Operationalising the triage concept in invasions management

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Summary Land managers are often faced with more weed problems than they have time or resources to deal with. In this situation, attempting to do everything everywhere usually results in nothing being done very well anywhere. This is not dissimilar to the situation emergency services face in the wake of major accidents, natural disasters or acts of terrorism. A well-established system known as triage, which assigns treatment and determines the order and priority of treatment based on the needs and prospects of the patient and the capacity of the responders, is standard practice in these situations.

We present a framework aimed at operationalising the triage concept for weed management decisions, providing an objective basis for committing resources based on the likelihood of success. The framework allows rapid prioritisation of management resources across multiple species and can also justify the adoption of a 'do nothing' approach to some weeds in certain situations. The application of this approach is discussed with reference to allocating resources to weed management in rainforest habitats after a severe cyclone, a situation analogous to that of a mass casualty situation following a major accident or disaster.

Keywords Triage, weeds, cyclones, prioritisation.

INTRODUCTION

Triage (derived from the French 'trier' meaning 'to sort') is now standard operating procedure in medical practice from getting an appointment with your GP through to responding to mass casualty incidents following catastrophes or natural disasters. The foundations of all triage systems operating today evaluate patient urgency and seek to maximise patient streaming – i.e. getting the right patient to the right resources at the right place and time. Importantly, triage is a dynamic process involving repeated re-assessment until the patient has received a definitive treatment. The triage concept has found its way into conservation biology (Bottrill *et al.* 2008, Hobbs and Kristjanson 2003) and more recently into prioritising management of invasions for biodiversity outcomes (Downey *et al.* 2010) but it lacks a clear operational framework and therefore has had limited uptake.

Resources are always in short supply for weed management and prioritisation is a key component of any management strategy. Weed managers undertake a form of triage for allocating resources on a day-to-day basis deciding what needs urgent attention, what can be delayed and how many resources to allocate to a given management action. Extreme events (e.g. cyclones, fire, flood) add another layer of complexity to decisions about where to allocate limited resources since they occur infrequently but create very particular conditions that potentially change the way weed species behave in the landscape, and therefore their management priority. For example, cyclones have been shown to accelerate invasions and alter the abundance of weed species in rainforests (Murphy and Metcalfe submitted). Research on weed dynamics post-cyclone Larry (Queensland, March 2006) showed that some weeds were transient, essentially disappearing from rainforest within a year or two, and some were much more persistent with the potential to have significant long-term impacts on tropical forests (Murphy *et al.* 2010). In an analogous way to mass casualty incidents, extreme events overwhelm the resources available and there may be many competing demands for resources. Triage shifts from doing what is best for the individual patient to doing what will do the greatest good for the largest number of people. Medical triage undertaken following disasters or catastrophes has many similarities to the prioritisation of weed management following extreme events.

Here we relate the standard triage categories (i.e. expectant, immediate, delayed, minor, no intervention; see Table 1) to the traditional strategic options for weed management (i.e. asset protection, eradication, containment, control, do nothing). Those responsible for triage ask: Who should be seen first? How long can a patient safely wait? What resources are necessary to achieve a favourable outcome? We consider these questions using the example of prioritising weed management in rainforest habitats following a severe cyclone.

TRIAGE AND STRATEGIC OPTIONS FOR WEED MANAGEMENT POST-CYCLONE

We examined the most commonly used mass casualty triage decision trees (e.g. START, ESI) and developed a decision tree for weed management post-cyclone based on the three key components; threat/impact, urgency, and likelihood of recovery (Figure 1). Table 1 gives the standard categories of mass casualty triage, the analogous weed management strategy and examples of species that may fit each category based on best available research and observation of post-cyclone weed risks and responses. Thus, depending on the likely impact or threat from a species, whether that impact or threat is likely to be immediate or delayed, and the probability of a successful outcome given the resources available, management of particular species in a particular situation can be triaged. As noted earlier, it is important to consider triage as a dynamic process. As soon as the 'patients' of immediate concern are stabilised (i.e. those in the eradication category), patients in the next most imminent threat category can be reassessed and moved up the scale if resources permit.

Where the severity of the situation is so far advanced that a favourable outcome is unlikely given the resources available, the triage category of 'Expectant' is given i.e. the patient is unlikely to survive and palliative care and pain relief should be provided. This is analogous to asset protection in weed management. We are relieving symptoms without expectation of a 'cure' being achieved.

Invasive vines at forest edges are an example of a suite of species for which even a large investment in resources is unlikely to result in a significant reduction in impact in the medium to long term.

Where potentially high (life-threatening) impacts are expected and if treated early enough the probability of recovery given the resources available is high, the species is categorised as requiring immediate attention, or eradication. Scrambling vines and shrubs may fall into this category in some instances. They are fast growing and can rapidly arrest succession in forests following cyclones, having significant impacts over a long timeframe. However, they are often not shade-tolerant and, if received immediate attention, the potential impacts can be averted.

Where impacts are likely to be high but may be delayed, the species may be categorised as suitable for containment. For example, the impacts of fleshy fruited, shade-tolerant trees are likely to be high but may not be evident for several years post-cyclone. In these circumstances, action could be delayed in the short term but will require significant investment to achieve a successful outcome in the medium term. This is consistent with the idea of containment as a 'holding' strategy until eradication can be resourced. Again, this situation should be regularly re-evaluated with the goal of moving species up into the eradication category as resources become available.

Shade-intolerant woody weeds may have significant medium-term impacts but have limited

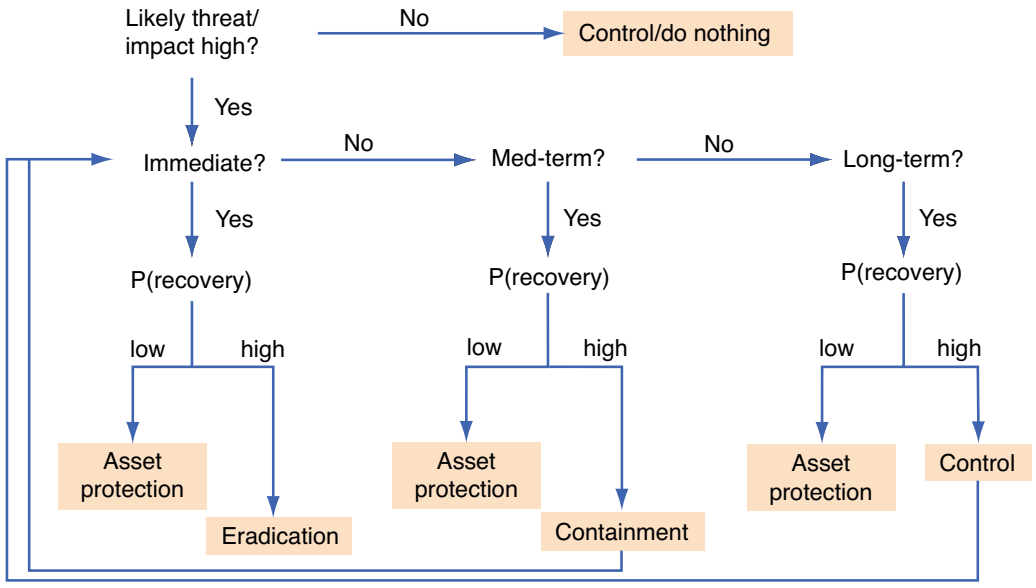

Figure 1. Post-cyclone triage decision tree for weed management.

Table 1. Triage categories, weed management strategies and a post-cyclone rainforest weed example.

Medical triage category	Weed management strategy	Example
Expectant Victim unlikely to survive given severity of injuries, level of available care or both. Palliative care and pain relief should be provided.	**Asset protection** Consequences already significant. Unlikely to achieve significant gains with the resources available.	**Vines at edges** Significant but localised impacts; already widespread across landscape. Large resource investment unlikely to have much effect in medium to long term.
Immediate Victim can be helped by immediate intervention with lots of resources needed. Requires medical attention within minutes for survival.	**Eradication** Consequences potentially very high. Can be achieved with high resource requirements. Requires attention immediately to prevent further impact/spread.	**Scrambling vines and shrubs in intact forest** Potential immediate impacts on structure and function persisting over long time periods. Significant investment in resources immediately has good chance of success over medium to long term.
Delayed Intervention can be delayed – includes serious and potentially life threatening injuries, but status not expected to deteriorate significantly over several hours.	**Containment** Consequences not expected imminently and can delay action. Medium resource investment. Requires management quickly to prevent further spread/impact.	**Fleshy-fruited, shade tolerant, trees** May take years for impacts to manifest but potentially significant consequences. Can delay eradication action but will need significant investment or escalation quickly.
Minor Victim with relatively minor injuries. Status unlikely to deteriorate over days. Likely to recover over time with minor/no further intervention.	**Control** Consequences not expected immediately and can delay action. Limited resource investment. Requires management in the medium term to prevent further spread/impact.	**Shade-intolerant woody weeds** Delayed consequences, unlikely to be significant in long term. Will disappear in the medium term regardless of intervention.
No intervention Will recover over time regardless of intervention, no consequences expected.	**Control/do nothing** Will recover over time regardless of intervention, limited/no long-term consequences expected.	**Herbaceous weeds** Generally transient in intact forest following disturbance. Limited, short-lived impacts. Will disappear over time regardless of intervention.

consequences in the long term regardless of the resources invested. They are likely to be shaded out eventually as the forest recovers. A limited investment in control may be required to prevent further spread. Similarly herbaceous weeds, while dominant immediately post-cyclone, are transient and appear not to have significant impacts on medium to long-term forest recovery. They disappear within a short time regardless of intervention (Murphy *et al.* 2010). These species may be classified as requiring no intervention.

DISCUSSION

Often, there is an influx of funding for environmental management activities following severe natural events. However, timely decisions about allocation of resources for maximum effectiveness can often be difficult in the immediate aftermath of an extreme event. That is why there are standard, practiced and critically assessed methods for medical triage following mass casualty incidents which all emergency response personnel are trained in, despite the fact that

they may never be involved in a real-life situation. It seems prudent to establish agreed guidelines for prioritising weed management decisions prior to an extreme event so that resources can be directed effectively and efficiently to minimise weed impacts.

Recently, Zimmer *et al*. (2012) published the 'Post-fire weeds triage manual' in response to the Black Saturday fires in Victoria in 2009. The aim of this guide is to assist in the prioritisation of weed management projects for funding following fire and is aimed at individuals managing the distribution of funding. The manual will no doubt be extremely useful for this purpose in the case of future severe fire events. Here, we have attempted to simplify and operationalise the well-tested concepts of triage as it relates to traditional weed management strategies at the scale of landscapes or regions. We suggest the concept of triage could be usefully applied in a range of situations from responding to severe weather events to prioritising weed management strategies for multiple species at local, regional and national scales.

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