Summary  Projections of future climate change raise significant issues for invasive species management. In this study, stakeholders' perceptions of invasive alien plant species are examined and compared to their perceptions of other environmental issues, including climate change, on the Mediterranean islands of Mallorca, Sardinia and Crete. While there is a general tolerance of invasive species, stakeholders note concerns with specific impacts. To limit uncooperative stakeholder responses towards management approaches, research needs to determine the most detrimental species within local contexts. Support is required to enhance stakeholder capacity to recognise and respond to invasive species. As climate change increases invasive species risk, the effective management of these species should be integrated more broadly within environmental programs in the Mediterranean.

Keywords  Invasive species, Mediterranean, perceptions, climate change, management, Ailanthus altissima.

INTRODUCTION
Invasive alien species have negative impacts on both ecological and social systems (Pimental et al. 2001). Some invasive species, such as disease-causing microbes, cause acute socio-ecological problems, while other impacts are subtler and lead to longer-term change, such as changes to the composition and function of biological systems (Grittì et al. 2006). While invasive species may have negative impacts, there are also advantages of using many alien species in different contexts such as agriculture, landscape gardening or forestry. Largely because of the perceived benefits of alien species, there can be opposition to restrictions on their use (Bardsley and Edwards-Jones in press). To become more effective, invasive species management must be perceived by stakeholders as aiming for both socio-economic and ecological sustainability.

The focus here is on the social attitudes towards invasive alien plant species in the Mediterranean region. The target islands for this study, Mallorca, Sardinia and Crete, have a long history of accidental and intentional species introductions because they have been centres of international trade for millennia (Baskin 2002). The islands are now in the European Union and the associated increases in the rapidity, volume and range of movement and trade provide numerous opportunities for the dispersal of alien species. As new organisms are introduced in large numbers, major management challenges are emerging. In particular, island biogeography theory suggests that islands are vital for the evolution and conservation of biodiversity and are especially vulnerable to invasion. Mallorca, Sardinia and Crete each contain important regional and local endemics of high conservation value. The impacts of invasive species on Mediterranean biodiversity are likely to increase with climate change.

All three islands have Mediterranean climates, typified by hot, dry summers and cool, wet winters, although there is a general drying gradient from west to east. More warmer days, fewer cold days, reduced average rainfall, more variable rainfall and more extreme weather events are projected to be important consequences of an enhanced Greenhouse effect in Mediterranean climatic systems. Such trends in climate are currently apparent in the Mediterranean (Smith et al. 2000, Dünkeloh and Jacobeit 2003, Piccarreta et al. 2004). Globally, ecosystems are responding to changing climates, with phenological changes apparent in some species and evidence some species ranges are extending poleward and towards higher altitudes (Kappelle et al. 1999, Hughes 2003, Parmesan and Yohe 2003, Thuiller 2004).

Future invasive species management in the Mediterranean will be occurring within a context of changing climates and extensive anthropogenic exchanges of alien species. The premise of this paper is that these conditions will require an evolution in invasive species management and policy.

Because of the importance of local actors in the management of invasive species on Mallorca, Sardinia and Crete, stakeholder perceptions of the impacts of invasive species were compared with perceptions of other important environmental issues and the opinions
were reviewed in the context of increasing evidence of global climate change.

MATERIALS AND METHODS
Stakeholders’ perceptions of invasive species management were examined on Mallorca, Sardinia and Crete in 2002, as part of a larger ecological study. Stakeholders were targeted because of their involvement in invasive species research and management. Questionnaires were used to quantify opinions of the relative importance on the islands of environmental issues, including invasive species and climate change impacts, using a Likert scaling procedure (Hayes 2000). Respondents were asked to rate the importance of environmental problems from one (irrelevant) through to six (extreme importance). The responses were analysed using the Kruskal-Wallis test with SPSS software (Bryman and Cramer 1997). Key stakeholders were also interviewed using a semi-structured interview approach. Respondents were asked specifically if *Ailanthus altissima* (P. Mill.) Swingle (ailanthus, tree of heaven) had a substantial impact on the island’s ecosystems, industries, infrastructure, human well-being or management processes.

RESULTS AND DISCUSSION
In total, 142 respondents completed part of the questionnaire. Neither invasive species nor climate change was ranked as the most important environmental issues (Table 1). Invasive species issues were ranked more highly on Mallorca than other islands, although issues of urban/tourism development and changes in agricultural practices were perceived as more important environmental issues on the island. On Sardinia, fires ranked highly, along with soil degradation and the impacts of industrial pollution and climate change. Stakeholders in southern Sardinia noted local impacts of a series of drier winters on water supplies and agricultural production. On Crete, the most important issues were urban/tourism development, loss of natural habitat and soil degradation.

The findings suggest that, at the time of the survey, the impacts of invasive species and climate change were less immediate than several other environmental issues for local environmental managers and researchers. The results also tend to support the argument that the success of invasive species relates not only to their ecological attributes and utility within human systems, but also the laissez faire attitude of many stakeholders towards their impacts. Ecological studies reveal significant effects of invasive species on local environments, and stakeholders often stated that they were aware of these impacts (Gritti *et al.* 2006). However, as a Sardinian NGO worker noted, ‘The problem of invasive alien plant species hasn’t been touched in Sardinia, probably because it has not become serious enough to have an impact either economically or on specific species.’

As the ‘natural’ is difficult to define within the Mediterranean context, local perceptions become important guides to a regional conservation ideal. In fact, a sense of place in Mediterranean landscapes could be seen to be directly associated with changing species assemblages. A Sardinian customs official (19/02/2002) stated, ‘in a country like Italy, the problem of exchange of organisms is not felt like in Australia, because people have taken things in and out for at least 6000 years’ and, ‘Australia is like a child that can catch everything, here we are old, we are immune to everything.’ The species ailanthus provides a good example of the complexity of local perceptions of alien species.

**Perceptions of ailanthus** Ailanthus is a fast growing tree, originating in East Asia and used as an ornamental in Europe since the 1780s (Gritti *et al.* 2006). The species is dioecious and the females can produce up to 325,000 seeds per year. It can also produce asexually via rhizomes and form dense clones. Ailanthus is popular in the Mediterranean as an attractive shady tree in areas with dry climates and poor soils. It is also used to provide firewood and was used in the past as a food source for the ailanthus silkworm, *Samia cynthia* (Drury). Responses such as ‘I think it is a good tree, it

<table>
<thead>
<tr>
<th>Environmental issue</th>
<th>Mallorca N = 42</th>
<th>Sardinia N = 75</th>
<th>Crete N = 25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invasive alien species*</td>
<td>4.31</td>
<td>3.81</td>
<td>3.48</td>
</tr>
<tr>
<td>Climate change**</td>
<td>4.03</td>
<td>4.70</td>
<td>3.57</td>
</tr>
<tr>
<td>Soil degradation**</td>
<td>4.42</td>
<td>5.16</td>
<td>4.48</td>
</tr>
<tr>
<td>Urban/tourism development**</td>
<td>5.86</td>
<td>4.07</td>
<td>5.00</td>
</tr>
<tr>
<td>Industrial pollution**</td>
<td>3.08</td>
<td>4.19</td>
<td>3.32</td>
</tr>
<tr>
<td>Loss of natural habitat</td>
<td>5.27</td>
<td>4.89</td>
<td>4.57</td>
</tr>
<tr>
<td>Agricultural practice change *</td>
<td>4.72</td>
<td>4.12</td>
<td>4.00</td>
</tr>
<tr>
<td>Fire**</td>
<td>4.97</td>
<td>5.76</td>
<td>3.86</td>
</tr>
</tbody>
</table>

*Significant difference at the 95% Confidence level using the Kruskal-Wallis test.

**Significant difference at the 99% Confidence level using the Kruskal-Wallis test.
resists pollution and it is beautiful, with an impressive
flower’ (Agronomist, Crete; 15/05/2002) and, ‘it is dif-
ficult to develop good plants in the city, but this plant
survives and gives shade in the summer’ (Agronomist,
Crete; 09/05/2002), suggest that substantial value is
attributed to this hardy invasive tree species.

However, respondents also raised significant
concerns about ailanthus. Ailanthus roots damage
walls, roads and other structures. A Sardinian botanist
(13/02/2002) stated, ‘Ailanthus causes problems with
cracks in monuments. As soon as there is a crack in
monuments the roots push down. In the historical part
of Cagliari it is a problem. It grows in the botanical
gardens, in cemeteries, along the street.’ Ailanthus
produces allelochemicals, which reduce establishment
in cemeteries, along the street.’ Ailanthus
provided shade for customers, other flowers
would not grow underneath the trees, they smelt badly
and they dropped flowers all summer.

Ailanthus is an excellent coloniser, but is rarely
found in areas where competition with native species
is high (Sukopp and Wurzel 2000, Trifilo et al. 2004).
In the Mediterranean, ailanthus remains largely re-
stricted to ruderal areas, close to urban development,
transport links or waterways. Rarely has it spread into
agricultural fields or natural vegetation on the islands,
although some specific sites, such as fields near the
ruins of Knossos, Crete, are infested. However, as
climates change there could be changes in disturbance
regimes and associated changes in ecological assem-
bilages. Native species may struggle to track shifting
bioclimatic envelopes and more opportunities may
arise for invasive species to migrate and out-compete
native species (Buckland et al. 2001, Walther et al.
2002). In a regional landscape experiencing rapid
climate change, the niches available to alien species
such as ailanthus may increase as native ecosystems
are disturbed.

Environmental management planning Planning
must recognise that ecosystem vulnerability is likely
to increase as change occurs to climates and associated
disturbance regimes, such as fires, storms, drought
or floods. Invasive species management could be
improved by identifying potentially high-risk species.

Once the presence of such species is recognised on
the islands, rapid responses could then be possible.

As climates change, effective biodiversity manage-
ment on private and public land will be required to
minimise ecosystem fragmentation and degradation.

The Natura 2000 European conservation program
could, for example, incorporate modelled impacts of
climate change into research and planning (Dimitra-
kopoulos et al. 2004). European biosecurity strategies
could also integrate climate change projections into
risk management, which could in turn, lead to stricter
quarantine controls.

Future invasive species management approaches
will present significant governance challenges within
intensively settled Mediterranean landscapes. Many
people on Mallorca, Sardinia and Crete justifiably
see the freedom of land ownership and use as funda-
mental rights. In fact, stakeholders suggested that
people largely accept environmental change as a
component of life on the islands. In such a context,
the application of top-down plans is unlikely to be
effective unless such plans are owned, designed and
applied by local communities. For example, it could be
difficult to convince people on the islands that restric-
tions in species exchanges are required. To achieve
environmental management goals, the awareness of
the need to manage invasive species must be raised
across the region.

The legitimacy of environmental governance
needs to be improved in the minds of all stakehold-
ers, by:

• Improving awareness of all environmental is-
sues;

• Enhancing scientific and socio-economic knowl-
edge of key biodiversity assets;

• Focusing on invasive species with high impacts,
perceived as ecologically and socially vital;

• Controlling new introductions; and

• Developing stakeholder involvement in an inte-
grated approach to limit the impact, density and
extent of established populations.

According to a government official in Mallorca
(20/3/2002), the Department of the Environment in the
Balearic Islands is developing legislation to increase
their jurisdiction over vegetation on private lands.
Such an approach could marginalise local people by
undermining their roles as managers, unless they are
empowered by the process. Informed local managers,
aware of the importance of controlling important
invasive species and grounded in the local cultural
interpretations of place, can be effective managers of
local ecological issues. To achieve that goal, a focus on
education and support programs for people who man-
age alien species and the provision of opportunities
to better control invasive species would be important
aspects of an appropriate policy approach.

Future impacts of climate change and globalisa-
tion on ecosystems remain uncertain. To respond to
this uncertainty, the European Union and Mediter-
ranean governments can support the establishment
of resilient and flexible systems by assisting regional
stakeholders to manage their local ecological complexity. By embedding responses in the community, the efficacy of management can be enhanced, as many individuals and communities with the awareness and capacity to bring about change will respond within their own biophysical and socio-cultural contexts. In this manner, the diversity of management responses across and between regions will be enhanced, as will opportunities for further learning as social and environment change impacts on southern Europe.

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