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United States Biofuel Production as Climate Policy: Tensions between Greenhouse Gas Reduction, Agricultural Economies, And Agro-ecological Practice

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Abstract

This article discusses U.S. biofuel production as a strategy for climate change mitigation, describing how energy independence and greenhouse gas emissions reduction goals may not be met as easily as initially hoped. Alternatively, it positions biofuel production as an "environmental fix," a socio-ecological project indicative of the contradictory imperatives to conserve, exploit, and create resources for accumulation. It examines how this "fix" has developed in rural production areas, focusing on Iowa, in the United States. It also describes how rural residents negotiate a biofuels future that bears significant ecological and economic risks, while it maintains accumulation opportunity for dominant energy and agro-industry actors.
Key words: biofuels, climate change policy, agriculture, Iowa, political economy, agro-ecology.

Resumen

Este artículo discute la producción de biocombustibles en Estados Unidos como una estrategia para mitigar el cambio climático, mostrando cómo las metas de independencia energética y de reducción de emisiones de gases de efecto invernadero podrían no alcanzarse tan fácilmente como se esperaba en un principio. Alternativamente, sitúa la producción de biocombustibles como un "fijo ambiental", un proyecto socioecológico indicador de la contradictoria exigencia de conservar, explotar y crear recursos para la acumulación. Examina cómo se ha desarrollado este "fijo" en lugares de producción rurales, enfocándose en Iowa, Estados Unidos. Describe asimismo cómo los residentes de zonas rurales lidian con un futuro de biocombustibles que implica severos riesgos ecológicos y económicos, mientras que mantiene la oportunidad de acumulación para los actores dominantes de las industrias energética y agro-industrial.
Palabras clave: biocombustibles, política de cambio climático, agricultura, Iowa, economía política, agroecología.

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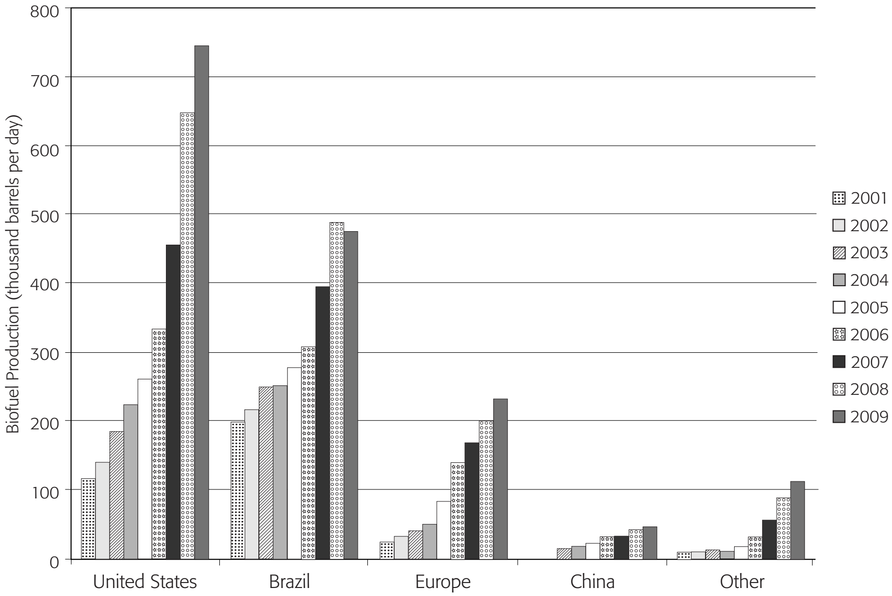
Introduction: Global Biofuel Production's Expanding Reach

Global biofuel production soared over the last decade. In 2001, production totaled 5.26 billion gallons (19.9 billion liters) annually, and by 2010 that number more than quintupled, reaching 28.45 billion gallons (107.7 billion liters) per year (USEIA, 2012). The United States, Brazil, and the European Union (EU) are responsible for the vast majority of global production, but biofuels' geographical imprint is expanding (see Figure 1). Newly producing countries' output is miniscule compared to the sheer volumes of biofuels produced by the U.S. and Brazil, but the biofuel-related change that is occurring in these places may have disproportionate socio-ecological consequences. Indeed, recent massive biofuel production increases have been highly controversial due to the uneven and sometimes dramatic effects of their production across the globe.

Figure 1
GLOBAL ETHANOL PRODUCTION



Source: RFA, 2011; USEIA, 2012.

Documented impacts include: foreign "land grabs," reorganization of land tenure arrangements, undermined food provisioning systems (Borras et al., 2011); exacerbation of food insecurity and hunger through pressure on land bases and food prices (Bello, 2009; Jonasse, 2009; Naylor et al., 2007); uneven and often negative consequences for rural livelihood opportunities (Borras, McMichael, and Scoones, 2010; *Journal of Peasant Studies*, 2010; Bello, 2009); and ecological change of enormous magnitude that carries consequences for carbon emissions and habitat availability (Dale et al., 2010; Fargione et al., 2008; Searchinger et al., 2008). Meanwhile, proponents continue to argue that biofuels offer an opportunity for improving energy security, reducing global greenhouse gas (GHG) emissions, and improving investment in rural economic development.

In the U.S. and EU, biofuel production increases are driven by policy with the stated intent to mitigate climate change. EU initiatives ask biofuels to replace 10 percent of transportation fuels by 2020. The U.S. Renewable Fuel Standard (RFS) mandates the production of 36 billion gallons of biofuels per year by 2022, up from the 1.7 billion gallons produced in 2001. Over 90 percent of current U.S. biofuel output is corn-based ethanol produced in the U.S. Midwest, but the EU mandates will rely much more heavily on imports. In both cases, biofuel policies will create significant demand for agricultural products, raise global agricultural commodity and food prices, and generate significant agricultural change. As I describe below, the consequences of biofuels for agriculture may be significant, even if biofuels' contributions to climate change mitigation are minimal.

In this article, I explore the social and ecological dimensions of biofuel policy and production that help explain tensions between the biofuel policy goal of reducing GHGs and outcomes for rural producing areas. This analysis helps reveal possible tradeoffs and issues to consider when moving forward with greenhouse-gas-reduction, agricultural, rural economic, and environmental policy objectives. Drawing on the U.S. case, I argue that U.S. biofuel production and use can be understood as an "environmental fix," a socio-ecological project indicative of the contradictory capitalist imperatives to conserve, exploit, and create resources for accumulation. I also suggest that stimulating and regulating agricultural production for biofuels based on carbon content alone contributes to ineffective climate change policy that ignores important socio-ecological dimensions of agriculture.

In the following section, I provide a very brief history of U.S. biofuel production, which has been variously positioned as a tool for bolstering rural economic development, improving energy security, and reducing GHG emissions. I then highlight how biofuel initiatives' role as climate policy has focused U.S. policy negotiation on their GHG content, instead of broader socio-ecological issues. I go on to describe how biofuels, given their small contribution to climate change mitigation, but big promise for business-as-usual investment opportunities, are best understood as an environmental fix. I then describe the dynamics of this "fix" and how it interacts with agricultural economies and ecologies in context.

U.S. Biofuel Production as Climate Policy

Biofuel production in the U.S. has a long history. The transportation fuel first emerged in the 1920s and 1930s at the urging of Henry Ford and farmer cooperative organizations. Ford was looking for a reliable fuel source for his new automobiles, and farmers sought to diversify markets for their products, increase their control of the supply chain, and improve their energy self-sufficiency. The oil industry, fearing a loss of automobile fuel market share in the context of a developing U.S. gasoline market, along with changing agricultural markets, thwarted biofuel proponents' early efforts (Carolan, 2010). Biofuels emerged again in the 1970s in the context of oil price spikes. This time, biofuels were positioned less as an agricultural product or *the* automobile fuel and more as a matter of national energy security –a concept then synonymous with independence from foreign oil (Labban, 2011).

More recently, biofuels have been supported for their potential to mitigate climate change. Proponents hope to slow the release of greenhouse gases by substituting plant biomass for fossil fuel. In the U.S., regulatory responsibility for implementing biofuel policy falls to the U.S. Environmental Protection Agency (EPA), the entity responsible for air quality regulation. The U.S. Renewable Fuel Standard (RFS), first published in 2005, determines biofuel production targets and sets criteria for determining different biofuels' renewability. Renewability is principally defined as the degree to which a particular biofuel's use reduces GHG emissions relative to gasoline. Indeed, the RFS represents "the first time that greenhouse gas emission performance is being applied in a regulatory context for a nationwide program" (Regulation of Fuels and Fuel Additives, 2010: 14670). Since the regulatory authority for mandating the production of particular biofuels in the U.S. stems from their ability to reduce GHG emissions, the process for determining the carbon and energy balances of biofuel production cycles has been a major focal point of political negotiation.

When the RFS was enacted, GHG reduction targets were more an assumed than explicitly measured goal. As biofuel production ramped up, however, debate over the biofuels' energy and GHG benefits grew. Different studies arrived at vastly different GHG and energy balance calculations. Part of the discrepancy stemmed from researchers' decisions about the appropriate spatial and temporal boundaries to be used in modeling the GHG and energy budgets for various biofuels. For example, some included the energy costs of the farmer's lunch and the energy costs of farm machinery manufacture, while others did not. The quantity of energy expended or GHG emitted in, for example, growing and processing an acre of corn also differed across studies (Farrell et al., 2006).

The debate led to new efforts to determine official calculations of biofuels' "renewability" or GHG reduction capacity and establish standards that biofuels must meet to qualify for support under the RFS. First generation biofuels, primarily corn-based ethanol, must reduce GHGs relative to gasoline by 20 percent, while advanced biofuel must reduce GHG by 50 percent and cellulosic biofuel by 60 percent (Regulation of Fuels and Fuel Additives, 2010). EPA efforts to measure the GHG emissions or savings of various biofuels were complicated by the widely varying study results. This feat became more difficult in 2008 when two studies published in *Science* (Searchinger et al., 2008; Fargione et al., 2008) argued that prior calculations were significantly flawed due to their omission of the carbon costs of indirect land-use change associated with increasing biofuel production. The studies asserted that increasing U.S. biofuel production raised global agricultural commodity demand and prices, inspiring increased agricultural production abroad. The newly cultivated acreages, the studies said, could come from rainforest, grassland, or other habitat conversion, releasing much more carbon than would be saved through biofuel production.

The EPA took indirect land-use change into account for its next round of RFS rulemaking. In its revised analysis, the EPA found that corn ethanol would reduce carbon emissions by 16 percent relative to gasoline, not the 20 percent required (Regulation of Fuels and Fuel Additives, 2009: 25042). Biofuel industry advocates responded swiftly and forcefully to the finding, which threatened future corn-ethanol production increases. The Renewable Fuels Association expressed their "grave concern" about the EPA's findings and suggested EPA calculations of corn ethanol's carbon and energy costs to be "wholly insufficient" (Dinneen, 2009). After protracted negotiations over carbon and energy accounting methodologies, the EPA found that corn ethanol would qualify. Citing new efficiencies in corn production and processing, the EPA revised its estimates and pegged corn ethanol's GHG reduction capability at 21 percent, just over the 20 percent threshold.

Also important in securing corn ethanol's dominant role in the RFS (currently over 90 percent of U.S. biofuel production) was the EPA's adoption of the "aggregate compliance approach" for monitoring U.S. land-use change. The second RFS stipulates that "renewable" biofuels cannot be derived from land converted to agricultural production after December 2007. The adoption of the aggregate compliance approach, as suggested by the National Corn Growers Association (see Informa Economics, 2009; Voegele, 2009), means that the EPA will monitor changes in the total number of agricultural acres only; these include pasture, cropland, and Conservation Reserve

Program (CRP) lands. If, in aggregate, no new acres are added, all biofuel production is presumed to be from existing agricultural land and in compliance the RFS.

Conversion of CRP land, however, may have big negative effects. The CRP pays farmers to "set aside" marginal cropland acreage as grassland to improve soil, water, and habitat quality in working agricultural landscapes. Converting CRP to cropland releases carbon (see Gelfland et al., 2011), which is not counted against corn ethanol production in the RFS, in addition to eliminating many of the CRP's ecological benefits. Fargione et al. (2008), for example, found that converting one acre of land at the end of a 15-year CRP contract creates a "carbon debt" that would take 48 years of corn ethanol production to repay (see Piñeiro et al., 2009; Searchinger et al., 2008; Uri and Bloodworth, 2000). As discussed below, since the biofuel boom began in the U.S., CRP acreage has declined.

The EPA's finding that biofuel production, including corn-based ethanol, significantly reduces GHG emissions relative to gasoline legitimizes U.S. biofuel production as effective climate change policy. This finding remains despite the fact that corn constitutes the vast majority of U.S. biofuel production, significantly reducing the value of U.S. biofuel production in mitigating climate change while creating the numerous negative socio-ecological consequences discussed below. Cellulosic targets have been scaled back significantly, and it is still unclear when this fabled industry will emerge on a scale sufficient to provide a GHG-reducing liquid fuel alternative. And despite strong rhetoric about reducing U.S. dependence on foreign oil, the production of biofuel does little to assuage growing U.S. oil imports. The conversion of the entire U.S. corn crop into biofuels –currently, approximately 40 percent of U.S. corn goes to ethanol– would displace only 12 percent of the U.S.'s growing gasoline consumption. When the biofuel production target of 36 billion gallons per year (BGY) is reached in 2022, the EPA estimates they will replace a scant 7 percent of U.S. gasoline and diesel consumption, which is expected to continue to rise (EPA, 2010). Biofuel policy seems to function simply to enable continued liquid fuel consumption, over and above supporting energy conservation. In short, current biofuel production is climate policy in name alone. That biofuels will not displace a significant amount of fossil fuel or reduce greenhouse gases suggests there may be alternative explanations for their role and prominence in U.S. policy.

Biofuels as "Environmental Fix"

Recent work in geography has examined processes and effects of contemporary environmental governance (see Castree, 2008; Himley, 2008; and Lemos and Agrawal, 2006 for reviews).[1] A significant number of these scholars have examined processes of "nature's neoliberalization," which describes the restructuring of socio-ecological relations according to varied neoliberal or capital-centric logics. These modes of governance include rollback of government intervention, deregulation, devolution of responsibility, commodification, privatization, and marketization of resources and environmental processes (see Peck and Tickell, 2002; Castree, 2008). One central goal of environmental governance under capitalism is to create and exploit resources toward their profitable and efficient –if not equitable– exchange and use. As Castree (2008) puts it, what various modes of environmental governance have in common is that they serve as an "environmental fix" for capitalism's problem of sustained growth. Multiple scholars have described capital-nature relations and this problem, that is, that capitalism must continue to grow, transforming and often undermining the social and ecological contexts and resources upon which it depends (e.g., Smith, 1984; O'Conner, 1998). In Castree's synthetic formulation, the neoliberalization of nature is constituted by "conservation *and* its two antitheses of destroying existing and creating new biophysical resources." He asserts, "It is not reducible to one or other rationale alone" (Castree, 2008: 150). That is, capitalist socio-natures simultaneously represent efforts to protect resources to enable future accumulation (conservation) and the creation and destruction of new and existing resources, which also allow for continued accumulation.

I argue that biofuels are one manifestation of nature under capitalism that constitutes an "environmental fix." First, making biofuel available as a "renewable" alternative to fossil fuels *conserves* stored carbon, reducing GHG emissions. This legitimizes biofuel as a sustainable *new resource*, even if not as effective in emissions reductions as hoped. Meanwhile, intensified agricultural production and expanding liquid fuel use continues to facilitate accumulation, primarily for dominant agribusiness and oil industry actors that receive the bulk of profits from extracting and processing cheap feedstocks from the agricultural landscape.[2] Indeed, support for biofuel production in the U.S. resonates with a long history of agricultural policies subsidizing the sector in order to provide a broad basis for accumulation. Massive U.S. agricultural subsidies provide cheap food for domestic consumption and international export, grain for livestock, inputs for industrial product manufacture, and other goods including automobile fuel (Goodman, Sorj, and Wilkinson, 1987; Friedmann and McMichael, 1989). I discuss biofuel production's interaction with agriculture and rural livelihoods in the U.S. Midwest in the next section.

[1] "Environmental governance" refers to the formal and informal institutional arrangements that influence resource use and allocation and, more broadly, mediate nature-society relations.
[2] See Huber (2009) on the centrality of gasoline consumption in American culture and capitalist accumulation.

As explained, U.S. biofuels production is mandated by the RFS and legitimized for its potential contribution to greenhouse gas reduction. In U.S. policy goals and metrics, biofuels' consequences for agricultural economies are secondary.

Mol (2007) points out that global biofuel support is constituted more by urban, global, or cosmopolitan consumers' desires for cheap energy or GHG emissions mitigation than by rural areas looking for economic or ecological opportunity in agriculture. In U.S. congressional debates over biofuel policy, for example, Minnesota Representative Guknecht, said, "The people who found the argument [for biofuels] interesting, it seems to me, were not necessarily farmers; it was people living in suburban communities. They want cheaper energy. They want a cleaner environment. They want all the things that renewable energy can bring" (U.S. House of Representatives, 2005: 6). Richard Lugar, a former Republican senator from Indiana put it this way: "We are talking about the ability of our country to continue on the lifestyle to which we are accustomed" (Truitt, 2007).

The creation of new liquid fuel sources as a "fix" for increasing (urban) GHG-intensive fossil fuel consumption, however, creates enormous and uneven change in agricultural economies and ecologies. In the following two sections of this article, I discuss how biofuel production initiatives develop on the ground, in terms of both political economic and ecological outcomes. I draw on the U.S. case, based on document and policy analyses and qualitative field research conducted in Iowa between 2006 and 2010. I use Iowa as an example, because this U.S. state produces more corn and more biofuel than any other (USDA, 2011). I first focus on the construction of biorefineries that process corn into ethanol. I then turn to interactions between biofuel industry development and farm economies. The final section of the article addresses the ecological consequences of pursuing biofuel production as an "environmental fix."

Biofuels and Agricultural Economies

Biofuels were once a strategy for rural agricultural producers to improve energy self-reliance, own agricultural product-processing capacity, and diversify and improve the market for their products. Today, as an "environmental fix," biofuels facilitate accumulation in agribusiness and energy sectors. Relative to grain traders and processors and oil company investors in biofuel technologies and infrastructure, many farmers' economic opportunity is limited by their marginal position in agricultural supply chains. In this section, I describe how biofuel initiatives connect to rural economies, drawing on insights from agricultural political economy.[3] I explain how those who have long benefitted from industrialized agriculture continue to benefit from biofuel-related climate policy, in addition to new entrant oil industry actors now in a position to profit from biofuels. I first discuss debates around the construction of biorefineries and then move on to farm-level dynamics associated with the U.S. biofuel boom.

A Biorefinery Rush in the Corn Belt

The building of biofuel processing plants, or biorefineries, in the corn-producing region of the U.S. Midwest has a history of changing forms. During several periods, small farmer-owned biorefineries were the mainstay of ethanol initiatives. In the 1920s and 1930s, farmers joined with Henry Ford and other ethanol enthusiasts to market farmer-owned fuel, ethanol branded as Argol. Ethanol rose again as an alternative fuel source as oil prices spiked in the 1970s, booming through the early 1980s. Farmers expanded their engagement with and ownership of the industry, with government backing for loans for plants producing less than 1 million gallons per year. Farmers would pool resources through cooperatives to finance small biorefineries and by 1984 at least 163 were in operation (Carolan, 2010; Morris, 2005).

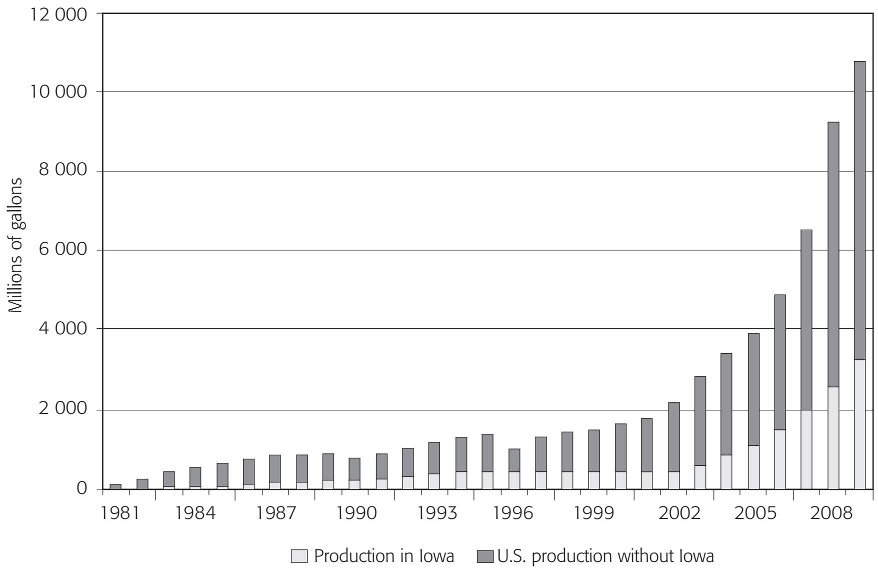
Nearly half of these farmer-owned biorefineries closed just a year later, after an oil price crash and oil industry efforts to slow the ethanol's growth. By 1990, after this extreme market contraction and devaluation of rural ethanol investment had finalized, only 56 plants remained. During this period, new ethanol refinery construction was no longer financed by rural cooperatives. Archer Daniels Midland, one of the world's most powerful grain merchants, began building ethanol refineries as part of their high-fructose corn syrup processing capabilities and came to control 75 percent of the ethanol market by 1990. After 1990, farmer-owned plants returned, but the size of these plants increased through the 1990s and into the early 2000s (by an average of 15-30 million gallons per year of production), along with the number of farm-

[3] This analysis draws on policy and document analyses; analysis of secondary data on land use, agricultural production, and biofuel industry development; and analysis of qualitative data from field research conducted in Iowa between 2006 and 2010. In Iowa, I interviewed farmers, county conservation agents, state-level public officials, Iowa residents, and biofuel industry investors, owners, and participants. I employed a snowball sampling method to interview over 75 regional residents, conservationists, and farmers. Interviews were transcribed, coded, and analyzed by theme. I focused semi-structured interviews in Northeastern Iowa, an area selected for 1) high farm-type diversity, allowing for analysis of agricultural change across production strategies; 2) a topographically varied landscape making conservation practice important; and 3) the presence of refineries and engagement with the biofuel industry. Participant observation of conservation practice planning and implementation were also completed in Northeastern Iowa.

er shareholders (up to 25 000). By the time the first RFS was mandated in 2005, linking biofuels with climate change mitigation policy, circumstances had changed again. In 2004, the first 100-million-gallon dry-mill ethanol plant opened in South Dakota, which created a new standard for biorefinery size. Since then, 100-million-gallon and larger biorefineries have been constructed at a staggering pace (Morris, 2005).

In 2000, there were 54 U.S. biorefineries producing 1.6 billion gallons per year (BGY); by 2011, 204 biorefineries can produce 13.5 BGY of biofuels annually (RFA, 2011). In Iowa, the focal point of this research, biofuel production increased over four fold, from 859 million gallons per year in 2002, to 3.9 BGY in 2011 (see Figure 2; Iowa RFA, 2011). Both federal and state policies have supported biofuel refinery construction with tax incentives, loan guarantees, and other incentives for production and distribution infrastructure. These are in addition to tariffs on ethanol imports, subsidies, and mandates for production. This new wave of biorefinery construction provides the opportunity to ask how the developing biofuels industry, this time connected to climate change mitigation, will connect with rural agricultural producing areas.

Figure 2
U.S. AND IOWA ETHANOL PRODUCTION



Source: RFA, 2011.

In the latest biorefinery boom, financial backing came from sources both internal and external to construction locations. During biofuel production's initial re-expansion in the U.S. Midwest, construction costs for a new 100-million-gallon-per-year biorefinery were approximately US$136 million (Farrell, 2007). In Iowa, where this research was conducted, rural residents would gather in hotel rooms, coffee shops, and high school gymnasiums to hear biofuel companies pitch investment opportunities in new plants. Rural resident investments were significant, varying from US$5 000 to US$25 000 or more. Initially, rural residents were thrilled at the opportunity to cash in on the "dot-corn" boom, as it was dubbed in news media accounts. Hoping for a rare income opportunity, many rural residents jumped at the chance to participate in the growing biofuels industry. During the initial industry boom, Morris (2007), drawing on an Iowa State University Study, found that a five-year investment in a biorefinery would bring an average return of 23 percent. This represents a significant opportunity for rural residents, considering farmers in 70 percent of Iowa's counties can expect to return only 2.5 percent on their investment in agricultural land.

In northeastern Iowa, several farmers interviewed told of a US$30-million capital drive ending after just seven hours. "That's how long it took people to write US$30 million worth of checks," said one corn and hog farmer (Pers. comm., 2007a).[4] A biofuels fundraiser interviewed boasted that it took him less than hour to raise US$700 000 from seven farmers for the construction of a different plant (Pers. comm., 2009b). Speaking during boom time, a major partner in an ethanol refinery jokingly complained that her family was "tired of hearing her preach the 'good news of ethanol,' but they're not tired of the dividend checks coming in at Christmas time" (Pers. comm., 2007a).

Despite the good times seemingly arriving with the biofuel industry in rural Iowa, some residents questioned whether the investment in corn and biofuel production was good for their economy, especially as market conditions began to change. One cautionary story often told in northeastern Iowa recounted how a biorefinery fundraiser fled to Florida with hundreds of thousands of dollars from regional residents as investments when industry profitability problems emerged. Even before the industry contracted, many rural residents became concerned about local government investments in biorefineries, environmental quality deterioration, water-use issues, and infrastructure expansion costs (see also Selfa, 2010). For example, the *New York Times* reported that in summer 2006, a Cargill biodiesel refinery in Iowa Falls, Iowa, "improperly disposed of 135 000 gallons of liquid oil and grease, which ran into a stream killing hundreds of fish" (Goodman, 2008). Air quality concerns

[4] All sources are protected by confidentiality requirements of the Institutional Review Board at the University of California, Santa Cruz.

also became prominent after the Bush administration lowered the standards for emissions requirements for biorefineries (Hunt, 2007). In some cases, this helps to accommodate on-site coal burning for providing biorefinery power, seriously threatening the credibility of biofuels as GHG reducers and contributing to local air pollution.

Other topics for debate in siting biorefineries included the costs of expanding railroad tracks and road infrastructure to accommodate new plants. Many residents lamented the consequences of sharply increased truck traffic for local roadways: semi-trucks carry corn to biorefineries and railroads transport ethanol out. County or municipal financial resources were often offered to help improve transportation infrastructure facilitating a biorefinery's consumption of 600 acres worth of corn per day. Some residents argued that their city and counties should not be forced to bear the cost. In other cases, biorefineries were exempted from significant taxes; sometimes these agreements called for complete property tax exemption for up to 20 years, eliminating a significant potential source of rural income in the biofuel boom.

My research engaged with several Iowa towns considering building a biorefinery. Manchester, Iowa, was one town whose residents were considering hosting an ethanol plant on the outskirts of town. The city of Manchester had agreed to grant a biofuel company US$6.6 million through a 10-year property tax abatement, extend the sewer systems to land annexed for construction, and make roadway improvements to accommodate increased truck traffic. The Iowa Department of Economic Development offered the biofuel company a US$10.4-million sales and use tax credit in return for the approximately 50 jobs to be created by the biorefinery. Interviews with residents and public meeting records raised a series of representative issues, including concerns about water use –the new plant would consume thousands of gallons of water per day (estimated at 3 gallons/liters water per gallon/liter ethanol produced); increased truck traffic effects on children's' safety; local air quality; zoning exemptions granted for the plant limiting potentially lucrative commercial development; high costs of incentivizing construction, despite biorefinery boasts it could pay for itself in three to seven years; and the consequences for the local livestock industry. Manchester residents interviewed were glad that biorefinery construction was not rushed through; soon after negotiations were complete, biofuel industry profitability suffered. The Manchester biorefinery developer, All Fuels and Energy Company, pulled out of the deal and sold the land annexed for the plant's construction in order to maintain liquidity in the face of an impending financial crisis.

These dynamics were characteristic of many biorefinery development plans across the state. After significant investments from rural residents and state, local, and federal government agencies, biorefinery construction seems to be paying much less back in rural economic benefits than was initially hoped. Northeastern Iowa residents interviewed began expressing skepticism that their investments in the industry were profitable for investors or the community. Excitement about rural economic opportunity quickly faded as residents came to realize biofuel production's profitability was closely tied to volatile corn and oil markets. As agricultural commodity prices climbed in the run up to the 2008 financial crisis, biorefineries in Iowa struggled to make their biofuel pay, especially with greatly expanded production capacity nationwide. Compounding problems, oil prices fell after the financial bubble burst, making biofuel production even less competitive with gasoline.

By late 2008, approximately 10 biofuel companies had closed 24 plants in the U.S., with U.S. biorefineries producing at nearly 20 percent under capacity (Krauss, 2009; RFA, 2009). A 2007 University of Nebraska study pointed out that if such a contraction occurred, smaller or locally owned biorefineries were the most likely to go out of business; they lacked the economies of scale and significant capital backing enjoyed by larger-capacity plants (Peters, 2007). Indeed, in 2005, 46 percent were cooperatively or locally owned, but by 2009, fewer than 23 percent of biorefineries were under local ownership (EPA, 2006; RFA, 2009).

Another northeastern Iowa town at the center of the biofuel industry development debate was Dyersville, the site of a biorefinery built by VeraSun in 2008. VeraSun, an independent company from South Dakota had just eclipsed Archer Daniels Midland to become the nation's top ethanol producer. VeraSun had recently doubled its ethanol interests to US$1.2 billion, producing 1.635 billion gallons per year. Just two months after the Dyersville, Iowa, plant opened, however, VeraSun filed for bankruptcy. VeraSun had signed up to purchase high priced corn to feed its biorefineries, just before oil and commodity markets took a dive in late 2008. The company lost US$476 million in one quarter and Valero Energy Corporation, the U.S.'s largest gasoline refiner, purchased seven of VeraSun's biorefineries for US$477 million, less than half the cost of construction. Meanwhile, VeraSun petitioned a bankruptcy court judge for the right to deny contracts made with Dyersville area farmers.

Just two months after opening, the Dyersville biorefinery closed. Valero did not purchase the plant and residents were concerned about the loss of approximately 50 jobs, the status of contracts to produce corn for the plant, associated regional corn market volatility, and the costs incurred in attracting the recently failed biorefinery (Pers. comm., 2008a and 2008b; Porter, 2008a, 2008b, and 2009). Some were hopeful that commodity markets and the biofuel industry would stabilize, but many remained concerned that regaining the benefits promised by their investments would not be possible (Pers. comm., 2008a; 2008b). Here, I quote a telling passage from the local newspaper on the subject:

> [VeraSun] issued a statement saying that farmers who delivered corn before Oct. 11 [2008] might not promptly receive payment. Finally, several area producers say they received a check from the company. An accompanying note said if farmers endorsed the check, they agreed to receive market cost for the corn instead of the agreed contract price. "That means I'm not going to get as much as I thought," said Dick Recker, of Dyersville. He started selling corn to the VeraSun plant in July for about $7 per bushel. He entered into another contract to deliver grain in July 2009, but a recent conversation with a VeraSun representative left him discouraged. "The price might have to be negotiated at the time of delivery," Recker said. "He said if corn went back up close to what we got a contract for, then we'd be OK, but if market price is $4, then he said we'd have to talk about it." With the Chicago Board of Trade closing Friday at $3.80 per bushel, Recker knows the future looks dim. By cutting the price per bushel in half, he could be out more than $40 000 next year.
> . . . "Well, I would have to say, it's almost like, 'I told you so,'" said Becky Schwendinger. She lives on the west end of Dyersville, close to the plant and opposed its construction from the beginning. "It was rushed through," she said. "The city didn't care that we had 600 signatures opposing it. That meant nothing to them." Another neighbor to the plant, Marty Steffen, who lives less than a mile from the facility, said the plant promised an economic boost and is failing to deliver. "My thought is that the light at the end of the tunnel isn't as bright as was originally portrayed," he said. "Don't get me wrong, I want this town to prosper. I want the farmers to prosper, but in one sense, Dyersville put all its eggs in one basket." (Porter 2008b)

Work on the political economy of agriculture can help put this biorefinery boom and bust in the context of farm-level dynamics. A large body of research in geography, rural studies and sociology, and agrifood studies has addressed the political economic dynamics of the U.S. Midwestern agricultural regions (e.g., Friedmann, 1978; Goodman, Sorj and Wilkinson, 1987; Blaikie and Brookfield, 1987; Lighthall and Roberts, 1995; Marsden et al., 1996; Page, 1997; Heffernan, 2000). Researchers have described how agriculture-related industries rose alongside agriculture in the U.S. Midwest, with agriculture providing an important basis for broader U.S. capitalist industrial growth, just as industry has been central to urban-rural relations and the functioning of farm economies since the late nineteenth century (Page and Walker, 1991). Biorefineries constitute another iteration of expansion of rural agricultural product processing capacity.

Researchers have also described the process of agro-industrialization and its farm-level effects. Over time, the agricultural sector has lost control over the agricultural product supply chain. Primary farm products are reduced to simple inputs for industrial processes, with the industrial sector capturing more of the "value added."

Farms also increasingly buy inputs from off-farm sources, rather than providing for them through their own labor and farm biological processes (e.g., nitrogen fertilizer, pesticides, and purchased seeds replace animal manure, crop rotation, and seed saving, respectively) (Goodman, Sorj and Wilkinson, 1987). Agricultural industrialization on these farms has increased farm productivity, but also marginalized farmers' position in agriculture. Farms' economic roles become industrial input buyer and provider of simplified agricultural products for industry, like corn, which can be exchanged as livestock feed, food, fuel feedstock, or industrial product input (e.g., plastic) (Goodman and Redclift, 1991). Farms and farm labor also become economically marginalized, as these relationships mean industry improves its profitability and economic stability, while agriculture takes on more supply-chain risk due to its reduced market control and continued vulnerability to market volatility and variation in the biophysical conditions of production (see FitzSimmons, 1986; 1990).

This model of agricultural production creates an agriculture that serves as a source of accumulation for industrial sectors. Biofuels production fits this mold. As a state-supported, agriculturally-based industrial product, biofuels provide an enormous investment opportunity for industry in research and processing and distribution infrastructure. In addition to agribusiness and oil industry investment in and domination of a consolidating biorefining industry, oil company investments in future biofuel technology research and development initiatives have also been significant (see Table 1). This trend may indicate that real profitability in biofuel production is likely to be in owning the engineering technological resources necessary for advanced biofuel production (cf., Goodman, Sorj, and Wilkinson, 1987).

In short, biofuels are meant to be a cheaper –if not more renewable– alternative to gasoline that builds on the capacity of industry to accumulate from agricultural labor and biological processes. In contrast to past biofuel initiatives, this time, biofuel production has received substantial investment from the oil industry, as seen in the table above. Carolan (2010) suggests this may be because biofuels constitute an alternative liquid fuel, not an alternative *to* liquid fuel. In the remainder of this section I describe how U.S. biofuel policy, volatile markets, and circuits of agro-industrial and energy investment and exchange offer little lasting rural benefit. Rather, building on current agro-industrial political economic structures with a biofuel industry reproduces political economic and ecological marginalization characteristic of industrialized agricultural production in the U.S. Midwest.

Table 1

BIOFUEL RESEARCH AND DEVELOPMENT FUNDING

Funder	Funded	Amount (US dollars)
BP	UC-Berkeley	$500 000 000
Exxon Mobile	Stanford	$100 000 000
U.S. Department of Agriculture	Michigan State University	$50 000 000
Chevron	UC-Davis	$25 000 000
Conoco-Phillips	Iowa State University	$22 500 000
U.S. Department of Energy	—	$944 000
Chevron	Georgia Institute of Technology	$12 000 000
U.S. Department of Agriculture	Washington State University	$840 000
U.S. Department of Agriculture	Baylor University	$492 000
Chevron	Texas A & M University	Undisclosed

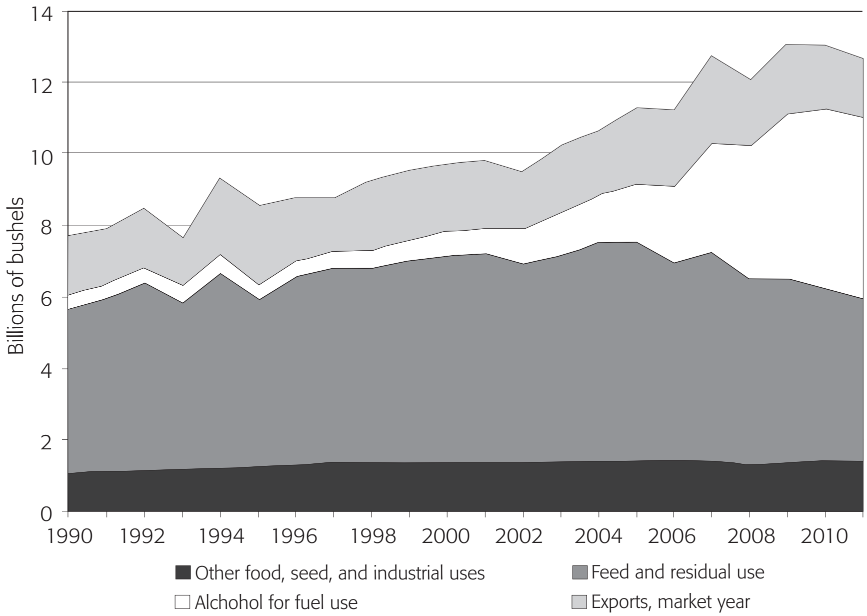
Source: Carolan, 2010.

Extracting Fuel from Farms

In order for biofuel production to be profitable, agricultural products must be abundant and relatively cheap. In the U.S., this is made possible by federal subsidies for agriculture, asymmetrical global and domestic market relationships that drive agricultural prices down, and vast acreages of industrialized farming operations designed to continually increase agricultural productivity with the application of new seed technologies, fossil-fuel-based fertilizers and agrichemicals, and large investments in farm machinery and precision agricultural technologies. The U.S. RFS explicitly builds on this agricultural capacity and its assumed trajectory.

Since RFS passage in 2005, corn acres planted have markedly increased. In 2000, 75.7 million acres of corn were planted in the U.S.; by 2012 this number is 95.9 million acres, representing the largest area planted since 1937 (see Figure 3). While rising production levels and increasing prices appear to be a boon for U.S. farmers, analysis reveals otherwise. Even a brief survey of media coverage of the ethanol boom revealed contradictory descriptions of rapid biofuel industry development. Some farmers welcomed the boom, saying, "It seems like a farmer gets one or two homeruns in his career. Is this our homerun? I think so" (Paulson, 2007). Other Iowa corn growers were more cautious, saying, "I don't want to get caught up in the euphoria" (Etter, 2007). A Minnesota corn grower said to a reporter, "Four-dollar corn is a bad thing –write that down" (Birger, 2007). The latter feared a bust, although that would not come until corn prices reached heights of US$7.00 per bushel.

Figure 3
U.S. CORN USE



Source: USDA, 2012.

My research in Iowa asked farmers about the costs, benefits, and risks of developing a biofuel industry in their region. I found that despite high agricultural commodity prices, farmers failed to receive significant profits. As prices rose for their products, input costs also increased, contributing to slim margins. Between 2006 and 2007, nitrogen fertilizer prices rose 26 percent and would continue to rise (USDA, 2008a; Westhoff, Thompson, and Meyer, 2008). Land prices in Iowa also jumped an average of 19 percent between 2007 and 2008 and continue to increase today (USDA, 2008b). One interviewee, for example, simply stated, "I made more money on $2.00

corn…. The price of land went up; the price of inputs went up…. There's less profit in an acre of corn now than there was five years ago. I can show you my books" (Pers. comm., 2009a). A usda Farm Service Agency representative identified the cost-price squeeze farmers faced as input prices rose, suggesting input suppliers increased prices behind commodity price spikes: "If your making it on this end, they'll be getting it on the other" (Pers. comm., 2007d). Another farmer interviewed said simply, "They keep 'er spent," implying that farmers' income is a known quantity to be chipped away at by industrial farm input suppliers (Pers. comm., 2007a).

Farmers interviewed also described increasing competition between farmers for land, as commodity and input prices rose with national biofuel production mandates. Interviewees described increasing rental rates, which only the largest farms could easily afford to pay. One corn and hog farmer described his frustration with increasing competition in regional agriculture and the imperative to continually reinvest farm profits in expansion, known as the "production treadmill" (see Cochrane, 1979). He said, "You have to be running pretty fast just to stay in place…. We just need to figure out a way to keep people from trying to farm the whole damn world" (Pers. comm., 2007b).

Iowa livestock farmers fared even worse during the initial phase of rapid biofuel industry growth. Dependent on the grain ethanol refineries were increasingly consuming, livestock farmers saw margins fall even more drastically than grain farmers. One hog farmer interviewed complained that the new ethanol plant in town had made livestock farming a "break-even proposition" –he hadn't earned an income for his work in two years (Pers. comm., 2007a). Members of a northeastern Iowa farming cooperative said that the new large-volume corn purchasers made it difficult for them to secure grain supplies to sell to their livestock-producing customers. The National Cattlemen's Beef Association, brazenly oppositional to ethanol, put it this way: "This ethanol binge is insane…. This talk about energy independence and wrapping yourself in the flag and singing God Bless America –all that's going to come at a severe cost to another part of the economy" (Herbst, 2007).

Despite assertions that rural benefits will arrive with a booming biofuels industry, the costs, risks, and benefits of biofuel production fell very unevenly across livestock producers, grain farmers, and biorefinery investors. These findings echo research in agricultural political economy that describes farms' relatively marginal economic standing with respect to agricultural input suppliers and commodity processors. While those investing in advanced biofuel technology or those with the market power to invest in infrastructure and weather initial market volatility may benefit, farm-level gains look less certain.

The agricultural outcomes and politics associated with the proposal to use biofuels as a ghg strategy should not be missed. Geographer David Harvey's 1996 work on understanding the politics underlying socio-ecological projects is insightful here. He writes, "One path towards consolidation of a particular set of social relations, therefore, is to undertake an ecological transformation which requires the reproduction of those social relations in order to sustain it" (184). Simply put, increasing biofuel production under an industrialized agricultural model that rewards already dominant agribusiness, industrial, and energy actors will do little to generate new, lasting benefits for biofuel feedstock producers.

Biofuels in the Agro-ecological Context

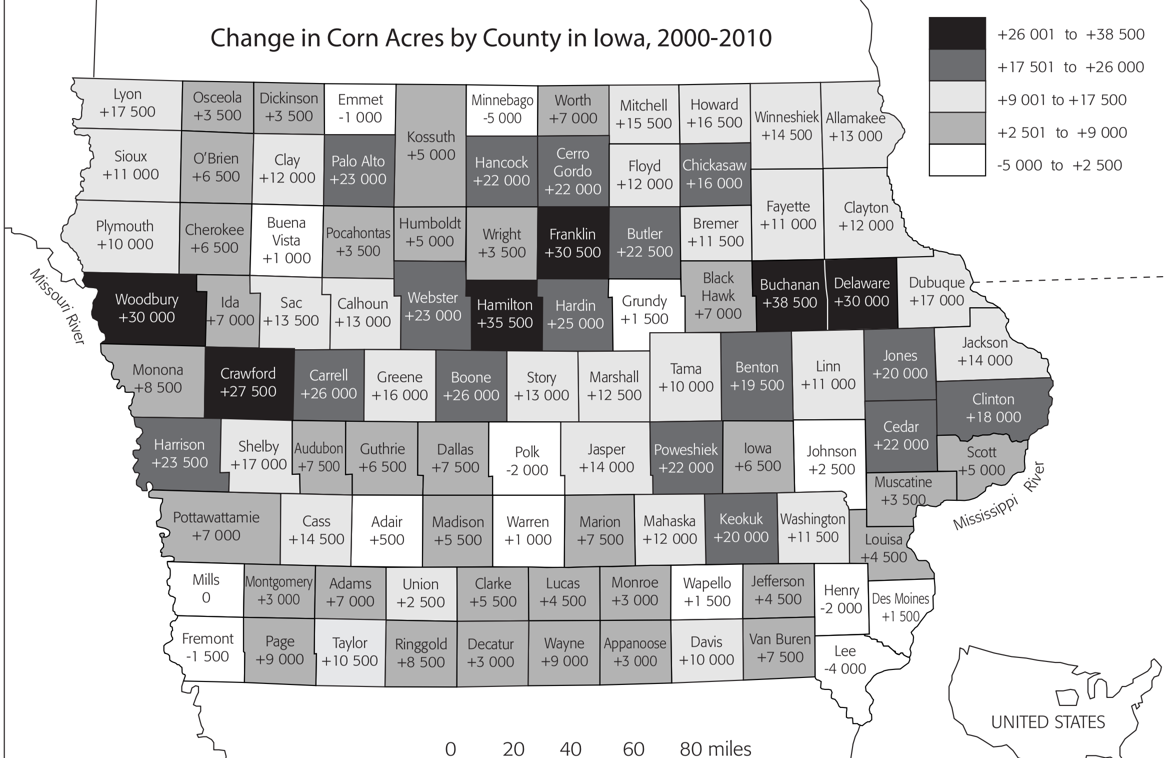
As discussed, biofuel policy is positioned as climate policy in the U.S. Renewable Fuel Standard. This conditions biofuel production's role as an "environmental fix," reducing greenhouse gas emissions while maintaining economic growth opportunities for some. Despite biofuels' questionable contributions to GHG emissions reductions, the ecological consequences of biofuel industry development are enormous. At the outset, for example, the U.S. EPA noted that RFS implementation "threatens to erase some of the gains of the last 20 years of Farm Bill and Clean Water Act implementation" (EPA, 2006*:* 23). Nonetheless, as a "fix" for climate change, biofuel policy's regulatory science has focused more on GHG emissions and less on ecological dimensions of biofuel production. I describe some of the ecological consequences of rapidly increasing agricultural commodity production in the U.S. in this section.

As the ethanol industry grew, Iowa farmers increased corn production from approximately 11.7 million acres to 14.2 million acres between 2001 and 2007, and corn plantings have remained high (see Figure 4; USDA, 2011). As more private agricultural land becomes devoted to crop production, conservation practices are suffering. These practices are particularly important in regions where much of the landscape is devoted to intensive agricultural production. Intensive agricultural landscapes often have highly impaired waterways, persistent problems with soil erosion, and little native habitat. Over 90 percent of Iowa's land area is devoted to farming and in 2008, nearly half of Iowa's 1 108 water bodies were considered impaired by the EPA (IDNR, 2010). Intensive agricultural production in the Mississippi River Basin, where Iowa lies, contributes to the hypoxic conditions in the Gulf of Mexico (Rabalais, Turner, and Wiseman, 2002; Donner and Kucharik, 2008). Since Iowa prairie was plowed in the mid-1800s, over half of the state's 14-16 inches of topsoil have disappeared with erosion. Iowa also ranks last among U.S. states for habitat availability, with only 0.01 percent of native prairies remaining.

Figure 4

CORN PRODUCTION INCREASES IN IOWA

Change in Corn Acres by County in Iowa, 2000-2010



Source: USDA, 2011.

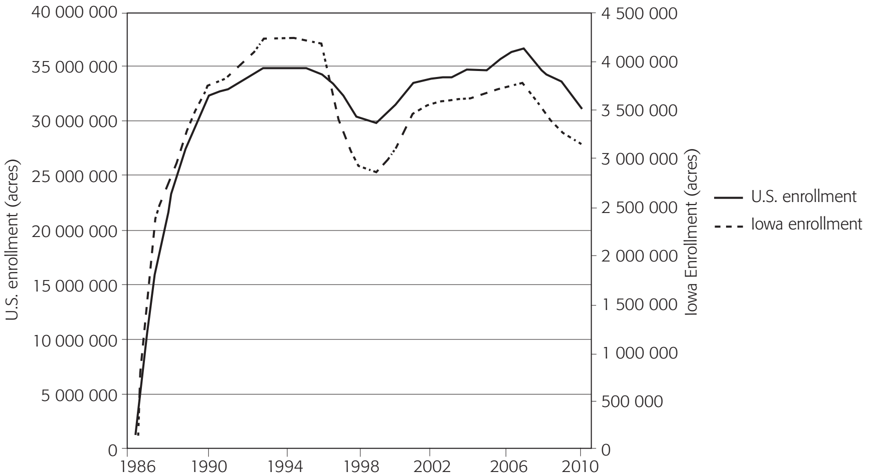
Corn production, in particular, exacerbates many of these problems. Corn is the most erosive and nutrient-intensive of the major row crops grown in the U.S. Midwest (Pimentel et al., 1995; Pimentel, 2005). Corn's low nitrogen-use efficiency of 37 percent also means much of the fertilizer is not used by the plant, increasing opportunity for nutrient run-off (Doberman and Cassman, 2002). These persistent ecological problems associated with corn production have led to estimates that nutrient loading into the Gulf of Mexico is likely to increase between 10 and 34 percent due to increased corn ethanol production (Donner and Kucharik, 2008). Nutrient management problems are exacerbated when corn is planted continuously, instead of rotated in with nitrogen-fixing or animal-fodder and cover crops like soy, alfalfa, oats, or hay, as has been the case amidst an ethanol boom. Corn production also emits more greenhouse gases than most crops, due to its high nitrogen-fertilizer use requirements, compromising its GHG reduction potential (Meyer-Aurich et al., 2006; and see Gelfland et al., 2011).

As biofuel production has increased, acreage enrolled in U.S. conservation programs, particularly the Conservation Reserve Program (CRP) has also sharply declined nationwide. The CRP was developed in the midst of the 1980s U.S. farm crisis characterized by collapsing markets for agricultural products, widespread farm debt and foreclosures, and chronic overproduction. The CRP was designed to decrease agricultural supply by removing marginal land from production and to provide ecological benefits. The CRP has proved highly effective for reducing soil erosion and surface water pollution (Davie and Lant 1994), thus maintaining important wildlife habitats (Johnson and Schwartz, 1993; Best et al., 1997; Coppedge et al., 2001). Recent research also shows that CRP lands sequester large amounts of carbon and that the land-use change associated with increasing corn production negates the GHG reduction benefits of these biofuels (Piñeiro et al., 2009; Searchinger et al., 2008; Fargione et al., 2008; Gelfland et al., 2011).

Throughout the U.S., since 2006, CRP acres dropped from 36.7 to 29.6 million (see Figure 5) (USDA Farm Service Agency, 2011). Between 2006 and 2010, Iowa lost over 320 000 acres or nearly 20 percent of its CRP land. Secchi et al. (2009) estimate that if CRP acreage losses continue with rising corn prices, soil, nitrogen, and phosphorous pollution from Iowa agricultural lands will significantly increase. These trends were particularly pronounced in northeastern Iowa, which is more topographically varied than much of the state. The topographical variation in the region contributes to its diverse agricultural base, which includes mixed crop and livestock farms and greater variety in the crops planted, since more steeply sloped or highly erodible land is used for pasture or animal-fodder crops. Conservation practices and diversified farming strategies that integrate multiple crops are particularly important for maintaining environmental quality in the region. Using this highly erodible land for crop cultivation would disproportionately increase soil erosion and nutrient run-off. Nonetheless, CRP participation declined substantially (see Figure 6) (USDA Farm Service Agency, 2011). Farmers interviewed cited multiple reasons for ending enrollment in the conservation program. The most common explanation was the most straightforward: corn prices made government conservation contract payments uncompetitive. As land prices rose, farming or renting land to be farmed became attractive options for landowners. Land that would have been considered too marginal to profitably cultivate became valuable as cropland when commodity prices rose high enough to justify planting for low yields. Even when an agricultural producer wanted to maintain conservation practices, his/her farm management decisions became constrained by the competitive dynamics in agriculture, forcing expanded production at a time of high prices (on these dynamics, see Lawrence, Cheshire, and Richards, 2004; Foster and Magdoff, 2000). One retiring farmer who decided to rent out land for crop cultivation instead of maintaining its enrollment in conservation programs said, "The big boys [large-scale producers expanding production] have their eyes on my land now . . . and they'll give me two times as much as [government conservation programs will]. How can I resist that?" (Pers. comm., 2008).

Figure 5

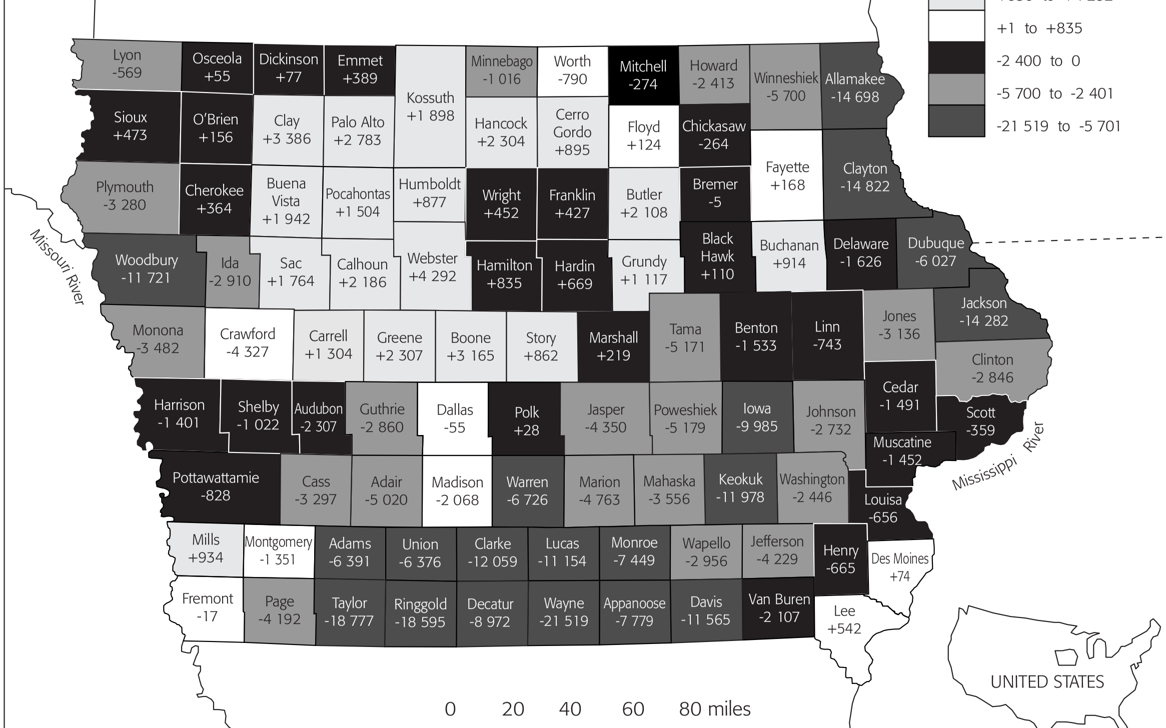
U.S. AND IOWA CONSERVATION RESERVE PROGRAM ENROLLMENT
1986-2010



Source: USDA Farm Service Agency, 2011.

Figure 6

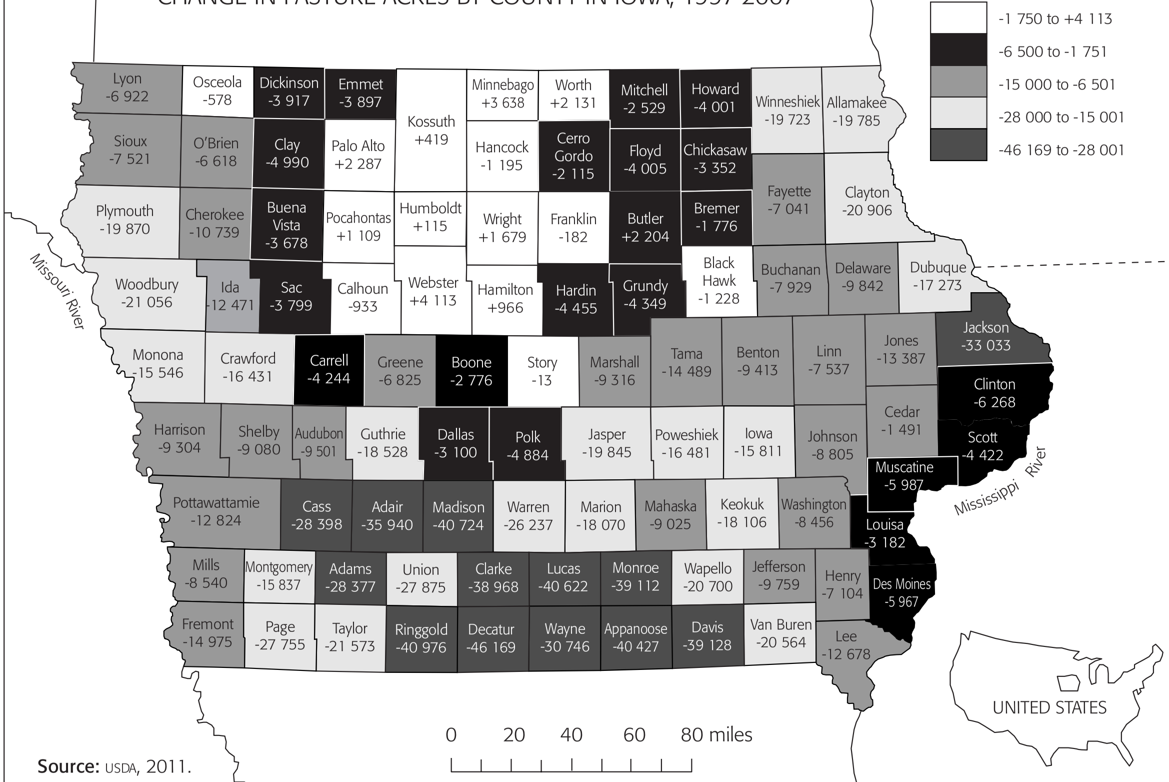
CHANGE IN CONSERVATION RESERVE PROGRAM ACRES BY COUNTY IN IOWA, 2005-2010



Source: USDA Farm Service Agency, 2011.

Figure 7

CHANGE IN PASTURE ACRES BY COUNTY IN IOWA, 1997-2007



Source: USDA, 2011.

Northeastern Iowa farmers also changed agricultural practices on working agricultural land (i.e., not "set-aside," marginal land), which contributed toward ecological goals that were not necessarily rewarded through government payments. As noted, many farmers ended crop rotations in order to plant more corn. Iowa soybean acreage was reduced from over 11 million acres to 8.6 million acres between 2001 and 2007 (USDA, 2011). Integrated crop-livestock operations also began to convert pasture and hay acreages into crop production, speeding up a long trend toward the disintegration of livestock and crop farms. Iowa pasture acreage fell from over 2 million acres in 1997 to approximately 830 000 acres in 2007, while the number of farms with pasture declined from 30 000 to 13 500 (USDA, 2011). Forage crop cultivation in northeastern Iowa also declined (see Figure 7); like pasture, land devoted to forage crops is not eligible for conservation programs that offset losses for improving environmental stewardship (see also Atwell, 2010). Nonetheless, forage crops like hay often provide a way for farmers to produce a profitable crop on marginal land, feed livestock, and break up row-crop planting to improve soil and nutrient retention.

In short, despite years of U.S. investment in improving conservation practice on agricultural lands, new biofuel production mandates, masquerading as climate policy, have significantly set back these efforts. A northeastern Iowa corn farmer said, "We're tearing the soils up so fast, in such a short time, to gain so little. It's just not worth it to me" (Pers. comm., 2009a). One regional USDA Natural Resource Conservation Service agent had this to say about increasing corn production's influence on conservation practice: "If that's what ethanol does, I'm not sure who it's helping" (Pers. comm., 2008b). These sentiments and agricultural practice changes encapsulate the consequences of increasing biofuel production for GHG mitigation under climate policy, demonstrating that one "environmental fix" can produce numerous unintended socio-ecological consequences.

Conclusion

Rapid biofuel production increases, legitimized by marginal GHG reductions, mean big changes in the political economic dynamics in agriculture that influence rural economic opportunity, as well as in the agro-ecological outcomes of producing regions. In this article, I have characterized some of these changes in socio-ecological relationships, focusing on Iowa, where much of the U.S.'s initial biofuel production is occurring. At the outset, I established that biofuel production is not currently a promising means for supplying adequate liquid fuel alternatives (for U.S. energy security), even if production increases are staggering. U.S. gasoline consumption simply overwhelms the capacity to convert agricultural resources into automobile fuel. I also established that current U.S. biofuel production has fallen short on substantially reducing GHG emissions to address climate change. GHG savings from using biofuels in place of gasoline are marginal and perhaps negative, depending on where carbon and energy budget boundaries are drawn and how land-use change is accounted for in biofuel lifecycle analyses. Cellulosic ethanol has thus far failed to emerge to provide a more carbon-negative and ecologically benign option as was hoped; in fact, the EPA has significantly scaled back cellulosic production targets.

Biofuel production's apparent failure to meet these two principle policy goals, suggests the need to explore other outcomes and logics of environmental governance. I have argued that biofuel production can be productively understood as an "environmental fix," a reorganization of socio-ecological relations aimed at addressing crises of capitalism. Biofuels are a potentially GHG-reducing fuel substitute supporters hope can address the climate crisis for capitalism: GHG emissions may limit future opportunities for growth and accumulation. Meanwhile, this "fix" maintains opportunities for accumulation by providing 1) investment and opportunities for dominant agribusiness, industrial, and energy sector actors; and 2) a liquid fuel substitute to maintain automobile fuel consumption, leaving the structure and function of disproportionately high U.S. (transportation and other) energy use intact.

I described the consequences of this fix as experienced in rural areas of biofuel production, focusing on Iowa. Biofuels are being built on the infrastructure and institutions of industrialized agriculture. Consonant with research in agricultural political economy, this means that outcomes for rural areas appear less promising than the opportunity for investment and profit the largest biofuel companies enjoy. The latter were able to weather the initial period of volatility and the 2008 financial crisis. Meanwhile, farmer ownership of biorefineries declined and farmers' marginal place in agricultural supply chain has meant that few profits from the agricultural commodity price boom have remained on the farm. Livestock producers have been especially vulnerable during the rapid expansion of the biofuel industry.

In ecological terms, biofuel production actually does little to establish the "fix" sought, even if biofuels qualify as GHG-reducers in regulatory terms. Globally, and independently of their carbon and energy budgets, biofuel production has inspired massive ecological change. Drawing on the U.S. case, I described significant losses to conservation program acreage, increases in soil erosion and nutrient pollution, and the reorganization of agricultural practices toward intensified commodity crop production and away from integrated crop-livestock operations. The narrow regulatory purview of the U.S. Renewable Fuel Standard, focused on the carbon content of biofuel alone, means that many of these ecological and political economic issues go unaddressed in policy. Since future global investment in biofuels is likely to increase, this research should serve as a cautionary tale about how policy might condition investment in biofuel production expansion.

Bibliography

Atwell, R. C., L. A. Schulte, and L. M., Westphal
2010 "How to Build Multifunctional Agricultural Landscapes in the US Corn Belt; Add Perennials and Partnerships," *Land Use Policy* 27, pp. 1082–1090.

Bello, W.
2009 *The Food Wars,* London, Verso.

Best, L. B., H. Campa, III, K. E. Kemp, R. J. Robel, M. R. Ryan, J. A. Savidge, H. P. Weeks, Jr., and S. R. Winterstein.
1997 "Bird Abundance and Nesting in crp Fields and Cropland in the Midwest: A Regional Approach," *Wildlife Society Bulletin,* vol. 25, no. 4, pp. 864-877.

Birger, J.
2007 "The Great Corn Gold Rush," *Fortune*, March 30, http://money.cnn.com/2007/03/29/magazines/fortune/corn_gold_rush.fortune/index.htm, accessed 30 August 2010.

Blaikie, P., and H. Brookfield
1987 *Land Degradation and Society*, London, Methuen.

Borras, Jr., S. M., P. McMichael, and I. Scoones
2010 "The Politics of Biofuels, Land and Agrarian Change: Editors' Introduction," *The Journal of Peasant Studies,* vol. 37, no. 4, pp. 575-592.

Borras, Jr., S. M., R. Hall, I. Scoones, B. White, and W. Wolford
2011 "Towards a Better Understanding of Global Land Grabbing: An Editorial Introduction," *Journal of Peasant Studies,* vol. 38, no. 2, March, pp. 209-216.

Carolan, M. S.
2010 "Ethanol's Most Recent Breakthrough in the United States: A Case of Socio-Technical Transition," *Technology in Society,* vol. 32, no. 2, May, pp. 65-71.

Castree, N.
2008 "Neoliberalising Nature: The Logics of Deregulation and Reregulation," *Environment and Planning A,* vol. 40, no. 1, pp. 131-52.

Cochrane, W.
1979 *The Development of American Agriculture: A Historical Analysis,* Minneapolis, University of Minnesota Press.

Coppedge, B. R., D. M. Engle, R. E. Masters, and M. S. Gregory
2001 "Avian Response to Landscape Change in Fragmented Southern Great Plains Grasslands," *Ecological Applications,* vol. 11, no. 1, pp. 47-59.

Dale, V. H, K. L. Kline, J. Wiens, and J. Fargione
2010 "Biofuels: Implications for Land Use and 190 Biodiversity. Ecological Society of America," 191, http://esa.org/biofuelsreports/files/ESA percent 20Biofuels percent 20Report_VH percent 20Dale percent 20et percent 20a192 l.pdf.

Davie, D. K., and C. L. Lant
1994 "The Effect of Conservation Reserve Program Enrollment on Sediment Loads in Two Southern Illinois Streams," *Journal of Soil and Water Conservation,* vol. 49, no. 4, 407-412.

Dinneen, B.
2009 "Renewables Fuels Association Letter to Lisa Jackson [administrator, U.S. Environmental Protection Agency]," 4 August.

Doberman, A., and K. G. Cassman
2002 "Plant Nutrient Management for Enhanced Productivity in Intensive Grain Production Systems of the United States and Asia," *Plant and Soil* 247, http://www.anz.ipni.net/far/farguide.nsf/926048f0196c9d4285256983005c64de/fd5d1be67e4bab9f8525719b00231886/$FILE/PS247_153.pdf, pp. 153-175.

Donner, S. D., and C. J. Kucharik
2008 "Corn-based Ethanol Production Compromises Goal of Reducing Nitrogen Export by the Mississippi River," *Proceedings of the National Academy of Sciences,* vol. 105, no. 11, pp. 4513-4518.

EPA (Environmental Protection Agency)

2012 F10-007, http://www.epa.gov/oms/renewablefuels/420f10007.pdf, accessed August 19, 2012.

2009 "EPA Lifecycle Analysis of Greenhouse Gas Emissions from Renewable Fuels. Technical Highlights," EPA-420-F-09-024, www.epa.gov/oms/renewablefuels/ 420f09024.pdf.

2006 Renewable Fuel Standard Program: Draft Regulatory Impact Analysis, www.epa.gov/oms/renewablefuels/420d06008.pdf.

Etter, L.

2007 "Ethanol Creates a Pricing Puzzle for Corn Farmers," *Wall Street Journal*, March 29, p. A1.

Fargione, J., J. Hill, D. Tilman, S. Polasky, and P. Hawthorne

2008 "Land Clearing and the Biofuel Carbon Debt," *Science,* vol. 319, no. 5867, pp. 1235-1238.

Farrell, A. E., R. J. Plevin, B.T. Turner, A.D. Jones, M. O'Hare, and D.M. Kammen

2006 "Ethanol Can Contribute to Energy and Environment Goals," *Science,* vol. 311, no. 5760, pp. 506-508.

Farrell, J.

2007 *Wind and Ethanol: Economies and Diseconomies of Scale. New Rules Project*, Minneapolis, Minnesota, Institute for Local Self-Reliance.

Fitz Simmons, M.

1990 "The Social and Environmental Relations of U.S. Agricultural Regions," in P. Lowe, T. Marsden and S. Whatmore, eds., *Technological Change and the Rural Environment*, London, David Fulton.

1986 "The New Industrial Agriculture: The Regional Integration of Specialty Crop Production," *Economic Geography,* vol. 62, no. 4, pp. 334-353.

Foster, J. B., and F. Magdoff

2000 "Liebig, Marx, and the Depletion of Soil Fertility: Relevance for Today's Agriculture," in F. Magdoff, J. B. Foster, and F. Buttel, eds., *Hungry For Profit, The Agribusiness Threat to Food, Farmers and the Environment*, New York, Monthly Review Press.

FRIEDMANN, H.
1978 "Simple Commodity Production and Wage Labour in the American Plains," *The Journal of Peasant Studies*, vol. 6, no. 1, pp. 71-100.

FRIEDMANN, H., and P. MCMICHAEL
1989 "Agriculture and the State System: The Rise and Decline of National Agricultures, 1870 to the Present," *Sociologia Ruralis* vol. 29, no. 2, pp. 93-177.

GELFLAND, I., Z. ZENONE, P. JASROTIA, J. CHEN, S. K. HAMILTON, and G. P. ROBERTSON
2011 "Carbon Debt of Conservation Reserve Program (CRP) Grasslands Converted to Bioenergy Production," *PNAS*, vol. 108, no. 33, pp. 13864-13869.

GOODMAN, B.
2008 "Pollution Is Called a By-product of a 'Clean' Fuel," *The New York Times*, March 11, http://www.nytimes.com/2008/03/11/us/11biofuel.html, accessed August 30, 2010.

GOODMAN, D., and M. REDCLIFT
1991 *Refashioning Nature: Food, Ecology and Culture*, London, Routledge.

GOODMAN, D., B. SORJ, and J. WILKINSON
1987 *From Farming to Biotechnology*, Oxford, Basil Blackwell.

HARVEY, D.
1996 *Justice, Nature and the Geography of Difference*, Oxford, Blackwell.

HEFFERNAN, W. D.
2000 "Concentration of Ownership and Control in Agriculture," in F. Magdoff, J. B. Foster and F. H. Buttel, eds., *Hungry for Profit: The Agribusiness Threat to Food, Farmers and the Environment*, New York, Monthly Review Press, pp. 61-75.

HERBST, M.
2007 "Ethanol's Growing List of Enemies," *Business Week*, March 23, http://www.businessweek.com/bwdaily/dnflash/content/mar2007/db20070316_016207.htm?chan=rss_topStories_ssi_5, accessed January 27, 2011.

HIMLEY, M.
2008 "Geographies of Environmental Governance: The Nexus of Nature and Neoliberalism," *Geography Compass* vol. 2, no. 2, pp. 433-451.

Huber, M.
2009 "The Use of Gasoline: Value, Oil, and the 'American Way of Life'," *Antipode*, vol. 41, no. 3, pp. 465-486.

Hunt, S.
2007 "Ethanol: Is Corn-based Fuel Worth Tax Deals, Pollution?" *The Columbus Dispatch*, August 6, http://www.dispatch.com/live/content/local_news/stories/2007/08/06/ethanol.ART_ART_08-06-07_A1_IB7HNVK.html, accessed August 30, 2010.

idnr (Iowa Department of Natural Resources)
2010 FINAL/Approved 2008 Iowa list of Section 303(d) Impaired Waters Watershed Monitoring & Assessment Section, Iowa Geological & Water Survey, Environmental Services Division, Iowa Department of Natural Resources, October, http://www.igsb.uiowa.edu/wqm/ImpairedWaters/Year2008/FactSheetForFinal-Approved2008List.pdf, accessed April 10, 2011.
2008 Iowa List of Section 303(d) Impaired Waters Watershed Monitoring & Assessment Section, Iowa Geological & Water Survey, Environmental Services Division, Iowa Department of Natural Resources. October 2010, http://www.igsb.uiowa.edu/wqm/ImpairedWaters/Year2008/FactSheetForFinal-Approved2008List.pdf, accessed April 10, 2011.

Informa Economics
2009 "Compliance Costs Associated with the Proposed Rulemaking for the Renewable Fuel Standard," prepared for National Corn Growers Association, http://ncga.com/files/pdf/RFS2RegulatoryComplianceCostReport9-21-09.pdf, accessed June 6, 2011.

Iowa rfa (Iowa Renewable Fuels Association)
2011 "Ethanol and Biodiesel Refinery Statistics," http://www.iowarfa.org/ethanol_refineries.php, accessed August 19, 2011.

Johnson, D. H., and M. D. Schwartz
1993 "The Conservation Reserve Program and Grassland Birds," *Conservation Biology,* vol. 7, no. 4, pp. 934-937.

Jonasse, R.
2009 *Agrofuels in the Americas*, Oakland, Food First Books.

THE JOURNAL OF PEASANT STUDIES
2010 Themed Issue on Biofuels, vol. 37, no. 4.

KRAUSS, C.
2009 "Ethanol, Just Recently a Savior, Is Struggling," *The New York Times*, February 12, p. A1.

LABBAN, M.
2011 "The Geopolitics of Energy Security and the War on Terror: The Case for Market Expansion and the Militarization of Global Space," in R. Peet, M. Watts and P. Robbins, eds., *Global Political Ecology,* London, Routledge.

LAWRENCE, G., L. CHESHIRE, and C. A. RICHARDS
2004 "Agricultural Production and the Ecological Question," in R. White, ed., *Controversies in Environmental Sociology*, Cambridge, UK, Cambridge University Press.

LEMOS M. C., and A. AGRAWAL
2006 "Environmental Governance," *Annual Review of Environment and Resources,* vol. 31, pp. 297-325.

LIGHTHALL, D. R., and R. S. ROBERTS
1995 "Towards an Alternative Logic of Technological Change: Insights from Corn Belt Agriculture," *Journal of Rural Studies,* vol. 11, no. 3, pp. 319-334.

MARSDEN, T., R. MUNTON, N. WARD, and S. WHATMORE
1996 "Agricultural Geography and the Political Economy Approach: A Review," *Economic Geography,* vol. 72, no. 4, pp. 361-375.

MEYER-AURICH, A., A. WEERSINK, K. JANOVICEK, and B. DEEN
2006 "Cost Efficient Rotation and Tillage Options to Sequester Carbon and Mitigate GHG Emissions from Agriculture in Eastern Canada," *Agriculture, Ecosystems and Environment,* vol. 117, nos. 2-3, pp. 119-127.

MOL, A. P. J.
2007 "Boundless Biofuels? Between Environmental Sustainability and Vulnerability," *Sociologia Ruralis,* vol. 47, no. 4, pp. 297-315.

Morris, D.
2007 *Energizing Rural America: Local Ownership of Renewable Energy Production Is the Key*, ed. by B. Hendricks, Center for American Progress, http://www.americanprogress.org/issues/2007/01/rural_energy.html, accessed August 30, 2010.
2005 "Fuel Ethanol Industry Structure, Past and Present," *Rural Cooperatives*, USDA Rural Development, November-December.

Naylor, R., A. J. Liska, M. B. Burke, W. P. Falcon,
J. C. Gaskell, S. D. Rozelle, and K. G. Cassman
2007 "The Ripple Effect: Biofuels, Food Security, and the Environment," *Environment,* vol. 49, no. 9, pp. 30-43.

O'Conner, J.
1998 *Natural Causes: Essays in Ecological Marxism,* New York, Guilford Press.

Page, B.
1997 "Restructuring Pork Production, Remaking Rural Iowa," in D. Goodman and M. Watts, eds., *Globalising Food,* London, Routledge, pp. 133-157.

Page, B., and R. Walker
1991 "From Settlement to Fordism: The Agro-industrial Revolution in the American Midwest," *Economic Geography,* vol. 67, no. 4, pp. 281-315.

Paulson, A.
2007 "In Corn Belt, Ethanol Boom a Bust for Ranchers," *The Christian Science Monitor* no. 29, March, http://www.csmonitor.com/2007/0328/p01s04-usec.html, accessed August 30, 2010.

Peck, J., and A. Tickell
2002 "Neoliberalizing Space," *Antipode,* vol. 34, no. 3, pp. 380-404.

Personal Communications
2009a Corn farmer, June 27, Bellevue, Iowa.
2009b Biofuel investor, July 15. Iowa City, Iowa.
2008a Retiring farmer, August, Clayton County, Iowa.
2008b Conservation agent, September, Manchester, Iowa.
2007a Corn and hog farmer, August 15, Epworth, Iowa.
2007b Corn farmer, August 15, Dubuque County, Iowa.

2007c Biorefinery investor, August 16, Underwood, Iowa.

2007d USDA Farm Service Agency representative, August 2007, Maquoketa, Iowa.

Peters, D.J.

2007 "Understanding Ethanol Plant Economics: Will Boom Turn Bust?" *Cornhusker Economics Newsletter*, November 14.

Pimentel, D.

2003 "Ethanol Fuels: Energy Balance, Economics, and Environmental Impacts Are Negative," *Natural Resources Research* vol. 12, no. 2, pp. 127-134.

Pimentel, D., C. Harvey, P. Resosudarmo, K. Sinclair, D. Kurz, M. McNair, S. Crist, L. Shpritz, L. Fitton, R. Saffouri, and R. Blair

1995 "Environmental and Economic Costs of Soil Erosion and Conservation Benefits," *Science,* vol. 267, no. 5201, 1117–1123.

Piñeiro, G., E. G. Jobbágy, J. Baker, B. C. Murray, and R. B. Jackson

2009 "Set-asides Can Be Better Climate Investment than Corn Ethanol," *Ecological Applications,* vol. 19, 277-282.

Porter, B.

2009 "Valero, Others Offer Hundreds of Millions of Dollars for Ethanol Plants, Including 1 in Dyersville," *The Dubuque Telegraph Herald*, March 18, p. A1.

2008a "Dyersville Abuzz over VeraSun," *The Dubuque Telegraph Herald*, November 16, p. A1.

2008b "Dyersville Plant Closes," *The Dubuque Telegraph Herald*, November 21, p. A1.

Rabalais, N. N., R. E. Turner, and W. J. Wiseman

2002 "Gulf of Mexico Hypoxia, Aka 'The Dead Zone,'" *Annual Review of Ecology and Systematics,* vol. 33, pp. 235-263.

Regulation of Fuels and Fuel Additives

2010 "Changes to Renewable Fuel Standard Program," 75 Fed. Reg. 58. 40 C.F.R. pt. 80, March 26, http://www.gpo.gov/fdsys/pkg/FR-2010-03-26/pdf/2010-3851.pdf.

2009 "Changes to Renewable Fuel Standard Program," Proposed Rule, 74 Fed. Reg. 99. 40 C.F.R. pt. 80. 26, May 2, http://www.epa.gov/otaq/renewablefuels/rfs2_1-5.pdf.

RFA (Renewable Fuels Association)

2011 "Industry Statistics", http://www.ethanolrfa.org/industrystatistics/, accessed January 11, 2011.

2009 "Industry Statistics", http://www.ethanolrfa.org/industrystatistics/, accessed October 12, 2009.

Searchinger, T. R. Heimlich, R. A. Houghton, F. Dong, A. Elobeid, J. Fabiosa, S. Tokgoz, D. Hayes, and T. Yu

2008 "Use of U.S. Croplands for Biofuels Increases Greenhouse Gases through Emissions from Land-use Change," *Science,* vol. 319, no. 5867, pp. 1238-1240.

Secchi, S., P. W. Gassman, J. R. Williams, and B. A. Babcock

2009 "Corn-Based Ethanol Production and Environmental Quality: A Case of Iowa and the Conservation Reserve Program," *Environmental Management,* vol. 44, no. 4 pp. 732-744.

Selfa, T.

2010 "Global Benefits, Local Burdens? The Paradox of Governing Biofuels Production in Kansas and Iowa," *Renewable Agriculture and Food Systems,* vol. 25, no. 2, pp. 129-142.

Smith, N.

2008 *Uneven Development: Nature, Capital, and the Production of Space,* 3rd ed., first edition published 1984, Athens, University of Georgia Press.

Truitt, G.

2007 "Lugar Has Strong Words for Ethanol Critics," *Hoosier Ag Today*, March 19, www.hoosieragtoday.com.

Uri, N. D., and H. Bloodworth

2000 "Global Climate Change and the Effect of Conservation Practices in U.S. Agriculture," *Global Environmental Change* vol. 10, pp. 197-209.

USDA (U.S. Department of Agriculture)

2012 "Quick Stats," National Agricultural Statistics Service, http://quickstats.nass.usda.gov/, accessed June 13, 2012.

2011 "Quick Stats," National Agricultural Statistics Service, http://quickstats.nass.usda.gov/, accessed April 10, 2011.

2010 "Economic Research Service Corn Backgrounder," http://www.ers.usda.gov/Briefing/Corn/background.htm.

2008a "Farm Production Expenditures Hit Record High in 2007," *usda Reports*, News Release, August 7, National Agricultural Statistics Service.

2008b "Land Values and Cash Rents: 2008 Summary," Agricultural Statistics Board, National Agricultural Statistics Service.

usda Farm Service Agency

2011 "Conservation Reserve Program Statistics," http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=rns-css, accessed June 14, 2011.

useia (U.S. Energy Information Agency)

2012 International Energy Statistics, http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=79&pid=79&aid=1, accessed January 27, 2012.

U.S. House of Representatives, One Hundred Ninth Congress

2005 "Committee on Agriculture," *Agriculture's Role in a Renewable Fuel Standard*, First Session, July 21.

Voegele, E.

2009 "Study Finds rfs2 Will Result High Compliance Costs for Producers," *Ethanol Producers Magazine,* September 15, http://www.ethanolproducer.com/articles/6002/study-finds-rfs2-will-result-high-compliance-costs-for-producers/, accessed June 6, 2011.

Westhoff, P., W. Thompson and S. Meyer

2008 *Biofuels: Impact of Selected Farm Bill Provisions and Other Biofuel Policy Options*, Food and Agricultural Policy Research Institute, The University of Missouri (FAPRI-MU Report # 06-08).