# Is bioenergy for the birds? An evaluation of alternative future bioenergy landscapes

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Bioenergy production—either for fuels or electricity—is the most land intensive form of energy production (1). The consequences of increased demand for land associated with bioenergy crops initially gained attention because of the implications for carbon emissions associated with land clearing (2, 3), but, more recently, the potential impacts of bioenergy's land demand on biodiversity have gained increased attention (4–6). The study by Meehan et al. (7) in PNAS provides a quantitative look at predicted landscape-scale biodiversity impacts under alternative bioenergy cropping scenarios. Specifically, the authors (7) predict impacts of either greatly expanded row crops or greatly expanded perennial grasses for bird communities in the Upper Midwest, making use of the Breeding Bird Survey (BBS) data to correlate bird species richness with landscape features at 265 sites across seven upper Midwestern states (Minnesota, Iowa, Wisconsin, Illinois, Michigan, Indiana, and Ohio).

Potential sources of biomass for bioenergy can be thought of as a continuum, ranging from low-input high-diversity (LIHD) crops, such as native prairie, to high-input low-diversity (HILD) crops, specifically corn and soybeans in this analysis (5, 7, 8). Current biofuel mandates in the United States require increasing production of biofuels to 136 billion L (36 billion gal) annually by 2022. The proportions of this total mandate that can come from corn ethanol, cellulosic ethanol, or other advanced biofuels are specified in the mandate, but are subject to change for political or technological reasons. Meeting the entire mandate exclusively with corn ethanol would require about 29 million ha; meeting the entire mandate exclusively with perennial grasses that yield 10 Mg/ha would require at least 34 million ha. The study by Meehan et al. (7) explores scenarios in which much of this national mandate is met through land use change to either LIHD or HILD (corn and soy) in the Upper Midwest. In the LIHD scenario, all available marginal cropland is converted to LIHD (which ends up being 8.3 million ha). In the corn/soy scenario, all available marginal herbaceous perennial crops and grasslands are converted to corn/soy (which ends up being 9.5 million ha). These provide endpoints of possible bioenergy futures. Biofuel scenarios that

**Fig. 1.** The bobolink (*Dolichonyx oryzivorus*) is one of several species of grassland nesting birds of conservation concern whose populations are predicted by Meehan et al. (7) to increase in response to the conversion of row crops to herbaceous perennial crops and grasslands (represented by big bluestem, *Andropogon gerardii*) and to decrease in response to the conversion of herbaceous perennial crops and grasslands to row crops (represented by corn, *Zea maize*).

resulted in a mix of LIHD and HILD crops, biomass production primarily from other regions, or reductions in goals for cellulosic ethanol production would all result in changes of smaller magnitude than the scenarios presented in this study. For example, the Environmental Protection Agency (EPA) is set to reduce the cellulosic production mandate for 2011 by 93–98% because of continued lack of commercial availability. Additionally, the Southeastern United States has a relatively long growing season and high precipitation that may make that region a preferable location for perennial biomass production.

To predict the implications of these bioenergy scenarios for bird species richness, Meehan et al. (7) characterize the landscapes surrounding BBS routes based on the cover of forest, wetland, urban, LIHD, and HILD. Areas planted to corn and soy are considered HILD; hay fields, alfalfa fields, pastures, and unmanaged grasslands are considered LIHD. Their model suggests that increases in percent cover of corn/soy exceeding 40% will lead to lower bird species richness, whereas increases in percent cover of LIHD will consistently lead to higher bird species richness. Their land use change scenarios target marginal lands that are currently either corn/soy or LIHD, such that predicted changes are concentrated in certain areas for each scenario, with nonsignificant change expected across most of the study area. However, in the 20% of the area with the highest predicted changes to bird species richness, the corn/soy scenario predicts a loss of >7% (typically equivalent to about eight species), and the LIHD scenario predicts an increase of >12% (also typically equivalent to about eight species). This is a striking result for those concerned about bird diversity, but the implications for conservation are even more striking for the subset of birds of conservation concern, such as the bobolink (*Dolichonyx oryzivorus*) (Fig. 1). For these 31 species, in the 20% of the area with the highest predicted changes, the corn/soy scenario predicts a loss of >20%, and the LIHD scenario predicts an increase of >30%. Thus, on a percentage basis, the magnitude of expected change for species of conservation concern is more than double that for species in general. This is consistent with previous work suggesting that species of higher conservation concern are more negatively impacted by the conversion of their habitat to cropland (4). This finding is not surprising: species of conservation concern are commonly those that have been most impacted by existing land use changes, such as the extensive conversion of land to agriculture in the Upper Midwest.

More generally, these results are consistent with other work that suggests a dichotomy between the environmental impacts of first- and second-generation biofuels (9). Expansion of corn for ethanol is expected to exacerbate issues associated with nutrient pollution (10), air quality (11), greenhouse gas emissions from land use change (3), and habitat for biodiversity (4–6) in contrast to cellulosic ethanol, which offers the potential for environmental benefits in these areas (2, 6, 8, 11, 12).

Additional research is needed to understand the biodiversity implications of alternative bioenergy futures: we need to consider a wider range of scenarios, crops, geographies, and taxa. For example, the consequences for wildlife of planting large areas of *Miscanthus x giganteus* are largely unknown. However, *Miscanthus* is very different in structure (more similar to dense thickets of bamboo than to prairie) than anything that native grassland species in the United States have previously experienced, raising serious questions about its potential value as habitat. In addition,

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fast growing trees may be the preferred crop for biomass production in many geographies. Additional research is needed to compare the wildlife value of woody vs. herbaceous crops, to compare the wildlife value among woody and herbaceous crops and crop mixes, and to understand how these wildlife values vary across regions. More generally, the consequences of shifting land use to any bioenergy crop will depend on the mix of current land use and the magnitude of these shifts. Additional spatially explicit models that quantify existing and potential land use, like the one presented by Meehan et al. (7), are necessary to improve our understanding of the likely biodiversity impacts of increased bioenergy production.

As the Meehan et al. (7) study illustrates, bioenergy policy is likely to have large impacts on our ability to conserve birds and, by extension, other wildlife. The consequences of biofuels policy for conservation are largely unintended but are nonetheless predictable. For example, increased demand for row crops can lead to commodity price increases that are likely to result in reductions in the amount of land enrolled in conservation programs (5, 13). A variety of financial and logistical factors currently limit the shift from first- to second-generation biofuels. Taken together, this suggests that, if society expects increased bioenergy production to provide benefits both for renewable energy and for conservation, payments explicitly for these environmental benefits will be necessary to incentivize landowners to choose wildlife-friendly perennial crops over the expansion of familiar and profitable first-generation biofuel crops.

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