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Trees on the Great Plains: Agro-Ecosystem Diversity

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L. Hodges presenting research results on impacts of tree shelterbelts on growth and yield of cabbage to visiting international agronomists.

The University of Nebraska and the Forest Service collaborate in an eight-discipline, twelve-person project. They look at "life on the edges."

Agriculture in the Great Plains faces increasing pressure for environmental stewardship and for more economical farming and pest management practices. The concept of sustainable agriculture was developed to address these needs. A sustainable agricultural system is one that consistently enhances environmental quality and the resource bases, provides basic human food and fiber needs, is economically viable, and enhances the quality of life for farmers and society. In the Great Plains, we define agroforestry as the use of trees to help make agricultural production systems more sustainable. The trees function to conserve soil, water, wildlife, and other natural resources. They also improve water quality while maintaining natural resources and crop and livestock productivity and profitability.

The use of trees in agroecosystems impacts the microclimate and biological environment of the systems. Agroforestry ecosystems are composed of crops, trees, soils, invertebrate and vertebrate wildlife, and many other components. The roles of each component and how the components interact within the system must be better understood before effective guidelines can be developed for managing the agroecosystem.

In the Great Plains, farmers and urban dwellers rely extensively on synthetic pesticides to control insect pests and help produce more crops. This has created problems such as pest resistance to pesticides, unintentional pesticide damage to nontarget organisms, and contamination of the ecosystems. New methods are needed to control pests. Native natural enemies can provide long-term protection from most forest defoliators and be used to control pests of crops in the Great Plains. However, farming, urban development, and other practices have destroyed most ecosystems that provided long-term habitat for natural enemies of crop pests. Crops now cover extensive areas of the Great Plains. Farming, urban development, and other practices have destabilized most of the ecosystems in the Great Plains that provided long-term habitat for natural enemies of insect pests. Because tree plantings are the most stable component of this otherwise unstable human-modified ecosystem, they can be used to enhance and conserve populations of natural enemies. Tree plantings can affect natural enemy abundance by altering the microclimate in adjacent areas, by providing food, protection and reproduction sites, and by providing the vertical and horizontal diversity needed by many vertebrate and invertebrate natural enemies.

Trees in agricultural ecosystems increase farm outputs and enhance the human and natural environment. Research in Nebraska and throughout the world has demonstrated that tree windbreaks (shelterbelts) modify wind profiles, temperatures, available moisture and other microclimate factors. Trees also provide food and shelter for many kinds of wildlife, including arthropods and birds. Many of these arthropods and birds are important natural enemies of tree and crop pests and have the ability to reduce destructive insect infestations. Insecticides, fertilizers, and cultural practices impact pest insects as well as their natural enemies. Furthermore, inputs of insecticides and fertilizers have replaced the interactions among pests and their natural enemies.

In agroecosystems, plant and animal diversity is particularly high along edges where crops and trees are in close proximity. These edges could serve as refuges for both beneficial and pest species during periods of unfavorable conditions within the crops. The use of tree windbreaks to enhance natural enemy populations is an attractive alternative to pesticides in the rural landscape. Little is known about the insect populations or the diversity of insect species found in tree windbreaks common in the Great Plains. Insect diversity in the edge zones where crop and trees meet is also largely unexamined. Most available information on the influences of tree windbreaks on arthropod natural enemies is scattered, was obtained in forest ecosystems, and does not pertain to agroecosystems of the Great Plains. In addition, information on how tree and crop management practices influence abundance of wildlife, such as resident and migratory birds is extremely limited.

In 1991, scientists representing eight disciplines from two agencies (the USDA Forest Service and the University of Nebraska) and five university departments (Forestry, Fisheries and Wildlife; Horticulture Agricultural Meteorology; Entomology; and Biometrics) met to form an Agroforestry Team. The purpose of the team is to explore the nature of agroforestry ecosystems, to understand the differences between sheltered and exposed systems, and to develop ways to optimize aspects of these systems most appropriate for sustainable management. Funding to date for the various projects has been through the U. S. Forest Service Hatch funds, McIntire-Stennis funds, and an Agriculture in Concert with the Environment (ACE) USDA grant. Two of the projects led by women researchers will be described a third project features the research of two women graduate students on the diversity and numbers of birds using riparian woody and herbaceous edges and windbreaks and herbaceous edges and adjacent crop fields.

Quality, Quantity, and Pests of Vegetable Crops

Project Leader: Laurie Hodges Although several studies show that windbreaks increase dryland yields of corn, wheat, and other field crops, and that the yield lost by ground occupied by windbreaks is more than compensated for by increases in the quality and quantity of the harvest, the precise effects of shelterbelts on vegetable production are not well understood. The direct effect of shelter on vegetable yield is only part of the story. The time of harvest and quality of the harvested product also have a major effect on the economic viability of an enterprise. Vegetable quality is as important as yield and has a direct impact on net profitability of the crop.

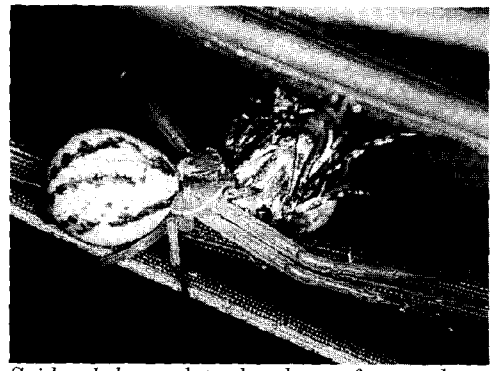
Muskmelon grown in sheltered and exposed sites, for example, are being compared for earliness, percent culls, average weight per head, head shape, cavity size, color, sugar and sugar components, and levels of damage from insects and diseases. Cabbage cultivars grown in sheltered and exposed sites are being compared for head density or solidity, color, pungency, levels of vitamin C and folic acid, percent culls, marketability, average weight per head, pest damage, and earliness. Sequentially planting snapbeans within the protected zone provided by tree windbreaks takes advantage of the microclimate changes in the protected zone, especially warmer air and soil temperatures, effectively extending the growing season by 7 to 10 days, thus providing a marketable crop when economic returns generally are highest. This information will be used to develop recommendations for growing vegetables near tree windbreaks, management guidelines for sequencing the vegetable crops, and harvest scheduling and labor needs.

Incorporating vegetable crop production with traditional grain production systems characteristic of the Great Plains provides diversification of the farm's economic base. It also provides additional food and habitat for the insect pests of the various crops and the natural enemies of these pests. Little research has been conducted toward understanding the extremely complex dynamics of predator and prey in relation to high value horticultural crop production in the lee of tree windbreaks. The landscape scale or systems approach to pest management within this agroecosystem will be necessary to develop sustainable production systems incorporating crops with very low tolerance for insect damage and where the damage has a direct economic impact on market quality. This aspect is being studied under the next set of projects.

Native Arthropod Enemies of Crop Pests

Project Leader: Mary Ellen Dix

In 1990, studies were initiated to determine the impact of trees on the distribution and abundance of invertebrate natural enemies of crop pests. These studies were initially conducted in windbreak systems at the Agricultural Research and Development Center (ARDC), University of Nebraska, near Mead, Nebraska and were expanded to private farms in 1993. Ground and foliage-inhabiting arthropods in the shelterbelts and crops were sampled periodically throughout the year with pitfall traps, foliage sweeps, and branch samples. Distribution of these generalist arthropod predators in the woody edge and other components of the ecosystem were compared, and the most common and effective predators will be targeted for furture studies to enhance their abundance. Preliminary results are encourageing because greater numbers of predators, especially ants and spiders usually were found in crop fields near shelterbelts than in similar fields away from shelterbelts. The tree species and tree species diversity within the shelterbelts influenced predator abundance and arthropod predator:prey ratios within the shelterbelt and neighboring crops. Crop management practices, such as harvesting wheat and alfalfa in adjacent fields, also affected the predator:prey ratios. In addition, predator:prey ratios were found in litter under the trees. Low ratios were found within grass edges, alfalfa, and muskmelon.



Spiders help regulate abundance of tree and crop pests in agroforestry systems.

Integrated Pest Management (IPM) commonly is targeted toward control of a specific pest problem, and frequently has not been integrated into the long-term management of crops, trees, or surrounding landscape. Future research will focus on habitat enhancement through manipulation of tree species components of windbreaks, their edges, and crop management to favorably affect the balance of natural predators to prey. The information we are gathering on insect abundance and diversity can be used to develop environmentally sound practices for managing the landscape instead of a single crop or crop pest.

M.E. Dix is installing a pitfall trap near a tree row. These traps are used to determine influences of trees on abundance of ground dwelling arthopods in agroforestry and tree/turf ecosystems. She is digging a hole for a pitfall trap.

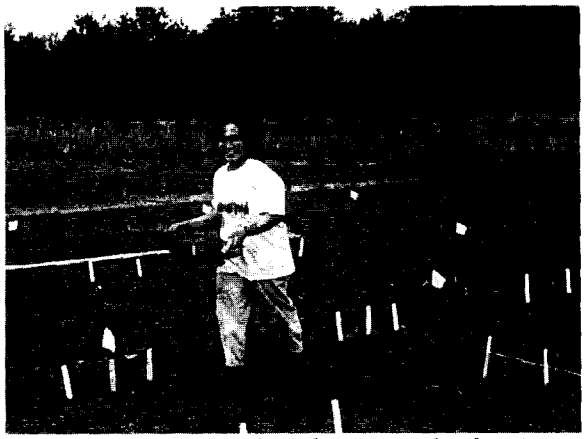
M.E. Dix is collecting arthropods caught in a pitfall trap located on the perimeter of a corn field and next to a juniper shelterbelt.

Avian Use of Shelterbelts and Adjacent Crop Fields

Project Leader: Ron Johnson

Graduate Students: Rebecca Fitzmaurice and Nathalie Sunderman

Additional studies are assessing wildlife use of trees and other vegetation in windbreaks and along riparian corridors through agricultural ecosystems. Species diversity and abundance of the birds and mammals in these ecosystems are being evaluated during the winter, breeding season, and spring and fall migrations. During the breeding season, many birds are insectivorous and also feed insects to their young. Common resident species as well as neotropical mi-



Indonesian graduate student planting muskmelons in a plot sheltered by trees.

grants were observed using the shelterbelts and riparian corridors. More birds and bird species used shelterbelts than edges without trees, i.e. herbaceous edges where cropland adjoins grassy edges. These birds may be consuming insect pests that spend a portion of their life cycle in the litter under trees or in the grass at edges. In fields, the variety of species was greater in those with woody edges (tree windbreaks or where trees formed borders to riparian areas), but the generally abundance (number) of birds in fields was similar regardless of edge type. However, more insectivorous species were found in fields next to windbreaks, especially within the first 150 feet from the windbreak.

Our preliminary data indicate that field edges, particularly woody edges, provide habitat for bird species in agricultural areas and potential benefits for sustainable agricultural systems. Some unique bird species prefer herbaceous edges without woody cover, and the requirements of these species need to be considered in landscape managment practices.

As we develop more comprehensive data bases, the information will be correlated with information on pest abundance. Future studies will evaluate prey preferences, feeding behavior, and other information needed to develop methods for enhancing the abundance of targeted species and increasing their impact on pests.

Laurie Hodges, University of Nebraska-Lincoln (UNL), Department of Horticulture, is a Vegetable Specialist and Plant Physiologist. She received her Ph. D. from Auburn University in Plant Pathology. She received her other degrees from the University of Arkansas (Agronomy) and the University of New Hampshire (Botany).

Mary Ellen Dix, USDA Forest Service, National Agroforestry Center, Lincoln, Nebraska (Agroforestry Center) is a Research Entomologist with the U. S. Forest Service. She received degrees from George Washington University, Mount Holyoke, and the University of Georgia

James R. Brandle is a Forest Physiologist in the Department of Forestry, Fisheries and Wildlife(FFW) at UNL. He received his Ph. D. from Missouri State and M. S. and B. S. degrees from the University of Tennessee.

Mark O. Harrell, also in FFW, is a Forest Entomologist. He received his Ph. D. and M. S. from the University of Wisconsin and his B. S. from the College of William and Mary.

Robert J. Wright, of UNL's Department of Entomology, is a Crop Entomologist. He received his Ph. D. from the North Carolina State University, the M. S. degree from the University of Arizona, and his B. S. from the University of California-Santa Barbara.

Ron J. Johnson, Department of FFW, is a Wildlife Biologist with research interest in sustainability in agricultural landscapes and the ecology of edge habitats and corridors. He received his Ph. D. from Cornell and the M. S. and B. S. degree from The Ohio State University.

Ronald M. Case, also FFW, is a Wildlife Biologist. He received his Ph. D. from Kansas State, his M. S. from the University of Illinois, and the A.B. from Ripon College.

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Rebecca L. Fitzmaurice, is currently a communications specialist in wildlife and natural resource conservation, employed with D. J. Case & Associates in Mishawaka, Indiana. She will received her M. S. degree from the University of Nebraska in Wildlife Biology. Her B. S. is from the University of Evansville (Indiana).

Nathalie J. Sunderman, FFW, received her M. S. degree from the University of Nebraska in Wildlife Biology and her B. S. in Biology from Concordia College (Nebraska).

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