Innovative Woodland Management Methods Produce Multiple Benefits

In Illinois, as in many parts of the country, most of the wooded landscape is controlled by nonindustrial private owners. Most of these private woodlands, however, are unmanaged or mismanaged. This is unfortunate because good management can greatly increase the economic and environmental values of woodlands.

Many attempts have been made by natural resource agencies to stimulate active management of private woodlands. Numerous factors are involved, but the traditional fixation of foresters on commercial timber production has been an important part of the problem. Foresters are now listening more carefully to the desires of woodland owners and are beginning to design management systems that will better meet the objectives of their clients.

Woodland owners are saying they want their woodlands to provide good wildlife habitat, natural beauty, firewood and timber for personal use, and recreational opportunities, as well as income from the sale of wood products.

Two "new" approaches to the problem of producing multiple woodland benefits on small acreages are being developed by Survey ecologist Christopher Burnett. The investigation of these methods was initiated as part of a study on Illinois' woody biomass energy resources (see *INHS Reports*, Nos. 261 and 267), but the practices have much broader application. Although the methods being researched are new to North America, they are based on ancient woodland management traditions of pre-industrial Europe where multi-purpose woodland management was practiced for many centuries.

The first method under study is coppice with standards. Coppicing is the practice of periodically cutting trees off at the ground and allowing them to regenerate from stump sprouts; a coppice is simply a woodland composed of such trees. Much research has been conducted recently on coppicing dense plantations of fast-growing trees as a commercial energy source, but these techniques are designed for large-scale industrial use rather than for small landowners. Furthermore, industrial energy coppices produce few environmental benefits. They usually contain only one species and are harvested in large clearcuts on very short cycles. In contrast, traditional coppices are composed of
several species, and include a substantial proportion of standards, trees that are allowed to grow for several coppice cycles before being harvested. Thus, the coppice-with-standards method continuously maintains a diverse vegetation throughout the entire woodland. This vegetation structure not only provides a ready supply of diverse wood products, it also provides good wildlife habitat, soil protection, and visual quality.

The second method is a variant of coppicing known as pollarding. Where livestock or certain kinds of wildlife are abundant, it is difficult to regenerate trees after a harvest by seedlings or sprouts because of browsing on the tender stems. Pollarding solves this problem by cutting trees off on tall stumps so that the regenerating sprouts are above the reach of browsers. Pollarding is still widely practiced in other parts of the world today and has good potential for several applications in the Midwest. In pasture systems, pollards can provide protection for livestock without reducing forage production, and they are compatible with fire management of native prairie grass forages. In fencerows, pollards provide a windbreak without occupying too much land. Wherever they are used, pollards tend to develop cavities that are critical for many types of wildlife.

Copies of the report, Woody Biomass Energy Resources of Illinois, (R982) may be obtained from the Survey.

By Christopher Burnett, Section of Wildlife Research

Identification of Toxic Substances in the Upper Illinois River

The Illinois River was once one of the most biologically productive rivers in the United States. In 1908, a 200-mile reach of the river between Hennepin and Grafton produced 10 percent of the total U.S. catch of freshwater fish. Over 2,000 commercial fishermen were employed to harvest 24 million pounds of fish (178 pounds per acre) annually. Waterfowl occurred in such abundance that they were hunted and trapped for commercial markets as well as for sport.

By 1970, the annual fish harvest had dropped to just 4 pounds per acre and waterfowl populations were a minute fraction of their former levels. The situation has not improved since then.

Past studies at the Natural History Survey suggest that the decline in populations of bottom-feeding fish and diving ducks was caused by the disappearance of their food base, sediment-dwelling aquatic invertebrate species. Other Survey studies have shown that these invertebrates cannot re-establish themselves in the Upper Illinois River because of one or more toxic substances in the bottom sediments.

In early 1989, two Aquatic Biology Section scientists, working in collaboration with Southern Illinois University, will begin a study of the problem to discover what is causing the toxicity and to pinpoint its source. They will sample sediments at 1-mile intervals along the river from Joliet to Chicago. These samples will be screened for toxicity by a series of rapid, low-cost laboratory tests with microscopic bacteria, algae, and nematode worms. Samples found to be "hot" will be studied in greater detail. Using differential solvent fractionation, groups of chemical constituents extracted from the sediments will be tested individually to detect the most toxic fractions, greatly narrowing the range of possible target compounds. The most toxic chemical fractions will then be tested in a functional bioassay with one of the invertebrate food species that has disappeared from the study area—the fingernail clam, *Musculium transversum*. Researchers will return to the sites where the most toxic samples were taken and sample again at much closer intervals.

At the conclusion of the 2-year study, the investigators hope to know the source and what caused the declines in invertebrate populations. Armed with this knowledge, the State's environmental managers will be able to reduce and control the contamination, allowing invertebrate populations from unpolluted tributaries to recolonize the Upper Illinois River.

This project is funded jointly by the Environmental Protection Trust Fund and Southern Illinois University, with microscopic bacteria, algae, and nematode worms. Samples found to be "hot" will be studied in greater detail. Using differential solvent fractionation, groups of chemical constituents extracted from the sediments will be tested individually to detect the most toxic fractions, greatly narrowing the range of possible target compounds. The most toxic chemical fractions will then be tested in a functional bioassay with one of the invertebrate food species that has disappeared from the study area—the fingernail clam, *Musculium transversum*. Researchers will return to the sites where the most toxic samples were taken and sample again at much closer intervals.

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Water Stress and Its Effect on Plant Growth and Crop Yield

Since the earliest days of agriculture, man has recognized the inhibitory, and sometimes devastating, effects of drought on crops. The summer of 1988 brought more awareness of the importance water plays in plant survival. When water is limiting, almost all aspects of plant development are affected, but the most visible effects of drought are a reduction in plant growth and a decrease in crop yield. Both plant growth and crop yield reflect dry matter accumulation by the plant, which depends largely on net photosynthesis; total photosynthates or sugars produced minus those that are used to maintain plant growth and vigor. Thus photosynthesis is a very critical plant function and it is affected greatly by availability of moisture. The level of water stress a plant experiences during periods of low rainfall depends on a number of factors; e.g., the rainfall pattern, the type and profile of the soil in which the plant grows, the root system of the plant (deep vs. shallow), and the environmental conditions to which the plant is exposed (wind, temperature, and relative humidity). The water-stressed condition or water potential of plants is generally expressed in bars or pascals (1 bar = 100,000 pascals) and they are always negative values since the free energy of pure water is zero.

Not all plant species respond to water stress to the same degree. For example, net photosynthesis, or dry matter accumulation, of two important Illinois crops is quite different. In soybean, net photosynthesis is relatively unaffected until the water potential of the plant drops below -11 bars. Corn, however, shows a decline in photosynthesis whenever the water potential drops below -3.5 bars. At a water stress of about -15 bars net photosynthesis is inhibited by about 75 percent in corn but only by about 40 percent in soybean; photosynthesis in soybean is less sensitive to water stress than in corn. The photosynthetic response to water stress is a physiological attribute and can be altered by plant breeders through genetic manipulation. For example, released soybean varieties between 1935 and 1975, an average water potential that plants experienced improved by 14 percent and grain yield increased by 18 percent. Once there is an understanding of the physiological mechanisms that are inhibited by water stress, further improvements will be forthcoming.

Plant water potentials of -3 bars are generally considered normal conditions, and values of -10 to -12 bars are common for plants grown out-of-doors during summer months. Some plants are quite resistant to water stress. Field-grown red beet for example does not show an inhibition in photosynthesis...
until the water potential drops below -20 bars, and some species of mimosa are even more resistant, inhibition of photosynthesis does not start till the water potential is well below -30 bars. In general terms it means that everything being equal, plants that show less inhibition in photosynthesis during dry summer conditions have a better chance of survival than plants that cannot tolerate drought.

Plant growth is a function of cell division, that is an increase in number of cells and of cell enlargement, an increase in cell size. Both cell division and enlargement result in an increase in biomass or dry matter. During drought stress when photosynthesis is inhibited, cell division is more dramatically affected than cell enlargement; and it is for this reason that formation of new twigs or branches is inhibited to a greater degree than twig or branch elongation.

The exact relationship between decreases in vegetative dry matter and grain yield is not clear. Yield is determined more by total photosynthesis taking place over the whole growing season rather than that which occurs during the seed-filling period alone. From all evidence, translocation of dry matter from the vegetative parts of the plant to the seed is less sensitive to drought than photosynthesis. From an evolutionary point, redistribution of biomass is probably a noteworthy mechanism for assuring the survival of a species under dry conditions.

It is well known that moisture stress increases membrane permeability, making the photosynthetic apparatus more fragile. The increase in membrane fragility has been explained in terms of changes in its structure and it was found that water stress significantly affects important structural lipid components of membranes. In future research, the biochemical control of membrane modification will be examined by Survey scientists.

By Claus Grunwald, Section of Botany and Plant Pathology