Waratah theft in Brisbane Water National Park – an analysis of the blue paint poaching reduction program

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Abstract: The flowers of Waratahs, *Telopea speciosissima* (family Proteaceae) are regularly harvested illegally from natural bushland, particularly close to urban areas such as the New South Wales Central Coast. The removal of Waratah blooms from the wild may have implications for the long-term survival of local populations because of the interaction between wildfire events, subsequent flowering and limited seedling recruitment opportunities.

To reduce the incidence of theft, blue acrylic paint was applied to blooms to reduce their commercial value. The painting of blooms in 2004 did not significantly reduce the incidence of wildflower theft when compared to unpainted blooms, but overall losses were lower (27%) than in 2003 (33%). However, painting of blooms had a deleterious affect on fruit production on plants with multiple heads with painted blooms having significantly reduced fruit set compared to unpainted blooms. Painting of blooms had no significant effect on seed quality (seed production per fruit, seed germination or seedling vigour) when compared to unpainted blooms.

The painting of Waratah blooms to reduce theft was relatively ineffective and decreased fruit production. Alternative strategies should be considered to reduce wildflower theft in the area.

Key words: Waratah, *Telopea speciosissima*, bush-harvesting, seed production seed germination, flower theft, fire management, adaptive management

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This paper is dedicated to the memory of George Robertson who tragically passed away before the completion of this study.

Introduction

The theft of plants and plant parts from the wild has been reported as an issue of concern in many countries. Timber theft is common in many countries; see Blundell and Mascia (2005) and Rodriguez (2000). Carnivorous plants (Robbins 1998), moss (Muir et al. 2006) and orchids (Sharma et al. 2003) are the targets of poachers in the United States. In Mexico, the theft of cacti (Godinez-Alvarez et al. 2003) and in Belize the theft of palm fronds for floriculture is common (Bridgewater et al. 2006). Callister and Williams (2000) discuss orchid, palm, fern and cycad theft in Australia and indicate that information on the extent and impact of illegal plant collection is not readily available.

The Waratah, *Telopea speciosissima* (Smith) R.Br.), a spectacular wildflower in the Proteaceae family and the floral emblem of the state of New South Wales (NSW) is restricted to localized pockets in the Sydney region and Blue Mountains, from the Watagan Mountains south to Ulladulla (Harden 2002). The flowering head, collectively known as a bloom, is a collection of about 80–250 flowers per conflorescence (Pyke 1981) and is a highly desirable cut-flower commodity. Waratahs are protected in NSW as a species of high conservation value (NSW National Parks & Wildlife 2002) and because there is a sustainable cut-flower industry based on plantation-grown Waratahs of commercially developed cultivars (Offord 1996), no pickers or wild-harvest licences are issued.

Waratahs bloom between August and November. Poaching of flowers in wild stands has been reported throughout the natural range of occurrence, but is particularly prevalent close to urban areas. On the Central Coast of NSW, local residents of Patonga near Gosford approached the National Parks and Wildlife Service (NP&WS) with concerns that

Waratah blooms were being deliberately picked from the wild from the 'Waratah Patch' in Brisbane Water National Park. The residents were concerned that the picking would reduce Waratah flowers available for seasonal wildflower viewing by park visitors. While investigating Waratah demography at the same site in 1987, Bradstock (1995) noted 'flower picking in some sites adjacent to roads'. During Waratah flowering season, visitors travel considerable distances to view these wildflowers and the local NPWS officers wanted to maximize the wildflower experience for visitors by reducing wildflower theft.

Waratah flowering is linked to wildfire events (Pyke 1981) and in the 1970s and early 1980s, sections of the 'Waratah Patch' were deliberately burnt every 6 years to encourage the Waratah flowering (Ian Webb pers. comm. 2006). Waratahs are one of a few species of Proteaceae that do not form persistent seed banks, but release non-dormant seeds following post-fire resprouting and flowering (non-bradysporous resprouters with non-dormant seed) (Myerscough et al. 2000, Denham & Auld 2002). Waratahs that survive summer wildfires resprout from vegetative tissue stored below the ground; the subsequent growth produces flowers the second spring after fire, with peak flowering occurring August – early September (Bradstock 1995, Denham & Auld 2002). The number of blooms produced decreases with time since fire, with flowering almost ceasing 5 years post-fire (Pyke 1983); seed production is generally restricted to the first 3 post-fire flowering years (Denham & Auld 2002). Because of this natural reduction in flowering and the reduction in fruit and seed production plus the fact that the seeds are non-dormant, the opportunity for seedling recruitment is restricted to the few years post-wildfire.

The removal of Waratah blooms may also be affecting the fecundity of the remaining unpicked Waratahs. In the closely-related Western Australian species *Banksia hookeriana* the reduction of flower numbers through commercial picking resulted in reduced seed production and storage in the remaining unpicked flowers (Witkowski et al. 1994).

The theft of Waratah flowers has been a conservation issue for reserves of the Central Coast Hunter Range, Sydney North and Sydney South NP&WS Regions. Rangers have attempted to reduce the amount of Waratah theft by spraying blooms with blue paint to make the flowers less attractive to plant thieves and to reduce their commercial value (Neil Martin and Teagan Burton pers. comm., Beale 1997). However, the degree of Waratah theft has not been quantified, nor whether the painting of the blooms reduces wildflower theft. The effect of the painting on the ecology of the Waratahs has not been investigated. This study investigated the degree of Waratah theft in the 'Waratah Patch', whether media coverage, signage, educational walks and the painting of Waratah blooms would reduce Waratah flower theft, and the influence that painting of blooms had on fruit and seed production, seed germination, seedling germination rate and seedling vigour.

Methods

Study Area

The 'Waratah Patch' in Brisbane Water National Park is between Pearl Beach and Patonga about 80 km north of Sydney (lat: 33° 32' S; long: 151 ° 17' E). The Waratahs are restricted to an isolated occurrence of deep sandy lateritic loam of very low soil fertility and low relief, mapped as Somersby soil landscape unit in a matrix of contrasting sandstone-derived shallow soils of the Lambert and Hawkesbury soil landscape units (Chapman & Murphy

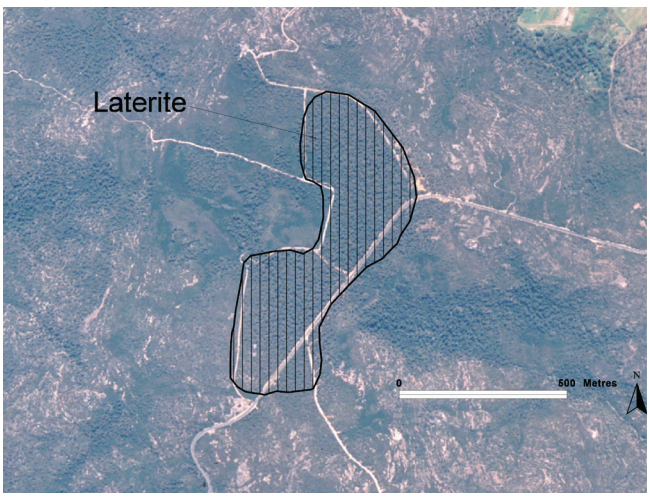

Fig. 1. The fire trail network surrounding the lateritic 'Waratah Patch' was constructed to facilitate the frequent burning to encourage Waratah flowering, a practice which ceased around the early 1980s.

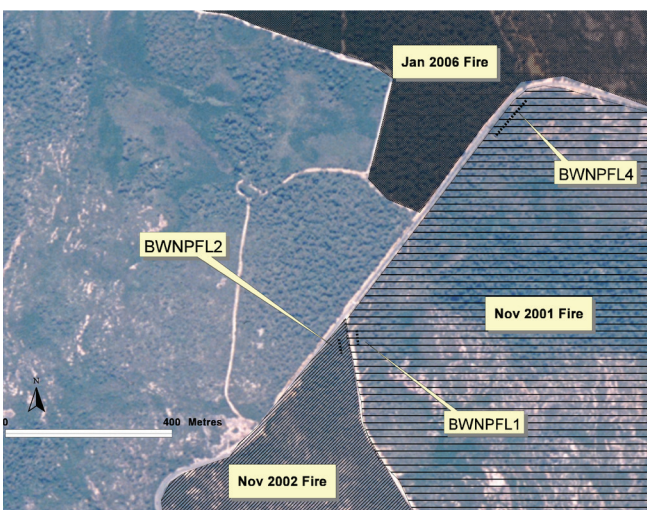

Fig. 2. The recent fire history of the site initiated the mass flowering of Waratahs. The entire area was burnt by wildfire in 1990 and sections of the 'Waratah patch' were burnt again in November 2001, November 2002 and January 2005. Transect locations indicated

1989). The fire trail network was constructed to facilitate the frequent burning of the 'Waratah Patch' to encourage Waratah flowering, a practice that ceased in the early 1980s (Fig. 1). The vegetation of the site is low open forest, mapped as Community 4P, Open Forest to Low Open Forest (Benson & Fallding 1981). Local dominants in the tree layer include *Eucalyptus haemastoma, Eucalyptus oblonga* and *Corymbia gummifera.* Shrubs include *Phyllota phylicoides*, *Boronia ledifolia, Pimelea linifolia, Platylobium formosum, Acacia myrtifolia, Acacia ulicifolia* and a high diversity of plants from the Proteaceae family including *Lambertia formosa, Persoonia levis, Banksia serrata, Banksia spinulosa, Banksia ericifolia, Conospermum longifolium, Grevillea buxifolia, Grevillea sericea, Hakea dactyloides, Isopogon anemonifolius, Petrophile pulchella* and *Xylomelum pyriforme*.

The entire area was burnt by wildfire in 1990 and sections of the 'Waratah patch' were burnt again in November 2001, November 2002 and January 2005 (Fig. 2) initiating a mass Waratah flowering.

Effects of painting on theft reduction

To determine the degree of wildflower theft, 3 transects were set up, two within the 2001 burn area (BWNPFL1 29.8 m long and BWNPFL4 83.5 m long) and the third (BWNPFL2 28.6 m long) within the 2002 burn area (Fig. 2). Each transect was marked with a single permanently placed stake at each end, so that repeated measurements could be taken. On 1st September 2003 a measuring tape was laid along the length of each transect, and the location of every flowering stem recorded as the distance from one end of the transect, plus the perpendicular distance from the tape, up to a distance of 10 m from the tape (i.e. an effective 20 m wide transect was sampled). The numbers of stems clean cut or snapped were recorded. Transects were resampled on the 22nd October 2003 to record the number of blooms removed and method of removal.

To determine whether the painting of blooms blue reduced the rate of bloom theft, 300 plants were chosen, with 100 painted (treatment) and 200 unpainted (control) blooms. Every Waratah plant with a bloom was sampled within the 2001 burn area (135 plants) and 165 plants, which were approximately 75% of all blooms at the site, were sampled in the 2002 burn area. Plants varied from having a single stem with a single bloom, to multiple stems each stem with a single bloom, or single stems with multiple blooms. Every third flowering Waratah plant was chosen for painting, and the intervening two plants used as controls. The blooms were only painted if the floral bracts were fully coloured (red) and expanded and the flowers were close to or beginning to open (Offord 2004). The painted plants had a patch of blue acrylic paint ('Burton Blues', low sheen acrylic, Berger Paints) hand-applied with a paintbrush to the three uppermost leaves closest to the bloom, a single patch of paint applied at the base of the bloom on the flower stalk and a small amount of paint, approximately 15 mm square, applied to each of three floral bracts (Fig. 3). When a plant to be painted had multiple blooms on the one stem, every bloom on the plant was painted. The height from the ground to the top of every bloom was measured using a surveyor's staff, the number of blooms on each stem recorded, and every plant tagged with a numbered aluminum tag and location recorded using a Garmin 76 GPS unit (between 3–6th September 2004) (Fig. 4).

The plants were assessed on 22nd December 2004 and the number of flowers removed recorded as either a clean cut or snapped. The number of fruits which developed on the remaining flowers was also recorded. For the analysis of the data, stems with multiple blooms were treated as a single unit.

Fig. 3. The painted plants had a single patch of blue acrylic paint hand applied with a paintbrush to the three uppermost leaves closest to the flower head, a single patch of paint applied at the base of the flower on the flower stalk and a small amount of paint, approximately 15mm square, applied to each of three floral bracts.

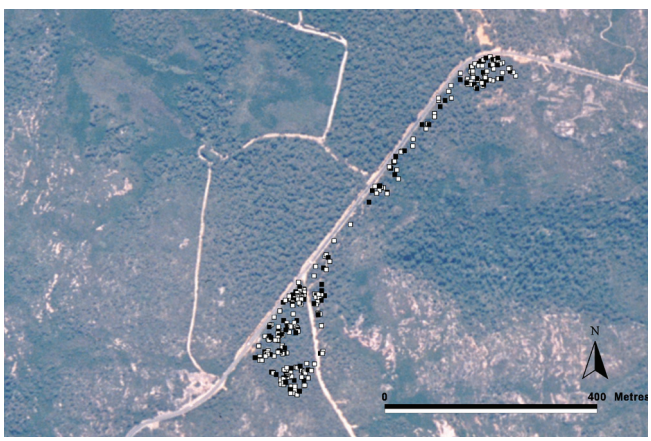

Fig. 4. The locations of tagged Waratah plants were recorded using a Garmin 76 GPS unit, painted plants are shown with a black square, unpainted plants shown with a white square.

Effect of painting on fruit and seed production

During late March 2005, 20 each of both painted and unpainted blooms that developed fruits were randomly selected and a single fruit from each selected plant was removed and allowed to dry in a paper bag. Each fruit was labelled according to the plant and applied treatment (painted or unpainted). The fruits were air dried on the laboratory bench until they had split and reflexed sufficiently to expose the seeds. The seeds belonging to each fruit were then counted and kept in separately labelled packets. Once the fruits opened, the number of filled seeds (see Denham & Auld 2002) and empty seeds per fruit were recorded.

Effect of painting on seed germination and seedling vigour

A total of 180 fresh seeds each from painted and unpainted blooms were sown onto 7 $g.L^{-1}$ agar in 40 mm diameter petri dishes (ten dishes for each treatment, each containing 18 seeds randomly assigned within the treatment dishes). Dishes were labelled such that the seed could be traced back to the original fruit/plant/treatment. The petri dishes were placed into a Thermoline incubator set at constant 20°C ($\pm$1), with 12 hours light in the diurnal period. Seeds were checked twice daily (7 am and 4 pm) for germination which was recorded when 2 mm of root was visible. Seedlings were then placed into potting mix in a 50 mm growing tube and grown in a glasshouse. Plant vigour was assessed by recording the survival, height and general appearance of the seedlings 30 and 90 days after germination.

The average cumulative seed germination for each replicate dish was calculated and plotted against the hours taken to germinate. Time to initial germination (T_I), time to 50% germination (T_{50}), time to maximum germination (T_{100}) and plant heights were compared for each treatment by a one-way ANOVA. The overall percentage of seeds germinated (G_{MAX}) was compared by one-way ANOVA, following Arcsin transformation of the data.

Fig. 5. Signs warning people not to pick the Waratah blooms were installed at several locations.

Media, signage and education walks.

A newspaper article highlighting the problem of Waratah theft accompanied with photographs, appeared in the local press during late September 2004 (Stubbs 2004). An interview at the site with ABC local radio was also aired on the Central Coast in September 2004. Signs warning people not to pick the Waratah blooms (Fig. 5) were installed at several locations. Guided education walks were conducted by NPWS staff at the site on 3rd September 2004, with over 25 people in attendance.

Results

Effects of painting on theft reduction

A significant rate of Waratah theft was recorded along the transects over the 52 day period in 2003 (Table 1) with overall losses of 32% and one transect losing 85 % of blooms. The majority of blooms were snapped with only a few removed with a clean cut.

In the spring of 2004 the overall theft rate of flowering stems was 27%, with 81% of these blooms being removed with a clean cut and the remainder being snapped. There was no significant difference between the rate of theft of painted stems compared to unpainted stems, although fewer painted stems were removed than unpainted stems (Table 2).

Effect of painting on fruit and seed production

Painting of blooms significantly suppressed fruit production when the stems had multiple blooms, but not when stems had single blooms (Table 3).

The blooms that did produce fruit showed no significant difference in the number seeds produced per fruit between

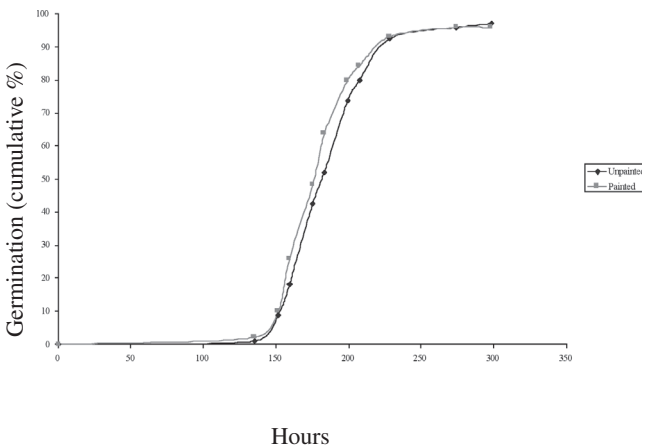

Fig. 6. Cumulative germination of fresh Waratah seeds from Brisbane Water NP at 20°C (12 hr light): comparison of seeds from untreated blooms and blue marker painted blooms.

Table 1. Waratah theft: the number of blooms observed, and subsequently removed along 3 transects in Brisbane Water National Park during a 52 day period in 2003.

Transect	Last burnt	Total no of blooms (1 Sept 2003)	No of blooms picked (1 Sept 2003)	No of blooms picked (22 Oct 2003)
BWNPFL4	Nov 2001	92	7	19
BWNPFL1	Nov 2001	19	1	17
BWNPFL2	Nov 2002	3	1	1

Table 2. Effects of painting on theft reduction: the proportion of blooms removed from painted and unpainted treatments.
(Statistical differences χ^2, NS1=non-significant, P=0.082; NS2=non-significant, P=0.599; NS3=non-significant, P=0.113).

	Single Blooms	Multiple Blooms	All stems
Unpainted Plants	29.9% NS1 (n=251)	18.8% NS2 (n=16)	29.1% NS3 (n=267)
Painted Plants	21.1% NS1 (n=114)	28.6% NS2 (n=7)	21.5% NS3 (n=121)

Table 3. Effect of painting on fruit and seed production: the proportion Waratah blooms that produced fruit according to the number of blooms produced per stem and whether the blooms were painted or unpainted.
(Statistical differences χ^2, NS1=non-significant, *P=0.0085).

	Single Blooms	Multiple Blooms
Unpainted Plants	40.7% NS1 (n=177)	62.9%* (n=13)
Painted Plants	32.2% NS1 (n=90)	0%* (n=5)

Table 4. Germination of fresh Waratah seeds from Brisbane Water National Park: comparison of seeds from untreated blooms and blue paint treated blooms.
T_I = average time to initial germination (hr), T_{50} = average time to 50% germination (hr), T_{100} = average time to 100 of germination (hr), G_{Max} = maximum germination (% $\pm$ se). There was no significant difference between the treatments for any germination variable measured.

	Unpainted blooms	Painted blooms
T_I (hr)	151.8 $\pm$ 3.0	147.6 $\pm$ 2.9
T_{50} (hr)	187.0 $\pm$ 3.4	179.0 $\pm$ 2.5
T_{100} (hr)	265.0 $\pm$ 8.6	243.5 $\pm$ 8.8
G_{Max} (%)	97.2 $\pm$ 0.8	97.2 $\pm$ 0.9

Table 5. Seedling vigour of Waratahs from Brisbane Water National Park: comparison of height, number of leaves and survival of seedlings from untreated blooms and blue paint treated.
There were no significant differences between the treatments, except for height at 30 days (P=0.002).

	Unpainted blooms		Painted blooms	
	30 days	90 days	30 days	90 days
Height (mm)	34.65 $\pm$ 0.7	98.1 $\pm$ 2.4	37.3 $\pm$ 1.0	104.9 $\pm$ 2.0
Number of leaves	1.48 $\pm$ 0.05	9.28 $\pm$ 0.19	1.71 $\pm$ 0.09	9.20 $\pm$ 0.14
Survival (%)	93.1 $\pm$ 1.8	90.8 $\pm$ 2.3	96.6 $\pm$ 1.5	95.5 $\pm$ 2.0

unpainted plants (15.8 seeds/fruit) compared to fruits from painted plants (15.7 seeds/fruit). The number of filled seeds per fruit did not differ significantly between unpainted (12.1 seeds/fruit) and painted plants (11.5 seeds/fruit).

Effect of painting on seed germination and seedling vigour

No significant difference was detected between the treatments for seed germination or the seedling growth variables recorded, with the exception of the plant height at 30 days which was greater in the painted treatment (P=0.002). However, this difference was no longer significant at 90 days (Tables 4 and 5, Fig. 6).

Discussion

Despite signage, media coverage, educational walks and painting of about a third of all Waratah blooms, over 26% of blooms, were stolen from the study area during the large flowering event in 2004. Although this is a lower loss than for 2003 (32%), it represents a substantial reduction in reproductive material for the species. Indeed increasing the profile of the flowering event through media coverage may in fact have contributed to the rate of theft by raising public awareness of the timing of the flowering.

Because of the high degree of theft, there is the question of why are the blooms stolen? The 2004 census revealed the majority (81%) of flowers were deliberately cut. When the fruits were being collected in March 2005 for the germination study, a bunch of seven picked flowers with stems averaging 80 cm long, each with a clean cut at the base were found withered on the ground. These flowers could have been destined for the cut flower market, as blooms in local florists at the time were fetching up to $12 per bloom.

Painting of blooms

The painting of Waratah blooms did not greatly reduce the amount of Waratah theft at this time within Brisbane Water National Park. A theft reduction program using paint conducted at several locations across a number of seasons would provide valuable information as to the robustness of this management action. The lack of fruit developed on the multiple bloomed plants may be due to a toxic effect of the paint on the fruit, in which case the use of a different type of paint could be explored. However, it is more likely that blue paint may deter the major cross- pollination vectors, birds, thus resulting in lower fruit set as Waratahs are on obligate outcrossing species. (Whelan & Goldingay 1989, Offord 2004) The phytotoxicity of paint treatments appears to vary between species as studies on seed germination of different conifer species showed that one species (Western larch) was affected by a range of paint formulations while three other species were unaffected (Dumroese 2003). Regardless of the potential phytotoxicity of the paint, the fact that fruit production was reduced in multiple bloomed plants is a cause for concern, although in this study the sample number was very low. The results of this study indicate that the painting of waratah blooms had minimal affect on reducing flower theft, and it is recommended that painting of blooms be discontinued as a flower theft reduction strategy.

But why were painted Waratah blooms picked at all? The answer to this question may lie in the timing of picking events. It seems logical for theft to occur when the likelihood of detection is at its lowest, hence theft in darkness or low light conditions is a likely possibility and the blue colour of the paint may not be discernable during low light conditions. Perhaps surveillance during the early morning and evening and using an alternative paint colour may reduce the rate of theft.

Because fruit production and seedling recruitment of Waratahs is basically restricted to the first few years post-fire (Denham & Auld 2002), the removal of over a quarter of the flowering heads by theft, and the subsequent reduction in seed production, may be affecting the population dynamics at the site. Bradstock (1995) recognized that high intensity burning at too frequent intervals, coupled with flower picking, could result in the depletion of local populations of Waratahs. Fortunately, the high intensity frequent fires have been reduced, with over 41% of the 'Waratah patch' remaining unburnt since 1991. Heavy picking of plant parts early in this cycle may affect not only the seed production ability and hence seedling recruitment, but the ability of the plants to regenerate by post-fire sprouting. Loss of nutrients, particularly nitrogen, following bush picking has been reported in natural stands of *Banksia hookeriana* (Witkowski & Lamont 1994) though studies on South African Proteaceae suggest that up to 80% of blooms can be harvested in some species without significantly reducing population seed fecundity (Maze & Bond 1996). Given that the species and habitats in these studies are different, it would be useful to study sustainable harvest levels in Waratah populations to determine the upper limit for this species in a given situation. Regardless, in areas such as National Parks where Waratah flowering is an annual tourist attraction, any loss of flowers is detrimental to the population.

The flowering Waratahs in this study were all close to the main road or management tracks with no picked Waratahs occurring further than 65 m from an access track. It is possible that the likelihood of picking is reduced in other areas of the 'Waratah patch' where Waratah plants are growing further from access roads and tracks.

Waratahs are easy to propagate from fresh seed as the germination data indicates, yet there was no evidence of fruit poaching; of the 40 plants randomly selected for fruit collection, only one plant could not be located. Horticultural waratah selections are now widely available in plant nurseries; this may be benefiting wild population by reducing the demand for wild seed.

Other theft reduction strategies

Other strategies that could be employed to reduce the amount of bloom theft, include increased surveillance. This need not be ongoing, as flowering is restricted to a 6–8 week period and in terms of seedling recruitment potential, only lasts for about 4 seasons after the initial post-fire flowering. Another strategy could be the establishment of a 'Waratah Watch' program, as there is considerable local interest in reducing the theft of the flowers.

In summary, the painting of blooms to reduce Waratah flower theft was found to be relatively ineffective, and led to reduced seed production in stems with multiple blooms. The painting of blooms is therefore not recommended. However the study is a good example of how research can be of benefit to adaptive management in the Park. The study resulted in the re-evaluation of current Waratah theft reduction strategies. Because of the deleterious affect to wildflower displays and visitor enjoyment, and the potential long term affect on the Waratah population, strategies to reduce Waratah theft should continue to be employed, particularly in the first few years after fire when the plants are fruiting.

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