Analysis of the Post-Fire Recovery of the Silver Peppermint Reserve in 2013

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April 2013

Prepared for the Tasmanian Land Conservancy
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1. Abstract

In January 2013 a high intensity bush fire passed through the entire 43 hectare Silver Peppermint Reserve, owned and managed by the Tasmanian Land Conservancy (TLC). To evaluate the ecological implications of the disturbance on plant and animal species, monitoring locations were set up within one week after the event. Data were collected through a sequenced photo series, audio recordings of birds, and systematic observations of plants and animals present. The objectives of the TLC analysis are to observe and further understand the rate of recovery and regeneration processes of the burned reserve. This active and immediate post-fire examination may be used to identify appropriate management actions that will assist with ecosystem restoration and recovery. Recommendations for improving the project's design were also developed throughout the initial monitoring phase.

2. Overview of the Silver Peppermint Reserve

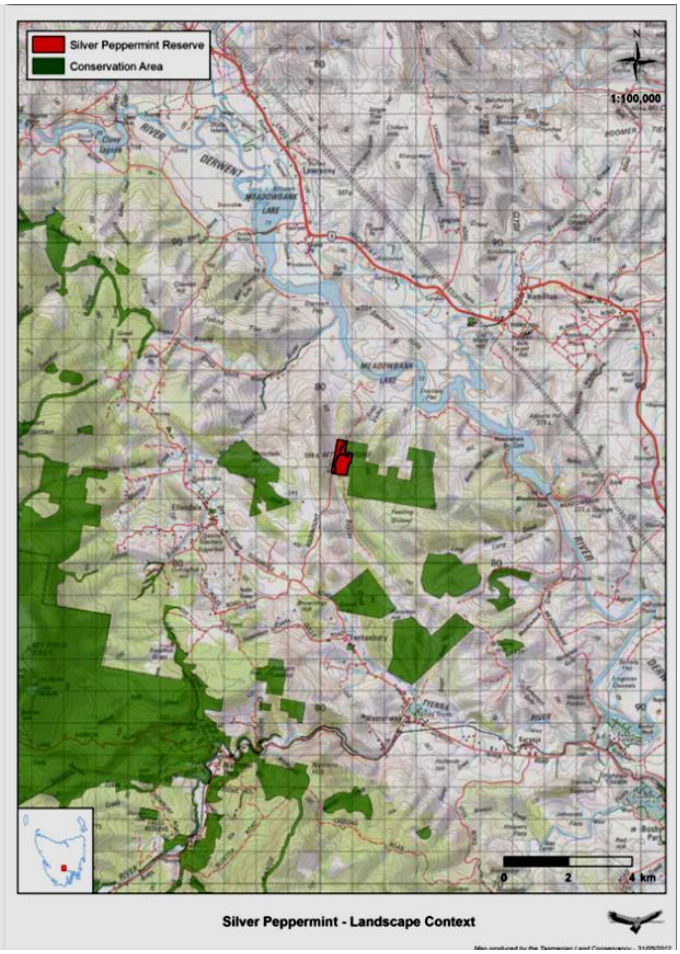

Figure1. Silver Peppermint Reserve location map and surrounding territory.

The Silver Peppermint reserve, named for the endemic *Eucalyptus tenuiramis* trees that grow abundantly in the area, is located in the Derwent Valley of south central Tasmania, near the town of Ellendale. The 43 ha tract of land was a gift from Dr. Damian Hope to the Tasmanian Land Conservancy (TLC), and offered the organization an opportunity to integrate ecological conservation traditions and social principles for landscape management (TLC, 2009). The reserve was established as a sanctuary for many conservation significant plants and animals in a biologically diverse and structurally complex ecosystem (Figure 1).

The Tasmanian Land Conservancy developed a management plan in September 2009 based on historical conditions, biological needs and overall future integrity. Climate patterns, local geomorphology, plant and animal communities, obligations to cultural heritage sites and threatened species, and requirements for ecosystem stability were all taken into consideration (TLC, 2009).

2.1 Physical and Ecological Features of the Reserve and Surrounding Region

2.1.1 Climate

Strong oceanic and atmospheric influences from the Indian and Pacific Ocean produce a temperate maritime climate in the region. With prevailing westerly winds and neighbouring hills and mountains, the Silver Peppermint Reserve is located in a slight rain-shadow. Precipitation events occur throughout the year with the wettest period typically occurring in the spring and fall. The annual precipitation accumulation in the Silver Peppermint Reserve area is 578 mm, with 80 days of rain. January is typically the warmest month of the year with a mean monthly temperature of 17 degrees Celsius. The month of July produces the coolest weather conditions with a mean monthly temperature of 6.3 degrees Celsius (BOM, 2013).

2.1.2 Geomorphology

For millions of years, periods of glaciation and geologic movements have slowly moulded the Central plateau region of Tasmania into a mosaic of valleys, hills, lakes, rivers and flood plains. Ice movements have strongly influenced the present geology found at Silver Peppermint Reserve including soil type and distribution of plant and animal communities. The Derwent valley consists of basalt hills that developed from lava flows and fault movements. On the slopes of the Derwent Valley where the reserve is located, the geology is dominantly quartz sandstone, and soils are sandy loam Spodosols; commonly found under Eucalypt forests (Duncan, 1990; Doyle and Farquhar, 2013).

2.1.3 Flora and Fauna

The Silver Peppermint Reserve has been host to several major flora communities including dry *Eucalyptus tenuiramis* forests, dry *Eucalyptus obliqua* forests, Bursaria-Acacia woodland, and regenerating land that was cleared in past. Some of the threatened fauna populations that reside in the area include the Tasmanian devil (*Sarcophilus harrisii*), white-bellied sea-eagle (*Haliaeetus leucogaster*), wedge tailed eagle (Auila audax), the Tasmanian saltmarsh looper moth (*Dasybela achroa*). Many bird species, marsupial, small mammal, reptile and insects species utilize the forest and shrub woodland habitat.

Endemic Tasmanian Silver Peppermint leaves on the 43 hectare reserve owned by the Tasmanian Land Conservancy.

Eucalyptus tenuiramis grows in mixed multi cohort stands with other Eucalypt species. Similar to other gum trees, silver peppermint is well adapted to a frequent, low intensity fire cycle. They have the ability to occupy very dry, fire prone sites. In a natural regime, a forest will typically burn at least once every 25 years. The thin papery bark is able to protect stem buds and lignotubers during a burn. After a disturbance, Eucalypts are able to re-sprout from surviving residual trees. With an open understory, the sprouting seedlings are typically able to out-compete the other regenerating plant species for available

resources. Prior to the 2013 bushfire, *Eucalyptus tenuiramis* was the dominate vegetation type, covering over half of the reserve (Duncan 1990; TLC, 2009).

Eucalyptus obliqua, also known as messmate, are also well adapted to frequent fire events. Prior to the fire, messmate was observed to cover approximately 7 hectares within the reserve. On dry sites the eucalyptus species is able to produce lignotubers which protect dormant buds until new shoots can safely develop after the disturbance has passed. Messmate prefer well-drained soils and grow in forest stands with multiple structural layers (DSE, 2006; TLC, 2009). "Eucalypts have made an art form of creating a charred landscape, then restoring the grey-green hues of the Australian bush with regeneration from seedling or coppice (Duncan, 1990)."

Bursaria-Acacia woodland shrub communities typically grow in drier areas as a collection of scattered short trees and shrubs. This vegetation community covered approximately 8 hectares of the Silver Peppermint Reserve. Similar to the Eucalyptus species, *Bursaria* and *Acacia* shrub species are able to re-sprout and regenerate quickly after a fire. However they are also able to dominate and thrive on fire excluded sites (Gill, Woinarski and York, 1999).

Due to past ownership, sections of the Silver Peppermint Reserve have been previously cleared and were dominated by a mix of grass species. These three acres of the reserve were observed to be slowly regenerating from the 2005 acquisition of the parcel by the TLC until the 2013 bushfire.

2.2 Reserve Land Use

The reserve is protected under a permanent statutory covenant under the 2002 *Nature Conservation Act*. This act allows the TLC to maintain, supervise and manage Silver Peppermint solely for conservation purposes in accordance with established regulations that aim to maximize biodiversity. Although the management plan was directed toward ecosystem protection, several surrounding properties are still used for agriculture, logging, and recreational purposes (Figure 1). The reserve area itself has encountered and experienced agricultural grazing during different ownerships in the past. Although most of the recent plant species on site are native to the region, agricultural activities may have caused soil degradation and led to introduced grass species over time. However prior to the 2013 fire, the dry land heath and Eucalypt forest communities were considered well preserved (TLC, 2009).

Currently the properties bordering the northern, western and southern boundaries are privately owned by individual land owners or by public companies. The property along the eastern side of the reserve is the Mount Bethune conservation area which is managed by the Tasmanian Parks and Wildlife Service (TPWS, 2013).

2.3 TLC Management Considerations

The TLC's ongoing management objectives for the reserve must align with cultural considerations as well as striving for ecosystem conservation and biodiversity. Management practices must align with the Tasmanian Aboriginal Relics Act 1975, Tasmanian Threatened Species Protection Act 1995, Commonwealth Environment Protection and Biodiversity Conservation Act 1999, Tasmanian Nature Conservation Act 2002, and Central Highlands Council Planning Scheme 1998. The Silver Peppermint Reserve is, and will continue to be managed using the following objective:

> "*To identify, conserve, assist people to appreciate, and where necessary, restore the Reserve's natural and cultural heritage values, and to ensure these values are passed on to future generations in as good or better condition than at present* (TLC, 2009)"

3. Current Conditions and Study Objectives for the Reserve

Charred Eucalyptus and a asphyxiated possum immediately after the 2013 January burn at Silver Peppermint Reserve

3.1 Impact of the 2013 Bushfire

Past disturbances and a small bush fire in 2007, which consumed one third of the Silver Peppermint Reserve, proved the Reserve's resilience to fire events. The 2007 fire resulted from an arson incident which was ultimately controlled and put out by the Tasmanian Parks and Wildlife Service. Although a monitoring project was not developed at this time, pictures taken soon after the incident and several months post fire show successful regeneration. In sum, these previous disturbances indicate that the Silver Peppermint Reserve appears to regenerate toward increased ecological function and biodiversity—a tendency that could be confirmed with an active monitoring plan.

On January 3rd, 2013 strong gusty winds, dry conditions and record breaking high temperatures combined to produce a series of bushfire outbreaks across areas of southern Tasmania. The Dawson Road- Lake Repulse fire located near the Mount Field National Park started from an escaped campfire, and eventually burned 11,620 hectares. From Lake Repulse, the fire moved south east along Meadowbank Lake and Ellendale road; eventually burning through the entire Silver Peppermint Reserve and into the Mount Bethune Conservation Area. Several homes and structures, livestock and farming equipment were lost in the blaze (TAS, 2013).

The initial aftermath at Silver Peppermint was quite dramatic, with very few signs of plant or animal life. The intense and severe fire had left a white, grey and black ash layer, where the top portion of the soil and vegetation had been completely burned. Shrubs and small trees were reduced to blackened sticks, and Eucalypts on site were entirely scorched. Only brown shrivelled leaves remained on charred branches and stems. The remains of small marsupials that were not able to escape the flames could be found near black stumps and burned out logs.

Although the smell of the bushfire strongly permeated throughout the reserve, and the ground still retained some heat in the few days immediately after the blaze, Silver Peppermint showed its first sign of recovery with a tremendous growth of mushrooms. The white fruiting bodies had pushed through the torched soil, and were growing abundantly across the reserve. Dusty robins were observed flying through the Eucalypts and kookaburra could be heard calling, indicating that recovery was possible immediately after a severe blaze.

3.2 Objectives and Scope for Monitoring Ecological Recovery at the Reserve

The 2013 bushfire appears visually devastating, but past experience indicates that the reserve is poised to begin rapid ecological recovery. The fire offers an opportunity to document how flora and fauna regenerate during the first two months post fire. The Tasmanian Land Conservancy has developed three objectives for the Silver Peppermint Monitoring Project:

- Develop a more thorough understanding of regeneration processes of Eucalypt, heath and grass forests after a bush fire event.
- Specifically understand the regeneration patterns of flora vegetation, species composition, and ecological structure.
- Observe the re-colonization of bird species to the site and recognize the species present.

Although there are countless ecological and biological aspects of post fire recovery that could be analysed for the reserve, the Tasmanian Land Conservancy decided that a monitoring plan that looked at large scale changes within a short period of time would be the most useful for developing future management strategies. Primary emphasis for monitoring will be in the detection of successional emergence and growth over time for all vegetation types in the reserve. Statistical correlations between different environmental variables will not be developed at this stage of the project, but could be considered in the future as more data is collected. Qualitative and quantitative observations about the reserve will be analysed for noticeable patterns in vegetation and bird recovery. After the immediate post-fire monitoring stage, monitoring the Silver Peppermint Reserve will become simpler as visits and observations occur less frequently. With finite resources and multiple people working on the project, the TLC opted for a monitoring plan that would be simple, fast, and easily manipulated if the project needed adjustments. Photo-point vegetation monitoring, bird surveys, and area observations of Silver Peppermint will provide information for future management consideration.

4. Vegetation Monitoring Component

Bracken fern regeneration in Silver Peppermint Reserve, 28 February 2013

The primary objective of the vegetation monitoring component of the post-fire analysis at the Silver Peppermint Reserve in 2013 is to review the timing and sequence of regeneration processes for the Eucalypt, heath, and grass forests. Additionally, the TLC is interested in exploring how revegetation patterns change over time and affect ecological structure and fauna in the future.

4.1 Selection of a Monitoring Strategy for Detecting Regeneration

The selection of a monitoring strategy depends on the study objectives, site conditions and management constraints, and resource availability in terms of equipment and personnel. Regeneration monitoring through time-sequence photography is an extremely useful tool for land managers: it allows them to extract information about a landscape using unintrusive and ecologically friendly techniques. Photo-point monitoring systems are particularly appropriate for areas that are managed for conservation purposes, have sensitive biological species present, or where managers wish to minimize human influence. Although this methodology is not used formally for scientific research where specific measurable data is needed on composition, growth rates, or fuel loading at a site, it can be used to complement other prescribed techniques and methods. Similar to most conservation projects, it is important that the monitoring plans are tailored for a specific purpose and align with landscape objectives and management needs (Wouters, 1992; Treloar, 2012).

As stated by Tolhurst and Gullan 1987 in Wouters 1992, the most important aspects of vegetation monitoring that need to be detected are: the increase/decrease of large structural plants, the increase/decrease of certain species of interest, changes in overall species composition, and the invasion of weeds. Based on resources available, schedules, and staff availability, the Tasmanian Land Conservancy determined that a simple ten plot photo-point monitoring project would be the most effective for documenting initial ecosystem recovery after the Dawson Road- Lake Repulse fire burned through the Silver Peppermint Reserve in January 2013. Monitoring visits would be used to take photos at specified plot points, and record field observations of flora and fauna.

4.2 Schedule and Location of Monitoring

Determining appropriate sizes, locations and monitoring frequencies for sample sites is crucial for detecting patterns in biological recovery and succession. Within days after the 2013 fire event in January, Matt Taylor from the Tasmanian Land Conservancy started plans for photo-point monitoring of Silver Peppermint. Sampling locations were randomly selected and organized so that a permanent plot centre was established approximately every five hectares within the 43 hectare reserve (Figure 2). The 10 monitoring plots were picked using “Create Random Points” tools in ArcGIS which ensured

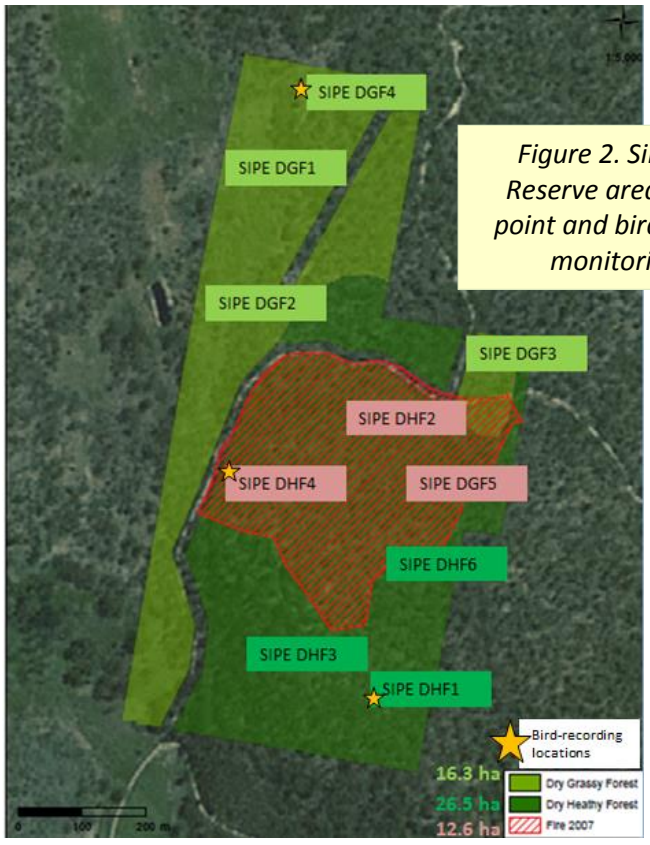

Figure 2. Silver Peppermint Reserve area map and photo point and bird sound recording monitoring locations.

that sites were not biased, and were appropriately spaced apart so that every vegetation community was represented.

Prior to the fire the reserve was composed of two types of dry Eucalypt forests: Bursaria-Acacia shrub, and open areas that had been cleared during past management practices. For simplicity in monitoring after the fire, the reserve was divided into two vegetation communities: dry grassy forest and dry heathy forest. It was also noted if the vegetation had been burned in 2007. This categorization ensured that recovery patterns would be detected in all vegetation communities (Steinfeld et al; 2007; TLC, 2009). Because the unburned dry grass forest vegetation type covers the most area within the reserve, it received four sample sites for photo points. The area within the reserve that also burned in 2007, and the portion of the reserve that was classified as dry heathy forest, both received three sample plots. Based on stratified random sampling techniques, the 10 plots should be representative of the Silver Peppermint Reserve as a whole. All permanent locations were marked using a GPS unit (GDA94 UTM), and a steel rebar stake was placed at plot centre.

Post-fire initial recovery requires a high frequency of monitoring visits (Treloar, 2012). Given the rapid nature of plant regeneration in the region, monitoring visits have occurred once a week during the first two months after initial access in January 2013. These visits will then transition to biweekly and monthly trips for the remainder of the year. Once initial colonizing plants are established, the monitoring will take place once a year during the early summer. For species identification purposes, late November, December and early January are the best time period for monitoring because plants are flowering. To accurately recognize shifts in the vegetation communities, these annual visits need to be done approximately at the same time every year (Steinfeld et al; 2007).

4.3 Sampling Method at Silver Peppermint

Monitoring vegetation and taking bird observations of the burned Silver Peppermint Reserve in January and February 2013

Vegetation Photo-point monitoring methodology and protocol

By taking sequenced photos over time, changes in the plant communities can be detected at each site. To observe the under-story and ground vegetation separately, photos were taken two meters and ten meters away from plot centre. These two locations were also marked by a GPS unit, and a 1 meter 15 mm steel rebar (pounded into the ground until 50 mm remain above ground). At plot centre, a 1.5 meter camera platform pole was place over the centre rebar. A D800 SLR Nikon 50 mm with UV filter camera was placed on the platform and then pointed in the marked direction of the under-story and ground vegetation photo plots. One photo was taken for ground vegetation and one for under-story vegetation per visit at each site location. A 1.5 m 20mm PVC tube marked in .5 meter increments

served as a reference point for taking vegetation photos. For the under-story vegetation photo, the reference post was placed ten meters away, and the photo was taken with the 1.5 meter mark in the centre of the camera's view finder. For the ground vegetation photo, the reference post was placed two meters away and the photo was taken with the .5 meter mark in the centre of the camera's view finder (Figure 3).

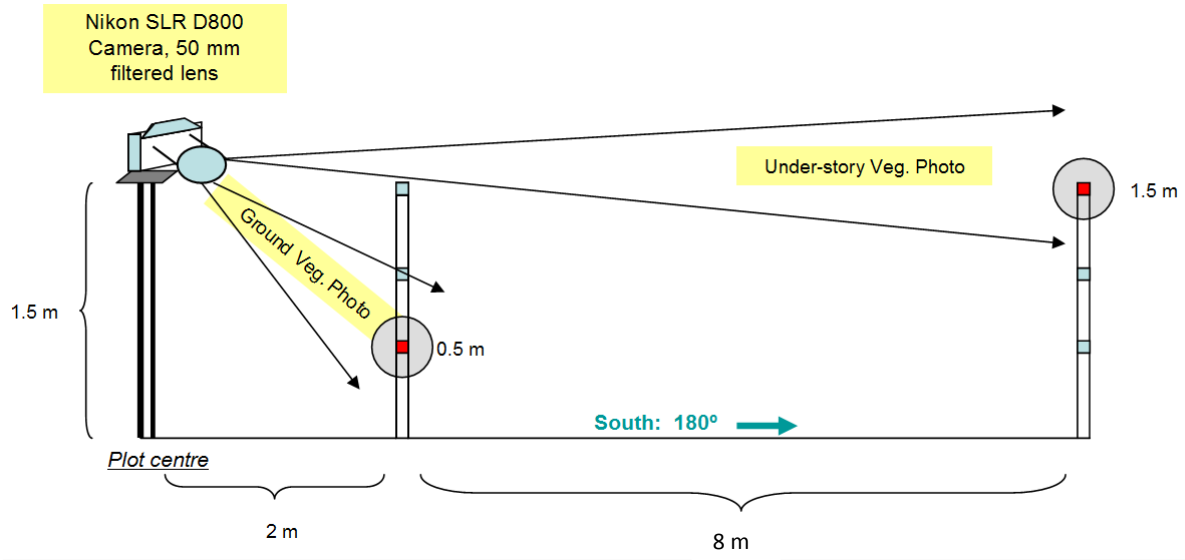

Figure 3. Photo- point monitoring equipment set up to monitor the understory vegetation and ground vegetation recovery. Protocols were repeated at all 10 site locations across the Silver Peppermint Reserve to effectively observe vegetation recovery.

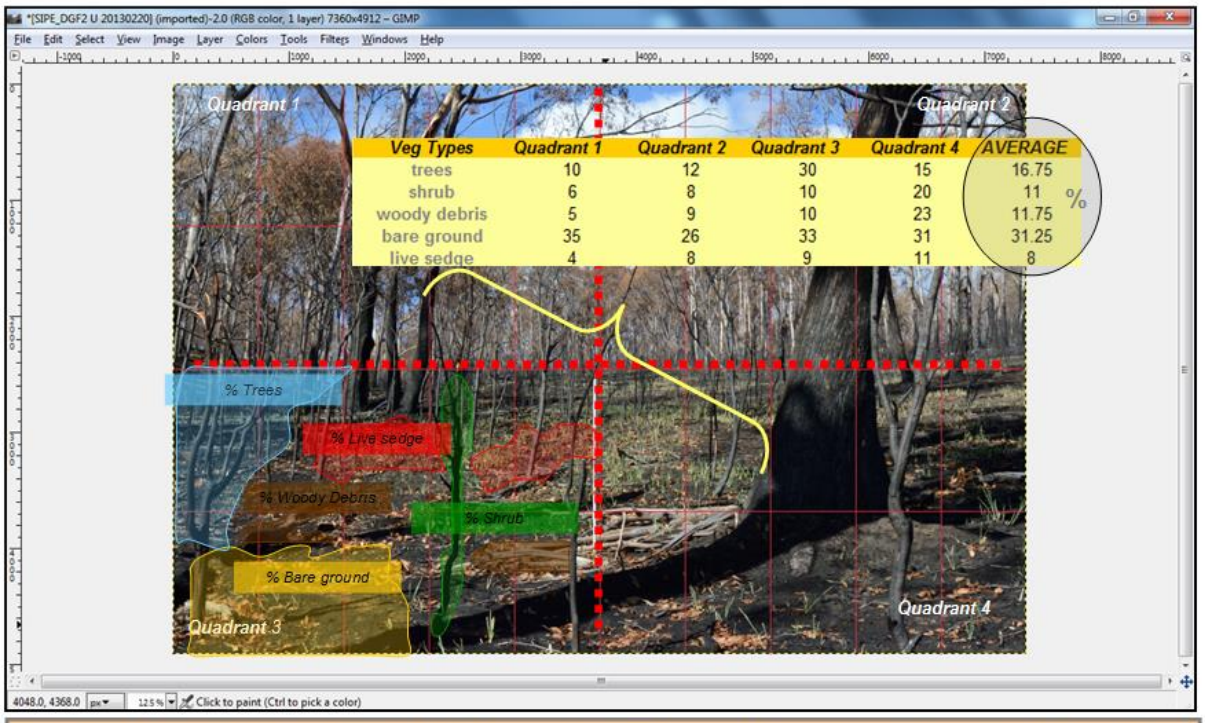

Figure 4. Example of photo-point monitoring analysis for understory recovery using GIMP 2.8. Photos from weekly visits to Silver Peppermint were analysed for percent cover changes in trees, shrubs, sedges, ferns, grasses, herbs, bryophytes, leaf litter, coarse woody debris, bare ground, and rock. Percent coverage estimations for each of the 10 sites were compared every week to detect changes in vegetation recovery at Silver Peppermint between January and February 2013.

4.4 Vegetation Analysis of Silver Peppermint

Photo-point monitoring sites were analysed using Adobe Photoshop and a free download photo editing software program known as G.I.M.P (2.8). Grids were placed over the photos and each picture of the understory and groundcover was divided into four equal quadrants to calculate averages and detect changes in plant coverage. Photos from the ten sites were analysed for species present, percent cover by category (bare ground, litter, CWD, bryophyte, grass, herb, sedge, fern, tree), recruitment of canopy species, presence of hollow-bearing trees, canopy cover, dieback indicators, weediness, and overall change from photo data from weeks prior measured in terms of reduction, no change, increase). For the initial vegetation recovery period, weekly photos for ground and under-story vegetation were compared and observed between January 14th and February 28th 2013 (Figure 4).

4.5 Vegetation Monitoring Conclusions

Species present and coverage

After the photos were collected and organized by site location, the initial post-fire recovery of Silver Peppermint Reserve was analysed for patterns and trends in vegetation regeneration. Changes in percent cover were detected in leaf litter accumulations, bracken fern growth, and sedge development (Table 1,2 and 3). The increase in Eucalypt litter in dry grassy forest and dry heathy forest occurred as the scorched canopy trees began to drop their burned dead leaves. Aside from the fungi growth that occurred during the first week at Silver Peppermint, the sedge (also known as common sagg, *Lomandra longifolia*)) was the first to recover, and began to regenerate on the reserve within a week after the fire. The grassy Eucalypt forest experienced an average increase in sedge cover of 2.2 percent between the beginning of the observation period (Jan 13th) and the end of the initial monitoring period (Feb 28th). The sedge on the heathy Eucalypt forest increased by an average of 1.7 percent in coverage area. Photo analysis indicated that sites with fewer rocks typically resulted in faster sedge development and higher percent cover values. Bracken fern *Pteridium esculentum*)was the second most noticeable species that started to grow in late February on the burned reserve. Because the ferns' recovery was just beginning, their percent coverage only amounted to 1 or 2 percent of a photographed sample area (by the end of the initial monitoring period).

Despite the fact that there were no other regenerating plant species captured in photo-point samples, general observations taken walking around the reserve showed that Sagg (*Lomandra longifolia*), Bracken (*Pteridium esculentum*), Silver peppermint (*Eucalyptus tenuiramis*),White gum (*Eucalyptus viminalis*), Black gum (*Eucalyptus ovata*), Stringybark (*Eucalyptus obliqua*), Silver wattle (*Acacia dealbata*), Broom spurge (*Amperea xiphoclada*), Blackwood (*Acacia melanoxylon*), Showy bossia (*Bossia cinerea*), Teatree (*Leptospermum* sp.), Grass (unknown species) Common raspwort (*Gonocarpus tetragynus*), and invasive Scotch thistle (*Cirsium vulgare*) were just beginning to develop during the last visit in February. The early stages of Eucalyptus regeneration through shoot and lignotuber development appeared to only be in tree individuals that were not as severely burned (based on bole char and canopy scorch) and were located near ravine or low elevation areas were water could collect. During the subsequent weeks it is likely that photo-point monitoring samples will pick up regeneration of several more species and their relative densities (Figure 5).

When comparing the photo monitoring sites that had previously burned in 2007 against those that had not burned until 2013, there is a noticeable difference in vegetation percent coverages (Table 1,2 and 3). Plots that were disturbed by arson in 2007 had tree, sedge and shrub percent coverage values lower than forest sites that had not been burned. Percent rock and bareground values were also higher at sites burned in the past, suggesting that plants at these locations were still recovering when the 2013 fire came through and

consumed the vegetation. Consecutive fires may have decreased the overall fertility of the sites burned in 2007, thus hindering vegetation regeneration after the 2013 fire. The difference in observed plant productivity between sites that burned twice, and sites that only burned in 2013 could also be attributable to the physical and environmental characteristics associated with each site. Plots burned in 2007 appeared much rockier than other plots within the burned reserve. A higher concentration of rocks may have influenced the 2013 post fire regrowth more than the plot's past fire history. Additional tests that looked specifically at rock coverage and soil fertility may be needed in the future to accurately access why the 2013 vegetation regeneration appeared less dense on sites burned in the 2007 arson fire.

Table 1. Average percent coverage change at dry grass forest sites, dry heathy forest sites and previously burned in 2007 sites on the Silver Peppermint Reserve between January 14th and February 22nd.

Summary of Silver Peppermint Reserve Vegetation Percent Coverage Changes (January-February 2013)

SITE	PHOTO	Trees		Shrub		Sedge		Ferns		Grass		Herb		Bryophyte		Leaf litter		Coarse woody debris		Rocks		Bare Ground	
		Avg. % cover	% change	Avg. % cover	% change	Avg. % cover	% change	Avg. % cover	% change	Avg. % cover	% change	Avg. % cover	% change	Avg. % cover	% change	Avg. % cover	% change	Avg. % cover	% change	Avg. % cover	% change	Avg. % cover	% change
Dry Grass Forest	Understory	33.3		8.5		2.2	2.4									4	2	3.5		1		37.3	
	ground			1												5	3.7	3.3		1.25		93.5	
Dry Heathy Forest	Understory	34.2		5.1		1.2	1.3	0.2	0.2							1.3	1.2	6.8		5.9		46.7	
	ground			2		0.4	0.4	0.1	0.1							3.5	2.1	8		9.6		78.3	
Previously burned in 2007	Understory	30.7		3.8		0.8	0.7	0.1	0.1							1.3	1.2	6.2		9.8		52.3	
	ground					0.4	0.6									5.5	3	4		16.7		71.8	

Figure 5. Dry grassy forest site: two understory photo-point pictures from January 14th (left) and February 22nd (right) show the change in sedge development since the January fire on Silver Peppermint Reserve.

Table 2. Average percent coverage change at dry grass forest sites, dry heathy forest sites and previously burned in 2007 sites on the Silver Peppermint Reserve between January 14th and February 22nd. Shows percent cover change for trees, shrubs, coarse woody debris, rocks, bare ground, grass, herb, and bryophytes for all sites each week. Note these variables did not change over time.

Silver Peppermint Reserve Post-Fire Recovery -- Vegetation Type Percent Covers -- NO CHANGE (Jan - Feb 2013)

			Trees	Shrub	Coarse Woody Debris	Rocks	Bareground	Grass	Herb	Bryophyte
			Trees that were over 5 m in height. Dominantely Eucalypt species that established before the fire and survived	Woody plants less than 5 m in height and greater than 25 cm. Represented by charred stems and branches	Woody material that was horizontal. Represented by charred woody biomass that was not entirely consumed	Geologic material found on site before fire	Area of ground not covered by woody biomass, litter, or live/dead vegetation	Herbaceous plant known as graminoid with narrow leaves	Small herbaceious plant bearing seeds	Distinguished as moss, lichens and liveworts
			Jan 14th - Feb 20th No regeneration % cover did not change	Jan 14th - Feb 20th No regeneration % cover did not change	Jan 14th - Feb 20th No change	Jan 14th - Feb 20th No change	Jan 14th - Feb 20th No change	Jan 14th - Feb 20th No change	Jan 14th - Feb 20th No change	Jan 14th - Feb 20th No change
Dry Grassy Forest	Site 1	Understory	35	18	3	2	38	0	0	0
		Ground	0	0	1	0	98	0	0	0
	Site 2	Understory	30	10	6	0	38	0	0	0
		Ground	0	2	2.5	0	93	0	0	0
	Site 3	Understory	35	3	3	2	35	0	0	0
		Ground	0	1	1.5	4	84	0	0	0
	Site 4	Understory	33	3	2	0	38	0	0	0
		Ground	0	0	8	1	99	0	0	0
										
Dry Heathy Forest	Site 1	Understory	38	2	4	1	38	0	0	0
		Ground	0	0	0	0.5	99	0	0	0
	Site 2 BURNED 2007	Understory	32	16	5.5	1	36	0	0	0
		Ground	0	7	1	2	88	0	0	0
	Site 3	Understory	49	1	2	4.5	42	0	0	0
		Ground	0	0	11	6	83	0	0	0
	Site 4 BURNED 2007	Understory	31	0	2	27	80	0	0	0
		Ground	0	0	10	46	36	0	0	0
	Site 5 BURNED 2007	Understory	29	9	11	1.5	41	0	0	0
		ground		4.5	1	2	91.5	0	0	0
	Site 6	Understory	26	2.5	16	0.5	43	0	0	0
		ground	0	0	25	1	72.5	0	0	0

Table 3. Average percent coverage change at dry grass forest sites, dry heathy forest sites and previously burned in 2007 sites on the Silver Peppermint Reserve between January 14th and February 22nd. Shows percent cover change for trees, shrubs, coarse woody debris, rocks, bare ground, grass, herb, and bryophytes for all sites each week. Note these variables did change over time.

Silver Peppermint Reserve Post-Fire Recovery -- Vegetation Type Percent Covers -- CHANGE (Jan - Feb 2013)

Dry Grassy Forest

		Leaf litter							Ferns							Sedge						
		Dominately dead Eucalypt leaves that had been scorched during the bush fire.							Dominated by bracken (*Pteridium*) fern							Dominated by sedge						
		Jan-14	Jan-23	Jan-31	Feb-08	Feb-13	Feb-20	Change	Jan-14	Jan-23	Jan-31	Feb-08	Feb-13	Feb-20	Change	Jan-14	Jan-23	Jan-31	Feb-08	Feb-13	Feb-20	Change
Site 1	Understory	3	3	3	3	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Site 2	Understory	2	2	3	4	6	6	2	0	0	0	0	0	0	0	2	3	8	10	10	10	8
	Ground	3.3	3.3	3.3	5	6.2	6.5	3.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Site 3	Understory	4	5	5	6	6	6	2	0	0	0	0	0	0	0	0	0	1	1	2	2	1
	Ground	7	7	9	10	12	12	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Site 4	Understory	2	2	3	4	4	4	2	0	0	0	0	0	0	0	0	0.5	1	1	1	1	0.5
	Ground	3	5	5	6	6	6	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Dry Heathy Forest

Site 1	Understory	0	0	1	2	2	2	2	0	0	0	0	0	2	2	0	2	2	3	3	3	1
	Ground	0.5	0.5	0.5	0.5	0.5	0.5	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1
Site 2 BURNED 2007	Understory	1	1	1	1.5	1.5	1.5	0.5	0	0	0	0	0	0	0	0	0.2	0.2	0.2	1.5	1.5	1.3
	Ground	2	5	5	5	5	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Site 3	Understory	0	0	1.5	1.5	1.5	1.5	1.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Site 4 BURNED 2007	Understory	1	1	1	3	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Ground	8	10	10	10	10	10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Site 5 BURNED 2007	Understory	0	0	1	1	1	1	1	0	0	0	1	1	2	1	0	0	2	2	3	3	1
	Ground	1	1	2	2	3.5	5	4	0	0	0	0	0	0	0	0	0	1	1	2	3	0
Site 6	Understory	2	2	2	2	2	2	0	0	0	0	0	0	0	0	0.5	1	2	2	4	5	4.5
	ground	1	1	2	3	5	5	4	0	0	0	0	0	0	0	0.5	0.5	0.5	1	1	2	1.5

Regeneration in conjunction with weather

Although there were no statistical correlations made at this stage in the monitoring project, weather data collected by the Australian Bureau of Meteorology (BOM) was analysed to determine whether there were links between temperature and precipitation events, and regeneration patterns. Weather records for the months of January and February were taken from the closest climate observation station in Bushy Park, Tasmania. The dry warm weather patterns that led up to the Dawson Road- Lake Repulse fire in early 2013 continued in the following weeks, with precipitation accumulations far below average for both January and February. At the Bush Park Weather station only 11.6 mm fell during the month of January, 2013, with rain events occurring on the 9th, 11th, 19th, 30th and 31st. On average, January receives 40.2 mm of rain at this location. As of February 25th, only 2.1 mm of rain had fallen in the area, which occurred entirely on February 1st. Given the low accumulations, it is surprising that that these precipitation events were able to foster any plant development on the reserve. Whether or not changes in vegetation growth can be attributed to the small rain events is difficult to tell. Based on the ten photo-point sites sedge growth was distinguishable on days following rain, particularly on the February 8th trip, one week after a rain fall of 7.2 mm.

The weather pattern that produced below-normal precipitation exhibited temperatures for January and February that were slightly above average. However, the day to day temperature and precipitation anomalies were likely too small for there to be a discernible change in vegetation recovery. A larger sample area and population would be needed to analyse the connections between the two weather variables and the vegetation response.

4.6 Discussion on recommendations for vegetation monitoring protocols

Many monitoring or sampling projects typically conclude with recommendations to expand research, increase the sample size, develop more refined protocols, and conduct additional statistical analyses. Similarly, the Silver Peppermint Reserve photo-point monitoring project exhibited several pros and cons in its design, execution, and analysis methods. Despite limited resources, personnel, and time, the Tasmanian Land Conservancy was able to take swift action to monitor the site post-fire and observe early regeneration processes. The use of photo point monitoring and photo analysis was an efficient and rapid method to undertake post-fire recovery monitoring at the Silver Peppermint Reserve. Setting up the different plots was simple and straightforward, and weekly visits to the reserve required fewer than 5 to 10 minutes per plot. Estimating percent coverage strictly from photographs also reduced the costly time spent in the field. The efficiency of tasks and methods of the Silver Peppermint Reserve post-fire recovery monitoring project was probably the project's greatest asset.

The major drawback in the use of the photo-point method as executed in the project was the potential for loss in precision, accuracy, and detail. To balance efficiency with accuracy, future improvement can be made both in the field and at the computer. Because the entire project is focused around photographs, it would be very helpful to conduct a few percent cover vegetation transects on the reserve. These transects could utilize principles from the Brown's point intercept, belt, or FIREMON percent coverage transect methods. This would provide the TLC with information to compare the accuracy of photo analysis with ground-truthed vegetation percent coverage tests done in the field.

When looking at photos using GIMP 2.8 or Adobe Photoshop, it would be useful to find a methodology that could be repeated by several different people at a similar level of precision. Two main methodologies were discussed for photo analysis. One was to break the photos into a grid and visually estimate how much area was covered by each vegetation type in each section of the photo (FIGURE). The second technique was to run three horizontal lines across the photo and treat the lines as though they were point intercept transects; in this case the analysis consisted of estimating the total

area of different plant types intersecting the transect line and dividing by the total line length. Both of these techniques would work well and different people may have a different preference as to which is easier. The common issue with both of these techniques is that the scale changes due to different depths of field are not accounted for. Developing a correction factor that could be applied to photos would be the best option. This could likely be achieved by utilizing principles of triangulation. However if the TLC's major aim is to develop a general understanding of different plant coverage approximations over time and scale, the current methodologies will provide the organization with these values.

5. Avifauna Monitoring Component

In conjunction with post fire flora development, the Tasmanian Land Conservancy is also interested in the re-colonization of Silver Peppermint by avian species. To monitor bird presence, three sites were selected for bird sound recordings: an established vegetation photo-point sample site from the dry grassy forest unit, one from the dry heathy forest unit, and a third from the previously burned unit within Silver Peppermint. These three locations were selected based on vegetation type and relative spacing to other sample locations. The specific recording sites were dry heathy forest sites 1 and 4, and dry grassy forest site 2 (map). Using a *Handy Recorder H2* sound recorder, a 20 minute recording of bird calls was captured at each site. Visual observations of bird species were also noted around the entire unit.

5.1 Avifauna Analysis of Silver Peppermint

Once sound recordings of bird calls at Silver Peppermint Reserve were captured within the initial regeneration period between early January and the end of February, Dr. Sally Bryant from the Tasmania Land Conservancy analysed the calls. Recordings were compared with observations taken on site. After bird recordings were analysed, species were further broken into guilds in case patterns could be identified between re-colonization activity and associated guilds. For simplicity, bird species were categorized by their eating and foraging habits and guilds. (Thomas, 1979) (Table 5).

5.2 Avifauna Monitoring Conclusions

Over the course of two months, Dr. Sally Bryant was able to identify 21 different bird species present on Silver Peppermint Reserve. These 21 species were not always identified at the same site or every week, but visual and audio samples indicated a relatively diverse mix of species after the fire. The species that were identified include: *Acanthiza pusilla, Acanthorhynchus tenuirostris, Anthochaera paradoxa, Aquila audax, Artamus cyanopterus, Cacatua galerita, Colluricincla harmonica, Corvus tasmanicus, Cracticus torquatus, Cuculus pallidus, Dacelo novaeguineae, Falco berigora, Gymnorhina tibicen, Lichenostomus flavicollis, Malurus cyaneus, Manorina melanocephala, Melanodryas vittata, Petroica multicolor, Phaps chalcoptera, Platycercus eximius, Strepera fuliginosa, Strepera versicolor.* For analysis purposes, bird species were further categorized into three different guilds based on food and foraging habits. Guilds included granivores which eat seeds and nuts, carnivores/insectivores which scavenge and hunt for meat sources and prey on insects, and omnivores which have a mixed diet (Thomas, 1979; Byrant 2013) (Table 6).

By February 13th 16 different bird species were recorded. Guild categorization based on dietary habits showed that birds classified as carnivores/insectivores were the most abundant in specie number (12 different species) across all three sites. Omnivores were the next most common guild at Silver Peppermint with 10 different bird species identified. Granivores (2 species) were the most infrequently identified bird type.

Sound and sight observations indicated that overall, large sized predatory birds were the most dominant species found at Silver Peppermint. It is reasonable to deduce that a readily available food source including insects, vertebrates and carrion after the fire allowed these large carnivorous birds to occupy the site immediately and in the highest densities. Based on species presence and foraging patterns, it appears that ground and canopy foraging is the most favoured. Within the first several weeks after the fire, mid layer and understorey species were still largely absent. Although it is reasonable to assume that food sources and availability are the primary drivers of species present on the Silver Peppermint Reserve, these deductions cannot be entirely established as there are many other variables that may be influencing species presence and their relative densities (Table 5 and 6).

As stated by Lindenmayer et al. 2008 in their paper Testing Hypotheses Associated with Bird Responses to Wildfire, overall bird richness after a fire in areas of Southeastern Australia was low initially, but was able to recover in two years after the fire. Furthermore, bird recovery and assemblage was fastest on areas that had structurally complex vegetation (Lindenmayer et al. 2008). When applying this information to the Silver Peppermint Reserve, the species richness of bird populations may favour insectivore and predatory species for the fall season while the insect densities stay high. However it is likely that as the winter months approach, this trend may decline as insects decrease in number, and food from plant sources becomes more available. This would likely provide a more balanced ratio of species between the different guilds in the future (Bryant, 2013).

As of February, 2013, birds most consistently observed through sound recordings and visual observations are birds that typically feed in the understory or canopy of forests. Birds that typically take refuge in the middle regions of forests are not present. Due to the severity of the fire, this structural layer in Silver Peppermint is not currently present. As the understory continues to grow back and mature, it is likely that observations of these types of birds will increase (Hobson and Schieck, 1991; Bryant 2013).

One important aspect of Silver Peppermint that may be influencing observation trends is the size of the reserve. The reserve's small size and linear shape means that it may be difficult to detect patterns or changes in bird habitation over a short period of time due to the surrounding context and edge effects. As the Dawson Road- Lake Repulse fire burned across the landscape, it left a mosaic of burned and unburned patches. These patches are likely influencing the speed of bird recovery and the observed diversity of bird species at Silver Peppermint (Gill, Woinarski and York, 1999). An un-burned Eucalypt

plantation borders one of the edges of the burned reserve. Its close proximity is likely allowing birds to take refuge in these trees, while foraging for food at the burned reserve during the day. If the plantation had also been consumed during the blaze, it is likely that specie richness and assemblage observations would be much lower (Olsen and Weston, 2005). However there are signs of permanent colonization of birds at Silver Peppermint Reserve. A pair of Dusky Swallows were observed for three consecutive weeks building a nest in one of the burned Eucalypt trees.

The guild that had the greatest number of total observations was the carnivore/insectivore guild. Over the initial 4 week monitoring period (January 23- February 14) 49 observations of carnivore and insectivore bird species were captured through sound or visual recordings across all three reserve sample sights. The omnivore guild had 30 observations. Site location did not appear to have a significant effect on the diversity of birds recorded. This is expected due to the reserve's relatively small size, linear configuration, and pronounced edge effect. The dry grassy forest site 2, dry grassy forest site 1, and dry grassy forest site 4 had observation totals that were very similar. The dry grassy forest site 4, which burned in 2007, had the highest recording density with 30 different observations. The dry grassy forest site 2 had 29 observations, and the dry grassy forest site 1 had 25 observations. Although it is difficult to draw significant conclusions about the data results at this stage, it is evident that birds that are able to eat insects and meats (carnivores and insectivores) are much more abundant on site. It is likely that this contrast between seed eaters and meat/insect eaters will lessen as vegetation regeneration continues (Olsen and Weston, 2005).

Table 5. Observation totals of birds (categorized by guild) heard and seen on Silver Peppermint Reserve between early January and late February.

Birds Seen on Silver Peppermint Reserve Post Fire (Jan-Feb 2013)				
Silver Peppermint Observation Sites	Bird Guild			
	granivore (2 species)	carnivore/ insectivore (12 species)	omnivore (10 species)	*SiteObservation totals*
Dry heathy forest site 1	2	16	7	*25*
Dry heathy forest site 4 (Burned 2007)	1	15	14	*30*
Dry grassy forest site 2	1	18	10	*29*
* Heard on reserve			* 2	*2*
* Seen on reserve	* 1	* 1	* 2	*4*
Guild observation totals	*5*	*49*	*30*	

Table 6. Observation totals of birds heard and seen on Silver Peppermint Reserve between early January and late February. Codes include: DHF (Dry heathy forest), DGF (Dry grassy forest), SOS (seen on site), HOS (heard on site).

Birds of Silver Peppermint Reserve post-fire (Jan-Feb 2013)						
SPECIES NAME	**COMMON NAME**	**Guilds by feeding habits**	**23-Jan-13**	**31-Jan-13**	**08-Feb-13**	**13-Feb-13**
Acanthiza pusilla	Brown Thornbill	*insectivore*	DGF2	DHF1, DGF2		DHF4, DGF2
Acanthorhynchus tenuirostris	Eastern Spinebill	*insectivore*	DHF4			DHF1
Anthochaera paradoxa	Yellow Wattlebird	*insectivore*				DHF4
Aquila audax	Wedge-tailed Eagle	*carnivore*		SOS		
Artamus cyanopterus	Dusky Woodswallow	*insectivore*	DHF1			SOS (nesting)
Cacatua galerita	Sulphur-crested Cockatoo	*granivore*		DHF1, DHF4, DGF2		DGF2, DHF1
Colluricincla harmonica	Grey Shrike-thrush	*omnivore*	DHF1			
Corvus tasmanicus	Forest Raven	*omnivore*	DHF4, DHF1, DGF2	DHF1, DHF4, DGF2	DHF4, DGF2	DHF4, DGF2, DHF1
Cracticus torquatus	Grey Butcherbird	*carnivore*	DHF4, DHF1, DGF2	DHF1, DHF4, DGF2	DHF1, DHF4, DGF2	DHF4, DHF1, DGF2
Cuculus pallidus	Palid Cuckoo	*insectivore*			DHF4, DGF2	
Dacelo novaeguineae	Laughing Kookaburra	*carnivore*	DHF4, DHF1, DGF2	DHF1, DHF4,		DGF2, DHF1, DHF4
Falco berigora	Brown Falcon	*carnivore*	DHF1	DGF2		DGF2
Gymnorhina tibicen	Australian Magpie	*omnivore*	DHF4	DHF4, DGF2	DGF2	DHF4, DGF2
Lichenostomus flavicollis	Yellow-throated Honeyeater	*omnivore*	DHF4, DHF1, DGF2			
Malurus cyaneus	Superb Fairy-wren	*insectivore*		DHF1, DHF4, DGF2		DHF1
Manorina melanocephala	Noisy Miner	*insectivore*	DHF4, DHF1, DGF2	DHF4, DGF2	DHF4, DGF2	DHF4, DGF2, DHF1
Melanodryas vittata	Dusky Robin	*insectivore*	DHF1, DGF2	DHF4	DHF4	DHF4, DGF2, DHF1
Petroica multicolor	Scarlet Robin	*insectivore*	DHF1, DGF2			HOS
Phaps chalcoptera	Common Bronzewing	*granivore*				SOS
Platycercus eximius	Eastern Rosella	*omnivore*		SOS		
Strepera fuliginosa	Black Currawong	*omnivore*		HOS	DHF4	
Strepera versicolor	Grey Currawong	*omnivore*		DHF4, DGF2		HOS
total		**21 total species**	13 species	14 species	7 species	16 species

5.3 Discussion on recommendations for avifauna monitoring

Any sampling, monitoring, or experimental project that involves living animal species is highly at risk to error since there are so many un-accounted for factors that can impact animal behaviours. Although it is perfectly feasible to collect general data on what bird species are seen or heard on site, drawing accurate conclusions about why certain species were at certain locations at specific times is more difficult. Understanding avifauna population dynamics and species diversity on Silver Peppermint before the Dawson-Road Lake Repulse bush fire would have been extremely helpful to detect change in bird behaviour correlated to a fire disturbance. Although this is not possible, taking a sample of birds present through sound and sight observations at the adjoining unburned portions of the Mount Bethune conservation area would provide the Tasmanian Land Conservancy a base for what bird species may

have been present on Silver Peppermint before the fire. This addition to the monitoring protocol would allow for more justified arguments in how different bird specie populations colonize an area after a bush fire. As a data set is compiled with the times and locations of bird sighting, it would be helpful to note the type of plant species the bird was found in, and how badly it was burned. This piece of information would be particularly interesting if links between Eucalypt burn severity and nest locations can be drawn.

The protocols of the avifauna portion of the Silver Peppermint Reserve monitoring project are in general, very simple, fast, and accurate when bird identification specialists are able to participate. Understanding the complexities of fire effects on bird species will continue to be difficult to pin point but improvements could be made by developing a pre-fire bird species record from neighbouring locations, noting the severity and species of burned vegetation where bird activity is high, and recording areas that appear to be habitat havens for different species. The previous recommendations could further bolster the completeness and accuracy of the bird monitoring project.

6. Summary of the Initial Recovery of Silver Peppermint Reserve

6.1 Flora Recovery

Using sound recordings and photo observations, the Tasmanian Land Conservancy has had the opportunity to monitor the initial recovery of the Silver Peppermint Reserve after a severe bush fire burned through the entire site in early January 2013. Initially the 43 ha reserve showed few signs of life but within a week, the first signs of green vegetation began to emerge from the blackened soil. Live sedge started recovery first and continued to increase in area in the following -weeks. Bracken fern, Eucalypt shoots, grasses and small forb recovery were only observable during the last visit to Silver Peppermint at the end of February. Although weather patterns were also analysed in conjunction with flora regeneration, no definite conclusions between the two variables can be drawn at this stage in the project. It must be noted though that January and February were abnormally dry in 2013 which may have impeded the overall recovery speed of the vegetation observed on site.

6.2 Avifauna Recovery

Even with a scorched Eucalypt canopy and charred understory, bird species across Silver Peppermint were surprisingly diverse. Twenty one different bird species were detected across the reserve within a five week period. After dividing the birds into three different guilds based on eating preference, it was obvious that carnivores/insectivores and omnivores had recolonized, or were using the burned reserve in the greatest densities. Because many food resources were likely consumed during the early January fire, it is understandable that birds that have flexible diets (omnivores), or are able to eat the insects and small animals found across the reserve (carnivores/insectivores), have had the greatest recolonization success. Continued avifauna monitoring will indicate if advanced vegetation recovery in the future affects the diversity and density of bird activity at Silver Peppermint.

Summary of vegetation and bird recovery on the Silver Peppermint Reserve after the January 4th 2013 bush fire.

7. Projections of the Future at Silver Peppermint Reserve

7.1 Continued Recovery

As the saying goes, *time heals all wounds,* even ecological and biological wounds. In the next several weeks, months and years, the Silver Peppermint Reserve will likely regain full ecological function and health. Vegetation found on the reserve will likely go through several successional changes as plant communities shift from early colonizers to climax species (Bradshock, Williams and Gills, 2002). While the Eucalypt forests mature and regain biological diversity, structure and ecosystem processes, bird recolonization will likely follow the recovery trend. With additional food sources provided by plant and insect populations, as well as habitat for nesting and protection, bird populations including those that

eat seeds, nuts and fruits will likely expand in terms of biodiversity and overall abundance. Although the complex interactions between the flora and fauna communities may not be fully understood, it is reasonable to assume that the biotic components of the ecosystem biomes will complement each other's recovery toward full ecosystem function after the fire (Olsen and Weston, 2005).

7.2 Management activities

The Tasmanian Land Conservancy's primary goal for the Silver Peppermint Reserve is to assist with its natural recovery towards a state of sustained ecosystem health and maximized biodiversity. Due to the severity of the fire disturbance, the reserve will require a heightened level of monitoring, observation and care. This stewardship may require adjustments to the original 2009 TLC management plan for the reserve. It will be important to make sure that potentially damaging illegal activities, such as the use of off-road vehicles and wood cutting, are kept to a minimum. After large disturbance events it is common for invasive plant species to establish and grow in the newly cleared areas. Frequent monitoring will help make sure that weeds are identified and removed in an attempt to maintain native flora development and composition on site (Treloar, 2012).

> *'Fire is a force in terrestrial ecosystems that is equalled only by the impact of humans as they transform, fragment and degrade the Earth's vegetation… Regardless of the changes wrought, fire is a central process in creating and maintaining ecosystem patterns and processes in most, if not all, Australian terrestrial ecosystems*.'
> (John Woinarski and Harry Recher, 1997 as cited in: Olsen and Weston, 2005).

Although fire is a visually devastating event, Tasmanian land managers understand that bushfires play an important role in ecosystem sustainability. Fire events have the unique ability to clear large areas of land. These open areas free up available resources including sunlight, water and nutrients for different communities of vegetation. Many species have evolved to depend on fire events for regeneration purposes (Bradshock, Williams and Gills, 2002). For example, Eucalyptus teniturmis use disturbances like the Dawson Road- Lake Repulse fire to re-sprout and send up new shoots during a period of time when vegetation competition is reduced and sunlight is readily available (Duncan, 1990). Recognizing that fire is an integral component of the Tasmanian ecosystem, managers should develop management plans that integrate a response to bushfire events into organizational management activities. Potential tasks may include prescriptions for fuel reductions and prescribed fires in order to prevent serious damage during a natural unplanned bush fire event, contingency plans for how to deal with a bush fire in case of an emergency, and lastly what restoration steps can be taken following a fire. Although the Tasmanian Land Conservancy can only focus on the post-fire management aspects of the Silver Peppermint Reserve at this point, it would be beneficial in the future to develop land management plans that outline the precautionary actions needed to reduce fire risk, actions to take during a burn in terms of safety and to prevent resource loss, and monitoring and recovery protocols for periods after the bush fire (Gill, Woinarski and York, 1999; Bradshock, Williams and Gill, 2002).

Signs of Eucalypt and bird recovery in late February 2013 at the Silver Peppermint Reserve after the burn

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