Weed risk assessment for botanic garden decision making

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Abstract

The purpose of this study was to investigate a potentially powerful tool, the Weed Risk Assessment, to help guide responsible development of botanical garden collections. Increasing concerns over invasive plant introductions have led to development of risk assessment measures. These measures can be applied to botanic garden practice to help mitigate the risks of plant introductions. The Weed Risk Assessment (WRA) originally developed for use in Australia has been modified for use in other parts of the world, such as South Florida. Active botanic garden research, utilizing plant records going back more than 70 years, compares WRAs in two categories: 1) conservation collections and 2) horticultural introduction/distribution plants. This assessment seeks to determine whether different kinds of plant collections pose different risks of naturalization.

Keywords

Native, alien, invasive, WRA, *ex situ*, *in situ*, *inter situ*, plant conservation

Changing foci of botanical gardens

Botanical gardens have a wealth of experience with exotic plant introductions, going back many centuries. Historically, most of these introductions have been for purposes of food, medicine and ornament (Foster, 1999). Intensive collection of food and ornamental plants was especially intense in the late 19th and early 20th centuries (Stoner and Hummer, 2007). Major botanical gardens in South Florida, especially Montgomery Botanical Center and Fairchild Tropical Botanic Garden, were born of this era and have long experience with exotic plant introductions. Concomitant to the collection of a large diversity of plants, gardens became centres for the study of this diversity through plant systematics research, as witnessed by the important herbarium collections often associated with gardens.

However, the past two decades have witnessed a shift in botanical garden focus and increasing interest in plant conservation (Heywood, 1990), and in a broader scope for scientific research, such as monitoring effects of climate change (Donaldson, 2009).

Making choices regarding *in situ*, *ex situ* and *inter situ* approaches:

Traditionally, plant conservation efforts have been classified as either *ex situ* or *in situ*, with *in situ* efforts focusing on preserving a species where it was first encountered and documented during historic times. Efforts to cultivate and preserve plants outside this criterion have been classified as *ex situ*. Many factors weigh on decisions regarding which conservation strategies to pursue for a given set of circumstances. Sometimes these decisions are made on largely *a priori* philosophical grounds, such as the view that only *in situ* conservation has merit because preservation of a species outside its historic

context does not allow a full appreciation of the "wild value" of the species in its natural state (Rolston, 2004). *Ex situ* conservation in botanical gardens is also often questioned on genetic grounds (Aplin, 2008), but recent research has demonstrated that population based collecting efforts can adequately capture well documented genetic diversity in a botanical garden collection (Namoff *et al*., 2010). Furthermore, many plant species can be successfully propagated by vegetative means, enabling *ex situ* preservation and duplication of wild origin genotypes indefinitely.

For a growing number of species, *in situ* conservation is no longer a practical option. Some species have lost their entire habitat to human activity, or to natural disasters, and a steadily increasing number of species owe their continued existence to cultivation. The plant conservation situation is becoming increasingly desperate in biodiversity hotspots such as New Caledonia (Bouchet *et al*., 1995). In Hawaii, deficiencies in both *in situ* and *ex situ* approaches have led to a third approach, *inter situ* conservation, that recognizes the value of restoring populations of critically endangered species to prehistoric and early historic sites once inhabited by a given plant species, but not part of its traditionally recognized habitat (Burney and Burney, 2007). Another approach, Quasi *in situ*, involves cultivating *ex situ* collections in a semi-natural environment (Volis and Blecher, 2010)

If mainstream climate change projections prove correct (IPPC, 2007), then the concepts of *in situ*, *ex situ* and *inter situ* may carry far less meaning as the Earth's climate shifts and the historical ranges of plant species become less habitable or uninhabitable, and new areas become more habitable. To come to terms with this challenge will require a deeper paleoecological perspective that sheds light on variability and change in natural systems to large changes in environmental conditions (Froyd and Willis, 2008).

Thus, the key question before the conservation community at large and before gardens is not "is *in situ* or *ex situ* conservation to be preferred?", but rather "are plant species worth preserving even outside their historical context?" We suggest that the latter question be answered in the affirmative, and suggest that biodiversity has great value even when circumstances prevent it from being appreciated in its historic natural setting. This opens up the possibility of gardens utilizing a very practical non-*a priori* approach to conservation that treats each challenge on its own terms with a mix of *in situ*, *ex situ* and/or *inter situ* approaches that best serves the needs of the plant species in question and takes into account the relevant biological, environmental, political and financial factors. Thus, we advocate a data driven, rather than philosophy driven, approach to *in situ* vs. *ex situ* questions.

How do we approach the natives and aliens?

Given the increasingly urgent conservation needs of many rare plants, there is growing motivation to bringing the full suite of practical conservation options to bear on conservation planning. However, as more gardens pursue *ex situ* conservation and assisted migration projects, necessitating cultivation of rare plants outside their native ranges, questions are beginning to arise regarding the risks associated with this approach (Ricciardi and Simberloff, 2009). In a few instances, a rare or endangered plant has become invasive outside its native range. A classic case is *Pinus radiata*, which is under considerable conservation threat in its handful of distinct native habitats

(Rogers *et al*., 2006), yet is becoming invasive through escape from mass forestry plantations in many countries (Richardson *et al*., 1994).

Problems caused by invasive non-native plants are very well documented in a variety of contexts. However, as is the case with questions of *in situ* and *ex situ* conservation, a temptation exists to oversimplify the issues and rely on broad *a priori* generalizations - such as considering non-native plants inherently "bad" and native plants as inherently "good" (Slobodkin, 2001). Yet this approach overlooks the many complexities that exist in questions of nativity and invasion (Warren, 2007). Such an approach would portray all *ex situ* efforts as "too risky" based on the precautionary principle that one can never be 100% sure that a plant species will not become a problem outside its native habitat one day under some circumstances (Ricciardi and Simberloff, 2009). The use of *a priori* generalizations becomes especially questionable when definitions of nativity depend more on political boundaries than on ecological considerations. For example, many species from other parts of Australia have become invasive in the Australian state of Victoria, yet are often not considered as such due to their being "Australian natives". In addition, some indigenous species in Victoria have begun to behave invasively in some contexts, forming thick stands that crowd out other native vegetation (Carr, 2001). The drive to develop generalized scientific laws (such as those that characterize physics), often where they may not exist, has been suggested as an impediment to progress in ecology (Weiner, 1995), whereas a focus on understanding the inherent variability of species and natural systems has been suggested as a remedy (Hansson, 2003). Local variability and contingencies appear to predominate in cases of invasiveness as well (Simberloff, 2009). Thus, we suggest that issues of invasiveness are best handled by considering the specific ecological context and the specific species involved, rather than resorting to *a priori* generalizations.

Botanical garden introductions and invasion risk

A small portion of plants introduced into cultivation through botanic gardens have become naturalized or invasive and the potential exists for further problematic introductions if proper precautions are not taken (Reichard and White, 2001). A recent example in South Florida involves exotic mangrove introductions by the Fairchild Tropical Botanic Garden (FTBG). Of 14 species introduced from the 1940's to the 1980s, five have survived in cultivation and one has escaped and shown invasive tendencies (Forqueran *et al*. 2009), another species has persisted for 70 years and produced some seedlings, due to horticultural intervention to control native vegetation, but has shown no tendency to spread beyond the original planting area. These results are not surprising given that the overwhelming majority of introductions are not invasive (Gordon and Gantz, 2008), and many garden introductions prove to be challenging to maintain in cultivation over the long term. The question thus arises: Can we reliably predict the small portion of plant introductions that are likely to become invasive?

Weed Risk Assessment

The Australian Weed Risk Assessment (WRA) was developed to attempt to screen plant introductions (Pheloung *et al*., 1999). This assessment evaluates each potential plant introduction using 49 questions that encompass a wide range of factors such as the biological characteristics of the plant, its environmental tolerances, any characteristics that may render it directly harmful to humans or agriculture, and its introduction history in other areas. The result of the assessment is a numerical score that classifies the weed

risk of the potential introduction as either low (<1), requiring further evaluation (1-6), or unacceptably high (>6). This assessment has subsequently been modified and evaluated for effectiveness in other countries (Gordon *et al*., 2008a). The Australian WRA has been adapted for use in Florida, USA and evaluated by Gordon *et al.* (2008b). The Florida WRA detected 92% of known invasives and correctly did not reject 73% of known non-invasive species.

Do *ex situ* conservation plants have a lower risk of invasiveness than horticultural distribution plants?

Botanic gardens frequently acquire non-native plants for different purposes. Some are introduced primarily for their ornamental horticulture purposes, others are primarily for education, research or conservation. To evaluate the effectiveness of the Florida WRA for different types of botanical garden collections, we compiled records of 24 non-native plants introduced to FTBG and the Montgomery Botanical Center (MBC) for purposes of conservation, with 20 species distributed to the gardening public by FTBG from 1955 to 1979, before species were being evaluated for weedy tendencies. Although the samples were originally of equal size, two of the distribution species were found to have IUCN assessments of "Vulnerable" and were thus included with the conservation species.

Raw scores of the conservation species were significantly lower than those of the horticultural introduction species and also varied significantly less (Figure 1). Scores of both groups were low overall. When examined categorically 92% of the conservation species, and 57% of the horticultural species were accepted, and one horticultural species, the known Florida invasive *Sesbania punicea*, was rejected (Figure 2). Another species that is known to be naturalizing in South Florida, *Diospyros maritima*, fell into the "evaluate further" category. Thus, the WRA proved to be accurate when assessing these 44 garden introductions and distinguished lower invasiveness risks associated with conservation introductions than horticultural introductions. Reichard, Liu and Husby (2010 in press) discuss this study in more detail.

Conclusions

In conclusion, we recommend use of the WRA as an important tool for evaluating potential invasiveness risk of *ex situ* garden introductions. This data-driven approach can correctly predict invasiveness potential distinctly, whereas *a priori* nativity criteria often do not. Thus, the WRA method can facilitate implementation of a full suite of conservation options to save rare plants from extinction: *in situ*, *ex situ* and intermediate approaches. The alternative *a priori* approach does not take into account the great complexity of the living world and the resulting complexity of conservation challenges, making assessment by nativity criteria alone arbitrary at best and, in a future of increasing habitat destruction and global climate change, irrelevant at worst.

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Figures:

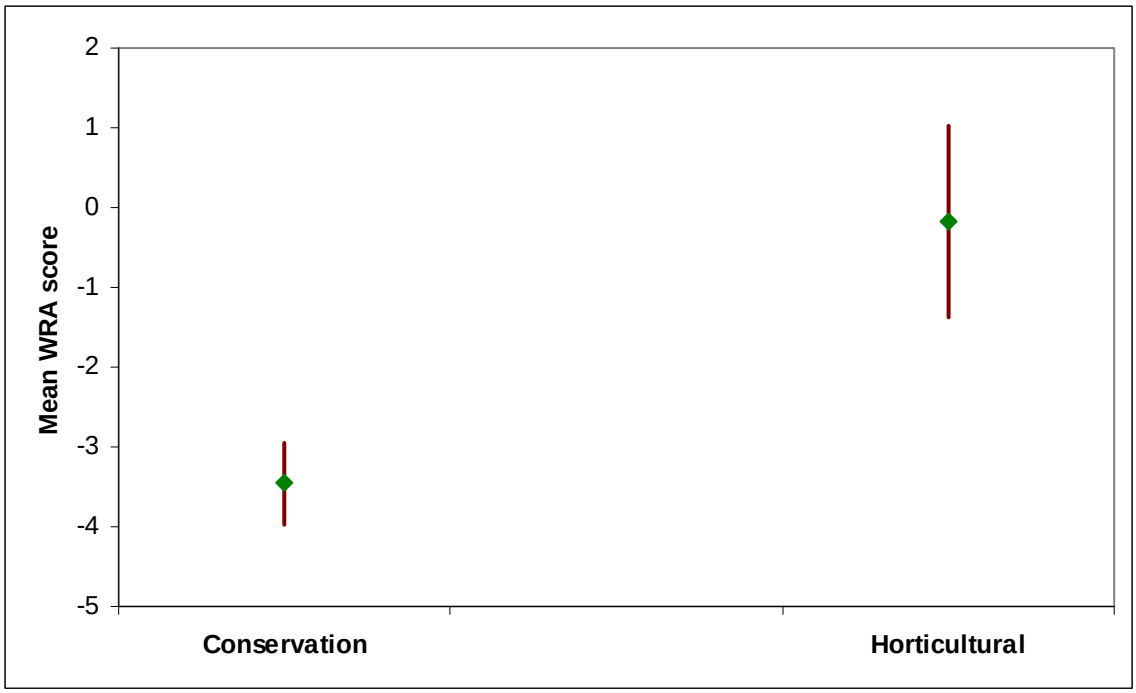

Figure 1. Weed Risk Assessment scores for plants introduced by Fairchild Tropical Botanic Garden for conservation and horticultural distribution purposes. Vertical bars are standard errors of the means. Adapted from Reichard, Liu and Husby (2010 in press).

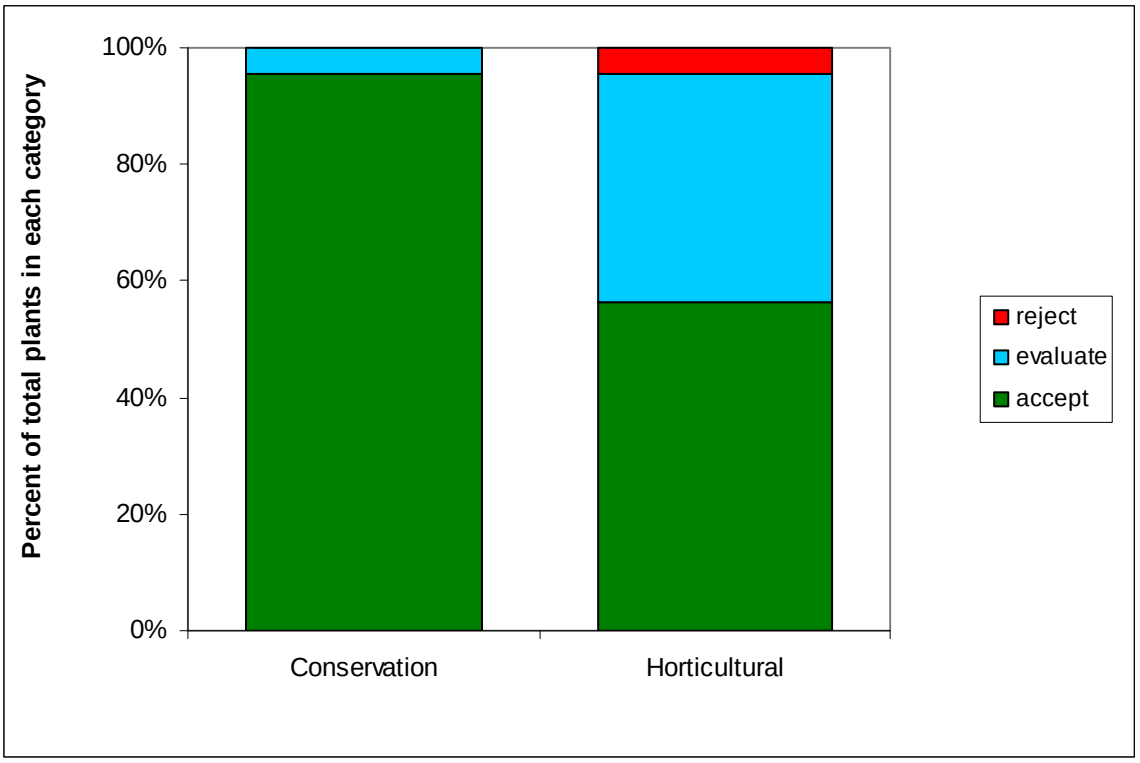

Figure 2. Weed Risk Assessment outcomes by category (accept < 1, evaluate further 1-6, reject >6) for conservation and horticultural introduction plants at Fairchild Tropical Botanic Garden. Adapted from Reichard, Liu and Husby (2010 in press).