WOODY INVASIVE SPECIES IN THE WESTERN INDIAN OCEAN: A REGIONAL ASSESSMENT

by C. Kueffer, P. Vos, C. Lavergne and J. Mauremootoo

INTRODUCTION

Within the framework of biosecurity and forestry (Cock, 2003), the FAO’s Forestry Department has set up a programme to investigate the invasiveness of forest trees. A global review, which identified considerable knowledge gaps in understudied regions, is reported in this issue of Forest Genetic Resources (Haysom and Murphy). This paper is a summary of a regional survey on woody invasive species in the Western Indian Ocean (Kueffer et al., 2003). The study comprised the small island states and territories of the Comoros Archipelago (Union of the Comoros and Mayotte), Mauritius and Rodrigues, La Réunion and Seychelles. The objectives were threefold:

- Compilation of knowledge on the biology and management of woody invasive species in the region;
- Development of a rapid assessment method;
- Initiation of a national and regional network of stakeholders and experts.

In this study an invasive species is defined as an exotic species, with a ‘fast’ spreading rate, and a negative environmental or economic impact. For each country, a written standardized questionnaire was developed and discussed with all concerned experts.

MAIN INVASIVE SPECIES, INVASIVENESS AND IMPACTS

Study area

Two of the studied island groups are equatorial (Seychelles, Mayotte and the Union of the Comoros), and two are subtropical (Mauritius and Rodrigues, and La Réunion). All except the granitic islands of the Seychelles are of volcanic origin. The land mass ranges from 438 km² (115 islands of Seychelles) to 2,512 km² (La Réunion). With the exception of the Comoros archipelago the studied areas are very isolated (>1,500 km from nearest mainland). Between c. 0-5 percent (Mauritius, Rodrigues, Seychelles) to c. 20-30 percent (the Union of the Comoros, La Réunion) of relatively undisturbed native vegetation remains.

While the Union of the Comoros still lives mainly on a subsistence agriculture economy, the others have transformed their economies during the last few decades into service-oriented economies with an important tourist industry. This transformation stopped deforestation and made nature protection a national priority.

The studied region is a priority area for international conservation because of its high endemism (WIO biodiversity hotspot, Global 200 Ecoregion, Centre of plant diversity (WWF, IUCN)). Introduction of invasive species that followed the colonial era can be broadly categorized into four phases (not applicable to the Comoros Archipelago):

- Phase 1: before 1760, first settlements. Limited impact, introduction of alien animals.
- Phase 2: 1760-1830, permanent settlements. Main introductions of alien plant species, destruction of lowland habitats.
- Phase 3: 1830-1960s, fast population and economic growth. Main habitat destruction.
Main invasive species

The invasive species compiled in the report were categorized into three groups: main invasives, non-consensus species, and potentially new invasives. Only invasives species that are most problematic in at least one country of the region are compiled in Table 1.

Table 1. The woody invasive species that are very problematic in at least one country of the Western Indian Ocean region.

<table>
<thead>
<tr>
<th>Species</th>
<th>Comoros Arch.</th>
<th>La Réunion</th>
<th>Mauritius</th>
<th>Seychelles</th>
<th>Tropics</th>
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<tr>
<td>A cota mangium</td>
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<td>A cota auriculiformis</td>
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<td>A istonia macrophylla</td>
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<td>A rdisia creata</td>
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<td>Casuarina equisetifolia</td>
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<td>Cinnamomum verum</td>
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<td>C lidemia hirta</td>
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<td>Hiptage benghalensis</td>
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<td>Lantana camara</td>
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<td>Ligustrum robustum subsp. walkeri</td>
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<td>L. itsea galatosa</td>
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<td>Paraserianthes falcataria</td>
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<td>Psidium cattleianum</td>
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<td>Ravnala madagascariensis</td>
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<td>Rubus alainifolius</td>
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<td>Schinus terebinthifolius</td>
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<td>Solanum mauritianum</td>
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<td>Spathodea campanulata</td>
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<td>Syzygium jambos</td>
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<td>Ulex europeaus</td>
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</table>

(*): potentially invasive or non-consensus, *: main invasive, **: most problematic invasive. 1: potentially invasive; 2: moderately invasive; 3: highly invasive according to Binggeli et al. (1998).

Compared to data on woody invasive species in the tropics as a whole (Binggeli et al., 1998), the invasive woody flora of the region has a higher proportion of large trees (41 percent vs. 21 percent), whereas shrubs are underrepresented (30 percent vs. c. 60 percent). In terms of taxonomy, the families of the Leguminoseae (21 percent vs. 15 percent) and Myrtaceae (9 percent vs 3 percent) are over-represented, and the families of the Rosaceae (1 species vs. 15 percent) and the Pinaceae (0 vs. 4 percent) are underrepresented among the most problematic invasive species in the region.

Habitat invasibility

A large proportion of invasive species preferentially invade disturbed, open, secondary habitats. These habitats are mostly of low biodiversity value. More problematic are species that invade habitats with a generally high resistance to invasions (low invasibility) (see Table 2).

Table 2. Habitat types that show a high resistance to invasions (low invasibility), and the few exotic species that are able to invade them.

<table>
<thead>
<tr>
<th>Habitat types</th>
<th>Description</th>
<th>Invading Species</th>
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<tbody>
<tr>
<td>Inselbergs (Seychelles)</td>
<td>Rocky granitic outcrops with a very high endemism and an abundance of exotics below 10% (Fleischmann et al., 1996)</td>
<td>A istonia macrophylla, Cinnamomum verum</td>
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<tr>
<td>‘Padzas’ Bad Lands (Comoros)</td>
<td>Denuded dry areas with very poor soils modeled by large-scale erosion.</td>
<td>A cota mangium</td>
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<td>Volcanic Flows (La Réunion)</td>
<td>Early successsion stages on young volcanic flows. One filter may be that they are mainly colonized by wind-dispersed species (Strasberg, 1995)</td>
<td>Casuarina equisetifolia</td>
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<tr>
<td>Undisturbed Mountain Forests (all islands, except Rodrigues)</td>
<td>Mountain forests harbor most undisturbed closed canopy forests left in the region. They are invaded by species with a high shade-tolerance</td>
<td>A rdisia creata, Cinnamomum verum, C lidemia hirta, Fuchsia spp., Ligustrum robustum, Psidium cattleianum and Syzygium jambos</td>
</tr>
<tr>
<td>High Altitude Ericoid Vegetation (La Réunion &amp; Comoros)</td>
<td>Shrub and heather vegetation above c. 2000 m asl.</td>
<td>Ulex europeaus, mainly invaded by herbs and generally after fire</td>
</tr>
</tbody>
</table>
The habitat specificity of invasive species may help to predict potentially invasive species in other regions. In bold in Table 2 are species that could become a problem in similar habitats.

**Impacts**

The impacts were broadly classified into environmental impacts on natural systems, and economic impacts on anthropogenic systems.

**Environmental Impacts**

Environmental impacts were classified into three biological levels: genetic effects, impacts on biological interactions, and ecosystem effects. For several exotic species the potential to hybridize with a native species has been shown, but in no case actual hybridization in the wild has been found so far.

The major environmental impact by invasive species perceived at present in the region is the reduction of the native regeneration through competition by exotic species. This becomes most apparent with thicket-forming species such as *Chrysobalanus icaco*, *Clidemia hirta*, *Lantana camara*, *Psidium cattleianum*, *Ravenala madagascariensis*, *Rubus alceifolius*, or *Syzygium jambos*.

A mutualistic relationship between exotic fruits (notably *Psidium cattleianum*) and exotic animals has been proposed for La Réunion and Mauritius. In Mauritius the following hypothesis has been formulated: fruit production of *P. cattleianum* in the austral winter when native fruit availability is generally low maintains high densities of pigs and monkeys. These exotic animals will then be at high densities at the end of the fruiting season of *P. cattleianum* when the main breeding season for native birds and the flowering season for native trees begins. Monkeys cause significant damage to both native birds and trees. Pigs in turn disturb forest trees and ferns and may cause considerable damage to ground-dwelling invertebrates (J. Mauremootoo, pers. comm., 2003).

However, most endemic bird species seem to prefer or need native vegetation. Leguminosae (e.g. several *Acacia* spp., *Paraserianthes falcataria*) and *Casuarina equisetifolia* are N-fixing species that have an ecosystem effect on nutrient cycling.

In the Mascarenes, exotic species generally prove to be less adapted to cyclones. Their higher vulnerability changes forest dynamics and increases the frequency of gaps. Gaps are often gateways for exotic invasions, and may increase soil erosion on steep slopes. *Casuarina equisetifolia* is supposed to interrupt early successions on volcanic flows (Macdonald et al., 1991).

**Economic Impacts**

Concerns over agricultural woody weeds were mainly mentioned in the Union of the Comoros (e.g. *Clidemia hirta*, *Lantana camara*, *Litsea glutinosa*, *Psidium cattleianum*). *Acaia nilotica* is a weed on rangeland in Rodrigues. Other agricultural weeds in the Mascarenes are for instance *Acaia mearnsii*, *Hiptage benghalensis*, *Homalanthus populifolius*, *Larrea leucophala* or *Rubus alceifolius*. In Seychelles creepers such as *Thunbergia grandiflora* or *Merremia peltata* are particularly perceived as very problematic weeds. Invasive species that are also agricultural weeds are an opportunity for awareness building, mainstreaming, and application of the existing legislation.

Besides agricultural weeds no major impacts on humans were mentioned for the region.

**MANAGEMENT PRIORITIES IN THE REGION**

**Prevention**

Preventive measures attempt to stop introductions of new potentially invasive species to a country, or further transport within the country (containment). Instruments for prevention at hand are:

- awareness building, that is best developed in the Seychelles by medias, ‘Wildlife Clubs’ and the Ministry of Environment;
- legislation and border control mechanisms, that are well developed within the framework of plant protection under the respective Ministries of agriculture by the plant protection unit of La Réunion for example;
- screening system for the identification of potentially invasive species, that is currently tested in La Réunion (Le Bourgeois et al., 2003; Kueffer et al., 2003);
- early detection mechanisms that the forestry service of La Réunion has institutionalized a mechanism for the early detection of exotic species in the field (Brondeau and Hivert, 2003; Kueffer et al., 2003).
Mechanical and chemical control

For the past 25 years the forestry service has, in many countries, been the main agency involved in the chemical and mechanical control of invasive species, first in forest plantations, later for nature conservation purposes. However, these experiences are rarely adequately documented.

They are not yet protocols for the documentation of control efforts that allow the assessment of their efficiency and negative impacts, as well as of the applicability of the method in other countries and habitats. The forestry service of La Réunion (ONF-Réunion) compiled its past control efforts and developed a method for their assessment (Hivert, 2003; Brondeau and Hivert, 2003; Kueffer et al., 2003). The ongoing INVABIO research project in La Réunion attempts to assess the impacts of mechanical control methods (Lavergne et al., 2003). Priorities for targeted species and areas have been set and the computerized information system developed by Hiebert (1996, 2001) has been tested (Cazanove, 1999).

Biological control

In La Réunion, two large-scale biological control research projects on Rubus aloifolius and Ligustrum robustum subspec. walkeri are about to finish (Le Bourgeois et al., 2003). Mauritius has a long history of past biological control attempts (for a review consult Fowler et al., 2000). Biological control programmes are expensive. Regional collaborations on species that are problematic in all countries, such as Psidium cattleianum, are advisable.

Habitat restoration

Continuous efforts of habitat restoration started about 15 years ago. Important aspects are the depletion of the exotic seed bank, the restoration of a native canopy, the reduction of the exotic propagule pressure (i.e. seed rain). Best practice is often a combination of mechanical, chemical control and ecosystem management (e.g. the currently investigated introduction of giant tortoises on Ile aux Aigrettes in Mauritius). Often past restoration projects are not well documented.

Comparative studies between restored and non-managed sites in Mauritius indicate that the impact on the native flora and fauna is ambiguous (mainly positive, but for some taxa neutral or even negative). Targets for habitat restoration should be more clearly defined and negative and positive effects on the native fauna and flora monitored. Habitat restoration so far has been done on isolated small offshore or mainland islands (0.5 to 30 ha).

Social and institutional framework

So far, no formal interagency network (national or regional), and no formal invasive species database (national or regional) exist. Recently, national invasive species committees have been set up in Mauritius and La Réunion.

In all countries except the Union of the Comoros, the forestry sector is at the moment reorienting from production forestry to nature conservation and invasive species control. In eco-tourism nature reserves, money generated from entry fees is partly used for habitat restoration (e.g. Ile aux Aigrettes in Mauritius; planned national park project in La Réunion; Cousin, Aride, Vallée de Mai in the Seychelles; Moheli Marine national park in the Union of the Comoros).

In the Seychelles, several luxury hotels do habitat restoration and rare species conservation on their islands.

CONCLUSION

This compilation of the most problematic woody invasive species of the Western Indian Ocean, the first of its kind in the region, should be used with caution. It is based on the contingent valuation of a few experts. However, it shows an extensive overlap of problematic species between the islands of the region and relates conflicts of interest. The following main controversial species have been identified:

- *Psidium cattleianum* (Goyave de chine, Goyavier, Cherry Guava). The fruits of *P. cattleianum* are very appreciated in several countries (Mauritius, La Réunion, and the Union of the Comoros).

- Horticulture industry: many invasive species are ornamentals. New ornamentals are probably introduced every year. The importation of potentially invasive ornamentals is currently not regulated.

- Erosion control: exotic species used in the past for erosion control became invasive (e.g. Casuarina equisetifolia, Chrysobalanus icaco). Currently, in the Seychelles Acacia mangium, a highly invasive species in the Comoros Archipelago, is planted for erosion control.
• Multi-purpose species in the Union of the Comoros: 70-80 percent of the population is still working in the agricultural sector where many invasive species are used.

It would be interesting to test the methodology in other region or eco-region and monitor at global level the phenomenon of invasiveness.

ACKNOWLEDGEMENTS

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The complete study (a set of five Forest Health and Biosecurity Working Papers in English and one document in French) is available in hard copy and on the Internet:


REFERENCES

Binggeli, P., Hall, J.B. & Healey, J.R. 1998. An overview of invasive woody plants in the tropics. School of Agricultural and Forest Sciences, University of Wales, Bangor, UK.


