Guidelines on Biofuels and Invasive Species

Draft for comment

Please send comments or suggestions to energy@iucn.org by 31 August 09.

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Introduction and rationale

Many governments in Africa are actively encouraging private investment in biofuels developments to harness the perceived benefits of biofuels such as agricultural development, increased energy security and independence, and reduced greenhouse gas emissions. However, in the rush to pursue the benefits of biofuels, the risks of invasion by introduced species have received little or no attention and are not being adequately prevented or managed. The situation is most acute in countries lacking the capacity and resources to adequately avoid and manage the risks of invasion. Lack of suitable pest and weed risk assessment and management regimes compromises the long-term viability of the biofuels sector and threatens local livelihoods and the environment.

Furthermore, many plant species currently being developed or considered for biofuels are potentially invasive. Whilst first generation biofuels are produced from food crops that are well understood and have been domesticated for centuries; new and planned biofuels will be produced from a wider range of ligno-cellulosic feedstocks and inedible plant oils. Whilst these new biofuel feedstocks are potentially more productive and profitable, they also pose a greater risk of becoming invasive pests and causing widespread damage to ecosystems, livelihoods and the economy.

While many organizations work on invasive issues and on biofuels, few have worked to address the two issues in tandem. IUCN and GISP published a news story in 2008 entitled "Alien Alert"[1] in response to the growing threat of biological invasions posed by biofuels. The story received widespread media coverage and the resulting interest in the issue and acknowledgement that the risks posed by new biofuel developments are serious, prompted IUCN to host a workshop on biofuels and invasive species in Nairobi, Kenya on April 20th -22nd, 2009[2]. The workshop convened a group of experts from regional governments, plant protection organisations, research institutions, NGOs and the private sector to identify risks along the biofuel production and supply chain and weaknesses with current regulations. Workshop participants identified a number of risks and deficits associated with current and emerging biofuel developments in the region and proposed some potential solutions that constitute the foundations of these guidelines.

These guidelines are intended to inform policies and practices of biofuels producers and decision makers both directly and through processes such as the Roundtable on Sustainable Biofuels (RSB), which is developing principles, criteria and indicators for the sustainable production of biofuels, and ultimately provide guidance to importing companies and countries. They will be refined and finalized at a 2nd workshop to be held in September 2009.

The biofuels context – opportunities and risks

This preliminary set of guidelines aims to highlight the risks of biological invasion by species introduced for biofuels production and to provide constructive recommendations on how to prevent the introduction, establishment and spread of invading species resulting from biofuel developments. The intention is not to either promote or discourage biofuel developments. It is also recognised that there are numerous factors other than biological invasion that affect the sustainability of biofuels which must be considered and addressed when promoting and implementing biofuels policies and projects.

Furthermore, a number of issues that cannot be fully covered in these guidelines affect the risk of an invasion by an introduced species. These include land tenure agreements, long term economic profitability, labour costs, the rule of law, and the relative prioritisation of biofuels for local development versus trade and export. These factors and many others will affect the likelihood of an invasion and the ability of a country or community to effectively manage the risk. However, these guidelines focus on the specific linkages between commercial scale biofuel developments and risks of biological invasions, especially in the Eastern and Southern African Region, where risks are already apparent and likely to be exacerbated in the near future.

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[1] http://www.iucn.org/media/materials/features/?1473/Alien-alert

[2] More information on the workshop, see http://www.iucn.org/about/work/initiatives/energy_welcome/energy_impacts/energy_bioenergy/invasives_biofuels_workshop.cfm

Target Audience

These guidelines are intended for use by governments and companies developing biofuels and to support general public awareness. They were also developed to support the Roundtable on Sustainable Biofuels, with which IUCN is engaging to refine their principles and criteria on sustainable biofuels.

Background Information

This section provides background information to clarify common misconceptions about invasive species and the process of invasion – more detailed information can be found in the IUCN workshop background paper.

Box 1 – Key Definitions

Invasive species – An alien species that causes (or has the potential to cause) harm to biodiversity, the environment, economies and/or human health. The term Invasive Species (IS) is often used interchangeably with Alien Invasive Species (AIS) or Invasive Alien Species (IAS). In this paper we use invasive species.

Alien species – A species that is introduced to a new location (ecosystem or area) where it does not occur naturally (i.e. non-native, non-indigenous)

Biological invasions – The phenomenon of invasions by an alien species that causes harm to the ecosystem to which it is introduced – which phenomenon is a combination of the characteristics of the alien species and of the recipient ecosystem

Propagule – Any plant component that can propagate a new specimen of the plant whether sexually or asexually. Propagules include seeds, cuttings, rhizomes, and clones.

Biofuel – Liquid fuel produced from non-fossil biomass.

First Generation – A biofuel produced using existing scalable technologies such as fermentation and distillation of starches and sugars to produce ethanol, or oil extraction and transesterification to produce biodiesel. First generation biofuels are normally produced from food crops such as corn (maize), sugar cane, soy, palm oil and rapeseed; or from inedible feedstocks such as *Jatropha.*

Second Generation – Biofuels produced using more complex processes (than those of First Generation) that make better use of cellulosic biomass from plants. Two groups of approaches have developed - biochemical methods using enzymes and fermentation, and thermochemical methods that gasify biomass and re-synthesise fuels using catalysts. These new processes allow for the use of a broader range of feedstocks since the main requirement is high biomass yield.

Impacts of invasive species

Invasive species cause a wide range of environmental, societal and economic impacts. Invasion by introduced species is the second greatest threat to biodiversity after habitat destruction. Invasive species often out-compete native species and can irreversibly alter ecosystem functioning and hydrology. Invasive species may also introduce new pathogens that damage ecosystems and human health (see box 3 on *Prosopis*).

By one estimate, biological invasions cost the global economy up to $1.4 trillion USD annually, representing 5% of global GDP. Most of this cost is the result of reduced productivity of agriculture, forestry and other production systems, but other direct costs include damage to infrastructure, lost tourism revenue and costs related to eradication, containment and

management. There are also indirect costs such as loss of ecosystem services, as well as cultural and social costs, for example from the loss of traditional livelihoods. While global calculations of the costs of invasive species are very difficult and often subjective, it is highly likely that the cost of an invasion by a biofuel feedstock or associated pest would, in the long-run, outweigh any economic benefit offered by biofuel development. Thus, the cost associated with avoiding the introduction and spread of an invasive species should be viewed as a sound investment to insure against future economic and environmental costs and should be a logical prerequisite of any biofuel development.

Invasiveness and invasibility

While many plants have invasives traits, not all alien species become invasive in a given situation. Most alien species are relatively benign and may bring significant benefits such as food production, forestry, and biological pest control. There is a commonly used "rule of tens" which suggests that about 10% of introduced species will escape and survive in the wild, 10% of these will become established and 10% of established species will spread and become invasive. Thus, 0.1% of introduced species are likely to become invasive after introduction to a new area or ecosystem. This figure may sound small but thousands of species are introduced into areas beyond their natural range every year and an invasion by just one species can have severe consequences for whole ecosystems. Introductions of non-native species are often the result of deliberate efforts by agriculture, aquaculture, forestry, agroforestry, horticulture, the pet trade, or for biological control of other pests, while accidental releases, particularly through transportation and trade can also occur.

A species is not invasive *per se* but can become invasive due to factors such as the local ecological conditions and the presence of vectors such as animals or flooding that distribute propagules. Nevertheless, species that become invasive often share common traits which increase the risk of invasion such as:

- A lack of predators in their new environment
- Fast growth and ability to out-compete local vegetation
- Large and abundant seed production
- Tolerance to wide range of conditions
- Presence of thorns or toxins that make them inedible to animals.

Other issues to consider:

- One of the best indicators of invasiveness is whether the species under consideration is invasive elsewhere in regions with similar biotic and abiotic characteristics.
- Factors such as residence time and number of introductions also affect the likelihood of invasion.
- Species may become invasive if their genotype is changed through breeding or genetic modification and hybridization can 'invade' wild genotypes. This also applies to introduced species that may hybridize with close relatives within recipient community.
- Ecosystems can become more susceptible to invasion due to disturbances from land use change and agriculture or construction, which can overturn soils and open up areas to light, aiding establishment and spread.
- Ecosystems are likely to be more vulnerable to invasion if they are ecologically distinct, or if they lack herbivores (predators), parasites or pathogens that would otherwise control the introduced species.

It should be emphasized that many of the species that are being proposed as suitable second-generation biofuel feedstocks happen to possess many of these traits and a study conducted by Buddenhagen et al. in 2009 found that potential biofuel feedstocks are two to four times more likely to become invasive in tropical regions than other plants.

Box 2 – Weed Risk Assessments

Weed Risk Assessments (WRAs) are key tools used to predict the likelihood of a plant species becoming invasive. WRAs offer a relatively rapid and simple system for approving or rejecting plants for importation. WRAs are usually based on a questionnaire that determines the invasive risk of the plant being assessed by asking whether the plant possesses a number of different attributes likely to increase the risk of an invasion. The answers to the questions are scored and the total score then determines whether a plant should be accepted, rejected or have further evaluation to reduce uncertainty. The assessment ask questions about attributes such as:

- Past history of invasiveness
- Environmental versatility
- Reproductive strategy
- Seed dispersal mechanisms
- Growth characteristics

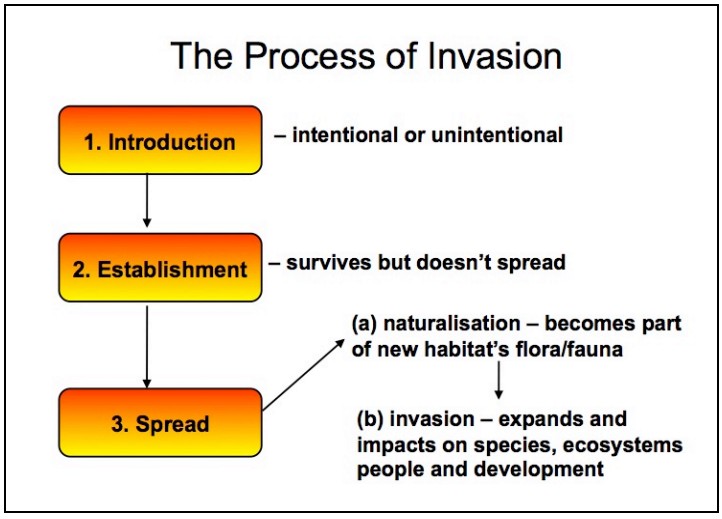
To be effective, WRAs should also be carried out by a separate and neutral body that is not responsible for approval or rejection of species for import.

Further information is available at the Australian Quarantine and Inspection Service (AQIS) WRA site: http://www.daff.gov.au/ba/reviews/weeds/system

The process of invasion

The means or route by which a species is spread is known as the invasion *pathway.* The pathway can involve physical elements such as transport by land, air and sea, and means such as international trade and tourism, which may result in the movement of species beyond their native range. The object or process that carries the species along the pathway is called a *vector*. Common vectors include people, soil, packaging, animals, machines such as trucks and cars, and natural forces such as wind and floods. Common pathways are roads and railways and international trade networks such as shipping lanes and air corridors.

Diagram to show the process of invasion



Biological invasion usually follows a common sequence beginning with introduction, and progressing to establishment, spread and invasion (see diagram). There can be a significant delay (lag phase) between introduction, establishment and spread. Some tree species have lag phases of hundreds of years. Such delays are hard to predict and may be dependent upon irregular tipping points such as unusually extensive floods or droughts, irregular or unusual wildfires, adaptation to a new environment, biological invasions by other species and disappearance of predators or herbivores previously present.

Box 3 – The case of Prosopis

Prosopis spp. are a group of species that might initially appear to be ideal feedstocks for second-generation biofuels. Commonly known as mesquite and native to Central and South America, *Prosopis* are fast growing and have low nutrient requirements. They are also nitrogen fixing and can improve soil fertility. These characteristics led to a number of *Prosopis* species being introduced to Australia, Asia, and dryland Africa for fuelwood, fodder, shade and to improve soils. However, it quickly became apparent that *Prosopis* was invasive due to traits such as rapid growth, abundant seed production, the tendency to form impenetrable thickets, the ability to thrive in dry, saline soils, and foliage that is unpalatable to livestock. *Prosopis* now covers millions acres in many countries in Africa and is severely impacting on grazing and traditional pastoralist livelihoods. The dense thickets have outcompeted local species and lower ground and surface water levels in many watersheds. Despite these negative effects, some groups benefit from *Prosopis* for wood, charcoal and other benefits and so there is often conflict over plans to control it.

Based on the above, the introduction of *Prosopis* for biofuel production should be avoided, though some argue that using invasive species for biofuels may provide sufficient economic incentives for controlling their spread. It is highly unlikely that using *Prosopis* as a feedstock where it has become invasive will be an effective strategy for managing the invasion. Current efforts to control *Prosopis* involve a mix of chemical, mechanical and biological control methods. Two biological control agents from the US (*Algarobius prosopis* and *Neltumius arizonensis*) have been used to reduce seed production with some success in South Africa, however more options such as fungi are being explored.

http://www.gisp.org/casestudies/showcasestudy.asp?id=64&MyMenuItem=casestudies&worldmap=&country=

Control of biological invasions

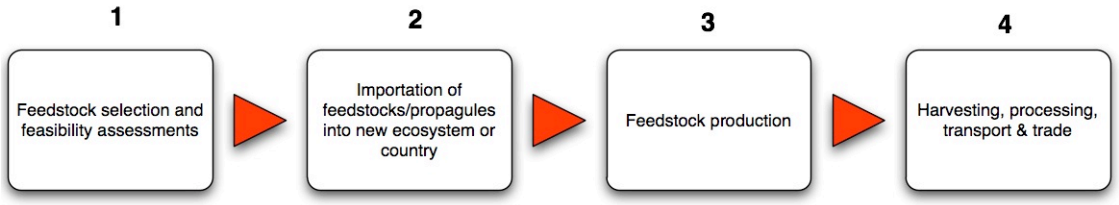
The best method for control is prevention. Other stages for control are recognised in the UN Convention on Biological Diversity(CBD). Efforts to control invasions should be prioritized in the following order:

- **Prevention** – Avoiding the introduction of a potentially invasive species through appropriate risk assessments and enforcement of quarantine procedures.
- **Eradication** – Removal of the entire population of an invasive species and all propagules through mechanical harvesting, chemical treatment with herbicides, and the use of biological control agents such as host-specific parasites. Eradication is the preferable course of action if an introduced species has become established and is showing evidence of becoming invasive. However, once an invasion has begun, it is often already too late for complete eradication.
- **Containment** – this involves stopping further spread of an invasive species by restricting further movement or spread
- **Management & restoration** are the final tools for controlling an invasion and are the most expensive and time-consuming option. Management involves ongoing efforts to manage an established invasion once eradication and even containment are no longer possible. It is important to recognize that many plants produce seeds which can accumulate in the soils (“the seed bank”) and germinate sequentially over many seasons or years. Restoration involves restoring an ecosystem to its pre-invasion state or to a preferred status - wherever possible.

Guidance on possible intervention points along the biofuel supply chain

For the purpose of these guidelines, the biofuels supply chain has been divided into four distinct stages; i.e. exploring sequentially the full process from selection of the biofuel feedstock and plantation site, to movement of the feedstock to site, production, harvest, transport, processing into biofuels, and finally transport to the point of sale. At each of these stages there are specific risks and options for avoiding or managing the risk of an invasion which may therefore require different interventions.

Simplified supply chain showing potential intervention points



1. Feedstock selection and development, and feasibility assessments

Overview of the issues

During this initial stage governments and private investors are in the best position to avoid an invasion by screening potential feedstocks for invasive risk and conducting assessments on the suitable scale and location of feedstock production, processing and transport routes. These assessments should be done as early as possible before significant investments in project development predispose investors and developers to a potentially invasive feedstock.

Guidance for governments: Ideally national governments should conduct a Strategic Environmental Assessment (SEA) at this stage to identify suitable biofuel feedstock species and plan plantation zoning at a national scale so that biofuels production is sensibly sited, for example to minimize soil erosion and water stress, and to avoid areas of high conservation value.

Guidance for developers and investors: This SEA should be accompanied by a project-specific Environmental Impact Assessment (EIA) funded by the developer, which should include a WRA (see box 2) of the potential feedstocks.

In cases where land has already been leased for biofuel development, developers should finance a strategic selection of the feedstock species and a WRA to identify the potential threat of invasion by the feedstock being considered. WRAs should be carried out by a neutral third party. Developers should also be required to include the possible costs of eradication, containment, management and restoration into their economic assessment of the project. A contingency fund should also be set up in some form at this stage that would go towards the cost of any remedial action required as a result of an invasion.

2. Importation of feedstocks/propagules

Overview of the issues

The importation of species and transfer of live organisms or propagules across regional, national or sub-national boundaries is normally (or should be) regulated by national and regional governments. Some governments have adopted quarantine regulations that meet International Standards for Phytosanitary Measures (ISPM) requirements and these regulations, overseen by National Plant Protection Organisatons (NPPOs) are adequate in principle. However, their effective enforcement is hampered by lack of capacity and resources.

Guidance for governments: Develop and strengthen quarantine regulations that meet ISPM requirements and allocate sufficient resources to NPPOs for monitoring and enforcement of regulations. Ensure that quarantine regulations are based on sound ecological principles (see box 4).

Guidance for developers and investors: Comply with all national regulations relating to the introduction of live plants or propagules during the importation of feedstocks and propagules. These may include requirements for weed risk assessments and gaining official approval, for example by obtaining a suitable import certificate, before embarking on production of biofuel feedstocks.

Box 4 – Basing plant assessments on ecosystems rather than political boundaries

It is commonly assumed that quarantine procedures at national borders are an effective means of controlling the introduction and spread of pests and diseases. However, this is somewhat misleading since regional, national and sub-national boundaries are manmade constructs that often bear little relation to natural barriers between ecosystems, climatic zones and other natural factors that have a bearing on the likelihood of an introduced species being invasive. This is especially the case in large countries such as the US or Australia where communities of species have long been separated by natural barriers such as mountain ranges and deserts, resulting in divergent evolution of species that may then become invasive if transferred to other, naturally isolated regions of the same country.

However this issue can also affect small countries. In Africa, there are ongoing negotiations to create regional free trade blocs such as COMESA and ECOWAS, which will ease restrictions on the flow of goods and services between member states. If quarantine regulations are relaxed or waived for the trade of plant species between member states this will exacerbate the risk of introductions of invasive species since these large regional blocs span different ecosystems and climatic zones.

In response to this risk, it may be preferable to use natural boundaries such as ecosystems and climate zones rather than political boundaries when determining the need for weed risk assessments and quarantine procedures so that assessments are carried out only where the movement of a species presents a realistic risk of invasion. Such an approach will require stronger regional co-operation and so we recommend that existing regional blocs develop coherent quarantine measures that are aligned with natural boundaries and vegetation zones within their borders.

One example of best practice comes from the state government of Western Australia, which requires a WRA to be carried out before any species that are native to other regions of the continent can be brought into the state. This precaution is in addition to the national requirement for a WRA for all species being considered for importation from overseas.

Risks associated with importation of feedstocks will be significantly reduced if industry can be persuaded to support and comply with voluntary standards for best practice. There is an urgent need to clearly communicate to industry that such processes are beneficial to their long-term viability. Best practices may include full and timely compliance with appropriate regulations and perhaps future certification by a third party such as the RSB on criteria such as WRAs during the planning stage of developments.

3. Feedstock Production

Overview of the issues

This stage deals with managing the risks of invasion during feedstock production. Assuming the previous steps of these guidelines have been followed, the risk of an invasion by the feedstock itself should already have been significantly reduced. However, the following recommendations will help ensure that developers are in a strong position to deal with an unforeseen escape or spread of the feedstock, or any hitchhiking pests and pathogens that may be introduced as a result of the feedstock plantation.

Guidance for governments:

In line with the "Polluter Pays" principle, government regulation should allow the polluter to be prosecuted and pursued for compensation in any case of negligence thereby encouraging the developer or producer to follow best practices as outlined in their management plan.

Guidance for developers and investors: All developers should be required to submit an Environmental Management Plan (EMP) that will outline the actions to be taken to produce biofuel feedstocks in a sustainable manner. EMPs should include:

- A contingency plan to be acted upon in the event of an "escape" of a plant species or pest organism that could cause an invasion to contain the spread, and ascertain the suitable course of action such as eradication versus containment or management.
- The provision of a fund to pay for eradication, containment, management, or restoration. Where appropriate (funds should be external – held by government). Funding could also be guaranteed through a requirement for insurance or a licensing system that requires a deposit to be made into a centrally managed fund.
- The development and implementation of a monitoring system that checks for escapes and the presence of pests and pathogens.

The plan should specify that certain best practices will be followed that are well suited to the specific local conditions. Such practices may include:

- The use of buffer zones and wildlife corridors.
- Zero-till planting to reduce exposed soil
- Planting of indicator species that act as an early warning of pest problems
- Appropriate rotation or mixed cropping systems to maintain soil health
- Fencing and other barriers to prevent animal vectors entering farms
- Biological control agents to reduce flower and/or seed production
- Pre fruit/seed harvesting of biomass
- Educating farm employees about risks of taking propagules from the site and introduction of an appropriate system of checks

Lastly, EMPs should be audited by a third party and it may also be appropriate to integrate invasive species risks into existing EIA requirements and agricultural regulations to further strengthen the system.

4. Transportation/Processing

Overview of the issues

This stage includes all risks related to invasion after the feedstock has been harvested. This includes escape during transport from farm to processing facilities, and export of any propagules or pathogens during transport and trade by air, sea or land.

Guidance for governments:

- Promote projects that add value to feedstocks by converting them at or near the site of production.
- Ensure that quarantine procedures monitor movement of any high-risk feedstocks within national borders
- Develop communication and education programmes for transport companies and other actors to highlight the risks of biological invasions and the need for monitoring systems.

Guidance for developers and investors:

- Propagules should be contained in an appropriate manner on site. Nurseries should ideally be sited alongside plantations to reduce transport distances and associated risk of escape.
- When feedstocks/propagules must be transported while still viable, there should be adequate monitoring of transport vehicles for the presence of seeds, pests etc…
- To reduce the risk of escape, feedstocks should ideally be converted on-site or as near to the farm as possible to an inert tradeable product (if not the finished biofuel). This has the benefit of containing propagules on site, but also adds value to the feedstock, which may then contribute to economic development in the communities where the feedstock is produced.
- Awareness of transporters in relation to propagules and the risk of escape, as well as the risk of transfer of pathogens is extremely important. Developers should ensure that transporters are well informed about the need for a monitoring system that checks vehicles and packing materials for soil and seeds and includes regular cleaning at each end of the transport pathway.

5. Summary of Guidelines

Planning

All stakeholders should conduct a cost-benefit analysis that includes the potential costs from an invasion. Governments should develop SEAs to plan biofuel production at national level and developers and investors should conduct EIAs at project level that include weed risk assessments. These plans should be underpinned by a contingency fund as insurance for any necessary remedial actions in the future.

Importation

Importation of feedstocks and propagules should occur within a suitably robust quarantine system. Governments should strengthen their capacity to monitor and enforce phytosanitary regulations and base policies on sound ecological principles. Developers and investors should comply with all national regulations relating to the importation and introduction of live plants or propagules.

Production

Feedstock plantations should only be developed subject to the development, submission and implementation of an Environmental Management Plan (EMP). EMPs should include:

- Specific best practices to be followed
- A contingency plan to be acted upon in the event of an "escape" of a plant species or pest organism that could cause an invasion.
- The provision of a contingency fund to pay for eradication, containment, management, or restoration.
- The development and implementation of a monitoring system that checks for escapes and the presence of pests and pathogens.

EMPs should be audited by a third party.

Transportation/Processing

Risks of invasion related to transportation and processing of feedstocks should be minimized by reducing the distances that viable feedstocks and propagules are transported, and ideally converting feedstocks in-site. Governments and developers should ensure adequate monitoring of transport vehicles for the presence of seeds and pests. Lastly, all stakeholders should promote awareness among transporters about the risks of invasive species and the need for a robust monitoring system.

The guidelines in this paper outline a number of best practices for managing invasive species risks along the biofuel supply chain. In many cases the guidelines are aspirational; a number of limitations and challenges to their successful implementation beyond the control of a government or developer should be recognised, including:

- Lack of public awareness about the risks of invasive species and the need to contain feedstocks on sites that are under adequate monitoring.
- Lack of funding to cover additional costs such as SEAs, extra administrative burdens for government departments, training and communication, quarantine facilities and sufficient staffing, especially for law enforcement.
- Lack of capacity, taxonomic databases, equipment, trained staff, robust environmental legal frameworks etc…

Thus, to successfully implement the guidelines in the region, there are some universal pre-requisites that are urgently needed to support such measures such as clear communication strategies, sufficient funding mechanisms, and targeted capacity building efforts.

Cost recovery is a key limitation and whilst there are a number of potential methods such as fines, permitting fees, insurance, refundable deposits and taxes, there are understandable concerns about such measures undermining the economic competiveness of biofuels and deterring investments. As a minimum, we recommend the adoption of the 'polluter pays' principle when developing a framework for investments in biofuels in the region. This will help to clarify where responsibility lies for covering any costs related to an invasion and encourage the adoption of best practices to protect economic investments in biofuels in the region.

Acronyms

WRA – Weed Risk Assessment

SEA – Strategic Environmental Assessment

EIA – Environmental Impact Assessment

EMP – Environmental Management Plan

HCV – High Conservation Value

RSB – Roundtable on Sustainable Biofuels

ISPM – International Standards for Phytosanitary Measures

IPPC – International Plant Protection Convention

GISP – Global Invasive Species Programme

IUCN – International Union for the Conservation of Nature

ICRAF – World Agroforestry Centre

NPPO – National Plant Protection Organisation

COMESA – Common Market for Eastern and Southern Africa

ECOWAS – Economic Community of West Africa States

Further resources

Other resources that may be useful include:

GISP - http://www.gisp.org/

IUCN Invasive Species Specialist Group - http://www.issg.org/

CABI - http://www.cabi.org/

IPPC - https://www.ippc.int/IPP/En/default.jsp

Howard, G. & Ziller, S. (2008) Alien Alert – plants for biofuel may be invasive. July/August issue of Bioenergy Business

Buddenhagen CE, Chimera C, Clifford P (2009) Assessing Biofuel Crop Invasiveness: A Case Study. PLoS ONE 4(4): e5261. doi:10.1371/journal.pone.0005261

ICRAF policy on invasives - World Agroforestry Centre Policy Guidelines on Invasive Alien Species (2004) www.worldagroforestry.org/downloads/policies%20and%20guidelines/ICRAF_policy_invasives.pdf

IUCN (2009) Biofuels and Invasive Species: Exploring the links between biofuel production systems and invasive species – A background paper prepared by John Mauremootoo for the IUCN Workshop on Biofuels and Invasive Species – Nairobi, Kenya, 20th-22nd April, 2009

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