THE WEEDY TRUTH ABOUT BIOFUELS

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INTRODUCTION

If dangerous climate change is to be averted, greenhouse gas emissions must be cut. Alternatives to fossil fuels have a major role to play. But alternative energy sources can create problems of their own—nuclear power plants generate dangerous radioactive wastes, and poorly located windfarms kill birds and bats. Ecologist David Ehrenfield has described such problems as 'friendly fire'.[1]

Plant-derived substitutes for petroleum—known as biofuels—have been touted as an important part of the solution to climate change. But they also have the potential to cause friendly fire problems, and some of them seem likely to do more harm than good. Their value has been called into question, with many critical articles and reports appearing in recent years. In Asia, Africa and South America, rainforests have been felled to grow oil palms, soybeans and sugar cane as biofuel crops, and in the United States the cultivation of corn as a biofuel has drawn criticism because it requires so much energy to produce that savings in greenhouse gas emissions are minimal or non-existent, and because rising demand for ethanol has increased the price of corn as a food. The cricitism is also made that biofuel crops compete with food crops for arable land, in a world where most arable land is needed for food.

Another problem with some biofuel crops—but one that is receiving little attention—is their potential to become serious weeds. Weeds have already inflicted massive ecological and agricultural damage on Australia. The costs to Australian agriculture alone exceed $4 billion a year,[2,3] Global warming is expected to increase the world's weed problems (even without taking into account the weed potential of biofuels).[4] Australia should not try to solve one problem by worsening another. This is particularly so when the potential of many biofuels to mitigate climate change is small at best.

> *"Of our eighteen worst environmental weeds, seventeen were intentionally imported – mesquite (Prosopis juliflora) for example, promoted in the Queensland Agricultural Journal in 1914 as 'one of the most valuable trees that farmers could plant'. In Victoria, two-thirds of weed species were purposely introduced; and in the Wet Tropics, fifty-one of the fifty-three environmental weeds, mostly garden and pasture plants, were deliberate imports."*
>
> - Tim Low (1999) *Feral Future*

In this report the Invasive Species Council assesses the weed threat posed by biofuels in Australia. We believe that biofuels could eventually play a role in reducing greenhouse gas emissions, but this should not be at the expense of Australia's biodiversity or agriculture. We recommend policy approaches to avoid the problems of weedy biofuels, and to promote an environmentally responsible biofuels industry.

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[1] Ehrenfield D (2006)

[2] Martin P (2003)

[3] For example, the costs to the Australian livestock industry are $315 million in weed control and $1.87 billion in yield losses. (Weeds CRC 2005a)

[4] Lovejoy T E and Hannah L (2005); Weeds CRC (2007)

WHAT ARE BIOFUELS?

Plants use sunlight to convert carbon dioxide into organic compounds via photosynthesis. The resulting biomass can be burned for power or transformed into liquid or gaseous fuels in the form of alcohols, methyl/ethyl esters, or hydrogen. Two categories of liquid biofuels are currently used for transport: ethanol produced from plant starch, sugar or cellulose;[1] and biodiesel (methyl/ethyl esters) produced from plant oils. These fuels can be used in existing vehicles, typically blended with petrol or diesel.

A more appropriate term for biofuels when they are grown as crops is 'agrofuels' (agriculture for fuels). This term avoids the automatic positive connotation associated with the 'bio' label. However, to avoid confusion, in this report we will continue to refer to crops grown for fuel as 'biofuels' rather than the more appropriate 'agrofuels'.

The major sources of ethanol today are sugar cane (especially in Brazil) and corn (particularly in the US). The main sources of biodiesel are rapeseed and palm oil, but other biodiesel crops include jatropha, coconut oil, peanuts, sunflower seeds and castor beans. Ethanol and biodiesel crops are readily converted to fuel using existing technology, and they are known as 'first-generation' biofuels.

'Second-generation' biofuels are derived from the cellulose in plant cell walls, the most abundant biological material on earth. Their potential for reducing greenhouse emissions is much higher, but a commercially competitive process for converting cellulose into fuel has yet to be developed.[2] The second-generation biofuels attracting most interest are fast-growing shrubs and trees such as willows, poplars and eucalypts, and tall perennial grasses. These crops are potentially high yielding because they have a high cellulose content, low nutrient requirements, few natural pests, and do not require annual tillage.[3]

Trees can also be harvested at any time of the year. There is a focus on developing new plant varieties to improve biomass productivity, including transgenic varieties. For example, researchers aim to increase the photosynthetic efficiency of plants.[4]

> *"Experts disagree about when facilities to convert lignocellulose to fuel will operate on an industrial scale —it may be five years or ten or twenty."*
> - Schubert (2006)

Algae are another potential biofuel. They can grow very quickly using carbon dioxide generated by power stations. Algal systems can allegedly produce 40 times as much fuel per hectare as corn.[5] In Australia there has been initial investigation of a green alga (*Botryococcus braunii*) found in lakes and reservoirs.[6]

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[1] Plant materials—the lignocellulosic biomass consisting of cellulose, hemicelluloses and lignin compounds, found in plant cell walls—can also be combusted to provide electricity (which is an emerging transport fuel) and process heat (Hill J 2007). The plants considered to have greatest potential as lignocellulosic bioenergy crops are typically perennials, both woody plants such as willows and poplars, and herbaceous species such as switchgrass, reed canary grass and miscanthus.

[2] To convert corn or sugar cane into ethanol is quite simple. Corn starch is converted via an enzymatic process into sugar, which is then fermented by yeast into ethanol. The process is even simpler (and more energy efficient) with cane sugar. In contrast, lignocellulose, the major component of plant cell walls, is very resistant to conversion, having evolved to resist degradation. Wood typically consists of 40–50% cellulose, 25% hemicelluloses and 25–30% lignins. The cellulose and hemicellulose are crystalline fibrils of glucose chains, "largely impenetrable to water or enzymes", and lignin is resistant to fermentation. One approach is to convert the biomass into 'syngas'—mainly carbon monoxide and hydrogen—which is then coverted into ethanol or biodiesel via the Fischer-Tropsch

process. Another approach currently used in pilot plants is to use high temperatures or acid to break apart the lignocellulose, then use enzymes to convert the exposed cellulose into sugars, which are fermented using yeast. The lignin can be burned to help power the plant (Schubert 2006). Bevan M and Franssen M (2006) discuss the significant technological barriers to widespread use of plant biomass.

[3] A high lignin and cellulose content is desirable because high carbon levels give a high heating value, and because lignin allows a plant to stand upright at low water content, which means the biomass can dry on the stem and improve biomass quality (Lewandowski *et al.* 2003).

[4] Ragauskas A J, Williams C K, Davison B H *et al.* (2006)

[5] Schubert C (2006). Also see the website for Greenfuel Technologies Corporation at <www.greenfuelonline.com>.

[6] Qin J (2005)

THE BIOFUELS INDUSTRY

In 2005, about 2% of the world's transport fuels were derived from biomass,[1] of which about 90% was ethanol (predominantly in Brazil from sugar cane) and 10% was biodiesel.[2] Many industry experts are very optimistic about the potential of the biofuel industry. BP's chief scientist, Steven Koonin, predicts that the US, European Union, and India will produce 5% of their road fuels from biomass by the end of 2010, and that eventually "biofuels could supply some 30% of global demand in an environmentally responsible manner without affecting food production".[3] He sees genetic improvements of crops like jatropha and switchgrass (which pose a weed risk) as a key to this future growth.

The benefits of a strong biofuels industry are typically cited as (i) reduced greenhouse gas emissions, (ii) greater energy security (because energy can be produced locally), and (iii) support of agricultural industries.[4]

Industry growth has been driven by government regulations in some countries that require a component of biodiesel and ethanol in diesel and petrol respectively. The corn-based agrofuel industry in the US is sustained by large agricultural subsidies and a 51-cent ethanol tax credit.[5] Governments are also investing in research and development. For example, the US Department of Energy funded the herbaceous energy crops research program which assessed the biofuel potential of 18 perennial grasses and pursued development of the most promising.[6]

Large energy companies have begun investing in biofuels research—BP announced $500 million investment in research over 10 years—and investment capital is becoming available—venture capital firm Kleiner Perkins Caufield & Byers recently launched a $200-million fund for investing in bioenergy.[7]

Australia's biofuels industry is small but growing fast. It is attracting enthusiastic advocates in government and industry, some of whom are making claims that seem highly exaggerated. Making Australia a "biofuels superpower" would "turn Australia from the world's worst emitter of per capita greenhouse gas emissions to one of the pioneers of the new bioeconomy," proclaims one Australian researcher.[8]

Talking up Biofuels

"Australia—the land of infinite sunshine, vast agricultural resources, reliable monsoon rains across the entire northern tropical belt, in other words a land made for biofuels… "
- An Australian business academic proposing a massive biofuels industry in Australia (Mathews 2007)

"Can the Prime Minister advise the House that his National Water Scheme will incorporate North Queensland, which with 50 percent of Australia's water can afford for 5 percent of this to grow sugar cane necessary to provide 100 percent of Australian petrol and 8 perecent of its electricity?"
- Hon. Bob Katter, Parliamentary question, 28 February 2007

"Indeed, ethanol seems to have many things going for it: it's biodegradable, it produces slightly less greenhouse emissions than fossil fuel …, it can replace harmful fuel additives …, it produces jobs for farmers and refinery workers …and it provides a convenient excuse for US and European politicians to subsidize their agriculture."
- Editorial, *Nature Biotechnology,* July 2006

According to the Biofuels Association of Australia, there is currently a biodiesel production capacity (which is distinct from actual production) of about 350 million litres a year, and this is expected to grow to a capacity of more than 800 million litres by 2008.[9] Currently, biodiesel is produced from used cooking oils and animal fats, and there are plans for plants to use imported feedstocks.[10]

Bioethanol production is also very small, with just three current commercial producers with a capacity of about 150 ML.[11] By law, ethanol can be blended with petrol only up to a limit of 10% by volume in Australia.

Biofuels enthusiasts in Australia often look north to the vast areas of 'unused' land across northern Australia. For example, business academic John Mathews, in a report on biofuel prospects in Australia, calls for a 10-year program for "extensive restructuring of Australian rural industry and agricultural activities, with a shift north towards opening up tropical lands fed by regular monsoon rains for sugarcane production and cultivation of new biofuel crops…"[12] Executive Director of the Australia Farm Institute, Mick Keogh, has called for an urgent acceleration of agricultural development in northern Australia and a removal of regulatory constraints. [13]

Apart from the major industry players, an interest in biofuels is coming from small landholders. State governments are receiving many enquiries from individuals seeking advice about jatropha and other possible crops.

[1] Brown L R (2006)

[2] Worldwatch Institute (2006)

[3] Koonin S (2006). The US Department of Energy Office has developed a scenario in which biofuels supply 30% of the gasoline demand of 2004 by 2030. The European Union has a vision for one-quarter of transport fuels to be met by biofuels by 2030. Cited in Cited in Himmel M E, Ding S-Y, Johnson D K *et al.* (2007)

[4] Koonin S (2006)

[5] Schubert C (2006)

[6] Lewandowski I, Scurlock J M O, Lindvall E *et al.* (2003)

[7] Schubert C (2006)

[8] Mathews J (2007)

[9] Biofuels Association of Australia (a recent merger of the Biodiesel Association of Australia and Renewable Fuels Australia) – see <http://www.biodiesel.org.au/>.

[10] Standing Committee on Rural and Regional Affairs and Transport (2007)

[11] O'Connell D, Batten D, O'Connor M *et al.* (2007)

[12] Mathews J (2007)

[13] Anonymous (2007a)

THE PROBLEMS WITH BIOFUELS

Biofuels have a misleading clean, green image. In the public mind they seem a positive alternative to polluting fossil fuels, with lush green plants poised to replace oil drills in providing transport fuel. But a 'bio' label is no guarantee of sustainability, and current analysis shows that there are major problems with biofuels. As with any large-scale industrial development, the environmental, social and economic costs and benefits of the biofuels industry should be thoroughly assessed before being supported.

SOCIAL AND ECONOMIC ISSUES

Worldwide, biofuel crops have a limited role to play because most arable land is already in use.[1] A 10% substitution of petrol and diesel fuel would require 43% and 38% of current cropland area in the United States and Europe, respectively.[2] If all the corn and soybeans grown in the US today were converted into biofuels, they would meet just 12% and 6% of American gasoline and diesel demand respectively.[3]

The African Biodiversity Network warns that the push to grow biofuels in Africa is opening up high conservation value areas to agriculture and pushing farmers off their land: "It seems that agribusiness and biotechnology companies are taking advantage of the biofuels craze to push through a wide range of changes in the trade and farming regulatory set-up that will favour their interests."[4]

It seems inevitable that there will be competition between cropping for food and energy production, to the likely detriment of the poor.[5] The Food and Agriculture Organisation estimates that the cereal import bill of low income, food-deficit countries will increase by about one quarter in 2007 as a direct result of the "ethanol effect".[6] In the US, the price of corn and soybean rose in 2006 due to biofuel demand, corn doubling in price between 2005 and 2007.[7]

Arable land and water are much scarcer in Australia than in most nations promoting biofuels, and competition for land and water would be even more significant.[8] Australia's peak farming group, the National Farmers' Federation, and the Australian Farm Institute, have said Australia does not have enough cropping capacity to sustain a major biofuels industry.[9]

CSIRO scientists have expressed serious doubts about the viability of the current biofuels industry in Australia. Spokesman for CSIRO-led Energy Transformed Flagship David Lamb says "We hear about plans to build new refineries, but even if you add up the total projected capacity, and then

> *"It requires production equivalent to 0.5 ton of grain to feed one person for one year, a value sufficiently large to allow some production to be used as seed for the next crop, some to be fed to animals, and some land to be diverted to fruit and vegetable crops. Compare this value with that for a car running 20,000 km/year at an efficient consumption of 7 liters/100 km. The required 1400 liters of ethanol would be produced from 3.5 ton grain (2.48 kg grain/liter), requiring an agricultural production seven times the dietary requirement for one person."*
>
> …
>
> *"Anything but a marginal contribution from biofuel would pose a serious threat to both food seccurity and the natural resource base of land, soils, and water. "*
>
> - Connor & Minguez (2006)

double it, it comes to only 10 to 15 per cent of Australia's oil consumption."[10] Paul Higgins, of Emergent Futures, says several biodiesel companies in Australia are struggling.[11] Furthermore, "it is far from clear that rapid expansion of Australia's nascent biofuels industry would deliver a cleaner, healthier, environmentally benign, renewable source of automotive fuel."[12]

There are, for example, health concerns about the use of ethanol as fuel, with a recent US study finding that a major switch to ethanol fuel would increase respiratory related illness and death. While use of ethanol reduces levels of two carcinogens—benzene and butadiene—it increases levels of carcinogens formaldehyde and acetaldehyde, and also ozone, a major component of smog.[13]

[1] While many biofuel proponents point to millions of hectares of 'wastelands' that could be transformed by energy crops (65 million hectares in India), and talk of 'miracle' crops such as jatropha that require no irrigation or fertilisation, the reality is that yields in such circumstances will be low. As a reviewer of jatropha projects in developing countries points out, "marginal yields are obtained from plants grown on marginal lands" (Benge 2006).

[2] International Energy Authority (2004)

[3] Hill J, Nelson E, Tilman D *et al.* (2006)

[4] African Biodiversity Network (2007)

[5] Connor D and Minguez I (2006)

[6] FAO (2007)

[7] Hill J (2007)

[8] Less than 7% of the Australian land area is considered arable—see the Geoscience Australia website at <http://www.ga.gov.au/education/facts/dimensions/compare.htm>. While Australia's land area is vast, soils are mostly infertile and water availability is limited. Currently about 50 million hectares are "croplands" – see EarthTrends Country Profiles at <http://earthtrends.wri.org/pdf_library/country_profiles/agr_cou_036.pdf>.

[9] ABC (2007)

[10] Quoted in O'Neill G (2006)

[11] Cited in O'Neill G (2006)

[12] O'Neill G (2006)

[13] Hampton T (2008)

Greenhouse issues

An Australian Taskforce on Biofuels appointed by the Prime Minister[1] concluded in 2005 that biofuels offer only very limited greenhouse benefits, which "alone would not warrant further assisting biofuels, given the availability of much cheaper carbon reduction options."[2] Life cycle analyses of 10% ethanol liquid fuel blends in Australia have found minimal greenhouse benefits compared to the use of fossil fuels—reductions in greenhouse gas emissions of just 1.7% using wheat to 5.1% with C-molasses using co-generation. The emissions savings for biodiesel using 100% canola oil amount to no more than 15 % and no more than 1.5 % for a 5% blend.[3]

A recent study published in *Science* found that when corn was used as a biofuel, emissions were reduced by about 18% below those for conventional gasoline, with an uncertainty band of -36% to +29% (factoring in the use of co-products).[4] Other studies have found even more marginal or negative greenhouse benefits .[5] The major sources of biofuel greenhouse emissions are the fossil fuels used in agriculture and processing of the feedstock, and agricultural practices, such as soil tillage and fertilisation. Nitrogen fertilisers increase outputs of nitrous oxide, a potent greenhouse gas.[6] A study about to be published in *Atmospheric Chemistry and Physics* concludes that generation of nitrous oxide from first-generation biofuel crops is about twice as much as previously thought, as a result of which some biofuels, such as rapeseed and corn, may emit more greenhouse gas emissions than fossil fuels.[7]

Where land is converted from another use that has a higher net sequestration of carbon—eg. native forests or grasslands—the cropping of biofuels contributes to, rather than mitigates, climate change. One of the worst examples is the clearing of Indonesia's peat forests to plant oil palm, in the process destroying carbon sinks, releasing large stores of greenhouse gases, and reducing biodiversity.[8] A recent study published in the

journal *Science* found that over a 30 year period the greenhouse gas emissions saved by biofuels would be much less than the savings that could be achieved by using the same land for forestion. "In all cases, forestation of an equivalent area of land would sequester two to nine times more carbon over a 30-year period than the emissions avoided by the use of the biofuel."[9] After taking this opportunity cost into account, the emissions cost of liquid biofuels was found to exceed that of fossil fuels. In other words, it is better to use fossil fuels more efficiently, conserve existing natural vegetation, and restore natural forest and grassland habitats on cropland not needed for food. The study concluded that the only biofuel option that may be efficacious in the short term is conversion of woody biomass, which is compatible with retention of forest carbon stocks.

> *"Biomass production for new industrial uses, such as automotive fuel, … is the ultimate marriage of convenience between the oldest and most powerful force that has shaped our civilization—agriculture…—and the modern chemical industry…. The latter is running out of cheap petrochemical feedstock, and the former strives to colonize the last few untouched corners of the earth."*
>
> - Ecologists Tad Patzek & David Pimental (2005)

There is considerable variation in the greenhouse potential of various biofuels, with second-generation fuels—perennial grasses and woody biomass—offering greater potential greenhouse savings.[10] As noted, the cultivation of algae may offer larger potential for emissions reductions than other feedstocks (although we caution that if exotic species are used and released into the environment, they also pose a pest risk).

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[1] The Taskforce was appointed to review a 2003 joint study by CSIRO, the Bureau of Transport and Regional Economics and the Australian Bureau of Agricultural Resource Economics on the appropriateness of a national target of 350 megalitres of biofuels by 2010.

[2] Biofuels Taskforce (2005)

[3] O'Connell D, Batten D, O'Connor M *et al.* (2007)

[4] Farrell A E, Plevin R J, Turner B T *et al.* (2006)

[5] Patzek T W and Pimentel D (2005)

[6] Hill J (2007)

[7] The paper by Paul Crutzen is not yet published, but see <http://www.rsc.org/chemistryworld/News/2007/September/21090701.asp>.

[8] Biofuelwatch, Carbon Trade Watch/TNI, Corporate Europe Observatory *et al.* (2007)

[9] Righelato R and Spracklen D V (2007)

[10] The Australian Biofuels Taskforce (2005), noting the potential for lignocellulosic ethanol "to impact materially on the economics of the biofuels industry" recommended that "further policy interventions based on current industry technologies and feedstocks should be limited without a close assessment" of that potential.

BIODIVERSITY ISSUES

There are mounting concerns about the impacts of the biofuel industry on biodiversity. A recent briefing for parties to the international Convention on Biological Diversity, the major international treaty on conservation, warned that:[1]

"large-scale biofuel production can have adverse impacts on biodiversity, including, *inter alia*, habitat fragmentation and degradation, increased greenhouse-gas emissions from degraded carbon sinks and deforestation, water pollution and eutrophication, and overexploitation caused by land conflicts and increase in food prices."

The biofuels industry is driving large-scale destruction of natural areas. Forests are being destroyed in Southeast Asia for palm oil plantations;[2,3] soybean plantations (sown for food as well as biofuels) are the main cause of deforestation in Brazilian Amazon and Paraguay;[4] soybean and sugarcane plantations in Brazil are being carved from the Cerrado, a highly threatened biologically diverse grassy ecosystem;[5] and conservation areas in Africa are coming under pressure from biofuel developments.[6]

In a recent paper in the journal *Climate Change* it was estimated that to replace fossil fuels (coal and oil) with energy from modern biomass, humans would need to increase their current demand on Earth's terrestrial photosynthetic resources (plants) by approximately 50% .[7] Humans already use about 40% of the earth's total photosynthetic productivity,[8] so this would exact a massive cost on other species. We would need to harvest 22% of all land plants just to equal the fossil fuel used in 1997.[9]

Biodiversity is also harmed by agricultural practices such as use of water, fertilisers and pesticides. Agricultural runoff from US corn farms into the Missisippi River creates a vast 'dead zone' in the middle of the Gulf of Mexico each summer.[10]

What most reports and reviews fail to address is the weed risk posed by many proposed biofuel crops. This issue rates only a passing mention in the Convention on Biological Diversity briefing paper, [11] and is not mentioned at all in a United Nations report on sustainability issues associated with biofuels.[12] In Australia, the issue was overlooked by the Biofuels Taskforce[13] and a recent Senate inquiry.[14]

[1] Executive Secretary (2007)

[2] Colchester M, Jiwan N, Andiko *et al.* (2006)

[3] Most existing palm oil plantations have been developed for cooking oil. The biodiesel industry is creating strong incentive to increase production, and is predicted to become the main driver of palm oil expansion in Southeast Asia (World Rainforest Movement 2006)

[4] World Rainforest Movement (2006)

[5] Klink C and Machado R (2005)

[6] African Biodiversity Network (2007)

[7] Dukes J (2003)

[8] Vitousek P, Ehrlich P, Ehrlich A *et al.* (1986)

[9] Dukes J (2003)

[10] Schubert C (2006)

[11] The one mention of the weed problem is of "the potential risks that, in an effort to increase production and meet growing demand for biofuels, energy crops that present many characteristics of a weed, such as jatropha, may become invasive." (Executive Secretary 2007)

[12] UN-Energy (2007)

[13] Biofuels Taskforce (2005)

[14] Standing Committee on Rural and Regional Affairs and Transport (2007)

THE WEEDY POTENTIAL OF BIOFUELS

The shrub called jatropha (*Jatropha curcas*) is often touted as the ideal biofuel crop because it can be grown with ease on 'waste lands', a virtue espoused in a recent article in *Scientific America*:[1]

"Jatropha seems to offer the benefits of biofuels without the pitfalls. The plants favour hot, dry conditions and hence are unlikely to threaten rain forests. There is no trade-off between food and fuel either, because the oil is poisonous."

But jatropha happens to be a weed. In 2006 the Western Australian government banned its use as a biofuel after a risk assessment found it was weedy in 14 countries.[2] Many other plants advocated as biofuels also have histories as weeds, including two grasses that appear on the IUCN's list of '100 of the World's Worst Invaders'.

There are sound ecological reasons why this should be so. As noted recently in the journal *Science*, "traits deemed ideal in a bioenergy crop are also commonly found among invasive species."[3] Biofuel crops such as corn and soybeans attract criticism because they require large amounts of water, fertiliser and fossil fuel inputs to produce a yield. These large inputs can be avoided if the biofuel plant can grow without care or attention—in other words, the plant has the attributes of a weed. Weedy attributes of ideal biofuel plants include hardiness, water thrift, a paucity of pests or diseases, and an ability to outcompete other plants.

Concerns about weedy biofuels have been expressed in the scientific literature. In 2006, seven scientists published an article in the journal *Science*, pointing out that two grasses with potential as biofuel crops—giant reed and reed canary grass—are invasive weeds in America. These same grasses are highly invasive in Australia. The article concluded that "Experts must assess ecological risks before introducing biofuel crops, to ensure that we do not add biofuels to the already raging invasive species fire."

> *"Experts must assess ecological risks before introducing biofuel crops, to ensure that we do not add biofuels to the already raging invasive species fire. "*
>
> - Scientists warning of biofuel weed risks in *Science* (Rhagu *et al.* 2006)

> *"The consequences of biotic invasions are often so profound that they must be curbed and new invasions prevented.*
>
> *...Rarely is the saying 'an ounce of prevention is worth a pound of cure' so applicable as with biotic invasions."*
>
> - Ecologists writing about weed ecology in *Ecological Applications* (Mack *et al*. 2000).

The weed risk may be especially high when biofuels are planted as a speculative venture. New agricultural ventures have a history of causing pest problems in Australia. In the 1970s deer farming was promoted as an exciting new highly profitable prospect for rural landholders. The 1978 book *Gold on Four Legs* used the same kind of rhetoric that is applied today to jatropha:[4]

"Deer are … relatively free from major disease problems, easy to look after, excellent converters of most types of fodder… They may be farmed under a wide range of conditions…"

But the profits failed to materialise, and by 2003, the value of venison had fallen below its 1978 value.[5] When the market for deer products crashed during the 1990s, "many deer were liberated when the cost of feeding them rose

above their value".[6] As a result, Australia now has at least 77 feral deer herds that can be attributed to escapes and releases from deer farms,[7] and a fast-growing feral deer problem. Deer are causing serious damage to crops and national parks, and an increasing number of car collisions.

The Invasive Species Council is concerned that biofuel crops will follow the same trajectory. Enthused by the biofuels hype, naïve landholders will speculatively plant fields of jatropha or Chinese tallow, and when markets for the products fail to emerge the plants will be left to shed their seeds and spawn weed problems. No method exists for mechanically harvesting jatropha or Chinese tallow seeds, so there is a technological barrier to their commercial use in Australia. In India and Africa, jatropha is harvested by hand by children and poor villagers, an option not available here.

Neem, which has been planted in northern Australia as a medicinal plant, and which is considered a potential biofuel, is already emerging as a serious weed because birds are spreading the seeds.[8] The olive is another potential biofuel following a similar trajectory, with many small plantings undertaken for culinary oil, which will not be viable to harvest mechanically, likely to create future weed problems as past plantings have done. The olive is the worst weed in the Adelaide region.

The more often a plant is grown, the more likely it is to become a major weed.[9] Giant reed became a major problem in California more than a century after it was introduced when it was planted widely to stabilise stream banks. At present it is not considered a major weed in Australia but the biofuels industry could change that. Jatropha is another weedy biofuel that could multiply dramatically if it is grown over vast areas.

Cultivation also increases the weed risk when vigorous new varieties are developed. The attributes that are bred for a biofuel—rapid growth rates, pest and disease resistance, drought resistance—increase the risk of a plant becoming a weed.

The greater risks associated with agricultural plantings are often not taken into account in weed assessments—if assessments are undertaken at all. The ecologists who wrote in *Science* about the weediness of biofuels criticized the lack of weed risk assessments of biofuels. In Australia, there have been only ad hoc risk assessments of biofuel prospects.

Ecologists emphasise the very high ecological and economic costs of not doing proper assessments. As noted in the Introduction, Australians are already paying a very high price for a failure to assess weed risks—with an agricultural cost estimated at $4 billion a year. Half a million dollars is being spent annually to keep just one weed, *Mimosa pigra*, at bay in Kakadu National Park.[10] Rubber vine in Queensland was estimated to cost the economy $27 million in 1995 alone.[11] Both of these weeds were introduced to Australia deliberately as ornamental plants.

Ironically, the risks associated with introduced species are often only assessed properly when species are introduced as biological controls to help reduce the harm caused by other introduced species. This sort of risk-based assessment should be applied to plants that will be planted agriculturally.

In the following sections we summarise the weed risks posed by various proposed biofuel plants. Our list is not comprehensive. It includes species that have either been nominated as potential biofuel crops for Australia or which are receiving enough attention overseas that there is likely to be some Australian interest as well.

There are many many more plants exciting biofuel interest. The Botanical Survey of India has apparently identified more than 400 species of plants and trees that yield oils of biodiesel potential.[12] Because there are few limitations on agricultural experimentation in Australia, landholders may try out different species that they read about over the internet. For example, there were recent newspaper reports of the planting of up to 1000 hectares of *Copaifera Langsdorffii*

(known as diesel tree) on the coast north of Mackay. While there are no indications that it is a weed, it exemplifies how easily a new, potentially invasive, species can be speculatively planted.

The plants in the next section are listed in the approximate order of the degree of weed threat we fear they pose, taking into account their popularity as biofuels as well as their weed history, with the worst plants considered first. It concerns us that *most* of the plants attracting serious attention as biofuels have a substantial history as weeds.

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[1] Renner R (2007)

[2] Randall R (2004)

[3] Raghu S, Anderson R C, Daehler C C *et al.* (2006)

[4] Anderson R (1978)

[5] Jesser P (2005); Anderson R (1978)

[6] Norris A and Low T (2005)

[7] Jesser P (2005)

[8] Grice T (2002)

[9] Mack R N, Simberloff D, Lonsdale W M *et al.* (2000)

[10] Martin P (2003)

[11] Martin P (2003)

[12] Balaji R (2005)

JATROPHA (JATROPHA CURCAS)

Other names: Physic nut, Barbados nut, curcas bean, purge nut, purging nut, tuba

Description: Jatropha is a tall shrub or small tree growing to about 6m, producing oil-rich seeds. It is native to Central America. The leaves and seeds are poisonous to people and livestock.

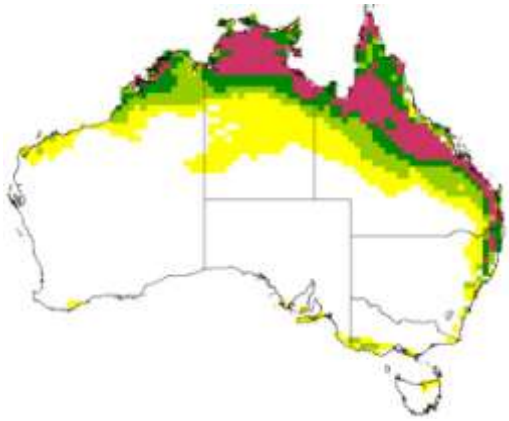
Weed Status: Jatropha is weedy in India, Brazil, Fiji, Honduras, Panama, El Salvador, Jamaica, Puerto Rico and other parts of the Caribbean, Florida, Hawai'I, the Galapagos Islands, the Comores and Australia.[1]

It is especially problematic in the Comores Archipelago, east of Mozambique, where it is rated one of the four main invasive woody weeds of coastal vegetation, along with lantana, leucaena and guavas.[2]

In Australia, jatropha is a weed in Western Australia, the Northern Territory and north Queensland. The largest infestations occur in north Queensland—Emu Creek near Petford is infested along its entire length of 60 kilometres.[3] Thickets of 20-30 plants occur along the creek, alternating with sections of stream where only scattered plants occur. The largest thicket is 100 m long and 50 m wide. [4]Jatropha is also invasive on the nearby Hodginkson River, where one very dense infestation is 40-50 metres across.

Jatropha is declared a weed in the Northern Territory and in Western Australia. Its weed risk is being assessed in Queensland. Australian Quarantine does not permit its import into Australia.

The Western Australian government risk assessment which led to the declaration of jatropha concluded that it would be virtually impossible to prevent the movement of seeds from plantations onto adjoining land.[5] This assessment modelled the potential distribution of jatropha as a weed, and concluded that it could establish as far south as central New South Wales and perhaps Victoria (see map below).[6] Climate change would expand the area suitable for establishment.



Jatropha is closely related to bellyache bush, (*Jatropha gossypiifolia*), one of Australia's worst weeds, and one that is subject to biological control programs which could be constrained by jatropha plantations, because an insect that attacked one might also attack the other.

Biofuel Status: Of all the weedy plants promoted as biofuels, none is attracting more global interest and hype than jatropha. It is regularly touted as a 'miracle plant', 'green gold in a shrub'[7], a plant that will 'break the cycle of poverty' in the developing world[8] and 'help to cure the planet'.[9]

Extravagant claims about jatropha have generated strong interest in Australia, promoting considerable discussion on biofuel list-servers, and leading to experimental plantings. In 2006 the Australian Biodiesel Group, which has two production plants, announced it would encourage producers to grow jatropha.[10] Reports have been received of landholders in New South Wales driving to north Queensland to collect the seeds from wild plants.[11] The administrator of the Bio Fuels Forum has sung its praises, describing it as

"an excellent crop", "perfect for growing in arid climates",[12] and a recent paper in *Farm Policy Journal* estimated that 20 million hectares of marginal land in northern Australia was suitable for its cultivation.[13] A recent report on biofuel prospects in Australia for the Rural Industries Research and Development Corporation notes that jatropha is a "tree crop with high production potential, largely untested in Australia", but also notes it has the “undesirable characteristic” of being a noxious weed.[14]

But Jatropha has little value as a crop in Australia at present. In Third World countries jatropha seeds are gathered by children or poor peasants, greatly limiting its value as a substitute for petroleum. A mechanical harvester for jatropha has recently been developed, but yields are limited by the uneven ripening of jatropha pods.

Exaggerated claims about jatropha first surfaced in India, where it was touted as a solution for major national problems. India is highly dependant upon imported petroleum supplies, has vast tracts of waste land, diminishing water supplies, and millions of rural poor. Hardy jatropha was proposed as something that would thrive on degraded lands without any fertilisation or irrigation, providing income for millions of rural poor, and reducing India's dependance on imported fuel.

Indian government agencies remain enthusiastic advocates of jatropha cultivation, despite mounting evidence that early claims were unrealistic. A 2004 review of several major jatropha projects—in India, Nicaragua and Belize—found that "actual economic, social and environmental effects have been mostly not noticeable, poor and disastrous."[15] That review was conducted by the Global Facilitation Unit for Underutilized Species, operating partly under the Food and Agriculture Organisation of the United Nations, a unit that was created to promote plants such as jatropha. It found that yields had been greatly overestimated and logistical problems ignored. Like any other crop, jatropha will not produce high yields unless it is watered and fertilised. Yields based on well-tended crops had been extrapolated to wastelands, when in fact "marginal yields are obtained from plants grown on marginal lands".[16]

Other reports appearing in recent years question the value of jatropha. A recent article in the *Wall Street Journal* tells of jatropha farmers suffering "financial losses after their crops yielded less oil than expected or buyers failed to pay sufficient prices."[17] *The Hindu* newspaper went further, reporting on jatropha farmers seeing their hopes "unfailing shattered".[18] A review of African projects also found that expectations were unrealised, concluding with respect to the Tanzanian project, for example, that “it is economically not interesting to use Jatropha oil as diesel substitute.”[19]

But large-scale plantings continue. Although jatropha is said to be good for the environment because it is only grown on wastelands, in Malaysia and Brazil rainforests have recently been destroyed to plant it.[20] And in China, concerns have been raised about the likelihood of jatropha plantations replacing highly diverse forests in Yunnan, Sichuan and Guizhou provinces.[21]
The most prominent company promoting global plantings of jatropha, D1 Oils, saw its share price slump 37 per cent early in March 2008, after reports emerged of financial difficulties[22].
Company founder Karl Watkin then resigned, delivering an angry broadside at the supposed ‘inability of the investment community, governments and NGOs to differentiate D1’s strategy from that of the suppliers of palm, soya and rapeseed whose biodiesel products have been well documented as being environmentally sustainable’.[23] Friends of the Earth countered with a statement saying that D1 Oils had unrealistic hopes for jatropha, that yields had been lower than expected, and that jatropha had been grown in an unsustainable way.[24] D1 Oils has expressed a strong interest in growing jatropha in northern Australia.

Recommendation: Jatropha should not be grown as a biofuel in Australia. Western Australia and the Northern Territory have declared jatropha a weed, thereby prohibiting its cultivation. Queensland and New South Wales—the other

states in which it can be grown—should also declare jatropha a weed.

[1] Holm L G, Pancho J V, Herberger J P *et al.* (1979); Binggeli P, Hall J B and Healey J R (1999); Gann G D and K.A. B (2000);Randall R (2004); Werren G (2001) USDA and NRCS (2007)

[2] Vos P (2004)

[3] Sid Clayton, Mareeba Shire (pers. comm.)

[4] Steve Csurhes, Biosecurity Queensland (pers.comm.)

[5] Randall R (2004)

[6] Map from Randall R (2004)

[7] Renner R (2007)

[8] Eg. the Centre for Jatropha Promotion & Biodiesel, Rajasthan, India, <www.jatrophaworld.org>.

[9] Macintyre B (2007)

[10] Collie G (2006)

[11] Jeff Cummings, Biosecurity Queensland (pers. comm.)

[12] Robert Fyvie, who also administers the Sydney Biodiesel Users' Group and Australian Biofuel Users, in a message to the Bio Fuels Forum posted 10 Jan 2006. He noted that jatropha will "grow in saline soils and already grows wild in many parts of Australia."

[13] Odeh I and Tan D (2007)

[14] O'Connell D, Batten D, O'Connor M *et al.* (2007)

[15] Euler H and Gorriz D (2004)

[16] Benge M (2006)

[17] Barta P (2007)

[18] Natarajan G (2007)

[19] Henning R (2003)

[20] Low T (2007)

[21] Hepeng J (2008)

[22] Essen Y (2008)

[23] Macalister T (2008)

[24] Ibid

GIANT REED (*ARUNDO DONAX*)

Other names: Oboe reed, E-grass, bamboo, danubian reed, elephant grass, giant danube reed, spanish reed

Description: Giant reed is a very large reed-like grass, growing up to 8 m tall, thought to be native to wetlands in eastern Asia. It can grow very quickly when water is plentiful.

Weed Status: Giant reed has become a weed in many countries, earning a place on the IUCN list of 100 of the World's Most invasive species.[1] It is one of the main threats to riparian habitats in the western US, and many millions of dollars each year are spent on control.[2] In California work is underway to develop biocontrol agents to attack this plant.[3] Nearly every coastal watershed in California has an infestation or is dominated by giant reed, except where it has been removed.[4] It can form very large stands in wetlands and on riverbanks, often extending over many hectares, and excluding all other plants. Its expansive root masses, which can grow to more than a meter thick, alter creek and stream flows. They also increase flooding because the roots are "mobilized by rushing water, pulling the stream bank with it." The plant has caused extensive damage to infrastructure because the stalks "collect behind a culvert or under a road overpass forming a matt that would apply pressure to the structure from the force of the water pressing against it"[5] (see photo section). Giant reed invades both disturbed and natural areas, even those in good ecological condition, and is highly flammable. It is spread by floods and flowing water transporting pieces of its underground stems.

Giant reed seriously depletes water supplies, imbibing as much as 2,000 litres of water per standing metre of growth.[6] In South Africa giant reed is considered "a national problem" because it threatens water security for the nation's growing human population. In the Santa Ana River system millions of dollars of drinking water have been lost.[7]

Giant reed was introduced to Australia long ago as an unusual ornamental grass. It has already invaded many Australian wetlands. Along the Swan River in Perth it has developed massive clumps, one at least 100m long.[8] It is invasive along the Hunter, Paterson and Williams rivers in New South Wales.[9] But giant reed is less invasive in Australia than California, a difference that apparently reflects the number of plantings—in California it was introduced over a hundred years ago but only became a serious weed after it was widely planted for erosion control during the 1950s. If giant reed is planted in Australia as a biofuel the level of weed invasion can be expected to rise dramatically. The head of the Australia Weeds CRC, Dr Rachel McFadyen, has warned about the serious weed risk posed by this plant.[10]

Biofuel Status: Under the name 'e-grass', giant reed has been promoted as a biofuel for ethanol production in the US. The Florida Native Plant Society has strongly opposed plans by the Biomass Investment Group, which claims to be an 'environmentally friendly' company, to cultivate e-grass in Florida. Because e-grass has been genetically selected for rapid growth it is likely to be weedier than previous cultivars of giant reed, which were selected for their ornamental striped leaves.[11] In Europe a Giant Reed Network was established in 1997 to promote the plant as a pulp and energy source.[12]

In Australia, giant reed has been promoted by the South Australian Research and Development Institute (SARDI) as a promising biofuel. A webpage on the SARDI website shows men standing beside giant reed crops two to three times their height. The webpage claims that 'The possible weed risk can be neglible with appropriate management strategies.'[13] While it is true that giant reed can be grown under circumstances where the weed risk is minimal (for example in isolated farm dams in arid areas), the history of pest problems in Australia shows that invasive species regularly escape human control as a consequence of carelessness or disregard for guidelines. If giant reed is promoted in South Australia as a biofuel there is a high risk of landholders ignoring any guidelines and growing it close to the Murray River, along which it would spread, especially during floods. Giant reed could also establish as a weed from pieces of stem falling from trucks. Giant reed does not produce seed, but spreads instead when stems or rootsocks are moved about by people or water.

Giant reed has been declared a weed by 14 local councils in NSW because of the problems it is causing along rivers.

Recommendation: Giant reed should be a declared weed in all states and territories of Australia. Given its existing wide distribution as a weed, and the impossibility of eradicating it at the landscape level, the appropriate level of declaration would be one that prohibits cultivation and sale but does not require the removal of wild infestations except where natural wetlands areas or croplands are threatened by its spread.

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[1] Lowe S, Browne M, Boudjelas S *et al.* (2000)

[2] Bell G (1998)

[3] Tom Dudley, Marine Science Institute, University of California (pers.comm.)

[4] Valerie Vartanian, Horticulture and Landscape Professions Liaison, The Nature Conservancy (pers.comm.)

[5] Valerie Vartanian, Horticulture and Landscape Professions Liaison, The Nature Conservancy (pers.comm.)

[6] Bell G (1998) citing others.

[7] Valerie Vartanian, Horticulture and Landscape Professions Liaison, The Nature Conservancy (pers.comm.)

[8] Rod Randall, Department of Agriculture & Food, WA Government (pers. comm.)

[9] Bunn K (2004)

[10] McFadyen R (2005)

[11] Florida Native Plant Society (2006)

[12] Lewandowski I, Scurlock J M O, Lindvall E *et al.* (2003)

[13] See http://www.sardi.sa.gov.au/pdfserve/water/products_and_services/use_of_giant_reed_a4_100dpi.pdf

CHINESE TALLOW TREE (*TRIADICA SEBIFERA*)

Other names: This tree is usually listed on biofuel websites as *Sabium sebiferum*, a previous scientific name for the plant.

Description:[1] Chinese tallow is a fast-growing, deciduous tree from China and Japan, which grows up to 12 m tall. In Australia and elsewhere it is grown as an ornamental tree. The foliage is toxic to cattle.

Weed Status: Chinese tallow is highly invasive. Each tree produces up to 100,000 seeds a year, which are spread by birds and water and can remain viable for decades. It rates as one of North America's worst weeds, and is also a serious problem in Australia. The American Nature Conservancy lists it as one of 'The Dirty Dozen'—the 12 worst invasive pests in the United States.[2] In Texas it has converted much of the upper coastal prairie to woodland, eliminating habitat of the endangered Attwater's prairie chicken. In Australia, an infestation of 5-10 hectares dominates the Casino wetland in northern New South Wales, and an eradication effort is underway.[3] The infestation in Casino has expanded extremely rapidly in a short period, almost doubling in size and quadrupling in numbers each year. According to the U.S. Natural Resources Conservation Service, once established, "it is virtually impossible to eliminate by known methods".[4]

Chinese tallow is currently a declared weed in northern NSW and would require assessment prior to being permitted in Western Australia. The Queensland government is considering declaring this plant a prohibited weed. The seeds and nursery plants are legally permitted entry into Australia by Australian Quarantine.

Biofuel status: In Asia the Chinese tallow tree has been used for over 1500 years for the oil in its seeds. It is now considered a potential source of biodiesel,[5] and touted on hundreds of websites. It is also regarded as a promising biomass candidate in the United States, because of its rapid growth rate, its ability to re-sprout, and its drought and salt tolerance.[6]

US Biofuel company AgriBioFuels claims that Chinese tallow can produce 500 gallons of oil per acre, compared to 48 gallons for soybeans.[7] They are working with Texas A&M Research Centre to develop the plant as a crop. Oil company Chevron has built a biodiesel plant in Texas, and Chinese tallow is considered a major potential feedstock.

There has also been interest in Australia. A 2001 report on biofuels by the Western Australian Department of Agriculture recommended Chinese tallow as one of several oil-bearing plants "that should undergo some preliminary studies in Western Australia".[8] Its potential has been discussed on the Biofuels Forum, the forum of the Australian Biofuel Users group.

Recommendation: Given the high weed risk, Chinese Tallow should not be considered as a biofuel. It should be declared a weed in all states.

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[1] USDA and NRCS (nd)

[2] Stein B and Flack S (1996)

[3] North Coast Weeds Advisory Committee (2004)

[4] US Departments of Agriculture and Energy (2007)

[5] Crymble S, Copeland B, Zappi M *et al.* (2005)

[6] USDA and NRCS (nd)

[7] See <http://www.agribiofuels.com/biofuels-market.php>.

[8] Carmody P, Carr H, Morcom A *et al.* (2001)

Reed Canary Grass (*Phalaris arundinacea*)

Other names: Swamp phalaris.

Description:[1] Reed canarygrass is a tall, coarse perennial grass growing 1.5-3 m high, with roots reaching down more than 3 m. It can form dense masses of broad, leafy foliage in wetlands, riparian areas and drier upland areas.[2]. Native to Europe, Asia and North America, it has been widely planted elsewhere as a forage crop.

Weed status: Reed canary grass is a very serious weed in several regions of the world. It "can aggressively take over whole plant communities,"[3] and in the United States has displaced native species on tens of thousands of hectares of wetlands.[4]

It is a serious wetland weed in southern Australia,[5] although not yet widespread. Reed canary grass is one of the species posing a serious threat to Yellingbo Reserve near Melbourne, one of the last refuges of the endangered helmeted honeyeater. Its weed potential will increase dramatically if it is widely planted as a biofuel.

Biofuel status: Reed canary grass has been extensively investigated as a biofuel crop in Sweden[6] and in Britain.[7] It has not received much attention in Australia but that could change in future.

Recommendation: Reed canary grass should not be grown as a biofuel in Australia.

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[1] Lewandowski I, Scurlock J M O, Lindvall E *et al.* (2003)

[2] Miller R and Zedler J (2003)

[3] Molofsky J, Morrison S and Goodnight C (1999)

[4] Miller R and Zedler J (2003)

[5] For example, in tussock sedge wetlands in Victoria. (DSE 2005).

[6] Lewandowskia I, Scurlockb J M O, Lindvallc E *et al.* (2003)

[7] DTI (2006)

Neem Tree (*Azadirachta indica*)

Description:[1] Neem is a tree with frond-like leaves native to India and Burma. It is popular in India as a source of medicines and insecticides. In northern Australia it is sometimes grown as a shade tree, and some landholders have planted it as a source of insecticide The fruits are attractive to birds.

Weed status: In recent years neem has emerged as a serious weed in the dry tropics of northern Australia. In a recent article published by the Weeds CRC, 'Neem - miracle tree or ecological menace?', there is a call for immediate action to prevent further spread of this tree.[2] Neem has become a prolific weed along the Gilbert River in the Gulf of Carpentaria, along the Victoria River in the Northern Territory, along the Ord River in Western Australia, and around Broome. Its seeds are spread down watercourses, and by fruit-eating birds such as bowerbirds. According to CSIRO scientist Tony Grice:

"There is a need for immediate policy measures and actions to remove the risk of further infestations developing, to document the scale of current infestations, and put in place strategies for containment or, where possible, eradication."

Neem is not declared as a weed in any Australian state or territory. All applications to import seed must be referred to the Plant Programs Branch,

Canberra for approval. But Australian Quarantine permits its importation as nursery stock.

Biofuel Status: Neem is one of the plants talked about as a promising biofuel, especially in India, although it is not attracting as much interest as jatropha.[3]

Recommendation: Neem should not be planted as a biofuel, or for any other purpose.

According to CSIRO weed scientist Tony Grice: "It seems unlikely that neem plantations can be managed in such a way as to remove the risk of birds dispersing viable seeds into nearby natural habitat.

[1] Grice T (2002)

[2] Grice T (2002)

[3] Eg. Desai R B (2005)

SWITCHGRASS (PANICUM VIRGATUM)

Description:[1] Native to North America, switchgrass is a tall perennial prairie grass, growing up to 3 m in height and with roots down to more than than 3:5 m. It is adapted to a broad range of conditions, growing naturally from southern Canada to Central America, on a wide range of soil types. Switchgrass spreads vegetatively (via rhizomes) and by seed. It has been used extensively, both naturally and planted, as a forage for cattle.

Weed status: Switchgrass is recognised as invasive in the US,[2] and is likely to have high invasive potential elsehwere.[3] Introduced grasses have a long history of invasiveness in Australia, and there are already weedy *Panicum* species here. However, switchgrass has been assessed as a weed and is not permitted entry into Australia by Australian Quarantine.

Biofuel status: There has been considerable research in the US on switchgrass as a biofuel, with the US Department of Energy funding a program to develop it as the model crop system for biofuels.[4] It has also recently been assessed in several studies in Europe as a potential energy crop.[5] US researchers concluded that the "energy flux in a switchgrass-based biofuels system is quite favorable."[6] But at this stage it has been assessed as not economically feasible in either the US or Europe—"market factors will need to change before switchgrass for energy is economically competitive" and establishing herbaceous biomass-based power systems will be a large undertaking.[7]

Switchgrass has been nominated in a biofuels report by the Rural Industries Research and Development Corporation as "worthy of further investigation for Australia".[8]

Recommendation: Many *Panicum* grass species are weeds and there is a high likelihood of switchgrass being invasive if it was planted in Australia. As a high-risk species, switchgrass should not be considered as a biofuel.

[1] Parrish D J and Fike J H (2005); Lewandowski I, Scurlock J M O, Lindvall E *et al.* (2003)

[2] USDA and NRCS (2007)

[3] Raghu S, Anderson R C, Daehler C C *et al.* (2006)

[4] Lewandowskia I, Scurlockb J M O, Lindvallc E *et al.* (2003)

[5] Montia A, Fazioa S, Lychnarasb V *et al.* (2007)

[6] Parrish D J and Fike J H (2005)

[7] Parrish D J and Fike J H (2005); Montia A, Fazioa S, Lychnarasb V *et al.* (2007)

[8] O'Connell D, Batten D, O'Connor M *et al.* (2007)

MISCANTHUS (*MISCANTHUS* SPECIES)

Other names: Amur silvergrass (for *M. sacchariflorus*) and Chinese silvergrass (for M. sinensis)

Description:[1,2] These are tall, long-lived grasses originating in East Asia. The most favoured variety, Miscanthus *x* giganteus, is probably a natural hybrid which does not form fertile seeds. It grows up to 4 m high. The other species of interest for bioenergy are *M. sacchariflorus* and *M. sinensis*. These grasses are very hardy, growing in tropical and warm temperate climates on a wide range of soils, and surviving in plantations for up to 25 years.

Weed status: Miscanthus is a weed in North and South America, Europe and Asia.[3] In Australia, Chinese silvergrass is weedy in New South Wales, South Australia and Western Australia.[4] In New South Wales, for example, it is spreading along railway lines.

In a recent article in *Science*, seven scientists warned about the weed risk posed by Miscanthus as a biofuel species.[5] In recognition of its invasiveness, the European *Miscanthus* Improvement project recommended that new genotypes be sterile.[6] But sterile grasses often spread very successfully as weeds, giant reed serving as an extreme example. Also, perpetual sterility cannot be guaranteed.[7]

Miscanthus x giganteus is prohibited entry in Austalia, but Australian Quarantine permits import of *M. sacchariflorus* and *M. sinensis*.

Biofuel status: The European Miscanthus Productivity Network has conducted extensive field trials in 10 European countries on the biomass potential of miscanthus, and the development of new hybrids.[8] Biomass yields are reportedly high, although establishment costs of the common hybrid Miscanthus *×* giganteus are high because of the need to propagate it vegetatively, and commercial yields are likely to be much less than trial yields.[9] There have been small-scale trials in the US and Canada, and it has been recommended that "serious investigation" proceed in the United States.[10]

Recommendation: Miscanthus should not be grown in Australia because of the weed problems it can be expected to create.

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[1] Lewandowskia I, Scurlockb J M O, Lindvallc E *et al.* (2003)

[2] Lewandowski I, Clifton-Brown J C, Scurlock J M O *et al.* (2000)

[3] Randall R (2002)

[4] Harden G W (1993)

[5] Raghu S, Anderson R C, Daehler C C *et al.* (2006)

[6] Lewandowski I, Scurlock J M O, Lindvall E *et al.* (2003)

[7] Raghu S, Anderson R C, Daehler C C *et al.* (2006)

[8] Lewandowski I, Scurlock J M O, Lindvall E *et al.* (2003); Lewandowski I, Clifton-Brown J C, Scurlock J M O *et al.* (2000)

[9] One review says that miscanthus does not "produce economic yields until a few years after establishment and that even then commercial yields tend to be below what is theoretically possible, given variations in rainfall, soil types, interception radiation and conversion efficiencies." Commercial yields may only be 20% of theoretical yields. (Sims R, Hastings A T, Schlamadinger B *et al.* 2006)

[10] Scurlock J M O (1999)

SPARTINA (*SPARTINA* SPECIES)

Other names: cordgrass, rice grass, marsh grass, townsends grass.

Description: Spartina is a group of lush grasses that grow on mud in brackish wetlands and saline riverbanks in temperate regions. The various species are native to North and South America, Europe and Africa.

Weed Status: Spartina appears on the World Conservation Union's list of 100 of the 'World's Worst' invaders.[1] In Australia these grasses have invaded saline areas in Victoria, Tasmania, and South Australia, where they convert mudflats into rank grasslands, eliminating habitat for wading birds and killing mangroves by altering sediment dynamics. The Natural Heritage Trust provided $1 million to control spartina in Tasmania. *Spartina anglica* is a prohibited plant in Western Australia and declared as a noxious aquatic plant in Victoria.

Biofuel Status: Spartina is considered to have good potential as a second-generation biofuel because it produces high levels of biomass. The US government is funding research on the use of *Spartina pectinata* as a biofuel[2], and *S. anglica* has been used as a biofuel in China.[3]
In Australia Spartina is listed in a report for the Rural Industries Research and Development Corporation as a potential fuel crop.[4]

Recommendation: Spartina should not be considered as a biofuel crop in Australia. There are many other plants capable of producing high levels of biomass that are not weeds.

[1] Hammond M (2001)

[2] US Departments of Agriculture and Energy (2007)

[3] Chung C-H (2006)

[4] Wondu Holdings Pty Limited (2000)

OLIVE (*OLEA EUROPAEA*)

Other names: *Olea europaea* ssp. *africana, Olea europaea* ssp. *cuspidata,Olea europaea* ssp. *Europaea,* African olive, common olive, European olive, olive tree, small-fruited olive, wild olive

Description: Olive is a small tree with slender leaves, native to the Mediterranean region. It produces edible oil-rich fruits.

Weed status: The olive is a "major environmental weed" in parts of south-eastern Australia, especially around Adelaide,[1] where whole hillsides are now clothed in dense olive thickets. An African variety of the olive is extremely invasive on Norfolk Island. Olive seeds are spread widely by birds and foxes.

The olive is likely to worsen as a weed in future, with many landholders in south-eastern Australia having established new plantations, many of which are unlikely to produce an economic return.

Biofuel status: Olive oil is often listed as a biodiesel, along with other standard oils,[2] although it is more expensive to produce than many oils. A WA Department of Agriculture report on biodiesel prospects refers to olives as one of the "of the best species which lend themselves to fuel production", and as "already adapted" to WA's Mediterranean environment.[3]

Recommendation: Olives should not be grown as biofuels. Given the high cost of producing olive oil, it is unlikely to prove viable as a biofuel, and any olives planted speculatively are likely to remain unharvested, resulting in birds and mammals spreading the seeds and creating a serious weed problem.

[1] Richardson F J, Richardson R G and Shepherd R C H (2006)

[2] For example, by Australian Renewable Fuels Limited at <http://www.arfuels.com.au/default.asp?V_DOC_ID=908>.

[3] Carmody P, Carr H, Morcom A *et al.* (2001)

CASTOR OIL PLANT (*RICINIS COMMUNIS*)

Other names: castor bean, castor oil bush, palma-christi

Description:[1] Castor oil plant is a tall shrub, with large soft leaves, which grows to 3 m high. Its ripe fruits explode, throwing seeds over several metres. The plant is native to Asia and Africa. The seeds are poisonous (due to ricin), and are the traditional source of castor oil, which has been used as a medicine, and also for coating fabrics, lubricating machinery, producing printing inks, textile dyeing, and leather preservation.

Weed Status: Castor oil plant is a well-known agricultural weed in Australia. It often forms thickets on riverbanks and in other damp and fertile settings. It is declared a noxious weed in the Northern Territory, and in many local government areas of New South Wales, requiring landholders to control it.

Biofuel Status: Because of the high oil content of its seeds and ease of cultivation, castor oil plant is often listed as a potential biofuel crop.[2] There has been research in Brazil, and it is promoted as "an opportunity for agricultural development in arid and impoverished areas".[3] One analysis concluded that it is a "potentially sustainable, yet weak, source of biofuel for the future".[4] The Queensland government was recently approached by an entrepreneur seeking government support to grow this plant, but support was refused.

Recommendation: Castor oil plant should not be grown as a biofuel.

[1] DNRW (2006b)

[2] Eg. see DoveBiotech at <http://www.dovebiotech.com/pdf/CASTOR%20BEAN%20(RICINUS%20COMMUNIS)%20-%20BIODIESEL.pdf>.

[3] Osava M (2003)

[4] Comar V, Tilley D, Felix E *et al.* (2004)

CHINEE APPLE (ZIZYPHUS MAURITIANA)

Other names: Indian jujube, chonky apple, Indian jujube, Chinese apple

Description:[1] Chinee apple is a small thorny tree native to southern Asia. It can grow to 8 m in height. It has edible fruits and was once grown as a fruit tree by Chinese miners in north Queensland.

Weed Status: Chinee apple is a major weed in parts of north Queensland, where it sometimes forms impenetrable monocultures. A single tree can yearly produce up to 10,000 seeds, which are spread by floods, cattle or wildlife. Chinee apple is a declared weed in Western Australia, Queensland and the Northern Territory. It is prohibited entry into Australia by Australian Quarantine without assessment.

Biofuel Status: In a paper appearing recently in the journal *Biomass and Bioenergy* Chinee apple was found to meet the major specification of biodiesel standards in the USA, Germany and European Standard Organization (one of 26 species to do so), and was described as drought resistant, frost hardy and able to be grown in arid and semi-arid wastelands.[2] Although no interest

has yet been shown in growing this plant as a biofuel in Australia, that could change in reponse to ongoing overseas research.

Recommendation: Chinee apple should not be considered as a biofuel in Australia. It is already illegal to plant it in Queensland, the Northern Territory and Western Australia.

[1] DNRW (2006c)

[2] Azam M M, Waris A and Nahar N M (2005)

WILLOWS (*SALIX* SPECIES)

Description: Willows are deciduous trees or shrubs that favour riverbanks and other wet situations. They are often cultivated as ornamental trees, and many species from the northern hemisphere have been introduced into temperate Australia.

Weed Status: Willows have been listed by the federal government as Weeds of National Significance, a category reserved for Australia's 20 worst weeds. They occupy thousands of kilometres of streams and other wetlands in Victoria, Tasmania, New South Wales and the Australian Capital Territory, where they worsen erosion, flooding, stream obstruction, aquatic habitat loss and water losses. According to the federal government's Willow Strategic Plan, "Losses to biodiversity have been very significant and are potentially catastrophic."[1] The plan estimates that "Most of temperate Australia is vulnerable to willow invasions, where hundreds of thousands of hectares of suitable habitat exist from sea level to high alpine environments." Willows have so far invaded only about 5% of their potential range. The cost of managing them to reduce flooding and other hydrological impacts has been estimated at more than $2 million a year in Victoria alone. Some species germinate from stems that wash downstream, and others from windborne seeds.

Biofuel Status: Willows are attracting great interest as second-generation biofuels in the United States, where the Salix Consortium was founded in 1994, and the Willow Biomass Project initiated almost 20 years ago. Willows are also attracting intense interest in Europe, where they are seen as one of the best biofuel prospects because of their rapid growth rates. In a recent article in *Nature Biotechnology*, Black willow (*Salix nigra*), one of the weediest species in Australia, is described as "particularly promising".[2] One reason for their popularity is ease of establishment—some willows can be propagated from pieces of stem. This same characteristic helps explain why willows are such serious weeds in Australia

In Australia, willows are listed as a potential fuel and energy source in a report prepared for the Rural Industries Research and Development Corporation.[3] A New Zealand company Biojoule trialing willows to make ethanol says there is interest in Australia in the process.[4]

Recommendation: Willows should not be considered for biofuel cultivation in Australia because of the enormous weed problems they are creating. But when willows are removed for landscape restoration, their biomass may be a suitable fuel for energy production.

[1] Agriculture & Resource Management Council of Australia & New Zealand and Australian & New Zealand Environment & Conservation Council and Forestry Ministers (2000)

[2] Herrera S (2006)

[3] Wondu Holdings Pty Limited (2000)

[4] See <http://www.scienceinpublic.com/2006/ABIC/willow%20release.htm>.

POPLARS (*POPULUS* SPECIES)

Description: Poplars are broad-leaved deciduous trees native to damp forests in the northern Hemisphere.

Weed Status: Several poplars have become weedy in southern Australia, including white poplar (*P. alba*) and Lombardy poplar (*P. nigra*), which are both declared weeds in the Australian Capital Territory. Poplars in southern Australia form "dense stands along roadsides and watercourses, also invading moist bushland and forest."[1] Lombardy poplar has proved very invasive in wetlands near Perth.

Biofuel Status: Poplars are attracting great interest in Europe and North America as fast-growing second-generation biofuels. The two species declared as weeds in the Australian Capital Territory are both cultivated as biofuels overseas.

New cultivars of poplars bred for high growth rates are likely to prove weedier than the forms already present in Australia.

Recommendation: Poplars should not be grown as biofuels in Australia. They would not offer any advantage over fast-growing Australian trees such as eucalypts, but would instead present an unacceptable weed risk.

[1] Richardson F J, Richardson R G and Shepherd R C H (2006)

MORINGA (MORINGA PTERYGOSPERMA)

Other names: *Moringa oleifera*, Ben-oil tree, horseradish tree, ben nut, drumstick tee, sprokiesboom

This tree is usually listed on biofuel websites as *Moringa oleifera*, its previous scientific name.

Description:[1,2] Moringa is a slender, quick-growing tree, up to 10 m high, believed to be native to India. The seeds are produced within pith in long pods. Moringa favours tropical and subtropical climates. It has been used in Asia for centuries as a medicine, food and live fence.

Weed status: Moringa is a weed in tropical Africa, tropical America, Sri Lanka, India, Mexico, Malaysia, the Philippines[3] and Australia. It is rated as "moderately invasive" on the World Species List of Invasive Woody Plants[4] and as a "low risk" for the Pacific Islands.[5]

Moringa occurs as an occasional weed in Western Australia, the Northern Territory and Queensland,[6] but is not declared in any state. It has the potential to become a more significant weed in tropical and subtropical Australia, and especially within the dry tropics, if it is grown more widely.

Biofuel status: There has been strong international interest in moringa, with claims made that it can produce 1000-2000 litres biodiesel/ha/year.[7] There are reports of plantings in India for biofuels.[8]

Moringa is attracting interest as a biofuel in Queensland and Western Australia. It was identified in a Western Australian scoping study, funded by the National Action Plan, as one of three plants suitable for saline land.[9] Trials are already underway in southwestern Australia and Carnarvon, and are planned for the Pilbarra region. The Queensland Department of State

Development has contacted Biosecurity Queensland seeking an assessment of this plant because of interest in its potential. In a report on biofuel prospects in Australia, the Rural Industries Research & Development Corporation noted that moringa is a "tree crop with high production potential, largely untested in Australia".[10]

Recommendation: Moringa seeds germinate readily, but seedlings do not appear to spread far from parent plants, except along watercourses. Moringa should not be grown close to national parks or watercourses. It should be declared a restricted plant that cannot be grown near sensitive areas. Some states have an appropriate declaration category but others do not.

[1] DEC (2007)

[2] Brockman H (nd)

[3] Institute of Pacific Islands Forestry (nd)

[4] See <http://members.lycos.co.uk/WoodyPlantEcology/Invasive/worldlist.htm>.

[5] See <http://www.hear.org/pier/wra/pacific/moringa_oleifera_htmlwra.htm>.

[6] DEC (2007)

[7] Brockman H (nd)

[8] Eg. Balaji R (2005)

[9] Brockman H (nd)

[10] O'Connell D, Batten D, O'Connor M *et al.* (2007)

PONGAMIA TREE (*MILLETIA PINNATA*)

Other names: Pongam tree, *Pongamia pinnata*

This tree is usually listed on biofuel websites as *Pongamia pinnata*, a previous scientific name.

Description: Pongamia is a leguminous tree growing up to 25 m tall, native to Asia, northern Australia and many Pacific Islands. The seeds are spread by water. In India it has many traditional uses.

Weed status: Pongamia does not pose the same threat as other plants listed here since it is native to northern Australia. But in southern Queensland, where it is grown as a street tree, it has spread into the wild on a small scale, well south of its natural range.[1] It seeds prolifically and the seeds germinate readily near parent trees. The spread of this tree into new regions of Australia would be ecologically undesirable, irrespective of its native status in the north. Australia has many examples of native plants spreading into new regions and becoming serious environmental weeds, for example Cootamundra wattle (*Acacia baileyana*), coast tea tree (*Leptospermum laevigatum*) and sweet pittosporum (*Pittosporum undulatum*).[2]

Biofuel status: Pongamia trees are said to produce 2 tonnes/ha of oil that can be processed using current technologies.[3] Along with jatropha, pongamia is most often touted as a promising biodiesel for developing countries in Asia and Africa. There has been particularly strong interest in India, primarily for local fuel use.[4]

Pongamia was identified in a scoping study in Western Australia, funded by the National Action Plan, as one of three plant species suitable for saline land.[5] In a report on biofuel prospects in Australia, the Rural Industries Research and Development Corporation (RIRDC) notes that pongamia is a "promising candidate … with high production potential, largely untested in Australia".[6] Another RIRDC report on biodiesels lists pongamia as a "potential new crop", and says there are plantations in production in northern Australia.[7] According to a recent article in the *Weekly Times*, "Australian biofuel companies have been eyeing its use in marginal arable land". Interest has also been expressed by many small landholders.

Recommendation: Because this plant has a demonstrated capacity to spread from cultivation, it should not be grown outside its natural range

close to national parks or watercourses. It should be declared a restricted plant that cannot be grown near sensitive areas. Some states have an appropriate declaration category but others do not.

[1] Stanley T D and Ross E M (1986)

[2] Richardson F J, Richardson R G and Shepherd R C H (2006)

[3] O'Connell D, Batten D, O'Connor M *et al.* (2007)

[4] Balaji R (2005)

[5] Brockman H (nd)

[6] O'Connell D, Batten D, O'Connor M *et al.* (2007)

[7] Australian Agricultural Crop Technologies Pty Ltd (2007)

CALOTROPE (CALOTROPIS PROCERA)

Other names: auricula tree, cabbage tree, calotropis,Indian milkweed, kapok tree, King Edward's crown, king's crown, king's crown kapok, Prince of Wale's crown, rubber bush, rubber plant, rubber tree

Description:[1] Calotrope is a shrub native to tropical Asia and Africa that grows to 4 m high. It has a milky sap that is toxic to humans, and also toxic to cattle in some circumstances. It was introduced to Australia as a garden plant.

Weed status: Caltrope is a serious weed in northern Australia, with extensive infestations occuring on islands in the Gulf of Carpentaria, in the Northern Territory and in Western Australia. It invades sandy foreshores,[2] watercourses, roadsides, overgrazed land and old cultivated areas.[3] It can form dense thickets on alluvial flats and along rivers. Its seeds are spread by wind and water.[4] Calotrope is a declared weed in Western Australia and the Northern Territory, but the Australian Quarantine permits its seeds to be imported into Australia.

Biofuel status: Calotrope is promoted as a biofuel in India, where plantings are proceeding. It has also been identified as a potential oil crop for EU biodiesel markets.[5]

Recommendation: Because it is a serious weed, calotrope should not be trialed as a biofuel crop in Australia. Its windborne seeds would soon spread from plantations. It should be declared a weed in Queensland and New South Wales, the two states where it can still legally be grown and where the climate is suitable.

[1] Weeds Australia (nd)

[2] DNRW (2006a)

[3] Weeds Australia (nd)

[4] Weeds Australia (nd)

[5] van Thuijl E, van Ree R and de Lange T J (2003)

GIANT MILKWEED (CALOTROPIS GIGANTEA)

Description: Giant milkweed is a shrub which grows to 5m tall. Flowers are produced throughout the year. The seeds are windborne.

Weed status: Giant milkweed is a weed in Asia[1] and northern Australia. It occurs around Broome, on Cape York and on Torres Strait islands. It is not yet a widespread weed, but this could change if it is cultivated as a biofuel.

It is not declared a weed in any state, and Australian Quarantine permits its import into Australia.

Biofuel status: Giant milkweed has been proposed as a biofuel in India.[2]

Recommendation: Because of the weed risk, giant milkweed should not be grown as a biofuel in Australia. If any interest in growing this plant is shown in Australia it should be declared a prohibited plant by state governments. It has the potential to become a serious weed like its close relative calotrope.

[1] Holm L G, Pancho J V, Herberger J P *et al.* (1979)

[2] Euler H and Gorriz D (2004)

Caper Spurge (Euphorbia lathyris)

Other names: False caper, petroleum plant, gopher plant, mole plant, myrtle spurge, *Galarhoeus lathyris, Tithymalus lathyris*

Description: Caper spurge is a shrubby plant native to southern Europe, northwest Africa and southwest Asia, growing to 1.5 high. It is poisonous to humans.

Weed status: Caper spurge is a weed in many countries, including the US[1] and Australia.

Biofuel status: Research on its biofuel qualities have been conducted in Europe and North America. Early hopes that it would prove suitable for 'petroleum plantations' in arid areas were dashed by research in Arizona during the 1980s.[2] In Australia, it was listed in a report for the Rural Industries Research and Development Corporation as a potential fuel crop.[3] It continues to appear on lists of potential biofuels published overseas.

Recommendation: Caper Spurge should not be grown as a biofuel. It has a proven history as a weed and no proven benefit as a biofuel.

[1] USDA and NRCS (2007)

[2] Kingsolver B (1982)

[3] Wondu Holdings Pty Limited (2000)

Jatropha (*Jatropha curcas*)

Giant reed (*Arundo donax*) invasion in California

Californian bridge damaged by reed debris

Giant reed flood debris in California

Giant reed in its preferred habitat

Aerial view of giant reed invasion in California

Chinese tallow (*Triadica sebifera*)

Reed canary grass (*Phalaris arundinacea*)

Neem tree (*Azadirichta indica*)

Switch grass (*Panicum virgatum*)

Miscanthus (*Miscanthus sinensis*)

Spartina (*Spartina alterniflora*)

Olive (*Olea europaea*) near Adelaide

Castor oil plant (*Ricinis communis*)

Willows (*Salix*) near Perth, Tasmania, completely dominating the river environment

Chinee apple (*Zizyphus mauritiana*)

Chinee apple thicket near Charters Towers

Moringa (*Moringa pterygosperma*)

Giant milkweed (*Calotropis gigantea*)

Pongamia (*Milletia pinnata*)

Caper spurge (*Euphorbia lathyris*)

CURRENT GOVERNMENT POLICY ON BIOFUELS

Australian governments are supporting the biofuels industry in various ways, although they have been criticised for not providing greater support.[1] The federal government has set a biofuels target of 350 million litres per year by 2010, equal to about 0.75% of Australia's expected oil consumption. However, the Prime Minister's Biofuels Taskforce considered that with current consumer demand and commercial risk this target is unlikely to be met. Nonetheless, various state governments have set or proposed higher targets, which would create a *de facto* national target of 5-10%. In February 2007 the NSW Government announced its intention to introduce a 2% ethanol mandate as the first step to a 10% mandate by 2011. The Queensland government has a mandate for a 5% ethanol blend by 2010. The Victorian government has a 5% target for biofuels use. In Western Australia, a Biofuels Taskforce recommended a target of 5% biofuels consumption by 2010.[2]

The biofuels industry is heavily subsidised. The federal government Cleaner Fuel Grant Scheme fully offsets the 38.1 cents per litre excise paid on biofuels (this expires in 2011). There was a $40 million Biofuels Capital Grants Program, which provided funding for new or expanded refineries. There is an Ethanol Distribution Program which provides grants to assist service stations with facilities to sell ethanol blended petrol. And government funds are contributing to research and development of biofuel products. For example, the Rural Industries Research and Development Corporation has a $1.6 million (for 2007-08) Bioenergy, Bioproducts and Energy program,[3] and natural resource management programs (eg. the National Action Plan) are financing field trials of various candidate crops.[4]

There are many other government programs and policies which are relevant to the future of the biofuels industry in Australia. The current Taskforce on Northern Australia chaired by Senator Bill Heffernan, for example, is laying the policy groundwork for an agricultural shift to Northern Australia, regarded by many industry proponents as the site for vast acreages of energy crops. In a recent paper in the *Farm Policy Journal* it was estimated that 20-30 million hectares of "marginal" lands in northern Australia are potentially suitable for the production of exotic biofuel crops like jatropha.[5]

Policy deficiencies

What is lacking is a comprehensive policy framework to address the potential weed problems arising out of such ambitions. Australia's history is replete with disasters arising from blind enthusiasm for new industries and a blithe disregard for the consequences of introducing new species into the landscape. Deer, neem tree, hymenachne, gamba grass and kochia are a few recent examples, and prickly pear, blackberries, rabbits, foxes, and cane toads are stand-out examples from an earlier era. Current weed and pest policies provide only limited means to prevent such mistakes recurring.

We note with approval that the Queensland Department of State Development has asked Biosecurity Queensland to assess the weed risks of certain proposed biofuel species prior to lending their support to such ventures. However, without formal policy and legislation requiring risk assessments, mistakes will continue to be made. Furthermore, unless a species is declared or is not available because of import restrictions, there is nothing to prevent individual landholders from speculatively planting agrofuel crops without consulting governments.

It was disappointing to see that the recent Senate report, *Australia's future oil supply and alternative transport fuels*, made no mention of many environmental risks associated with a biofuels industry, including the weed risks. With ethanol, for example, it noted only two "key criteria" against which its environmental performance may

be assessed—effects on air quality and greenhouse gas impacts.[6]

The Invasive Species Council hopes this present report convinces policy makers that a more far-sighted, risk-based approach should be taken towards biofuels, to prevent serious mistakes being made.

[1] As reported in the Senate report on biofuels: Standing Committee on Rural and Regional Affairs and Transport (2007)

[2] Mathews J (2007)

[3] The objectives of the program are to (a) meet Australia's R&D needs for the development of sustainable and profitable bioenergy and bioproducts industries and (b) develop an energy cross-sectoral R&D plan. See <http://www.rirc.gov.au/programs/bbe.html>.

[4] However, the support for the biofuels industry in Australia is less than that in the US. Herrera (2006) describes some of the measures signed into law in 2005 with the Energy Policy Act: "Refiners are mandated to double the volume of ethanol and biodiesel added to the US's fuel supply to 7.5-billion gallons annually by 2012. It also earmarks $2.9 billion over ten years for R&D/demonstration projects (to assess crop suitability for biofuels, biomass processing and development of bio-based products like corn-based plastics and soy-based lubricants), establishes a program of loan guarantees for the construction of up to four demonstration biorefineries capable of producing ethanol and other high-value products from biomass, and includes $1 billion in grants and incentives for the first commercially implemented manufacture of cellulosic ethanol."

[5] Odeh I and Tan D (2007)

[6] Standing Committee on Rural and Regional Affairs and Transport (2007)

RECOMMENDED POLICY APPROACHES

Most biofuel ventures rely on government subsidies and other incentive schemes—a situation likely to continue for years to come. There is thus ample opportunity and justification for governments to insist that biofuels provide a genuine benefit without causing problems. Government commitments to sustainabilty also require that new industries not create environmental problems. Australia has the opportunity to develop a policy framework for biofuels that addresses all the environmental risks, including weed risks.

The lack of awareness of weed issues exposed by this report reflects a broader failure in Australia to recognise the risks inherent in introducing exotic species. With the emerging biofuels industry we have an ideal opportunity to apply the hard-won understanding of those risks before new problems are created.

Although this report only assesses weed risks, there are other issues that must be addressed to ensure sustainability. Biofuel crops should reduce greenhouse gas emissions more than other possible land uses.[1] Instead of a scramble by hundreds of landholders to trial different plants, there should be comprehensive environmental, social and economic assessments prior to policy or investment support for biofuel ventures.

Because the ecological and economic costs of weed mistakes are so high, and control is often ineffective once a weed is established, a highly precautionary approach is warranted. Pest experts recommend that a 'guilty until proven innocent' approach should be taken to exotic and invasive species.[2]

To properly address the weed risks of biofuels, the Invasive Species Council recommends the following policy reforms.

Develop an Environmentally Sound Biofuels Policy Framework

Australia's state and federal governments should work together to develop a policy framework for the biofuels industry that addresses all the environmental concerns, including the weed risks. Best practise guidelines are needed, and a website that identifies all the weed risks.

Upgrade State Weed Lists

The lists of plants declared as prohibited weeds by each state should be enlarged to include weedy biofuels such as Chinese tallow, miscanthus and giant reed.

Improve Processes of Weed Declaration

Most state governments lack an efficient process for assessing the risk posed by newly noticed weeds. Queensland, for example, has a list of about 150 weeds (including jatropha and Chinese tallow) that are candidates for declaration as prohibited plants, but only a few of these are assessed each year. Progress is slow because of inadequate resources dedicated to risk assessments,[3] and because of slow and cumbersome processes of declaration.

Ensure that Assessments Consider Increased Weediness of Cultivars

Some potential biofuel species may not pose a high weed risk in their original form, but new varieties, including hybrids and genetically modified cultivars, can be more invasive. This is especially likely for biofuel crops bred for rapid growth rates or high seed output. Weed risk assessments should take account of new, more invasive cultivars.

Amend Legislation to Create More Weed Categories

Some state governments are unwilling to prohibit weeds such as giant reed because the act of declaration obliges landholders to remove all wild infestations—an unrealistic ask. In most states there are categories of declaration that in effect prohibit new plantings without requiring the removal of old infestations. Those states such as Victoria which lack such categories should amend their legislation.

Some biofuel crops, such as pongamia, may be a threat to the natural enviornment only in certain circumstances, such as when planted near a national park or on a floodplain. Queensland has a weed category that allows a pest control notice to be issued for land that is, or is adjacent to, an environmentally significant area. All states should have similar provisions to protect environmentally sensitive or significant areas.

Include Risk Assessment in New Industry Promotion and Support

Many pest problems in Australia are created by landholders trialing alternative agricultural enterprises such as deer farming, emu farming, neem tree cultivation and olives. The Rural Industries Research and Development Coorporation produces reports promoting such enterprises, and also aquarium fish culture, big game park development and biofuels, but almost never mentions the pest risks they pose. Organisations that promote new industries should also assess and explain the environmental risks. As it stands today, Australia has some government departments promoting weedy plants, while other departments spend public funds removing them. Weed risks associated with emerging industries such as biofuels should be assessed at an early stage, prior to government support for them.

Promote Landholder Responsibility

Currently, landholders can plant many weed species without having to accept responsibility for subsequent harm to the environment or agriculture. Landholders should accept that their duty of care to the land extends to a responsibility for weed spread. Legislation should be reformed to strengthen duty of care provisions, making explicit reference to the need for landholders to assess the risks of planting new species.

The polluter pays principle should apply when plants escape from deliberate plantings and harm the environment or other agricultural businesses. State law in Florida requires landholders to pay a bond to cover rehabilitation costs should the planting of a new crop, including a biofuel, result in a weed problem (see Box). Australia should adopt this model.

It is obvious from biofuel blog sites that the weed risk is poorly understood, and often treated with scorn. There is a need for landholder education about such risks.

A legislative model for biofuels

The Florida statute (581.083 F.S.) intended to protect Florida against new invasions due to the large-scale planting of species that could pose escape risks, has provisions specific to biofuels. It states that:

"A person may not cultivate a nonnative plant, including a genetically engineered plant or a plant that has been introduced, for purposes of fuel production or purposes other than agriculture in plantings greater in size than 2 contiguous acres, except under a special permit" unless the relevant agencies determine that the plant is not invasive.

The statute also requires that:

"Each permitholder shall maintain for each separate growing location a bond or a certificate of deposit in an amount determined by the department, but not less than 150 percent of the estimated cost of removing and destroying the cultivated plants. The bond or certificate of deposit may not exceed $5,000 per acre, unless a higher amount is determined by the department to be necessary to protect the public health, safety, and welfare or unless an exemption is granted by the department based on conditions specified in the application which would preclude the department from incurring the cost of removing and destroying the cultivated plants and would prevent injury to the public health, safety, and welfare."

Assess Native Biofuels

Many of the plants promoted as biofuels have as their main attribute a capacity to quickly produce large quantities of biomass with minimal inputs of water and fertiliser. Many Australian plants—for example eucalypts and wattles—share the attribute of growing quickly without high inputs of nutrients. Australian plants have not received much attention as biofuels to date because the research on second-generation biofuels has been conducted mainly in Europe and North America. Eucalypts have, however, been recognised as potential biofuel feedstocks.[4] There should be more investigation of the potential of Australian trees, shrubs,[5] and perhaps grasses, to serve as biofuels. Any risks associated with these species should be investigated before their use is considered. Some Australian wattles, for example, are very invasive when grown outside their native range.[6]

Act Cautiously by Allowing Low-Risk Plants and Banning the Rest

The best approach to weedy biofuel species is prevention—preventing the planting of a species unless it has been assessed as low risk. However, in all states except Western Australia the current approach is to allow the planting of all species except those that are declared weeds. This means that plantings of potential biofuel species may occur before government weed agencies know about them and have a chance to assess the risk. All states should adopt an approach similar to Western Australia by maintaining lists of permitted and prohibited plants, and by banning all other species until they have been assessed.

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[1] WWF-Germany recommends that a "maximum life-cycle GHG balance of bioenergy cultivation of 30 kg/GJ must be demonstrated"—this "represents a 67% reduction on the life-cycle GHG emissions from (unprocessed) crude-oil combustion" Fritsche U R, Hunecke K, Hermann A *et al.* (2006)

[2] Mack R N, Simberloff D, Lonsdale W M *et al.* (2000)

[3] A 'permitted list' approach as explained in the final recommendation would overcome much of this problem.

[4] O'Connell D, Batten D, O'Connor M *et al.* (2007)

[5] A University of Sydney scientist is reportedly seeking support for research into saltbush and eucalypts among other plants as lignocelluloses feedstock Anonymous (2007b)

[6] *Acacia saligna* is an example of an Australian wattle that is often promoted for reclamation although it behaves as a serious weed by displacing local vegetation.

CONCLUSION

Will biofuels help avert climate change, or are they another example—like deer farming, ostriches and aloe vera—of an over-hyped alternative farm enterprise?

> *"…traits deemed ideal in a bioenergy crop are also commonly found among invasive species."*
>
> - Raghu & colleagues in *Science* (2007)

It is not the role of the Invasive Species Council to assess their potential to reduce carbon emissions, although we note the many recent analyses that cast doubt on this. Our interest is in the weed risks that biofuels pose. While some biofuel crops, such as sugar cane and canola, have a long history of use without having caused weed problems, others have bad reputations as weeds without any proven value as crops. Speculative agricultural enterprises have a history of causing unexpected problems while failing to meet expectations. Jatopha hailed as a 'miracle crop' when there is no technology to harvest its seeds has all the hallmarks of a plant destined to disappoint. Calls to sow it on a vast scale on marginal lands should be resisted at all costs.

The large number of weeds proposed as biofuel crops should serve as a warning that all such plants must be treated cautiously. Two of the plants touted as biofuels in Australia— giant reed and spartina—even appear in the World Conservation Union's list of *100 of the World's Worst Invaders*.[1]

Governments and industry should work together to ensure that any emerging biofuels industry operates sustainably, which will entail, in part, that Australia's weed problems are not made worse. To date, there is almost no evidence of governments and industry recognising that any weed issue exists. With the publication of this report, ignorance no longer remains an option.

[1] Lowe S, Browne M, Boudjelas S *et al.* (2000)

ABOUT THE INVASIVE SPECIES COUNCIL

The Invasive Species Council is a non-government organisation established in 2002 to promote better policies on invasive pests. The activities of the ISC are outlined on its webpage (see <http://www.invasives.org.au/home.html>), and especially within the pages of its newsletters, which appear on the website. The ISC invites those who share its concerns to join. The membership form can be downloaded from the webpage. A pdf copy of this report can also be downloaded, by visiting <http://www.invasives.org.au/home.html>.

Tim Low, co-author of this report, is a project officer for the Invasive Species Council. He wrote the book, *Feral Future: The Untold Story of Australia's Exotic Invaders* (Penguin, 1999), which outlines the threat to Australia posed by invasive species. Tim has also written many magazine articles about pests, served on government pest committees, made submissions to government, and spoken at many pest venues, often as a keynote speaker, in Australia and overseas. He was a member of the Australian Biosecurity Group, which produced the report, *Invasive Weeds, Pests and Diseases: Solutions for Australia* (2005), available at http://www.wwf.org.au/publications/ABGInvasiveSolutions/.

Carol Booth, PhD, the co-author of this report, is an environmental consultant and conservationist. She has done consultancy work on biodiversity priorities, wildlife conservation and rural land management. As a conservationist she has coordinated state and regional conservation groups and been an advocate for wildlife conservation, sustainable water and land management, and environmental law reform. Carol also has a background as a biologist and journalist, and is currently doing research in environmental philosophy.

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Photo credits

Jatropha: R.K. Henning of www.jatropha.org
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Pongamia: L. Shyamal
Giant milkweed: William M. Ciesia

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