Bird communities, biomass, and carbon sequestration in habitat restorations in northwest Illinois

Grant Agreement #10-L19W

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Timeframe
Summary

In 2010 and 2011, we investigated the biomass potential of oldfield/shrublands in northwest Illinois and the quality of this habitat for birds. Many shrublands and grassland are experiencing significant population declines in Illinois. Although these species are declining, shrublands, as opposed to grasslands, rarely are the target of management efforts. Historically, shrubland bird populations flourished during the harvesting of much of the Midwest’s lumber. This lumbering resulted in an increase in the amount of shrubland habitat. Previous to European settlement, it is likely that periodic disturbances facilitated the establishment of shrublands. Over the last century, fire suppression has resulted in many shrublands succeeding into second-growth forests. This conversion of shrublands to second-growth forests is common throughout the state. Intensive management is likely needed to restore many shrublands that have succeeded to second-growth forests. Given the limited resources for conservation, one potential mechanism to restore shrubland habitats is to harvest trees and shrubs in second-growth forests for cellulosic biofuels, while creating shrubland habitats. In addition, other biofuels such as switch grass may provide habitat for grassland birds. This approach may be a win-win. If done correctly, the establishment of biofuels could restore shrubland and grassland habitat and cost little in conservation resources, if the profit margin for harvesters was sufficient. In this study, we did not intend to produce a comprehensive plan on how to achieve ecological and economic goals associated with harvesting cellulose, but rather to collect ecological data that could be used to evaluate the potential management of shrublands via harvesting wood (i.e. managing second-growth forest) or the creation of grasslands via biofuels grass (i.e. miscanthus or native switch grass).
While the shrublands of northwest Illinois are at the range limits of many bird species, they do support good populations of species of conservation concern such as field sparrow, Bell’s vireo, and yellow-billed cuckoo. We conducted a nest survival study at Apple River Canyon State Park (Salem unit) and at Lost Mound Unit of the Upper Mississippi River Fish and Wildlife Refuge. Nest success was not particularly high (27%), but compared to other studies throughout the state the success was similar. We deployed nest cameras on a few nests and the primary predators of nests were snakes and small mammals. A survey of the plants of the Salem Unit of the Apple River Canyon S. P. suggests a robust shrubland plant community. The most abundant tree (stems/ha) are eastern red cedar, riverbank grape, black raspberry, prickly ash, red oak, and boxelder. While different trees have different cellulose content the economics associated with harvesting trees for cellulose will be dictated by federal policy and it is extremely unlikely that biofuel mills will only accept or pay different amounts for different species. From an ecological perspective there remains relatively-high quality shrublands in northwestern Illinois and management is needed to protect these habitats. While there is the possibility that the market for cellulosic biofuels will increase providing a mechanism to create and manage shrublands, the future is unknown. The economics are such that at present an increase in biofuel production is unlikely to improve the populations of most birds in Illinois.

Introduction

Due to changes in personnel at the Illinois Natural History Survey, the principal investigator that developed this proposal and project left the employment of INHS/ the University of Illinois mid-stream in this project. Fortunately, the majority of objectives of this project were in-line with a shrubland bird conservation project T.J. Benson and Mike Ward were conducting throughout Illinois. This project on the quality of shrubland habitat is ongoing and
this grant was associated with the quality of northwestern Illinois shrublands. The initial project (designed by D. Wenny) was very ambiguous in its hope of providing very specific recommendations bridging ecological conservation, the harvesting of biomass, and carbon sequestration. Over the course of this project, various economic pressures have resulted in many changes to the outlook of biofuel harvesting. The future of biofuels remains extremely difficult to predict. Regardless, our goal was to determine the status of shrubland and to a lesser extent grassland birds in northwestern Illinois and identify the shrubland plant community. While we did not explicitly sample grassland communities there is a large amount of botanical data associated with Lost Mound and randomly selected grasslands in northwest Illinois (Critical Trends Assessment Program).

**Project Objectives:**

1. Survey bird communities in grassland, oldfield, and shrubland habitats to determine species richness and abundance of breeding species. Bird surveys will give information on which species use each habitat and therefore which species will probably increase or decrease with changes in habitat.

2. Measure vegetation to estimate above-ground carbon storage, amount of biomass available to harvest, and structural features of wildlife habitat.

3. Combine results to make recommendations on integrating bird conservation and sustainable biomass harvest in the Driftless region.

**Bird Community**

We conducted point counts, searched for and monitored nests, and deployed nest cameras at Lost Mound and the Salem unit of Apple River Canyon S. P. The census data illustrate that Lost Mound had a much richer shrubland bird community than the Salem unit, however both
supported shrubland bird communities comparable with other locations throughout Illinois. Lost Mound also supports the best sand prairie bird community in Illinois. The most common shrubland bird encountered was field sparrow (2.8 per point count), followed by common yellowthroat (1.8 per point count), American goldfinch (1.3 per point count), and brown-headed cowbirds (1.2 per point count: Table 1). Other species of interest that were recorded include relatively large numbers of Bell’s vireos and brown thrashers, and at Lost Mound loggerhead shrikes and orchard orioles. While we were unable to analyze the long-term census data from Lost Mound, multiple sources of data illustrate how Lost Mound has the highest density of grasshopper sparrows, eastern and western meadowlarks, and loggerhead shrikes in northern Illinois (Spring Bird Count data, D. Elbert unpublished thesis 2009). In the context with other locations, the composition of the shrubland bird community was lower (average of 5.1 shrubland species per point) than in other location in Illinois such as northeastern Illinois (6.2 per point) or east-central Illinois (9.0 per point). Though the exact reason for this is unknown, northwest Illinois appears to be in a transition zone where many shrubland species’ ranges stop just south and others stop just north.

Nest searching proved to be more difficult at the Salem unit than anticipated, due to the extremely high number of locations that shrubland birds could put their nests and the relatively low number of birds at the site. In total, 10 nests were located of which one was successful, the fate of one was unknown, one was abandoned, and the remaining seven were predated. We had nest cameras on 4 nests at the Salem unit, two were predated by snakes (1 milk and 1 fox snake), one was predated by a raccoon, and someone sliced the cables of the other camera resulting in its failure to capture any footage. The species whose nests were located were field sparrows (6), gray catbird (2), song sparrow (1), and common yellowthroat (1).
Nest searching at Lost Mound was also more difficult than expected, primarily due to access to the installation which is administrated by the US Fish and Wildlife Service. Fifteen nests were located at Lost Mound, these included field sparrows (6), brown thrasher (4), orchard oriole (1), eastern kingbird (3), and yellow-billed cuckoo (1). We were aware of other data from the site but were unable to obtain these data. Six of these 15 nests were successful, we experienced some technical issues with the cameras on Lost Mound, but did obtain footage of snakes and possibly a weasel depredating nests.

**Plant Community**

We used the Critical Trends Assessment Program (CTAP) protocol to assess the plant community at the Salem unit (species list Table 3). We expect that the plant community at this site reflects much of the shrubland plant community throughout northwestern Illinois. As can be assessed from simply observing the site, the shrubland is dominated by eastern red cedars (Table 2). Cedar is the dominant plant in terms of stem density and basal area. No comprehensive plant survey of the Lost Mound shrublands was conducted, however the structure of these was much different that the Salem unit. The shrublands were generally clumps of vegetation in a larger grassland. While the overall structure of the shrubland differed, many of the nests were located in cedars or clumps of small oaks, similar to the Salem unit.

**Biofuel Harvesting and Ecological Conservation**

**SHRUBLANDS**

The August 2011 publication U.S. billion-ton update, Biomass Supply for a Bioenergy and Bioproduct Industry (Perlack and Stokes 2011) outlines the current supply and potential future demand for assorted sources of bioenergy. Forest biomass and wood waste products are
listed as potentially important sources and the publication lists one source of these produce being the residue of results of woodland management. These “residue” products have value but only in situations in which the product is near the mill and there are significant amounts of the product. Figure 1 is an excerpt from (Perlack and Stokes 2011) that suggests that the price of residue (i.e., logging residue or thinning) will not increase until the market increases. Figure 2 suggests that the current and future availability of logging residue in Illinois is very small.

We do not know the status of a proposed cellulosic biofuel mill in northwestern Illinois, but given the projection and economic value of residue products (Figure 2), it seems likely that outside contractors will not be scrambling to harvest cedar from shrublands or second-growth forests in northwest Illinois. Also, estimates of cellulose and above ground carbon in shrubland trees are currently very coarse, and to directly estimate the amount of carbon would be very expensive.

The shrubland bird community is declining throughout Illinois, and northwest Illinois is no exception, extremely low nesting success dictates efforts be made to restore shrublands. The small sample size of nests precludes any intensive analysis, and even in areas of the state where over 500 nests have been located and monitored, questions remain about the attributes of a shrubland that promote nesting success. However, there is one obvious recommendation from this study. Areas such as the Salem unit would benefit from periodic fires if the goal is to promote shrubland communities. Young cedars can be effectively managed and reduced via prescribed burns and these management activities would likely perpetuate shrubland habitat.

**GRASSLAND**

Since the initiation of this study there has been a handful of studies highlighting how the conversion of Conservation Reserve Program (CRP) grasslands to a grassland biofuel such as
miscanthus or native switchgrass, while it would produce more fuel, it would be detrimental for native wildlife (Robertson et al. 2010; Hartman et al. 2011). Current economics preclude large scale establishment and harvesting of native grasses (Table 4; Perlack and Stokes 2011), and it is unlikely that biofuel grass will replace corn, suggesting there may be pressure on CRP fields to be converted to biofuel grasses.

**CARBON SEQUESTRATION**

When the initial author of this grant was developing and submitting this grant, there was a Senate Bill to create a carbon credit system. This bill was never enacted and there appears to be little political will to create a carbon trading system. Currently, it is impossible to speculate about the potential conservation benefit of carbon trading. There are a number of large studies investigating carbon sequestration of soils in Illinois, however, current estimates of soil carbon are highly variable and current efforts will better characterize how soils of different habitat store carbon (currently almost all estimates in Illinois are associated with actively farmed soils; Krug and Hollinger 2003).

**Conclusion**

This grant provided the resources to address a pressing issue in avian conservation and to begin to explore how the advent of a biofuel market may impact wildlife management and conservation. Northwest Illinois supports a healthy population of grassland birds (at least at Lost Mound) and shrubland birds. While northwestern Illinois supports a lower diversity of shrubland birds, I initially thought reproductive success would be higher because major nest predators such as black rat snake are uncommon in the areas. However, snakes still appear to be an important nest predator. Red cedars can be an important vegetative component of shrublands but the red cedars can quickly spread and convert a high-quality shrubland into a poor quality second-
growth forest. Periodic prescribed fires would provide a good management technique, but harvesting of small trees for biofuel is another possibility. The outlook for biofuels is at best hazy, and the implications for wildlife are mixed. Biofuels could provide new habitats and could contribute to managing shrublands and forests, but it is likely there will be a slow implementation of biofuels on the landscape.

Acknowledgements:

T.J. Benson (INHS), Dan Elbert (U of Illinois), Jeff Horn (Jo Daviess County Conservation Foundation), Mark Alessi (INHS), and Jamie Ellis (INHS) all helped with various field work.

Literature Cited


Table 1. List of species detected on censuses or while nest searching at the Salem Unit and Lost Mound. The bolded species are considered shrubland species (i.e., probably bred within the shrublands). Note that the Swainson’s hawk was observed twice on the road approaching the Salem Unit only in 2010.

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Branta canadensis</td>
<td>Canada Goose</td>
</tr>
<tr>
<td>Anas platyrhynchos</td>
<td>Mallard</td>
</tr>
<tr>
<td>Phasianus colchicus</td>
<td>Ring-necked Pheasant</td>
</tr>
<tr>
<td>Ardea herodias</td>
<td>Great Blue Heron</td>
</tr>
<tr>
<td>Cathartes aura</td>
<td>Turkey Vulture</td>
</tr>
<tr>
<td>Haliaeetus leucocephalus</td>
<td>Bald Eagle</td>
</tr>
<tr>
<td>Accipiter cooperii</td>
<td>Cooper's Hawk</td>
</tr>
<tr>
<td>Buteo swainsoni</td>
<td>Swainson's Hawk</td>
</tr>
<tr>
<td>Buteo jamaicensis</td>
<td>Red-tailed Hawk</td>
</tr>
<tr>
<td>Falco sparverius</td>
<td>American Kestrel</td>
</tr>
<tr>
<td>Charadrius vociferus</td>
<td>Killdeer</td>
</tr>
<tr>
<td>Scolopax minor</td>
<td>American Woodcock</td>
</tr>
<tr>
<td>Zenaida macroura</td>
<td>Mourning Dove</td>
</tr>
<tr>
<td>Coccyzus americanus</td>
<td>Yellow-billed Cuckoo</td>
</tr>
<tr>
<td>Caprimulgus vociferus</td>
<td>Whip-poor-will</td>
</tr>
<tr>
<td>Chaetura pelagica</td>
<td>Chimney Swift</td>
</tr>
<tr>
<td>Archilochus colubris</td>
<td>Ruby-throated Hummingbird</td>
</tr>
<tr>
<td>Ceryle alcyon</td>
<td>Belted Kingfisher</td>
</tr>
<tr>
<td>Melanerpes carolinus</td>
<td>Red-bellied Woodpecker</td>
</tr>
<tr>
<td>Sphyrapicus varius</td>
<td>Yellow-bellied Sapsucker</td>
</tr>
<tr>
<td>Picoides pubescens</td>
<td>Downy Woodpecker</td>
</tr>
<tr>
<td>Colaptes auratus</td>
<td>Northern Flicker</td>
</tr>
<tr>
<td>Contopus virens</td>
<td>Eastern Wood-Pewee</td>
</tr>
<tr>
<td>Empidonax traillii</td>
<td>Willow Flycatcher</td>
</tr>
<tr>
<td>Sayornis phoebe</td>
<td>Eastern Phoebe</td>
</tr>
<tr>
<td>Myiarchus crinitus</td>
<td>Great Crested Flycatcher</td>
</tr>
<tr>
<td>Tyrannus tyrannus</td>
<td>Eastern Kingbird</td>
</tr>
<tr>
<td>Lanius ludovicianus</td>
<td>Loggerhead Shrike</td>
</tr>
<tr>
<td>Vireo bellii</td>
<td>Bell’s Vireo</td>
</tr>
<tr>
<td>Cyanocitta cristata</td>
<td>Blue Jay</td>
</tr>
<tr>
<td>Corvus brachyrhynchos</td>
<td>American Crow</td>
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<tr>
<td>Progne subis</td>
<td>Purple Martin</td>
</tr>
<tr>
<td>Tachycineta bicolor</td>
<td>Tree Swallow</td>
</tr>
<tr>
<td>Stelgidopteryx serripennis</td>
<td>Northern Rough-winged Swallow</td>
</tr>
<tr>
<td>Riparia riparia</td>
<td>Bank Swallow</td>
</tr>
<tr>
<td>Petrochelidon pyrrhonota</td>
<td>Cliff Swallow</td>
</tr>
<tr>
<td>Hirundo rustica</td>
<td>Barn Swallow</td>
</tr>
<tr>
<td>Scientific Name</td>
<td>Common Name</td>
</tr>
<tr>
<td>------------------------------------</td>
<td>----------------------------</td>
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<tr>
<td>Poecile atricapillus</td>
<td>Black-capped Chickadee</td>
</tr>
<tr>
<td>Sitta carolinensis</td>
<td>White-breasted Nuthatch</td>
</tr>
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<td>Troglodytes aedon</td>
<td>House Wren</td>
</tr>
<tr>
<td>Sialia sialis</td>
<td>Eastern Bluebird</td>
</tr>
<tr>
<td>Turdus migratorius</td>
<td>American Robin</td>
</tr>
<tr>
<td>Dumetella carolinensis</td>
<td>Gray Catbird</td>
</tr>
<tr>
<td>Toxostoma rufum</td>
<td>Brown Thrasher</td>
</tr>
<tr>
<td>Sturnus vulgaris</td>
<td>European Starling</td>
</tr>
<tr>
<td>Bombus cedrorum</td>
<td>Cedar Waxwing</td>
</tr>
<tr>
<td>Dendroica petechia</td>
<td>Yellow Warbler</td>
</tr>
<tr>
<td>Geothlypis trichas</td>
<td>Common Yellowthroat</td>
</tr>
<tr>
<td>Icteria virens</td>
<td>Yellow-breasted Chat</td>
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<td>Pipilo erythrophthalmus</td>
<td>Eastern Towhee</td>
</tr>
<tr>
<td>Spizella passerina</td>
<td>Chipping Sparrow</td>
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<tr>
<td>Spizella pusilla</td>
<td>Field Sparrow</td>
</tr>
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<td>Chondestes grammacus</td>
<td>Lark Sparrow</td>
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<tr>
<td>Ammodramus savannarum</td>
<td>Grasshopper Sparrow</td>
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<tr>
<td>Ammodramus henslowii</td>
<td>Henslow’s Sparrow</td>
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<td>Melospiza melodia</td>
<td>Song Sparrow</td>
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<tr>
<td>Cardinalis cardinalis</td>
<td>Northern Cardinal</td>
</tr>
<tr>
<td>Pheucticus ludovicianus</td>
<td>Rose-breasted Grosbeak</td>
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<tr>
<td>Passerina cyanea</td>
<td>Indigo Bunting</td>
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<tr>
<td>Spiza americana</td>
<td>Dickcissel</td>
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<td>Agelaius phoeniceus</td>
<td>Red-winged Blackbird</td>
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<td>Sturnella magna</td>
<td>Eastern Meadowlark</td>
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<td>Sturnella neglecta</td>
<td>Western Meadowlark</td>
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<tr>
<td>Quiscalus quiscula</td>
<td>Common Grackle</td>
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<tr>
<td>Molothrus ater</td>
<td>Brown-headed Cowbird</td>
</tr>
<tr>
<td>Icterus spurius</td>
<td>Orchard Oriole</td>
</tr>
<tr>
<td>Icterus galbula</td>
<td>Baltimore Oriole</td>
</tr>
<tr>
<td>Carduelis tristis</td>
<td>American Goldfinch</td>
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Table 2. The relative cover and basal areas of plants at the Salem unit of Apple River Canyon State Park shrublands.

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
<th>Form</th>
<th>stems/ha</th>
<th>Relative stems/ha</th>
<th>Sum dbh</th>
<th>Basal area /ha</th>
<th>Relative Basal Area</th>
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<tr>
<td>Acer negundo</td>
<td>boxelder</td>
<td>native tree</td>
<td>249.96</td>
<td>5.8</td>
<td>16</td>
<td>0.42</td>
<td>0.9</td>
</tr>
<tr>
<td>Juglans nigra</td>
<td>black walnut</td>
<td>native tree</td>
<td>104.15</td>
<td>2.4</td>
<td>32.5</td>
<td>1.73</td>
<td>3.5</td>
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<tr>
<td>Juniperus virginiana</td>
<td>eastern red cedar</td>
<td>native tree</td>
<td>1478.93</td>
<td>34.1</td>
<td>158</td>
<td>40.85</td>
<td>83.1</td>
</tr>
<tr>
<td>Morus alba</td>
<td>white mulberry</td>
<td>non-native tree</td>
<td>83.32</td>
<td>1.9</td>
<td>4</td>
<td>0.03</td>
<td>0.1</td>
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<tr>
<td>Parthenocissus quinquefolia</td>
<td>virginia creeper</td>
<td>woody vine</td>
<td>187.47</td>
<td>4.3</td>
<td>9</td>
<td>0.13</td>
<td>0.3</td>
</tr>
<tr>
<td>Populus deltoides</td>
<td>cottonwood</td>
<td>native tree</td>
<td>83.32</td>
<td>1.9</td>
<td>11.5</td>
<td>0.22</td>
<td>0.4</td>
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<tr>
<td>Prunus serotina</td>
<td>wild black cherry</td>
<td>native tree</td>
<td>124.98</td>
<td>2.9</td>
<td>7</td>
<td>0.08</td>
<td>0.2</td>
</tr>
<tr>
<td>Quercus macrocarpa</td>
<td>bur oak</td>
<td>native tree</td>
<td>229.13</td>
<td>5.3</td>
<td>38.5</td>
<td>2.42</td>
<td>4.9</td>
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<tr>
<td>Quercus rubra</td>
<td>red oak</td>
<td>native tree</td>
<td>249.96</td>
<td>5.8</td>
<td>13</td>
<td>0.28</td>
<td>0.6</td>
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<tr>
<td>Rubus occidentalis</td>
<td>black raspberry</td>
<td>native shrub</td>
<td>479.09</td>
<td>11.1</td>
<td>23</td>
<td>0.87</td>
<td>1.8</td>
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<tr>
<td>Toxicodendron radicans</td>
<td>poison ivy</td>
<td>woody vine</td>
<td>41.66</td>
<td>1.0</td>
<td>2</td>
<td>0.01</td>
<td>0.0</td>
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<tr>
<td>Vitis riparia</td>
<td>riverbank grape</td>
<td>woody vine</td>
<td>666.56</td>
<td>15.4</td>
<td>32</td>
<td>1.68</td>
<td>3.4</td>
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<tr>
<td>Zanthoxylum americanum</td>
<td>prickly ash</td>
<td>native shrub</td>
<td>354.11</td>
<td>8.2</td>
<td>17</td>
<td>0.47</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Table 3. List of all plant species encountered at the shrubland within the Salem Unit of Apple River Canyon State Park.

<table>
<thead>
<tr>
<th>Scientific Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acer negundo</td>
<td>boxelder</td>
</tr>
<tr>
<td>Andropogon gerardii</td>
<td>big bluestem</td>
</tr>
<tr>
<td>Asclepias syriaca</td>
<td>common milkweed</td>
</tr>
<tr>
<td>Aster lateriflorus</td>
<td>side-flowering aster</td>
</tr>
<tr>
<td>Aster pilosus</td>
<td>hairy aster</td>
</tr>
<tr>
<td>Bromus inermis</td>
<td>Hungarian brome</td>
</tr>
<tr>
<td>Carduus acanthoides</td>
<td>acanthus bristle thistle</td>
</tr>
<tr>
<td>Carex grisea</td>
<td>wood gray sedge</td>
</tr>
<tr>
<td>Carya cordiformis</td>
<td>bitternut hickory</td>
</tr>
<tr>
<td>Centaurea maculosa</td>
<td>spotted centaurea</td>
</tr>
<tr>
<td>Daucus carota</td>
<td>Queen Anne's lace</td>
</tr>
<tr>
<td>Erigeron strigosus</td>
<td>daisy fleabane</td>
</tr>
<tr>
<td>Geum canadense</td>
<td>white avens</td>
</tr>
<tr>
<td>Hackelia virginiana</td>
<td>stickseed</td>
</tr>
<tr>
<td>Hypericum punctatum</td>
<td>spotted St. John's-wort</td>
</tr>
<tr>
<td>Juglans nigra</td>
<td>black walnut</td>
</tr>
<tr>
<td>Juniperus virginiana</td>
<td>eastern red cedar</td>
</tr>
<tr>
<td>Lonicera maackii</td>
<td>amur honeysuckle</td>
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<tr>
<td>Lonicera tatarica</td>
<td>Tartarian honeysuckle</td>
</tr>
<tr>
<td>Monarda fistulosa</td>
<td>wild bergamot</td>
</tr>
<tr>
<td>Muhlenbergia schreberi</td>
<td>nimblewill</td>
</tr>
<tr>
<td>Nepeta cataria</td>
<td>catnip</td>
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<tr>
<td>Oenothera biennis</td>
<td>common evening primrose</td>
</tr>
<tr>
<td>Pastinaca sativa</td>
<td>wild parsnip</td>
</tr>
<tr>
<td>Phalaris arundinacea</td>
<td>reed canary grass</td>
</tr>
<tr>
<td>Poa pratensis</td>
<td>Kentucky blue grass</td>
</tr>
<tr>
<td>Populus deltoides</td>
<td>eastern cottonwood</td>
</tr>
<tr>
<td>Quercus macrocarpa</td>
<td>burr oak</td>
</tr>
<tr>
<td>Quercus rubra</td>
<td>northern red oak</td>
</tr>
<tr>
<td>Rhus typhina</td>
<td>staghorn sumac</td>
</tr>
<tr>
<td>Setaria glauca</td>
<td>pigeon grass</td>
</tr>
<tr>
<td>Solidago canadensis</td>
<td>Canada goldenrod</td>
</tr>
<tr>
<td>Toxicodendron radicans</td>
<td>poison ivy</td>
</tr>
<tr>
<td>Ulmus americana</td>
<td>American elm</td>
</tr>
<tr>
<td>Verbena urticifolia</td>
<td>white vervain</td>
</tr>
<tr>
<td>Vitis riparia</td>
<td>riverbank grape</td>
</tr>
<tr>
<td>Zanthoxylum americanum</td>
<td>prickly ash</td>
</tr>
</tbody>
</table>
Table 4. Reported perennial grass yield and acres required for a 50-million gallon cellulosic ethanol plant (Perlack and Stokes 2011).

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Yield, dry tons/acre</th>
<th>Acres need to grow 588,000 dry tons/year</th>
<th>Percent of land in 25-mile radius</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIHD prairie(^a)</td>
<td>1.75</td>
<td>336,000</td>
<td>27</td>
</tr>
<tr>
<td>Managed native prairie(^b)</td>
<td>2.5</td>
<td>235,200</td>
<td>19</td>
</tr>
<tr>
<td>Shawnee switchgrass(^c)</td>
<td>5</td>
<td>117,600</td>
<td>9</td>
</tr>
<tr>
<td>Bioenergy switchgrass(^d)</td>
<td>7.4</td>
<td>79,500</td>
<td>6</td>
</tr>
<tr>
<td>Hybrid switchgrass(^e)</td>
<td>9.4</td>
<td>62,600</td>
<td>5</td>
</tr>
</tbody>
</table>

\(^a\) Low-input, high-diversity man-made prairies (Tilman et al., 2006).
\(^b\) Native tallgrass prairie burned in late spring (Mitchell, 1992).
\(^c\) Shawnee is an upland forage-type switchgrass cultivar released in 1995.
\(^d\) Lowland bioenergy-specific switchgrass in the cultivar release process.
\(^e\) F1 hybrid of ’Summer’ and ’Kanlow’ switchgrass (Vogel and Mitchell, 2008).
Figure 1. The predictive economics of logging residue assuming a mill is in the area (Perlack and Stokes 2011). Note that currently logging residue (harvesting trees and shrubs) is not economically viable as Illinois does not produce enough logging residue to support a market.
Figure 2. The availability of cellulosic biofuels in the U.S (Perlack and Stokes 2011). Note the low potential in Illinois.
Figure 3. The estimated spatial distribution of simulated forest residue thinning at $30$ (top) and $60$ (bottom) per dry ton (Perlack and Stokes 2011). Notice the low potential in Illinois.
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