Impact reduction and asset protection

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Summary Management of weed impacts occurs across a spectrum of activities from: quarantine, to exclude species entirely; eradication or containment, where feasible; and asset protection strategies to reduce the impact of established weed species. The transition between containment and asset protection strategies occurs after containment of a weed species is no longer economically rational. Weed management efforts are then directed at reducing or maintaining a weed's rate of spread and/or its population below a notional threshold level.

Management activities aligned with a putative weed invasion curve have 'containment' followed by 'asset protection'. We propose that the weed management activities previously commonly termed 'asset protection' be split into at least two categories: 'impact reduction' and a new 'asset protection' category. The transition between the two proposed categories occurs when management activities are no longer directed at the management of a weed species, that is species-led.

'Impact reduction' would involve species-led management activities, generally aimed at managing the recovery of some asset/s. The long-term program to manage the recovery of threatened species populations and ecological communities from bitou bush (*Chrysanthemoides monilifera* (L.) Norlindh subsp. *rotundata* (DC.) Norl.) in eastern Australia is an excellent example. In contrast, the new more restricted 'asset protection' category occurs after this point, when a decision to protect areas/assets from multiple species weed invasions is made. The New South Wales state framework evaluating and prioritising biodiversity priorities from widespread weeds is an example of this. Both new categories will help better tailor weed investment, and management activity parameters.

Keywords Weed invasion curve, containment.

INTRODUCTION

All weed management activities can be placed on a generalised weed invasion curve, for example Charlton *et al.* (2009). This paper focuses on the latter part of the curve where asset (based) protection (AP) is the primary motivation for weed control, and the transition from containment to asset protection.

The initial phases of most plant invasions can be described by a constant exponential *population* growth curve (Cousens and Mortimer 1995). However linear models may well fit *area occupied* vs. time data (Lacey 1957, Auld and Coote 1980, Cousens and Mortimer 1995) for long periods. This will be somewhat dependent on the size of the unit area used: the larger the unit area, the slower the rate of total area occupied will be, and thus a linear fit may be suitable in spite of exponential population growth.

While the initial shape of the curve may be difficult to characterise as an invasion proceeds, at some point saturation of an area must be approached and the invasion curve asymptotes to a maximum value. This is the basis for the generalised weed invasion curve (Figure 1, Auld and Johnson 2014).

Often, the first management response to a high risk invasion is eradication. Experience has shown that eradication is only feasible in the very early stages of an invasion (Panetta 2015). Should this fail to be achieved, the next weed management tactic employed is containment although there is no identifiable turning point in the invasion curve at which to switch tactics from eradication to containment.

CONTAINMENT TO ASSET PROTECTION VIA IMPACT REDUCTION

Many weeds have invaded to such an extent that containment (C, see Figure 1), across their entire occupied range is no longer feasible, for example the Weeds of National Significance (WoNS, AWC 2015). While containment activities proceed, the weed population may still be notionally increasing exponentially and if the invaded area continues to grow at a constant (exponential or linear) rate there is, likewise, no identifiable point indicating where containment is no longer feasible. Having said this, a signal may occur when an increasing number of satellite populations occurs (Auld *et al.* 1979) and there are insufficient resources to contain the dispersed populations.

Overall, implementation of a containment strategy does not mean that Quarantine (Q)/exclusion and prevention, and eradication activities (E, see Figure 1) should not occur, particularly in areas where the

weed is not found but could still invade. Such activities often aim to protect environmental assets from damage (Cherry 2008, 2010, Cherry *et al.* 2012, Grice *et al.* 2013, Auld and Johnson 2014). These efforts are usually focused on the expanding margins and satellite infestations of existing weed invasions, even though there has been little research examining how spatial characteristics of an invasion or landscape characteristics affect optimal control policies and resourcing: for example, see Epanchin-Neill and Hastings (2010) and Auld and Johnson (2014), but note recent exceptions include Steel *et al.* (2014) and Sydes and Murphy (2014).

Policy advisors commonly tend to aggregate a range of weed management activities at the asset protection end of the weed invasion curve. Auld and Johnson (2014) suggested splitting what has been termed the asset protection stage into two stages, these being impact reduction (IR) and asset protection (AP, see Figure 1).

In contrast to the earlier part of the invasion curve, there is an identifiable region in the latter part of the curve where the invasion rate slows and asymptotes towards a maximum area. Beyond this region, impact reduction (in the broad sense) is no longer logical and asset protection remains as the final tactic. The effect of 'impact reduction' may not necessarily reduce the area finally occupied but may increase the time taken to reach that point, potentially providing added net economic benefits (dotted line, Figure 1). Delaying the spread of a weed may also buy time for finding a more effective means of controlling it; for example introducing a biological control agent.

Local eradication and containment may form part of 'impact reduction'. An excellent example is the long-term program to manage the recovery of threatened species populations and ecological communities from bitou bush in eastern Australia. Impact reduction will involve management activities located closest to (to the immediate right of) the containment side of the invasion curve.

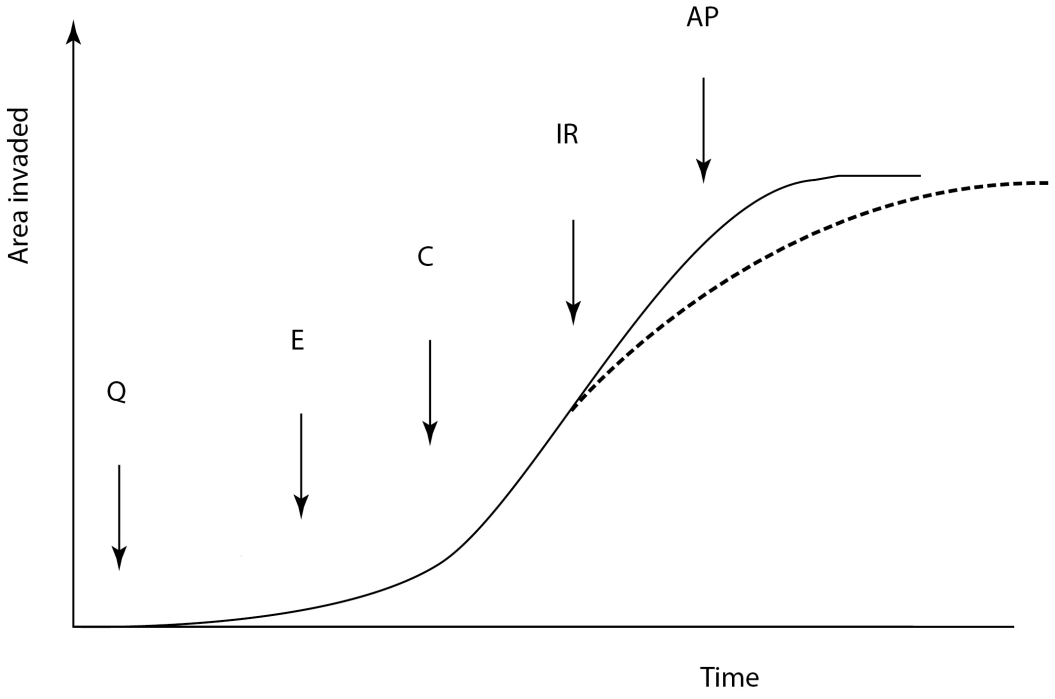

Figure 1. Notional weed management strategies/activities at various stages of the weed invasion curve with the following stages highlighted: Q, Quarantine/prevention; E, Eradication; C, Containment; IR, Impact Reduction; and AP, Asset (based) Protection (from Auld and Johnson 2014 c.f. Charlton *et al.* 2009, originally based on Chippendale 1991). The addition of stages to this curve also originated in Chippendale (1991), was expanded in Hobbs and Humphries (1995) and further refined in Environmental Weeds Working Group (2007). The dotted line indicates the possible effect of impact reduction activities.

In contrast, traditional asset (based) protection activities focus on assets, rather than the invading weed species. The transition point between impact reduction and the refined asset protection activities is, necessarily, when it is no longer economically feasible to focus on the species across its invaded range (species-led management) and a decision to protect areas/assets (asset-led protection) from weed invasion occurs (Auld and Johnson 2014). This acknowledges more recent work within, for example, biodiversity conservation in New South Wales, that environmental assets are often overlooked in natural resource management (Williams *et al.* 2009, Auld and Johnson 2014). To redress this imbalance, a state-wide framework was prepared across former Catchment Management Authorities (CMAs) in NSW:

> '*prioritizing areas for protection from widespread weeds based on the conservation status of ecosystems (e.g. the number of endangered species present) under threat from widespread weeds*' (Auld and Johnson 2014, also see Whiffen *et al.* 2011).

The scope of asset protection may vary with asset type and invading species. For instance, some exotic species are tolerated in native pastures and rangeland but not in annual crops. In nature conservation areas, ideally, no exotic species are allowed. Hence some assets are not species-specific in their 'asset protection' strategy and therefore actually have a local quarantine policy. While excluding all exotic species may not be feasible in many cases, those plant types that could transform ecosystems such as vines, legumes, shrubs and trees may be the target of species-specific asset protection.

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