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A sociocultural and biogeographic assessment of weed management at Bundanon Trust

Linden M. Brown

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Abstract

Species invasions are becoming more and more prevalent globally, largely due to human influences. Certain invasive species have the ability to drastically change ecosystems, but can also have significant social and economic effects. Consequently, managing and controlling these species is a goal of many public, private, and government stakeholders. However, there are very few case studies where the various social, ecological, and economic factors affecting management have been explored. This thesis explores these various factors at Bundanon Trust, an arts Trust which also manages an area of 1100 hectares of varying land uses. Field assessments of the weed management sites at Bundanon Trust were combined with interviews with key players associated with weed management at Bundanon Trust in order to determine the exact factors which are affecting management. Through these methods, a range of factors were discerned. The key factors which were determined included public perceptions regarding weed management practices, and therefore the need for public education and involvement in weed management programs; the ability connected properties to aid the spread of weeds, and therefore the need for regional cooperation in managing weeds; and the need for long-term funding in order to implement successful weed management programs. It is critical to understand and address these factors in order to ensure that weed management programs such as those implemented at Bundanon Trust have the highest chance of success.

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By

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Abstract

Species invasions are becoming more and more prevalent globally, largely due to human influences. Certain invasive species have the ability to drastically change ecosystems, but can also have significant social and economic effects. Consequently, managing and controlling these species is a goal of many public, private, and government stakeholders. However, there are very few case studies where the various social, ecological, and economic factors affecting management have been explored. This thesis explores these various factors at Bundanon Trust, an arts Trust which also manages an area of 1100 hectares of varying land uses. Field assessments of the weed management sites at Bundanon Trust were combined with interviews with key players associated with weed management at Bundanon Trust in order to determine the exact factors which are affecting management. Through these methods, a range of factors were discerned. The key factors which were determined included public perceptions regarding weed management practices, and therefore the need for public education and involvement in weed management programs; the ability connected properties to aid the spread of weeds, and therefore the need for regional cooperation in managing weeds; and the need for long-term funding in order to implement successful weed management programs. It is critical to understand and address these factors in order to ensure that weed management programs such as those implemented at Bundanon Trust have the highest chance of success.

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1. Introduction

1.1 Context

Biological invasions are natural processes which have been occurring for millions of years before the arrival of humans. However, with the rise of civilisation, greater human populations, and the breaking down of biogeographic barriers, the rates of biological invasions have increased rapidly, and continue to rise at an exponential rate (Sharma et al, 2005; Hobbs et al, 2006; Hobbs et al, 2009). This has had significant effects on invaded ecosystems, such as losses of biodiversity, alteration of soil conditions and structure, and alteration of the functioning of the ecosystem (Hobbs et al, 2006; Richardson et al, 2007; Lindenmayer et al, 2008). However, simply because an ecosystem is not functioning in exactly the same fashion as it was pre-invasion, is not necessarily a sign that the ecosystem has been degraded. Although there are many cases where the human-instigated arrival of an exotic species has had severe deleterious effects on an ecosystem, there are some examples where an ecosystem, post-invasion, will function similar to its pre-invasion state, albeit with an altered species composition (Zavaletta et al, 2001; Hobbs et al, 2006; Hobbs et al, 2009).

Not all exotic species are equal in their ability to invade and alter ecosystems. The species which have the ability to rapidly invade ecosystems are generally known as invasive species, and often referred to as 'weeds'. However, there is not clear definition of a 'weed', and as such the term can be applied to a variety of species, including native and exotic species. Traditionally, exotic invasive species have been associated as weeds, with less attention paid to native invasive species. If a species is defined as a weed, it will usually have a negative stigma attached to it, even if the species is having a positive effect in an ecosystem. Consequently, weeds are viewed as something to be managed or eradicated.

Weed management practices are influenced by numerous factors. These include social factors such as legislation, human attitudes, time, and money available; as well as ecological factors such as resilience, disturbance regimes, seasonal variations, climatic conditions, and weed density. These factors are often competing with each other, which means that weed management can be a complicated issue. Traditionally, weed management practices have focused on exotic species, with much less attention paid to native species (Mansergh, 2010; Davis et al, 2011). However, it is now well known that many native species can become invasive in a disturbed environment, and many

exotic species have positive effects in ecosystems. These effects may include providing habitat or food for species, and suppression of other invasive species (Zavaletta et al, 2001; Hobbs et al, 2009; Head, 2012). Therefore, the labelling of species as native, exotic, and ultimately as a 'weed' is potentially problematic. In Australia, these labels focus on a plant's status prior to the arrival of Europeans on the Australian continent, rather than the ecological functions which they play in a landscape (Head, 2012). On a more global scale, defining a species as native or exotic is more complicated, owing to the long history of human-induced changes. Therefore, there is a need to discern what species should be targeted in weed management practices, and the factors which have led to this decision, whether they be environmental, social, economic, or some other factor. This project aims to examine the past and present weed management practices at Bundanon Trust, and determine the various factors which have affected the work which has been undertaken on the property.

1.2 Bundanon Trust

Bundanon Trust which is the focus of this study, is an arts Trust located on the south coast of New South Wales which was gifted to the Australian people by Arthur & Yvonne Boyd in 1993. Although primarily functioning as an arts, cultural, and education organisation, there is a need to manage the land which comprises the Bundanon Trust properties; Bundanon Trust is quite unique for an arts organisation in that they are situated on a property totalling a contiguous area of 1100 ha, with 15 kilometres of river frontage along the Shoalhaven River, NSW. In this area there are 11 different vegetation communities, with various rainforest, forest, and heath communities being present. Some areas on the properties have been cleared for past and present grazing. In addition, there is historic curtilage and heritage buildings present on the properties (CAB, 2011). This has important implications regarding the work which can or cannot be done in some areas on the properties.

Invasive species are becoming a significant problem on the properties, with Lantana (*Lantana camara*), and Fireweed (*Senecio madagascariensis*) being two species of note. Both are identified as Weeds of National Significance (WONS) by the Australian Government (Weeds Australia, 2013). A land management plan formulated in 2011 found that 'Bundanon has a fantastic diversity of landforms, flora, and a stunningly diverse population of threatened animals' (TEC, 2011). However, it also noted that of the 1100ha of property, 186ha was densely populated with weeds, and recommended formulating a Bushland Management Plan to help manage these weeds (TEC, 2011).

In 2012, a Land Rehabilitation Works Plan was created, recommending that a range of techniques be used to control the invasive weeds which are present on the properties (Waugh, 2012).

The creation of these land management and rehabilitation plans has led to Bundanon Trust partnering with Landcare Australia, Greening Australia, and Southern Rivers Catchment Management Authority (SRCMA) to create the 'Living Landscape' project; a \$1.1 million, three year project with the aim of increasing biodiversity and reconnecting native habitat within the Bundanon Trust properties (Bundanon, 2012). Some of the goals of this project include controlling noxious and priority environmental weeds, reforestation, continuous native riparian habitat along the river frontage, carbon sequestration, and greater community education (Bundanon, 2012). Although weed management practices have been implemented at Bundanon Trust for many years prior to the Living Landscape project, this represents the largest input of funding for weed management since the creation of the Trust. Therefore, there is the need for Bundanon Trust to determine the importance of the weed management practices which are being undertaken on the property, and how this will affect the Trust in the present and into the future.

1.3 Project Aims

The overall aim of this project is to examine in detail the key biogeographic and socio-cultural factors which have affected weed management practices both past and present at Bundanon Trust, with the goal of informing future management. This will be achieved through interviews of key players in weed management practices at Bundanon Trust, and on-ground assessments of weed management sites at Bundanon Trust. Specifically, this study will aim to:

1. Discern how human perceptions and attitudes regarding native, exotic, invasive and weedy species help to shape weed management strategies and practices.
2. Document the range of practices necessary to manage weeds at Bundanon Trust.
3. Examine past and present weed management sites at Bundanon Trust to determine the key historical, ecological, and social factors which shape how and why weed management is implemented at these sites.
4. Determine the future implications of the results found through the previous three aims.

1.4 Thesis Structure

The following chapter of this thesis provides a review of the current literature regarding invasive species and their effects, human perceptions surrounding these species, and ultimately the factors affecting human decisions in managing these species. Chapter three describes the methods used to collect and analyse data regarding both human perceptions and weed management practices at Bundanon Trust. Chapter four introduces the weed management sites, and contains the results of the field data. Chapter five presents the results of the interview data, and discusses these results in the context of existing literature. Chapter six then discusses the results of the interview data in the context of the field sites introduced in chapter four, determines which factors are having the greatest effect on weed management at Bundanon Trust, and the implications for future management. Chapter seven provides the recommendations for Bundanon Trust and conclusions of the study.

2. Literature Review

This chapter aims to synthesise the literature relevant to the project aims. Firstly, I will examine the science relating to invasive species, in particular *Lantana camara*, and how these species can invade ecosystems, and the wide range of effects they have on the environment. Secondly, the human perceptions of native, exotic, and invasive species will be examined, showing how these perceptions can affect the management of species. Thirdly, I will examine the wide range of ecological, social, and economic factors which affect invasive species management.

2.1 Invasive species and their effects on ecosystems

There is extensive literature available regarding the spread of invasive species. This review will highlight the key points relating to the introduction, spread, and effects of invasive species on ecosystems. Lantana (*Lantana camara*) is one such invasive species which will be investigated in detail.

Humans are playing an ever-increasing role in the functioning of ecosystems. The impacts of humans can be seen in most ecosystems on Earth (Hobbs et al, 2006; Richardson et al, 2007). Human-caused disturbances such as land clearing, grazing and logging, artificial alteration of hydrological regimes, and introduction of exotic species have all had drastic impacts on ecosystems (Mack et al, 2000; Hobbs et al, 2006; Richardson et al, 2007; Buckley et al, 2007; Lindenmayer et al, 2008). In addition to these human-caused disturbances, natural disturbance events such as flooding and fire regimes also play important roles in shaping ecosystems (Richardson et al, 2007; Buckley et al, 2007, Lindenmayer et al, 2008). Disturbance in ecosystems is important as it allows invasive species to colonise environments (Mack et al, 2000; Sharma et al, 2005; Hobbs et al, 2006; Buckley et al, 2007). Largely through human disturbance, numerous species have been able to spread globally, to environments which they would not be able to occur under normal circumstances without human intervention (Mack et al, 2000; Zavaletta et al, 2001; Hobbs et al, 2006; Buckley et al, 2007). Although biological invasions are a natural process, the rates of invasion which are seen today are much higher than pre-human rates, and humans have been the large drivers of invasions in this day and age (Mack et al, 2000; Sharma et al, 2005; Hobbs et al, 2006).

Invasive species are largely thought of to be exotic species (Warren, 2007; Preston, 2009; Davis et al, 2011), and indeed the majority of invasive species are exotic. However there are many cases

worldwide where native and indigenous species have become invasive (Head & Muir, 2004). Examples of these native invasive species in Australia include *Pittosporum undulatum* (Pittosporum), *Acacia mearnsii* (Black Wattle), and *Eremophila sturtii* (Turpentine) (Head & Muir, 2004; NSW Government, 2004). Many scientists are now arguing that more weight should be given to the ecological effects of a species, rather than their definition as a native or exotic species (Preston, 2009; Davis et al, 2011).

Invasive species will usually exhibit certain key traits which make them effective at invading ecosystems. These traits include rapid growth, allelopathy, adaptability to varying climates and soil conditions, and aggressive reproduction (Mack et al, 2000; Head et al, 2005; Robbins, 2005). This in turn places much greater pressures on native non-invasive species. Invasive species will also usually thrive in disturbed environments, whereas natives may suffer (Mack et al, 2000; Head et al, 2005; Robbins, 2005). Once established, invasive species can rapidly reproduce and colonise ecosystems, often forming dense monocultures. The colonisation of an ecosystem by invasive species has a variety of impacts; reductions in biodiversity, alteration of soil structure and properties, increased competition for nutrients and other natural resources, changes to erosion rates, changes to the disturbance regime, alteration of seed bank composition, changes in biomass, and ultimately extinctions (Parker et al, 1999; Mack et al, 2000; Sharma et al, 2005; Hobbs et al, 2006; Strayer et al, 2006; Rodriguez, 2006; Buckley et al, 2007; Richardson et al, 2007; Mason et al, 2007; Lindenmayer et al, 2008; French, 2012;). In addition to ecological impacts, invasive species also have social and financial impacts (Head & Muir, 2006).

Although the majority of invasive species have a largely negative ecological impact on ecosystems, removal of these species may not necessarily result in a positive ecological outcome. The concept of novel ecosystems is an emerging idea. Novel ecosystems are ecosystems which contain species combinations which would not come about naturally- these ecosystems contain both native and exotic species, as the result of human disturbances (Hobbs et al, 2006; Hobbs et al, 2009; Rodriguez, 2006; Buckley, 2008; Lindenmayer et al, 2008). These novel ecosystems sit somewhere between natural ecosystems and highly degraded or highly managed landscapes (Hobbs et al, 2006). Although these novel ecosystems have come about as the direct result of human disturbance, there is no need for ongoing maintenance by humans; essentially they have reached a new state of equilibrium (Hobbs et al, 2006). Therefore, the removal of exotic or invasive species in these novel ecosystems

will not necessarily bring out positive outcomes, and may degrade the ecosystem further (Zavaletta et al, 2001; Hobbs et al, 2006; Schlaepfer et al, 2011). Further, certain native plants and animals may now rely on exotic or invasive species to survive; Hobbs et al (2009) notes that 'many butterfly species in California now depend on exotic plants for some or all of their food resources' (p. 602). Additional benefits which exotic species may provide include pollination, habitat for birds, suppression of other invasive species, and substitution for extinct native species (Zavaletta et al, 2001; Hobbs et al; 2009; Head, 2011; Schlaepfer, 2011). Therefore, invasive and exotic species can maintain functional roles in ecosystems (Zavaletta et al; 2001). The chance of restoring these novel ecosystems to a 'natural' state is unlikely to impossible, and would require large inputs of time and money. Therefore, careful consideration must be given to the management practices which are used in these ecosystems (Zavaletta et al, 2001; Hobbs et al, 2006; Buckley et al, 2007).

One species which has the ability to rapidly invade ecosystems is *Lantana camara*, a small woody shrub commonly known as Lantana. Originally introduced to Australia as an ornamental plant in the 1840's (Ghisalberti, 2000; Turner & Downey, 2010; Bhagwat et al, 2012), Lantana has become invasive along the Eastern coast of Australia; occupying over 5 million ha (Bhagwat et al, 2012), and is identified as a Weed of National Significance (WONS) in Australia. Lantana exhibits a wide range of characteristics which make it a good invader of ecosystems; the ability to thrive in a wide range of habitats, adaptability to numerous soil types, year-round flowering, seed dispersal by birds and mammals, production of large numbers of seeds, ability to produce and release allelochemicals, phenotypic plasticity, resilience to moderate fires, and the ability to quickly regenerate post-fire (Gentle & Duggin, 1997; Head & Muir, 2004; Sharma et al, 2005; Kohli et al, 2006; Bhagwat et al, 2012). Disturbance plays a huge role in the spread of Lantana (Gentle & Duggin, 1997; Duggin & Gentle, 1998; Bhagwat et al, 2012). Gentle & Duggin (1997) and Duggin & Gentle (1998) noted that nutrient addition, biomass removal, low-moderate intensity fire, and soil disturbance all increase Lantana growth and survival. Lantana will easily invade disturbed environments, and therefore is prevalent along roadsides, disturbed riparian zones, and forests where the understory or canopy has been removed (Duggin & Gentle, 1998; Sundaram & Hiremath, 2012). However, Lantana is less effective at invading pristine bushland (Head & Muir, 2004; Sharma et al, 2005).

The effects that Lantana has on an ecosystem are numerous. Lantana will readily outcompete native species especially in disturbed environments, and has the ability to reduce native species richness

and biomass, threatening the survival of these species in the process (Kohli et al, 2006; Gooden et al, 2009a; 2009b; Turner & Downey, 2010; Bhagwat et al, 2012; Sundaram & Hiremath, 2012). Lantana will often form dense monocultures, climb trees, and strangle the development and growth of other species, reducing biodiversity in the process (Sharma et al, 2005; Turner & Downey, 2010; Bhagwat et al, 2012). Additionally, Lantana is toxic to fauna and livestock, and will reduce pasture productivity through alteration of soil nutrients (Ghisalberti, 2000; Sharma et al, 2005; Kohli et al, 2006; Bhagwat et al, 2012). Although there are a plethora of negative impacts which Lantana has upon ecosystems, it is also able to provide some benefits to ecosystems, such as providing habitat for fauna, and the stabilisation soil, particularly along riverbanks in riparian zones (Bhagwat et al, 2012; Head, 2012).

Extensive practices aimed at controlling and ultimately eradicating Lantana have been undertaken for over a century both in Australia and overseas. However these management efforts have been largely unsuccessful, with the rates of Lantana invasion continuing on an upward trend (Ghisalberti, 2000; Sharma et al, 2005; Kohli et al, 2006; Bhagwat et al, 2012). A range of physical, mechanical, chemical, and biological techniques have been used, each with associated limitations (Sharma et al, 2005; Bhagwat et al, 2012). Despite the extensive management practices which have been undertaken, Lantana has continued to spread its range and occupational area over the past century (Bhagwat et al, 2012; Sundaram & Hiremath, 2012). Rates of Lantana invasion have typically spiked in times where there was rapid land-use change, highlighting the relationship between disturbance and its spread (Bhagwat et al, 2012). The best practices to manage Lantana both now and in the future are debatable (Sharma et al, 2005; Bhagwat et al, 2012). Part of the problem lies in the short-term nature of the majority of control and monitoring programs, meaning that long-term data is either unreliable or unavailable (Bhagwat et al, 2012; Sundaram & Hiremath, 2012). These problems relate not only to Lantana in Australia, but rather a whole suite of invasive species worldwide (Mack et al, 2000).

Although we can examine the effects of invasive species, especially in the short-term, the long-term effects of both species invasion and invasive species management are harder to predict. This is one of the factors which affect the ability to manage invasive species. However, there are numerous other factors, which will be examined in the later sections of this literature review.

2.2 Human perceptions of ‘weeds’, exotic, native, and invasive species

One of the issues surrounding invasive species involves the terminology used to describe different species (Calautti & MacIsaac, 2004; Warren, 2008; Preston, 2009). For example, there is no ecological definition of a ‘weed’ (Calautti & MacIsaac, 2004; Gibson, 2010). Rather, the use of the term ‘weed’ to describe species has become associated with a wide range of different plant species and compositions. This includes exotic non-invasive species, exotic invasive species, and native invasive species. This shows that there is a wide and varying range of ideas regarding what exactly constitutes a ‘weed’. Ecologists may have one set of views; farmers another; and the general public another (Head & Muir, 2004; Gibson, 2010). Mansergh (2010) sums it up well; “To perceive a weed is to ascribe meaning to the landscape where it occurs and ecosystem services required from that landscape. These perceptions change over time” (p. 173).

The concept of biotic nativeness is also debated in the literature (Lamb & Purcell, 1990; Head & Muir, 2004; Trigger et al, 2008; Trigger, 2008; Head, 2012). Traditionally, a native species is thought of as one which has arrived in an area without any aid or intervention by humans. This idea was developed in the 1830’s by John Henslow and H.C. Watson, and has remained relatively unchanged since that time (Davis et al, 2011; Chew & Hamilton, 2011; Head, 2012). However, there are numerous arguments against this historical definition of biotic nativeness. Chew & Hamilton, (2011, p. 36) notes that “Biotic nativeness is theoretically weak and internally inconsistent, allowing familiar human desires and expectations to be misconstrued as essential *belonging* relationships between biota, places and eras”. Head (2012) highlights that the boundaries associated with this definition are human-created boundaries, and in an Australian case, boundaries centred around European colonisation. Warren (2007) points out that this designation of a species as native or exotic is only correct at a particular time and place. The definition relies on identifying a point in which “nature was natural” (Warren, 2007, p. 431). Trying to define the time in which nature became ‘unnatural’, and exotic species appeared is difficult. Globally, both indigenous and colonising humans have modified the land for thousands of years, although to differing extents. In Australia, the most accepted moment is the arrival and subsequent colonisation in 1788 of Europeans to the continent, which represented a time of drastic ecological change in Australia, with many new species arriving and colonising in the country (Head & Muir, 2004; Head, 2012). However, this boundary is not entirely accurate; species arrival is a natural process, and had been occurring between Australia and its nearest neighbours for thousands of years prior to European arrival, albeit on a relatively small scale. Certain species which may be classified as natives may have only occupied the country in the

last 500 years (Head, 2012). Globally, the line between native and exotic is even more blurred. Australia, as an isolated island, was mostly immune to large-scale species invasion prior to European colonisation. However, on the large land masses of the Americas, Europe, Asia, and Africa, it has been easier for species and humans to travel across boundaries, whether they be political (ie the defined boundaries of a country), or biogeographic. This means that species have been migrating through both natural and human means for millions of years, and this makes it difficult to determine whether species movement is the result of human or other means (Warren, 2007).

The classification of a species as native or exotic has had important implications for weed management practices. Although Australia has a history of clearing native vegetation since 1788, in the last 50 years there has been a far greater importance placed on maintaining biodiversity and protecting native species (Trigger et al, 2008; Mansergh, 2010). Historically, there has been a perception that native species are inherently good for ecosystems, while exotic species can have deleterious effects on ecosystems (Warren, 2007; Larson, 2007; Trigger et al, 2008; Mansergh, 2010; Davis et al, 2011; Head, 2012). These perceptions have helped to shape weed management practices and targets in Australia (Mansergh, 2010). However, the question must be asked as to whether this is the best ecological practice. The designation of a species as a native does not necessarily signify that the species is having positive effects on the ecosystem, or that the species is there because of its biological fitness (Warren, 2007). Rather, it is native to that area due to having arrived there without human intervention, in conditions which suited its growth. However, as biotic and abiotic conditions change, species which were suited to an area at a previous time in history may now be invasive, or be providing little benefit to an ecosystem (Warren, 2007).

As noted earlier, in some cases exotic species are often able to supplant native species, and possibly provide ecological benefits over the species they have replaced (Trigger et al, 2008; Hobbs et al, 2009; Mansergh, 2010; Head, 2012; Larson & Kueffer, 2013). In addition, the blurry definitions about what exactly constitutes a native or exotic species suggests that simply aiming to manage exotic species may not bring about the best ecological outcomes. More and more so, scientists are turning away from traditional views, where natives are good and exotics bad, towards a more objective view of ecosystems, focusing on the functional effects of species in ecosystems (Zavaletta, 2001; Hobbs et al, 2006; Larson, 2007; Hobbs et al, 2009; Davis et al, 2011). This is not to say that new exotic species are being welcomed with open arms, rather that species which are already established and

naturalised are being differentiated based on their overall contribution to an ecosystem (Zavaletta, 2001; Davis et al, 2011).

Although the ecological effects of native, exotic, and invasive species must be examined in a society which is becoming more and more environmentally aware, there are numerous social factors which also must be examined regarding these species. Native species are thought of as 'belonging' to the land, and as such are valued as having some form of intrinsic value as part of our society (Head & Muir, 2004; Trigger, 2008; Trigger et al, 2008; Mansergh, 2010; Head, 2012). Head et al (2004) provides some interesting examples. *Pittosporum undulatum* is a native invasive species in Australia. In Victoria, *Pittosporum* is classified as both an invasive and endangered species. Although landowners were aware of its invasive nature, some chose not to remove it from their property, as they viewed it as 'belonging' to the land (Head, 2004). In addition to the social values placed upon native species, there are values which humans place upon exotic and invasive species too.

Cinnamomum camphora (Camphor laurel) is a exotic invasive species, but many landowners chose to keep it on their land, due to the social values and attributes it provides, such as a climbing tree or shade (Head & Muir, 2004). Trigger (2008) notes many examples of Aboriginal Australian's views towards exotic species. Although viewing exotic species as 'Whitefella' plants, the Aboriginals have "adapted and modified their customary law such that introduced species may come to be regarded as 'belonging' on 'country'" (Trigger, 2008 p. 640). This acknowledgment by indigenous Australians that an exotic species may 'belong' to the land highlights how perceptions can vary between different people and groups. It is these differences in perceptions which this study is aimed at; specifically determining how human perceptions of different species can lead to differing management goals and outcomes.

2.3 Factors affecting weed management practices

Invasive species management comes about from the accumulation of the two previous topics outlined in this literature review. Ecologically, there is a potential need to manage invasive species to avoid any deleterious effects they will have on ecosystems. Socially, weeds can be looked at as unsightly and unbelonging. However, there is often a disconnect between different groups regarding the best possible course of action regarding weeds. An ecologist may have a completely different view to a farmer. Therefore, there is a need to examine the various factors which affect weed management practices, and how to get the best possible outcome; economically, socially and ecologically. Some of the factors which affect weed management practices include available time,

money, and resources, resilience of the land, potential for follow-up practices, human-pressures, legislation, land-use pressures, and disturbance regimes (Mason et al, 2005).

Public perceptions and support can play a large role in determining the outcomes of weed management practices (Bremner & Park, 2007; Larson et al, 2011; Selge et al, 2011). The species being managed and the control methods being used can affect the public perception regarding weed management practices (Bremner & Park, 2007; Larson et al, 2011; Selge et al, 2011). Although members of the public may view invasive species as harmful to an ecosystem, they may not realise the full extent of their effects, both negative as well as positive (Selge et al, 2011; Sharp et al, 2011). There are cases worldwide where public opposition has led to the interruption or termination of invasive species management programs, due to a variety of factors (Bremner & Park, 2007; Selge et al, 2011). Quite often, the goals of invasive species management programs are not clearly explained to the public, and this has the possibility to cause confusion regarding the success of a project (Sharp et al, 2011; Larson et al, 2011). Therefore, education, and community involvement is important in delivering successful outcomes of invasive species management (Mason et al, 2005).

Perhaps the greatest factors affecting invasive species management are money and resources, which are often limiting for projects (Januchowski-Hartley et al, 2011). The vast majority of invasive species management programs will require a large amount funding before they even commence, with machinery, herbicides, consultants, and labour amongst other things all requiring money for their use and services (Januchowski-Hartley et al, 2011; Larson et al, 2011). Quite often, these costs will be high, and insufficient funding available (Januchowski-Hartley et al, 2011; Larson et al, 2011). The time-frame in which money must be spent also presents a potential problem to invasive species management programs. Often funding must be spent within a specified period of time, usually short-term (Mason et al, 2005; Larson et al, 2011). Although large amounts of work can be achieved in the short-term with this funding, quite often the long-term objectives of a project such as preventing reinvasion and improving resilience will not be achieved. This places the long-term ecological health of a site at risk (Mason et al, 2005; Larson et al, 2011). Failure to acquire funding for long-term management can lead to the degradation of land to a greater extent than pre-management (Larson et al, 2011). Repeated short-term management solutions will generally require significantly more funding than approaches which aim for long-term management (Larson et al, 2011). Often there is disagreement regarding who should pay for these invasive species management projects, and

perceptions of a project by both the public and stakeholders can play a large role in the ability of a project to secure funding (Garcia-Llorente et al, 2011). The goals of a project, the species being managed, and the socio-economic status of stakeholders all play a large role in determining whether a stakeholder will be willing to contribute funding for a project (Garcia-Llorente et al, 2011). Garcia-Llorente et al, (2011) found that many stakeholders in their research thought that the government should be responsible for managing invasive species, and therefore funding management projects.

Because the amount of resources needed to implement invasive species management projects is high and often prohibitive, the economic, ecological, and social costs of the invasive species themselves must be examined (Sinden & Griffith, 2005; Garcia-Llorente et al, 2011). In many cases, examining this in economic terms is often quite difficult, as it is hard to put a monetary or market value on biodiversity, ecosystem functioning, or the social effects of invasive species (Garcia-Llorente et al, 2011). We can estimate some of the costs of not managing invasive species in agricultural settings, where farmland will become degraded and lose productivity through invasion (Sinden & Griffith, 2005; Cook et al, 2007; Klepeis et al, 2009). However, as Sinden & Griffith (2005) puts it, “defensible economic information on the environmental and social gains is scarce” (p.406).

There is often a clash of opinions regarding best practices which can be used to manage invasive species (Fielding et al, 2005; Llewellyn et al, 2005; Wilson et al, 2009; Doohan et al, 2010; Larson et al, 2011). Traditionally, invasive species management has been aimed at employing the most cost-effective management strategy. Preventing invasive species from arriving in an area in the first place is one of the most cost-effective management strategies (Hulme, 2006; Larson et al, 2011; Mehta et al, 2007; Mason et al, 2005). However, focusing solely on prevention fails to address the fact that numerous invasive species have already become established across the globe (Mehta et al, 2007). Consequently, many weed management projects have revolved around the heavy use of herbicides, as this is viewed as the most cost-effective way to manage weeds. Although this strategy has seemingly been effective especially in the short term, there is a growing global trend of herbicide resistance (Mortensen et al, 2000; Wilson et al, 2009; Doohan et al, 2010). Additionally, herbicides often have deleterious effects on other species in proximity to the invasive species being targeted (Rinella et al, 2009). Therefore, there is a push by ecologists for those managing invasive species to move away from traditional herbicide-based management, towards more integrated weed management (IWM) practices, or a more holistic approach to management (Wilson et al, 2009;

Buckley, 2008; Llewellyn et al, 2004; Swanton et al, 2008; Young, 2012). These IWM practices focus on a whole suite of management techniques, such as prevention, ongoing monitoring, and a variety of control methods. Singularly, these techniques and methods are inadequate to manage invasive species, but once integrated, they can potentially have long-term positive outcomes (Llewellyn et al, 2004; Wilson et al, 2009). However, these IWM practices have not been widely implemented, for a variety of reasons (Swanton et al, 2008; Llewellyn et al, 2004; Wilson et al, 2009). Perceptions of IWM plays a large part in this; Wilson et al., (2009) found that farmers in Ohio were aware of both the issue of herbicide resistance, and integrated management practices, but were reluctant to implement these practices on their farms. IWM practices require more time and effort to implement than herbicide-based management practices, and the short-term outcomes are significantly less visible (Llewellyn et al, 2004; Swanton et al, 2008; Wilson et al, 2009). Additionally, the costs of IWM in the short-term are much higher than traditional control methods, such as herbicide spraying. However, cost-benefit analysis in the long-term favours IWM practices (Swanton et al, 2008; Wilson et al, 2009; Llewellyn et al, 2004).

From this, we can see that there are many different methods available to manage invasive species, and in each case there will be different factors affecting management practices. This study aims to examine each of the factors present at Bundanon Trust, and correlate this information with the management practices which have been undertaken at the site.

2.4 Conclusion

As noted in the previous sections of this literature review, the management of species and ecosystems is a complicated issue, with many different factors which may affect the decisions being made. Each situation is different, and therefore there isn't a 'best practice' which will apply every time. The various ecological, social, and economic factors which have been examined in this literature review all need to be considered carefully when determining whether to manage an invasive species, and how to best manage this invasion. Although there is significant literature available regarding the ecological effects of invasive species, people's perceptions of invasive species, and the factors affecting invasive species management, there are very few cases where each of these issues have been combined into a single, practical study. This hole in the research is what helped to shape the goals of this research project.

3. Methods

3.1 Introduction

This chapter outlines the methods used to meet the aims of the project. After the initial meeting between myself, my supervisors from Bundanon Trust, and my university supervisor, the aims of the project were tentatively defined. The overarching aim of the project is a socio-cultural and biogeographic assessment of past and present weed management practices on the property, with a secondary aim of informing future management. As such, there are two dominant themes of the project; firstly, the socio-cultural assessment, and secondly, the biogeographic assessment of weed management practices. Due to this, the data for the project was collected in two main ways: The biogeographic assessment required a combination of on-ground field assessments of biogeography, noting of the weed management practices used in different areas, interviews and informal talks with Bundanon staff, and analysis of archival and current documents. The socio-cultural assessment required interviews with key players associated with weed management at Bundanon. This was done to discern the range of views and attitudes regarding weed management at Bundanon Trust. In some cases, the methodologies used to assess the socio-cultural side of weed management at Bundanon Trust also helped to assess the bio-geographic side, and vice versa.

3.2 Biogeographic assessment of weed management practices at Bundanon Trust

One of the goals of the project was to biogeographically assess the main weed management sites at Bundanon Trust. This section of the methods chapter outlines the range of methods and techniques used to perform this assessment

3.2.1 Archival document analysis

The first step which needed to be taken in order to assess the weed management sites at Bundanon Trust was to consult archival documents regarding Bundanon Trust, and the social and environmental history of the Trust. Numerous documents were provided to me by Bundanon Trust, which proved invaluable to the project. In particular, “Land Management Plan for the Bundanon Trust Properties” (TEC, 2011), “Land Rehabilitation Works Plan; Bundanon Trust” (Waugh, 2012), and “Living Landscape; Memorandum of Understanding” (Bundanon, 2012) proved particularly useful. The first two documents provided details of the history of the sites, historic curtilage and heritage

information, landscape assessments, flora and fauna inventories, and proposed bush regeneration works. This allowed me to examine the range of factors, both biogeographic and socio-cultural, which affect different weed management sites at Bundanon Trust. The Living Landscape Memorandum of Understanding gave details of the weed management and bush regeneration works which were being undertaken at the time of the study, and planned future works. In addition to the documents provided to me, aerial and on-ground photographs ranging from the 1890's to the 1950's were also provided. These photographs helped to provide information regarding the history of certain areas within the study. Although these photographs were not comprehensive in their coverage, they provided a historical picture of some of the sites; in particular the riparian zones, previously grazed, and currently grazed areas.

3.2.2 Site selection

After the initial meeting between myself and my Bundanon Trust and university supervisors, a tour of the grounds of Bundanon Trust was arranged on Monday 11/02/2013. During this tour my supervisors from Bundanon Trust identified areas where weed management practices have occurred, were occurring, or were planned to occur in the future. Five sites were identified; Haunted Point, Bundanon, Lilli Pilli Gully, Eearie Park, and Riversdale. The locations of these sites can be seen in Figure 1. A wide range of weed management practices were being used on these sites. Haunted Point, Bundanon, Riversdale, and Eearie Park were being managed as part of the Living Landscapes project, which involved industrial management practices, such as large-scale mechanical clearing of Lantana (*Lantana camara*), with revegetation and assisted regeneration works planned in the future. Some areas of Riversdale are being managed under the Bush Incentives Scheme, which was largely based on herbicide-based management techniques. Lilli Pilli Gully has previously been managed by the Bundanon Landcare Group, which used a range of manual and chemical techniques to manage Lantana in the area. These five sites were selected to be the focus of this study.

3.2.3 Field assessments

In order to assess the weed management work which has occurred in the past and is currently occurring at Bundanon Trust, and determine some of the ecological factors which have led to this work, the sites named above needed to be examined. Each site has a different history, not only in terms of what the land has been used for, but also in terms of the weed management practices which have been undertaken there. During these assessments, seven things were noted: any weed

species defined by the Shoalhaven City Council as either a noxious or environmental weed (Shoalhaven City Council, 2013) currently present on the site, any other species which could be described as a 'weed' present on the site, the diversity of native species present, the range of weed management practices which implemented on the site, the responses to these practices (such as any regrowth), any site management issues (such as wildlife present or riparian issues), and any social factors (such as historic curtilage) present. These field assessments were undertaken in July and August of 2013. The aim of these assessments was not to note every species present and their density, but rather to paint an overall picture of the diversity and health of the site. As there were numerous weed management practices being undertaken at Bundanon Trust during the time of my project, many of the sites where I undertook field assessments changed drastically over the course of the study. This provided useful in some instances, as it allowed me to note changes over time in response to weed management practices. However, it also meant that in some cases sites could not be observed prior to drastic weed management practices being undertaken. Numerous photographs were taken during these assessments, in order to fully document each site. Once all the field data was collected, data from both the field assessments and archival documents was combined and presented as seen in Chapter 4.

3.3 Socio-cultural assessment of weed management practices at Bundanon Trust

One of the main aims of the project was to gather the views and attitudes of the key players associated with weed management programs at Bundanon Trust. The views sought regarded an array of ecological, social, and economic issues surrounding weed management practices at Bundanon Trust. This section of the methods chapter outlines the techniques used to gather and analyse these views.

3.3.1 Ethics

As the research involved interviews with key players associated with weed management at Bundanon Trust, the project required approval from the University of Wollongong (UoW) Human Research Ethics Committee (HREC). An initial application for ethics approval was submitted on 10/04/2013, and a revised application submitted on 16/04/2013. This application highlighted how subjects would be recruited, and how the project would ensure that subjects consent would be freely and ethically obtained. As there were no risks to the participants present, this application process was relatively easy to complete. A participant information sheet, consent form, and

interview questions were also attached to this application. This application for ethics approval was accepted on 18/04/2013. A copy of this approval is given in Appendix A

3.3.2 Recruitment

Recruitment of participants was achieved through a combination of direct contacts and the snowballing technique. Initially, direct contact was made with my two supervisors at Bundanon Trust. These two contacts then identified other potential participants who would be of use to the research project. Although snowballing can lead to the recruitment of a narrow group of people (Valentine, 1997), the aims of the research required that the attitudes of people directly associated with weed management at Bundanon Trust be discerned. This meant that a relatively small number of participants were of use to the project, and the snowballing technique was the most effective technique to determine who these people were. Five of the participants identified came from within Bundanon Trust; the Chief Executive Officer, Education Manager, Property Manager, Property Officer, and Property Assistant. The Property Manager, Officer, and Assistant were all directly associated with on-ground weed management practices at Bundanon Trust. One participant from Landcare Australia was identified, who is the project manager of the Living Landscape project at Bundanon Trust. One participant from the Southern Rivers Catchment Management Authority was also identified, who had an advisory role with weed management practices at Bundanon Trust.

These participants were then contacted through email outlining the aims of the research project. A participant information sheet was attached to this email, outlining the demands and ethical issues surrounding the project. A copy of this information sheet can be seen in Appendix B. Seven potential participants were contacted to arrange an interview. All of these participants agreed to be interviewed for the research project.

3.3.3 Semi-structured interviews

The research project used semi-structured interviews. Interviews were an important part of this project for a variety of reasons. As noted by Valentine (1997), interviews, in particular semi-structured interviews, allow the interviewee to fully expand on views and experiences which they may have; in my case, this allowed me to collect a wide range of views and attitudes regarding weed management at Bundanon. In addition, issues which I had not anticipated were raised by some of the interviewees, which is another strength of interviews raised by Valentine (1997). A set of interview questions was developed as an interview guide, but the order and how these questions

were asked was flexible. However, if an interview was heading off-track, it allowed me to refocus the interview to points of interest.

Two initial one-on-one interviews with my supervisors from Bundanon Trust were undertaken on 16/05/2013 at Nowra City Library and Riversdale respectively. These interviews were used as pilot interviews to ensure that the questions asked were of use, and if not, to allow further refinement of the interview questions. These interviews also allowed me to interview someone known to me, which allowed me to be comfortable and further refine the interview technique. One-on-one interviews were used as this and ensures that one person's views are not altered by another person present, and ensures confidentiality according to the participants wishes. However, all of the participants consented to being identified by name in the study. These interviews were recorded using a digital recorder, and then later transcribed for analysis. After analysing the pilot interviews with my supervisor, some of the questions were altered to be more open, and allow further discussion in future interviews. Interviews with the five other participants were undertaken between 11/07/2013 and 31/07/2013 either at Bundanon, Riversdale, or Nowra. These interviews were also recorded and later transcribed for analysis.

3.3.4 Interview design

These interview questions used for the study were designed as open questions, so as to allow expansion on points of interest. A list of interview questions is attached in Appendix C. Several key themes regarding weed management at Bundanon Trust were explored:

- **Attitudes towards weeds**

Participants were questioned regarding their attitudes regarding what constitutes a weed, possible benefits of weeds, the best practices of managing weeds, and ultimately why it is important to manage weeds. These questions were formulated to gain a sense of the views and feelings participants attributed towards weeds, and how this shaped the work they thought should be done.

- **Current weed management practices at Bundanon Trust**

Participants were questioned regarding the current weed management practices at Bundanon Trust, in particular the Living Landscape project, the goals of these practices, the factors affecting site selection within these practices, goals of these practices, and measuring success of these projects.

The aim of these questions was to detect how participants felt about the current and past weed management practices at Bundanon Trust, and whether they felt the right weeds and areas were being targeted in these practices

- **Conflicting factors affecting weed management practices at Bundanon Trust**

Participants were questioned regarding the historical, ecological, and social factors which affect weed management at Bundanon Trust, and whether there was any conflict between these factors. Questions were also asked regarding whether the funding, and funding time-frame, available for weed management practices at Bundanon Trust was sufficient for the work which is currently occurring, and will continue in the future. These questions aimed to discern how different factors had different effects on weed management practices at Bundanon Trust, and whether funding available was dictating the work which was being done.

3.3.5 Analysis of data

In order to analyse the interview transcripts, they first needed to be coded in a way that would allow me to determine key themes, similarities, and differences from the interviews. Additionally, interesting, unexpected points also needed to be examined. Initially, the transcripts were open coded, which involved noting key ideas and themes which came from each interview. This was done so that recurring themes and ideas could be highlighted, which helped to narrow the scope of the research. A top-down approach to coding was then undertaken, where some questions were noted as particularly important for the project; the results of these questions were then coded according to the answers given and the interviewee giving them. This allowed me to examine in detail any factors which may have led to a certain participant giving a certain answer, and highlight any reasons for similarities or differences in answers.

In some cases there were ideas and themes presented which were of particular interest, but may have been unexpected or only presented by a few participants. From these responses, a bottom-up approach to analysing the data was taken. This involved highlighting these responses during the open coding stage of analysis. These responses could then be analysed to examine whether there was any repetition of themes and ideas between participants, and to see how these responses came about.

4. Weed management at Bundanon Trust

This section of results introduces the five major weed management sites at Bundanon Trust. The aim of this section is to examine the key similarities and differences at each of the sites, and how this has affected weed management works which have been or will be undertaken in the future. Factors examined include histories of the sites, weed species present, vegetation communities present or in the surrounding area, history of weed management works, and any social factors visible on the site.

4.1. Introduction

Bundanon Trust comprises a total area of 1100 ha, which is made up of four historical sets of lots; Bundanon, Riversdale, Earie Park, and Beeweeree. The sites which are of interest to this project are the areas surrounding Riversdale homestead (Riversdale), the cleared area on the southern side of Earie Park (Earie Park), a formerly cleared area north-east of Bundanon homestead (Haunted Point), the areas surrounding Bundanon homestead (Bundanon), and a small creek line which crosses the road between Earie Park and Bundanon (Lilli Pilli Gully). The relative locations of these sites can be seen in Figure 1. Of these sites, four are being managed as part of the Living Landscape project- Earie Park, Bundanon, Riversdale, and Haunted Point. Lilli Pilli Gully has been managed by the Bundanon Landcare Group in the past. The creek lines to the north of Riversdale have been managed as part of the Bush Incentives Scheme funded by Southern Rivers Catchment Management Authority (SRCMA).



Figure 1: Map of weed management sites at Bundanon Trust (Image © Google Images)

It is not apparent from examining the archival documents or photographs exactly when weeds, in particular Lantana, arrived or begun invading the property. Through the interviews, many of the participants noted somewhere between 15 and 20 years ago as the time when Lantana began to proliferate. Since this time, Lantana and other weeds have spread through many areas of the property, particularly in riparian zones and former grazing lands, as seen in Figure 2. This issue is compounded by the fact that managing Lantana on the property was not a high priority of the Trust until a few years ago, as noted in the interview data. Since this time, a Land Management Plan (TEC, 2011) and Land Rehabilitation Works Plan (Waugh, 2012) have been developed in order to address some of the problems facing Bundanon Trust; namely the invasion of weeds, degradation of riparian zones and losses of biodiversity. These documents acted as the precursor to the Living Landscape project which is currently being undertaken by Bundanon Trust.

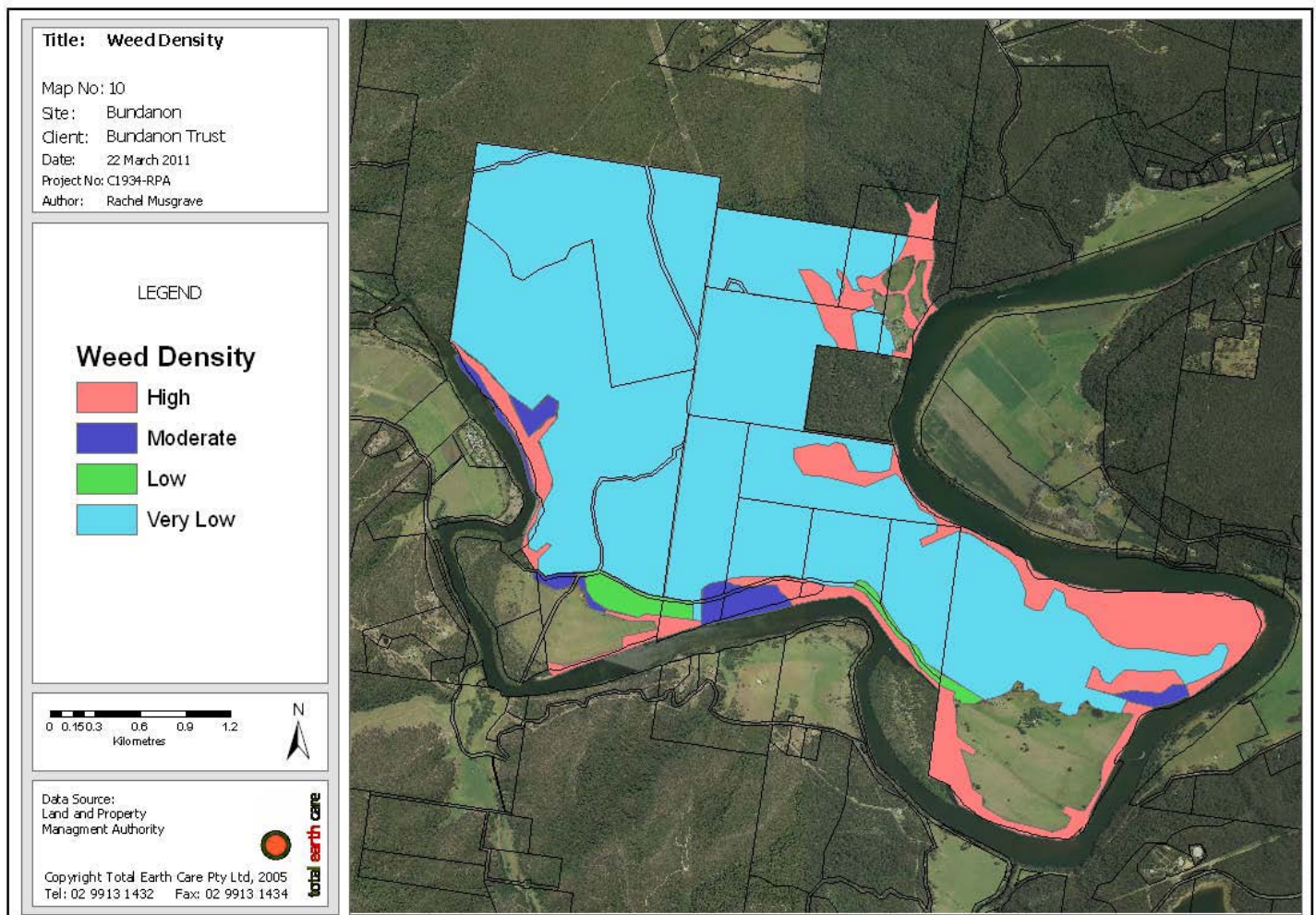


Figure 2: Map of weed density at Bundanon Trust (TEC, 2011)

The Living Landscape project represents the largest undertaking of weed management works in the history of Bundanon Trust, and is the result of a partnership between Bundanon Trust, Landcare Australia Ltd, Greening Australia, and Southern Rivers Catchment Management Authority (Bundanon, 2012a). There are a broad range of goals with this project, including reconnecting fragmented habitat, reductions in cattle grazing across the Trust, control of noxious and environmental weeds, improve riparian health, education of students and the community, and gain entry into environmental markets in order to generate ongoing revenue (Bundanon, 2012a). \$1.1 million has been allocated over a three year timeframe (mid-2012 to mid-2015). During this time, a variety of weed control methods will be employed, including physical, chemical, and mechanical methods. Follow-up control of weeds is planned, followed by planting of native species and natural regeneration in certain areas. The weed management works which have been undertaken as part of the Living Landscape, as well as through other programs, will be described in this section.

4.2. Eearie Park

Eearie Park is a site located on the south-western side of the property. The Eearie Park property comprises a total of 407ha of land. Of this, 39 ha are cleared of trees, which have largely been replaced with Kikuyu, and 368 ha are bushland (TEC, 2011). The site borders the Shoalhaven River along the southern boundary. The focus of this study is the cleared area of the site and their immediate surrounds- the Shoalhaven River to the south, and native forest to the north, as seen in Figure 4. The site was extensively cleared in the mid-1800's and actively cattle grazed until 2011. The extent of the clearing can be seen in Figure 3. Since cattle have been removed from the site, it has largely been unmanaged. Due to the lack of management, Fireweed has become prevalent in the cleared area, and Lantana has invaded the riparian and forested areas surrounding the cleared area, and now occurs in high density across the site.



Figure 3: Eearie Park Circa 1930 (Image supplied by Bundanon Trust)



Figure 4: Eearie Park study area, showing cleared areas (A2) and riparian areas (A5) (Bundanon, 2012)

As part of the Living Landscape project, a large-scale planting of 22000 native species was undertaken in early 2013 in the A2 area shown in Figure 4. Examples of this planting can be seen in Figure 5. Along the southern side of the site in the riparian zone (A5) extensive herbicide spraying of Lantana has occurred. Along the eastern and northern borders of the site extensive mulching of Lantana occurred in early 2013, with the mulch being left *in situ*. At the time of the field assessments, much of the regrowth in these areas constituted weedy species, namely Lantana, with small patches of Turkey Rhubarb (*Acetosa sagittata*), and Wandering Jew (*Tradescantia fluminensis*). Scrub Nettle (*Urtica incisa*) is also very prevalent in the regrowth of this site. Although this species is a native, it exhibits many weedy and invasive qualities, the evidence of which can be seen on this site.



Figure 5: Native species planting at Earie Park

The biodiversity in the cleared area is very low (prior to planting), with the only two species of note being kikuyu grass and Fireweed. Along the riparian zone biodiversity is similarly very low. The two dominant tree species are Black Wattle (*Acacia mearnsii*), and River Sheoak (*Casuarina cunninghamiana*), with very few other species noted aside from Lantana and Scrub Nettle. The riparian vegetation present has come about largely though natural recruitment once cattle were fenced off from the immediate riparian zone. Due to the fencing and cattle which were previously present on the site, the width of vegetation in the riparian zone is very narrow, often less than 10 metres. This has led to problems regarding the banks of the river being eroded, as can be seen in Figure 6.



Figure 6: Bank erosion at Earie Park

As the site is off the main road to Bundanon, it is rarely visited by members of the public. The only remaining building on the site is an old building used by Arthur Boyd and Sidney Nolan. The implications of these social factors will be further discussed in Chapter 6.

4.3. Riversdale

Riversdale is a small site comprising of 42ha of land. Of this, 10ha are cleared, and 32 ha are bushland. The cleared areas include the main areas for public visitation and education within Bundanon Trust. The site borders the Shoalhaven River on the south-eastern edge of the site. Two major creek lines are present in the north-western area of the site and these two creeks meet before entering the Shoalhaven River. The area of interest for this study is highlighted below in Figure 7. Within this site, there are two distinct areas; the creeklines mentioned formerly, and the riparian zone along the Shoalhaven River. Although these two areas are somewhat connected, they represent two distinct landscapes.



Figure 7: Riversdale study area (Bundanon, 2012)

The creeklines to the north of the site represent a biologically diverse ecosystem, with numerous native species present. However, Lantana has invaded parts of this site, often forming dense thickets. The Lantana in these creeklines is largely congregated around the immediate creeklines; the density of Lantana decreases significantly both upstream and upslope of the creeks. Some other weed species are present in this area, such as Wild Tobacco (*Solanum mauritianum*), and Castor Oil Plant (*Ricinus communis*). However, only a few isolated specimens of these were noted. Scrub Nettle is also prevalent on the site, forming dense infestations throughout the area. Under the Bush Incentives Scheme, large amounts of Lantana have been sprayed with herbicide and removed since 2007, with native species being planted. As part of the Living Landscape project, some parts of this site were mulched in mid-2013, as seen in Figure 8 and Figure 9. As noted earlier, the site represents a diverse habitat of native species, and this is highlighted by the species which are regenerating in response to the weed management practices implemented on the site. Although some of the regrowth consists of weeds such as Lantana and Scrub Nettle, there are numerous native species regrowing, such as Lilly Pilly (*Syzygium smithii*), Rosewood (*Dysoxylum fraserianum*), and Bleeding Heart (*Omalanthus populifolious*).



Figure 8: Riversdale creekline landscape with evidence of mulched Lantana in the foreground and native forest in the background



Figure 9: Riversdale creekline landscape with evidence of mulched Lantana in the foreground

In the river riparian zone, Lantana occurs in a high density, along with numerous other weeds. These include Turkey Rhubarb (*Acetosa sagittata*), Wandering Jew (*Tradescantia fluminensis*), Cape Ivy (*Delairea odorata*), Moth Vine (*Araujia sericifera*), and Scrub Nettle. In mid-2013 much of the riparian zone was mulched as part of the Living Landscape project. At the time of the field work there was very little regrowth occurring, due to the short time between the mulching and field work. Very few native species are present in the riparian zone, with Black Wattle (*Acacia mearnsii*) being the dominant species present, with isolated specimens of River Sheoak (*Casuarina cunninghamiana*) and Broad-leaved Paperbark (*Melaleuca quinquenervia*) also present. The width of riparian vegetation is very low, often less than 5 metres as shown in Figure 10. In many places, Lantana is the only species present on the immediate riverbanks. As such, there are areas where the river bank has been eroded, especially towards the north of the site.



Figure 10: Shoalhaven River riparian zone at Riversdale

The Riversdale site has a long and storied history. Cattle have grazed the site since the late 1800's, but these have been removed in the last 20 years. The Riversdale homestead is heritage listed, with historic curtilage surrounding the homestead. The site represents one of the two areas of highest visitation within the Trust (the other being Bundanon), being used for educational programs, public visitation, concerts, as well as the administration for the Trust. As such, the site represents a highly visible landscape, and this has important implications which will be discussed in Chapter 6.

4.4. Haunted Point

The Haunted Point site represents an area of 27ha of formerly cleared land which can be seen in Figure 11. The Shoalhaven River bounds the site to the north and the east. To the south and west are areas of native vegetation. The site was formerly used for cattle grazing; however the cattle were removed around 10 years ago. Since that time, the site has largely been unmanaged and allowed to naturally regenerate. The extent of historical clearing can be seen in Figure 12. Due to the lack of management, the site has seen a large proliferation in weed species present on the site.



Figure 11: Haunted Point study area (Bundanon, 2012)



Figure 12: 1949 aerial photograph of Haunted Point and Bundanon (Image supplied by Bundanon Trust)

Lantana has begun to colonise large parts of the site, especially in areas closer to the river. The south-western boundary of the site backs onto native forest, and Lantana density is much lower in these areas. Additionally, Scrub Nettle has also invaded the site, often forming dense thickets throughout the site as seen in Figure 13. Additional weeds present on the site include Cape Ivy (*Delairea odorata*), and Moth Vine (*Araujia sericifera*), albeit in relatively low densities.



Figure 13: Scrub Nettle thickets at Haunted Point

In the areas closer to the river, overall species diversity is low; Black Wattle and River Sheoak dominate the landscape, with a few specimens of Austral Bracken (*Pteridium esculentum*) and White Cedar (*Melia azedarach*) also present in this area. Additionally, the width of riparian vegetation is low along many parts of the site, as can be seen in Figure 15. However, towards the south-western boundary of the site the diversity and density of native species is much higher, with a range of both tree and understory species present. This includes a variety of Eucalyptus, Casuarina, Pittosporum, and Cycad species throughout the area. Examples of this can be seen in Figure 14.



Figure 14: Native forest along the south-west border of the Haunted Point study site

In early 2013 the Lantana on the site was extensively mulched and left *in situ* as part of the Living Landscape project. The response to this management has varied across the landscape. In areas closer to the river, much of the regrowth present has constituted weed species, namely Lantana and Scrub Nettle. However in the along the south-west border of the site, numerous native species are regenerating, such as Sweet Pittosporum (*Pittosporum undulatum*) and Tuckeroo (*Cupaniopsis anacardioides*). However Lantana is also regenerating in these areas, although to a lesser extent than closer to the river.

As the site can only be reached by foot or 4WD vehicle, and there are not historic buildings present on the site, visitation by the public is very low. The implications of this lack of visibility will be examined in chapter 6.



Figure 15: Shoalhaven River riparian zone at Haunted Point

4.5. Bundanon

The Bundanon property comprises a total of 349ha, of which 74 ha are cleared, and 275 ha are bushland. The area of interest for this study is an area of 86ha on the southern side of the property, around the Bundanon homestead and surrounding agricultural and riparian areas, as seen in Figure 16. The Shoalhaven River borders the site to the west, south, and east. Native forest borders the site to the north.



Figure 16: Bundanon study area (Bundanon, 2012)

The site was cleared for cattle grazing in the mid-1800's, the extent of which can be seen in Figure 17. The site is the only area within the Trust where cattle are actively grazing. This occurs in the paddocks between the two A1 zones shown above in Figure 16. Fireweed occurs in both the actively grazed paddocks as well as the paddocks which have been abandoned. In the riparian zone which borders much of the site, Lantana is prevalent, often forming dense monocultures. Other weeds are present in this area, including the Common Coral Tree (*Erythrina x sykesii*), Turkey Rhubarb (*Acetosa sagittata*), Wandering Jew (*Tradescantia fluminensis*), and Cape Ivy (*Delairea odorata*), as well as Scrub Nettle and Castor Oil Plant (*Ricinus communis*).



Figure 17: Bundanon from Pulpit Rock, Circa 1940's (Image supplied by Bundanon Trust)

There are few native species present in the riparian zone at the site, with Black Wattle (*Acacia mearnsii*) and River Sheoak (*Casuarina cunninghamiana*) representing the vast majority of native species present within this zone. At the north-eastern corner of the site the diversity of native species increases, owing to the proximity to native forest in this area. In early 2013, much of the Lantana present in the riparian zone was mulched as part of the Living Landscape project as shown in Figure 18, leaving a thin strip in the immediate riparian zone. The regeneration in these areas largely constitutes of weedy species, such as Lantana, Scrub Nettle, Cape Ivy, and Wandering Jew.



Figure 18: Bundanon riparian zone, showing mulched Lantana in the foreground

Similar to Riversdale, the site represents an area of high visitation within the Trust, as it is used for educational programs, artist's residence, and administration. The Bundanon homestead is also heritage listed, with surrounding areas listed as historic curtilage. The effects of these social factors will be explored in chapter 6.

4.6. Lilli Pilli Gully

Lilli Pilli Gully is a small site located on the road between Earie Park and Bundanon. The site is centred around a small creek flowing from the escarpment down to the Shoalhaven River. There are two areas of interest for this study; the area to the north of the road, and the area to the south of the road. On the northern side of the road the canopy of the forest forms a dense cover and allows very little light in, as can be seen on the left of Figure 19. This is especially apparent in the immediate creek riparian zones. However, there is a small cleared area to the east of the creek alongside the road where Lantana has invaded the landscape, which can be seen on the right side of Figure 19.



Figure 19: Lilli Pilli Gully to the north of the road, showing dense canopy on the left and an open area on the right

The majority of the Lantana on the northern side of the road occurs in this cleared area. In the areas where canopy cover is much higher, Lantana density is much lower or non-existent as seen in Figure 20. However, the vast majority of species present on the site are native, such as Sandpaper Fig (*Ficus coronata*), Rosewood (*Dysoxylum fraserianum*), and many species of Lilly Pilly. In 2012 the Bundanon Landcare Group undertook works to manage the Lantana in this area, mainly through manual and chemical methods, with much of the Lantana left *in situ*. This was supervised by the Property Manager, Property Officer and Property Assistant of Bundanon Trust. Numerous native species are regenerating in these managed areas, such as Sandpaper Fig, Poroporo (*Solanum aviculare*), Forest Nightshade (*Solanum prinophyllum*), and numerous Lilly Pilly species.



Figure 20: Dense forest to the north of the road at Lilli Pilli Gully

On the southern side of the road the forest is less dense, with Black Wattle the dominant species in this area as shown in Figure 21. Lantana is the dominant groundcover species, although not occurring in high densities. The Lantana in this area was mulched in mid-2013, leaving very little groundcover present on the site.



Figure 21: Open forest to the south of the road showing mulched Lantana in the foreground

Although the site represents an area of ecological health, there are challenges facing this site. The major challenge comes from the fact that the Bundanon Landcare Group is made up mainly of volunteers, so the group manages a site for 12-18 months before moving on to a different site, in order to avoid volunteers 'burning out'. Therefore, the site is not currently being managed by the Landcare Group. There are important implications regarding this lack of management challenges, which will be further explored in Chapter 6.

5. Socio-cultural assessment of weed management at Bundanon Trust

This chapter presents the results of the interviews, and discusses these results in the context of the project aims, and existing literature. This chapter is divided into two sections; section 5.1 represents the results of the top-down analysis of the interview data, and section 5.2 represents the results of the bottom-up analysis of the interviews as outlined in the methods.

5.1 Top down analysis of interview data

When quoting a participant an initial is given, corresponding to a certain person. These initials and their role regarding weed management at Bundanon Trust are given below:

Table 1: Initials given to interview participants

CEO	Chief Executive Officer, Bundanon Trust. Initiator of the Living Landscape project and serves on the steering committee.
PM	Property Manager, Bundanon Trust. Directly involved with on-ground weed management at Bundanon Trust, especially with regards to the rolling out of the Living Landscape project. Serves on the Living Landscape steering committee.
EM	Education Manager, Bundanon Trust. No official role with the weed management side of the Living Landscape project, but heavily involved in the educational side of the project.
PO	Property Officer, Bundanon Trust. Directly involved with on-ground weed management at Bundanon Trust. Coordinator of the Bundanon Landcare Group.
PA	Property Assistant, Bundanon Trust. Directly involved with on-ground weed management at Bundanon Trust. Coordinator of the Bundanon Landcare Group.
LC	National Farming and Major Projects Director, Landcare Australia Ltd. Project Manager for the Living Landscape project and serves on the steering committee.
SR	Senior Land Services Officer Industry Partnerships, Southern Rivers Catchment Management Authority. On the Living Landscape steering committee with a mostly advisory role.

5.1.1 Perceptions and attitudes towards weeds

The first aim of the project was to determine how human perceptions and attitudes regarding native, exotic, invasive and weedy species help to shape weed management strategies and practices.

As such, participants were asked about their definition of a weed, and the effects, both positive and negative, of these weeds, in particular Lantana.

Table 2: Participant definitions of weeds

<p>PO: “I guess I was taught as I was doing horticulture, I’m a horticulturalist, that a weed is essentially something growing where it’s not desirable”, “So very simply I’d say a plant that isn’t desirable in a particular area would be my definition”</p> <p>LC: “You know the typical definition, something that’s not mean to be there”</p> <p>SR: “Something that grows where it’s not supposed to be”</p> <p>PA: “I mean the standard definition is any plant that grows where it’s not wanted. But basically for weeds are any of the exotics that we have here, and we have the whole plethora of standard south-coast weeds”</p> <p>PM: “I don’t know whether I have my own definition, but I have heard a weed being described as a plant species that’s in a place that a person doesn’t want it, or its undesirable”</p> <p>CEO: “Art in the wrong place”*</p>
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* The full definition from CEO was not recorded due to a flat battery. However, this quote was noted during the interview.

All of the participants answers centred on the idea that a weed was something which as undesirable or out of place. However, it is important to determine exactly why these weed species are thought of as undesirable or out of place. When further pressed about the effects of weeds, in particular Lantana, the main answers were centred on the invasive effects of weeds, such as the formation of monocultures, damage to native fauna, degradation of landscapes, and ultimately losses of biodiversity.

Table 3: Negative effects of Lantana and other weeds

<p>PA: “obviously the whole notion of biodiversity”, “we’ve got monocultures of it that are smothering everything else”</p> <p>LC: “So it’s really all about that biodiversity outcome. I mean it’s much nicer to be able to get access to an area too, than having to bash your way through and get scratched up by Lantana and every other blasted thing”</p> <p>PO: “I think it takes over, and it takes over your native species and your fauna suffers as a result, biodiversity is diminished”, “It has a takeover effect, and it’ll climb trees and kill your trees, and it will impede your access into the bush, and change the dynamic of the bush in significant ways. More</p>

often than not for the worse”

CEO: “In the case of Lantana, I think it’s that thing about opening up the property”, “there’s the bigger thing about the health of it, and perceived ideas of the health of the property, and being good custodians of it. People don’t want to come here if it looks damaged”

SR: “Of course there’s all the downsides to weeds as well that we know about; outcompetes all the natives and the like, monocultures and things like that”

However, there are also many cases in the literature where the positive effects of environmental weeds are highlighted. When participants were questioned regarding whether the weeds at Bundanon Trust (in particular Lantana) were having any positive effects, many responses were garnered.

Table 4: Positive effects Lantana and other weeds

SR: “They provide great habitat for some species”, “they can be good, some of the deep rooted ones” (In relation to stabilizing soil).

PA: “And yeah sure Lantana probably does provide habitat for various things, I’ve got no doubt”

LC: “But you know, its habitat of a type”, “it’s pretty good as a soil stabiliser”.

PM: “I think they can definitely increase biomass, like weeds I think can be looked at in a positive light from a perspective of biological biomass, whereby if you mulch them and put them back into the ground before they get to set seed and therefore regenerate, there’s potential benefit there form a biological matter in the soil perspective. I think one of the good things that weed species can do is maintain soil moisture really”, “if you clear the Lantana out, then you get secondary infestation of a plethora of different weed species. So the Lantana is inadvertently keeping those species at bay”, “So there’s a potential benefit of Lantana is that it’s holding the riverbank there to a certain degree”.

EM: “Yeah, it’s a real sanctuary for native birds”.

PO: “The Lantana can create a little habitat for your animals and things like that. I’ve seen it create bank stabilisation along riparian zones, which is really helpful”, “If you do get rid of that weed, often other weeds will come in its place”.

Many of the responses focused on two potential benefits of Lantana: soil stabilisation, and provision of habitat. However, a sentiment shared by many of the participants was that there are many native

species which could provide much greater benefits than Lantana. **SR** noted “So there are some benefits, but I’m still not going to plant them”.

Many of the participants referred to a standard or taught definition. However, there is no exact consensus in literature regarding what exactly constitutes a ‘weed’ species. Gibson (2010) notes six different definitions which have come from academic literature. These include “a plant growing out of place (Davies 1992)”, “any plant growing where it is not wanted (Hussey et al. 1997)”, “any useless, troublesome or noxious plant (Emmerson and McCulloch 1994)”, and “a plant that interferes with man’s use of land for particular purposes, with his wellbeing or with the quality of his environment (Buchanan 1989)”, as well as noting that the terms “‘exotic’, ‘alien’, ‘naturalised’ or ‘introduced’” are often substituted in place of the term ‘weed’ (p. 96). Richardson et al, (2000) suggests a definition of “Plants (not necessarily *alien*) that grow in sites where they are not wanted and which usually have detectable economic or environmental effects (synonyms: plant pests, harmful species; problem plants). Environmental weeds’ are *alien plant* taxa that invade natural vegetation, usually adversely affecting native biodiversity and/or ecosystem functioning” (p. 98). Arcioni (2004) splits weeds into four broad categories- agricultural, environmental, urban and noxious, and states that “Underlying each of these categories is the central idea that weeds are plants growing where they are not wanted” (p.442). The participant’s answers regarding the definition of a weed are very similar to some of the definitions contained in the literature regarding environmental weeds; both Arcioni (2004) and Richardson et al. (2000) highlight the definition of an environmental weed as a species which negatively effects native biodiversity. However, an important note made many times in the literature is that the definition of a weed has the ability to change over time and space; it is essentially a result of the context of a particular set of circumstances (Arcioni, 2004; Gibson, 2010; Mansergh, 2010).

Although there are many cases in the literature where weeds and invasive species are providing benefits to ecosystems (Gentle & Duggin, 1997; Head & Muir, 2004; Sharma et al, 2005; Kohli et al, 2006; Bhagwat et al, 2012), or have supplanted a native species (Zavaletta et al, 2001; Hobbs et al, 2009), often the benefits are outweighed by the negative effects the species is having. Although Lantana will provide good habitat and provide some soil stabilisation (Bhagwat et al, 2012; Head, 2012), native species are often better placed to provide those services. One interesting point noted by **SR** was that “In terms of the amount of habitat that already exists around the site, there's always

plenty of room to move for those animals”, suggesting species which use Lantana for habitat will not be adversely affected by the large-scale clearing of Lantana occurring at Bundanon Trust.

There are many cases worldwide where native species have become dependent on exotic and invasive species for food, habitat and protection from predators (Zavaletta et al, 2001; Hobbs et al, 2006; Hobbs et al, 2009; Schlaepfer et al, 2011). It is often the case in these situations that an exotic species is replacing an absent or extinct native species, and as such, the native species is now relying on the exotic species out of necessity. However at Bundanon Trust, the vast majority of the site is vegetated with native forest. Lantana and other weeds are very prevalent in the riparian zones, and on the borders of cleared and forested areas, but very little occurs in areas where the forest is undisturbed. Therefore, whilst the clearing of Lantana in the riparian zones is likely to have short-term impacts on certain individual animals such as losses of immediate habitat, it is likely they will be able to migrate and adapt, leading to long-term benefits.

5.1.2 The goals and measuring success of weed management projects at Bundanon Trust

A wide assortment of views were discerned regarding the goals and desirable outcomes of weed management practices at Bundanon Trust, representing a wide range of social, economic, and ecological outcomes. These goals are expressed below

Table 5: Goals of weed management at Bundanon Trust

Social goals	<p>LC: “Try and ensure that that environmental considerations are very much part of what they walk away from their visit to the place”, “There’s a real interest in integrating the type of work that we’re doing into the school-targeted education programs that they’ve got”</p> <p>SR: “We can help Bundanon Trust to manage their land better, they can also help us with our educational needs, and they're a marketing machine out there as well”, “How it’s viewed by the community is important. Whether they see it as being important and strategic”, “if we could get some good learning’s out of the sites, there's been a few demonstrations, trial sites out there, different methods”.</p> <p>EM: “how we present the property to our visitors, and yeah I think that’s a really important aspect of it, that we can actually show them that these changes are</p>
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	<p>being made”.</p> <p>PM: “Hopefully there are some successes to be gained from the methodology used within the project”.</p> <p>CEO: (Regarding Haunted Point) “we are now talking about putting a continuous walking trail through it”.</p>
Ecological goals	<p>PM: “Improve biodiversity, and revegetate former grazing land, and regenerate some areas of bushland that have degraded mainly due to incursion of exotic weed species. And also improve riparian areas definitely”, “improve resilience and restore habitat, restore environmental integrity”.</p> <p>LC: “Degradation; turning that around to improve the quality of the vegetation communities in place, and of course the biodiversity benefits that flow on from there. In association with that, is also the implications for water quality, I mean that’s a direct consequence really, of the nature of the work that we’re putting in place”</p> <p>CEO: “the intention is to be best possible custodians of the landscape for which we’re responsible”.</p> <p>SR: “sustainable landscapes, healthy landscapes”, “To know that a lot of work has been done there and it’s become sustainable”.</p> <p>EM: “try and tackle the massive problem that lantana is on the properties, to try and rid, maybe rid the property of lantana, that’s probably unrealistic given that there’s only a three year funding for the project”.</p> <p>PO: “get the bush back to, or back to somewhere similar to its original state. And in a state where it takes care of itself, so that people don’t have to go in there and continue to work on it”.</p> <p>PA: “in the places that have been previously grazed, then a return to what they were hopefully.”, “For river riparian zones to be reveged, hopefully a useful distance as I’ve already said, bank stabilisation works to be undertaken and fully implemented”.</p>
Economic goals	<p>CEO: “see if there was any carbon, to see if we could become a bit of a carbon sink, as opposed to other forms of agricultural activity”.</p> <p>LC: “the two key opportunities there are mainly in the carbon side of things as well as the embryonic bio banking market”.</p>

Participants were asked about how the success of weed management projects at Bundanon Trust would be measured. Measuring the success of weed management at Bundanon Trust is an area of interest that is intrinsically linked to the goals of weed management outlined above, and as such, many of the responses regarding the goals of weed management at Bundanon Trust could be used interchangeably in this section, and consequently have not been repeated. However, certain additional responses were garnered from this question, which can be seen below.

Table 6: Measuring success of weed management at Bundanon Trust

Socially	<p>LC: “we’re also hoping to involve more students like yourself. And so we would appreciate that anybody that’s participating at either an undergrad or a postgrad level, they’re obviously been attracted to the project through one means or another; that is a pretty good indication that the projects a value as a resource”, “there’s some pretty basic ways of gauging media pickup about this stuff, and so we do that as a routine anyway, and so that simply provides an estimate of the exposure that a particular activity has”.</p> <p>CEO: “recovering some of the landscapes that have been impenetrable or inaccessible for any purpose”.</p> <p>PM: “increased visitation or increased benefit to the community from being able to visit Bundanon”.</p>
Ecologically	<p>EM: “visible aesthetic evidence that the project has been successful, there are areas that have been replants and are looking like they're being regenerated”.</p> <p>PM: “flora/ fauna surveys in the future to compare before the project and after the project, and therefore hopefully measure species density and distribution, and ultimately biodiversity.”</p> <p>PA: “And I’m talking about reveg as well in terms of the phragmites being returned”.</p> <p>LC: “And one of the things for the bio banking is that you need to undertake a pre-work or a site assessment, with a pretty rigorous methodology. So that work’s been done, (...) it allows us to have a really good pre-intervention baseline”, “There’s a lot of biophysical monitoring planned too, that’s a direct consequence. I mean as well as that there are also some pretty basic scientific things such as photo points, we’ve got photo points all around the joint as well”.</p>
Economically	<p>PM: “there's a cost-benefit analysis that potentially could have been conducted, or could be conducted, between revenue generated from grazing previously, and the</p>

	costs of maintaining the land, cost of weed management prior to the project compared to after the project. Also there's potential economic benefit/ success from sequestered carbon, and trading carbon credits".
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CEO was beginning to express views relating to measuring success ecologically; "they were pre-audited before Living Landscape started by SKM, and so now", but unfortunately the battery of the recording device went flat at this time.

Two interesting point come from these results; firstly, that the goals and outcomes that on-ground weed management practitioners mentioned were mostly ecologically-based, such as improving resilience, and riparian zone management. Others more associated with the management side of the projects were more likely to take into account a range of social, economic, and environmental factors. This is highlighted by a later quote by **PM**: "That's a really interesting one, because traditionally success is measured in our society by the dollar sign, by the economic benefit or disadvantage, and this project clearly has environmental, or hopefully will have environmental benefits, as well as social benefits too. So it comes to that sort of triple bottom line type accounting. So I suppose to measure success it depends what we're looking at".

The second point of interest from these results is the acknowledgement that educating the community about the weed management projects at Bundanon Trust is a very important social goal. This idea is explored extensively in the literature, and is a recurring theme throughout this study. This was highlighted by many of the participants not only in relation to this question, but also throughout the interviews:

"Education is the key to everything"- **RD**

The need to educate the public and community regarding weed management practices is explained numerous times in the literature, and failure to properly educate the public and community can lead to opposition and ultimately failure of weed management practices (Bremner & Park, 2007; Larson et al, 2011; Selge et al, 2011; Sharp et al, 2011; Garcia-Llorente et al, 2011). Bremner & Park (2007) found there was a direct link between public support for weed management practices and public education and awareness regarding these projects. There can be a wide range of reasons for opposition of weed management practices. Most commonly this is due to a failure of the public to

fully understand the effects that weeds are having in an ecosystem (Bremner & Park, 2007; Garcia-Llorente et al, 2011; Larson et al, 2011). Additionally, public perceptions regarding the nativeness of a species, its ability to be managed, and its aesthetics can all play large roles in aiding or hindering weed management practices (Selge et al, 2011). The techniques being used to manage weeds can also affect support (Sharp et al, 2011; Larson et al, 2011; Selge et al, 2011). Quite often, what the public perceives to be the most effective management strategy is the least practical (Bremner & Park, 2007). Involving the community in weed management practices is one way in which public perceptions of weed management practices can be greatly improved, as the public will often develop a sense of ownership regarding the land being managed (Bremner & Park, 2007; Larson et al, 2011). Therefore, there is a need to ensure that education and involvement of the community are integral parts of weed management practices.

Bundanon Trust is in an excellent position in that is an arts, cultural, and educational institute, and therefore has the means available to increase public education and awareness through its own programs. This point which was noted both by participants from within the Trust and from outside it. **EM** noted that “We try and, every education group that comes to visit the properties, we now are mentioning the Living Landscape project as part of our formal introduction to the history and the current use of the Bundanon Trust properties”. The ability and need for Bundanon Trust to educate the public regarding weed management practices will be further explored later in this chapter, as well in chapter 6.

5.1.3 Factors affecting weed management at Bundanon Trust

In order to determine the effect of various ecological, social, and economic factors on weed management at Bundanon Trust, participants were asked what they saw as the main competing factors. Responses to this question largely focused on factors relating the resources. Many of the social factors identified could also be construed as economic factors and vice versa.

Table 7: Social, Ecological, and Economic factors affecting weed management at Bundanon Trust

Social	PM: “Prior to Living Landscape and this injection of funds, we had minimal funds directed towards land management and environment let alone lantana on its own; lantanas just a part of it. And one of the big drivers of where those funds were directed was areas of visibility, either by the public or by the board when they’re visiting, or by other staff members”, “Because it’s a pretty unique place this, in that its arts and
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	<p>cultural organisation that also has vast environmental assets and cattle, and all sorts of things going on that you hardly ever see under the one banner ever really. So it's a real challenge to get all of those things looked after and operating and pointing in the same direction".</p> <p>CEO: "Well we do recognise the heritage, the social history aspects of the sites we're managing; it's not just that those are things people come to see, it's also that there is, I suppose its arguable, that there is certainly a kind of obligation to maintain those to some extent as well, and so maintaining those vistas and landscapes that reflect the social history of the property is really important", "no-one's planting eucalypts right up to the doorstep of the homestead, I mean we are maintaining the paddocks and views and so on", "There are members of my board and certainly there are other views in the trust I'd say, who go 'well, it's really terrible that it's not all the main front door of Bundanon that's been done as a priority, because that's where the visitors come'".</p> <p>SR: "when staff have got to go and change heritage light bulbs instead of managing the weeds it's a bit of a problem", "They really wanted to clean up some areas so they look good for the community, some of the visitors"</p> <p>EM: "it would be good too if the program could extend to those areas that are very visible; the things that every visitor sees, every visitor that drives along that road sees the stuff on the side of the road".</p>
Ecological	<p>LC: "You can think about the ecological implications of how it occurs. Why is lantana now such an issue in the area? When previously it wasn't. You know, you'd have to start really thinking that through".</p> <p>SR: "Well a lot of the neighbours have lantana up and down the riverbanks, and doesn't matter how much you clear off the riverbanks, it's going to come back again. So everybody along the whole river, that's the main vector"</p>
Economic	<p>PM: "The land management and environmental side of the organisation has probably been the poor cousin, just been under resourced and what have you".</p> <p>LC: "Labour.", "But the other thing is people, its time and labour, massive, big big part of it".</p> <p>CEO: "I think the main thing, the two things, its resources and resources, money money money", "when I arrived seven years ago (...) the trust had enough resources to maintain certain parts of the property, there were no resources available to maintain others", "The particular funding, one particular source of funding that comes through Landcare Australia, can't be used for riparian zones, and we have other funding for</p>

	<p>that, which comes through the CMA”.</p> <p>PA: “it’s just whether the money is available”.</p> <p>PO: “I guess resources is the big one”.</p> <p>SR: “The time of the staff out there, they don’t have enough time to manage it as much as they'd like to”.</p> <p>EM: “But that’s hard too, because we're not funded as an environment place, we're funded as an arts, cultural and educational institute”.</p>
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Two particular points of note came from this question; the suggestion by all participants that resources was one of the main factors affecting weed management at Bundanon Trust, and the perceived pressure from both inside and outside the organisation that work should be prioritized to areas of highest visibility.

The resources required for weed management practices is a limiting factor in programs worldwide. However at Bundanon Trust, a further complicating issue is the fact that that the Trust operates mainly as an “arts, cultural and educational institute”. This means that funding is allocated more towards these areas of the Trust. However, there is still a need to manage a land area of 1100ha, comprised of past and present grazing land, forest, riparian zones, in addition to maintaining heritage buildings and historic curtilage. The spread of resources within the Trust has largely been biased towards the arts, cultural, and educational side of the Trust, as noted by many of the participants. Both the Property Manager and Property Officer have duties maintaining buildings and heritage, in addition to managing weeds at Bundanon Trust. However, many of the participants from Bundanon Trust noted a shifting in the priorities of the trust, with an increase in the allocation of funding towards environmental outcomes. Indeed, in the Bundanon Trust Annual Report 2011-12, the Chairman of the Trust reiterates this change:

One of Bundanon’s significant assets is its extraordinary site. Rather than treating the land as a mere backdrop to the arts activities, the board has determined to make Bundanon an exemplar of restoration and environmental custodianship (Bundanon, 2012b p.5)

However, much of the funding for the Living Landscape project and other weed management projects at Bundanon Trust has come from outside sources, such as Government and private organisations. It seems apparent that without this funding, very little weed management work would have been undertaken at Bundanon Trust. This is supported by answers given during other

parts of the interviews, such as “But because we haven’t had any funding, we haven’t done anything. I mean obviously there the funding is the driver between doing something and doing nothing” (**PM**), “So if we hadn’t had the biodiversity funding on top of that, we’d obviously have been doing even less, and we’d have focused on a different part, and we might have made a different decision as well, because it was considerably less” (**CEO**). Indeed, it seems that the Trusts prior focus on the arts, cultural, and educational areas is one of the reasons why weeds such as Lantana have become so prevalent on the property. One particular story was noted by the CEO, Property Manager, and Property Officer, which explained when the Trust started to become aware of the problem that lantana was presenting:

One of the catalysts for managing lantana here at Riversdale was prior to me arriving, the lantana was starting to grow over the culvert on the main access road here into Riversdale, and scraping down the side of buses and sort of forming a natural barrier for people trying to get to their workplace. So it sort of came, what brought it onto the agenda of the previous property manager was people saying 'oh, shouldn't we do something about the lantana'. You know, it was visible in their face. And that's what's prompted some of the work onto the road into Bundanon. There are vast areas of lantana here, in bushland that aren't seen. But because that's seen and visible it sort of attracted funds in the past (**PM**).

The potential conflict regarding where weed management resources should be allocated is again highlighted in this question. In response to an earlier question **CEO** noted that “People don’t want to come here if it looks damaged”, relating to visible infestations of Lantana. Although the Trust is supported by the Australian Government, internal funds also come from visitors and programs run by the Trust. Therefore, it seems that focusing some weed management works on highly visible areas of Bundanon Trust is almost necessary, in order to present the property as visually acceptable. This ties into the second interesting point to come from these results; the perceived pressure from both inside and outside the Trust that work should be prioritized to areas of highest visibility. A quote by **CEO** highlights this:

There are members of my board and certainly there are other views in the trust I'd say, who go 'well, it's really terrible that it's not all the main front door of Bundanon that's been done as a priority, because that's where the visitors come'

The fact that Bundanon Trust were not overly concerned about the effects that Lantana was having until it directly affected them highlights the priorities of the Trust at the time. However, Bundanon Trust are not alone in this oversight of the effects of invasive species. Garcia-Llorente et al, (2011) states that “IAS (Invasive alien species) damage to ecosystems is often less visible to the public than it is to the scientific community. When IAS limits access to resources, or the IAS as a resource becomes limited, the people most directly affected believe that they are personally impacted and consequently take action” (p. 419). The perceptions of invasive species can vary greatly between scientists and members of the general public (Bremner & Park, 2007; Garcia-Llorente et al, 2011), and as such, education of the staff members of Bundanon Trust is necessary to ensure that the shift in the priorities of the Trust can adequately be explained to visitors by all staff members, not only those with a scientific background.

5.1.4 Funding of weed management at Bundanon Trust

Since funding and resources are seen as potentially limiting in weed management programs worldwide, participants were asked whether the funding which Bundanon Trust had secured for the Living Landscape project could be used effectively, over the timeframe for which that funding was allocated.

Table 8: Factors relating to funding of weed management at Bundanon Trust

PM: “I’m sure we’ve been doing some things inefficiently, but I really couldn’t tell you what they are, like they’re not blaringly obvious. But I think most of the time we’re, I mean it’s always a moving feast, trying to allocate funding and calendar timeframe”, “Overall, I think the funding’s been spent really wisely and really well, we’re addressing numerous different areas and different factors, and obviously trying to get the job done”, “I think the big challenge I see is that we have the funding cycle if you like. Dollars, and calendar, timeframe, money needs to be expended by here, now. Lantana, land, environment, doesn’t work like that, couldn’t give a damn about that. You know, it works on biology, sunlight, day length, seasons, temperature, so therefore, optimal, key word there; optimal land management, most effective land management doesn’t, rarely fits with that funding cycle.”, “I mean ultimately I think the effectiveness of how efficiently the project works in the long term is long-term management”, “And the reality is, if we didn’t have the funding from biodiversity fund, we could still be not quite sitting on our hands, but we’d be just chipping at the edges”.

LC: “Sure, absolutely. We’re not wasting our time. Ideally if we had more time we’d be doing it slightly differently, but the nature of funding arrangements are that you’ve got to have a project completed by this date (...) And it doesn’t always work in the best interests of the project”, “I’d like

to just delay the project by at least a couple of years, delay the completion of the project, and it would just allow us to have more time for the rehab phase, that's all".

CEO: "It seems to be being used very effectively at the moment", "So I suppose in an ideal world, we'd hope that our energies around this project, and as part of the reason why we've spent a lot of energy promoting it as well, is that we hope that we will attract more funding, in order to keep going".

PO: "I think it (funding) can be, definitely", "Once you've got your funds in place, you can start to plan for how you're going to tackle it and how much of an area you're going to tackle et cetera. So I guess once your funding's in place than a lot of other things fall into place. And conversely a lack of it will stop you progressing", "Where the rubber hits the road is whether you have the resources to continue on with that maintenance and see it through to its end. Which is a very long term project".

PA: "It's always unfortunate to my mind that you've got these constraints of time, because the timeframe is that this must be done by year one, this must be done by year two, this must be done by year three et cetera. (...) Personally I would have wondered whether a better approach would have been over a longer period of time, with more assisted reveg, rather than reveg. Direct broadcast seeding et cetera."

SR: "Within the timeframe now? Yes. Beyond that, we need more. Absolutely. Maintenance on that site is going to be for many years yet. And that's why we've been trying to work to look at other options for attracting funding. Bio banking and the like", "If there wasn't an opportunity for ongoing funding post-project, I don't think anyone would have done it".

EM: "Yeah. I think it just needs to be over a long time frame. Like it needs to be something like 15-20 years", "So far we've really just relied on external sources of funding, but it needs to be embedded in the long term".

The need to obtain long-term funding to ensure that weed management programs at Bundanon Trust have the highest chance of success was noted by all of the participants. However, at present there is very little funding set in stone beyond this current round of funding. The ability to enter environmental markets, such as Biobanking and Carbon Farming is seen as important for the project to become self-sufficient, as this would allow an ongoing source of funding on order to manage the sites in the long-term.

Another point of interest regarded the timeframes in which funding must be spent, and how this could possibly be improved. One particular quote of note by **LC** was that timeframes in which

funding must be spent “doesn’t always work in the best interests of the project”. At Bundanon Trust, the Living Landscape project is a \$1.1 million project over a timeframe of three years. To fully regenerate bushland and control weeds will take much longer than that; at least 10-20 years as noted by many of the participants, and require ongoing funding over this period. Failure to secure additionally funding after the completing of this project will mean that many of the areas currently being managed will become further degraded, possibly to a worse state than before. Those associated with decision-making are faced with the conundrum of whether to spend the allocated money within the timeframe give, potentially opening themselves up to further problems in the future, or to spend a lesser amount which will be able to be maintained in the long-term. This conundrum is summed up by **PO**:

If you bite off more than you can chew it can be a more negative thing than a positive thing, but if you take the approach that you wait until we’ve got all our funds in place ready to see this through for the next 15 years, you’ll probably never even start it because you’ll never get those.

However, this is not a problem limited to weed management programs at Bundanon Trust. Funding for weed management projects is usually allocated in short-medium term lots of 3-4 years (Mason et al, 2005; Larson et al, 2011). This means that in some cases, short-term answers to weed management are implemented as opposed to longer-term management solutions, simply due to the fact that funding must be spent within a specified period of time (Mason et al, 2005; Larson et al, 2011). Additionally, the costs of managing weeds increases with an increase in the area which has been invaded by a weed (Sinden & Griffith, 2005; Mason et al, 2005; Mehta et al, 2007; Larson et al, 2011). Prevention and early-detection strategies are often the most cost-effective methods to managing weeds, however this is not possible in areas where weeds have already proliferated (Mason et al, 2005; Hulme, 2006; Mehta et al, 2007; Larson et al, 2011). The most cost-effective measures taken to control weeds will usually focus on areas where weed density is lowest, and the potential for recovery highest (Larson et al, 2011). However, managing weeds in these areas may not bring about the best social goals, as these sites may be invisible to the public. Therefore, the resources which are allocated to weed management projects must be prioritised according to the goals of the project (Larson et al, 2011).

5.2. Bottom-up analysis of interview data

This section of results represents the results of the bottom-up analysis of the interview data, as explained in the methods section. Some of these themes came up as obvious repeated themes, whilst others were only mentioned by one participant. The themes which were most interesting and relevant to the study were selected.

5.2.1 The ability of cattle to maintain land

One of the obvious points which came from the bottom-up analysis was the views regarding cattle grazing and its effects on weeds on the property. The opinions expressed below came about through a variety of questions:

Table 9: Positive effects of cattle identified during the interviews

CEO: “Now where the grazing was being maintained, certainly wasn’t weed free, but it was less weed prone than other areas where it was former grazing”.
PM: “Whereas somewhere like the areas on Bundanon and Earie Park, former grazing land, the reason they don’t... Oh they do have Lantana on the edges, but the reason they don’t have Lantana on them is because they’ve had Kikuyu based pasture, and cattle there. And yeah, I would always argue that cattle on Kikuyu pasture, they’re not four-legged bovines; I see them as a least-cost land management tool. They’re very low cost compared to chemical, mechanical, human interventions”.
PO: “I think the work in Earie Park was chosen because there was no longer use for cattle there as far as I could tell, the cattle had all been moved to Bundanon, and therefore you’ve got paddocks left unattended, so to do regeneration work on those paddocks is important because, as you probably know, a paddock left alone will turn out like Haunted Point”
SR: “Some of the sites were not managed as intensively as they used to be, they were grazing lands, so when the (cattle) stock was taken off, they were just left. I don’t know if you’re aware, but stock are a fantastic land management tool and some people don’t recognise that. So when the stock were pulled off, all the weeds came in”.
EM: “I know up at Haunted Point it was an area where there used to be cattle, and then Gary, the caretaker told me stories of how the cattle used to roam around up in that area, and there was not Lantana there maybe even 15-20 years ago”

The perception presented here is that cattle are excellent at managing weeds in agricultural areas. However, views were also expressed regarding the degradation that cattle can cause to riparian zones, as well as the costs associated with maintaining a herd of cattle:

Table 10: Negative issues relating to cattle grazing at Bundanon Trust

<p>CEO: “There’s no fencing there, so the idea that you allow the cattle to go willy-nilly down on to the river, is clearly something that at some point we decided not to do in the Trust, before my time, quite rightly, and so the cattle came off that piece of land. So maintaining grazing there would not be possible, you can’t just send the cows in to keep it clear of stuff, because you’d then be going against what is now a new set of benchmarks about what you can and can’t do”, “We used to run a pedigree herd of Angus cattle here, and we stopped that a few years ago because really the amount of resources in maintaining a pedigree herd is considerably more than running the very small commercial herd we do at the moment (...) And the small amount of return from that herd, very small, was no compensation for the amount of time people spent looking after it.”, “One of the reasons the grazing came off it was the fencing infrastructure hadn’t been maintained, and it was a big property, and we had no economic capacity to re-fence it, in order to re-graze it, and because the maths didn’t add up”.</p> <p>EM: “There’s a whole lot of areas there where the cattle, before we had our historic curtilage done, a whole lot of our fencing had been really really degraded, and the cattle were actually getting down to the beach”.</p> <p>PM: “If you want to look at it from an economic perspective, I suppose there’s a cost-benefit analysis that potentially could have been conducted, or could be conducted, between revenue generated from grazing previously, and the costs of maintaining the land, cost of weed management prior to the project compared to after the project”.</p>

Therefore, the issue of cattle at Bundanon Trust presents an interesting conundrum; on one hand, cattle are seen as a “fantastic land management tool” in actively grazed areas, but also present a problem to riparian zones if adequate fencing is not maintained. At Bundanon, active cattle grazing has been reduced to an area of 48ha surrounding the Bundanon homestead. In areas of Eearie Park, Haunted Point, Riversdale and Bundanon where grazing has previously taken place, cattle have been taken off the land which has essentially been unmanaged since, leading to varying levels of degradation and species invasion. The reasons for taking the cattle off these areas largely seem to be economic; due to the income gained from cattle being less than was needed for maintenance of the cattle. However, these economic calculations have seemingly failed to take into account the cost of managing the land on which the cattle were grazing; the removal of cattle in these areas occurred at least two years ago, when the priorities of the Trust were less directed towards environmental

outcomes. Now that the Trust has made a decision to invest more into the natural environment, the cost of managing these previously grazed areas is becoming known. Therefore, there is a potential cost-benefit analysis which could be completed regarding the costs of cattle versus the benefits they provide in managing weeds. However, it is most likely unfeasible to reintroduce cattle to large areas of the property, due to dilapidated fencing, and the extent to which weed density has increased in many of these areas.

The idea that cattle are effective at managing weeds is a contentious issue. Popay & Field (1996) highlights many of the potential positive and negative effects that grazing can have on weed densities, noting that in order for grazing to be beneficial in controlling weeds, fencing must be maintained to constrain animals to certain areas, and adequate grazing pressure also maintained. Also of note was the assertion by Popay & Field (1996) that grazing was “more effective weed control than with herbicides”, and required “lower direct costs” (p. 219). However, many potential negative effects of using cattle to control weeds were also noted, such as damages to soil and non-target species, and the spread of weed seeds by the grazing animals. In the case of Lantana, it has been shown that cattle grazing in association with other disturbances has the ability to greatly increase Lantana biomass, growth, and survival rates (Gentle & Duggin, 1997; Duggin & Gentle, 1998). Therefore, whilst cattle grazing can have some potential benefits in actively grazed areas, it is unlikely that reintroducing cattle to previously grazed areas at Bundanon Trust to control Lantana would have a positive impact, due to the extent to which Lantana has invaded these areas. However, grazing has the potential to be a beneficial practice in integrated weed management systems (Popay & Field, 1996), and as such, could form part of the ongoing weed management around Bundanon homestead, where grazing has been maintained.

5.2.2 Visually obtrusive weed management practices at Bundanon Trust

One interesting point brought up by the Property Manager regarded the visibility of the industrial weed management practices which were being employed as part of the Living Landscape project:

You know, it's going to be an industrial landscape with yellow machines, and wholesale slaughter of plants. You know it's going to be really ugly. Whereas the perception is, oh, there's lovely green regenerative natural environment; people are like 'oh, what are you doing with massive machinery'. So there's a bit of that aspect at Haunted Point that it's not hidden from view by any means, but it is around the corner and away from public eyes. So

therefore we have the chance to sort of rip into it, for want of a better term (...) It's good to be able to show progress, at the same time realising it might be a bit ugly and a bit of an eyesore for a few years down the track."

Public perceptions and support can play a large role in determining the outcomes of weed management practices, as noted in section 5.1.2 (Bremner & Park, 2007; Larson et al, 2011; Selge et al, 2011). At Bundanon Trust, where large-scale management with machinery is occurring, the visually obtrusive nature of these practices has the ability to affect public support for the weed management practices being undertaken. Since the highly visible areas of the Trust (Bundanon and Riversdale) are being managed as part of this project, there is a potential perception by the public and those within the Trust that these areas are not being managed in a socially or ecologically sustainable way. This could possibly lead to opposition to the works being done within the Trust. This ties into points made earlier (5.1.2) in this results section relating to the value of educating the public regarding weed management practices, and will be further discussed in chapter 6.

5.2.3 The challenges facing long-term management

Through the top-down analysis of the interview data, it was noted that all participants stressed the need for long-term management in order to remove Lantana from the property. Several participants also noted some of the challenges facing long-term management, such as the transport of weeds from neighbouring properties and the river.

Table 11: Potential challenges to long-term weed management at Bundanon Trust

<p>PO: "And it's a tough thing because you've always got, take Lantana for an example, if you get rid of the Lantana from all of Bundanon, your neighbours are just choked with Lantana, and it's going to come down the river from the valley, in floods, the birds are probably going to chew on it and shit it everywhere, you know. So you could put the question out there will it ever end really? Maybe not, unless everyone is sort of committed to getting rid of it", "Sometimes you've got to weigh up is it best to get rid of this weed or am I just creating a rod for my own back"</p> <p>SR: "Well a lot of the neighbours have Lantana up and down the riverbanks, and doesn't matter how much you clear off the riverbanks, it's going to come back again. So everybody along the whole river, that's the main vector", "The challenge is to start managing the weeds that are outside of the area that's being managed at the moment. As we know, Lantana will move quite quickly across the landscape where it's dropped the seed"</p> <p>PM: I remember sitting down at a table with someone in the consultation process who said that I;</p>

me in my role as property manager, I won't see any, I mean I'll see some success, but I won't see the end of the Lantana on Bundanon; neither will the person that takes my place; and maybe the person that takes their place, they might almost start to see, or think they're getting on top of it. So it's pretty long term, and there's a lot; there's truckloads to do".

The points raised in this section represent a range of ecological and social problems which could potentially affect long-term weed management at Bundanon Trust. The ability of Lantana to rapidly spread through a variety of vectors was noted; these include transport via the Shoalhaven River, by birds, and through the natural spread of seeds. The vector of the Shoalhaven River is an area of particular note. Although Bundanon Trust are implementing works to control Lantana in some of the riparian zones on their property, there are many more kilometres of river frontage which are infested with Lantana, both on Bundanon Trust property as shown in Figure 2, and throughout the entire Shoalhaven River catchment. Therefore, there is a need for action from not only Bundanon Trust, but also neighbouring properties to tackle the problem that Lantana presents, as noted by some of the participants. This presents both an ecological and social barrier to successful management of Lantana at Bundanon Trust.

The need for cooperative weed management practices is noted many times in the literature. In areas where land is becoming more and more divided, the need for cooperation between neighbouring and connected landholders in order to manage weeds becomes significantly greater (Klepeis et al, 2009; Espanchin-Niell et al, 2010). However, the barriers to cooperation also become much larger, owing to the larger number of landholders who must agree on the management practices. Additionally, lack of one landholder to manage weeds has large flow-on effects for neighbouring properties, whose own weed management programs become less effective (Klepeis et al, 2009; Espanchin-Niell et al, 2010). The barriers to implementing weed management programs across numerous landholders are numerous. These can include disagreements regarding whether the management is important or not, the impact of a species being management, the management practices being implemented, where funding for these programs should come from, as well as communicational and logistical barriers to implementation of these programs (Jacobson et al, 2006; Stokes et al, 2006; Bremner & Park, 2007; Klepeis et al, 2009; Espanchin-Niell et al, 2010; Selge et al, 2011; Garcia-Llorente et al, 2011; Larson et al, 2011).

At Bundanon Trust, the property is connected both directly and indirectly through the river to a range of public and private lands. As noted above, there are numerous barriers to implementing widespread control programs. Even if widespread control programs were to be implemented across the catchment, it is likely that Lantana would still be an omnipresent factor across the region in the riparian zone, owing to its invasiveness. Therefore, even if Lantana is successfully managed in the Bundanon Trust riparian zone through the Living Landscape project, it is likely that it will be an ongoing battle. Therefore, it is important for Bundanon Trust to consider why they are conducting the weed management works they currently are, the overall benefits of these works, and the ways in which they could improve the outcomes of these works.

6. The implications for Bundanon Trust

The aim of this chapter is to link the results of the field assessments found in chapter 4 with the results of the interview data in chapter 5, in order to examine exactly which key issues affect Bundanon and their weed management programs. As noted in the previous chapter, there are many social, environmental and economic factors which have the ability to affect long-term weed management at Bundanon, all of which help to shape the work which is being carried out, its effects, and ultimately the chances of the work being successful.

6.1. The visibility of weed management at Bundanon Trust

Numerous points were raised in the interviews relating to visibility. These included points regarding the presentation of the property to visitors (section 5.1.2), whether weed management should focus on visible areas or not (section 5.1.3), and the visibility of current weed management practices (section 5.2.3). These points raise an interesting challenge which faces Bundanon Trust relating to where work should be undertaken. The Bundanon and Riversdale sites which are being managed as part of the Living Landscape project represent the areas of highest visitation within the Trust, and therefore are highly visible landscapes. Both these sites contain historic vistas, heritage buildings, historic curtilage, and are frequently visited by artists, students, and the public. Consequently, the weed management works being undertaken in these areas are highly visible; this has the potential to have both positive and negative effects.

On the positive, the visibility ensures that visitors are aware of the weed management works being undertaken in these areas, meaning that Bundanon Trust can exhibit the work which is being undertaken, explain what is trying to be achieved, and why this is of benefit. Through this, Bundanon Trust has the ability to improve public awareness and perceptions of the weed management practices being undertaken, and achieve some of the goals of the Living Landscape project such as increasing community education and involvement. A flow-on benefit from this is the potential to attract future funding as noted in section 5.1.4. Although one of the goals of the Living Landscape project is to enter environmental markets such as Biobanking and Carbon Farming, if this proves to be unviable in the future it is likely that Bundanon Trust will rely heavily on external funding, as is the case with the Living Landscape project. Whilst increasing public engagement and education does not guarantee further funding, a point made in section 5.1.4 was that exhibition of the weed management practices being undertaken at Bundanon Trust opens the door for ongoing funding in

the future. Therefore, if the public is actively engaged and educated regarding the weed management practices at Bundanon Trust, the potential for ongoing funding is likely to be higher.

On the negative, some of the techniques being used to manage weeds, such as the mechanical clearing of Lantana, may be unsightly to visitors, artists, and stakeholders in the Trust. As noted in sections 5.1.2 and 5.2.2, public perceptions can have large effects on the success of weed management practices. If the public view the weed management practices as unsightly, without fully understanding the long-term benefits of the works which are being undertaken, there is the potential to derail the long-term weed management practices at Bundanon Trust. Therefore, there is the need for Bundanon Trust to educate the community and stakeholders regarding the decisions which have been made, and why the techniques being used are necessary to manage the large amounts of Lantana present on the sites.

On the other hand, Haunted Point and Eearie Park are largely invisible to the public, and rarely visited. Therefore, whilst there is a potential to manage Eearie Park and Haunted Point in an industrial manner without any negative public backlash, it also means that the public may be largely unaware of the works being undertaken in these areas and the potential benefits of this work; these two areas essentially represent the opposite conditions that Bundanon and Riversdale represent in terms of visibility.

Another factor which must be considered is how the public views the property currently. As Lantana is prevalent in many areas of the Trust including along roadsides, in the riparian zone, and on the borders of the forests and cleared areas, it in itself represents a highly visible element of the property. Although scientists generally agree on the negative effects that Lantana will have in an ecosystem, and the key players associated with weed management at Bundanon Trust are also aware as noted in section 5.1.3, members of the public may not be as aware of the issues which Lantana presents on the property. As a somewhat aesthetically pleasing species, Lantana has been used as an ornamental plant in many parts of the world. As such, the management of Lantana at Bundanon Trust has the potential to lead to public backlash. Therefore, there is the need to educate the public about the negative effects which Lantana is having on the property, to ensure positive public perceptions of weed management at Bundanon Trust.

6.2. The effects of the Shoalhaven River on weed management at Bundanon Trust

As noted in section 5.2.3, there are ecological factors which have the ability to affect the long-term management of weeds at Bundanon Trust. The four sites being managed as part of the Living Landscape project represent former grazing lands and riparian zones. The aim of this management is to revegetate former grazing lands, and to improve riparian conditions through assisted regeneration. If Lantana and other weeds were to be removed from these areas, it would provide a raft of ecological benefits, a summary of which can be seen in section 2.1. However, to revegetate and regenerate these areas will require ongoing funding for many years to come. The four sites represent varying levels of degradation, owing to the level of management which they have experienced over the past 20 years. However, all share a border with the Shoalhaven River. The implications of this cannot be understated; as noted in section 5.2.3, the river serves as a major vector for the transport of weeds. The immediate riparian zones of these sites were once completely cleared of vegetation, as highlighted by Figure 3 and Figure 17. The flora which is now present in these riparian zones has largely come about as the result of natural recruitment once cattle were fenced off from these areas. Three species have become dominant in these areas; Black Wattle, River Sheoak, and Lantana.

Through the weed management works which have been undertaken as part of the Living Landscape project, much of the Lantana in these riparian areas has been mulched, leaving only a thin strip of riparian vegetation. Therefore, there is great potential for these mulched areas to be colonised. Without assistance in the form of weed control and planting of native species, it is highly likely that the species which colonise these areas will largely constitute the three species listed above. In particular, Lantana is highly likely to colonise, owing to the spread of this species upstream and downstream of Bundanon Trust; a point which was noted by participants in section 5.2.4. This will be an ongoing problem, unless there is widespread cooperation along the entire river and surrounding areas to try and remove Lantana from the area. However, owing to its invasive nature, ability to thrive in a range of conditions and large seed-bank, it is likely that Lantana will maintain a presence in the riparian zones even in the face of drastic control practices.

Additionally, the river riparian areas at Eearie Park, Bundanon and Riversdale back onto previously cleared areas, and as such are largely disconnected from native forest. This means that there is very

little chance for native species from the forest to colonise the riparian areas. Consequently, the species which are regenerating in these areas in response to weed management practices largely constitute weed species. At Haunted Point, the native forest is in a much closer proximity to the river, and as such the regeneration which is occurring at the site represents a much higher diversity of native species.

Bundanon Trust are aiming to rectify this problem through the planting of native species in the cleared areas of the four sites. However, this comes with its own associated challenges, namely from herbivory by Kangaroos and Wombats, and the low resilience in these highly degraded landscapes. These plantings are still in their early stage, with only Eearie Park having been planted at the time of the field assessments. As such, it is far too early to make a judgement regarding the long-term effects of this strategy. However, if this strategy eventually leads to a connection between the native forest and the riparian zone, it has the ability to considerably inhibit the spread of Lantana in the riparian zone.

6.3. Management of the sites which are not part of the Living Landscape project

So far this implications chapter has largely focused on the four sites which are being managed as part of the Living Landscape project: Bundanon, Riversdale, Haunted Point, and Eearie Park. These sites have a long history of degradation, and as such, will require large-scale management solutions. However, the Riversdale creeklines and Lilli Pilli Gully are smaller sites which do not have histories of land clearance and grazing. As such, the ecological health of these sites is much higher than the Living Landscape sites, and the capacity to respond positively to weed management practices is much greater. However, the large amounts of funding allocated as part of the Living Landscape project largely do not extend to these sites. The Riversdale creeklines are largely managed through the Bush Incentives Scheme, whilst Lilli Pilli Gully has formerly been managed by the Bundanon Landcare Group. However, as this site is not presently being managed by the Landcare Group, there is the potential for the site to become further degraded by Lantana invasion.

Both of these sites represent highly visible landscapes. As such, there is the ability for Bundanon Trust to educate and involve the public through these sites, which can lead to improved public perceptions of weed management at Bundanon Trust, as noted in section 6.1. The ability of these sites to respond positively to weed management practices means that if they were to be continuously managed over the course of the Living Landscape project, Bundanon Trust could exhibit these sites as examples of successful weed management. Although eradication of Lantana is unfeasible over this timeframe, there is the ability to make drastic visible changes in these areas, which can greatly aid Bundanon Trust in educating the community regarding the weed management practices which are being implemented over the entire property.

7. Recommendations and Conclusions

7.1. Recommendations

The weed management practices which Bundanon Trust are implementing have the potential to bring about large-scale changes to local ecosystems, in addition to drastic social changes. The key recommendations of this study are that Bundanon Trust:

- Continue the works planned through the Living Landscape project in order to greatly improve biodiversity, riparian health, and habitat connectivity.
- Invest further in weed management works in the Riversdale creeklines and Lilli Pilli Gully over the course of the Living Landscape project. These areas are not only highly visible, but also represent sites where resilience and the potential for recovery is high. Presenting these sites as areas where managing Lantana is effective will help to ensure positive public perceptions of the weed management works being undertaken across the property. In particular it is important to manage Lilli Pilli Gully to ensure that further degradation does not occur.
- Ensure that the community is adequately engaged and informed regarding the weed management works being undertaken on the property. It is important to connect not only with visitors to Bundanon Trust, but also with the wider community, especially with landholders who are connected through the Shoalhaven River. The only way in which Lantana will be controlled in the riparian zone is if there is significant agreement along the whole river about the need to manage Lantana. Engaging with these landholders is therefore of utmost importance.
- Undertake further monitoring of the density of Lantana and other weeds on the site at the completion of the Living Landscape project. This is necessary to ensure the viability of long-term weed management on the property, especially with regards to funding.
- If ongoing funding is not able to be secured after the completion of the Living Landscape project, prioritise weed management funding initially towards Bundanon and Riversdale. Although these areas may be the least resilient of the sites currently being managed, they are also the most visible and visited sites. Therefore, people are more likely to see the good work which is being undertaken in these areas, which has the potential to attract community involvement, and potentially further funding. The need for long-term funding cannot be understated in this case. Although prioritising funding towards areas where success is most likely such as in areas of native vegetation would be the most cost-effective strategy, if Bundanon Trust are aiming to control and ultimately eradicate Lantana from the property,

the only way this will be achieved is through large-scale management solutions, which require large amounts of funding. The social factors surrounding Bundanon and Riversdale mean that these sites have the greatest ability to engage the community and attract further funding, which is key to long-term success.

There is a great scope for future research on the property. Some research areas of note are:

- A follow-up study completed at the completion of the Living Landscape project in mid-2015. This would allow Bundanon Trust to compare any social issues and the ecological health of the sites post-management.
- A study of the public opinion and perceptions of weed management at Bundanon Trust. Ideally this would involve visitors to the Trust, and landholders along the Shoalhaven River. This could allow the Trust to determine whether the public are being adequately educated regarding Lantana and other weeds, the importance of managing weeds, and the need for cooperation in managing these weeds.
- A study of herbivory rates in the areas which are to be planted as part of the Living Landscape. Although this study did not deal with this issue, it poses the potential to be a large problem relating to the revegetation of weed management sites at Bundanon Trust.
- A quantitative investigation into the overall riparian health of the weed management sites at Bundanon Trust. It is necessary to monitor vegetation density, width of riparian vegetation, and overall species diversity. This is particularly important due to the weed management practices which have been implemented at Bundanon Trust often leaving only a thin strip of Lantana stabilising the riverbanks.

7.2. Conclusions

The broad aim of this project was to determine the range of biogeographic and socio-cultural factors which affect weed management at Bundanon Trust, with the secondary goal of informing future management. This study has assessed a vast array of social, ecological, and economic factors which affect the weed management practices being implemented on the site, and found that there are several key factors which have large implications for Bundanon Trust.

One of the dominant socio-cultural factors which was repeated throughout the study related to the public perceptions of weed management practices at Bundanon Trust. Numerous points made in the

study related to this factor, such as the visibility of weed management practices, perceptions of weed species, and the need for public education and engagement regarding weed management practices and their importance.

There are many biogeographic factors which affect weed management at Bundanon Trust. Of particular note were some of the ecological barriers to successful long-term weed management; the Shoalhaven River acts a major vector for weeds in the area, and as such, Lantana and other weeds are continuously being transported to the property. This has the potential to play a large part in determining the success of weed management at Bundanon Trust. The long history of degradation of many of the weed management sites, and how this affects their capacity to be successfully managed is also an important factor which was examined.

The ability to secure ongoing funding for weed management practices is the factor which will play the largest role in determining the success of weed management practices at Bundanon Trust. The Living Landscape project represents a good start to a long-term problem. However, due to the short-term nature of the funding agreement, the project alone will not be enough to ensure long-term ecological health of the weed management sites. Therefore, the larger challenge will come once this funding allocation is exhausted in mid-2015. The practices used as part of the Living Landscape project mean that large amounts of Lantana on the property have been mulched, and these areas represent somewhat of a clean slate. However the potential is for weeds to rapidly invade these cleared areas. Failure to secure additional external funding for ongoing management, monitoring and rehabilitation could potentially overturn the good works achieved as part of the Living Landscape project and lead to further degradation.

However, the works which have been planned and undertaken have the potential to bring about large-scale positive changes in the area. Failure to implement these works would ensure that weeds become more prevalent on the property, and degradation will continue to occur. Therefore, it makes sense for Bundanon to implement these large-scale control measures, with the aim that they will be able to help secure future funding either through entry into environmental markets or through external grants. Through public education and engagement, alongside exhibition of successful weed management practices, there is potential to attract further external funding. The fact that Bundanon Trust are an arts, cultural, and educational institute means that they have the means to successfully achieve these social goals through their own programs, which places them in good stead to continue implementing weed management works across the site.

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Appendices

Appendix A: Copy of UOW Human Research Ethics Committee Approval



APPROVAL after review
In reply please quote: HE13/159
Further Enquiries Phone: 4221 3386

18 April 2013

Mr Linden Brown
14 Shauna Crescent
MT KEIRA NSW 2500

Dear Mr Brown

Thank you for your letter responding to the HREC review letter. I am pleased to advise that the Human Research Ethics application referred to below has been **approved**.

Please ensure that the Consent Form is issued on UOW Letterhead and a copy sent to us for our records.

Ethics Number:	HE13/159
Project Title:	A sociocultural and biogeographic assessment of weed management at Bundanon
Researchers:	Mr Linden Brown, Professor Lesley Head
Approval Date:	18 April 2013
Expiry Date:	17 April 2014

The University of Wollongong/llawarra Shoalhaven Local Health District Social Sciences HREC is constituted and functions in accordance with the NHMRC National Statement on Ethical Conduct in Human Research. The HREC has reviewed the research proposal for compliance with the National Statement and approval of this project is conditional upon your continuing compliance with this document.

A condition of approval by the HREC is the submission of a progress report annually and a final report on completion of your project. The progress report template is available at <http://www.uow.edu.au/research/rso/ethics/UOW009385.html>. This report must be completed, signed by the appropriate Head of School, and returned to the Research Services Office prior to the expiry date.

As evidence of continuing compliance, the Human Research Ethics Committee also requires that researchers immediately report:

- proposed changes to the protocol including changes to investigators involved
- serious or unexpected adverse effects on participants
- unforeseen events that might affect continued ethical acceptability of the project.

Ethics Unit, Research Services Office
University of Wollongong NSW 2522 Australia
Telephone (02) 4221 3386 Facsimile (02) 4221 4338
Email: rso-ethics@uow.edu.au Web: www.uow.edu.au

Please note that approvals are granted for a twelve month period. Further extension will be considered on receipt of a progress report prior to expiry date.
If you have any queries regarding the HREC review process, please contact the Ethics Unit on phone 4221 3386 or email rso-ethics@uow.edu.au.

Yours sincerely,



AProfessor Garry Hoban
Chairp, Social Sciences
Human Research Ethics Committee

cc: Professor Lesley Head, Earth & Environmental Sciences

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Appendix B: Participant Information Sheet

UNIVERSITY OF
WOLLONGONG



PARTICIPANT INFORMATION SHEET FOR:

Title: *A sociocultural and biogeographic assessment of weed management at Bundanon*

Purpose of the research

Bundanon Trust supports arts practice and engagement with the arts through its residency, education, exhibition and performance programs. In preserving the natural and cultural heritage of its site Bundanon promotes the value of landscape in all our lives.

Bundanon Trust aims to maintain and restore its bush and former agricultural land (1,100 hectares, including freehold and Crown land) with an environmental focus and retain a small working farm. The property encompasses several different plant community types as well as weeds of national significance, particularly lantana. A program of weed eradication and restoration/revegetation has been undertaken however to date it has only been able to address some affected areas. Supported by the Borland Bequest, administered through Landcare Australia; with a Biodiversity Fund grant from the Federal Government; and in partnership with the Southern Rivers Catchment Management Authority and Greening Australia, *Living Landscapes* is a major project aimed at restoring the land. This project is informed by the Land Management Plan 2011, created by Total Earth Care; Landscape Assessment 2012 by Craig Burton detailing the historic and cultural curtilage, together with the Land Rehabilitation Works Plan by Jock Waugh 2012.

With limited resources and time, competing issues can impede effective management of this significant parcel of land with many users/ visitors with differing values and needs attached to the property. This project aims to assess the dominant socio-cultural and biogeographic factors which affect or have affected past and current restoration weed management on the property. This research will be used to inform future management, including the Living Landscapes Project.

Investigators

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Method and demands on participants

If you choose to be included, you will be visited by a member of the research team at a time and place appropriate to you. On this visit the researcher will conduct a 30-60 minute interview that will be audiotaped to determine the dominant socio-cultural and biogeographic factors which affect your views on weed management practices.

Possible risks, inconveniences and discomforts

Apart from the hour of your time for the interview, we can foresee no risks for you. Your involvement in the study is voluntary and you may withdraw your participation from the study at any time and withdraw any data that you have provided to that point. Refusal to participate in the study will not affect your relationship with the University of Wollongong or with Bundanon Trust.

Funding and benefits of the research

This research may be used to inform future weed management practices at Bundanon. Findings from the study will be published in a thesis paper and possibly published in educational journals.

Ethics review and complaints

This study has been reviewed by the Human Research Ethics Committee (Social Science, Humanities and Behavioural Science) of the University of Wollongong. If you have any concerns or complaints regarding the way this research has been conducted, you can contact the UoW Ethics Officer on (02) 4221 3386 or email rso-ethics@uow.edu.au.

Appendix C: Interview Questions

What is the full name of your organisation and your role within this organisation?

What is your/ your organisations relationship with Bundanon Trust?

What is your role in Bundanon Trusts 'Living Landscape' project?

What are your organisation's goals with the Living Landscape project?

- Why these goals? –What are the factors which have influenced these goals?

- How will you measure the success of this project?

What is a weed?

- What are the effects these weeds have on ecosystems?

- Are there any positive things about weeds?

- Are there any positive things about lantana?

- Where weeds are having positive effects within an ecosystem, what is the best course of action in managing these species?

Is there any particular weed which you think should be focused on as part of the Living Landscapes project?

The areas within Bundanon which are being managed as part of the Living Landscape project- why/ what are the factors which led to these sites being chosen?

- How resilient are these sites? And how likely are they to be successful in the long run?

- Are there any other sites which should be managed as part of the Living Landscape project?

What are the factors affecting weed management at Bundanon Trust?

Can the funding that the Living Landscape project has secured be spent effectively, especially in regards to the timeframe the funding is allocated over?

- Is there a better way to spend this money?

Is there anything else you would like to add?