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 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 eliminated, pastures have disappeared, farmers, livestock and wildlife 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 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 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.

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.
Invasive species are among 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 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 invasiveness, 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 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 invasiveness, 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 are 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 1: Species currently promoted for biofuels that are known to be highly invasive in some circumstances**

<table>
<thead>
<tr>
<th>Species scientific name</th>
<th>Common names</th>
<th>Native range</th>
<th>Habitat type</th>
<th>Invasive in</th>
<th>Vectors of dispersal</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azadirachta indica</td>
<td>Neem</td>
<td>India, Sri Lanka, Myanmar, Bangladesh</td>
<td>Arid lands</td>
<td>West Africa, Australia, Fiji, Mauritius</td>
<td>Birds, bats</td>
<td>Global Compendium of Weeds</td>
</tr>
<tr>
<td>Eleus guineensis</td>
<td>African oil palm</td>
<td>West Africa</td>
<td>Tropical riparian forests</td>
<td>Brazil, Micronesia, Florida in US</td>
<td>Animals</td>
<td></td>
</tr>
<tr>
<td>Jatropha curcas</td>
<td>Physic nut, Barbados nut, curcas bean, purging nut, purple nut, tuba</td>
<td>Tropical America</td>
<td>Arid and semi-arid lands</td>
<td>Australia, South Africa, US (Florida, Hawaii), Pacific islands including Fiji, India, Brazil, Honduras, Panama, El Salvador, Caribbean including Jamaica and Puerto Rico, Galapagos Islands</td>
<td>Water, mud on vehicles and on machinery and animals</td>
<td>Department of Water Affairs and Forestry, South Africa. The Weedy Truth About Biofuels</td>
</tr>
<tr>
<td>Pisonia spp. (especially Pisonia jutila)</td>
<td>Mesquite</td>
<td>Tropical America</td>
<td>Arid and semi-arid lands</td>
<td>Eastern Africa, Horn of Africa, southern Africa, India, Australia</td>
<td>Animals, wind</td>
<td></td>
</tr>
<tr>
<td>Ricinus communis</td>
<td>Castor bean, castor oil bush, palma-christi</td>
<td>East Africa and Asia</td>
<td>Riparian areas</td>
<td>More than 100 countries – Brazil, Australia, Pacific islands, New Zealand, South Africa, Mexico, US, western Europe</td>
<td>Animals, water</td>
<td>The Weedy Truth About Biofuels</td>
</tr>
</tbody>
</table>

Source: Global Invasive Species Programme

Invasive species are among 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.

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? |
| 2.01 | Does it have prolific seed production (>1000/m2)? |
| 2.02 | Does it grow in heavily trafficked areas? |
| 2.03 | Does it have allelopathic qualities? |
| 2.04 | Is it a grass? |
| 2.05 | Is it a garden/amenity/disturbance weed? |
| 2.06 | Is it unsuitable for grazing animals? |
| 2.07 | Is it suited to disturbance? |
| 2.08 | Is it a grassland? |
| 2.09 | Is it a forest? |

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 RSB 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.

Geoffrey Howard, based in Nairobi, Kenya, is technical director of the Global Invasive Species Programme and global co-ordinator for invasive species at the International Union for the Conservation of Nature. E-mail: g.howard@gisp.org.

Silvia Ziller, based in Curitiba, Brazil, is regional invasive species co-ordinator for South and Central America, Global Invasive Species Programme/The Nature Conservancy. E-mail: sziller@tnc.org.