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Inconvenient Truths about Landowner (Un)Willingness to Grow Dedicated Bioenergy Crops

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Nearly a decade after enactment of the Biomass Crop Assistance Program (BCAP), the emergence of new biomass supplies for bioenergy and bioproduct end-uses remains scant, with little progress evident especially for dedicated grass and short-rotation tree crops. First signed into law through the 2008 U.S. Farm Bill, BCAP seeks to complement the Renewable Fuel Standard established by the U.S. Energy Policy Act of 2005 and expanded in the Energy Independence and Security Act of 2007.

The goal of BCAP is to catalyze the cultivation of cellulosic, or non-food, biomass on private landholdings. The focus on cellulosic biomass is important because it cannot readily be used for food or feed and because perennial dedicated bioenergy crops—like switchgrass—offer environmental benefits. Specific incentives of BCAP include subsidies for the establishment and maintenance of new dedicated biomass cropping systems—namely grass and tree crops—and matching payments for the collection and harvest of existing biomass resources—such as crop or forest residues—that currently lack an established end-market.

As of 2016, BCAP had assisted nearly 900 landowners to establish dedicated biomass plantings on 49,000 acres across eleven geographically-diverse project areas (USDA-FSA, 2016). Overall, this represents a negligible share of the repeated and recent projections by the Department of Energy's Billion Ton Report envisioning tens of millions of acres in biomass production by 2022 (DOE, 2016). But the shortcoming ran deeper: Half of the BCAP project areas fell short of their targeted acreage enrollment goals by 30% or more. In two cases, they fell short by over 80% (USDA-FSA, 2013). By comparison, BCAP's matching payment programs to subsidize the collection of existing biomass had greater success.

While not a formal criterion for BCAP, the program was implemented during a period of policy interest in expanding dedicated biomass production on 'marginal lands.' In the bioenergy policy arena, this term refers to (1) non-crop land that is currently unused for feed and forage production, and (2) crop and pasture land which could be made more sustainable through incorporation of a perennial biomass production system. Ideally, biomass production on marginal land would sidestep social, ecological, economic and ethical concerns associated with biomass for energy production (Searchinger et al., 2008; Shortall, 2013). However, the USDA-FSA reports that only two of nine BCAP project areas contracted for any biomass production on marginal lands. Within those areas marginal land represented only 4–7% of all contracted acres, with the remainder being cropland.

Why did BCAP subsidies attract so little land into dedicated bioenergy crops? And why was such a tiny fraction of it in marginal land? The BCAP experience seems to fly in the face of projections of vast land areas available for bioenergy crops in general (DOE, 2016) and specifically on marginal lands (Cai, Zhang, and Wang, 2010; Gelfand et al., 2013). Was the BCAP shortfall in spending on dedicated energy crops due solely to "[in]sufficient producer outreach and education" (USDA-FSA 2013)?

The answer is no. Four inconvenient truths detract from landowner willingness to grow dedicated bioenergy crops. While the physical availability of cropland or marginal land is a necessary condition for growing bioenergy crops, the condition requires that private landowners must be willing to use those lands to produce energy crops.

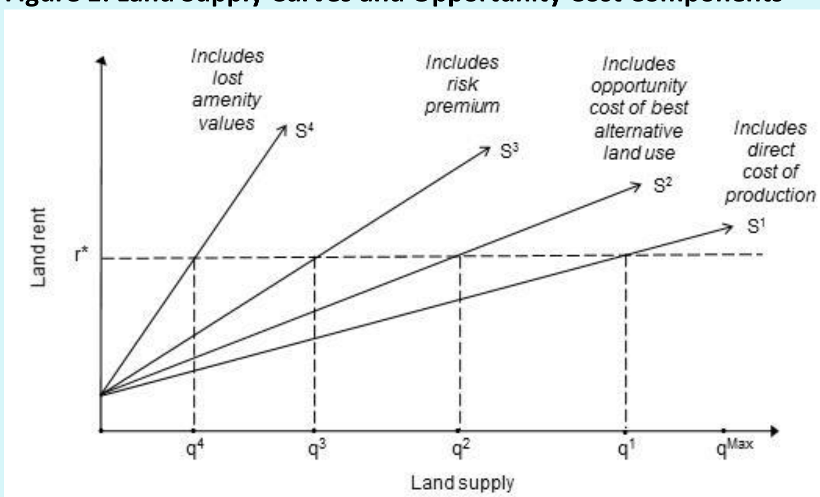
The four inconvenient truths emerge from a set of empirical studies in the U.S. Great Lakes states. The studies used direct surveys to elicit farmer willingness to devote land to growing bioenergy crops (For more information about the studies see the Appendix). The inconvenient truths are these:

1. The overall supply of land for dedicated bioenergy crops is modest even at relatively high biomass prices, so cellulosic biomass supply is likely to be scarce and highly inelastic to price.
2. Crop residues, especially corn stover, are the dominant source of biomass supply, not dedicated cellulosic energy crops.
3. Marginal lands are less likely to be called into use for biomass production than croplands, which means that despite their apparent physical abundance marginal lands are economically scarce.
4. Farm enterprises, especially dairy, provide attractive earnings that limit the appeal of switching land into dedicated bioenergy crops.

The Basics of Land Supply for a New Crop

The supply of land for a bioenergy crops is driven by the marginal cost of producing those crops. Four cost factors lie at the heart of the matter. They are illustrated by the stylized supply curves in Figure 1. Each curve adds a new cost factor that needs to be compensated by the biomass price in order for landowners to shift land into bioenergy crops. Curve S^1 captures the direct costs of producing a dedicated bioenergy crop. At a minimum, a grower would need to be paid the simple breakeven price that covers the cost per ton of growing, harvesting, and storing the bioenergy crop (Mooney et al., 2009).

Figure 1: Land Supply Curves and Opportunity Cost Components



Source: Authors' conceptualization

But covering direct costs is only the start. In order to attract land away from an existing enterprise that generates a profit above direct costs, the biomass price needs to also cover the opportunity cost of the expected profits that could be earned from the best alternative income-generating enterprise—such as dairy or cash grain farming. Curve S^2 adds on that opportunity cost and reflects the comparative breakeven price needed to compensate for switching away from an income-generating land use (James, Swinton, and Thelen, 2010; Kells and Swinton, 2014). But comparative breakeven prices omit risk concerns.

Curve S^3 adds on compensation for added risk and uncertainty. All crops pose production and price risks. But unfamiliar bioenergy crops pose additional learning risks until farmers understand their production well; they also pose unusual price risk as the relevant markets and contracts evolve. Perennial bioenergy crops such as switchgrass involve up-front investments that take time to mature and may be costly to undo. When decision-makers face investment decisions that involve uncertainty or irreversibility they need a higher relative return to forego the option of waiting to see whether the risks decline and make the investment a more certain bet (Dixit and Pyndick, 1994). The option value required to plant a new perennial bioenergy crop can be large. Song, Zhao, and Swinton (2011) find the annualized return to switchgrass would need to exceed that for corn by a factor close to 2.5 before a landowner might consider switching cropping systems when accounting for costly reversibility and uncertainty. Skevas et al. (2016b) report that the high-yielding perennial bioenergy crop, Miscanthus giganteus, can have a 45% chance of failing to overwinter in its first year in south-central Wisconsin. The hidden costs described thus far are based on agricultural income generation. However, income is not the only source of value that people derive from land.

Curve S^4 adds the implicit cost of losing amenities from current land uses relative to a new use. For example, concerns about the potential loss of biodiversity, threats to water quality, and "the land changing in a way that I can no longer use it as I want" associated with intensified cultivation were variables that deterred landowners in northern Wisconsin and Michigan from being willing to rent non-crop marginal land for bioenergy crops (Swinton et al., 2016; Skevas, Swinton, and Hayden, 2014). These changes can lower the amenity value of that land, and hence require a higher price to compensate for the loss of nonmarket benefits. However, the amenity effect need not add to implicit cost; it can also add implicit benefit. Landowners who care about environmental goals such as habitat improvement or carbon sequestration may find that perennial bioenergy crops advance these objectives, particularly in converting the use of cropland (Mooney, Barham, and Lian, 2015; Skevas et al., 2016a).

Which Lands Are Available?

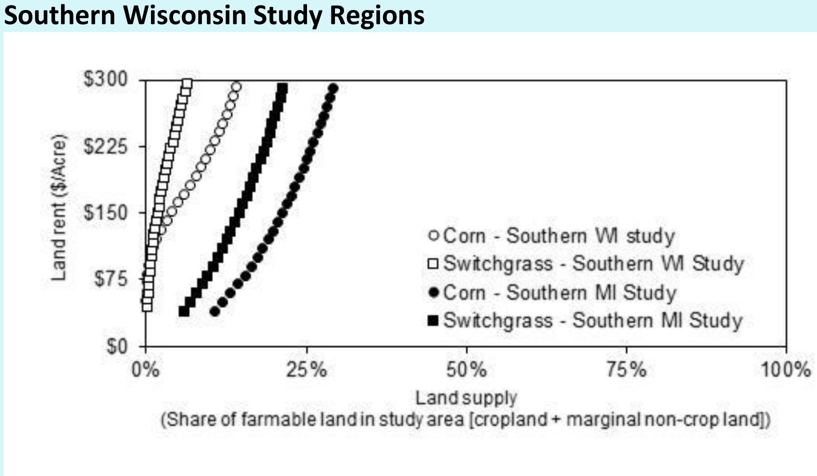
Assuming that they are willing to provide land for bioenergy crops, what type of land would landowners supply? Would it be cropland, non-crop marginal land, pasture, or woodland? The answer is key to identifying whether bioenergy is complementary to, or in competition with, food, feed, and fiber uses. The appeal of non-crop marginal lands—if landowners find this option attractive—is to permit increased supply of dedicated bioenergy crops without triggering reductions in food supply and higher food prices associated with displacement of crop production (Searchinger et al., 2008)

But producing cellulosic energy biomass does not necessarily require new land. Crop byproducts like corn stover can be harvested by intensifying production practices on current cropland. Corn is pervasive in the U.S. agricultural landscape, so stover is the most immediately available source of biomass from agricultural lands. It also becomes available at the lowest marginal cost, which is simply the cost to harvest, store, and transport it (Khanna et al., 2011; Egbendewe-Mondzozo et al., 2015). So a market for cellulosic energy biomass can induce more land to shift into corn.

First Inconvenient Truth: Bioenergy Crop Supply Is Modest Even at High Prices

Supply curves estimated from the landowner survey data in Figure 2 illustrate how land use in the southern Michigan and southern Wisconsin study regions would shift in response to increases in the land rental rate paid by bioenergy crop growers. Switchgrass curves show the share of farmable land—cropland plus marginal non-crop land—that landowners would make available for the establishment of a new dedicated bioenergy cropping system. The curves for corn represent the amount of farmable land that would become economically available for corn grain production systems where stover residues are designated to a bioenergy end use.

Figure 2: Land Supply Curves for the Southern Michigan and Southern Wisconsin Study Regions



Source: Adapted from Mooney, Barham, and Lian, 2015, and Skevas et al., 2016a

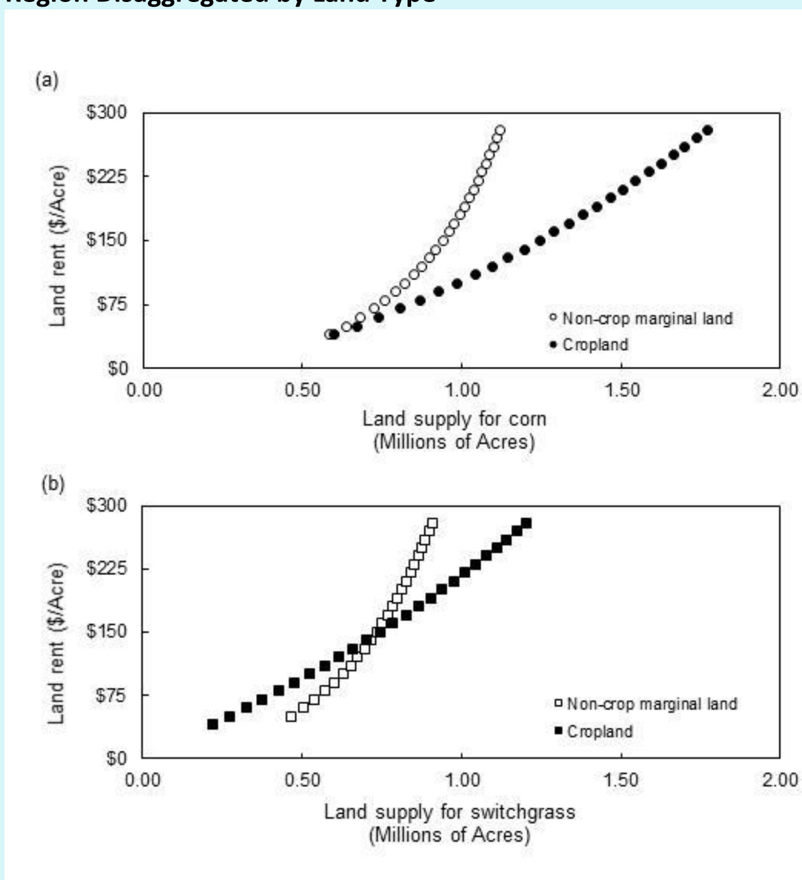
Two takeaways stand out: First, overall land supply prospects are modest even at high rental rates. In all cases, less than one-third of farmable area in either region would be designated to a given bioenergy purpose. Second, the estimated curves are highly price inelastic. At $100/acre—close to the prevailing 2010 rental rate for rain-fed cropland in Michigan—landowners in the southern Michigan study report a willingness to shift 17% of their total farmable land area to corn and 11% to switchgrass. Comparable numbers for farm operators in Southern Wisconsin are less than 2% for either crop. At double that rental rate, or $200/acre, southern Michigan landowners are willing to supply 25% of their land for growing corn and 17% for switchgrass, whereas farmers in southern Wisconsin are willing to supply just 9% and 2% of their land to corn for stover and switchgrass, respectively. In short, even at high land rental rates, potential shifts in land area toward bioenergy crops would only be a small fraction of the total.

Second Inconvenient Truth: Most Biomass Would Come from Crop Byproducts, Like Corn Stover

Figure 2 also shows that rising land rental rates for bioenergy crops attract more interest for growing annual corn than perennial switchgrass. Growing corn for both grain and stover comes at very low opportunity cost, because there is no need to abandon the corn grain sales. Corn is also a crop whose production and markets are familiar, so they prefer to avoid the added risks of an unfamiliar perennial crop (Skevas et al., 2016b; Song, Zhao, and Swinton, 2011).

The relative appeal of expanding corn production holds two significant implications. The first is that on existing croplands where corn is not grown, if farmers switch to a bioenergy crop, they are likely to switch into corn. The second is that non-crop marginal lands are quite likely to switch into corn, as opposed to dedicated perennial energy crops. The recent major expansion of corn and soy production onto non-crop lands that were previously held in the Conservation Reserve Program is a case in point.

Figure 3: Land Supply Curves for the Southern Michigan Study Region Disaggregated by Land Type



Source: Adapted from Skevas et al., 2016a

Third Inconvenient Truth: Supply of Marginal Lands for Bioenergy Crops Is Economically Scarce Despite Physical Abundance

The current uses of land made available for growing corn and switchgrass in southern Michigan are illustrated in Figure 3. As rental rates for bioenergy crops increase, landowners would supply more cropland than they would marginal non-crop lands for both corn and switchgrass. The supply of cropland for corn production (denoted by closed circles) exceeds the supply of marginal non-crop land (open circles) at all rental rate levels considered. The same is true of the supply of cropland for switchgrass (closed squares) at high rental rates.

The scarcity of non-crop marginal land is reflected by the highly price inelastic supply curves relative to those for cropland in both panels of Figure 3. The gap between the areas of the two land uses widens as land rental rates rise, suggesting that active cropland will be the main land mobilized as energy biomass prices rise. Although not illustrated here, this lesson is echoed in southern Wisconsin (Mooney, Barham, and Lian, 2015) and the northern tier of both states (Swinton et al., 2016) studies. Even in this latter ecoregion, where forest covers 56% of total land area, landowners prefer to supply land for bioenergy crops from the 28% that is cropland, rather than the 11% that is non-crop marginal lands.

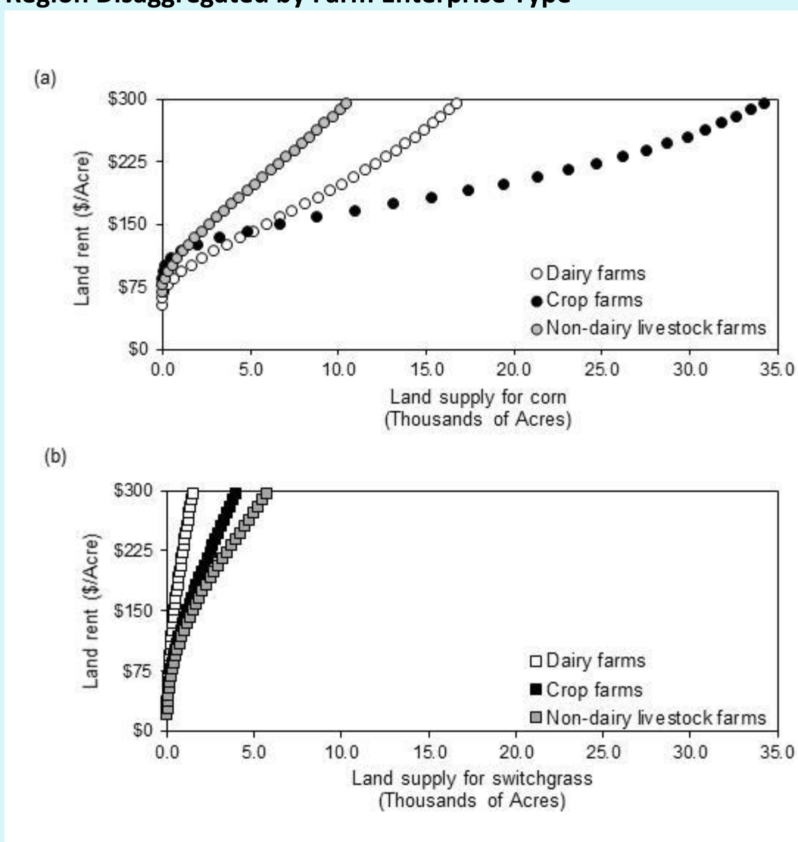
The scarcity of marginal land arises because for many landowners, such lands are not 'in play' for production. Amenity value is one reason, but transaction cost and inertia play roles as well. Hence marginal lands for bioenergy crops can be economically scarce despite being physically abundant.

Moreover, because cropland is the most likely land type that private owners are willing to avail for energy biomass production, markets offer no firewall to ensure that bioenergy crops will come from marginal land rather than competing cropland—and hence affect food and feed prices.

Fourth Inconvenient Truth: Existing Farm Enterprises Pose High Opportunity Costs

The fact that cropland is the main land type being made available for bioenergy crops means that those crops must clear the bar of opportunity costs from existing enterprises. Figure 4 illustrates how the supply of land for bioenergy crops plays out among Wisconsin farmers. At rental rates above $150/acre, crop farms (closed circles) supply the most land for corn stover in aggregate, followed by dairy farms (open circles) and then non-dairy livestock farms (shaded circles). In contrast, dairy farms supply more land in aggregate at lower rental rates. The largest aggregate supply of land for switchgrass comes from non-dairy livestock farms (shaded squares) followed by crop farms (closed squares), with the least coming from dairy farms (open squares). Comparing panels, land supply across all enterprise types in southern Wisconsin is highly price inelastic for switchgrass but much more price elastic for corn (including stover).

Figure 4: Land Supply Curves for the Southern Wisconsin Study Region Disaggregated by Farm Enterprise Type



Source: Adapted from Mooney, Barham, and Lian, 2015

The most striking contrast is shown in the top panel of Figure 4, where cash grain farmers are twice as responsive in the amount of land they dedicate to corn stover as compared to dairy and other livestock farmers over the range of land rental prices considered. Unfortunately for potential buyers of stover, cash grain farm enterprises also own the smallest share of land among the three enterprise types in the southern Wisconsin study region. By contrast, dairy farms, which control most farmland, exhibit a highly price inelastic supply of land for both corn stover and switchgrass. These outcomes reflect the higher opportunity costs that dairy farmers face at the prospect of giving up production of forage and feed for their herds for the sake of shifting that land into bioenergy crops. Hence, even lands with similar biophysical attributes can vary hugely in economic supply based on characteristics of the landowners—especially the opportunity cost of shifting land to bioenergy crops.

Implications for Estimating Land Use Choices and Policy Design

Circling back to the low take-up of BCAP subsidies to grow dedicated bioenergy crops, we have identified four inconvenient truths that explain why the economic supply of land for these crops has fallen far short of their biophysical availability. Even when land is physically available for a new use like bioenergy crops, its economic supply depends upon the opportunity costs associated with existing income-generating activities, the riskiness and costly reversibility of investments into the crops, and possible disamenities from the changed land use.

Empirical analysis to measure these cost factors will generally require a ‘bottom-up’ approach that accounts for current land uses and the tastes of a representative sample of landowners. Stated preference survey methods like those referenced here can guide researchers and policymakers toward empirically-grounded estimates of supply that may vary substantially across locations, enterprise activities, amenity types, and landowners.

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Appendix: Landowner Surveys in the U.S. Great Lakes Region

Our four lessons are based on empirical findings largely from stated-preference mail surveys undertaken 2011-2015 in southern Michigan (Skevas et al., 2016a), southern Wisconsin (Mooney, Barham, and Lian, 2015), and northern Michigan and Wisconsin (Swinton et al., 2016). These studies implemented standard survey methods including multiple contacts with respondents and achieved response rates ranging from 35% to 58%. Questionnaires captured variations in the type and size of landholdings, income-generating enterprises, and other land and landowner characteristics. Questions elicited landowners' willingness to supply land for corn—with stover as a by-product—and switchgrass at different biomass prices or land rental rates. Different versions of each questionnaire varied the prices and rental rates in the accept/reject scenarios offered. Certain surveys asked about other bioenergy crops, including poplar trees and native prairie.

The studies were similar in that they all focused on marginal lands, but differed in sampling procedure. The southern Michigan survey targeted rural landowners with 10 acres or more of non-crop marginal land and included both farm and non-farm landowners. Offer prices were framed in terms of land rental rates and the study considered the willingness to rent three distinct types of land: cropland, hay and pasture land, and other marginal lands. The target population in the southern Wisconsin study consisted of active farm operators with 10 or more acres of agricultural land in a four-county area in which non-crop marginal lands were prevalent. Offer prices were posed as biomass price per ton. This study asked about willingness to shift land into these crops.

All three studies used econometric hurdle models, with a participation model to estimate the share of landowners willing to supply land at a given price or rental rate and an intensity model to estimate how much land would be supplied by those willing to participate. Aggregate supply estimates were obtained by combining results from these participation and intensity models and applying population weights to arrive at predictions of land area that would be dedicated to each bioenergy crop. Explanatory variables differed slightly across studies but were selected from comparable sets of broad control factors hypothesized to influence the land supply decision, including current land uses, extant enterprises and management practices, and land and landowner characteristics.

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