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Turning Weeds Into Ethanol – Why Not?

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Media coverage of the controversy surrounding the use of certain non-native feedstocks for bioenergy is as pervasive as invasiveness itself. Plants such as giant reed (*Arundo donax*) and elephant grass (*Pennisetum purpureum*) are known to be weedy or invasive in natural habitats; the concern lies in their ability to spread propagules into natural habitats outside intended areas. So are bioenergy crops on the path to being the next kudzu (*Pueraria montana*)? The US Environmental Protection Agency (EPA) recently put in place growing restrictions and management plans to minimize the potential for escape when planting giant reed and elephant grass (Federal Register 2013, Scott et al. 2013).

The bad reputation and accompanying safeguards that require onerous record-keeping, monitoring, and reporting may dissuade farmers from planting feedstocks with invasive potential. But what if, on the flip side, bioenergy can serve as a motivator to remove existing weeds in farms, forests or even natural areas? That is, could ecologically damaging invaders be converted into cash crops that contribute valuable biomass to ethanol supply chains? Several authors already have proposed gasification or combustion (Jakubowski et al. 2010, Nielsen et al. 2011, Nackley et al. 2013) of existing stands of kudzu (Zaleski 2008, Sage et al. 2009); woody invaders like Russian olive (*Elaeagnus angustifolia*) and saltcedar (*Tamarix spp.*), and wetland invaders such as common reed (*Phalaris arundinacea*).

To date, however, the literature has not addressed whether this could actually be feasible from an economic, ecological or practical sense in the ethanol context. Sustainability standards such as the CSBP (2013) have entertained the notion that standards should reward producer actions to clear invaders for bioenergy purposes. In a recent study (Quinn et al. 2013), we examine existing barriers that could preclude commercial use of weedy and invasive biomass as a source of ethanol.

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An Overarching Philosophical Dilemma

Biorefineries require a consistent and abundant source of biomass to operate profitably. Landowners and conservationists, on the other hand, primarily seek to eradicate invaders permanently from the landscape to restore ecological balance and eliminate economic losses. While weeds and invasive plants likely will reemerge even after aggressive control measures, their numbers will not be at the level required to meet consistent feedstock needs of a biorefinery.

Logistical and Economic Barriers

Even if stakeholders could reconcile philosophical approaches, several economic and logistical barriers stand in the way. First, the vast majority of existing biorefineries in the US process corn into ethanol; only a widely-dispersed handful currently process cellulosic feedstocks. Within these, conversion into ethanol requires a great deal of specificity regarding cell wall composition. Invaders – whose chemical composition is likely untested – would not necessarily be acceptable at cellulosic biorefineries. For those cellulosic biorefineries capable of converting an array of different feedstocks, the distance weedy or invasive biomass would have to travel to the appropriate biorefinery would, in most cases, be prohibitively expensive.

Second, commercial scale biorefineries demand delivery of 1,800 to 9,000 MT biomass per day (more than 15 truck deliveries per hour), harvested from 70,000 to 350,000 hectares over the course of a year. Most invasive plant removal projects occur on the scale of tens (not thousands) of hectares spanning numerous private property boundaries. Biorefineries would be forced to negotiate with several property owners who may not be cooperative, at least initially, due to simple privacy concerns and other issues. These holdouts could perpetuate refugia for invasive plants that could reinvade the area following control efforts on participating properties. In sum, biorefineries who seek to source invaders would be constantly faced with uncertain supplies.

Labor and processing costs also could be prohibitive. Most invasive plant control projects operate on small scales by groups of volunteers with hand tools. To achieve biomass yields large enough to justify transportation costs, mechanization will be required. Moreover, invasive plants often grow in a matrix of other species (some of which may be rare and endangered or otherwise undesirable to remove); mechanization cannot selectively harvest invaders without increasing time and skilled labor costs in the field. Separation at the processing phase to remove undesirable contaminants also incurs increased costs. Incentives would be necessary to cover the increased costs of removal to achieve desirable removal of invaders from the landscape. From a sustainability perspective, policy should consider this balance.

Ecological Considerations

While control and removal of invaders can benefit ecosystems (e.g., Flory 2010), there exists the potential for ineffective control (Kettenring and Adams 2011) or unintended consequences (Zavaleta et al. 2001). If landowners do not properly or completely implement management protocols, landscape disturbance may harmfully reawaken dormant seeds, eliminate direct and beneficial competitors, and precipitate reinvasion by the same or similar invaders due to incomplete removal. Desirable natives may be damaged or removed as well, further challenging native regeneration and aiding invaders. Inspection for remaining propagules must occur after harvest, and closed transportation and/or chipping or pelletizing biomass prior to transportation would be essential.

Significant costs attach to restoration, especially at large scales, and may negate any potential profits to be made by the sale of invasive biomass. One study has estimated that control of giant reed in California riparian areas and subsequent restoration can total $25,000 per acre (0.4 ha). The estimated sale price of giant reed biomass for conversion into ethanol at $800 per acre simply would not justify the cost of its removal without further incentives.

Legal and Policy Frameworks to Address Invaders-As-Biomass

Any invaders that appear on state or federal noxious weeds lists are technically not permitted to be sold in any form, nor are they allowed to cross state lines. Thus, interstate compacts would be needed between states to allow for transport and sale of “noxious” biomass. It is unlikely that EPA’s authority to qualify feedstocks for renewable identification numbers (RINs) would allow invasive feedstocks to cross state lines without further state approval. The Clean Air Act's Renewable Fuel Standard (RFS) in no way evidences intent to preempt the Plant Protection Act, which grants states the ultimate authority to control invaders. Further, EPA under the RFS provisions would have to conduct complex lifecycle GHG analysis of the different invasive biomass pathways.

State by state policies beg the question of how efforts to eradicate invaders could be synergized holistically with bioenergy policy to achieve the greatest ecological benefits that surpass political jurisdictional lines. Voluntary, third party standards such as the Roundtable for Sustainable Biofuels (RSB) require "legality" for certification, but where regional ecosystem coordination does not exist publically, such consultation would fall completely short. Policy should consider whether and how to establish coordinating bodies that could help to synchronize the efforts of multiple regional control or eradication projects, and direct the collective biomass to storage and/or processing centers prior to shipment to the nearest feedstock-appropriate biorefinery. These coordinating bodies could also help to source personnel and equipment for large-scale eradication and restoration projects.

Concluding Thoughts

While invaders may not be a primary source of ethanol, they theoretically could be sustainably harvested to provide contributory inputs for biorefineries. One could imagine a consortium of landowners organized to harvest and sell invasive biomass, potentially generating sufficient quantities to satisfy demands of a small local biorefinery, for at least a limited time. These landowners would have a vested interest in improving the economic and ecological performance of their land through invasive species removal and restoration, and consequently may be willing to pay the up-front costs.

We have focused our discussion on the use of invasive biomass for conversion to ethanol; this does not preclude conversion of invasive biomass to other forms of energy. As mentioned above, several researchers have evaluated the feasibility of using invasive biomass for combustion or gasification, with positive outlooks. In fact, we see combustion as the most viable option at present for conversion of invasive plants to energy sources because combustion is not forced to consider individualized cell wall deconstruction. On the other hand, biomass combustion still faces an uncertain future with regard to how its GHG benefits, if any, will be counted by regulators (see Endres 2013). While the need for processing (drying, size reduction, densification) may present some barriers (van Loo and Koppejan 2008), invasive biomass could drop into the existing supply of biomass being co-fired with coal in the huge network of electrical power plants across the country, as is currently being done in some municipalities.

Perhaps as the biomass-to-ethanol industry matures over the next half century, technical innovation may reduce the currently insurmountable logistical and economic concerns associated with utilizing existing invasive feedstocks for viable sources of liquid fuel. In the meantime, however, this concept of invaders-to-energy currently tossed about in policy discussion warrants careful scrutiny grounded in economic, ecological, and legal aspects of the bioenergy supply chain.

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