additional funding was provided by the Illinois Department of Transportation, Bureau of Design and Environment.

The poster is two-sided: the front shows the striking diversity of form and color of freshwater mussels (including commercial, common, rare, threatened, endangered, and extinct species); the back contains information on mussel anatomy, life history, commercial harvest, conservation, and a short glossary and bibliography of useful references.

Teachers may obtain single copies free of charge by written request on school letterhead to:

Illinois Department of Natural Resources Educational Services Section
524 South Second Street - Room 530
Springfield, IL 62701-1787.

Individuals, other than teachers, wanting a poster should send $5 (to cover the cost of the mailing tube, postage, and handling) to:

Illinois Natural History Survey Distribution Center
607 East Peabody Drive
Champaign, IL 61820

Make checks payable to Illinois Natural History Survey. For more information, please call the INHS Distribution Office at (217) 333-6880.

**Field Guide to Northeastern Longhorned Beetles**

This hardcover book by Douglas Yanega contains 184 pages including color photos of the nearly 350 species of longhorned beetles to aid in identification. Each photo is accompanied by a complete diagnostic description and synopsis. Chapters also cover beetle morphology, natural history, and collection and care of specimens. The book is designed to be taken into the field. It sells for $15 (price includes postage for domestic or international orders) and can be ordered from:

Illinois Natural History Survey Distribution Office
607 East Peabody Drive
Champaign, IL 61820
Ph (217) 333-6880

**Land Cover of Illinois**

A 1:500,000 scale wall map measuring 52 x 31 inches and containing 20 land-cover classes is available from the Department of Natural Resources. Cost is $5 for folded maps and $10 for unfolded maps shipped in mailing tubes. This striking full-color map shows the location and extent of Illinois’ land cover. Land Cover of Illinois is based on satellite data and was developed at the Illinois Natural History Survey. For ordering information, please contact:

Illinois Department of Natural Resources - Clearing House
524 S. Second St.
Springfield, IL 62701-1787
Ph (217) 728-7498

**Fishes of Champaign County, Illinois, During a Century of Alterations of a Prairie Ecosystem**

The latest in the INHS Bulletin series, Volume 35(2), summarizes four surveys of Champaign County streams from 1889 to 1988. Written by Weldon Larimore and Peter Bayley, this publication compares the abundance, distribution, and variety of fish species collected in the four surveys and how these variables have changed from survey to survey in response to human-induced changes to the ecosystem. The Fishes of Champaign County provides accounts of one of the most thoroughly surveyed areas for fishes anywhere on earth. The cost of this bulletin is $10 (price includes postage for domestic or international orders) and it can be obtained at:

Illinois Natural History Survey Distribution Office
607 East Peabody Drive
Champaign, IL 61820
Ph (217) 333-6880
A winter walk in the woods is the best time to appreciate the stately American beech with its rounded crown of many long-spreadling and horizontal branches. The most distinguishing feature isn’t its shape, however, but the smooth, steel-gray bark that covers the trunk and branches like a tight skin. To the envy of humans, even in old age the beech retains its smooth bark. Unfortunately, this smoothness is as irresistible as wet concrete to human scribes and the bark is usually disfigured by initials or carvings that remain for the life of the tree. This permanent, arboreal record-keeping is made possible by the rapid formation of wound cork (the tree’s equivalent to a scab that forms over skinned knees). Tears, cuts, or incisions in the bark are quickly sealed over by the cork cambium, leaving distinctive scars. One of the oldest scars on an American beech was made by Daniel Boone—“D. Boone cilled a bar on tree in year 1760.”

Only one species of beech, _Fagus grandifolia_, grows in North America, and colonists quickly learned that its presence indicated good soil; the trees grow in deep, rich loam. Beech trees are typical of the hardwood forests of the eastern United States. In Illinois, growing along the eastern border, they represented a transition between the beech-maple forests of the east and the prairie and oak-hickory forests of the west. The American beech can be found in Lake and Cook counties, the southern fourth of the state, and extending along the eastern border from Vermilion County south.

Beeches are slow-growing and may attain an age of 300 to 400 years. Heights of 70-120 feet are common. Their roots are shallow and spreading, except for a deep tap root. The flowers and leaves appear together, from April to May, and both sexes are on the same tree. Male flowers (staminate) are in round heads on long drooping stems. The female flowers (pistillate) are in clusters on short stems. The leaves are alternate, shiny green, elliptical, and have saw-toothed edges. In the fall they turn yellow or bronze. Pioneers collected the leaves in autumn to fill their mattresses. A settler wrote in 1862, “The smell is grateful and wholesome, they do not harbor vermin, are very elastic and may be replenished annually without cost.”

The fruits of the beeche are small triangular nuts enclosed in a spiny bur. The bur splits open in October releasing the nut meats. These nuts, which are 20% protein and 50% fat, are responsible for the generic name _Fagus_, which means “to eat.” The early pioneers fattened their Thanksgiving turkeys and hogs on beech nuts. The beech nut was also the number one food choice of the passenger pigeon. A single bird could consume a half pint of nuts a day.

When Prince Maximilian toured the Midwest in 1833, he commented that the beech forests were “the most splendid forests I had yet seen in America.” For a glimpse of a beech forest visit the Russell M. Duffen Nature Preserve at Forest Glen in Vermilion County. American Beech Woods Nature Preserve in Lincoln Trail State Park in Clark County, Robeson Hills Nature Preserve in Lawrence County, and along Hamburg Hill in Union County.

### Teacher’s Guide to “The Naturalist’s Apprentice” (facing page)

**What Tree Is That?**

**Objective:** to acquaint students with the concept of biological keys

**Materials:** multiple copies of _What Tree Is That?, leaves from various trees found in the key_

**Vocabulary:** biological key, dichotomous, systematist, taxonomist

**Comments:** Scientists who locate, describe, name, and determine the relationships of species of organisms to other species are called taxonomists or systematists. To identify organisms, these scientists assemble taxonomic information and arrange it in a logical form called a key. Although there are dozens of types of keys, we will use the dichotomous key, _dich_ meaning two parts and _tomous_ to divide. Thus, a dichotomous key consists of two choices that have other choices associated with them. Students will construct a key to the leaves of the most common types of trees.

**Procedure:**

1. Have students learn the various types of leaves and become familiar with the key.

2. Students then try to identify the three unknown samples at the bottom of the activity. Answers: _oak, maple, yellowwood._

3. Bring in leaves from the various type of trees found in the key and have students attempt to identify each from actual specimens.
What Tree Is That?
Use the key to identify the three unknown trees shown below.

1. Leaves alternate ........................................................................................................................................2
   Leaves opposite or whorled ..........................................................................................................................7
2. Leaves simple ..................................................................................................................................................3
   Leaves compound .........................................................................................................................................6
3. Leaves fan-shaped with notch at tip..........................................................................................................gingko
   Leaves not fan-shaped, lacking notch at tip .................................................................................................4
4. Leaves entire ..................................................................................................................................................magnolias
   Leaves lobed or toothed ...............................................................................................................................5
5. Leaves lobed ..................................................................................................................................................oaks
   Leaves toothed .............................................................................................................................................elms
6. Leaflets small .............................................................................................................................................honeylocust
   Leaflets large .............................................................................................................................................yellowwood
7. Leaves whorled .............................................................................................................................................catalpa
   Leaves opposite ...........................................................................................................................................8
8. Leaves simple ..................................................................................................................................................9
   Leaves compound .......................................................................................................................................10
9. Leaves palmately lobed ..............................................................................................................................maples
   Leaves entire ...............................................................................................................................................dogwoods
   Leaves palmately compound .....................................................................................................................buckeyes
10. Leaves pinnately compound .....................................................................................................................ashes

Leaf Types Used in Key
fan-shaped     entire     lobed     toothed     small leaflet
large leaflet  whorled  opposite  compound  palmately lobed

palmately compound  pinnately compound  simple

Unknowns:
Factors documented to have decimated prairie chicken numbers include (1) poor nest success due to predation in some years, (2) intense interactions with pheasants, (3) declining egg quality symptomatic of genetic deficiencies, and (4) intensifying land use on private cropland adjacent to the sanctuaries (the list of other probable negative factors is too long for this report). Illinois Department of Natural Resources (IDNR) sanctuary managers have successfully controlled nest predators and pheasants in recent years. So far, genetic management via translocation of prairie chickens from large populations in Minnesota, Kansas, and Nebraska also appears successful. From only 6 Illinois cocks in spring 1994, numbers increased to 70 cocks by spring 1996 on at least four well-established booming grounds in Jasper County. Limited data on egg fertility and hatchability suggest that egg quality has returned to normal. Moreover, new sanctuary acquisitions by the IDNR of 60 and 215 acres in 1995 bring the total to 1,636 acres in Jasper County. These changes enhance the survival prospects for prairie chickens in Illinois.

Still, an answer to our initial question, How much grassland is enough?, remains evasive. Attainment of 1,500 acres of quality grassland may soon become a reality, at least in Jasper County. Sanctuary land in Marion County remains at 760 acres, only half the minimum goal.

Estimates derived from one predictive model suggest a need for about 4,000 acres of suitable grassland to sustain a population containing 200-250 prairie chicken cocks. The estimate from this model was based on prairie chicken research in Minnesota and Wisconsin conducted on range acquired after European settlement, that is, not the species’ original range. Application of the same formula to Illinois data (using means for interbooming ground distances and cock numbers per booming ground) suggests that only 1,500 acres may indeed do wonders on Illinois’ original prairie chicken range. This quantity of grassland appears especially workable if brome (Bromus inermis), a preferred grass, is emphasized in sanctuary management. However, using several other estimation approaches, a need for several thousand acres of grassland is indicated. Currently, some geneticists calculate that more than 10,000 individuals might be needed to ensure long-term species survival. Researchers are clearly challenged to identify quality habitats and determine how much will be enough.

Ron Westemeier, Center for Wildlife Ecology