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HARDWOOD ENERGY CROPS AND WILDLIFE DIVERSITY: INVESTIGATING POTENTIAL BENEFITS FOR BREEDING BIRDS AND SMALL MAMMALS

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ABSTRACT

Hardwood energy crops have the potential to provide a profit to growers as well as environmental benefits (for water quality, soil stabilization, chemical runoff, and wildlife habitat). Environmental considerations are important for both sustainable development of bioenergy technologies on agricultural lands, and for public support. The Environmental Task of the U.S. DOE's Biofuels Feedstock Development Program (BFDP) is working with industry, universities and others to determine how to plant, manage and harvest these crops to maximize environmental advantages and minimize impacts while economically meeting production needs. One research objective is to define and improve wildlife habitat value of these energy crops by exploring how breeding birds and small mammals use them. We have found increased diversity of birds in tree plantings compared to row crops. However, fewer bird and small mammal species use the tree plantings than use natural forest. Bird species composition on hardwood crops studied to date is a mixture of openland and forest bird species. Restricted research site availability to date has limited research to small acreage sites of several years of age, or to a few larger acreage but young (1-2 year) plantings. Through industry collaboration, research began this season on bird use of diverse hardwood plantings (different ages, acreages, tree species) in the southeast. Together with results of previous studies, this research will help define practical energy crop guidelines to integrate native wildlife benefits with productive energy crops.

Keywords: Wildlife, Energy Crops, Environment, Breeding Birds, Small Mammals

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INTRODUCTION

Short-rotation woody crops such as hybrid poplar (*Populus*), sycamore (*Platanus occidentalis L.*) and sweetgum (*Liquidambar styraciflua L.*), and perennial grass crops such as switchgrass (*Panicum virgatum*), can be used to produce liquid fuels, for direct combustion to produce electricity, or to make paper or other fiber products. These crops are well-suited to grow on erosion-prone or marginally productive agricultural lands, and may provide farmers alternative crops for such lands (Tolbert & Schiller 1996*a*).

These crops have the potential to provide multiple environmental benefits (for water quality, soil stabilization, atmospheric carbon sequestration, and wildlife habitat) (Hansen 1993; Hoffman et al. 1993, 1995; Christian et al. 1994, Ranney & Mann 1994; Tolbert & Downing 1995; Tolbert & Schiller 1996*a*), as well as to reduce U.S. dependence on foreign oil. Tree and grass energy crops could become significant components of the American agricultural landscape in the future (Hohenstein & Wright 1994), depending on the economics of fossil fuel and other energy sources, and energy crop productivity and cost. Commercial-scale plantings of hardwood crops already exist -- 35,000 acres in the southeast, and nearly that many acres in both the north central and Pacific northwest regions (Wright 1995). Additional large tracts of land have recently been purchased by private companies to expand hardwood crop production. Information is needed on environmental impacts and benefits of these crops before large-scale adoption across the landscape to ensure both appropriate stewardship of lands and public support for industry use of energy crops.

The Environmental Task of the U.S. Department of Energy's Biofuels Feedstock Development Program (BFDP) is conducting and funding research on how to plant, manage and harvest these crops to maximize environmental advantages and minimize impacts. One primary research objective is to define/enhance wildlife habitat value of hardwood tree and switchgrass crops by exploring breeding bird and small mammal use of such crops compared to probable alternative land uses -- row crops and naturally regenerating forests. The role of planting location, harvesting and various management strategies on wildlife use of hardwood energy crops is also being investigated.

Birds and small mammals were selected as indicator organisms for survey because they differ in both mobility and relationship to vegetation structure and composition (Hoffman et al. 1989, 1994, Christian et al. 1994). Together, these species groups can provide broader insight into the quality of habitat provided by energy crops than if only a single taxon were studied (Christian et al. 1994). Habitat value of biomass crops for these wildlife species should change through time, due to vegetation structural changes as tree crops are planted, grow and mature to closed canopy, and are finally harvested and replanted. Energy crop plantings are not homogeneous; vegetation can be patchy within the planting because trees fail to establish in some areas; management of the crop can also produce patches of more or less diverse vegetation.

Through identification of wildlife benefits from planting and management of biomass crops, the BFDP can help growers meet energy crop productivity needs cost-effectively, while also

increasing the lands' value for native wildlife. Other research objectives are to help growers manage energy crops to increase soil stability and improve water quality over traditional agricultural crops (Tolbert & Schiller 1996*b*). All these objectives link together through understanding how planting, management and harvesting strategies affect each, and in turn how such strategies increase or reduce crop productivity and management costs. To integrate these benefits for growers, the Environmental Task maintains close working relationships with industrial and university partners, and links with other tasks in the BFDP.

Practical guidelines for growers to meet and integrate these endpoints are the products we see as most useful. These guidelines are to be built upon the hardwood crop information gathered through our research. Highlights of research accomplished to date are reported in this paper.

WILDLIFE USE OF HARDWOOD TREE CROPS: RESEARCH FINDINGS TO DATE

Studies of bird and small mammal use of hybrid poplar plantings are being conducted by researchers from the University of Minnesota at Duluth, and The National Audubon Society. Study sites are in Oregon, Washington, Minnesota, Wisconsin, South Dakota and Ontario, with new research just begun in Virginia and North Carolina. Research-scale plantings of switchgrass in Iowa have also been surveyed for bird use by The National Audubon Society (Beyea & Hoffman 1996). Research has been ongoing since 1992.

Most research on use of hardwood tree crops by wildlife has been conducted on *Populus* plantings, though sweetgum, sycamore, willow and other tree species may also be used as energy crops in various regions of the U.S. (Hohenstein & Wright 1994). Studies begun during late spring of 1996 in Virginia and North Carolina are being conducted on sweetgum and sycamore plantings.

Twenty eight *Populus* plantings in the upper midwest have been studied by University of Minnesota at Duluth (UMD) researchers for bird use, and eleven in eastern Ontario and nine in the Pacific Northwest by The National Audubon Society. Small mammals were also surveyed on twenty six of the *Populus* sites in the upper midwest by UMD. Birds and small mammals have been surveyed on plantings and adjacent or nearby land-cover types to make comparisons between populations inhabitating different cover types. Primary research objectives have been to document bird and small mammal species composition, abundance, and diversity on hardwood tree plantings relative to other habitats. Understanding how surrounding habitats affect bird and small mammal use of tree crops has also been an objective, but opportunities to investigate these relationships have been limited due to limitations in availability of sites for study with that key variable (landscape character) being quantitatively different, and all or most other variables (planting acreage, age and management) being similar.

Sites in Minnesota surveyed during 1992 and 1993 for bird and small mammal use were generally 3-4 ha and 4-5 years old. In 1994, larger acreage sites (>30 ha) of hybrid poplar

were planted, and subsequently surveyed in 1995. Ontario plantings average about 10 ha and 2-5 years of age, while Pacific Northwest plantings were extensive in acreage but only a few years old (Christian et al. *in review*). These site factors may limit applicability of findings to older and larger acreage plantings, or differently managed plantings in some regions due to the lack of larger acreage, and particularly older (near harvest age) plantings in surveys to date. Further research is needed to determine if such older and larger acreage plantings will have similar or different bird and small mammal use. The comparison of results from the different studies can help us determine how sites might change in habitat value as they are planted, grow and are eventually harvested and replanted.

Species abundance and richness

In the midwest, abundance and number of species of both birds and small mammals were found to be lower in hardwood tree plantings than in forests and shrublands, and lower than in grasslands for small mammals (Christian et al *in review*). Abundance and species richness were found to be higher in hardwood tree plantings than on row cropped lands for both taxa. Bird densities were higher in forests than in hardwood tree plantings surveyed in Ontario as well. Comparisons between bird abundance in plantings and native forests were not made in the Pacific Northwest because of the lack of comparability between hardwood tree crops and coniferous forests. These findings generally indicate that overall density and species richness associated with hardwood tree crops studied to date are at least as high as traditional small grain and row crops, but considerably less than in non-agricultural land uses. More mature hardwood tree plantings of sizable acreage, or sites of different management (less "cleanly" maintained) may have different species abundance and richness than those suggested from surveys to date. Results thus far obtained lead us to believe that hardwood tree crops, when replacing traditional agricultural crops on marginally productive farm lands, may enhance native wildlife habitat for some species (Christian et al. 1994, Hoffman et al. 1995).

Species composition

Beyond numbers of species, the types of bird and small mammal species using plantings provide insight into the type of habitat the plantings are providing. The composition of birds and small mammals varies among study sites, and between regions. However, trends show that there are fewer forest-associated bird species in hardwood tree plantings than in forest/shrub habitat. In the midwest, long-distance migrant birds have been less abundant in plantings than in forest/shrub habitats. Both short- and long-distance migrants have been more abundant in surveyed plantings than in surveyed row crops (Hanowski & Niemi 1996) (Table 1). Habitat generalist bird species -- those capable of using a diverse set of breeding habitats, and which are species that are regionally abundant -- are the bird species most frequently found on surveyed plantings.

The most abundant small mammals on hybrid poplar plantings in the midwest -- like survey results for bird species -- are habitat generalists. These small mammal species often occur in open habitats, including agricultural lands. Small mammals that characteristically use forest

habitat are notably absent from surveyed plantings or are found only in very low densities, as is true for agricultural land uses (Christian 1996 (Table 2).

Table 1. Mean numbers for breeding bird community and bird group parameters for plantings and surrounding land-use types from 12 plantings surveyed in 1994. From Hanowski & Niemi 1996.

Parameters	Row Crop	Plant-ing	Forest & Shrub	Other non-wild	Other wild	Grass-es
Total individuals	3.21	12.84	44.03	12.30	12.20	8.40
Total Species	2.72	5.60	10.88	8.46	6.66	4.37
Long-distance migrants	0.01	0.19	1.44	3.37	0.26	0.12
Short-distant migrants	0.29	0.70	2.33	0.50	0.70	0.39
Forest birds	0.02	0.23	0.74	0.33	0.06	0.06

Bird and small mammal species composition on plantings surveyed to date is a mixture of openland and forest species that is unique compared to species composition in other nearby habitats, and does not resemble that of either grasslands or forests. More complex "patches" of vegetation within plantings, often resulting from clonal failure (due to flooding, drought, soils or other factors), or less frequent mowing, were associated with increased small mammal abundance and diversity. More research is needed to determine if plantings may buffer existing forest patches and increase habitat in these patches for birds that require interior forest habitat. Ongoing research is addressing not just how adjacent habitats affect species use of nearby hardwood tree plantings, but how hardwood tree plantings, and subsequent harvest, affect species use of adjacent habitat.

FUTURE DIRECTIONS

Diverse and extensive hardwood plantings deployed by industry on the Southeastern Coastal Plain of Virginia and North Carolina are currently beginning surveyed for breeding bird use. These stands of sweetgum and sycamore, ranging in age from two to 19 years, and from three to nearly 120 ha, promise to provide fertile comparisons to neighboring row crops and forests. From a two-year breeding bird study begun in late spring of 1996, information will be gleaned to help address questions of wildlife use in more mature and extensive plantings, and bird use of habitats adjacent to plantings both before and after planting harvest. The National Audubon Society is conducting this research.

Young and older (near harvest) age hardwood tree plantings of the same species are being compared, as are larger and smaller acreage plantings of the same tree species and similar age. Sweetgum plantings are being compared to sycamore plantings of similar age and acreage as

Table 2. Small mammal captures per 100 traps from one 3-night trapping period in the late August-early September, 1995 at the Belle River, MN site. From Christian 1996.

	Grassland	Poplar Planting	Woodland
Short-tailed shrew (Blarina brevicauda)	1.28	1.59	1.20
Red-backed vole (Clethrionomys gapperi)	0	0	1.50
Meadow vole (Microtus pennsylvanicus)	8.97	2.95	0.30
White-footed mouse (Peromyscus leucopus)	0.32	0.68	21.62
Prairie deer mouse (P. maniculatus bairdii)	0	0	0
Eastern chipmunk (Tamias striatus)	0	0	5.41
Meadow jumping mouse (Zapus hudsonius)	3.53	0.45	0
Total	14.10	6.35	30.63

well. Planting edges are being surveyed, and compared to areas in the heart of larger acreage plantings. Naturally regenerating hardwood stands (clear cut in the past and left to regrow without site preparation or replanting) embedded within extensive tree plantings are being surveyed, and compared to naturally regenerating hardwood stands of similar age recently left exposed to field conditions by harvest of surrounding tree crops. Finally, all of the studied hardwood tree plantings will be compared to surveyed stands of naturally regenerating hardwoods of similar age and acreage, and to row crop land in the vicinity.

This information will add to that being collected in the upper midwest and Pacific Northwest, and help us begin to develop guidelines to help farmers and industrial growers plant, manage and harvest hardwood energy crops in ways that integrate maximum benefits to wildlife in agricultural landscapes with productive, economically viable energy crop production.

In addition, these data will provide helpful information for future efforts to model large-scale, regional breeding bird habitat changes that could result from hardwood tree crop deployment on suitable lands across selected agricultural regions of the United States. With this effort, site- or farm-level hardwood tree crop management decisions can be used to understand potential landscape-level benefits or impacts to selected native wildlife species -- the level at which changes can significantly benefit species survival over the long term.

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