Pest adaptation response planning: a practical application of species distribution science in forecasting strategic planning for weed managers

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Summary Weed management planning generally occurs within a contemporary or near-future time-frame. It identifies current issues and emerging risks, and responds by assigning some measure of priority to guide on-ground management tactics. This approach facilitates the practical implementation of the most effective strategies at hand, as well as providing a degree of capacity to respond to new outbreaks as they occur.

Future uncertainties in weed distribution are fuelled by forecast transitions in climate, anticipated increase in human population and the consolidation of species we are already actively managing. As a consequence future management scenarios will need to respond to the introduction of new species from multiple sources as well as the expansion and contraction in currently established species. In this paper we demonstrate an avenue for practical application of forecasting and responding to future weed distributions of species we are currently managing in a Pest Adaptation Response Strategy (PARS).

Keywords Modelling, pest management planning, *Clidemia hirta*.

INTRODUCTION

Weed managers in Local Government Areas (LGAs) of the Wet Tropics Bioregion have used a spatially-explicit zoned and prioritised approach to pest management planning, interpreting best available information about the current distribution and impacts of species to determine management objectives. However, projected changes in the suitability of climate for establishment and growth, and the potential for spread or contraction of species distributions, are likely to have implications for where, when and how many resources may be needed to manage weed invasions in the future.

Forecast models (climate/habitat/spread) exist most commonly in the realm of risk assessment on a state or continental scale. They are usually presented to on-ground managers as a static often single 'image', in the form of the ubiquitous climate suitability model, or less commonly, a habitat suitability model. Rarely is the model interrogated in any other process prior to consumption, and even more rarely is it supported by other spatial knowledge (distribution/land-use/assets) or model processes (dispersal/spread). This is certainly the case at a local/regional scale where time and expertise to progress beyond the static image is often not available.

A collaboration between end users and researchers as part of the Tropical Ecosystems Hub of the National Environmental Research Program (NERP) has resulted in the development of a Pest Adaptation Response Strategy (PARS) for priority weed species in the Wet Tropics region. The PARS adds a new layer of intelligence to the process of forecasting and spatially explicit pest management planning, by integrating a sequence of often disconnected model outputs into a single planning support tool (Figure 1).

Important in the design of this approach is the ability to both critique and compliment the current planning tools in place. By considering how a current management plan interacts with future trends in suitable habitat and climate, a profile of risk and a range of appropriate and proactive management responses can be considered. In addition, the PARS provides managers with a future investment forecast, for example, identifying areas that are likely to require a sustained high investment in management over long time-frames, or those areas where investment may decrease over time.

Forecasting and adaptation in pest management planning Pest management is a learning-by-doing process and there is a growing emphasis placed on our ability to adapt to a dynamic management and planning landscape. Alongside this is an increasing demand for the modelled component of the adaptive cycle of visualising contemporary or future scenarios in the distribution, impact or spread of the target species to better inform 'real' scenarios. Much of our future capacity to respond to pests and weeds will be reliant on our ability to adapt management objectives to suit shifts and changes in environmental conditions; as well as the usual socio-political climate and a continually evolving understanding of invasive species. New opportunities to consider long term trajectories of management programs may assist to better

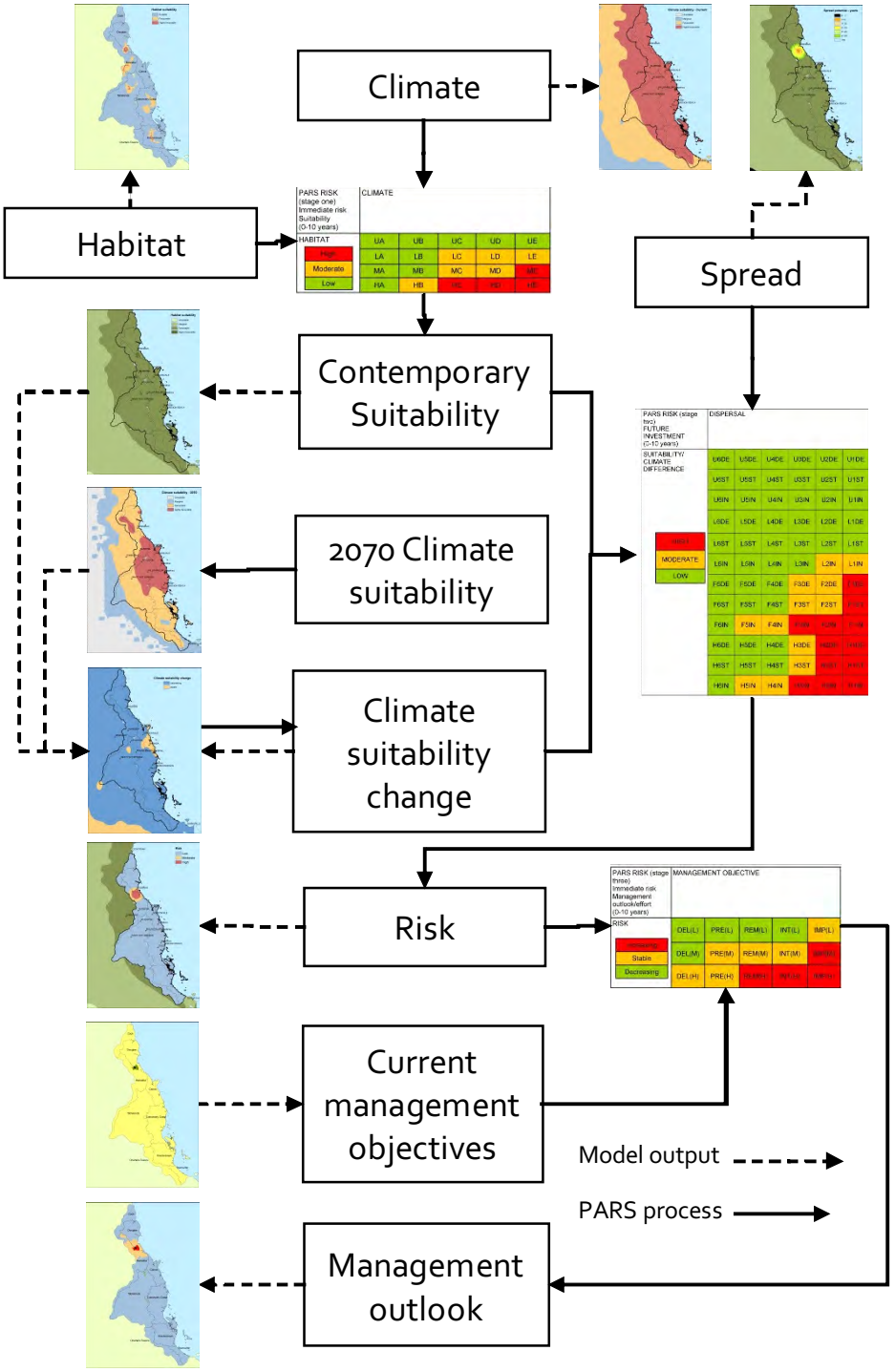

Figure 1. The Pest Adaptation Response Strategy (PARS) process.

communicate the spatial and temporal scales management actually occurs within.

Here, we demonstrate the PARS process and outputs for one priority species in the Wet Tropics bioregion – clidemia (*Clidemia hirta* (L.) D.Don).

MATERIALS AND METHODS

Clidemia hirta (family Melastomataceae) is a Class 1 weed species in Queensland and the target of a National Eradication Program. It currently occurs over a limited area in one LGA in North Queensland; Mareeba Shire Council. The species has a small, fleshy fruit that may be dispersed up to 500 metres by birds. Dispersal may also occur via water and mammals (Breadon *et al.* 2012). Suitable climatic conditions for clidemia occur along the entire eastern coast of Queensland and in the northern Cape York region (Breadon *et al.* 2012).

Three widely utilised modelling approaches have been used to project current and future climate suitability (CLIMEX Sutherst *et al.* 1999), habitat suitability (Maxent, current only, Phillips *et al.* 2006), and potential spread (MigClim, Engler and Guisan 2009). The parameters used in the CLIMEX model, as well as the dispersal kernel and life-history parameters used in the MigClim model were sourced from Breadon *et al.* (2012). Habitat suitability modelling incorporated spatial layers of land-use type, broad vegetation group, foliage projected cover and population density. Climate and habitat suitability models are integrated into a contemporary suitability landscape. A species dispersal model (MigClim) is run on the suitability layer over a 50-year time period. Contemporary habitat suitability, likelihood of spread and climate suitability change are combined in a matrix to generate a low, moderate or high score for future risk. The risk layer is overlaid on the current management objectives and the management outlook for each management unit in the relevant LGA is calculated.

RESULTS

Climate suitability Climate suitability for clidemia is generally projected to decrease or remain relatively stable over the Wet Tropics region. However, almost the entire Wet Tropics region remains favourable under future climate scenarios. Similarly, habitat suitability is favourable to highly favourable across the entire bioregion.

Spread Spread modelling indicates the capacity for clidemia to disperse into the adjoining Douglas Shire Council within 10 years. It should be noted that the spread model does not take into account the current intensive management of clidemia under the National Eradication Program; rather it reflects the potential for natural dispersal (by birds primarily) in the absence of management. The initial phase of the PARS does not include potential long distance spread by anthropogenic means.

Future risk and investment outlook Using the process matrix shown in Figure 1, the future risk profile and management investment outlook can be generated (Figure 2). The risk profile indicates an increasing risk in the Mareeba and Douglas LGAs. The investment outlook thus reflects an ongoing high

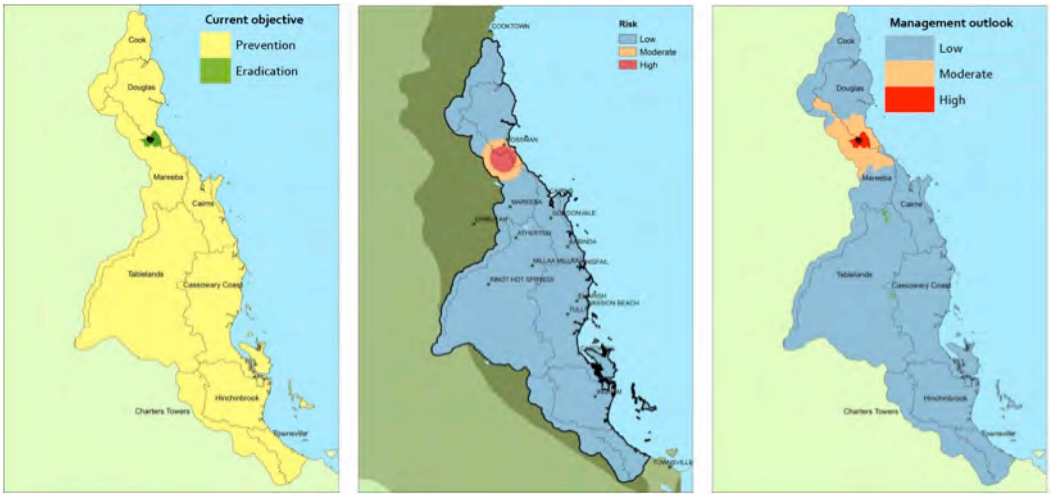

Figure 2. Current management objective (from Local Area Pest Management Plan), PARS risk assessment and future management outlook resulting from PARS process.

future management investment for parts of the Mareeba Shire under the management objective 'Eradication' and the need for a continued moderate investment in management ('Prevention') over parts of the Douglas and Mareeba Shires (Figure 2). Across the remaining areas of the Wet Tropics bioregion management, investment may remain low over time as climate suitability decreases and the potential for spread by natural means is relatively low.

DISCUSSION

The PARS serves a need to not only better inform the conversations of on-ground managers but to expand the audience that is engaged. It also goes some way to demonstrate the key modes of predictive modelling available to us and the distinction and limitations of these when interpreted in isolation. The project targets a suite of 20 priority species from across the Wet Tropics which are identified within the seven Local Area Pest Management Plans developed by Local Governments and stakeholders in weed management. The PARS is developed to play an advisory, decision support role in the annual review of the Local Area Pest Management Plans.

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