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# Weedy Biofuels: What can be done?

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**Abstract**

Biofuels are likely to cause significant weed problems because the attributes of an ideal biofuel species – including rapid growth with minimal fertiliser and water needs – match those of typical weeds, and because cultivation will be on a vast scale. The valued biofuel giant reed is one of the world's worst invaders. To reduce weed risk, biofuels could be cultivated under voluntary guidelines or legislative controls. But self-regulation has a poor track record, and legislative controls would impose a cost on society because biofuels are high-volume low-value crops with limited profit margins to fund weed management.. Extreme weather events can exceed landholder capacity for control of escapes. Restricting candidate species to those with low weed risk is advisable, and many native species would offer safe potential.

## Introduction

In most developed countries, weed lists are dominated by plants that were deliberately imported for garden ornamentation, agriculture, or to meet some other need or fancy. This has been well documented in the United States [1,2], Australia [3] and New Zealand [4]. To escape from cultivation and become a weed, a plant has to have attributes that suit it for invasion success in the local environment. Plants are sometimes cultivated in part because they have such attributes, e.g. a strong flowering effort, capacity to self-pollinate or reproduce vegetatively, germination under variable conditions, and few natural enemies. The high invasion rate of exotic pasture plants is unsurprising because, as noted both by proponents [5,6] and their critics [7,8], the attributes required of pasture plants – i.e. aggressive growth rates, prolific seeding, tolerance of drought and grazing – overlap with those of typical weeds.

That most new weeds are escapes from cultivation is reason to monitor emerging trends in plant cultivation. Biofuels have recently gained global popularity and political support as a major new agricultural sector [9]. Like pasture plants, the attributes required of biofuel crops – rapid growth rates with minimal input of fertilisers, high water use efficiency, lack of pests and diseases – are those of many weeds [10]. That is, "the very traits that characterise an ideal biofuel crop also typify much of our invasive flora" [9]. More than two-thirds of the plants proposed for use as biofuels in Hawaii, or which are cultivated in Hawaii and proposed as biofuels elsewhere, have been assessed as having a high risk of becoming invasive in Hawaii [11], and most of the species attracting attention in Australia have a substantial history as weeds [12]. Giant reed (*Arundo donax*) epitomises the problems. It is a plant on the IUCN list of 100 of the world's worst invasive alien species [13] that is highly valued as a biofuel because of its exceptional growth rates [14].

A key determinant of invasion success is propagule pressure – the number of propagules (seeds or self rooting plant fragments) available for establishment and spread [15,16]. The large scale of proposed biofuel plantings will ensure high propagule pressure, so that even plants with low invasion potential will have many opportunities to escape.

Contributing to this risk are widespread market failures. In Asia and Africa, jatropha (*Jatropha curcas*) was widely planted in response to government directives, speculation and

venture capital availability. Many plantings have proved ill conceived, with no available markets for the seeds [17] or generating poor yields [18,19], resulting in abandoned plantings with the potential to spawn weed problems [20]. New business ventures often fail, especially in the agricultural sector, and this is proving particularly true of biofuels.

The invasion potential of biofuel crop species may also be facilitated by genotype selection or breeding for weed-like attributes such as higher competitiveness, higher biomass yields, greater tolerance for poor growing conditions, and reduced input needs [9,21]. There can be considerable differences in invasion potential of different genotypes, which may partly explain why giant reed has proven more invasive in the United States than Australia to date [22]. Varieties selected for rapid growth as biofuels are likely to prove more invasive than past cultivars with ornamental striped leaves.

The sustainability challenge is to realise the benefits of biofuel crops without creating major agricultural and environmental weed problems, taking into account that:

- biofuel crops are high-volume, low-value crops, implying high propagule pressure and limited producer profits to fund weed control;
- the large scale of plantings and long timeframe over which weed risk must be managed increases the likelihood of low-frequency extreme events or management lapses resulting in weed escape;
- detectability of escapes and traceability to a particular producer, and hence application of the polluter pays principle, may be difficult; and
- the potential for remedial action is limited, as weed escapes are usually irreversible and control expensive, requiring a long-term commitment of labour and resources.

**Regulatory and policy options**

Farmers need to make a profit. However, as custodians of the land they also have responsibilities to maintain the productive capacity of the land, to conserve ecosystem services (those that contribute to water quality and carbon sequestration, for example), and to limit harm to biodiversity. Particularly in times of hardship, landholders are liable to prioritise short-term productivity at the expense of sustainability. Governments have a role to play in preventing this.

The problem of balancing private and public goods is compounded by a lack of methodology for directly comparing costs and benefits (including economic costs and benefits) of short-term production and long-term sustainability. The paradigm of economic productivity is poorly integrated with that of natural resource and ecosystem management.

Weedy biofuel crops epitomise the problem. They may provide immediate economic benefits while diminishing future land use options and productivity and biodiversity. With biofuel proponents promoting only the benefits, often unrealistically, and landholders often ill-equipped to evaluate the risks, governments have a vital role to play in assessing and managing risks on behalf of the wider community.

There are two main policy approaches to managing weed risks, the low-cost option of industry self-regulation, and the higher cost option of legal regulation.

**Self-regulation**: Voluntary codes of conduct/practice or guidelines are often advocated as a low-cost flexible alternative to the ‘command and control’ approach of black letter law

[23,24]. The IUCN [25] has recently produced guidelines for biofuel farmers, which call upon operators to conduct a weed risk assessment to identify the potential threat of invasion and avoid cultivating any species deemed highly invasive. They recommend that operators develop a management plan to minimise weed risks, including control of escaped plants and a monitoring system.

But the effectiveness of self-regulation depends on the voluntary measures being adequate to prevent weed escape and operators being willing and competent to comply, and there are several features of biofuel production likely to be incompatible with these criteria.

There have been no field assessments of the conditions that would prevent weed escape and spread of invasive biofuel crop species. Such assessments would need to take into account low-frequency extreme events, for many weeds have become a problem only after exceptional weather events have caused widespread propagule dispersal [26]. Infrequent floods have been a major cause of spread of athel pine (*Tamarix aphylla*) in Australia [27] and of tall whitetop (*Lepidium latifolium*) in the United States [28], for example. No conditions may be sufficient to prevent weed escape during cyclones and floods, which are often disregarded as part of the operating environment, but which are inevitable and increasingly likely in many places under future climate change [29]. Rare floods and cyclones can spread propagules many kilometres, well beyond the capacity of a landholder to control them, at times when landholders face more immediate management problems. Giant reed is spread mainly by floods transporting its stems and rhizomes [30].

Even where management actions can prevent weed escape, self-regulation is unlikely to be effective for biofuel cropping because of financial and accountability impediments. Investment in monitoring and high levels of compliance cannot be expected when crops have low value and weed management imposes substantial costs and inconvenience, and when escapes cannot necessarily be traced to any particular grower and there is no independent monitoring of compliance or sanctions for non-compliance.

There has been little empirical assessment of the effectiveness of codes of practice or similar types of self-regulation applying to environmental management, in part due to "problems of data availability, credibility, self-selection, or poor design" [31], but the few published analyses show they have mostly been ineffective. These include assessments in the banking, chemical manufacturing, electricity, whalewatching, ski resort tourism, and plant retailing sectors [31-41]. The Queensland Government recently imposed regulations on cane farmers to prevent pollution of the Great Barrier Reef after five years of voluntary measures failed [42]. Even with occupational health and safety, "the track record of self-regulation is a poor one" when there is no profit advantage [24].

Consistent with this, the Australian Government's [43] *Best Practice Regulation Handbook* defines only a limited list of circumstances under which self-regulation should be considered, none of which apply to potentially invasive biofuel crops:

> When there is no strong public interest concern, in particular, no major public health and safety concern;
> When the problem is a low-risk event, of low impact or significance; and
> When the problem can be fixed by the market itself. For example, there may be an incentive for individuals and groups to develop and comply with self-regulatory arrangements (industry survival, market advantage).

Governments should be realistic about the limited capacity of landholders to manage weed risk, particularly when crops may be subject to extreme weather events, and cautious about relying on voluntary measures when there are financial and logistical impediments to compliance.

**Regulating new industries or crops:** Most governments have mechanisms to assess the risks, including weed risks, posed to society and the environment by new industries and products. Genetically engineered crops have received considerable scrutiny from regulators, but assessment of other crops typically occurs on an ad hoc basis. New species that pose weed risks can usually be prohibited under legislation. In Australia, for example, one state has effectively banned cultivation of jatropha by placing it on a 'noxious weed' list (under Western Australia's *Agriculture and Related Resources Protection Act 1976*). There is, however, no automatic assessment of potentially invasive plants in most jurisdictions, and noxious weed declarations are often not considered until weed spread has already occurred. Governments are often reluctant to prohibit plants perceived to offer economic value, especially where landholders have already made investments. Legislation also imposes transaction costs because of the need to achieve community acceptance, and develop, implement, enforce and review laws. In the absence of policies that adequately weight the long-term environmental and economic costs of weeds, most governments prioritise short-term economic benefits [44]. In addition, the promotion of biofuels as a solution to an urgent global problem encourages trivialisation of weed problems.

Governments should intervene early and systematically to assess proposed crop species for weed risk, before there is strong industry momentum and investment. By the time a crop is ready for production, there has already been considerable research and product development (often conducted or funded by governments), ensuring opposition to any prohibition, sometimes coming from government agricultural agencies. Weed risk assessment should be applied to all proposed genotypes to prevent the introduction of more-invasive cultivars [45]. The public benefits of weed prevention should be clearly expounded to increase public acceptance of a precautionary regulatory approach and to counter the hype of biofuel proponents.

**Regulating cultivation**: When a new crop offers economic benefits, which in this case may include increased energy security, governments are tempted to manage risks at the production stage. Biofuels could be grown under regulatory regimes to minimise weed risks. In Australia, for example, protocols were proposed to ban plantings of giant reed near watercourses that might transport seeds or rhizomes downstream [46]. Although such processes can appear sensible, in practice they are likely to fail for the same reasons that voluntary measures are likely to fail. The proposed condition of no cultivation of giant reed on floodplains subject to a 1 in 50 year flood risk is far from precautionary given that cultivation is likely to extend well beyond a 50 year timescale. Giant reed can propagate from stems that fall from trucks onto damp ground so, because of the varied land tenures along roads, weed risk management would require government roadside monitoring and control, an ongoing cost to society that would need to be taken into account as part of a cost-benefit analysis. Any monitoring program funded by government would be vulnerable to budget cuts imposed during difficult economic times.

Regulations imposed on cultivation have worked successfully for a few high-value, low-volume crops such as opium poppies, but biofuels represent the other extreme: low-value,

high-volume crops. Low value implies limited landholder capacity to invest in weed management and high volume implies many opportunities for plants to escape.

**Government subsidies**

Governments with limited energy supplies and with concerns about carbon emissions have very quickly, perhaps too quickly, jumped on the biofuels bandwagon. The United States and the European Union have both legislated energy production targets from renewable sources with the expectation that biofuels will help meet those targets. They have funded research, offered subsidies, and made commitments to buy crops at prefixed prices, in theory to help biofuel industries reach an economically viable scale. The use of subsidies to promote crops such as maize has attracted strong criticism, not least because the production of those with high nitrogen demands may not lower greenhouse gas emissions [47] (see Sheppard et al. this volume ). Attracting far less criticism have been subsidies that facilitate weed invasion. While governments recognise that biofuels will only become viable if they genuinely reduce carbon emissions and can be cultivated without state subsidies, the risks of weed escape, landscape degradation and loss of ecosystem services [48] are usually neglected, despite the threat they pose to other production systems. The US farm bill (*Food, Conservation and Energy Act 2008*), which facilitates biofuel production, includes statements about the need to avoid planting known invasive species (Tasker this volume), but lacks a regulatory process to evaluate invasion risks and to shape decisions about which crops to plant. In some southern US states, giant reed is being widely planted for biofuel production, although it is a major weed of watercourses and wetlands [30,49] and the focus of a biological control program [50]. There is no 'polluter pays' mechanism in the farm bill to ensure that any costs of weed control or removal of uneconomical plantings are met by the grower. The public is therefore insuring growers against weed problems as well as providing direct subsidies.

A sustainable industry needs to adopt a polluter pays system for environmental remediation, including eradication of weed escapes. This will be difficult because invasions may not be traceable to any particular producer. The alternative - an industry-wide levy to fund weed monitoring and control - may also prove problematical because of the low value of biofuel crops.

**Low-risk options for biofuels**

Fortunately, the biofuels industry has a wide choice of potential crop species, particularly for second-generation fuels based on biomass, and non-weedy options can be selected. Every country has native plants that grow rapidly without imposing a weed risk, which may also provide some biodiversity benefits. In Western Australia, mallee eucalypts are showing promise as biofuels, while also providing habitat for small possums [51] and birds [52]. Invasive crops such as giant reed produce biomass at a faster rate than most native plants, but a cost-benefit analysis that considered the weed costs, which usually continue into the future, would conclude that native plants were a better option. Risk assessment should be applied to native species as well because some can prove invasive [21].

**Conclusions**

As high-volume, low-value crops with many of the attributes of weeds, biofuels present a dangerous combination of high propagule pressure and limited landholder capacity for weed management. For these reasons, the biofuels industry warrants high levels of weed precaution: the risks and costs of invasion are high and long-term while the benefits may be transient. Government regulators should assess the risk of proposed biofuel crops before research or producer investments are made and only permit the cultivation of species assessed

as low-risk. Weed risk assessment protocols are available to assist this. Governments should be realistic about the limited potential for regulations or codes of practice to prevent weed escapes, given their poor track record in other arenas and the difficulty of managing for low-frequency extreme events. A precautionary approach to biofuels does not compromise the industry's future because there are many low-risk species, including native species, that can be used instead of invasive species.

The emerging biofuels industry offers the opportunity to implement well-recognised principles of prevention in weed management, and to show that the lessons of past failures have been learnt.


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