Alien alert – plants for biofuel may be invasive

There are big risks associated with growing some biofuel crops – but also some solutions, say **Geoffrey Howard** and **Silvia Ziller**

Well-meaning introductions of plants can result in destruction of native biodiversity and human livelihood options (see panel, below). One example is *Prosopis juliflora*, a spiny shrub/small tree from Central America where it is called mesquite and grows in dry areas.

This plant, which is being considered as a feedstock for "second-generation" biofuels. was chosen as an agroforestry species and introduced to countries in Eastern Africa and the Horn of Africa to reduce soil erosion, provide shade in hot, dry areas and improve soil fertility, as it is a legume.

At the time this was thought to be a wise choice and introductions were carried out after requests from the countries concerned. Alas, over the next 20 years, prosopis took over with disastrous results for people and biodiversity.

In one case prosopis was established in the 1970s in eastern Ethiopia to improve an arid area by reducing wind and water erosion, providing more trees to a relatively treeless area, adding shade and providing nutrients to the soil.

The plant established itself and grew so well that today there are more than 700,000 hectares of former grazing land completely covered by prosopis. Native vegetation has been excluded, pastures have disappeared, a monoculture of this close-growing, spiny plant has prevented people and both domestic and wild animals from entering the area and pastoralists have lost their lands and their livelihoods.

That is typical of a non-native species invasion. It will take decades and vast investments to curtail, let alone to reverse.

Worldwide, invasive species are reckoned to cost in the order of $1.5 trillion in lost productivity and other damage, in addition to the costs of prevention and management.

Another potential biofuel feedstock plant is the African oil palm, *Elaeis guineensis*, which originated in tropical West Africa and was introduced to Brazil in the 1500s

The oil is extracted from the seeds and used traditionally in cooking in north-eastern Brazil. But African oil palm also adapted and spread in its new home to the extent of forming self-sustaining populations and inhibiting native plant growth – a classic case of biological invasion.

The palm adapts very well to wet areas close to rivers and wetlands. Its large and fleshy seeds are dispersed by mammals and large birds, so any control efforts necessarily need to be carried out on a long-term basis and imply permanent costs to keep natural forests and open areas clean.

Some areas of formerly rich Atlantic Forest are nearly converted to monoculture palm plots, not of planted palms, but of areas invaded for lack of any concern or control. African oil palm has also been recorded as invasive in forest areas in in the Amazon region of Colombia.

As this species is promoted and spread by informal plantations all over the Amazon region, there is potential for gradual conversion of natural areas into impoverished ecosystems that will not supply the ecological services currently provided by the pristine forest areas.

As more plantings for biofuel production develop, there will be permanent control costs that may become significant due to the difficulty in finding these palms in lush native forests. At the same time, there is research to produce biofuels from the nuts of native palms in the Amazon and the cerrado (savanna) regions, which should be considered as alternatives that would generate no negative side-effects on the environment.

CHARACTERISTICS OF INVASIBILITY

The potential to invade is present in many types of plants, but it does not usually become apparent until they are introduced to a new ecosystem. This capacity (termed invasibility) is especially prevalent in those species that:

- ☐ have a rapid growth rate;
- ☐ grow well in dry or otherwise adverse conditions (have broad environmental tolerance);
- ☐ have many and well-protected fruits and seeds (high-yielding species);
- ☐ produce fruit and seeds (or other propagules) early in their growth and development;
- ☐ are able to disperse widely through wind or water or by animals that feed on them or carry their propagules; and
- ☐ are effective competitors with other plants.

It must be emphasised that these characteristics do not guarantee invasion, as that will also depend upon the nature of the new ecosystem to which the plants are introduced. If there is no successful establishment or naturalisation and spread after introduction, invasion may not occur.

Another aspect of invasion is that the time from introduction to the appearance of invasion may take varying amounts of time (eg days for water hyacinth, months for some herbs and often decades or even centuries for trees.)

The basic characteristics of plants that are likely to become

INVASIVE PLANTS HIT ECOSYSTEMS AND HUMANS

Invasive species are organisms (animals, plants and micro-organisms) that, when introduced to a new environment, establish themselves and spread, causing problems for native biodiversity and human livelihoods.

Such species are often benign in their original locality but are able to become aggressive or highly competitive in a new environment. In new homes they often become invasive because they have left behind the control mechanisms (predators, parasites, pathogens, competitors) that kept them in check.

Invasive plants (often referred to as "alien invasive plants") are able to out-compete plants in their new environment by faster growth, better access to nutrients, light and water, greater adaptability to harsh conditions (such as aridity, flooding or poor soils) and production of seeds or other reproductive plant parts in larger numbers or more regularly.

This results in the demise of native vegetation and a reduction of valuable goods and services from the affected ecosystems. Invasive plants may alter the availability of food and shelter for animals and bring in plant diseases. Invasions can reduce or eliminate biodiversity as well as impose costs on people and their development – both directly by affecting the invaded ecosystem and indirectly through costs of prevention and control.

Table 1: Species currently promoted for biofuels that are known to be highly invasive in some circumstances

Species scientific name	Common names	Native range	Habitat type	Invasive in	Vectors of dispersal	References
Arundo donax	Giant reed, oboe reed, e-grass, bamboo, danubian reed, elephant grass, giant danube reed, Spanish reed	Eurasia	Wetlands and riparian areas	US including Hawaii, Mexico, the Caribbean, southern Europe, South Africa, Thailand, Australia, New Zealand	Water (vegetative spread)	*Global Compendium of Weeds* (2002. RG and FJ Richardson). *The Weedy Truth About Biofuels* (2007. Invasive Species Council)
Azadirachta indica	Neem	India, Sri Lanka, Myanmar, Bangladesh	Arid lands	West Africa, Australia, Fiji, Mauritius	Birds, bats	*Global Compendium of Weeds*
Elaeis guineensis	African oil palm	West Africa	Tropical riparian forests	Brazil, Micronesia, Florida in US	Animals	
Jatropha curcas	Physic nut, Barbados nut, curcas bean, purge nut, purging nut, tuba	Tropical America	Arid and semi-arid lands	Australia, South Africa, US (Florida, Hawaii), Pacific islands including Fiji, India, Brazil, Honduras, Panama, El Salvador, Caribbean including Jamaica and Puerto Rico, Galapagos Islands	Water, mud on vehicles and on machinery and animals	Department of Water Affairs and Forestry, South Africa. *The Weedy Truth About Biofuels*
Prosopis spp. (especially *Prosopis juliflora*)	Mesquite	Tropical America	Arid and semi-arid lands	Eastern Africa, Horn of Africa, southern Africa, India, Australia	Animals, wind	
Ricinus communis	Castor bean, castor oil bush, palma-christi	East Africa and Asia	Riparian areas	More than 100 countries – Brazil, Australia, Pacific islands, New Zealand, South Africa, Mexico, US, western Europe	Animals, water	*The Weedy Truth About Biofuels*

Source: Global Invasive Species Programme

invasive are some of the attributes sought in plants that are likely to be good producers of biomass or substances (such as oils) which would make effective biofuel feedstocks.

The Global Invasive Species Programme (GISP) group of organisations devoted to biodiversity conservation, agricultural production, pest and weed control and the sustenance of human livelihoods – which strive to reduce the impact of invasive species – warns that plants used for biofuels may become invasive when introduced to new areas.

During the recent 9th Conference of the Parties of the Convention on Biological Diversity (in Bonn, Germany, 9–30 May), a GISP briefing on plants for biofuels listed the most-used feedstock plants and characterised them according to their potential and history for becoming invasive. Table 1 lists some of the worst species with traits of invasiveness.

GISP warns that biofuel plants should not be introduced to areas without due diligence to test for their likely invasibility in the new environment. If this is not done, invasibility may emerge during an Environmental Impact Assessment – which is not usually complete until after costly pre-feasibility and feasibility studies for biofuel production have been completed.

Worse for the investor, once a plantation has been established and biofuel production is under way, it may become clear that biological invasion has occurred. This would require a change in approach, possibly compensation and a loss of goodwill. It would also require some mitigating

RISK ASSESSMENT CAN AVOID MANY PROBLEMS

Risk assessments serve the purpose of supporting decisions on the introduction or use of a species in countries or regions. They are protocols of questions about the biology of the species, its physical characteristics, habitat adaptations and climatic preferences and the difficulties of control and management (see Table 2).

Other questions relate to the area in which the species would be introduced. Here the environmental conditions of the target area (altitude, rainfall, temperature, relative humidity, soil conditions, sunshine hours, etc) are compared with the conditions under which the target species is known to have been invasive – to see if there is any level of matching.

The most well-tried protocols available were developed in Australia and New Zealand, which have a long and serious history of biological invasions and very strict national biosecurity systems.

Once the questions are answered, the protocol provides a numerical grade that is adjusted to infer high or low risk of invasibility, therefore supporting decision-making with a scientific and technical background. Intermediate grading infers that more information is required for the assessment to be concluded.

The precision of the risk assessment tools is 80 or 85%, which means that if these tools had been used from the start countries would have 15–20% of their current invasive species problems, simply by making wiser choices of species to import.

The main traits to be tested in these assessments refer to the history of invasion elsewhere of the species under evaluation, as it tends to repeat the patterns in new locations. This should be a very helpful guide to the choice of species.

The adoption of strict risk assessment procedures can prevent many future problems of invasion.

Table 2: Examples of questions in risk assessment protocols

1.01	Is the species highly domesticated?
1.02	Has the species become naturalised where grown?
1.03	Does the species have weedy races?
2.03	What is its broad climate suitability (environmental versatility)?
3.01	Has it been naturalised beyond its native range?
3.02	Is it known as a garden/amenity/disturbance weed?
3.03	Or as an agricultural/forestry/horticultural weed?
3.04	Or as an environmental weed?
4.01	Does it produce, spines, thorns or burrs?
4.02	Does it have allelopathic qualities?
4.03	Is it parasitic?
4.04	Is it unpalatable to grazing animals?
5.01	Is it aquatic?
5.02	Is it a grass?
6.01	Is there evidence of substantial reproductive failure in native habitat?
6.02	Does it produce viable seed?
7.01	Are its propagules likely to be dispersed unintentionally (plants growing in heavily trafficked areas)?
7.02	Are its propagules dispersed intentionally by people?
8.01	Does it have prolific seed production (>1000/m2)
8.02	Is there evidence that a persistent propagule bank is formed (> one year)?
8.03	Can it be well-controlled by herbicides?

Source: Hawaiian Ecosystems at Risk project. For more detail go to www.hear.org/pier/wra/pacific/jatropha_curcas_htmlwra.htm measures; at worst the whole plantation may be condemned as a source of risk to surrounding environments and peoples' livelihoods. Also, it would require continuous control work, which is very difficult and can often be costly.

RISK ASSESSMENT NEEDED FOR ALIENS

The best solution to this possible problem is to choose the most appropriate species for the area.

GISP recommends the use of native (and locally-used) species which will have a known history and so can be judged as likely or not to become invasive. If this is not possible, then GISP suggests that any non-native species is first subjected to a risk assessment (see panel, page 15) for invasibility.

If the risk is high, the species concerned should not be introduced and an alternative sought. If the risk is low, the species could be introduced but with acknowledgement of that risk and procedures to monitor for any escapes, as well as preventative measures that would make it difficult for the species to disperse if it became invasive.

A contingency plan should be prepared for escapes – involving rapid response including containment and, it is hoped, eradication outside the plantation. Restoration of any affected ecosystems may also be required at the cost of the developer or investor (using the "polluter pays" principle).

Some species with good characteristics for biofuels are, however, extremely difficult to keep confined. Those that bear seeds dispersed by wind or water are possible to manage, but dispersal by animals has unpredictable patterns and can lead to spread over long distances, starting new foci of invasion far from the plantation and out of sight of any monitoring.

Several groups have developed best practices for feedstocks and for plantations in general. These include the Principles and Criteria for Sustainable Biofuel Production developed by the Roundtable on Sustainable Biofuels (RSB) and the Principles and Criteria for Palm Oil Production developed by the Roundtable on Sustainable Palm Oil (RSPO).

The RSPO guidelines include principle 5: "Environmental Responsibility and conservation of natural resources and biodiversity" as well as criterion 4.5: "Pests, diseases, weeds and invasive introduced species are effectively managed …".

The RSB principle 7.b includes "No use of exotic invasive species'" in areas of high conservation value, native ecosystems, ecological corridors and other biological conservation areas. However GISP would suggest that any species that has a significant chance of becoming invasive should not be introduced under any circumstances.

These criteria (especially in relation to biodiversity and ecosystems that people rely upon) are still evolving and the biofuels industry can join the debates. In addition to the RSB and RSPO, such groups as the Forest Stewardship Council, the Rainforest Alliance/Sustainable Agriculture Network give guidance on how to avoid damage to wild and used ecosystems – which may be of benefit to this discussion.

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