August 17, 2018

Mr. Andrew Wheeler
Acting Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, D.C. 20460

Submitted via regulations.gov

RE: Comments from ActionAid USA, Clean Air Task Force, Earthjustice, Mighty Earth, National Wildlife Federation, and Sierra Club on the U.S. Environmental Protection Agency's Proposed Rule - "Renewable Fuel Standard Program: Standards for 2019 and Biomass-Based Diesel Volume for 2020" 83 Federal Register 32024 (July 10, 2018); EPA–HQ–OAR–2018–0167

Dear Acting Administrator Wheeler:

As national environmental, conservation, and development organizations representing millions of members and supporters across the country who are profoundly harmed by the Renewable Fuel Standard (RFS) program as it currently is implemented, we respectfully submit these joint comments on the Environmental Protection Agency's (EPA) proposed rule - Docket No. EPA–HQ–OAR–2018–0167 - "Renewable Fuel Standard Program: Standards for 2019 and Biomass-Based Diesel Volume for 2020" published in the Federal Register at 83 Fed. Reg. 32024 on July 10, 2018. Our members are deeply concerned with fighting global warming, protecting human health, promoting human rights, preserving natural habitats, halting deforestation, and advocating for clean energy. We believe that setting appropriate volumes for the RFS and effectively implementing both the Endangered Species Act (ESA) and habitat-conversion protections in the RFS (as set forth in the Energy Independence and Security Act (EISA)) are critical to achieving these goals. As explained below, modifications to the RFS are necessary not only to accomplish these objectives, but also to ensure compliance with both the letter and spirit of the governing law.

Our comments are centered around six primary aspects of the proposed rule, which are listed below. More details on many of these issues can be found in joint comments that many of our groups submitted to EPA on previous proposed rules, which can be found here: http://www.catf.us/resources/filings/biofuels/.

I. Reducing Corn Ethanol Volumes

As EPA's Second Triennial Report to Congress (hereinafter "Second Triennial") acknowledges, the expansion of first-generation biofuels (particularly corn ethanol and soy biodiesel) over the last decade has resulted in numerous negative impacts to water quality and quantity, soil and air quality, ecosystem health, and biodiversity.[1] Government-mandated biofuels demand has also led to environmentally-damaging international and domestic land use changes that have increased greenhouse gas (GHG) emissions and contributed to "cropland expansion and natural habitat loss (including forests)."[2] For these reasons, the undersigned groups urge EPA to finalize 2019 Renewable Volume Obligations (RVOs) that limit the consumption of corn ethanol, a

[1] US Environmental Protection Agency (EPA), Biofuels and the Environment: The Second Triennial Report to Congress (2018 Final Report) (hereinafter "Second Triennial") (https://cfpub.epa.gov/si/si_public_record_report.cfm?dirEntryId=341491).
[2] *Id.* at 48.

biofuel that has not only resulted in numerous environmental problems but also constrained commodity markets.

More specific impacts of corn ethanol production, many of which are detailed in the Second Triennial, include the following:

- **Greater GHG emissions:** According to EPA's own data, current corn ethanol production may *increase* – instead of *decrease* – lifecycle GHG emissions.[3] Multiple independent analysts agree that corn ethanol may be worse for the climate than gasoline.[4]
- **Land use impacts on wildlife habitat and biodiversity:** Increased production of corn ethanol (and greater demand for corn) has resulted in the loss of millions of acres of native grasslands and wetlands,[5] important wildlife habitat for more than 60 percent of the nation's ducks and other waterfowl, monarch butterflies, and numerous threatened and endangered species. EPA's Second Triennial estimates that "…actively managed cropland in the U.S. [has increased] since the passage of EISA by roughly 4-7.8 million acres…"[6] This includes at least 1.6 million acres of prairie land that remained untouched since at least the 1970s and only became cropland after EISA's enactment.[7] This land conversion has caused "negative impacts to ecosystem health and biodiversity," according to EPA's Second Triennial[8] and other recent academic literature.[9] For example, EPA noted that "degradation and loss of wetlands has been found to adversely affect grassland bird populations," while "the loss of wetlands to row crops and related production practices is associated with reduced duck habitat and productivity of duck food sources, including aquatic plants and invertebrates."[10]
- **Land conversion results in significant loss of soil carbon and increase in nitrogen:** Conversion of previously uncultivated land significantly exacerbates climate change, thereby undermining a fundamental objective of EISA and harming the very farmers the RFS program aimed to support. It does this in three primary ways. *First*, when land is cultivated, carbon stored in soil is exposed to oxygen, forming CO2 – a harmful GHG – that is then released into the atmosphere. *Second*, when vegetation is cleared to prepare the grassland for cropland use, it must be burned or left to decompose, and each of these processes releases CO2 into the atmosphere. *Third*, newly cultivated land requires increased nitrogen fertilizer, which is energy intensive to produce – releasing additional GHGs. Excess nitrogen not taken up by crops is converted by bacteria to N2O – a highly potent GHG – that is then released into the atmosphere. Given the environmental and climate harms resulting from land conversion, EISA prohibits

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[3] Lester Lave, *et al.* 2011. *Renewable Fuel Standard: Potential Economic and Environmental Effects of U.S. Biofuel Policy* (Report by the National Research Council Committee on Economic and Environmental Impacts of Increasing Biofuels Production) (internal citations omitted) (http://www.nap.edu/openbook.php?record_id=13105); Clean Air Task Force (CATF), Corn Ethanol GHG Emissions Under Various RFS Implementation Scenarios (April 2013) (http://www.catf.us/resources/whitepapers/files/20130405-CATF%20White%20Paper-Corn%20GHG%20Emissions%20Under%20Various%20RFS%20Scenarios.pdf).

[4] *See, e.g.,* Lave, *et al*. (2011); Congressional Budget Office. 2014. *The Renewable Fuel Standard: Issues for 2014 and Beyond* (internal citations omitted) (https://www.cbo.gov/publication/45477).

[5] Tyler Lark, *et al.* 2015. Cropland Expansion Outpaces Agricultural and Biofuel Policies in the United States. *Environmental Research Letters* 10. DOI: 10.1088 (http://iopscience.iop.org/article/10.1088/1748-9326/10/4/044003/meta).

[6] Second Triennial at 44.

[7] Lark, *et al.* (2015) at 1.

[8] Second Triennial at 87.

[9] S. Kent Hoekman and Amber Broch. 2018. Environmental Implications of Higher Ethanol Production and Use in the U.S.: A Literature Review. Part II–Biodiversity, Land Use Change, GHG Emissions, and Sustainability. *Renewable and Sustainable Energy Reviews* 81(2): 3159-3177. DOI: 10.1016 (https://www.sciencedirect.com/science/article/pii/S1364032117306883?via%3Dihub).

[10] Second Triennial at 87.

biofuels produced from feedstocks grown on recently cleared farmland from qualifying as "renewable fuel" under the RFS.[11]

- **Water pollution:** Hoekman and Broch (2018) also note that "extensification of corn cropping into Conservation Reserve Program (CRP) lands is occurring, which raises concerns about erosion, nutrient runoff, and other adverse environmental impacts."[12] The expansion of corn production and associated nitrogen fertilizer runoff has contributed to harmful algal blooms and dead zones in the Gulf of Mexico and Great Lakes, respectively, in recent years.[13] In addition, the expansion of corn production to meet greater biofuels demand has led to "elevated nitrate pollutant levels in drinking water sources" and public health concerns, according to Hoekman *et al.* (2018).[14]
- **Air quality:** As Hoekman *et al.* (2018) also found, "upstream emissions of most air pollutants of concern are considerably higher for corn ethanol compared to gasoline... [and] [c]urrent fuel ethanol levels do not provide any benefit with respect to ground level ozone…"[15]
- **Food security:** Increased demand for corn ethanol and substitute crops has also been linked to food security risks due to volatile commodity prices.[16]

II. Limiting Growth of Vegetable-Based Biofuels by Ending Practice of Backfilling and Setting Appropriate RVOs

We commend EPA for ending the practice of backfilling gaps in cellulosic and advanced biofuel consumption with other food-based biofuels such as soy biodiesel and sugar ethanol in the final 2018 RVOs and for proposing to do so again in 2019. By reducing the overall renewable fuel and advanced biofuel mandates by the same amount that the cellulosic biofuel mandate is reduced (via EPA's cellulosic waiver authority), EPA proposes to limit incentives to further increase production of biofuels derived from food crops, especially vegetable oils. Ending the use of backfilling is something that the undersigned groups have supported for several years.[17] We share EPA's view that if gaps in cellulosic consumption are backfilled with food-based biofuels such as soy or palm biodiesel, we would "expect diminishing GHG benefits and higher per gallon costs as the required volumes of advanced biodiesel and renewable diesel increase."[18] Soy and palm biodiesel may lead to GHG emissions that

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[11] CAA §211(o)(1)(I), (J).

[12] Hoekman and Broch (2018).

[13] Second Triennial at 73.

[14] S. Kent Hoekman, *et al.* 2018. Environmental Implications of Higher Ethanol Production and Use in the U.S.: A Literature Review. Part I – Impacts on Water, Soil, and Air Quality. *Renewable and Sustainable Energy Reviews* 81(2): 3140-3158. DOI: 10.1016 (https://www.sciencedirect.com/science/article/pii/S1364032117306871?via%3Dihub).

[15] Hoekman, *et al.* (2018).

[16] International Food Policy Research Institute, Biofuels and Food Security: Balancing Needs for Food, Feed, and Fuel (2008) (http://www.ifpri.org/publication/biofuels-and-food-security).

[17] Joint comments from ActionAid USA, Clean Air Task Force (CATF), Environmental Working Group, and National Wildlife Federation (NWF) (hereinafter "Joint NGO 2017 RVO Comments") on the U.S. Environmental Protection Agency's Proposed Rule - "Renewable Fuel Standard Program: Standards for 2017 and Biomass-Based Diesel Volume for 2018" 81 Federal Register 34778 (May 31, 2016) (EPA-HQ-OAR-2016-0004), at 8-9 (http://www.catf.us/resources/filings/biofuels/20160711-2017_RVO_Joint_ENGO_Comments_Final.pdf); joint comments from ActionAid USA, CATF, Earthjustice, NWF, Oxfam America, and Sierra Club (hereinafter "Joint NGO 2018 RVO Comments") on the U.S. Environmental Protection Agency's Proposed Rule - "Renewable Fuel Standard Program: Standards for 2018 and Biomass-Based Diesel Volume for 2019" 82 Federal Register 34206 (July 21, 2017) (EPA-HQ-OAR-2017-0091), at 2 (http://www.catf.us/resources/filings/biofuels/Joint_NGO_comments_on_2018_RVO.pdf).

[18] EPA, Renewable Fuel Standard Program Standards for 2019 and Biomass-Based Diesel Volume for 2020 – Proposed Rule, 83 Fed. Reg. 32038/3 (July 10, 2018).

are two to three times higher than those from fossil diesel, according to a 2015 report produced by Hugo Valin *et al.* for the European Commission.[19]

Finalizing an RVO that does not backfill "missing" cellulosic biofuel will also reduce incentives for further production of palm oil, as EPA acknowledges in the proposed rule:

> "Moreover, to the extent that higher advanced biofuel requirements cannot be satisfied through growth in the production of advanced biofuel feedstocks, they would instead be satisfied through a re-direction of such feedstocks from competing uses. Products that were formerly produced using these feedstocks are likely to be replaced by products produced using the lowest cost alternatives, likely derived from palm or petroleum sources. This in turn could increase the lifecycle GHG emissions associated with these incremental volumes of non-cellulosic advanced biofuel. There would also likely be market disruptions and increased burden associated with shifting feedstocks among the wide range of companies that are relying on them today and which have optimized their processes to use them. Higher advanced biofuel standards could also be satisfied by diversion of foreign advanced biofuel from foreign markets, and there would also likely be diminished benefits associated with such diversions."[20]

Palm biodiesel not only fails to meet even the minimum 20 percent GHG reduction threshold in the RFS (and may actually triple GHG emissions as compared to fossil diesel[21]), but it is also tied to the destruction of forests and loss of carbon-rich peatlands in countries such as Malaysia, Indonesia, and Thailand, leading to increased GHG emissions and other environmental, social, and land rights problems. Deforestation and the draining of peat lands in Southeast Asia are a major source of GHG emissions.[22] As EPA acknowledges, even if palm biodiesel is not directly being incentivized through the RFS, feedstock switching due to higher RVOs can still impact vegetable oil markets, including palm.

For these reasons, EPA should also reduce the 2020 volume of biomass-based diesel (BBD) and 2019 volumes of advanced biofuels and total renewable fuel below the proposed levels of 4.88 billion gallons and 19.88 billion gallons, respectively, to levels that do not result in an increase in the demand for vegetable-oil based biofuels or, indirectly, for the vegetable oils (primarily palm and soy) that are used to make those fuels, thereby avoiding competition with food markets and other industries that use vegetable oil. The Second Triennial found that internationally, "demands for biofuel feedstocks have led to market-mediated land use impacts (both direct and indirect land use changes) in the past decade."[23] For instance, in Argentina, deforestation rates have reached levels seen in the early 2000s in the Amazon rainforest due to the expansion of soy production for biodiesel and other uses.[24] The expansion of soybeans into previously forested areas has increased water pollution from pesticide sprayings, led to health problems for residents of local communities, and resulted in vast swaths of

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[19] Hugo Valin, *et al*. 2015. The Land Use Change Impact of Biofuels Consumed in the EU: Quantification of Area and Greenhouse Gas Impacts, at 39 (Fig. 15) (https://ec.europa.eu/energy/sites/ener/files/documents/Final%20Report_GLOBIOM_publication.pdf).
[20] 83 Fed. Reg. 32038/3 (July 10, 2018).
[21] Valin, *et al.* (2015) at 39 (Fig. 15).
[22] Jukka Miettinen, *et al.* 2012. *Historical Analysis and Projection of Oil Palm Plantation Expansion on Peatland in Southeast Asia* (commissioned by the International Council on Clean Transportation (ICCT)) (internal citations omitted) (https://www.theicct.org/sites/default/files/publications/ICCT_palm-expansion_Feb2012.pdf).
[23] Second Triennial at 108.
[24] Matthias Baumann, *et al.* 2016. Land-Use Competition in the South American Chaco. *Land Use Competition:* 215-229 (https://link.springer.com/chapter/10.1007/978-3-319-33628-2_13).

biodiverse forests being burned to make way for agriculture production.[25] The undersigned groups urge EPA to set RVOs at levels that avoid both direct and indirect biofuels-induced land use changes given their negative social and environmental impacts.[26]

III. Consideration of Severe Environmental Harm Waiver

While EPA does not propose to use severe environmental harm as justification for invoking its general waiver authority to reduce RFS volumes, the Agency again requests comments on such an approach.[27] As our organizations have commented in the past[28] and as the Second Triennial found, increased production of first-generation biofuels such as soy biodiesel and corn ethanol has caused a wide range of environmental problems for soil, water, air, and wildlife habitat. As EPA noted in its Second Triennial, some of these impacts have worsened since the last triennial report was released in 2011 (see Section I above for more details).[29] While the corn ethanol industry has touted a 2017 report claiming that ethanol reduces GHG emissions by up to 43 percent,[30] that claim is severely undermined by a subsequent analysis that finds that the U.S. Department of Agriculture-commissioned report relies on several inaccurate assumptions and flawed methodologies.[31] In addition to the other resource concerns already discussed, additional GHG emissions from corn ethanol production contribute to climate change, which constitutes a severe environmental harm.

As detailed in comments submitted to this docket by the International Council on Clean Transportation (ICCT), EPA's proposal to significantly increase the BBD RVO for 2020 will push demand for suitable BBD feedstocks to an unsustainable level by exacerbating the effect of international trade restrictions, rising demand for vegetable oil in the US food market, and other factors. We agree with ICCT that EPA should consider using the waiver authority at CAA §211(o)(7)(A) to reduce the total renewable fuel and advanced biofuel standards below the statutory minimum in 2019.

Moreover, even with application of the cellulosic waiver, EPA has consistently set renewable fuel volumes at levels that imply conventional biofuel volumes at or near the maximum statutory level of 15 billion gallons.[32] Further the 2018 final rule documented that conventional corn-based biofuel production is higher than 15 billion gallons.[33] EPA has set maximum conventional biofuel volumes without providing any consistent and comprehensive assessment of severe environmental harm despite peer reviewed publications providing evidence of harm and EISA's requirement to do so.[34] Nor has EPA engaged in Section 7 ESA consultation with US

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[25] Garr, R. and S. Karpf. 2017. *Burned: Deception, Deforestation and America's Biodiesel Policy* (commissioned by Mighty Earth and ActionAid) (internal citations omitted) (https://www.actionaidusa.org/wp-content/uploads/2018/01/AAUSA_MightyEarth_Burned_FINAL_web.pdf).
[26] Garr and Karpf (2017).
[27] 83 Fed. Reg. 32048/1 (July 10, 2018).
[28] Joint NGO 2017 RVO Comments at 2-7.
[29] Second Triennial at 97.
[30] ICF. 2017. *A Life-Cycle Analysis of the Greenhouse Gas Emissions of Corn-Based Ethanol* (prepared for the U.S. Department of Agriculture Climate Change Program Office) (https://www.usda.gov/oce/climate_change/mitigation_technologies/USDAEthanolReport_20170107.pdf).
[31] Malins, C. 2017. *Navigating the Maize - A critical review of the report 'A Life-Cycle Analysis of the Greenhouse Gas Emissions of Corn-Based Ethanol'* (commissioned by CATF and NWF) (http://www.catf.us/resources/publications/files/Navigating-the-maize_July2017.pdf).
[32] 82 Fed. Reg. 58486 (Dec. 12, 2017); 80 Fed. Reg. 77419 (Dec. 14, 2015); 81 Fed. Reg. 89746 (Dec. 12, 2016).
[33] 82 Fed. Reg. at 58517 n.135.
[34] U.S. EPA Office of Inspector General, EPA Has Not Met Certain Statutory Requirements to Identify Environmental Impacts of Renewable Fuel Standard (Aug. 18, 2016) (https://www.epa.gov/sites/production/files/2016-

Fish and Wildlife Service or National Marine Fisheries Service (NMFS) to determine if the induced land conversion and attendant environmental impacts from setting maximum level corn-based ethanol standards will jeopardize the continued existence of federally listed endangered and threatened species.[35] Although EISA does not specify what constitutes "severe" environmental harm, Congress in the ESA already determined that preventing jeopardy to listed species takes highest priority.[36] As such, it would be a per se "severe" adverse effect under EISA to set biofuel volumes at a level that adversely impacts listed species or critical habitat. EPA must do a comprehensive assessment of severe environmental harm in this rulemaking to determine if total renewable volumes should be further reduced to levels that adequately ensure against severe harm to the environment, and specifically to federally listed species.

IV. Resetting Future RFS Volumes

As discussed in previous comments to EPA,[37] the RFS's reset provision offers the Agency an important opportunity to establish a more rational, environmentally sensible path forward for RFS volumes. The provision requires EPA to assess the impact of biofuels "on the environment, including on air quality, climate change, conversion of wetlands, ecosystems, wildlife habitat, water quality, and water supply" in addition to energy security, future production of renewable fuels, impact on infrastructure, consumer costs, and "other factors, including job creation, the price and supply of agricultural commodities, rural economic development, and food prices."[38] Our organizations look forward to working with EPA as the Agency soon begins to reevaluate each of the RFS mandates to ensure that the environmental benefits envisioned by Congress are best realized.

V. Ending Unlawful RFS-Induced Land Use Conversion and Loss of Sensitive Land

EPA should stringently implement the statutory requirement that RFS biofuel feedstocks be derived from "renewable biomass," as defined by EISA,[39] rather than from feedstocks grown on recently cleared land. Currently, EPA violates this requirement in two ways. First, EPA's "aggregate compliance" approach to the RFS permits feedstock production on previously uncultivated land as long as the aggregate amount of land in cultivation at any given time does not exceed the amount of land used for cropland at the time of EISA's passage. This approach to renewable biomass runs directly counter to the language and clear intent of the statute and fails to consider the destructive environmental and climate impacts of land conversion – including, but not limited to: the emission of millions of tons of GHGs into the atmosphere; reduction in water quality and supply; and destruction of wildlife habitat and diversity.[40] As stated in the Second Triennial,

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08/documents/_epaoig_20160818-16-p-0275.pdf). (2016 Inspector General investigation concluding EPA violated its EISA duties by failing to complete the Program's Triennial Reports and air quality impact study, and that the violations impede EPA's decision making, including its general waiver authority determination.); EPA issued the June 29, 2018 Triennial Report the day Sierra Club filed its motion for summary judgment in the pending lawsuit challenging EPA's failure to prepare the Triennial Reports and conduct the air quality study. *Sierra Club v. Pruitt*, D.D.C. no. 1:17-cv-02174-APM. The June 29, 2018 Triennial Report was four-and-one-half years overdue, another Triennial Report due December 2016 is past due, and EPA still has not conducted its air quality impact study of the program, due in June 2009.

[35] 16 U.S.C. 1536(a).

[36] *Tennessee Valley Auth. v. Hill*, 437 U.S. 153, 185 (1978).

[37] Joint NGO 2017 RVO Comments at 7-8; Joint NGO 2018 RVO Comments at 3.

[38] CAA 211(o)(2)(B)(ii).

[39] CAA §211(o)(1)(J).

[40] *See, e.g.*, Lark, *et al.* (2015); C. K. Wright and M. C. Wimberly. 2013. Recent Land Use Change in the Western Corn Belt Threatens Grasslands and Wetlands. *Proc Natl Acad Sci USA* 110(10): 4134-9. DOI: 10.1073 (http://www.ncbi.nlm.nih.gov/pubmed/23431143).

> "Evidence since enactment of EISA suggests an increase in acreage planted with soybeans and corn, with strong indications from observed changes in land use that some of this increase is a consequence of increased biofuel production... There are strong indications that biofuel feedstock production is responsible for some of the observed changes in land used for agriculture since enactment of EISA."[41]

The report goes on to cite five distinct national studies that have documented this cropland expansion – four of them conducted by federal agencies – and specifies that "there is a consistent signal emerging that demonstrates an increase in actively managed cropland by roughly 4-7.8 million acres,"[42] despite the annual determination by the Agency that crop acreage has not increased in a significant way to breach the limit established under its aggregate approach. An increase of 4-7.8 million acres is non-trivial, and it clearly warrants a new approach to verify that biofuels being produced and blended to meet the obligations under the RFS are coming from lands that meet the statutory definition of "renewable biomass." EPA should end the practice of unchecked land conversion under the RFS program by implementing a land use tracking and mapping system that robustly enforces EISA's land use protections and EPA's own prohibition on the conversion of native grasslands for biofuel crop production.

The second way in which EPA's implementation of the RFS violates EISA land use protections is allowing the production of renewable biomass on land exiting CRP. EPA should modify its treatment of lands coming out of CRP to exclude them from eligibility under the definition of renewable biomass. CRP lands were previously cultivated and purposefully taken out of production as part of a US Department of Agriculture (USDA) program aimed at improving environmental health and quality, the benefits of which taxpayers have paid for through annual rental payments to landowners. The lands are then maintained in a state of non-production and conservation cover for a minimum of 10 years, with some now having been in the program for 30 or more years. This amount of time is sufficient for these lands to lose their status as actively managed cropland and to build up the important environmental qualities for which the program was established: soil and water conservation, wildlife habitat, nutrient filtering and retention, water quality improvements, and carbon sequestration.

Land eligible for use to grow renewable biomass must be actively managed or fallow, and well as nonforested. CRP land is none of these. It is not fallow, as it is not kept in a state of non-production for the purpose of regenerating the land for future agricultural use, but rather is kept idle for the express purpose of improving long-term environmental health and quality. It is also not actively managed, as it is not tilled, fertilized, or irrigated like cropland. Cultivation of this land threatens the release of GHGs and a loss of biodiversity. CRP land is also not nonforested, as much CRP land does, in fact, contain forests. Thus, under EISA's limitations on the landscape that can be used to produce renewable biomass, feedstocks grown on former CRP land do not qualify as "renewable biomass."

Though corn and soy produced on this former CRP land does not meet the definition of renewable biomass under EISA, EPA expressly permits use of this land under the RFS program. And as EPA acknowledges, since EISA's enactment, there has been extensive conversion of expiring CRP lands into crop production, particularly of corn and soy, for use as biofuels. Use of this land contravenes both the language and intent of EISA and causes significant climate and environmental harm. For these reasons, lands coming out of CRP should be treated as other non-cropped lands and should not be deemed eligible for biofuel feedstock production under the RFS.

[41] Second Triennial at xi.

[42] Second Triennial at 37.

VI. Assessing Impacts under the Endangered Species Act

EPA should also evaluate the impacts to water and air quality and biodiversity that would result from the Agency's proposed RVOs. Specifically, the Agency also must fulfill its ESA Section 7 duties by consulting with wildlife agencies (U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration Fisheries) to ensure that any loss of habitat, including modification or pollution resulting from land use changes associated with the increased production of biofuels, does not jeopardize the continued existence of any federally-listed endangered and threatened species or cause the destruction or adverse modification of designated critical habitat.[43]

To date, EPA has never completed or even initiated Section 7 consultation to ensure against jeopardy to federally listed species in taking any discretionary actions under the RFS program, including, but not limited to, setting annual renewable fuel volumes, approving new renewable fuel pathways using new feedstocks and advanced technologies, and determining whether to exercise its general waiver authority on the basis of severe environmental harm. Nor has EPA engaged in programmatic consultation given the nationwide scope of the RFS program and its geographic impacts, as federal agencies have done in other similar contexts.[44] However, recent studies, including the June 29, 2018 Triennial Report, and expert reports have documented induced land conversion and the attendant environmental impacts, including potential effects on federally listed endangered and threatened species. In fact, documented land conversion is occurring in or adjacent to designated critical habitat for listed species and could decrease the critical habitat's functionality through landscape fragmentation, microclimate modification, encroachment of anthropogenic activities, or other proximity effects, and thereby alter the physical or biological features that were the basis for critical habitat designation. Thus, any critical habitat located in agriculturally active areas and especially those in areas with large amounts of conversion or even in close proximity to an ethanol refinery may be directly affected by the RFS and should be evaluated and mitigated pursuant to ESA.[45]

Federally listed species that may be affected by the RFS span the entire Midwest down through the Mississippi River watershed into the Gulf of Mexico where nutrient loading from biofuel production is a major contributor to the region's growing dead zone. Affected listed species include, but are not limited to: the endangered Poweshiek Skipperling butterfly; the threatened Dakota Skipper butterfly; the endangered Rusty Patched Bumble Bee; the endangered Hine's emerald dragonfly; the endangered Salt Creek Tiger beetle; the endangered Whooping crane bird; the threatened Yellow Billed Cuckoo bird; the endangered Piping Plover bird; the endangered Black-footed ferret; the endangered Topeka shiner minnow; the threatened Purple Bankclimber mussel; the endangered Fat Threeridge mussel; endangered Oval Pigtoe mussel; the threatened Gulf Sturgeon;

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[43] 16 U.S.C. § 1536(a); 50 C.F.R. § 402.14(a).

[44] *See Am. Rivers, Inc. v. U.S. Army Corps of Eng'rs*., 421 F.3d 618, 626-627 (8th Cir. 2005) (consultation on future impacts of multiple structures spread over hundreds of river miles and multiple endangered species upheld); *See, e.g., Dow AgroSciences LLC v. Nat'l Marine Fisheries Serv*., 707 F.3d 462 (4th Cir. 2013) (BiOp covering EPA's re-registration of decades old, commonly used pesticides must evaluate their continuing uses); *Ctr. for Marine Conservation v. Brown*, 917 F. Supp. 1128, 1137 (S.D. Tex. 1996) (BiOp regarding Gulf Coast shrimp fisheries asks whether "the continued long-term operation of the shrimp fishery … [is] likely to jeopardize the continued existence of the Kemp's ridley sea turtle. . . ."); *Greenpeace v. Nat'l Marine Fisheries Serv*., 80 F. Supp. 2d 1137, 1143-1144 (W.D. Wash. 2000) (quoting *Conner v. Burford*, 848 F.2d 1441, 1458 (9th Cir. 1988)) (BiOp reviewing the fishery management plans (FMPs) governing annual Alaskan groundfish catches must "be equal in scope to the FMPs" because "biological opinions under the ESA must be 'coextensive' with the agency action.").

[45] 16 U.S.C. § 1536(b); 50 C.F.R. §§ 402.14(g)-(i).

the threatened Loggerhead Turtle; and the endangered Sperm whale. See attached Affidavit of Dr. Tyler Lark,[46] included in the addendum to Environmental Petitioners' [Initial] Opening Brief, Sierra Club v. EPA, No. 18-1040 (D.C. Cir. July 27, 2018) (current litigation challenging the Renewable Fuel Standards for 2018 and Biomass-Based Diesel Volume for 2019), incorporated verbatim herein. Dr. Lark's affidavit documents the RFS program's induced land use conversion, associated environmental impacts, and potential effects on federally listed species. The EPA must complete its long overdue ESA Section 7 duties to evaluate the impacts of the RFS on listed species and ensure against their jeopardy.

VII. Conclusion

The undersigned groups urge EPA to ensure that the 2019 RVOs (and those for biomass-based diesel for 2020) do not allow for the expansion of food-based biofuels, which have had numerous unintended consequences on our environment, not to mention impacts on food and feed prices. In addition to limiting volumes of corn ethanol, we urge EPA to alleviate demand for soy and palm biodiesel (and other market effects leading to greater demand for these vegetable oils), which have been linked to destructive land use changes, deforestation in countries such as Indonesia and Argentina, and other social and environmental problems. EPA can limit these impacts by finalizing a 2020 volume requirement for biomass-based diesel and 2019 volume requirements for advanced and total renewable fuels that do not incentivize increased production of food-based biodiesel and various vegetable oils. We also urge EPA to exercise its authority to reduce RFS volumes based on severe environmental harm, to comprehensively adjust future RFS volume mandates based on the statutorily required "reset" provision, fulfill its ESA Section 7 duties, and give full effect to the "renewable biomass" definition in the RFS that was enacted to limit land use change from increased biofuel production.

Finally, these joint comments are based on information provided in the proposed rule, as published in the Federal Register on July 10, 2018. Some signatories to these comments also submitted a separate letter to EPA on July 30, 2018, that urges the Agency to issue a new, more comprehensive, more coherent RVO proposal to account for the effect of small refiner waivers on overall RFS compliance and hence, allow for a fuller assessment of the RVO proposal.

Thank you for the opportunity to provide comments. We hope that our remarks provide useful guidance for EPA's final decision. We appreciate your consideration.

Respectfully submitted,

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[46] Tyler Lark is an associate researcher at the University of Wisconsin-Madison's Center for Sustainability and the Global Environment. He leads research on U.S. agricultural land-use change and its impacts on land and water resources. Dr. Lark received his Ph.D. from University of Wisconsin-Madison's Nelson Institute Environment & Natural Resources program in 2017 for his research on America's changing "Food- and Fuel-Scapes."

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Andrew Linhardt
Sierra Club

AFFIDAVIT OF DR. TYLER LARK

1.

My name is Tyler Lark, and I give this affidavit for use by petitioners Sierra Club and Gulf Restoration Network in *Sierra Club et al. v. Environmental Protection Agency;* case number 18-1040. This affidavit is based on my own personal knowledge, experience, training, and review of the data and literature set forth below.

2.

Currently, I am an associate researcher at the University of Wisconsin-Madison's Center for Sustainability and the Global Environment, where I have been researching U.S. agriculture, land use, and bioenergy for the past 6 years. I received my Ph.D. from UW-Madison's Nelson Institute Environment and Resources program in 2017 and continue to perform research on U.S. agricultural land use change and its impacts on our nation's natural resources.

3.

I have lead- and co-authored reports and published scientific studies on topics including U.S. agricultural land use and its implications for biofuel policies, best practices for measuring U.S. land use change, the accuracy of mapping crops and cropland conversions in the U.S., the location and rates of native prairie conversion, and the relationship between grassland conversion and ethanol refinery locations. My 2015 paper, entitled "Cropland expansion outpaces agricultural and biofuel policies in the United States" received "highly commended" accolades as a top paper of 2015 by the journal Environmental Research Letters and has been highly cited since its publication. My 2016 presentation, entitled "Mapping grassland and cropland conversion across the United States" was awarded "best presentation" at the North American Congress for Conservation Biology, and I have been invited and given presentations on U.S. land use change and federal biofuel policy at academic conferences and industry workshops across the nation. A list of my relevant publications and presentations from the last 6 years is included in my CV and attached as Appendix 1.

4.

Executive Summary

I have been asked to provide a summary of the potential impacts to federally listed endangered and threatened species from the United States' Renewable Fuel Standard (RFS) program. I review these potential impacts in section 5.6 of the report attached hereto as Appendix 2 and incorporated as part of this declaration as if repeated verbatim herein. I make reference to it as the "Expert Report" throughout this declaration. In the Expert Report, I conclude that the existing body of research on this matter ties the Renewable Fuel Standard to documented land use changes and ensuing environmental consequences which may potentially have detrimental impacts on federally listed species and their designated critical habitat. Following the passage of the amended Renewable Fuel Standard (RFS2) in 2007 there was a steady pattern of conversion of uncultivated land to biofuel feedstock crops such as corn and soybeans, leading to increases in active cropland area in the U.S. Both the initial conversion of land to biofuel feedstock crops as well as ongoing cultivation of these crops can lead to negative environmental outcomes. Such potential environmental outcomes can include, but are not limited to, decreased water quality, increased water usage, increased greenhouse gas emissions, and loss or degradation of biodiversity and habitat. Any of these outcomes could negatively affect listed species. For example, nutrient pollution from expanded corn production in the Mississippi river basin contributes to hypoxia in the Gulf of Mexico, which could impair aquatic listed species that inhabit the region. While increased knowledge and documentation of the land and environmental impacts of the Renewable Fuel Standard have recently emerged in the scientific literature, the effects of these impacts on threatened and endangered species has not been comprehensively assessed. However, given the role of the Renewable Fuel Standard in land use change, the known environmental impacts of associated changes, and the potential mechanisms for influence on listed species described here or reported by the listing wildlife services, I believe further review and evaluation is warranted.

5.

There are two key pathways by which the Renewable Fuel Standard can induce agricultural land use changes—intensification and extensification—and both of these processes have the potential to jeopardize threatened and endangered species. "Intensification" is the process of getting more production from a fixed area of land. This often is achieved by increasing use of agronomic inputs such as nitrogen fertilizer, implementing irrigation, or switching to continuous production of a single crop rather than crop rotation, for example. "Extensification," also known as land conversion, means bringing new land into cultivation by converting uncropped land into cropland, thus changing the structure and function of the land and affecting interactions with water, soils, and other natural resources. Biofuel production requires large amounts of feedstocks to use as input, and as such, available data suggests it has contributed significantly to both intensification and extensification (see Expert Report and Appendices 3 and 4).

6.

Corn has played a uniquely strong role in the conversion of land to cropland—it was the most common crop planted on newly converted land after 2007. Between 2008 and 2012 corn was planted on 27% of newly converted agricultural land in the U.S. (Lark et al. 2015). This finding has been supported by multiple other studies, including several focused on particular regions. For example, Mladenhoff et al. (2016) found most previously open land converted to crop production between 2008 and 2013 in the Great Lakes region was planted to corn; Morefield et al. (2016) found that for newly cultivated cropland exiting the federal Conservation Reserve Program in the Midwest, corn and soybeans (both potential biofuel feedstock crops) were planted on 34% and 40% of converted land, respectively.

7.

Many studies have tied the Renewable Fuel Standard to increased corn and commodity crop prices as well as increased cropland acreage. Carter, Rausser, and Smith (2016) found that corn prices on average were 30% higher each year from 2006 to 2014 than they would have been without the Renewable Fuel Standard. A synthesis of 29 studies published between 2007 and 2014 found that the Renewable Fuel Standard likely raised corn prices between <1% to over 80%, depending on various conditions, and that corn prices rose on average 3-8% per billion gallon increase in ethanol mandate (Condon, Klemick, and Wolverton 2015).

8.

Yet another study found that from 2007 to 2009, for every 1% increase in crop price, there was an expected 0.029% increase in U.S. cultivated area (Barr et al. 2011). Similar response elasticities have been found to be even greater within specific regions like the cornbelt—for example, 0.059 by Langpap and Wu (2011). Using the more conservative of these two numbers (an expected response elasticity of 0.029) in combination with the above-referenced price increases (specifically a 30% increase in the price of corn due to the RFS; Carter, Rausser, and Smith, 2016) and an approximate base U.S. cropland area of 236 million acres in 2007 as accounted by Barr et al. (2011), this would translate to roughly 2 million acres of expected cropland expansion due to the impact of the Renewable Fuel Standard on national corn prices. This widespread conversion of land to cropland presents a large opportunity for impact on listed species and the habitat upon which they rely.

9.

The placement of an ethanol refinery in a community can also have significant impacts locally. In areas surrounding ethanol refineries, local demand for corn increases, which in turn induces increases in local corn prices and planted acreage (Fatal and Thurman 2014). A study of new ethanol production facilities built between 2002 and 2008 found that every million gallons of new ethanol capacity in a county was estimated to trigger an additional 5.21 acres of corn in that county. This effect is frequently compounded by many refineries sited in a single region, and can be felt across hundreds of counties. The study found that the typical refinery increased corn planting in its home county by over 500 acres, and increased planted acreage in surrounding counties up to nearly 300 miles away. Once converted, cropland in close proximity to an ethanol refinery is likely to stay that way: Wright et al. (2017) found that existing cropland is less likely to be abandoned or restored to grassland if it is close to a refinery.

10.

Conversion of nonagricultural land to cropland often disrupts habitat and reduces biodiversity by simplifying the landscape and reducing the number of species it supports (Meehan, Hurlbert, and Gratton 2010; Fletcher et al. 2011). Grasslands were the most common land cover converted to crop production after implementation of the Renewable Fuel Standard, accounting for approximately 80% of the land converted to crop production across the U.S. from 2008 to 2012 (Lark, Salmon, and Gibbs 2015). Furthermore, the rate of grassland conversion to crop production has been shown to be significantly higher near ethanol production refineries, with the rate of conversion decreasing linearly as the distance to refineries increases (Wright et al., 2017, Figure 2). Grasslands have higher species carrying capacities and harbor significantly greater plant, microbial, and animal diversity than croplands (Werling et al. 2014). Thus, in addition to any impairment of listed species through direct conversion or adverse modification of critical habitat, the conversion of grasslands to cropland to expand or maintain biofuel production volumes likely resulted in a reduction in wildlife-supporting services and resources and therefore may have also indirectly impaired grassland-dependent species.

11.

The Renewable Fuel Standard may also harm biodiversity and habitat by disincentivizing participation in the federal Conservation Reserve Program, a program which helps support farmers to remove environmentally sensitive lands from crop production for periods of 10-15 years and restore the areas to grasslands or other types of conservation land covers. By driving up corn prices (Carter, Rausser, and Smith 2016; Condon, Klemick, and Wolverton 2015), the Renewable Fuel Standard increases the profitability of growing corn for ethanol relative to keeping land in the Conservation Reserve Program. From 2007 to 2012, approximately 50% of all land converted to cropland came from acreage previously enrolled in the Conservation Reserve Program (USDA 2015).

12.

Loss of Conservation Reserve Program land has been clearly tied to negative environmental outcomes. These include decreased pheasant populations (Sullivan et al. 2004; Haroldson et al. 2006; Errington and Gewertz 2015), decreased bird diversity and prevalence (Fletcher et al. 2011; Ryan, Burger, and Kurzejeski 1998), and increased water pollution with risk of nitrogen contamination (Randall et al. 1997; Feather, Hellerstein, and Hansen 1999; Secchi et al. 2009). Any listed species which inhabit or benefit from Conservation Reserve Program land would similarly be affected.

13.

The Renewable Fuel Standard may also affect listed species through the loss of native grasslands which, unlike Conservation Reserve Program lands, have never been used for agricultural production. Under the EPA's 2010 rule implementing the Renewable Fuel Standard program, native grasslands specifically qualify as nonagricultural lands and thus should be ineligible for renewable feedstock production. However, the 2010 rule did not implement a feedstock mapping and tracking system to explicitly enforce the land protections required under the Energy Independence and Security Act, nor have any annual volumetric Renewable Fuel Standards, including the Renewable Fuel Standards for 2018 and Biomass-Based Diesel Volume for 2019. The absence of such a feedstock tracking system means that areas converted from native sod can currently be used for renewable feedstock production without restriction, thus enabling the Renewable Fuel Standard to contribute to ongoing prairie loss. Indeed, native grasslands and prairie have specifically been identified as having been converted to cropland in recent years (Wimberly et al. 2017; Lark, 2017). Native grasslands provide habitat that is superior to restored or planted grasslands (Bakker and Higgins 2009) and supply critical food and nesting resources for grassland dependent wildlife like wild bees and other pollinators (Moranz et al. 2012; Kwaiser and Hendrix 2008; Pleasants 2016).

14.

The conversion of land for increased biofuel feedstock production may also affect endangered and threatened species through the destruction or adverse modification of critical habitat. For example, conversion of land near designated critical habitat could decrease the critical habitat's functionality through landscape fragmentation, microclimate modification, encroachment of anthropogenic activities, or other proximity effects, and thereby alter the physical or biological features that were the basis for critical habitat designation. Thus, any critical habitat located in agriculturally active areas and especially those in areas with large amounts of conversion and in close proximity to an ethanol refinery (e.g. Figure 6b of Wright et al. 2017) may potentially be affected by the Renewable Fuel Standard. Note that while land converted to biofuel feedstock crops such as corn and soybeans is most directly linkable to the Renewable Fuel Standard, any conversion of land to cropland (including for other crops) could be induced by the policy due to its cascading impacts on multiple commodity crop markets beyond those directly used as feedstocks (see Expert Report, section 4). Thus, the Renewable

Fuel Standard may affect endangered species through the conversion of habitat to any type of crop production.

Based on the locations of recent land conversion, feedstock crop production, and ethanol refineries, there are a number of federally listed species and critical habitats at heightened risk of impairment. Potentially impacted species groups include insects, birds, fishes, mussels, and others. Examples of specific species as well as potential mechanisms of impairment are described below.

15.

Poweshiek skipperlings (*Oarisma poweshiek*) are endangered butterflies that inhabit tallgrass prairies in Minnesota, Wisconsin, North Dakota, South Dakota, and Iowa. Habitat fragmentation poses a key threat to the Poweshiek skipperling, and there are several instances where land has recently been converted to cultivate either corn or soybeans within close proximity to its critical habitat in Minnesota, North Dakota, and South Dakota (see Appendix 6 for an example map and imagery). Loss of habitat and especially tallgrass native prairie over the years has led to isolated pockets of Poweshiek skipperling populations, making it difficult for them to recolonize, as they are only able to fly for short periods at a time and therefore are unable to travel necessary distances in search of a new home (Pogue et al., 2016). Furthermore, if the Poweshiek skipperling is lost in one locale, there are often no nearby populations to recolonize (USFWS, 2018). Adult Poweshiek skipperlings feed on nectar from prairie flowers, and thus the species may also be affected indirectly by the Renewable Fuel Standard due to the loss of nectar sources from the spraying of pesticides during crop production. Because they do not burrow into the ground in their larval stages, the species may also be vulnerable to airborne wafting pesticides (Gould, 2013).

16.

Other insects which could potentially be affected by biofuel feedstock production via similar and/or other mechanisms of influence include the threatened Dakota skipper (*Hesperia dacotae*), the endangered Rusty patched bumble bee (*Bombus affinis*), the endangered Hine's emerald dragonfly (*Somatochlora hineana*), and the endangered Salt Creek tiger beetle (*Cicindela nevadica lincolniana*).

17.

Whooping Cranes (*Grus Americana*) are endangered birds that inhabit prairie wetlands of North America and may be negatively affected by the Renewable Fuel Standard through the loss and fragmentation of habitat. There is substantial conversion of land to biofuel feedstock crops near the species' designated critical habitat in Kansas (see Appendix 7), as well as conversion to crop production adjacent to its critical habitat and wintering grounds on the Texas coast, which could adversely influence the conservation of the species and the effectiveness of its habitat. Furthermore, the Whooping crane frequently inhabits wetlands throughout its species range, and thus may be impacted by the widespread conversion and drainage of wetlands for crop production that has occurred throughout the region (Lark et al., 2015). Other birds which may be impacted include the threatened Yellow Billed Cuckoo and the endangered Piping Plover.

18.

The threatened Yellow Billed Cuckoo (*Coccyzus americanus*) is a medium-sized bird found in Texas, New Mexico, Arizona, Utah, Colorado, Wyoming, Nevada, Montana, Idaho, Oregon, Washington, and California. The Yellow Billed Cuckoo inhabits riparian areas especially under willows, cottonwoods, and woodlands. They use the vegetation underneath the trees to nest, breed, and search for food, and their threatened status is due in large part to the destruction of these habitats from anthropogenic activities, including agriculture. Pesticide use may also harm the yellow-billed cuckoo, as reproduction problems caused by eggshell thinning have been documented in the population (USFWS, 2014).

19.

Piping Plovers (*Charadrius melodus*) are small shorebirds that live along the Atlantic coast, the Great Lakes, and rivers in the Northern Great Plains. They are threatened on the Atlantic coast and Northern Great Plains and are endangered in the Great Lakes region, and may be affected by habitat fragmentation or water quality contamination.

Piping plovers lay only a few eggs in shallow nests along shorelines, and rely on the associated wildlife and resources for both food and nesting material. Land conversion for crop production could affect this population, as disruption of plover habitat has specifically been shown to be destructive in the Great Lakes endangered population (Cohen, 2009), and human activity near the nest can cause abandonment or can interrupt incubation, resulting in egg mortality due to exposure (Lingle 1989). There has been substantial conversion of land to corn and soybean production throughout the Piping plover's range, including the conversion of riparian areas along its designated critical habitat (Appendix 8). Agricultural pollution to waterways could also affect the species. Northern Great Plains Piping plovers nest around small alkaline lakes, river islands, and other shorelines (Haig and Pilsner, 1993), and pesticides or other contaminants from agricultural practices could jeopardize the birds' egg survival near streams and watersheds where Piping plovers nest (Fannin, 1993).

20.

Black-footed ferrets (*Mustela nigripes*) are listed as endangered across their entire range, which overlaps with substantial amounts of cropland expansion for corn production across the Great Plains (Lark et al., 2015). Although a critical habitat area has not been designated, the loss of habitat—including the conversion of native grasslands to agricultural land—has specifically been cited as a key risk to Black-footed ferrets (USFWS, 2017). The conversion of grasslands to croplands also has been detrimental to populations of prairie dogs, a species upon which the Black-footed ferret is heavily reliant for both food and nesting habitat. Given the connection between the Renewable Fuel Standard and the conversion of grasslands to agricultural land within the Black-footed ferret's range, further assessment seems warranted.

21.

The Renewable Fuel Standard's contribution to land use change has likely also led to adverse outcomes for water quality and thus may have affected aquatic species. Corn has the highest fertilizer application rates of any feedstock crop (U.S. EPA 2011), and approximately one-fourth of all nutrients applied to corn are lost to the environment. The application of synthetic fertilizers, animal manure, and pesticides during crop production contributes to pollution in runoff and pesticide contamination and exposure. Fertilizer and manure inputs contain high levels of nitrogen and phosphorus, which are routed to waterways through surface erosion and runoff, or can leach into groundwater. In waterways, this nutrient loading promotes the growth of plants and algae. This is known as eutrophication, leading to dissolved oxygen depletion and thus hypoxia, making waterways inhospitable to many forms of life. Other effects of eutrophication and excessive nutrient loading include increases in algal toxin levels and the frequency of harmful algal bloom events (U.S. EPA 2017a; Carpenter et al. 1998).

22.

Nutrient runoff, eutrophication, and hypoxia due to increased corn production and the associated decreases in water clarity and oxygen content could jeopardize the health of federally threatened and endangered aquatic species. As of 2007, according to the U.S. Fish and Wildlife Service's endangered species database, 139 fish, 70 mussels, four crayfish, 23 amphibians, and one water dependent dragonfly had endangered or threatened status, and it was estimated that approximately 60 of these species are at least partially imperiled by eutrophication (Dodds et al. 2009). Species within the corn belt and other agriculturally intensive regions and their watersheds may be at greatest risk of impairment from increased ethanol production and associated land use changes.

23.

Based on the location of designated critical habitat in relation to recently expanded corn production and its estimated effects, potentially affected endangered and threatened aquatic species include the endangered Topeka Shiner, the threatened Arkansas River Shiner, and the threatened Purple Bankclimber, endangered Fat Threeridge, endangered Gulf Moccasinshell, endangered Shinyrayed Pocketbook, and endangered Oval Pigtoe mussels.

24.

The Topeka Shiner (*Notropis topeka*) is a small endangered minnow that resides in prairie streams in the central United States where it is usually found in pool and run areas. Its range includes Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, and South Dakota (USFWS, 2018). There has been substantial conversion of land to corn and soy production throughout the Topeka Shiner's habitat range as well as within the immediate vicinity of its designated critical habitat in southwest Minnesota and northwest Iowa (Lark et al., 2015). A primary threat to the Topeka shiner that requires special management in its critical habitat watersheds includes agricultural practices that increase sedimentation and other water quality impacts (Federal Register / Vol. 69, No. 143 / Tuesday, July 27, 2004 / Rules and Regulations). Given this impact mechanism, it is feasible that increased corn production due to the Renewable Fuel Standard could negatively affect the survival or recovery of this endangered species. The Arkansas River shiner (*Notropis girardi*) is a minnow found in Texas, New Mexico, and Oklahoma that faces similar threats as the Topeka shiner. An example of conversion near the Arkansas River shiner's critical habitat is included in Appendix 9.

25.

Mussels can experience habitat fragmentation through the processes of sedimentation and impoundment. The sediment buildup that may occur due to an increase in agricultural practices can lead to the covering of mussels which can result in both resource deprivation as well as isolation of different populations (USFWS, 2006). Excessive chemicals and nutrients in water systems are also a major threat to mussels such as the Purple Bankclimber due to its lifestyle as a filter feeder (McCann and Neves, 1992; Havlik and Marking, 1987), and the inflow of chemicals from nearby cultivated fields can be directly ingested by and harm these mussels. For example, ammonia is linked to fertilizers and is most often found in streams at the interface of the substrate and water, where mussels reside (Frazier et al., 1996), and ammonia has been shown to be lethal to mussels at concentrations of 5.0 ppm (Havlik and Marking, 1987). Young mussels are especially susceptible to these negative impacts (Robison et al., 1996), and deadly levels of pesticides and fertilizers from crop agriculture have been specifically reported in the Apalachicola-Chattahoochee-Flint river basin where many mussels inhabit (Frick et al., 1998).

26.

Recent extensive conversion of land to crop production occurred within the watersheds of many mussels' designated critical habitat in Southwestern Georgia and the surrounding states (see Appendix 10). Potential species impacted include the Fat Threeridge (*Amblema neislerii)*, Purple Bankclimber (*Elliptoideus sloatianus)*, Gulf Moccasinshell (*Medionidus penicillatus)*, Oval Pigtoe (*Pleurobema pyriforme)*, and Shinyrayed Pocketbook (*Lampsilis subangulata).* Fat Threeridges, Gulf Mocassinshells, Oval Pigtoes, and Shinyrayed Pocketbooks are all endangered mussels found in Georgia and Florida. Purple Bankclimbers are threatened mussels found in Georgia, Florida, and Alabama.

27.

The link between the Renewable Fuel Standard, increased cropping intensification, and hypoxia in the Gulf of Mexico has also been well established (Hendricks et al. 2014; Donner and Kucharik 2008) (see section 5 of Expert Report). Many Americans may be familiar with the Gulf "dead zone"—a major hypoxic zone which forms seasonally in the northern Gulf of Mexico and that is caused by the interaction of environmental conditions, water stratification, and excess nutrient pollution from the Mississippi River (NOAA 2017). Harms to aquatic life in the "dead zone" include reduced growth and reproduction, habitat destruction, and death (Mississippi River/Gulf of Mexico Watershed Nutrient Task Force 2015; U.S. EPA 2017b; NOAA 2017).

28.

Corn and soybean cultivation is the greatest source of nitrogen loading to the Gulf of Mexico, contributing approximately half the total loading (Alexander et al.

2008; Mississippi River/Gulf of Mexico Watershed Nutrient Task Force 2015). Donner and Kucharik (2008) estimated that increases in corn ethanol production specifically related to the Renewable Fuel Standard would increase the annual average flux of dissolved inorganic nitrogen exported by the Mississippi and Atchafalaya Rivers to the Gulf of Mexico by 10–34% (Donner and Kucharik 2008). Another study, which focused only on Iowa, Illinois, and Indiana, estimated that for each additional billion gallons of corn ethanol produced under the Renewable Fuel Standard in these states, the size of the Gulf dead zone would grow by approximately 33 square miles.

The large seasonal dead zone in the Gulf may affect the critical habitat or migration and feeding ranges of current and pending federally listed species, including the threatened Gulf Sturgeon, threatened Loggerhead Turtle, and endangered Sperm Whale.

29.

The Gulf Sturgeon (*Acipenser oxyrhynchus desotoi*) has designated critical habitat immediately at the mouth of the Mississippi river, and the species is vulnerable to low dissolved oxygen levels and hypoxia, which could be impacted by eutrophication and agricultural runoff due to the Renewable Fuel Standard.

30.

Loggerhead sea turtles (*Caretta caretta*) spend the majority of their lives in coastal and offshore waters of the Gulf of Mexico, Caribbean Sea, and Atlantic Ocean. The nearshore waters of the Gulf provide valuable foraging habitat for juvenile and adult sea turtles, as well as important mating and inter-nesting habitat. Loggerheads in the near-shore northern Gulf of Mexico waters may be exposed to hypoxia (Hart et al. 2013) and thus could be affected by the expanded Gulf hypoxic zone due to the Renewable Fuel Standard. The increasing frequency of red tides and harmful algae blooms in the Gulf of Mexico as well as the increased duration and extent of the hypoxic dead zone caused by agricultural runoff in the Mississippi River have been reported to both directly and indirectly affect sea turtles (NMFS et al. 2011). Thus, further review of the potential impacts is recommened.

31.

The Sperm whale (*Physeter macrocephalus*) is listed as endangered throughout its range, which includes a substantial year-round population in the Gulf of Mexico. Sperm whales may experience a potential reduction in their food sources due to the annual Gulf hypoxic zone, and consequently a possible reduction in their presence and number of sightings in this region.

32.

Increases in cultivated cropland and ethanol production spurred by the Renewable Fuel Standard also influence water use and availability both through the biofuel production process at refineries, as well as through the demands of growing large volumes of corn and other feedstocks.

33.

Corn ethanol refineries use approximately 2.5 to 3 gallons of water per gallon of ethanol produced (Hoekman, Broch, and Liu 2017). While these numbers may not sound particularly alarming, they can strain water resources where supplies are limited, such as the semi-arid Great Plains. The impact of these refineries is shocking when compared to typical human use: a corn ethanol refinery with production capacity of 100 million gallons per year is estimated to consume as much water as a community of 5000 people (Hoekman, Broch, and Liu 2017; Service 2009). Furthermore, the water requirements associated with production of corn for ethanol can be far greater depending on whether the crop is irrigated or rainfed. As of 2009, approximately 70% of the corn used to produce ethanol was estimated to have water requirements of 10-17 gallons of water per gallon of ethanol produced. In some regions high in irrigation and water use, the ratio can be over 300 gallons of water per gallon of ethanol produced (Hoekman, Broch, and Liu 2017). Example listed species potentially impacted by water use and consumption for biofuel feedstock production and refining, as described below, include the aforementioned Hine's emerald dragonfly and Piping Plover.

34.

Hine's emerald dragonflies (*Somatochlora hineana*) are endangered dragonflies that inhabit marshes and meadows that are calcium carbonate-rich in Missouri, Wisconsin, Michigan, and Illinois. High capacity pumping of groundwater for agricultural irrigation, as is common in the agricultural locations like Central Wisconsin, Michigan, and Illinois, may lead to habitat fragmentation due to water level alteration. Groundwater is vital to maintaining a healthy wetland environment, and changes in water flow rates due to upstream pumping may also lead to a reduction in available habitats to successfully reproduce (USFWS, 2001).

35.

Similarly, water use and consumption for irrigated biofuel feedstock production as well as flooding from increased erosion may influence the Piping Plover, whose nests are very dependent on the stability of water levels (Haig, 1992). When water levels rise too much, the nests of Piping Plovers flood; if water levels dip too low, vegetation that is destructive to successful nesting may grow (USFWS, 1996).

36.

While one of the stated intentions of the Renewable Fuel Standard is to reduce greenhouse gas (GHG) emissions from motor vehicles, any induced land use conversion from the Renewable Fuel Standard can be a major contributor of atmospheric greenhouse gases. Nonagricultural or non-cropped land is typically a significant carbon sink and also contains substantial carbon stocks, so the clearing of these lands, as well as the cultivation and perturbation of the soil, usually generates a net release of greenhouse gases to the atmosphere (Hoekman and Broch 2017). In general, conversion from grassland to crop production releases an estimated 68 to 134 Mg CO_2 per hectare (Fargione et al. 2008; Gelfand et al. 2011). As such, the conversion of noncropland to corn and soy cultivation following implementation of the Renewable Fuel Standard (2008-2012) was estimated to have led to emissions of 94 to 186 Tg CO_2e. This is equivalent to a year's worth of CO_2 release from 34 coal-fired power plants or an additional 28 million cars on the road (Lark, Salmon, and Gibbs 2015). The processes by which these releases occur are detailed further in section 5.4 of the Expert Report. The U.S. Fish and Wildlife Service specifically identifies climate change as a key threat to many of the species listed in this declaration. Thus, any of the species and their critical habitat that are sensitive to climate change may thereby be impacted by emissions of greenhouse gases associated with crop production and expansion induced by the Renewable Fuel Standard.

37.

To date, little research has been performed regarding the potential impact of the Renewable Fuels Standard on federally threatened and endangered species. Given this lack of information as well as the potential mechanisms of influence enumerated here, further evaluation and review of the possible impacts is recommended.

I declare under penalty of perjury under the laws of the United States that the foregoing is true and correct to the best of my knowledge.

Dated this 27th of July, 2018 Signed,

Dr. Tyler Lark

Appendix 1 to Declaration of Dr. Tyler Lark

Tyler J. Lark

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EDUCATION

Ph.D. Environment & Resources, University of Wisconsin-Madison, 2017 *GPA: 4.0*
Dissertation: Quantifying agricultural land-use change across the United States. Advisor: Holly Gibbs

B.S. Biomedical Engineering, 2^{nd} major in Mathematics, University of Wisconsin-Madison, May 2011 *GPA: 3.9*

HONORS & AWARDS

"Innovation in Teaching" university-wide Teaching Assistant (TA) award, *UW-Madison*, 2017
"Administrative Improvement Award" for receipt waste reduction project, *UW-Madison*, 2016
"Best Oral Presentation" – *North American Congress for Conservation Biology*, 2016
"Highly Commended Paper" – *Environmental Research Letters'* Top Papers of the Year, 2015
Kurt F. Wendt award for outstanding character, dedication, and leadership in a UW program, 2011
Global Stewards Committee's Climate Leadership Challenge award winner, 2010
"Best Presentation Award" and Schoofs Prize for Creativity, *UW Innovation Days*, 2010
"Gold project for International Outreach" *United Nations Mondialogo challenge*, 2009

PROFESSIONAL EXPERIENCE:

Associate Researcher, University of Wisconsin-Madison, *December 2017 – present*

Lead research on U.S. agriculture, land use, and conservation as part of the Gibbs Land Use and Environment lab at the Center for Sustainability and the Global Environment (SAGE). Manage multi-institutional projects and a local team of analysts, graduate students, and researchers to answer policy-relevant research questions and share the results with stakeholders.

Graduate Research Assistant, University of Wisconsin-Madison, *January 2012 – December 2017*

Research Intern/Co-op, Kimberly-Clark Corporation, Neenah, WI & Roswell, GA, *Summer 2014, 2010, Spring 2009, Fall 2007*

Conducted research of renewable & bio-based products and materials as a member of the Environmentally Sustainable Technology team. Considered the full life-cycle impact of product development and use.

Project Manager, Engineers Without Borders UW-Madison Haiti Program, *Spring 2009 – Summer 2011*

Coordinated and co-directed an international community development program with over 30 students and 5 professionals. Managed partner relations, project finances, and full process assessment, design, and implementation of projects including irrigation canal construction, reforestation, and land surveying technical education.

RESEARCH GRANTS AND FUNDING

2018 Nations Wildlife Federation: *Mapping irrigation and endangered species in the Ogallala aquifer and Apalachicola-Chatahooche-Flint (ACF) basin.* ($23,374 – PI; Co-PI H. Gibbs)

2018 World Wildlife Fund: *Mapping undisturbed lands in support of HOS grassland sustainability*. (39,886 – PI)

2017-2018 Great Lakes Bioenergy Research Center: *Estimating marginal lands available for cellulosic biofuel feedstock production.* ($70,000 – Project co-lead with PI Holly Gibbs)

2017-2018 National Wildlife Federation: *Quantifying the impact of the Renewable Fuel Standard on America's land and water resources.* ($544,500, Project co-lead with PI Holly Gibbs; Co-PIs C. Kucharik, N. Hendricks, A. Smith, and J. Brown)

2017 American Carbon Registry / Ducks Unlimited: *Avoided grassland conversion modeling support.* ($20,000 – PI)

2017-2018 Packard Foundation / National Wildlife Federation: *Mapping global biomass and estimating carbon emissions from U.S. cropland expansion.* ($144,000 – Project co-lead with PI Holly Gibbs)

2015-2016 UW Sustainability Innovation in Research and Education grant: *Solutions for Food Waste Reduction--Integrating teaching with research on Sustainability*. ($20,634 – Co-I with Holly Gibbs)

2014-2015 National Wildlife Federation: *Assessing native prairie conversion in Minnesota.* ($6,000 – Co-I with Holly Gibbs)

2013 Roy F. Weston Distinguished Graduate Fellowship in Sustainability Science, Technology, and Policy. ($44,000 – PI)

2010-2012 Ira and Ineva Reilly Baldwin Wisconsin Idea Endowment: *Alternative Energy: Plant-based Biofuels and Sustainable Stove Design for Haiti and Deforested Nations.* ($12,000 – PI)

2010-2012 Morgridge Center for Public Service: *Expanding student and community involvement via greenhouse and agroforestry test plots in Madison, Wi, and Bayonnais, Haiti.* ($6,000 – PI)

MEDIA OUTREACH & SCIENCE COMMUNICATION:

Interviews: National Public Radio, Washington Post, Minnesota Public Radio news, Pacific Standard, Frontiers in Ecology and the Environment, Grist, Environmental Research Web, Mongabay

Research Coverage: Associated Press, ClimateWire, ThinkProgress.org, Harvest Public Media, Inhabitat, TreeHugger.com, NSAC, Land Stewardship Project, Environmental Working Group, World Wildlife Fund, National Wildlife Federation,

TEACHING EXPERIENCE:

Spring 2014. Enviro St. 600: Consumer-driven sustainability. Co-designed and co-taught a new environmental studies capstone section focused on campus food connections.

Spring 2015 & Fall 2016. Geography 309: People, Land, and Food. Developed and delivered 4 weeks of lectures, discussions, and assessments as a special instructor for classes of 60 and 95 undergraduate geography students.

Spring 2016. Enviro St. 600: Solutions for Food Waste Reduction. Proposed, created, and instructed a new special topics capstone section on the local to global causes and consequences of food waste.

MENTORED STUDENTS

Calder Sell, “Impacts of Biofuel Feedstock Production Land Conversion on Endangered Species in the United States”, 2-cr. Independent Project (Bio 152), 2018

*+Stephanie Herbst, “Coupled land and water availability in the United States”, Masters Thesis, Environment and Resources program, x2018

+Seth Spawn, “Carbon implications of U.S. and global land use change and conservation efforts”. Master’s Thesis, Geography, x2019

Jumana Dahleh, “Policy recommendations for municipal food waste reduction in Madison, WI”, 2-cr. Independent Study (IES 699), 2017

Megan Bohl, “Food waste reduction in campus dining halls”, 1-cr. Independent Study (IES 699), 2017

+Liu Luo, “Multiple Cropping Systems for China under Climate Change”, Chinese Exchange Workshop on Research Innovation and Scientific Writing, April 3-17, 2016

Madeline Fischer, “Food Waste media communication strategies”, 3-cr. Independent Study (IES 699), 2015

Collin Higgins, “Urban turf grass as Potentially Available Cropland”, Sophomore Honors Program, 2013

Aaron Schroeder, “The potential of home gardens to reduce food waste in the U.S.”, Undergraduate Research Scholars Program (2012-2013)

Maxwell Albrecht, “Supply chain analysis of commercial vs home vegetable production”. Undergraduate Scholars Program (2012-2013)

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SERVICE:

Campus Advisory Board, *Morgridge Center for Public Service*, 2016-present
Advisory Committee, *UW-Madison Arboretum*, 2015-present
Board Member & Parks committee chair, *Tenney-Lapham Neighborhood Council*, 2013-present
Advisory Board member, *UW-Madison Office of Sustainability*, 2013-present
University Shared Governance Member – *Associated Students of Madison*, 2012-2017
Regular reviewer for journals including *Global Change Biology*, *GCB-Bioenergy, Geo: Geography & Environment*, *Journal of Land Use Science*, *Land Use Policy*, *Mitigation and Adaptation Strategies for Global Change*, and *Ecosphere*

JOURNAL PUBLICATIONS

Published:

Lark, TJ, R. M. Mueller, D. M. Johnson, H. K. Gibbs. Measuring land-use and land-cover change using the USDA Cropland Data Layer: Cautions and Recommendations. *Intl J of Applied Earth Obs and Geoinformatics.* (2017) (IF=3.9)

Wright, CK, B Larson, **TJ Lark**, HK Gibbs. Recent grassland losses are concentrated around U.S. ethanol refineries. *Environmental Research Letters. (*2017*) (IF=4.1)*

Lark, TJ, JM Salmon, HK Gibbs. Cropland expansion outpaces biofuel policies in the United States. *Environmental Research Letters.* (2015) (IF=4.1)

Submitted / In review:

Lark, TJ, B. Larson, I. Schelley, S. Batish, H. K. Gibbs. Conversion of native prairie grasslands in the Midwest, USA. *Environmental Conservation*.

Available as report / In preparation for journal submission:

Lark TJ, I Schelley, HK Gibbs. Accuracy of mapping crops and cropland conversions in the United States. *Published as dissertation chapter / In prep for Remote Sensing.*

Lark TJ and HK Gibbs. The land gap and Potentially Available Cropland in the United States. *Published as dissertation chapter / In prep for Agricultural Systems.*

Lark TJ. Protecting our prairies: A science and policy agenda for conserving America's grasslands. *In prep for Land Use Policy.*

PRESENTATIONS

Lark, T.J., and H.K. Gibbs. "Mapping Potentially Available Cropland in the United States." American Geophysical Union, San Francisco, CA. Dec. 3-7, 2012.

Lark, T.J., J.M. Salmon, and H.K. Gibbs. "Mapping agricultural land-use change in the U.S. 2008-2012." American Geophysical Union, San Francisco, CA. December 18, 2014.

Lark, T.J. "Conservation and Biofuel Policy Implications of Recent Cropland Expansion in the United States." Nelson Institute Brownbag Public Lecture Series. Madison, WI. February 12, 2015.

Lark, T.J. "Post-Renewable Fuels Standard domestic land use change." Seminar presentation for the Union of Concerned Scientists and National Wildlife Federation, Washington, D.C. February 18, 2015.

Lark, T.J. "Land-use change and biofuels." Presentation to the U.S. Environmental Protection Agency, Office of Transportation & Air Quality. Washington, D.C. February 18, 2015.

Lark, T.J. "Policy implications of U.S. cropland expansion 2008-2012." Official commentary to the White House Office of Information and Regulatory Affairs, in support of Renewable Fuels Standard (RFS) Program final rule. Washington, D.C. February 18, 2015.

Lark, T.J. "Cropland Expansion and its impacts on Grassland and Wetlands Nationwide." Public teleconference and interview hosted by National Wildlife Federation, Washington, D.C. April 2, 2015.

Lark, T.J., J.M. Salmon, and H.K. Gibbs. "Recent U.S. cropland expansion and implications for carbon and policy." Invited presentation to the National Association of Clean Air Agencies, Committee on Agriculture. (online) April 21, 2015.

*Lark, T.J., J.M. Salmon, and H.K. Gibbs. "Cropland expansion outpaces agricultural and biofuel policies in the United States. American Association of Geographers annual meeting. Chicago, IL. April 23, 2015.

Lark, T.J. and Gibbs, H.K. "Mapping agricultural land-use change in the United States." Stakeholder presentation to the Wisconsin Corn Growers, Wisconsin BioFuels Association, and the Renewable Fuels Association. May 21, 2015

Lark, T.J. "Agricultural land-use change and implications for conservation organizations." Presentation to state and federal grasslands and wetlands working groups. (online). August 13, 2015.

Lark, T.J. "Mapping agricultural land-use change in the United States." Recorded webinar for The Nature Conservancy's national grasslands network. September 21, 2015.

**Lark, T.J. "Grassland conversion across the United States: Status, impacts, and policy implications." America's Grasslands Conference hosted by the National Wildlife Federation and Colorado State University. Fort Collins, CO. September 30, 2015.

*Lark, T.J. and Gibbs, H.K. "Land-use change in the US: Recent results, accuracy, and implications." Coordinating Research Council Workshop on Life Cycle Analysis of Transportation Fuels, Argonne National Lab, Chicago, IL. October 28, 2015

Lark, T.J. "Mapping grassland and cropland conversion across the United States." Society for Conservation Biology (SCB) North American Congress. Madison, WI. July 20, 2016 (Best presentation award)

*Lark, T.J. "Monitoring land use for agricultural sustainability." International Sustainability and Carbon Certification (ISCC) North American Stakeholder Dialogue and Technical Committee Meeting on implementation of sustainable supply chains. Las Vegas, NV. September 29, 2016.

Lark, T.J., Mueller, R.J., Johnson D.M., and Gibbs, H.K. "Measuring Land-Use and Land-Cover Change Using the USDA Cropland Data Layer: Cautions and Recommendations." American Geophysical Union, San Francisco, CA. December 16, 2016

Lark, T.J. "U.S. agricultural land use change Data: Opportunities for monitoring habitat conversion." Workshop on High-Oleic Soybean sustainability hosted by World Wildlife Fund and United Soybean Board. Washington, D.C. February 14, 2017

Lark, T.J. "Mapping U.S. agricultural land-use change using remote sensing products: Recent results, methods, and future directions." Seminar at the USGS Center for Earth Resources Observation and Science (EROS). Sioux Falls, SD. November 1, 2017

**Lark, T.J. "State of America's Grasslands: Recent Conversion & Research Frontiers." America's Grasslands Conference. Fort Worth, TX. November 15, 2017

*Lark, T.J. "Land use and environmental implications of the RFS." America's Grasslands Conference. Fort Worth, TX. November 15, 2017

Lark, T.J. "America's Food- and Fuel-Scapes: Agricultural land-use change across the United States." Public PhD seminar. Madison, WI. November 29, 2017

Lark, T.J. "Identifying undisturbed lands to support HOS sustainability criteria. Webinar hosted by the World Wildlife Fund. March 23, 2018.

Lark, T.J. "Biofuels and Land Use: Opportunities and challenges for sustainability." Recorded public seminar at WI Energy Institute. Madison, WI. April 2, 2018

Lark, T.J. "The scales of marginal lands and availability for cellulosic biofuel feedstock production." Great Lakes Bioenergy Research Center, Annual Science Meeting. Lake Geneva, WI. May 9, 2018.

*Invited conference presentation

**Plenary/Keynote Speaker

Appendix 2 to Declaration of Dr. Tyler Lark

Potential Land Use and Environmental Impacts of the United States Renewable Fuel Standard

Tyler J. Lark, Ph.D.

2/21/2018

1 EXECUTIVE SUMMARY

In 2011, the U.S. Environmental Protection Agency (EPA) completed its first triennial report to Congress on the environmental and resource conservation impacts associated with increased biofuel production and use in the United States. At the time, many of the impacts were uncertain and had been estimated using predictive models of anticipated land use change and potential responses. Since that report's release, sufficient time has passed to quantify observed changes on the landscape and document them in scientific literature and government reports. The purpose of this current account is to highlight a selection of that recent data and research, with a focus on land use changes relevent to corn ethanol production and associated impacts on the environment and conservation.

The Renewable Fuels Standard (RFS) is the federal policy which mandates the production and use of biofuels in the U.S. Following passage of the expanded RFS in 2007, total actively cultivated cropland area in the U.S. increased. Part of this cropland expansion came from the conversion of non-agricultural land and was used to grow biofuel feedstock crops such as corn and soybeans. According to land protections written into the RFS, this land should be ineligible for renewable biomass feedstock production. However, to date, converted lands have not been explicitly monitored under the RFS program and consequently have not yet been restricted from use for feedstock production.

Since 2007 there has also been widespread conversion of other types of land to active crop production including the conversion of pasture and previously idled cropland. These lands *are* considered eligible for renewable feedstock production under RFS definitions. Regardless of eligibility though, any conversion of land to grow the crops commonly used for biofuels can lead to negative environmental outcomes. Potential impacts include degradation of water quality that engenders both environmental and human health repercussions, direct emissions of carbon dioxide and other greenhouse gases to the atmosphere, loss of wildlife habitat and declines in plant and animal biodiversity, and the possible impairment of endangered species.

Due to an absence of chain-of-custody tracking in U.S. commodity crop supply chains, there is uncertainty regarding the exact location and magnitude of land conversion and impacts that are directly attributable to biofuel production and the RFS. Despite this limitation, a growing body of economic and statistical research has shown a direct causal link between the RFS, increased crop prices, and resultant effects on land use and natural resources. The available findings indicate that the RFS has stimulated national corn prices and total cropland area expansion, and that land conversion and increased corn cultivation is locally concentrated around ethanol refineries.

The influx of recent evidence that ties the RFS to documented land use changes and ensuing environmental consequences stresses the need to update comprehensive assessments of biofuel production impacts. Such a review would enable accurate and timely evaluation of the merits and drawbacks of existing renewable fuel volumes and policy. To inform these efforts, it will be important that the scientific and regulatory communities continue to conduct and support research on the evolving impacts of the RFS including those from biofuel feedstock production and associated land use changes.

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2 BACKGROUND

2.1 EISA AND EPA'S 2010 RULES ON IMPLEMENTATION

The Renewable Fuel Standard program (RFS) was established as part of the Energy Policy Act of 2005, which was passed as an amendment to the Clean Air Act. The RFS functions as a mandate: it sets minimum levels of renewable fuels that must be blended into the nation's transportation fuel supply. The original RFS required that at least 4 billion gallons of renewable fuel be blended in 2006 and at least 7.5 billion gallons by 2012. In 2007, the RFS was revised and expanded as part of the Energy Independence and Security Act of 2007 (EISA), a further amendment to the Clean Air Act. EISA increased the mandated volume of renewable fuels to 36 billion gallons by 2022 and established specific annual volumetric targets for individual fuel categories, including total renewable fuels, advanced biofuels, biomass-based diesel, and cellulosic biofuels.

Given its responsibility for implementing Clean Air Act rules, the U.S. Environmental Protection Agency (EPA) was charged with the responsibility of implementing and regulating the RFS. After proposal and review, the EPA established its initial plan for enforcing the RFS which was published in the Federal Register as 40 CFR Part 80 "Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program; Final Rule" on March 26, 2010 (Federal Registrar 2010). This final rule continues to guide implementation of the RFS, and outlines how the statutorily-mandated program has thus far been administered in practice.

Under EISA, the EPA also has authority to waive or adjust the volumetric targets specified in the RFS (U.S. EPA Office of Inspector General 2016). Targets may be waived based on inadequate domestic supply of renewable fuels or if implementation of mandated levels would cause severe harm to the economy or environment. To date, the EPA has only waived blending targets based on inadequate domestic supply. However, up-to-date information regarding the environmental impacts of renewable fuels has not been available to aid annual volumetric decisionmaking. In lieu of more comprehensive environmental assessments, this report summarizes recently documented impacts that may support waiver decisions concerning potential environmental harm.

2.2 RENEWABLE FEEDSTOCKS, ELIGIBLE LAND, AND AGGREGATE COMPLIANCE

Under EISA, land eligible for growing crop-based renewable feedstocks must have been cleared or cultivated prior to the date of enactment, December 2007, and be "actively managed or fallow, and nonforested." In determining what biomass feedstocks would qualify under this definition, the EPA interpreted these guidelines to include all planted crops and crop residues harvested from existing agricultural land. Existing agricultural land was further defined to include cropland, pastureland, and Conservation Reserve Program (CRP) land, which suggests that each of these sources could be used or converted to grow biofuel feedstocks (Federal Registrar 2010) (p14692). Pastureland was described as property managed primarily for the "production of indigenous or introduced forage plants for livestock grazing or hay production, and to prevent succession to other plant types." Rangeland was excluded from qualifying for renewable biomass production on the basis that it is land where the vegetation is predominantly grasses, grass-like plants, forbs or shrubs and which — unlike cropland or pastureland — is predominantly managed as a natural ecosystem (Federal Registrar 2010) (p14693).

In its 2010 rulemaking, the EPA proposed three mechanisms to monitor the EISA land eligibility stipulation and enforce compliance. The first approach required establishment of a feedstock recordkeeping and reporting system, which would enable and require tracking of feedstock production locations to ensure they were existing cropland sites. The second, consortium-based proposal suggested development of a supply chain quality assurance program that would allow groups of fuel and feedstock producers to attain certification, subject to verification by an independent auditor. The final proposed mechanism for planted crops and crop residues from agricultural land provided an alternative means of compliance in which all feedstocks within the U.S. would be deemed eligible if certain nationwide cropland area thresholds were not exceeded.

Ultimately, the EPA chose the third, “aggregate compliance,” approach to determine feedstock eligibility (Federal Registrar 2010). The aggregate compliance approach was justified, in part, by assumptions that “in practice, new lands will not be cleared, at least in the near future, for purposes of growing renewable fuel feedstocks” (p14698). Under aggregated compliance, the EPA set a threshold of 402 million acres of existing cropland in 2007 from which eligible biomass could be sourced. If total cropland exceeded this threshold in subsequent years, the ruling stated that recordkeeping and reporting requirements would be enacted. If a lower, 397-million-acre threshold was reached, the EPA proposed to re-evaluate the aggregate approach. Despite reaching the lower threshold in some years, the EPA has not yet reformed the aggregate compliance approach (Wright et al. 2017).

Aggregate compliance was supported by several factors at the time of its proposal, but recent studies have found potential challenges to its efficacy (Wright et al. 2017). For example, the EPA relies on nationally aggregated measures of total cropland from the Department of Agriculture’s Farm Service Agency (FSA) and National Agricultural Statistics Service (NASS) to monitor the regulation. However, these aggregate indicators report only *net* changes in cropland area at the county level and fail to identify *gross* conversions to and from cropland. As such, any ineligible land that was converted to biofuel feedstock production could essentially be hidden or offset by abandonment of existing cropland in other areas. In addition, use of 2007 as the sole baseline year for comparison may be problematic, as 2007 planted area was already above previous year averages due to multiple factors, including favorable planting conditions, and some land may have already been converted in anticipation of the RFS update. Furthermore, a growing body of recent data suggests the foundational assumptions supporting aggregate compliance may no longer be valid. These issues are further described in sections 3 and 4 of this report.

2.3 SUMMARY OF EXISTING FEDERAL REPORTS

Several government studies that summarized the anticipated environmental impacts of biofuel production were published during or soon after EISA enactment and EPA's 2010 ruling on implementation. In February 2010, the EPA released its Regulatory Impact Analysis (RIA), which included reporting on the Life Cycle Analysis (LCA) of various biofuels' greenhouse gas (GHG) intensities and their relation to meeting GHG reduction thresholds of the RFS (U.S. EPA 2010). The assessment found that most renewable fuel pathways reduced emissions relative to gasoline. However, the review also concluded that land-use change was a significant determinant of a renewable fuel's net GHG balance, and thus represents a pivotal component to monitor and understand. The EPA has not yet updated the 2010 RIA, which could now incorporate observed data on land-use changes and associated GHG emissions to reasses renewable fuel pathway emissions estimates.

In 2011, the National Academies of Sciences (NAS) published their statutorily mandated study on the economic and environmental effects of biofuels (Committee on Economic and Environmental Impacts of Increasing Biofuels Production; National Research Council 2011). This report summarized many of the broad environmental impacts of biofuels known at the time. They concluded that the effects of increasing biofuel production are highly variable and depend on feedstock type, site-specific factors, and management, among other conditions.

Also in 2011, the EPA submitted its first triennial report to Congress on the environmental and conservation impacts of the RFS program. Of relevance, this report concluded that "the extent of negative impacts to date are limited in magnitude and are primarily associated with the intensification of corn production" and that "whether future impacts are positive or negative will be determined by the choice of feedstock, land use change, cultivation and conservation practices." These statements as well as the findings of the RIA and NAS study emphasize the importance of agricultural land use and spatial and crop specificity for understanding biofuel impacts. They also demonstrate the need for regularly updated environmental impact reviews to continue to inform the RFS program.

Under section 204 of EISA, the EPA is required to reassess the environmental and resource conservation impacts of the RFS program and report their findings to Congress every three years. The 2011 triennial report was the first and only such review (although an update was planned for delivery by the end of 2017, as of the date of this report, a new triennial report has not been released (U.S. EPA Office of Inspector General 2016)). At the time of the existing federal reports, many environmental impacts, particularly surrounding land use change, were uncertain and estimated using predictive models. Since then, substantial documentation of the role of biofuels and the RFS in modifying the landscape has emerged, which underscores the need for the updated review.

3 RECENT U.S. LAND USE CHANGE

Many of the environmental impacts of the RFS manifest through land use and land-use change (LULUC). Biofuel production requires large areas of land to grow feedstocks to use as input, and the effects of this production possibly constitute the largest potential environmental harm of the RFS. Although the environmental consequences of existing crop production are relatively well-known, the impacts of shifting crop patterns and further cropland expansion are less certain.

Agricultural land use changes induced by the RFS could occur through two key pathways: intensification and extensification. Both processes increase the overall production of a crop. Intensification refers to the process of getting more production from a fixed area of land, typically by increasing the yield of a crop or by increasing its acreage on existing cropland. Common examples of intensification for a specific crop include the initiation of irrigation, increased use of agronomic inputs like nitrogen fertilizer, or switching from other crops (e.g. continuous corn production rather than crop rotations). Extensification, or land conversion, increases crop production by bringing new land into cultivation, thus expanding the total area of production. This process converts uncropped land into cropland, and thus causes concomitant changes to the structure and function of the land, which in turn affects interactions within water, soils, and other natural resources.

Since the first triennial report to Congress from the EPA, a number of studies have documented extensificaiton and the domestic response of agricultural land to biofuel production. Several federal reports have also been released that detail the overall change in agricultural area across the U.S. following RFS enactment in 2007. These reports and data provide a snapshot of the response and dynamics of the agricultural industry during implementation of the RFS and help situate the policy within a broader context.

3.1 U.S. CULTIVATED CROPLAND AREA FOLLOWING PASSAGE OF THE RFS

The footprint of U.S. cropland has increased over the last decade. While there is some uncertainty concerning the total area of recent expansion, nearly all data sources suggest a net increase in total land under cultivation (Appendix 3-1)[1]. This expansion represents a reversal of the previous 30-year trend of crop area decline (Lark, Salmon, and Gibbs 2015). Data on cropland area are collected via a variety of methods, which include farmer-reported census, statistical surveying of crop fields by USDA field agents, and satellite-based observations of crop production and land use change.

The USDA's Census of Agriculture is often cited as the gold standard of agricultural land use data (Laingen 2015; Johnson 2013). For the period 2007 to 2012, the most recent years for which data are available, the Census of Agriculture shows an increase in harvested area of 5.3 million acres (Appendix 3-2). The area of failed cropland (planted but not harvested) also increased by 4.0 million acres to create a combined increase of 9.3 million acres of actively managed cropland. During the same period, fallow and idle cropland—two sources of land eligible for increasing feedstock production area under the RFS – decreased by 1.5 and 1.6 million acres, respectively. The remaining difference between the increase in actively managed cropland and the decrease in fallow and idle land suggests at least 6.2 million acres of cropland must have come from other sources, including pastureland, rangeland, or land enrolled in the Conservation Reserve Program. Note that if any fallow or idle land went into other non-crop uses such as development, the amount of increased cropland coming from pastureland, rangeland, or land enrolled in the CRP would be greater.

The National Resources Inventory (NRI), a long-term observational study of statistically representative sites across the country, also showed net cropland area expansion from 2007 to 2012. The NRI estimated 11.1 million acres of cropland gains from other uses, offset by only 7.2 million acres of

[1] Depending on the specific years, crops, and survey products selected, the annual NASS Survey products can suggest either an increase or decrease in planted or harvested area. As such, evaluating these individual metrics in isolation in not recommended.

cropland conversion to other uses, a net increase of about four million acres of cropland over the five-year period (appendices 3-4 and 3-5).

The satellite-based USDA Cropland Data Layer (CDL) is a landcover classification product that maps the distribution of cropland and specific crops each year and was used by Lark et al. (2015) to measure recent land use change. Their analysis accounted for errors, misclassifications, and mapping bias in the underlying CDL data. Their analysis found 7.3 million acres of cropland expansion from 2008 to 2012, offset by only 4.3 million acres of cropland loss, for a net increase of 3.0 million acres (Lark, Salmon, and Gibbs 2015).

The National Land Cover Database (NLCD) provides an alternative satellite-based assessment of land cover and land cover change that is independent of the USDA CDL and associated assessments. The NLCD is produced by a consortium of organizations that includes the USGS, USDA, EPA, and others. According to the NLCD, from 2006 to 2011 approximately 1.5 million acres were converted to cultivated crop production from other uses, offset by only 1.3 million acres of cropland loss, for a net increase of 172,000 acres of cropland(Appendix 3-6).

Although each of these datasets use different means of data collection and yield different estimates (see Appendix 3 summaries for each dataset), collectively they reveal a consensus that active cropland area increased in the U.S. during the period immediately following 2007. These nationwide assessments are further supported by a plethora of regional studies which have identified conversion of noncropland to active production during the RFS era (Wright and Wimberly 2013; Johnston 2014; Mladenoff et al. 2016; Reitsma et al. 2015; Wimberly et al. 2017).

There remains some debate regarding the magnitude of land cleared following 2007, how much of it was used for biofuel production, and how much of it should be ineligible for such use. However, there is irrefutable evidence that there was at least *some* cleared and converted land that should be ineligible for renewable feedstock production. In 2012 the USDA Farm Service Agency reported specifically on first-time conversions of noncropland to crops and identified over 400,000 acres of conversion (USDA 2013). Based on the definitions established by the EPA and the sources of data selected to determine the eligible area in the U.S., this land should be excluded from qualifying for renewable biomass production. Given that these data were tracked by the USDA and based directly on the data adopted by the EPA to define cropland, they provide the strongest evidence of ineligible land conversion and the inability of aggregate compliance to uphold the land protections established by EISA and the EPA.

3.2 Limitations of Net and Aggregated Data

Use of net and aggregated data to monitor total cropland extent and compliance with the RFS can be problematic. Within the overall net increase in cropland area observed since 2007, there are concurrent annual increases and decreases as well as significant regional variations in the distribution of land use changes. However, land conversions and regional variations are often masked when cropland area is reported only by measures of net change or when the data are aggregated into larger administrative units.

When land use change data are reported only as net changes in total cropland area — as is the case in the Census of Agriculture and NASS Survey data — the amount of conversion to and from cropland is actually unknown. For example, areas of expansion in one location could be offset by abandonment in others, which would result in a net zero change in total cropland area, despite substantial landscape alteration. Instead, land use changes should more appropriately be reported based on both *net* change and the more detailed *gross* changes--into and out of cropland--which sum to equal the overall net change in cropland area. Unfortunately, the Census of Agricultural, NASS Surveys, and the FSA crop planting data used by the EPA to establish its baseline area for aggregate compliance all report only net changes in cropland.

Land use changes can be further obscured when data are spatially aggregated into larger administrative units. For example, several counties within a given state might show substantial cropland expansion while another group of counties exhibit countervailing losses. When county level results are aggregated to broader spatial extents, the magnitude of local changes are attenuated or can be completely offset. Aggregated measures of crop area are thus ineffective at quantifying the actual amount of land use change that occurs. Appendix Figure 3-7 from Lark et al. (2015) as well as figure 2 of Swinton et al. (2011) illustrate the heterogeneous nature of cropland use and change and exemplify the importance of measuring gross, dissaggregated changes on the landscape (Swinton et al. 2011; Lark, Salmon, and Gibbs 2015).

The obfuscation that results from net change measures and spatially aggregregated data is most pronounced at the national level. For example, even if cropland area had remained constant following passage of the RFS, some cropland is continuously lost to development and would need to be replaced with conversions elsewhere in order for the total area to remain the same (Coisnon, Oueslati, and Salanié 2014; Emili and Greene 2014). Thus cropland losses to development can mask increases elsewhere, including any increases for corn ethanol production. By the definitions of eligible land in EISA and EPA’s 2010 rule on implementation, nonagricultural land converted after 2007 should not qualify for production of renewable fuel feedstocks. As it stands, however, the current "aggregate compliance" enforcement mechanism tracks only net changes at the nationally aggregated scale and therefore ineffectively monitors land conversion. As a result, all U.S. cropland is currently deemed compliant, even if it was recently converted from nonagricultural use.

3.3 CORN WAS FREQUENTLY PLANTED ON NEWLY CONVERTED LAND.

Several studies show that corn was frequently planted on land converted after 2007. Lark et al. (2015) found that corn was planted on 27% of new cropland between 2008 and 2012, followed by wheat (25%) and soybeans (20%) (Lark, Salmon, and Gibbs 2015). Mladenhoff et al. (2016) found that most previously open land converted to crop production between 2008 and 2013 in the Great Lakes region was planted to corn (Mladenoff et al. 2016), with large areas converted to soybeans and other crops as well. For newly re-cultivated cropland exiting the Conservation Reserve Program, researchers found that in the Midwest corn and soybeans were planted 34% and 40% of the time, respectively (Morefield et al. 2016). Collectively, the findings that cropland area has recently expanded and that corn was frequently planted on this land provide a clear mechanism for potential influence of the RFS on land use change, which is detailed in the following section.

4 RFS CONTRIBUTION TO CHANGE

The RFS affects land conversion through two key pathways. Broadly, the RFS can induce corn prices to rise nationally, thereby spurring increased planting of corn. Locally, the presence of an ethanol refinery can also influence planting decisions by guaranteeing a local market or increasing local demand and therefore providing an incentive to nearby farmers to plant more corn.

4.1 RFS IMPACTS ON NATIONWIDE COMMODITY PRICES AND ACREAGE

An economic analysis that isolated the role of the RFS from other crop price drivers like weather and global markets recently determined that corn prices were on average 30% higher each year, from 2006 to 2014, than they would have been without the RFS, with a 90% confidence interval of a price increase of 13-54% (Carter, Rausser, and Smith 2016). The study also identified a permanent increase in overall demand from the updated 2007 version of the RFS of roughly 5.5 billion gallons of ethanol, or 1.3 billion bushels of corn, which caused a 31% increase in its long-run (persistent) price. This estimate is scalable, such that future increases in corn demand are expected to increase prices proportionally (Carter, Rausser, and Smith 2016).

Earlier economic studies found similar price impacts. For example, a 2013 analysis that used calorie-weighted indices of prices estimated the effect of the RFS on food prices, quantities, and consumers. It found that their consumer food price index was 20-30% higher than it would have been without ethanol production, depending on the amount and quality of byproduct (i.e. distiller's grains) used for animal feed (Roberts and Schlenker 2013).

A review of 29 studies published between 2007 and 2014 found that corn prices rose on average three to eight percent per billion gallon increase in ethanol mandate (Condon, Klemick, and Wolverton 2015). Estimates from various scenarios suggested that the RFS could raise corn prices from less than one percent to over 80% in certain conditions. They further estimated that moving forward, each additional billion gallon expansion in corn ethanol mandate as of 2015 would cause an additional 3-4% increase in corn prices (Condon, Klemick, and Wolverton 2015). Overall, the available economic studies are in strong agreement that the RFS mandates have increased national corn prices.

Increased prices send signals to farmers to increase acreage planted to a given crop. Barr et al. (2011) estimated multiple acreage elasticities for the U.S. in attempt to quantify this short-term extensive response of cropland area to price. By taking the average of expected returns with respect to expected price for 2007 to 2009 for actual acreages and returns compared to baseline predictions, the authors found a cropland acreage response elasticity of 0.029. That is, for every one percent increase in crop price, there was an expected 0.029 percent increase in U.S. cultivated area. Other studies have found a similar response of noncropland acreage to price and have made estimates at the regional level. For example, Langpap and Wu (2011) suggest a 0.059 response elasticity within the corn belt region (Langpap and Wu 2011).

While these response values are relatively inelastic--meaning proportionally small changes in acreage in response to changes in price--the overall impact and change in area becomes substantial at the national scale. For example, using the reported 30% increase in price due to the RFS (Carter, Rausser, and Smith 2016), the 0.029 acreage response elasticity (Barr et al. 2011), and a base U.S. cropland area of 236 million acres in 2007 (Barr et al. 2011), it can be estimated that the RFS induced roughly 2 million acres of cropland expansion via its impact on national corn prices.

4.2 LOCAL IMPACTS OF ETHANOL REFINERIES ON CORN ACREAGE AND LAND CONVERSION

The construction and operation of ethanol refineries has also been observed to directly stimulate corn production at the local level. This interaction between ethanol refinery location and corn production is bidirectional. Availability and proximity to feedstock is the key determinant of refinery siting, since corn costs represent 50-70% of all ethanol production costs (Lambert et al. 2008). However, the placement of a refinery also increases local demand, which induces increases in local corn prices and planted acreage (Fatal and Thurman 2014). A study of new ethanol production facilities built between 2002 and 2008 found that every million gallons of new ethanol capacity in a county was estimated to trigger an additional 5.21 acres of corn in that county, and this effect was frequently compounded by many refineries and felt across hundreds of counties (Fatal and Thurman 2014). Thus, the typical refinery increased corn planting in its county by over 500 acres and increased planted acreage in surrounding counties up to nearly 300 miles away.

A separate study by authors at the USDA Economic Research Service (Motamed, McPhail, and Williams 2016) estimated corn and total agricultural acreage response to local refining capacity and found significant effects. From 2006 to 2010, local response elasticities for corn acreage and total agricultural area ranged from 1 to 1.7, that is, for every one percent increase in ethanol refining capacity within a 10 x 10 km neighborhood, there was an equal or larger percentage increase in both corn and total agricultural land cultivated in that neighborhood. Furthermore, in every year the response of total agricultural acreage was larger than that of corn acreage. This implies that ethanol refining influenced land use *extensification*, that is, it required conversion of new land to crop production, more than *intensification,* where other crops were switched to corn. The observed effects were greatest in locations that had low acreage of existing corn and total agriculture, which the authors suggest partially supports the hypothesis that ethanol production spurred cultivation in areas with previously unfarmed and low-quality land. Local responses were strongest within a 100 km radius of ethanol refineries, but remained positive and significant up to 200 km away (Motamed, McPhail, and Williams 2016).

Ethanol refinery location is also strongly correlated with rates of grassland conversion to corn and soy production. Analysis of conversion of all land in the U.S. from 2008 to 2012 has shown that the percentage of suitable land converted to crop production increases linearly with proximity to an ethanol refinery (Appendix Figure 4-1a). Within 100 miles, corn and soy are planted on well over half of newly converted croplands, and the fraction of new cropland planted to these crops increases with proximity

(Appendix Figure 4-2). Beyond 100 miles from a refinery, the fraction of new corn or soy crops drops below 20%. In addition, existing cropland is less likely to be abandoned or restored to grassland if it is located in close proximity to a refinery (Wright et al. 2017) (Appendix Figure 4-1).

These studies collectively provide evidence that the RFS has caused a change in both the use and conversion of land in the U.S. through their observations of nationwide price impacts and aggregate land conversion response, observed increases in local corn and cropland area, and the spatial concentration of land conversion surrounding ethanol refineries.

4.3 Indirect Land Use Change

The RFS may also influence land conversion outside the U.S. through indirect land use change (ILUC). ILUC occurs when existing crops diverted for use as biofuel feedstock in one location are replaced by expanded crop production elsewhere. This framework is commonly used to discuss connections that cross multiple regions or nations. For example, if corn for ethanol production replaces soybeans on existing cropland in the U.S., it may induce an increase in soybean prices on the global market and, in turn, lead to expansion of soybean cultivation in the Brazilian Amazon (Searchinger et al. 2008; Keeney and Hertel 2009). Most research on ILUC effects of the RFS focus on international land conversion and therefore are not reviewed here. However, the same market-mediated mechanisms of ILUC can occur within a single region or nation and thus may contribute to the observed domestic land use responses discussed earlier.

5 ENVIRONMENTAL IMPACTS BEYOND LAND USE CHANGE

The RFS's influence on land use has likely contributed to certain adverse environmental outcomes. Many of these outcomes stem from increased cultivation of corn but could also arise from the expansion of other feedstock crops, such as soybeans for biodiesel. Issues of concern include impairment of water quality and use, emission of greenhouse gases, loss of biodiversity and habitat, and potential risks to endangered species. There may also be air quality impacts and other effects associated with the refining process, transportation of feedstocks, or the combusion of end products, but these are not reviewed here. The following sections summarize potential environmental outcomes of the RFS as manifested specifically through land use change.

5.1 WATER QUALITY

Increased corn production can lead to water quality concerns about nutrient pollution and runoff, pesticide contamination and exposure, and contamination of groundwater and potable wells.

Agricultural nutrient pollution of waterways is driven primarily by the application of synthetic fertilizers and animal manure during crop production (U.S. EPA 2017a). These inputs contain high levels of nitrogen and phosphorus, which affect water quality when the nutrients are routed to waterways through surface erosion and runoff or are leached into groundwater. Excessive loading of these nutrients into waterways promotes the growth of plants and algae, a process referred to as eutrophication. As these organisms die their decomposition consumes oxygen and depletes the available dissolved oxygen in the body of water. If oxygen levels are sufficiently low (less than 2 mg/l dissolved oxygen), conditions are considered hypoxic (Smith et al. 2017). Eutrophication can also contribute to increases in algal toxin levels and the frequency of harmful algal bloom events (U.S. EPA 2017a; Carpenter et al. 1998).

Oxygen depletion and algal toxins can each lead to fish kills and thus decrease commercial and sport fishing, biodiversity, and recreational values of waterways (Dodds et al. 2009). Declines in water clarity, which arise from increased algal growth or sedimentation from eroded soils, also tend to negatively affect these aquatic uses and value. Algal toxins further pose risks to both human and livestock health (U.S. EPA 2017a).

The connection between corn and these impacts on water quality is clear. Corn has the highest fertilizer application rates of any feedstock crop (U.S. EPA 2011) and approximately one-fourth of all nutrients applied to corn are lost to the environment. In the Mississippi River Basin — the enormous watershed that encompasses the majority of U.S. corn and ethanol production — an estimated 16% of all nitrogen applied to corn and soybeans ends up in its waterways (Alexander et al. 2008). Several studies have also reported specifically on the link between increased biofuel crop production and water quality deterioration from nutrient pollution (Welch et al. 2010; Committee on Economic and Environmental Impacts of Increasing Biofuels Production; National Research Council 2011).

The state of U.S. waterways in regards to nutrient pollution is dire. A national assessment found that median concentrations of total nitrogen and phosphorus in agricultural streams are about six times greater than background levels (USGS Dubrovosky 2010). Findings also indicated that concentrations in streams frequently were two to 10 times greater than regional nutrient criteria recommended by the EPA to protect aquatic life. A 2009 study found that the highest levels of stream eutrophication occurred in the heavily cultivated Corn Belt and Great Plains regions, where 100% of the streams sampled contained nutrient levels above their reference state (Dodds et al. 2009).

In collaboration with states, territories and tribes, the EPA also identifies waters that are impaired or in danger of becoming impaired (threatened). These waterways are reported under Section 303(d) of the Clean Water Act and include areas that do not meet water quality standards established by their state. For each body of water on the list, the state identifies the pollutant causing the impairment. The data show that a number of 303(d) waterways are indeed impaired due to nutrient pollution and that many occur in heavily cultivated areas. Appendix Figures 5-1 to 5-6 provide mapped examples of select nutrient-impaired waterways specifically located in areas with high levels of recent conversion of land to corn and soy production and often in close proximity to ethanol refineries.

At the mouth of the Mississippi River Basin, a major regional hypoxic zone forms seasonally in the northern Gulf of Mexico. The Gulf Hypoxic zone, or ‘dead zone,’ is caused by the interaction of environmental conditions, water stratification, and excess nutrient pollution from the Mississippi River system (U.S. EPA 2017b). It is the largest dead zone in U.S. coastal waters and one of the largest globally (Diaz and Rosenberg 2008). Despite multi-organizational efforts to reduce the Gulf hypoxic zone, the 2017 dead zone was the largest ever recorded due to high delivery of nutrients from the Mississippi River (National Oceanic and Atmospheric Administration 2017).

Exposure to hypoxia can cause severe health problems for aquatic life including reduced growth and reproduction. Under hypoxic conditions, most fish and mammals are unable to survive and must leave the region. Less mobile animals like young fish, seafloor dwellers, and mussels or crabs frequently die (U.S. EPA 2017b). The loss of oxygen can also destroy fish habitat, decrease reproductive fitness, and reduce the size or value of commercially important species like shrimp and crab (U.S. EPA 2017b; National Oceanic and Atmospheric Administration 2017).

Corn and soybean cultivation is the source of the greatest contribution of nitrogen loading to the Gulf of Mexico, and provides approximately half the total loading (Alexander et al. 2008; Mississippi River/Gulf of Mexico Watershed Nutrient Task Force 2015). Donner and Kucharik (2008) estimated that the increase in corn ethanol production specifically related to RFS2 would increase the annual average flux of dissolved inorganic nitrogen exported by the Mississippi and Atchafalaya Rivers to the Gulf of Mexico by 10–34% (Donner and Kucharik 2008). Hendricks et al. (2014) used observed increases in crop prices (e.g. see section 4) to estimate the specific role of increased continuous corn (i.e. intensification) in Iowa, Illinois, and Indiana alone. They calculated that for each additional billion gallons of corn ethanol produced under the RFS, the size of the Gulf of Mexico hypoxic zone would grow by approximately 33 square miles.

Nutrient pollution and hypoxia from agricultural production and expansion also brings about economic consequences. Conservatively, the estimated costs of the economic impacts of U.S. freshwater eutrophication is approximately $2.2 billion per year (Dodds et al. 2009). These losses result from lakefront property value decline ($0.3 – 2.8 billion per year), recreational use loss ($0.37 – 1.16 billion per year), recovery of threatened and endangered species ($44 million), and drinking water treatment and purchase ($813 million). Recent research has also demonstrated a causal effect of hypoxia on shrimp markets, showing for the first time statistically significant economic consequences of nutrient pollution in the Gulf region (Smith et al. 2017).

Working to mitigate nutrient pollution once it has been generated can also be costly. A study published by the National Academy of Sciences indicates that agricultural conservation investments targeted at the most cost-effective locations of mitigation to reduce nutrients exported by fields would require a combined federal, state, local and private investment of $2.7 billion per year to reduce the size of the hypoxic zone (Rabotyagov et al. 2014). Modifying the RFS to reduce crop intensification and extensification could alleviate pollution generation and the associate impacts and costs of mitigation. Alternatively, increased corn production under the RFS is likely to lead to greater costs of pollution due to control and mitigation expenses as well as lost economic revenue (U.S. EPA 2011; Committee on Economic and Environmental Impacts of Increasing Biofuels Production; National Research Council 2011).

5.2 DRINKING WATER CONTAMINATION

Both the expansion of corn area and its intensification through increased fertilizer application or continuous monoculture practices can also affect drinking water quality, particularly through nitrate contamination. When nitrogen on crop fields is not taken up by plants or immobilized in the soil, the excess can leach out and contaminate groundwater. The EPA specifically reports that increased fertilizer application associated with expanded corn production may worsen nitrate contamination of drinking wells and water supplies (U.S. EPA 2011). Nitrate contamination can cause severe health problems in humans such as reproductive and developmental effects, increased risk of certain cancers, and infant methemoglobinemia or blue baby syndrome (Bouchard et al. 1992; Ward et al. 2005; Weyer et al. 2001). To protect public health, the EPA sets a maximum nitrate-nitrogen contaminant level of 10 parts per million (ppm). Other sources, such as the National Cancer Institute, recommend a lower threshold of 5 ppm nitrate-nitrogen.

To manage increases in water nitrate contamination, municipalities and utilities in agriculturally intensive regions have frequently had to augment their treatment. For example, in Minnesota between 2008 and 2014, the number of public water supply systems that required nitrate treatment increased from six to eight and the number of people directly served by systems actively treating for nitrate rose from 15,000 to 50,000 (Minnesota Department of Health 2015). More than 60 Iowa cities and towns have battled nitrate levels over 5 ppm in their drinking water over the past five years ("Database: High Nitrate Level Incidents in Iowa | DesMoinesRegister.Com" n.d.). In certain cases, municipal water treatment plants have sued over nitrate pollution, such as when Des Moines, Iowa, sought to recover damages from counties located upstream in their agricultural watershed after spending $1.5 million in 2015 to remove nitrates from drinking water (Cullen 2016).

Private water wells are also at risk of nitrate contamination from increased production of corn and other crops. A USGS study of nitrate in private wells across the northern U.S. found approximately 5% of them exceded 10 ppm of nitrates (Warner and Arnold 2010). A number of studies throughout Minnesota revealed similar levels of nitrate contamination, from 4.6% of wells in the Central Sand Plains to 14.6% in the southeast Karst region (Minnesota Pollution Control Agency 2016). A nationwide assessment by the USGS found that in agricultural areas the 10 ppm maximum contaminant level was exceeded in more than 20 percent of shallow domestic wells (those less than 100 feet below the water table).

Keeler and Polasky (2014) modeled the specific impact of grassland converted to corn production in southeastern Minnesota. They found that the land conversion from 2007 to 2012 was expected to increase the number of private wells exceeding the 10ppm threshold by 45% (from 888 to 1292 wells)(Keeler and Polasky 2014). Costs per contaminated private well were estimated to range from $1,790 to $16,725, with total costs estimated at $1.4 million to $4.8 million to treat all wells that exceeded 10 ppm due to land use change in the 11 county study region. Economic costs associated with groundwater nitrate contamination include remediation actions to replace contaminated wells, installation of filtration or treatment systems, or purchase of bottled water.

More broadly, a recent study by researchers at the EPA and elsewhere has shown that increased corn production between 2002 and 2022 is projected to cause the total nationwide area vulnerable to groundwater nitrate levels above 5ppm to increase by 56% to 79%, depending on the scenario of biofuel production and demand (Garcia et al. 2017). Looking at nationwide expenses, a study by the USDA Economic Research Service estimated that the cost to all public and private sources of removing nitrate from drinking water is over $4.8 billion per year, with the share specifically attributed to agriculture costing about $1.7 billion (Ribaudo et al. 2011). Given the role of the RFS in land use change and its impacts on groundwater quality, it is likely that the RFS has exacerbated existing nitrate contamination of drinking water, a conclusion supported by previous EPA reviews (U.S. EPA 2011).

Other chemicals, including pesticides, may also impair water quality. Studies of surface waters in agricultural regions have found complex mixtures of pesticides in wetlands and in the tissues of frogs living there (Smalling et al. 2015). While pesticides are widespread in surface waters across agriculturally intense regions, a 2017 study reported for the first time the presence of three neonicoinoid insecticides in finished drinking water and their persistence during conventional water treatment (Klarich et al. 2017). Given the prevelence of agriculturally generated contamination and new findings surrounding potential exposure risks, an updated review of the non-nutrient water quality impacts associated with expanded biofuel feedstock production may be warranted.

5.3 WATER USE

The RFS influences water use and availability via consumption during the biofuel production process at refineries as well as through the growth of corn and other feedstocks.

Corn ethanol production facilities use approximately 2.5 – 3 gallons of water per gallon of ethanol produced (Hoekman, Broch, and Liu 2017, 1). For a typical corn ethanol refinery with production capacity of 100 million gallons per year, this is estimated to consume as much water as a community of 5000 people (Hoekman, Broch, and Liu 2017; Service 2009). While these requirements are modest, they could strain water resources if located in a region of limited supply, such as the semi-arid Great Plains.

The water requirements of corn feedstock production are highly dependent upon location and whether the crop is irrigated or rainfed. On average, the current water use intensity of corn ethanol production is over 100 gallons of water per gallon of corn ethanol produced on a volume-weighted basis, which greatly exceeds the 5 gal/gal efficiency of gasoline (Hoekman, Broch, and Liu 2017). As of 2009, approximately 70% of the corn used to produce ethanol was estimated to be from regions with water requirements of 10-17 gal/gal. However, 19% of the corn was estimated to be grown in regions high in irrigation and water use, resulting in ethanol water intensities of over 300 gal/gal. Many studies confirm the substantial water footprint of corn production, leading ethanol to have a significantly higher per-volume (and per-mile) water intensity than other fuels (Committee on Economic and Environmental Impacts of Increasing Biofuels Production; National Research Council 2011; Hoekman, Broch, and Liu 2017). When paired with models of corn demand under the RFS, these studies predict substantial nationwide water consumption. For example, Cai et al (2013) estimate a 1.95 – 2.81 trillion gallon increase in national water consumption between 2005 and 2022 attributable to clean vehicle deployment, with 65% to 80% of this due to increased corn ethanol use.

Geographically, these water use impacts are expected to have greatest influence in locations of intensive corn production, especially where it is irrigated. Thus, water consumption for corn-based ethanol production is expected to be greatest in areas like Nebraska and Kansas, where upwards of half of all corn production is irrigated and ethanol refineries exert additional water stresses (Brown and Pervez 2014).

5.4 GREENHOUSE GAS EMISSIONS

Increased biofuel production, corn cultivation, and associated land use changes also affect greenhouse gas emissions. The study of the net GHG benefits of biofuel production and the RFS has been a key focus of many environmental assessments, including the EPA's Regulatory Impact Analysis (U.S. EPA 2010). These studies have investigated the full life cycle emissions of biofuels from "cradle to grave" or "well to wheels," and include evaluation of the impacts of feedstock cultivation, fuel production, distribution, and combustion. Some assessments have also included estimates of emissions from land use change, which are typically modeled using the economic effects of changes in biofuel and crop supply and demand.

Land use changes such as converting non-agricultural land to crop production typically involve clearing of standing vegetation and biomass as well as perturbation of the soil, which generates a net release of GHGs (Hoekman and Broch 2017). The carbon stored in vegetation is either released when above- and below-ground biomass is burned or decomposes, or released later if the vegetation is transformed into a product (e.g. fuel or furniture). Perturbation of the soil through plowing or cultivation generally increases microbial respiration and oxidation of stored carbon and results in a net release of GHGs to the atmosphere, except in rare cases where the previous land use caused soil organic matter to be substantially degraded, in which case conversion to cropland and its associated inputs can occasionally improve sequestration (Post and Kwon 2000; Lal and Bruce 1999). In general, conversion to crop production from grasslands — the most common source of new croplands — has been estimated to release between 68 and 134 Mg CO_2 per hectare (Fargione et al. 2008; Gelfand et al. 2011).

Given the emissions associated with conversion to crop production, total GHG emissions from domestic land use change following passage of the RFS are likely to be sizeable. For example, the emissions from the conversion of noncropland to corn and soy cultivation between 2008 and 2012 are estimated to range from 94 to 186 Tg CO_2e and may be closest to 131 Tg CO_2e, which is equivalent to a year's worth of CO_2 release from 34 coal-fired power plants or an additional 28 million cars on the road (Lark, Salmon, and Gibbs 2015). However, only part of this crop expansion may be directly attributable to the RFS, and substantial uncertainty exists in the magnitude of both land conversion and associated emissions. A rough estimate of the land-use associated emissions due to the RFS could be generated by applying the same emissions factors used above to the amount of estimated land conversion calculated in section 4.1. For example, the estimated two million acres of domestic land conversion attributable to the RFS would suggest 56 – 111 Tg CO_2e of associated emissions.

5.5 BIODIVERSITY AND HABITAT

The conversion of nonagricultural land to cropland to grow biofuel feedstocks often reduces biodiversity by simplifying the landscape and reducing the number of species it supports (Meehan, Hurlbert, and Gratton 2010; Fletcher et al. 2011). Grasslands were the most common land cover converted to crop production after implementation of the RFS, accounting for approximately 80% of the conversion across the U.S. from 2008 to 2012 (Lark, Salmon, and Gibbs 2015). Grasslands provide a number of benefits to society, including recreational use, forage for livestock, and water quality improvement services (Keeler et al. 2012; Blair, Nippert, and Briggs 2014; Glaser 2014). Their ability to mitigate floods and sequester carbon also make grasslands a key landscape element for combating climate change.

With respect to habitat quality, grasslands have higher carrying capacities for species and harbor significantly greater plant, microbial, and animal diversity than croplands (Werling et al. 2014). They also generate higher levels of nearly all vital agricultural ecosystem services, including pollination and pest suppression. Thus, people who farm close to those who are actively converting grassland to crop production could experience a reduction in agricultural productivity due to the loss of surrounding grasslands and their associated ecosystem services.

Types of grasslands recently converted to biofuel feedstock crops include areas that were actively managed and grazed, land enrolled in the Conservation Reserve Program, and unmanaged prairie and range. According to the USDA National Resources Conservation Service Inventory, approximately 50% of all land converted to cropland from 2007 to 2012 came from acreage enrolled in the Conservation Reserve Program (USDA 2015). Their analysis showed that the remaining land came primarily from areas previously used for pasture (41%, including both permanent and rotational pasture) and rangeland (4%). Other analyses, including one by the Renewable Fuels Association, also assert that a significant portion of the land converted for biofuel production after implementation of the RFS came from reductions in CRP land and pastureland (Cooper 2017).

While CRP land is eligible for renewable feedstock production under the EISA definitions, research has shown that the loss of CRP is directly tied to negative environmental outcomes. Impacts of CRP conversion include decreased pheasant population and recreational opportunities (Sullivan et al. 2004; Haroldson et al. 2006; ERRINGTON and GEWERTZ 2015), decreased bird diversity and prevalence (Fletcher et al. 2011; Ryan, Burger, and Kurzejeski 1998), and increased water pollution with risk of nitrogen contamination (Randall et al. 1997; Feather, Hellerstein, and Hansen 1999; Secchi et al. 2009).

Native grasslands and prairie, that is, locations that have never been cultivated, have also specifically been identified as having been converted to cropland in recent years (Wimberly et al. 2017; Lark 2017). Native grasslands are of especially high conservation value due to the rich mix of plant species and millenia of sequestered carbon stored in their soils. Furthermore, native grasslands provide habitat that is superior to restored or planted grasslands (Bakker and Higgins 2009) and supply critical food and nesting resources for grassland dependent wildlife like the Monarch butterfly and wild bees

(Moranz et al. 2012; Kwaiser and Hendrix 2008; Pleasants 2016). Given EISA and EPA's 2010 rulemaking on implementation, native grasslands should specifically qualify as nonagricultural lands and thus be ineligible for renewable feedstock production. However, the absence of a feedstock mapping and tracking system for enforcing EISA's land protections means that converted native locations can currently be used for renewable feedstock production without restriction, thus enabling the RFS to contribute to ongoing prairie loss.

Furthermore, the rate of grassland conversion to crop production has been shown to be significantly higher in close proximity to ethanol production refineries (Wright et al. 2017). This rate of conversion decreases linearly as the distance to refineries increases (Appendix Figure 5-7). In addition, the likelihood of cropland being restored or reverting into grassland decreases with proximity to ethanol refineries. Shrublands, forests, and wetland ecosystems have also been converted to crop production following passage of the RFS, and similar proximity effects are seen with these ecosystems — the closer they are to an ethanol refinery, the more likely they are to have been converted to cropland (Appendix Figure 5-8). All of these ecosystem types provide valuable habitat and typically improve biodiversity when located within agriculturally intense landscapes. Thus, their increased conversion to cropland is likely to lead to negative environmental outcomes for wildlife.

5.6 ENDANGERED SPECIES

The conversion of land for increased biofuel feedstock production may affect endangered and threatened species and the federally designated critical habitat upon which they rely. Section 7 of the Endangered Species Act (ESA) requires federal agencies to consult with the Fish and Wildlife Service or the National Marine Fisheries Service to ensure that the agency's actions are not likely to jeopardize the existence of any endangered or threatened species, or result in the destruction or adverse modification of critical habitat. Currently, there is no documentation of an endangered species consultation between the EPA and the relevant wildlife agencies nor evidence of other precautionary steps required under the ESA.

There is also a dearth of research in the scientific community to determine whether the RFS is likely to adversely affect listed species or their critical habitat. The land conversion and environmental impacts summarized in this report, however, imply a potential impact and thus advocate further review and consultation between EPA and the federal wildlife agencies.

To help species survive and recover, the ESA designates areas of critical habitat that are essential for reproduction, population stability, or distribution. Destruction or adverse modification of critical habitat could occur either through direct conversion of critical habitat or indirectly through conversion of nearby land. For example, conversion of land adjacent to critical habitat could decrease its functionality through landscape fragmentation, microclimate modification, encroachment, or other proximity effects, and thereby alter the physical or biological features that were the basis for critical habitat designation. Such alteration would qualify as adverse modification. Thus, any critical habitat located in agriculturally active areas may be affected by the RFS due to the expansion of corn production and the associated loss of grasslands and other ecosystems.

Critical habitat in locations of both substantial land conversion and close proximity to an ethanol refinery is likely at greatest risk, and should represent top priority areas for initial evaluation. Based on the location of recent land conversion, feedstock crop production, and ethanol refinery locations, possible species and locations of critical habitat at risk of impairment include the Piping Plover in North Dakota, the Whooping Crane in Kansas, and the Dakota Skipper in Minnesota and the Dakotas.

The RFS could also negatively affect a number of freshwater and marine species. Specifically, nutrient runoff, eutrophication, and hypoxia due to increased corn production and the associated decreases in water clarity and oxygen content could jeopardize the health of threatened and endangered aquatic species. As of 2007, according to the Fish and Wildlife Endangered Species database, 139 fish, 70 mussels, four crayfish, 23 amphibians, and one water dependent dragonfly had endangered or threatened status, and it is estimated that approximately 60 of these species are at least partially imperiled by eutrophication (Dodds et al. 2009). Species within the corn belt and other agriculturally intense regions and their watersheds may be at greatest risk of impairment from increased ethanol production and associated land use changes. Based on location of critical habitat in relation to recently expanded corn production and its estimated effects, potentially endangered and threatened aquatic species for further evaluation include a minnow, the Topeka Shiner, in southwest Minnesota and northwest Iowa, and the Purple Bankclimber, Fat Threeridge, and Oval Pigtoe mussels in southwest Georgia.

The link between the RFS, increased cropping intensification, and hypoxia in the Gulf of Mexico has also been well established (Hendricks et al. 2014; Donner and Kucharik 2008) (see section 5.1). The large seasonal dead zone in the Gulf may affect the critical habitat or migration and feeding ranges of current and pending listed species. Species that could potentially be at risk include the Gulf Sturgeon, Loggerhead Turtle, and Sperm Whale.

To date, little research has been performed regarding the potential impact of the Renewable Fuels Standard on threatened and endangered species. Given this lack of knowledge as well as the potential mechanisms of influence enumerated here, further review and evaluation of the possible impacts seems warranted.

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Appendix 3 to Declaration of Dr. Tyler Lark

Appendix 3: U.S. Land conversion following passage of RFS2.

Table 3-1: Summary of data on U.S. land conversion

Data Source	Time Period	Years	Net Cropland Expansion *(Mill. Ac.)*	Ave. Annual Net Expansion *(Mill. Ac./yr.)*
Census of Agriculture[1]	2007 – 2012	5	7.8	1.56
NASS Acreage Reports[2]	2008 – 2012	4	2.6	0.65
Cropland Data Layer-derived[3]	2008 – 2012	4	3.0	0.75
National Resources Inventory[4]	2007 – 2012	5	4.3	0.86
National Land Cover Database[5]	2006 – 2011	5	0.2	0.03

Notes:

1. Data from the sum of harvested + failed + fallow cropland between 2007 and 2012. See table 3-2.
2. Data from the official NASS June Acreage Reports, published and archived at http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1000
   Total area reported is “principle crops” (which includes 10 major crops’ planted area plus harvested area of alfalfa and non-alfalfa hay) minus “non-alfalfa hay harvested area” in order to remove those areas which include mixed used grasslands and uncultivated land.
3. Data based on a time-series analysis of the USDA Cropland Data Layer by Lark et al. (2015). Crops include all row and closely planted crops, and horticultural/tree crops. Alfalfa was considered a crop. Non-alfalfa hay was considered non-crop, and thus not included in the reported area of change.
4. Data based change in cultivated cropland. The NRI cultivated cropland class comprises land in *row crops* or *close-grown crops* and also other cultivated cropland, for example, hayland or pastureland that is in a rotation with row or close-grown crops. Noncultivated cropland includes permanent *hayland* and *horticultural cropland*, and is not included in the reported area of cropland change.
5. Data based on changes to and from cultivated crops category (class 82). Alfalfa and non-alfalfa hay are not distinguished in the NLCD and are included in the pasture/hay category, and thus are not included in the reported area of cropland change.

Table 3-2: Data synthesized from the 2007 and 2012 USDA Census of Agriculture.

Category	2007 *(acres)*	2012 *(acres)*	Δ 2007 to 2012
Harvested	309,607,601	314,964,600	5,356,999
Failed	7,405,898	11,395,368	3,989,470
Fallow	15,671,507	14,145,567	-1,525,940
Idle	37,968,749	36,382,032	-1,586,717
Other Pasture*	35,771,154	12,802,847	-22,968,307

Combined Categories	Δ 2007 to 2012
Harvested + Failed	9,346,469
Harvested + Failed + Fallow	7,820,529
Harvested + Failed + Fallow + Idle	6,233,812
Harvested + Failed + Fallow + Idle + Other Pasture*	-2,680,154

Notes: The Census definition of "total cropland" includes that of other pastureland, which is defined as "other pasture and grazing land that could have been used for crops" but was not. Thus, combinations of Harvested, Failed, and Fallow land offer more specific and representative portrayals of total tilled or actively cultivated cropland area than the aggregate category of "total cropland".

Census of Agriculture Background:

The Census of Agriculture is USDA's flagship agricultural data product. Conducted by the National Agricultural Statistics Service (NASS) every 5 years, the Census provides a plethora of information about both crop and animal agriculture, the land it occupies, and overall trends in the industry ("USDA - NASS, Census of Agriculture," n.d.). It is particularly valuable for its comprehensiveness, as every farm and producer in the U.S. is included (or accounted for via correction estimates). All results are aggregated to and released at the county level, although certain county/state data points are withheld from the public record if there is a risk of respondent confidentiality being breached (for example, due to only one farmer operating in a given county). Measures from the Census that are of greatest relevance for land use and grassland conservation include total pasture and grazing land area, total cropland area and its subsets—harvested, idle, failed, and fallow cropland areas—and cropland-pasture area, which represents farmers' interpretations of locations used for grazing that could have been used for crops without additional improvement (USDA NASS, 2009). Additional information is also collected and released through supplemental census studies on special topics such as organic production and irrigation practices.

Regarding accuracy, the Census of Agriculture is often considered the “gold standard” for land use data (Johnson, 2013; Laingen, 2015). In addition to a rigorous outreach campaign in attempt to capture responses from all producers, NASS also accounts for biases from undercoverage, nonresponses, and misclassifications using a number of corrective statistics. Nonetheless, errors still exist, and these are reported at the county, state, and national level for each data point measured. Although these errors are all reported, it should be noted that some are quite large, and in many cases, the amount of change between 5-year censuses for a given metric—e.g. total cropland—in a given county is less than the standard error of that measure, meaning that the change is insignificant and thus should be considered unreliable. The margins of error are often overlooked, however, even though they can limit the utility of the Census for understanding changes to cropland and grassland area. This has led some to suggest that while the Census remains the most comprehensive and detailed set of information on US farming, it is not the end-all (“Just How Trustworthy Are Agricultural Statistics?,” 2014), and thus there may be substantial value in considering the Census in within the context of other sources.

Table 3-3: Data synthesized from USDA NASS Acreage Reports for 2008 and 2012 for principle crops, other hay, and their difference.

Year	Principal Crops *(acres)*	Other Hay* *(acres)*	Principle Crops - Other Hay *(acres)*
2008	324,029,000	39,661,000	284,368,000
2012	325,825,000	38,842,000	286,983,000
Δ 2008 to 2012	1,796,000	(819,000)	2,615,000

*Other hay excludes Alfalfa and Alfalfa mixes

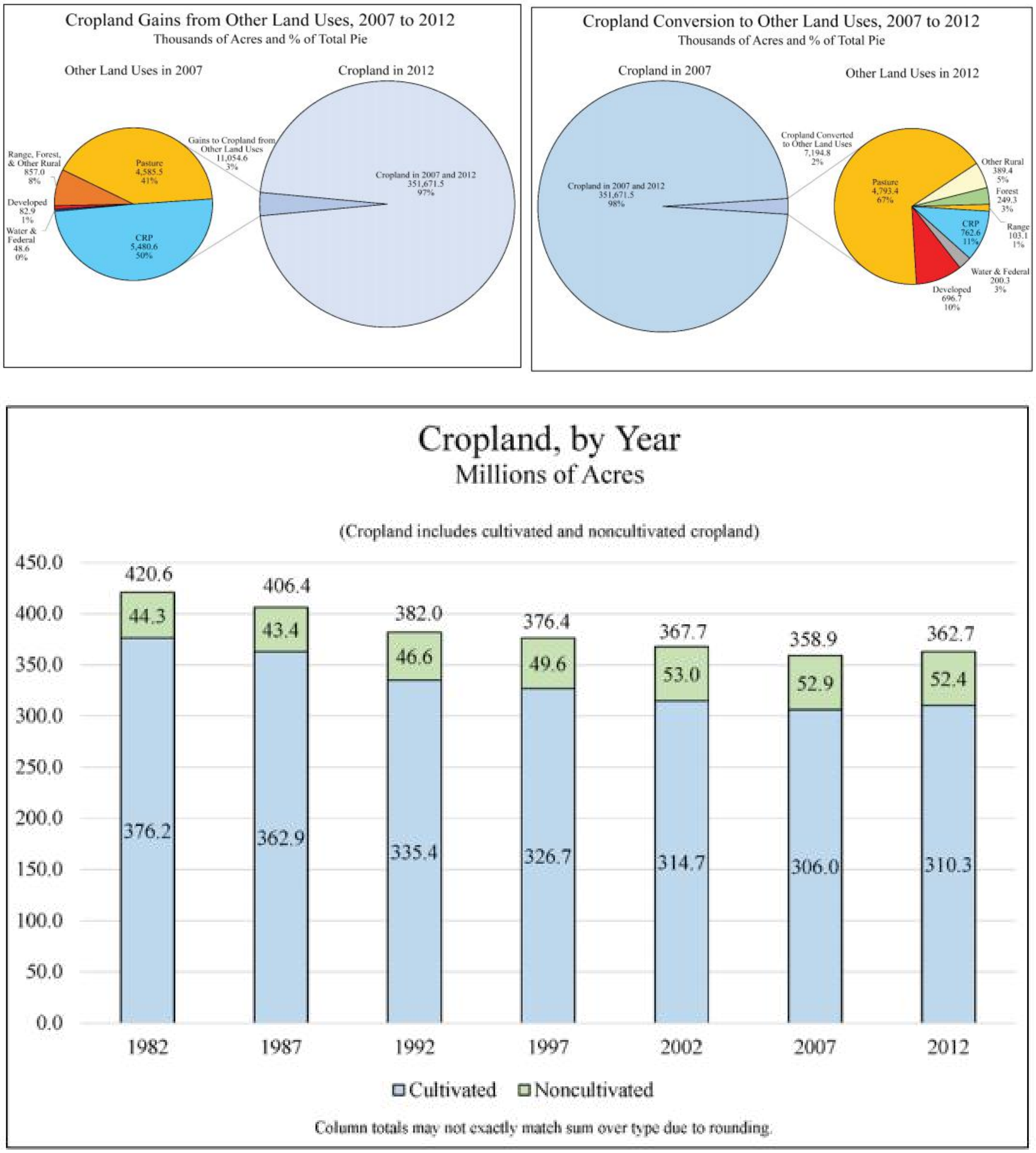
Notes: The NASS Survey and Acreage category of "Other Hay" closely corresponds to the CDL class of Non-alfalfa / Other Hay and includes harvested grasslands not typically tilled on an annual basis. The category of Principle crops includes changes in other hay. To facilitate comparison with other estimates such as those based on the CDL, the area of Other Hay can be subtracted from the total principals crops to align with the definition of cultivated cropland used by Lark et al (2015), the National Resources Inventory, and others.

<u>NASS Survey Background:</u>

The other primary source of traditional agricultural statistics comes from annual NASS surveys. NASS's Agricultural Survey data, while often referenced as a collective dataset, represent not a single source but rather a series of surveys administered to agricultural producers throughout the year as well as data collected through direct observation and measurement by NASS field agents. NASS surveys include the June Area, the Objective Yield, and Crops/Stocks (sometimes referred to as the "agricultural survey") as well as around 100 others for specific industries and products, and together provide detailed estimates of crop acreage, yields and production ("USDA - National Agricultural Statistics Service," n.d.). The results of these surveys are summarized and released individually through reports such as Prospective Plantings, June Acreage, monthly Crop Production, and January Crop Production Summary. Collected data of most relevance to cropland expansion and grassland conversion are planted area and harvested area for principle field crops. While these totals do not fully capture cropland area--missing are actively tilled fallow land and less prominent crops--they can be highly valuable due to their annual frequency of reporting.

The accuracy of survey data is subject to two main types of error--sampling and non-sampling. Sampling errors are a result of NASS enumerators talking to or collecting data from a sampling of farmers, rather than the entire population (USDA NASS, n.d.). Because most of the NASS surveys use probability sampling, however, it is possible to estimate this error, and these figures are typically published in NASS survey-derived reports as a standard error or coefficient of variation. Non-sampling errors, on the other hand, represent all of the other issues that can affect an estimate, including respondent biases, misworded questions and inaccurate responses, and missed or inaccurately transcribed data. These types of error are difficult to quantify, and as a result are often just discussed during reporting of the NASS Survey data.

Figure 3-4: Data directly from the USDA National Resources Inventory for 2007-2012 (USDA 2015).



Source: 2012 National Resources Inventory Summary Report (USDA 2015). The NRI shows an increase in both cultivated and total cropland area between 2007 and 2012.

Table 3-5: Data directly from the USDA National Resources Inventory for 2007-2012 (USDA 2015).

Table 8 - Changes in land cover/use between 2007 and 2012
In thousands of acres, with margins of error

Land cover/use in 2007	Land cover/use in 2012								2007 total
	Cropland	CRP land	Pastureland	Rangeland	Forest land	Other rural land	Developed land	Water areas & Federal land	
Cropland	351,671.5 ±1,920.5	762.6 ±110.0	4,793.4 ±326.0	103.1 ±37.0	249.3 ±83.4	389.4 ±72.2	696.7 ±47.2	200.3 --	358,866.3 ±2,009.3
CRP land	5,480.6 ±289.8	23,277.1 ±344.1	3,097.8 ±330.9	249.7 ±55.8	319.2 ±58.9	26.5 ±18.8	11.8 ±15.0	1.3 --	32,464.0 --
Pastureland	4,585.5 ±330.3	180.6 ±77.4	112,059.9 ±1,390.8	142.6 ±50.0	1,858.8 ±221.6	272.0 ±61.6	561.5 ±56.8	83.2 --	119,744.1 ±1,468.5
Rangeland	485.8 ±180.5	1.7 ±2.6	199.5 ±142.7	404,854.9 ±3,427.9	390.7 ±147.1	452.6 ±182.6	554.5 ±63.3	291.2 --	407,230.9 ±3,447.5
Forest land	257.9 ±123.7	0.0 --	562.5 ±100.1	122.5 ±55.8	410,027.8 ±2,551.9	333.7 ±80.2	1,406.7 ±69.3	412.3 --	413,123.4 ±2,541.0
Other rural land	113.3 ±52.1	0.0 --	344.5 ±63.8	168.0 ±89.9	215.4 ±89.7	43,950.0 ±1,340.2	137.3 ±18.6	6.1 --	44,934.6 ±1,377.5
Developed land	82.9 ±12.5	0.0 --	48.0 ±10.1	22.0 ±12.5	161.7 ±11.4	22.6 ±8.6	110,738.6 ±1,240.0	5.0 --	111,080.8 ±1,238.1
Water areas & Federal land	48.6 --	0.0 --	32.4 --	114.1 --	114.3 --	1.7 --	5.4 --	456,382.0 --	456,698.5 --
2012 total	362,726.1 ±1,933.0	24,222.0 --	121,138.0 ±1,334.2	405,776.9 ±3,419.6	413,337.2 ±2,593.2	45,448.5 ±1,343.0	114,112.5 ±1,271.6	457,381.4 --	1,944,142.6 ±195.1
Net Change	3,859.8 ±670.3	-8,242.0 ±359.1	1,393.9 ±587.4	-1,454.0 ±394.1	213.8 ±403.6	513.9 ±304.0	3,031.7 ±133.4	682.9 ±31.7	0.0 --

Notes:
- Acreages for total Conservation Reserve Program (CRP) Land and Water areas and Federal land are established through geospatial processes and administrative records; therefore, statistical margins of error are not applicable and shown as a dashed line (--). CRP was not implemented until 1985.
- Cropland includes cultivated and non-cultivated cropland.
- When the estimate is 0.0, margins of error are not applicable and shown as a dashed line (--).
- Estimates in red = STOP, these estimates are not reliable. The margin of error is equal to or greater than the estimate so the confidence interval includes zero.

- 2007 land cover/use totals are listed in the right hand vertical column, titled 2007 total. 2012 land cover/use totals are listed in the bottom horizontal row, titled 2012 total. The number at the intersection of rows and columns with the same land cover/use designation represents acres that did not change from 2007 to 2012. Reading to the right or left of this number are the acres that were lost to another cover/use by 2012. Reading up or down from this number are the acres that were gained from another cover/use by 2012.

<u>NRCS National Resources Inventory Background:</u>

The Natural Resources Conservation Service's (NRCS) National Resources Inventory (NRI) is a statistically sampled land use dataset that surveys the country's non-federal lands, soils, and water-related resources (U.S. Department of Agriculture, 2013). The NRI currently provides a nationally consistent dataset spanning 30 years, with the latest 5-year update having been completed in 2012 and release last year (USDA, 2015), although the collection's history dates back to the original Soil Conservation Service's inventories of the 1930s and 40s. Rather than a comprehensive census of land, the NRI estimates state- and national-level trends based on statistical estimation from point observations. By tracking the same points on the landscape over time, however, it provides a valuable longitudinal view of the changing U.S. landscape.

The dataset was originally produced using field observation collected by staff, however more recent implementations mostly utilize aerial photo interpretation with some local verification via NRCS county field office records (USDA, 2015).   Being based on a statistical sampling, the NRI has calculable margins of error, which are published with each rendition of the report. For relevant metrics such as stable cropland (351.7 M acres total), the margin of error is +-1.9 M Acres. As with other datasets, the margin of error for dynamic (change) classes are much wider. For example, cropland expansion 2007-2012 was measured to be 11 M Acres +-1.9 M Acres (~17% margin of error).

With respect to cropland expansion and grassland conservation, the dataset provides valuable independent data on the transformation of land between cultivated cropland, pastureland, and land enrolled in the Conservation Reserve Program (CRP). Because of this, it can be a useful dataset to calibrate land change models (Radeloff et al., 2011) or confirm changes identified through other means, such as analysis of the CDL. The drawbacks of the NRI include its lack of comprehensive spatial coverage (due to it being a point sampling) and lack of publicly available estimates at resolutions finer than the state level.

Table 3-6: Conversion data synthesized from the National Land Cover Database

Time period	Converted to Cropland *(acres)*	Converted away from cropland *(acres)*	Net cropland change *(acres)*
2006 – 2011	1,548,000	1,376,000	172,000

<u>National Land Cover Database (NLCD) Background:</u>

The National Land Cover Database is a U.S. nationwide land cover product produced by the Multi-Resolution Land Consortium, under the leadership of the US Geological Survery (USGS). Other partnering agencies include the EPA, NOAA, USFS, BLM, NASS, NPS, NASA, USFWS, and US Army Corps—mostly through the contribution of supplementary data or advisement on potential uses of the end product. The NLCD is produced consistently at 30-meter resolution, and maps land cover using 16 Anderson level II classifications (Homer et al., 2012). The NLCD is now produced on a 5-year cycle, with the most recent product available for the year 2011 (Homer et al., 2015). Previous years available include 2006, 2001, and 1992.

A unique aspect of the NLCD (particularly compared to the CDL) is its focus on land cover change (Jin et al., 2013). Thus, with recent product releases, the USGS has also included data layers of land cover change (e.g. 2006-2011). To achieve this, the NLCD implements a “linked” approach to mapping landcover, where each new product is dependent on the previous products’ classification. The spectral changes from baseline are then measured and interpreted to generate the more recent year’s classification. A benefit of this approach is that it is more suited to detecting changes and avoids many of the false positives and issues that annually-independent classifications often run into (Kline et al., 2013; Laingen, 2015; Reitsma et al., 2015; Wright and Wimberly, 2013). A drawback of the linked approach, however, is that errors can propagate throughout the time series, and even if these are identified by the producers or users, correction of problematic areas on the landscape require reclassification and reproduction of the entire time series (Danielson et al., 2016; Jin et al., 2013; Wickham et al., 2013).

The primary input of the NLCD is Landsat 5 Thematic Mapper satellite imagery, with ancillary data coming from the National Elevation Dataset (NED), USDA Natural Resources Conservation Service Soil Survey Geographic (SSURGO) database, National Wetlands Inventory (NWI), the CDL, and nighttime stable-light satellite imagery (NSLS) from the NOAA Defense Meteorological Satellite Program (DMSP) (Homer et al., 2015). Of particular note for dataset interdependence, the 2011 CDL was also used during post-classification to help in refinement of agricultural areas.

Accuracies for the static classes of the NLCD are generally high, with accuracies of the change product much lower (as is normal for landcover change products). Agricultural loss and gain between 2001 and 2006, for example, had users accuracies of just 39% and 27%, respectively, while the static agriculture class performed at a much higher 91% (Wickham et al., 2013). Compared to the CDL, the NLCD is generally considered less accurate in agricultural areas, but more accurate for non-agricultural classes (Johnson, 2013). Thus, the NLCD is used as a training input for CDL's non-ag locations, while the CDL is used as input to refine the NLCD's agricultural regions.

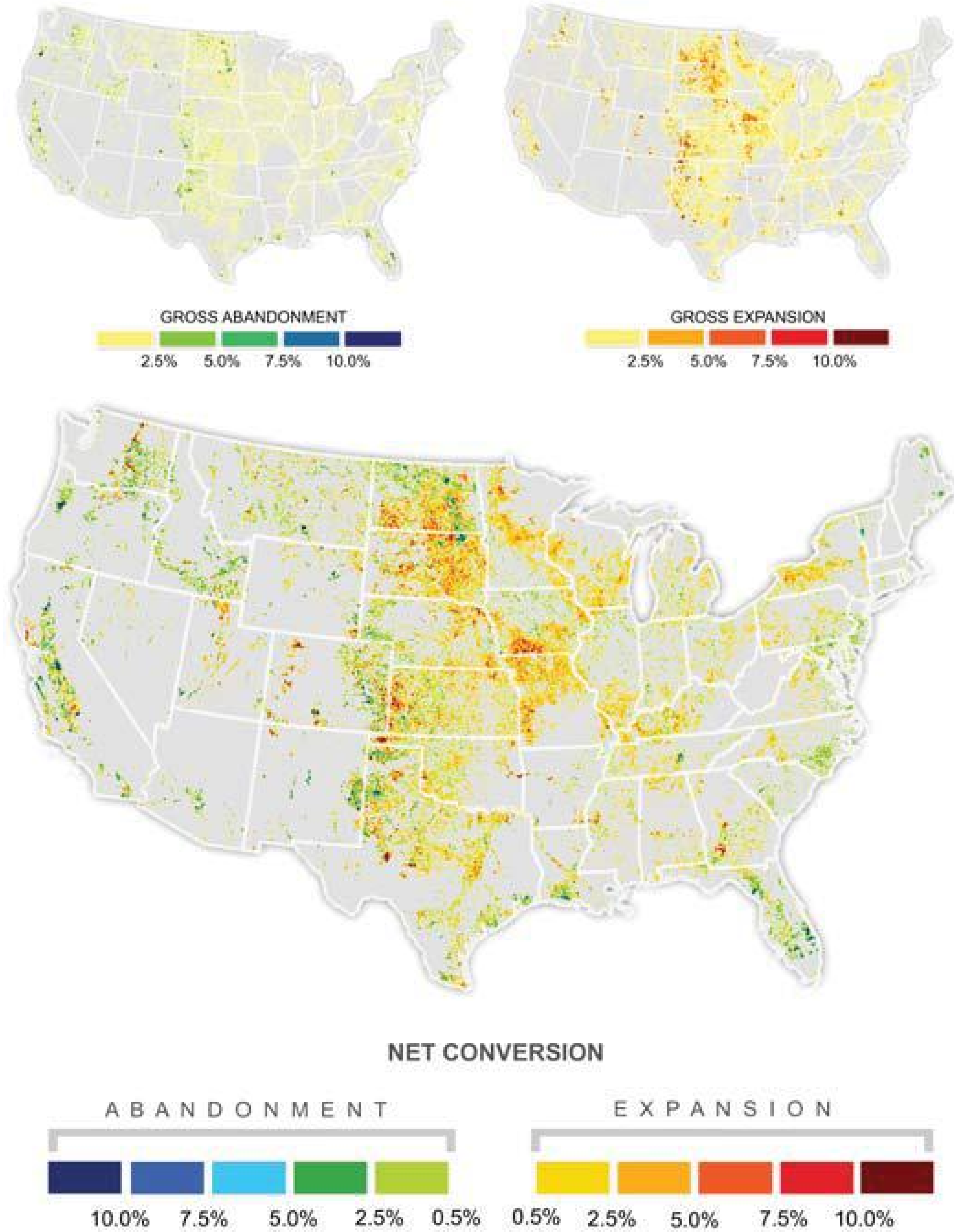


Figure 3-7: Maps of net and gross cropland conversion across the U.S. 2008-2012. The heterogeneous nature of cropland use and change can be masked by net and/or aggregate measures of total cropland area. Source: Lark et al (2015)

Appendix 4 to Declaration of Dr. Tyler Lark

Appendix 4: RFS contribution to change

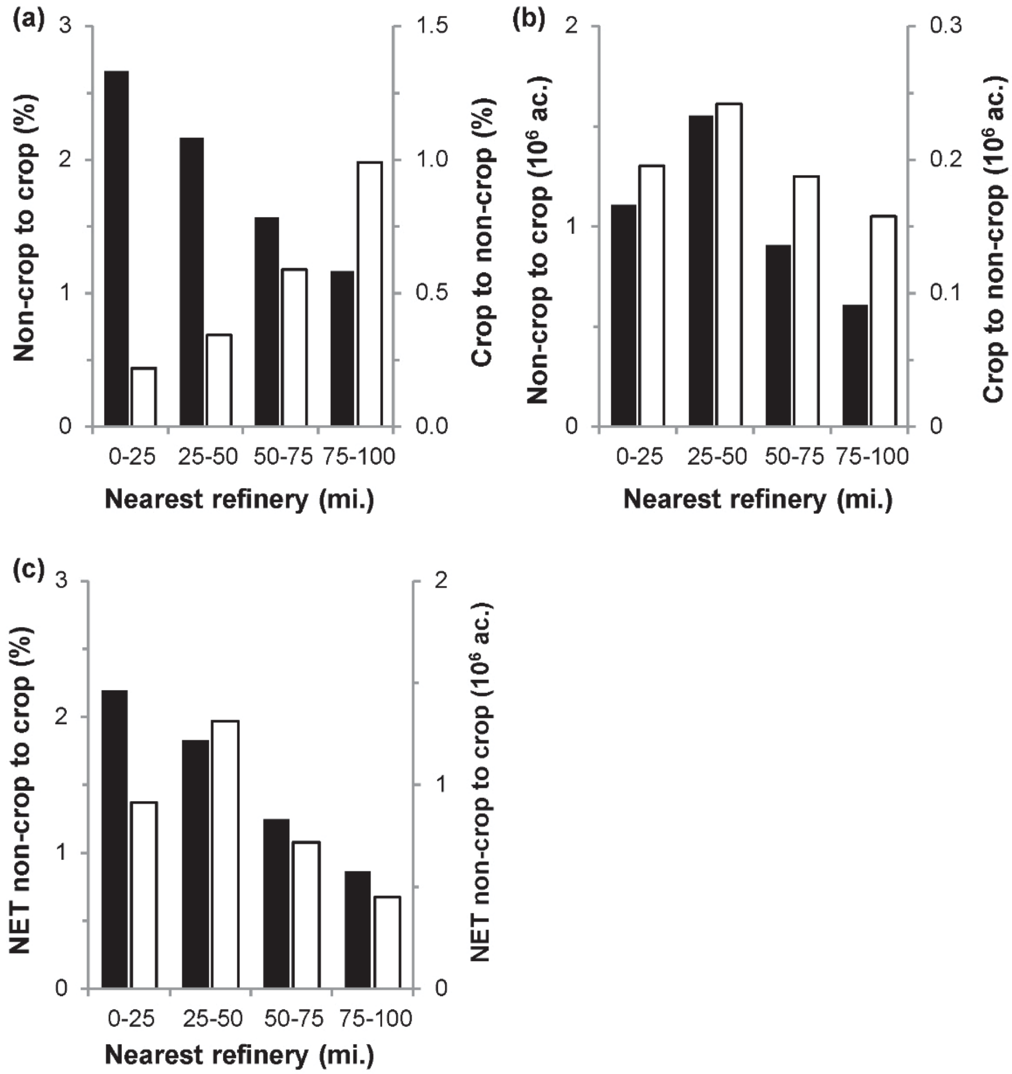


Figure 4-1: Data on location of land conversion in proximity to ethanol refineries, from Wright et al (2017). "Aggregate rates of change between arable non-cropland and cropland (2008–2012) plotted as a function of proximity to ethanol refineries. Distance intervals as in figure 1(c). (a) On the primary axis (black bars), relative conversion rates normalized by 2008 non-cropland area. On the secondary axis (white bars), relative rates of cropland reversion to non-cropland normalized by 2008 cropland area. (b) Gross conversion (primary axis, black bars) and reversion (secondary axis, white bars), both in 106 acres. (d) On the primary axis (black bars), net conversion (conversion minus reversion), normalized by 2008 non-cropland area. On secondary axis (white bars), net conversion in 106 acres." Figure and description from Wright et al. (2017).

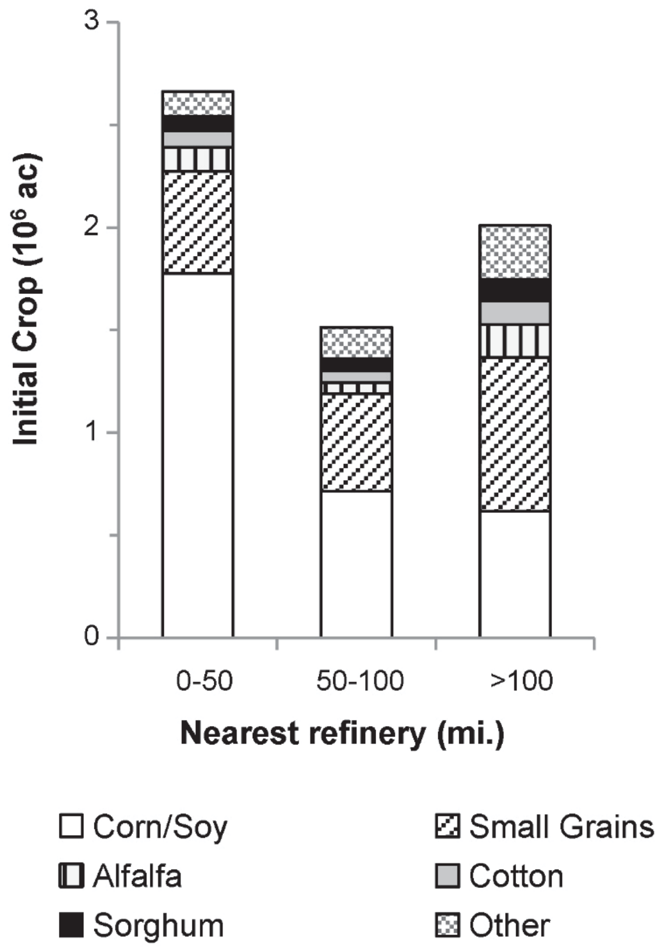


Figure 4-2: Initial crops following conversion of arable non-cropland to cropland as a function of proximity to ethanol refineries (in 10^6 acres). As the distance to the nearest ethanol refinery decreases, the frequency of corn and soy being planted on converted land increased. Figure and description from Wright et al. (2017).

Appendix 5 to Declaration of Dr. Tyler Lark

Appendix 5: Environmental Impacts

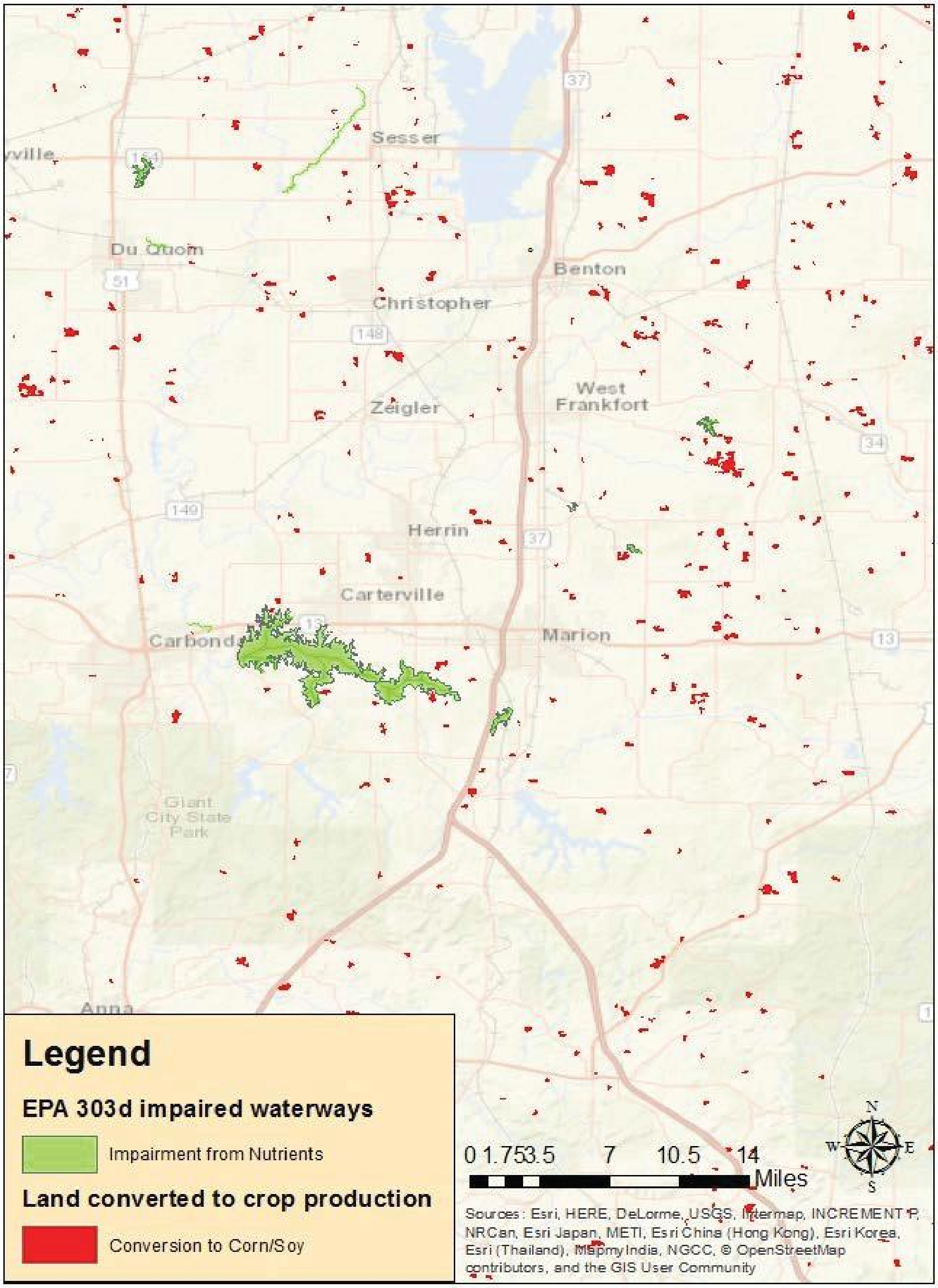
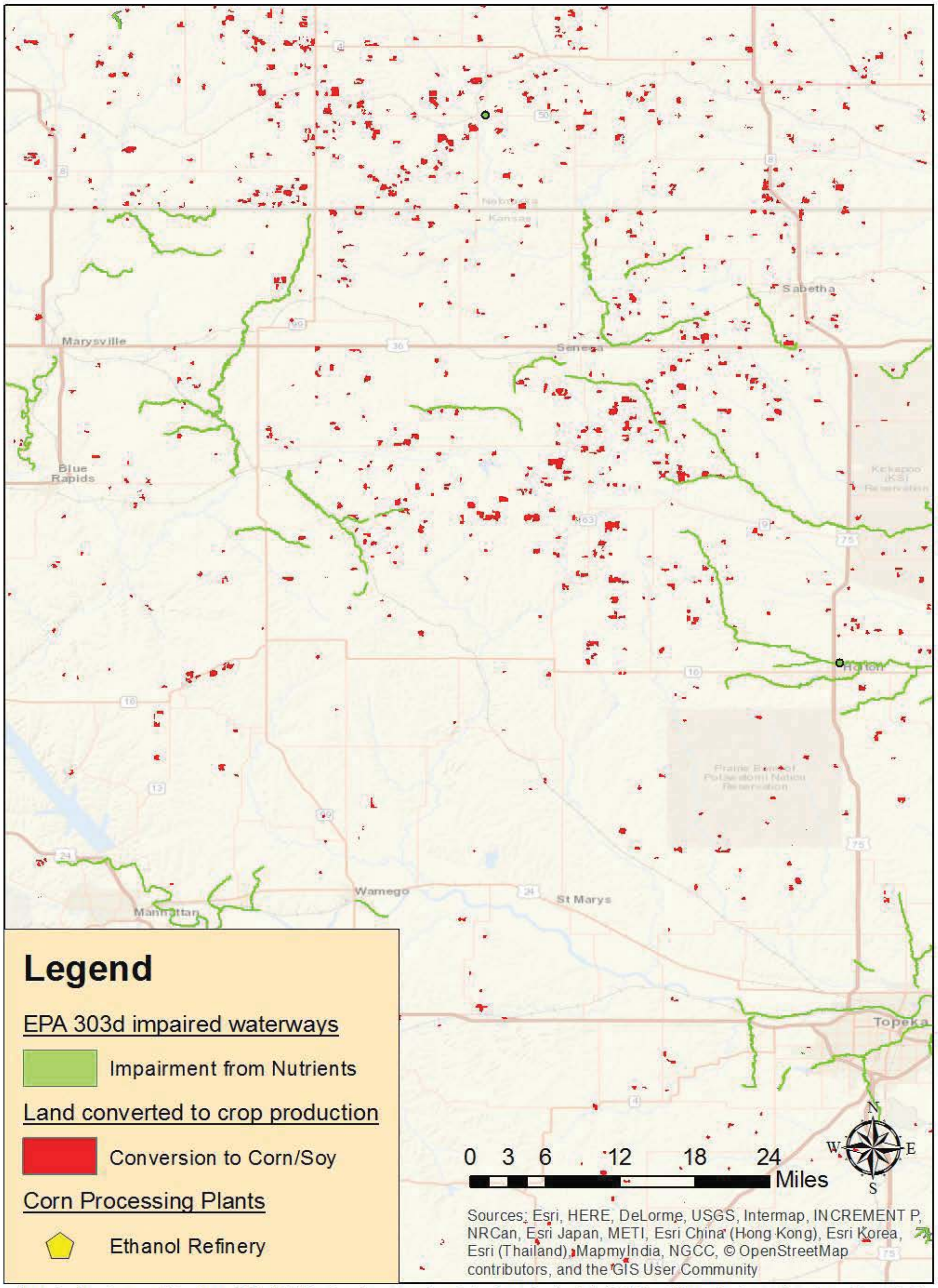
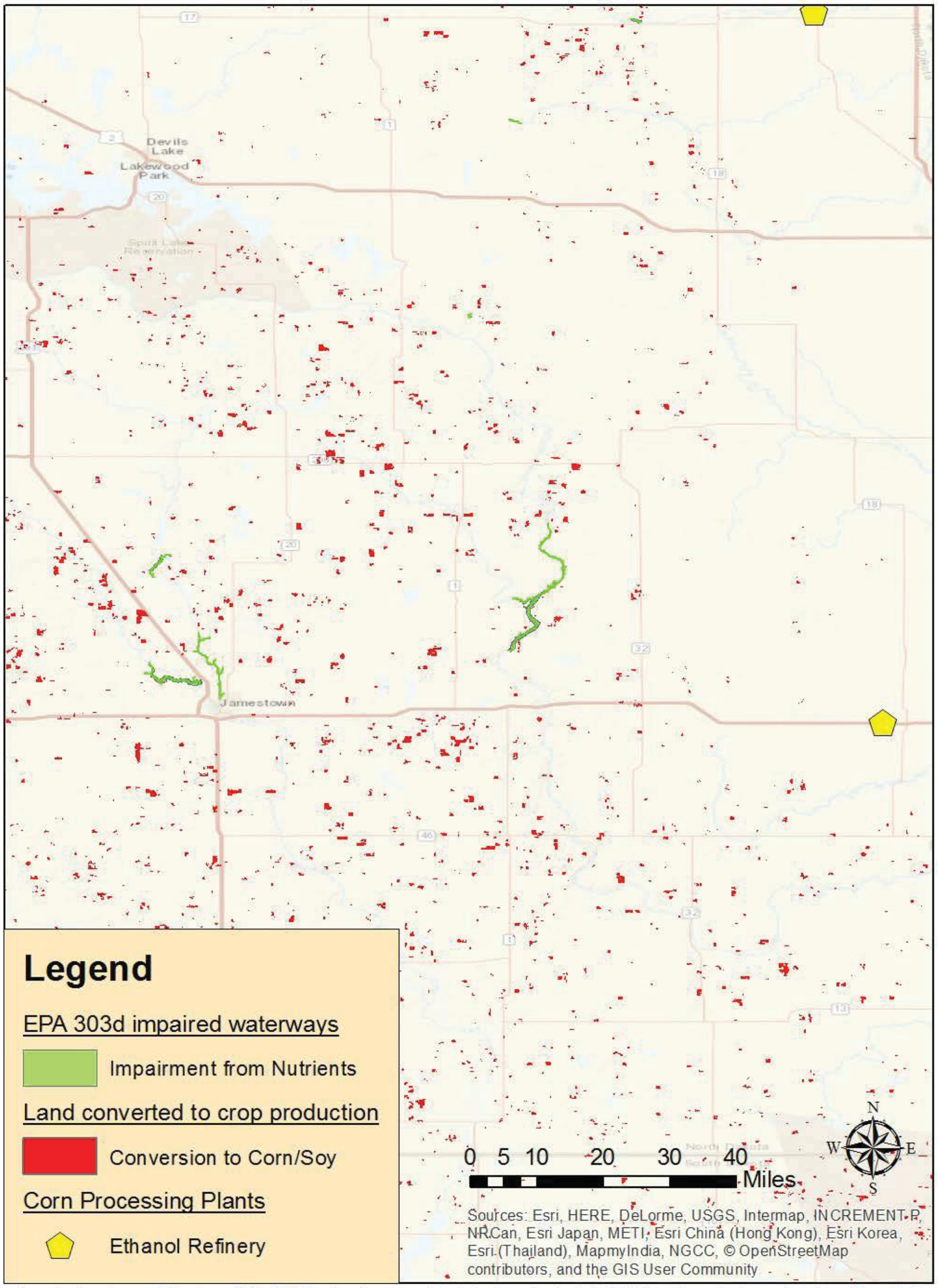


Figure 5-1: Map of 303(d) listed waterways that are impaired due to nutrient (nitrogen and phosphorus) pollution in Southern Illinois. Streams and waterbodies are highlighted in bright green; probable locations of recent conversion of non-cropland to corn or soybeans production are highlighted in red. Data from U.S. EPA and Lark et al (2015).



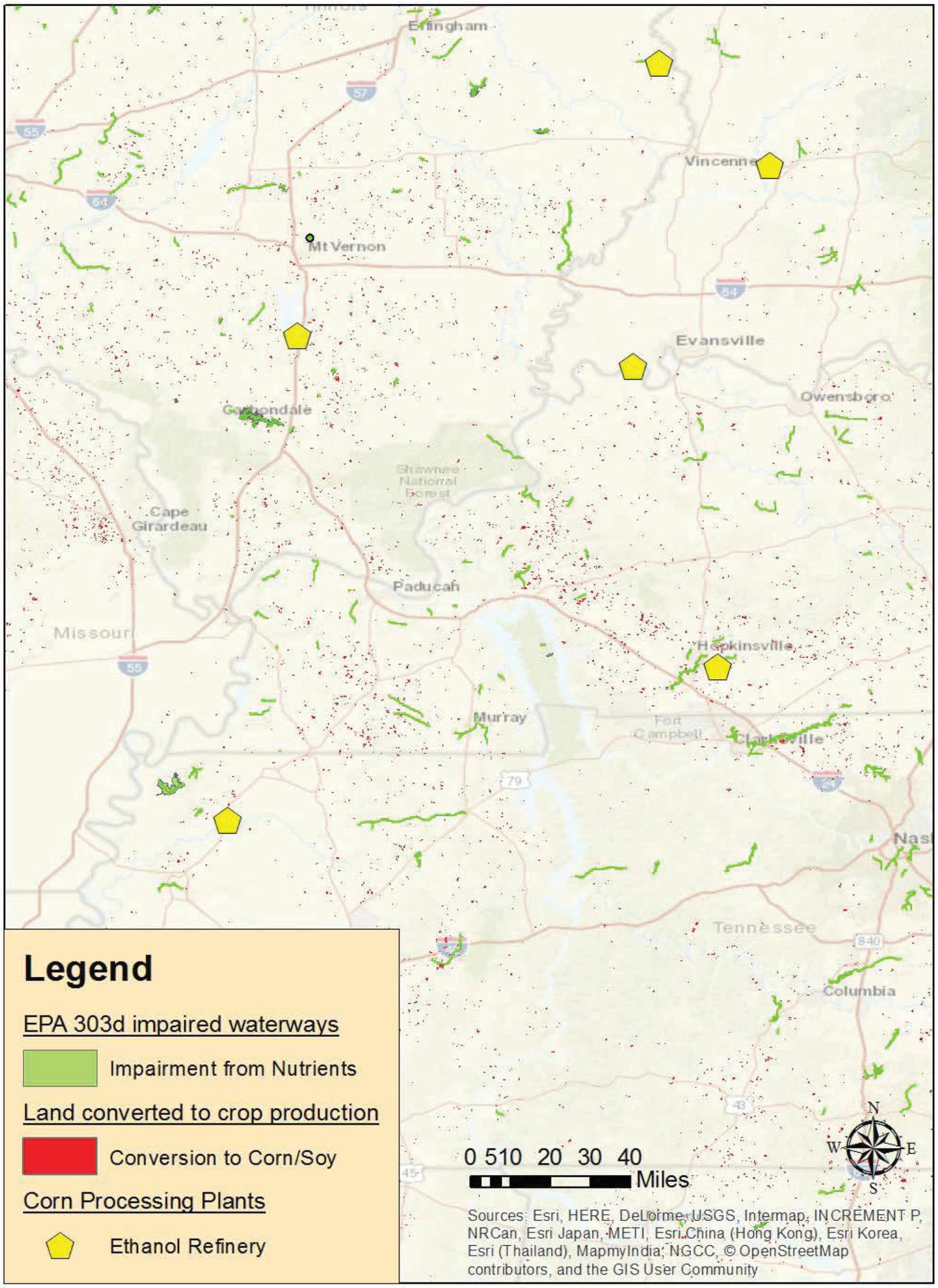
Impaired waterway data from EPA (2015). Land conversion data from Lark et al (2015). Ethanol refinery locations from Esri.

Figure 5-2: Map of 303(d) listed waterways that are impaired due to nutrient (nitrogen and phosphorus) pollution in northern Kansas. Streams and waterbodies are highlighted in bright green; probable locations of recent conversion of non-cropland to corn or soybeans production are highlighted in red. Data from U.S. EPA and Lark et al (2015).



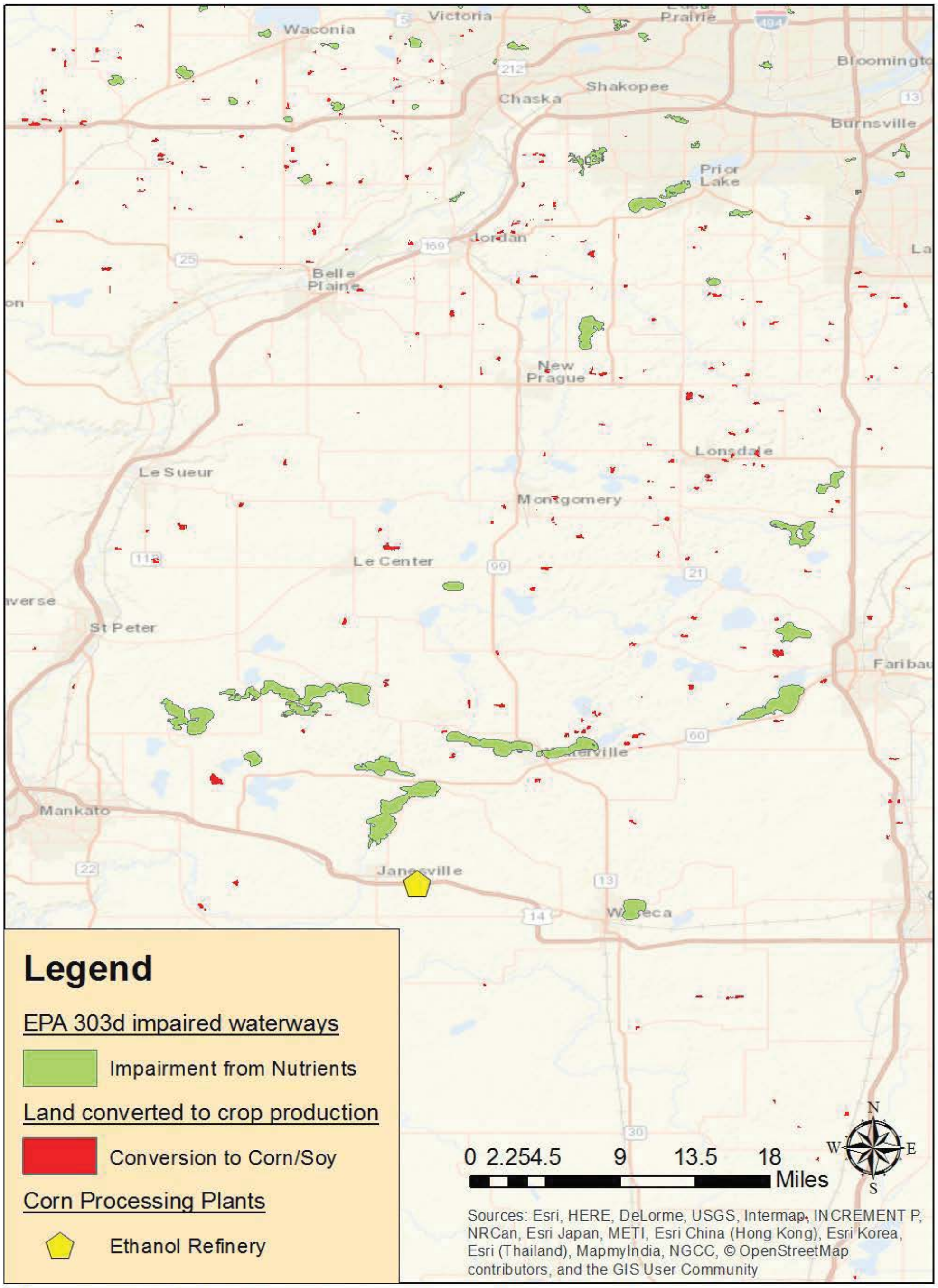
Impaired waterway data from EPA (2015). Land conversion data from Lark et al (2015). Ethanol refinery locations from Esri.

Figure 5-3: Map of 303(d) listed waterways that are impaired due to nutrient (nitrogen and phosphorus) pollution in central North Dakota. Streams and waterbodies are highlighted in bright green; probable locations of recent conversion of non-cropland to corn or soybeans production are highlighted in red. Data from U.S. EPA and Lark et al (2015).



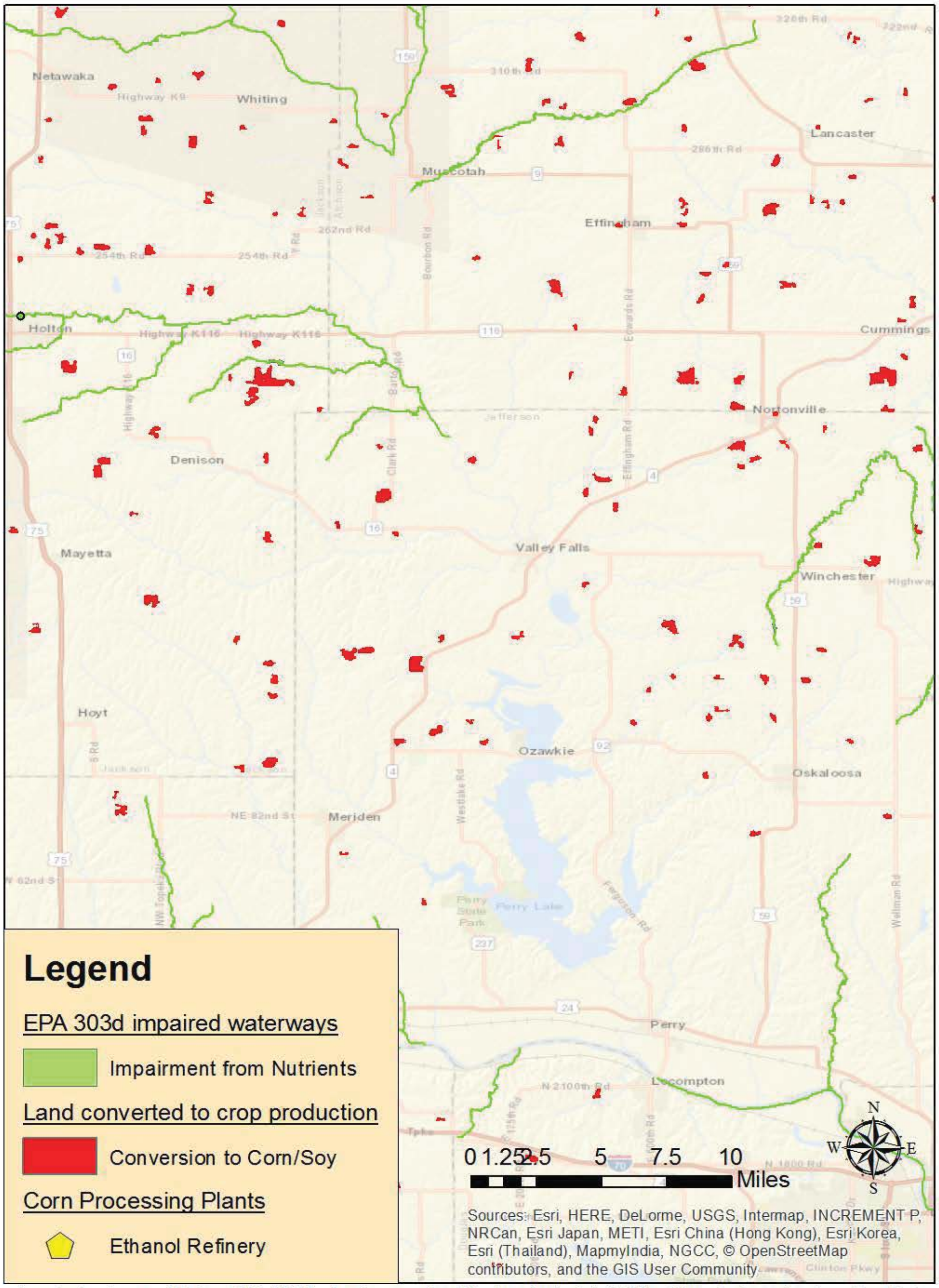
Impaired waterway data from EPA (2015). Land conversion data from Lark et al (2015). Ethanol refinery locations from Esri.

Figure 5-4: Map of 303(d) listed waterways that are impaired due to nutrient (nitrogen and phosphorus) pollution along the Illinois, Kentucky, and Tennessee borders. Streams and waterbodies are highlighted in bright green; probable locations of recent conversion of non-cropland to corn or soybeans production are highlighted in red. Data from U.S. EPA (2015) and Lark et al (2015).



Impaired waterway data from EPA (2015). Land conversion data from Lark et al (2015). Ethanol refinery locations from Esri.

Figure 5-5: Map of 303(d) listed waterways that are impaired due to nutrient (nitrogen and phosphorus) pollution in southcentral Minnesota. Streams and waterbodies are highlighted in bright green; probable locations of recent conversion of non-cropland to corn or soybeans production are highlighted in red. Data from U.S. EPA and Lark et al (2015).



Impaired waterway data from EPA (2015). Land conversion data from Lark et al (2015). Ethanol refinery locations from Esri.

Figure 5-6: Map of 303(d) listed waterways that are impaired due to nutrient (nitrogen and phosphorus) pollution in northeastern Kansas. Streams and waterbodies are highlighted in bright green; probable locations of recent conversion of non-cropland to corn or soybeans production are highlighted in red. Data from U.S. EPA and Lark et al (2015).

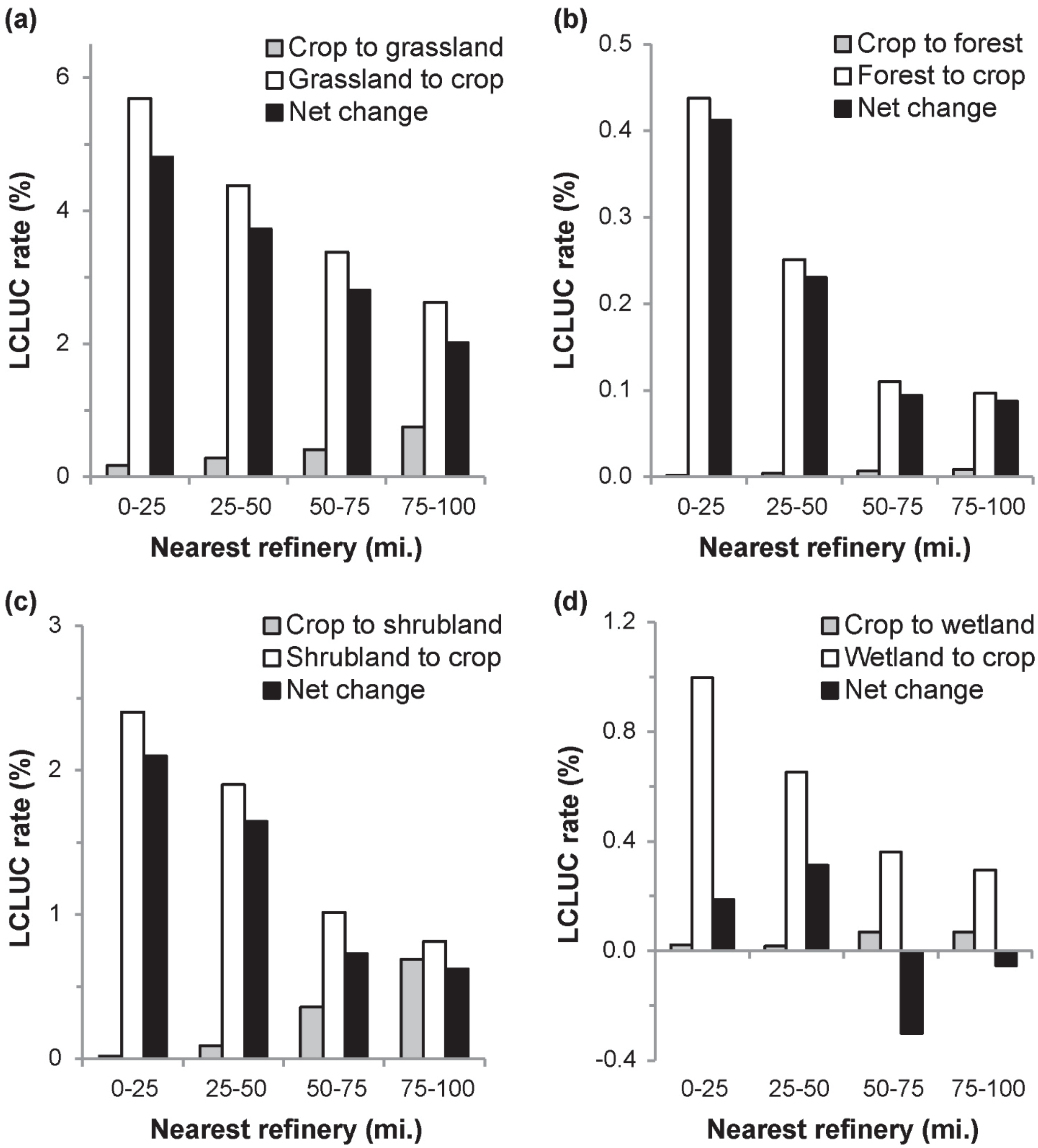


Figure 5-7: "Relative LCLUC rates (2008–2012) as a function of generalized land cover class and proximity to ethanol refineries. Conversion and net change rates normalized by arable land in the applicable non-cropland class in 2008. Reversion rates normalized by cropland area in 2008." Figure and description from Wright et al. (2017).

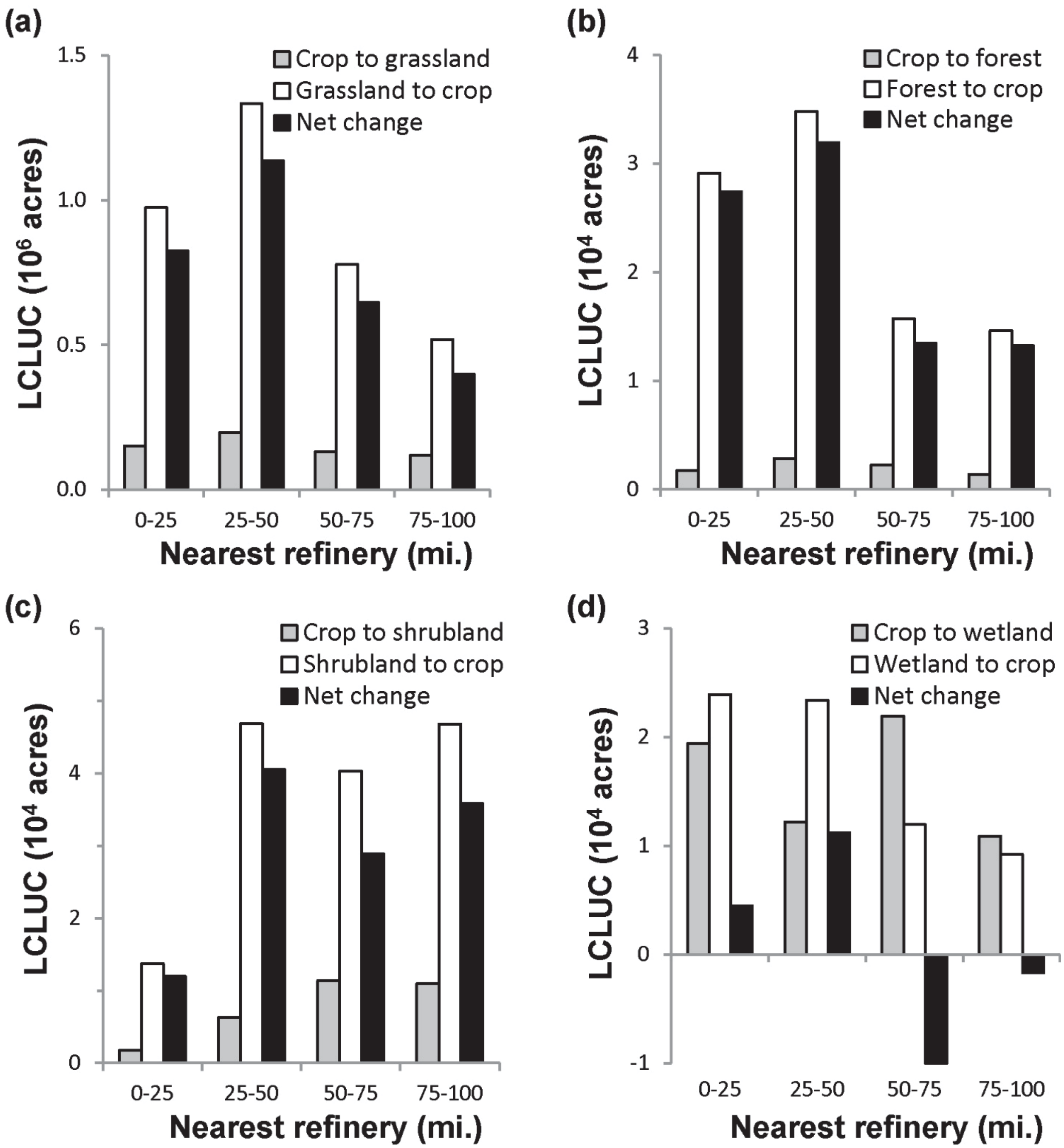
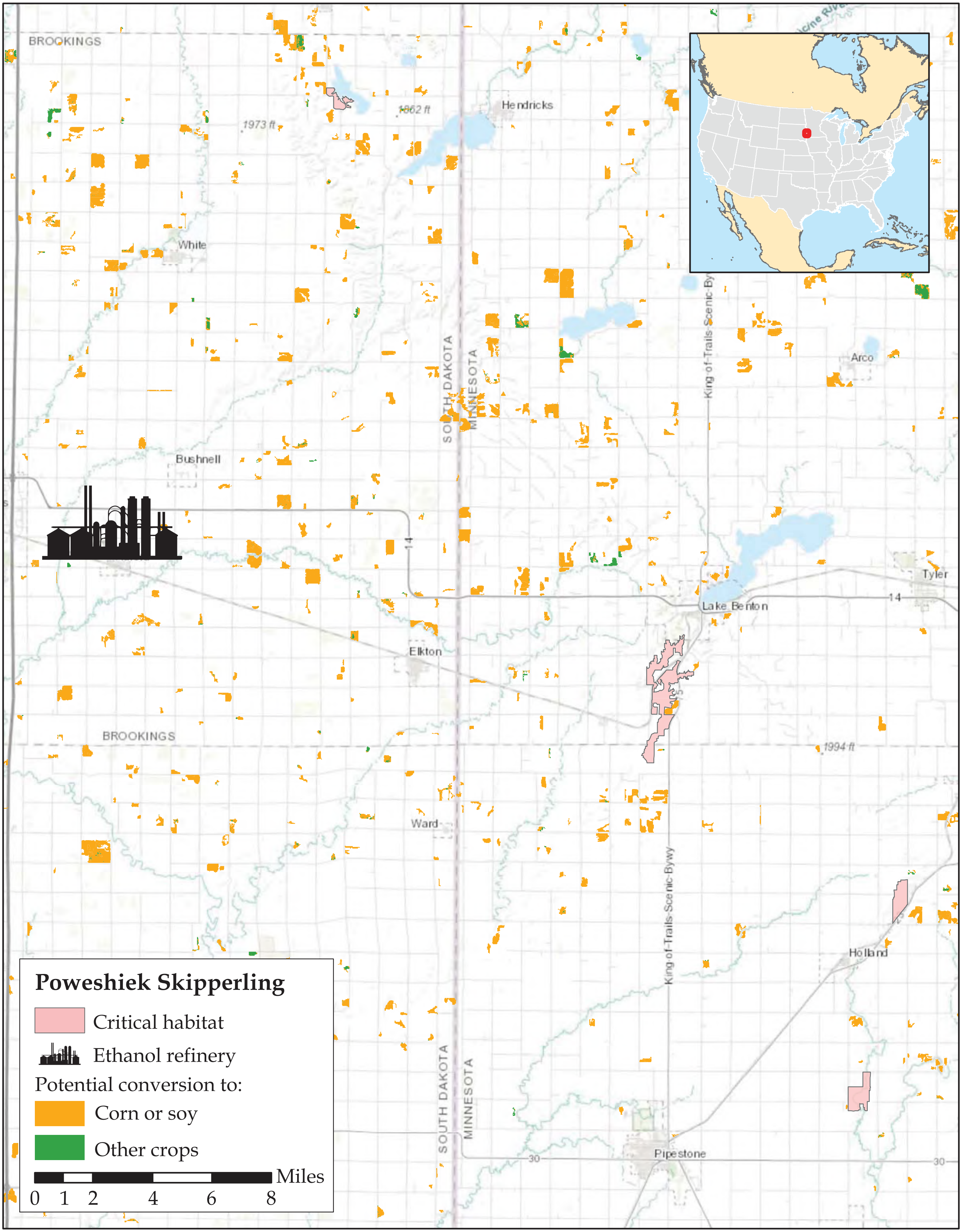


Figure 5-8: "Gross LCLUC (2008–2012) as a function of generalized land cover class and proximity to ethanol refineries. Note that grassland values are in 10^6 acres; forest, shrubland, and wetland in 10^4 acres. A positive net change (conversion minus reversion) represents a net loss in a given category; negative values indicate net gains (wetland only)." Figure and description from Wright et al. (2017).

Appendix 6 to Declaration of Dr. Tyler Lark



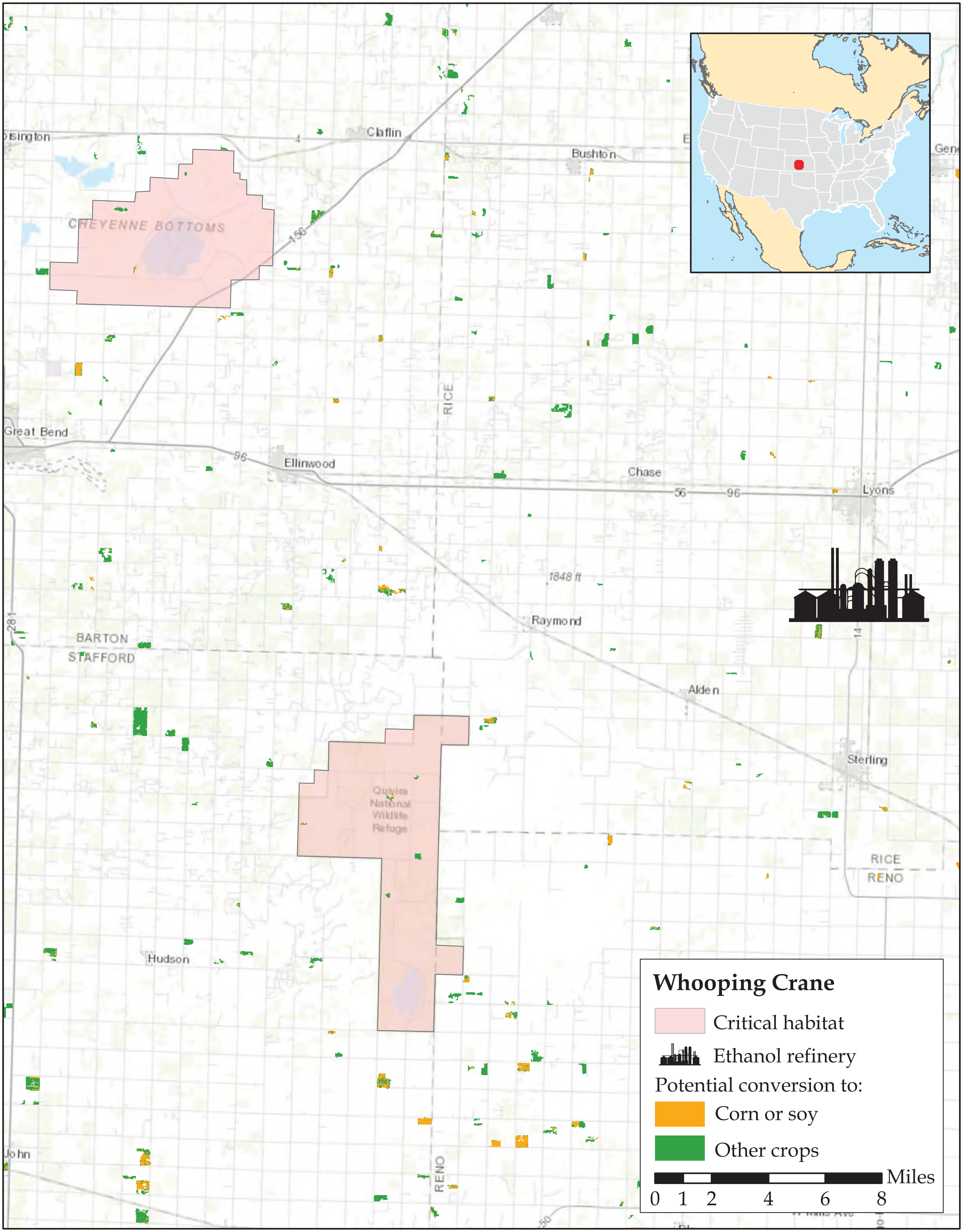
Critical habitat data from US Fish and Wildlife services
Land conversion data 2008-2016 based on approach of Lark et al. 2015
Ethonal refinery locations from Open Energy Info, basemap from Esri

Above Image Date: 5/21/2008 44°12'49.48"N 96°18'29.90"W

Above Image Date: 6/23/2010 44°12'49.48"N 96°18'29.90"W

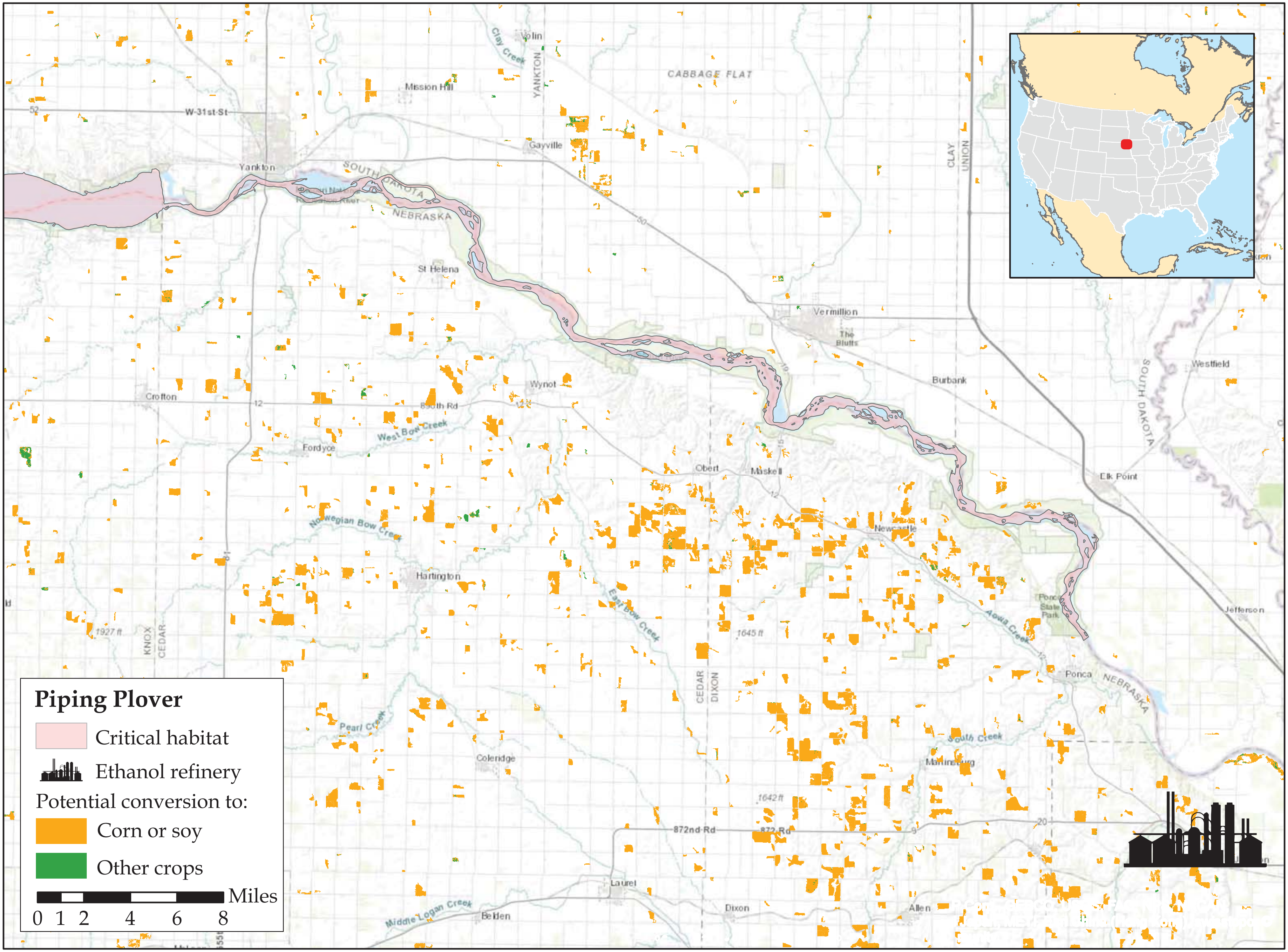
Aerial photographs of conversion from grassland to cropland located adjacent to designated critical habitat for the Poweshiek skipperling butterfly. Example is located south of Lake Benton in Lincoln County, Minnesota. Critical habitat area is highlighted pink, example of conversion is circled in red.

Appendix 7 to Declaration of Dr. Tyler Lark



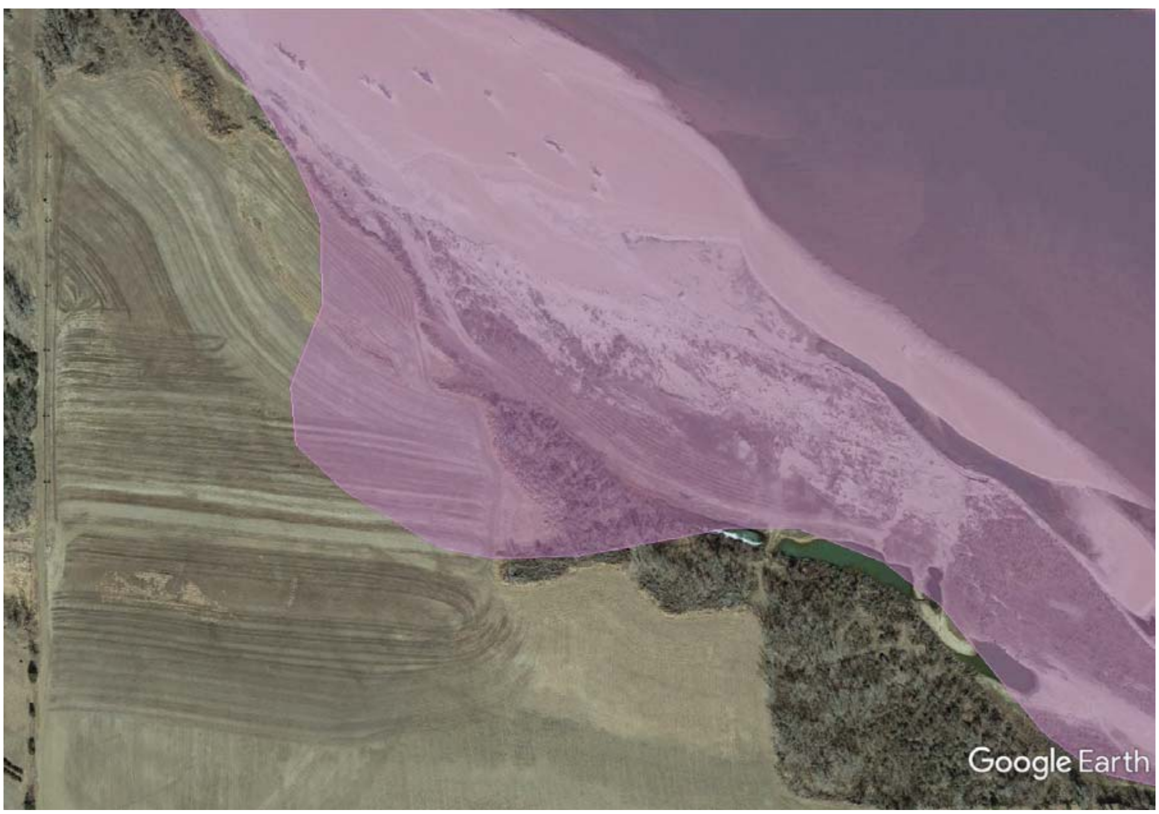
Critical habitat data from US Fish and Wildlife services
Land conversion data 2008-2016 based on approach of Lark et al. 2015
Ethonal refinery locations from Open Energy Info, basemap from Esri

Appendix 8 to Declaration of Dr. Tyler Lark



Critical habitat data from US Fish and Wildlife services
Land conversion data 2008-2016 based on approach of Lark et al. 2015
Ethonal refinery locations from Open Energy Info, basemap from Esri

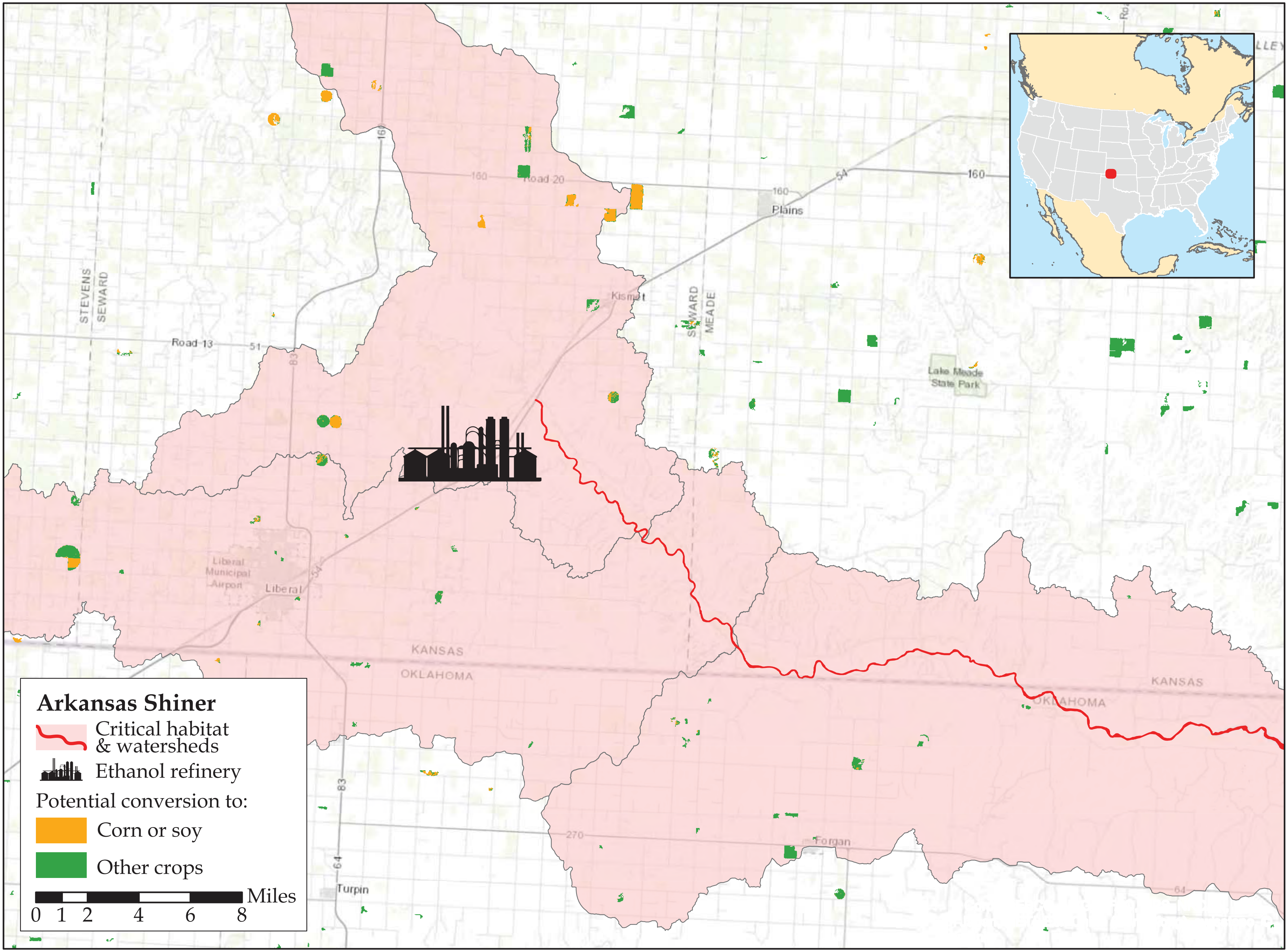
Above Image Date: 5/9/2012 42°51'11 N 97°17'26 W



Above Image Date: 3/13/2015 42°51'11 N 97°17'26 W

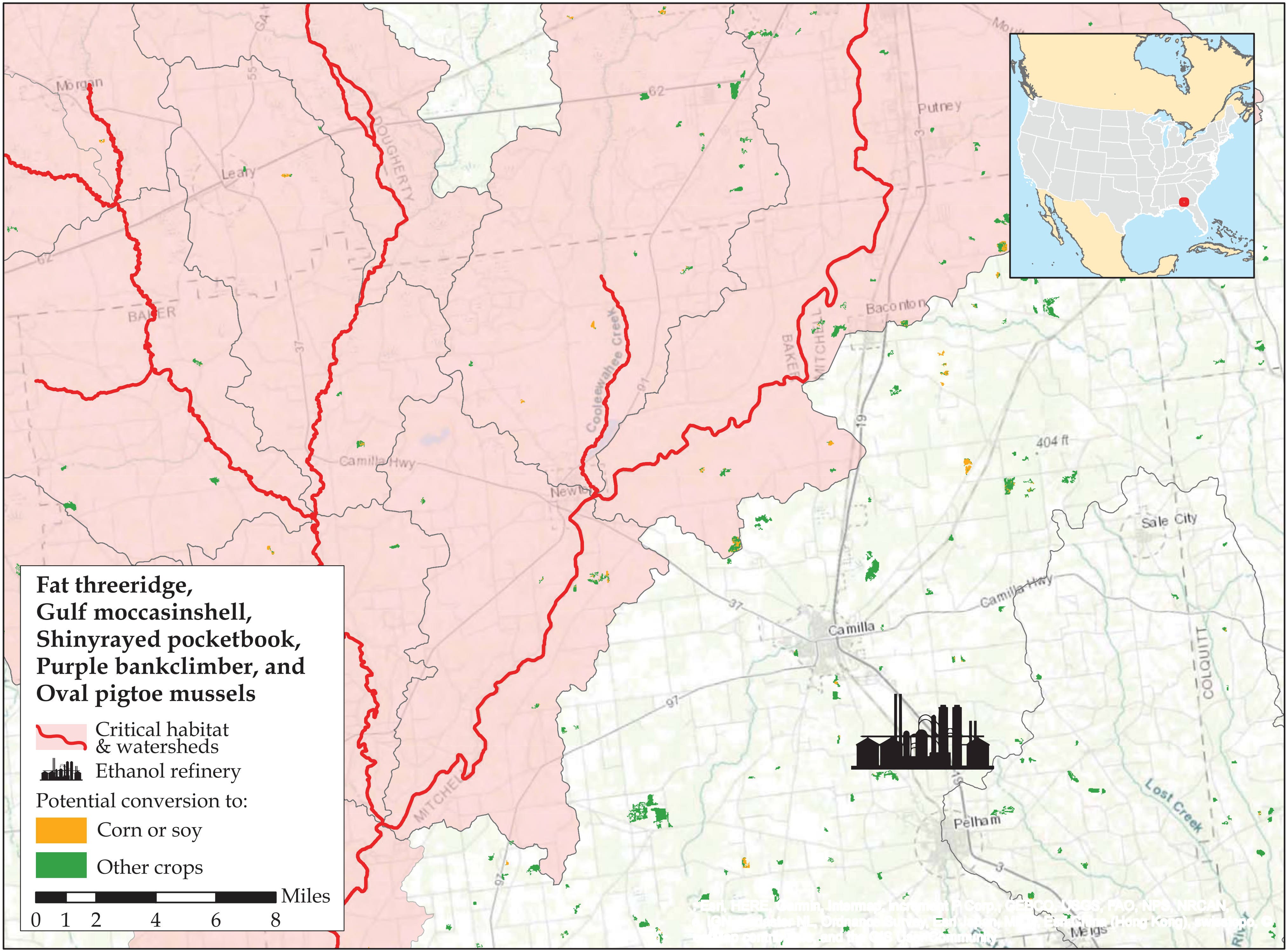
Aerial photographs of conversion of natural riparian habitat to cropland along the shoreline of the Missouri River, which is designated as critical habitat for the Piping plover. Example is located just east of Yankton, South Dakota, in Cedar County, Nebraska. Critical habitat area is highlighted pink.

Appendix 9 to Declaration of Dr. Tyler Lark



Critical habitat data from US Fish and Wildlife services
Land conversion data 2008-2016 based on approach of Lark et al. 2015
Ethonal refinery locations from Open Energy Info, basemap from Esri

Appendix 10 to Declaration of Dr. Tyler Lark



Critical habitat data from US Fish and Wildlife services
Land conversion data 2008-2016 based on approach of Lark et al. 2015
Ethonal refinery locations from Open Energy Info, basemap from Esri

Appendix 11 to Declaration of Dr. Tyler Lark

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