Monitoring macrofungi on DRF sites sprayed with Phosphite

Progress report — December 2014

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Cover images. *Main*: *Laccaria* sp. B at Gull Rock; *Below from left*: infested woodland at Vancouver Peninsula sprayed with phosphite an undescribed species of *Mycena* common at Vancouver Peninsula and *Banksia coccinea* in flower in healthy woodland at Gull Rock (Photos: Richard Robinson)

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Summary

Aerial application of phosphite is critical for the protection of susceptible plant populations in the south coast region of Western Australia. In order to determine if phosphite has any effect on epigeous macrofungal communities, surveys were conducted at Gull Rock and Vancouver Peninsula in July 2004, June 2007 and July 2014, where populations of *Banksia* have been sprayed at 2–3-year intervals since 1996. Sprayed and non-sprayed infested areas had similar macrofungal assemblages at both Gull Rock and Vancouver Peninsula. The Gull Rock site showed that the diversity of macrofungi is greater in healthy woodland than in woodland infested with *Phytophthora cinnamomi*, and that fungal communities in infested woodland (either sprayed or non-sprayed) are considerably different to that found in healthy woodland. It would appear from this and other findings that dieback has a far greater impact on fungal communities than that of phosphite. We also suggest that any benefit of Phosphite on plant communities is indirectly beneficial to macrofungal communities. More effort should be directed towards determining the impact of Phytophthora dieback disease on fungal communities in the south coast region, and the associated impacts on native fauna populations that utilise hypogeous truffle-like fungi as a food source.

Introduction

Phytophthora cinnamomi, the cause of Phytophthora dieback disease, is a significant threatening process in the south west botanical province (Shearer *et al.* 2007) and is pushing some threatened flora species to the brink of extinction. Although spot infections of *P. cinnamomi* have been eradicated experimentally in both Western Australia and Tasmania (Dunstan et al. 2010), there is no known method of eradicating the disease across large areas. The use of phosphite to control *P. cinnamomi* is one of the most important tools available to land managers for the protection of threatened flora (McComb *et al.* 2008). Phosphite is applied directly to plant foliage by spraying, or by stem injection. The chemical is systemically translocated through the plant in both the xylem and the phloem. Although not fully understood, the mode of action of phosphite involves a direct 'fungicidal' effect on the pathogen (Smillie *et al.* 1989) and an indirect effect by stimulating host plant defence mechanisms (Guest and Grant 1991) that slow down or halt pathogenic lesion development. The phosphite concentration threshold at which this occurs differs for individual plant species (Shearer et al. 2012) and depends on the method of application (Crane and Shearer 2014).

Aerial application of phosphite was developed for use in native plant communities in the early 1990's by the then Department of Conservation and Land Management (now Parks and Wildlife). Ongoing research and monitoring of phosphite-treated plant communities continues to show that regular application of phosphite reduces the rate of disease extension, and is effective in increasing plant survival rates and enhancing the health of threatened ecological communities in Western Australia (Shearer *et al.* 2004, Tynan *et al.* 2001, Moore and Barrett 2007) and in Victoria (Ali and Guest 1998). Ongoing aerial application of low volume phosphite to threatened flora and threatened ecological communities is a critical part of the management actions required by Parks and Wildlife to meet biodiversity protection objectives until effective alternative treatment options are developed.

Fungi comprise a major component of the biodiversity of Australian forest and woodland ecosystems (May and Simpson 1997) and they play important roles in the decomposition of organic matter, nutrient recycling and nutrient uptake into plants via mycorrhiza formation (Tommerup and Bougher 2000). These roles are especially important in ecosystems on nutrient poor soils such as those of southwestern Australia (O'Connell and Grove 1996). Hypogeous truffle-like fungi also form a significant part of the diet of many species of native Australian mammals (Claridge *et al*. 1996) and decay fungi that colonise logs and standing dead or living trees contribute to the development of suitable habitat for many species of native birds and animals (Perry *et al.* 1985, Simpson 1996).

While it is recognised that phosphite application is critical for the protection of susceptible plant populations, it is also important to monitor effects on other components of the biota. In order to determine if phosphite has any effect on epigeous macrofungal communities, surveys were conducted at Gull Rock and Vancouver Peninsula in July 2004, June 2007 and July 2014, where populations of *Banksia* have been sprayed bi- or triennially since 1996. Monitoring is also necessary to satisfy requirements set out by the Australian Pesticides and Veterinary Medicines Authority for the renewal of Parks and Wildlife's off-label permit for the aerial application of phosphite to native vegetation which states "*Further monitoring of effects on non-pathogenic and beneficial fungi and secondary effects on organisms that depend on these fungi for food and nutrient cycling is required*". Although they are an important component of the Australian mycota, hypogeous fungi were not included in the survey, as foraging for them would require major disturbance to the sites. This would affect future monitoring and also create hygiene issues associated with infested sites.

Monitoring at Gull Rock

Site and treatment

The Gull Rock location occurs in open low *Allocasuarina fraseriana – Eucalyptus staeri* woodland dominated by several species of thicket-forming banksias, including *Banksia coccinea* and *B. attenuata*. The monitoring site located on Ledge Beach Road is infested with *Phytophthora cinnamomi*. Of around 1 ha in size it is comprised of about 0.5ha on either side of an unnamed track. The area on the western side of the track (Fig. 1) had two autumn applications (4–6 weeks apart) of phosphite, each a rate of 12 kg ha^{-1} (or 40% Phosphite at the rate of 30 L ha^{-1}), in 1996, 1999, 2001, 2004, 2006 and 2008. In 2003, 2009, 2010, 2012 and 2014, only one autumn application of phosphite was undertaken (in 2003 60% phosphite was applied at the rate of 20 L ha^{-1}, which also equates to 12kg ha-1). The eastern side of the road has not been sprayed (Fig. 1). Each area extends about 120m north-south and about 30–40m east-west on either side of the road. Healthy woodland dominated by *B. coccinea* (Fig. 1), about 200m north of the infested (and sprayed) area, was used as a 'control' to determine the fungal community on an equivalent Phytophthora-free *B. coccinea/ B. attenuata* site.

Survey method

In each sprayed and unsprayed area of infested woodland, and within the adjacent healthy woodland, all macrofungal species and the numbers of fruit bodies were recorded along two 100m-long transects. At each area, the two transects were 10m apart, and each was 4m wide. Surveys were conducted in July 2004, June 2007 and July 2014.

Figure 1. *Banksia coccinea* - *Banksia attenuata* woodland at Gull Rock. Healthy woodland (above), woodland infested with *Phytophthora cinnamomi* and sprayed with Phosphite (above right) and unsprayed infested woodland (right). Photographed in July 2014.

Results

Over the survey period, a total of 50 species of macrofungi were recorded at the Gull Rock sites (see complete list in Appendix 1), including 19 in 2004, 26 in 2007 and 26 in 2014. Overall, 30 species were recorded in healthy (non-infested) woodland, 26 on the infested area sprayed with phosphite and 17 in the adjacent infested but unsprayed area (Table 1).

Multi-dimensional scaling (MDS), Canonical analysis of principal coordinates (CAP) and Venn diagrams were used to examine and display differences between and within species compositions recorded in each of the treatments. Macrofungal species assemblages in healthy and infested areas were very different (Fig. 2). While species assemblages on infested sites were similar from year-to-year (forming a cluster in Fig. 2), assemblages on healthy uninfested sites tended to vary. Only eight species were recorded across all treatments (Fig. 3). They included an unidentified *Cortinarius* and *Inocybe australiensis*, both of which are mycorrhizal; *Coltricia cinnamomea, Gymnopilus allantopus, Galerina* spp*.* and *Pycnoporus coccineus*, all of which are saprotrophic; a species of *Hypomyces* parasitic on *C. cinnamomea* and the lichenised basidiomycete *Lichenomphalia chromacea*.

Overall, *Cortinarius* was the dominant mycorrhizal genus, with seven species recorded. Saprotrophic fungi were dominated by nine species of *Mycena*. The most abundant species overall was *Laccaria* sp. B, a mycorrhizal fungus which was recorded on infested sites. The most abundant saprotrophic species was *Coltricia cinnamomea*, also recorded predominantly on infested sites.

Infested sites tended to be dominated by one or two abundant species. The most abundant species, *Laccaria* sp. B, was not recorded in the healthy woodland site. There were more mycorrhizal and saprotrophic species on the healthy and sprayed sites compared to the unsprayed site. Although fewer species were present on the unsprayed site, they produced considerably more fruit bodies (Table 1).

Table 1. Richness and abundance of macrofungi recorded in 2004, 2007 and 2014 at Gull Rock in healthy, dieback-infested (Pc) woodland sprayed with phosphite and adjacent unsprayed dieback-infested woodland

	Healthy			**Pc + Phosphite spray (+P)**			**PC, no Phosphite spray (-P)**			**Total**		
	2004	2007	2014	2004	2007	2014	2004	2007	2014	Healthy	+P	-P
Number of species	10	16	9	6	10	16	9	9	8	30	26	17
Number of fruit bodies	73	134	49	474	686	59	209	3178	555	256	1219	3942
Number of species in each life-mode												
Coprophilous							1					1
Lichenised	1	1			1		1	1		2	1	1
Parasitic		1	1		1	1	1		1	2	2	1
Saprotrophic	5	8	5	1	3	11	3	5	3	16	13	8
Mycorrhizal	4	6	3	5	5	4	3	3	4	10	10	6
Number of fruit bodies in each life-mode												
Coprophilous							1					1
Lichenised	9	3			3		1	2		12	3	3
Parasitic		1	1		2	2	2		1	2	4	3
Saprotrophic	50	78	43	9	36	47	89	27	301	171	92	417
Mycorrhizal	14	52	5	465	645	10	116	3149	253	71	1120	3518

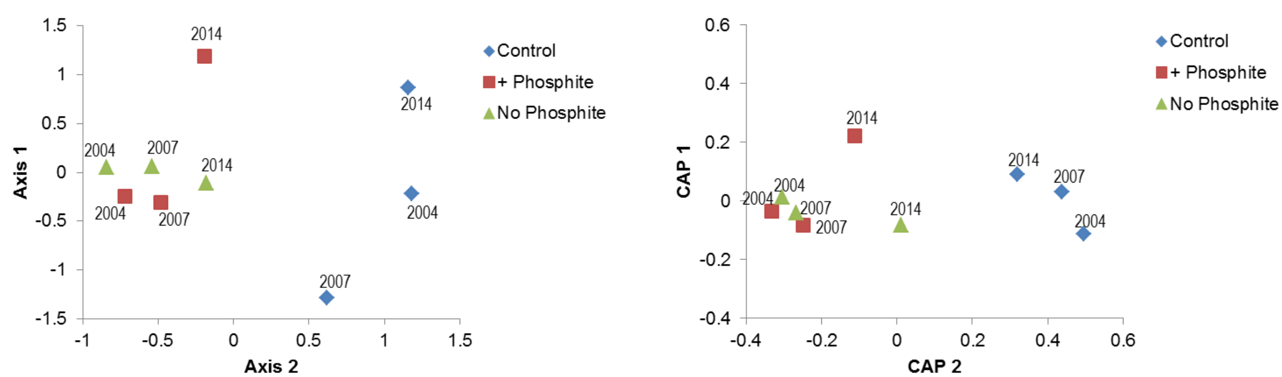

Figure 2. Output from MDS (left) and CAP (right) analysis showing relationship between species assemblages in each treatment at each survey date at Gull Rock (MDS 2D stress: 0.11, P-value for differences between treatments within years for CAP= 0.157)

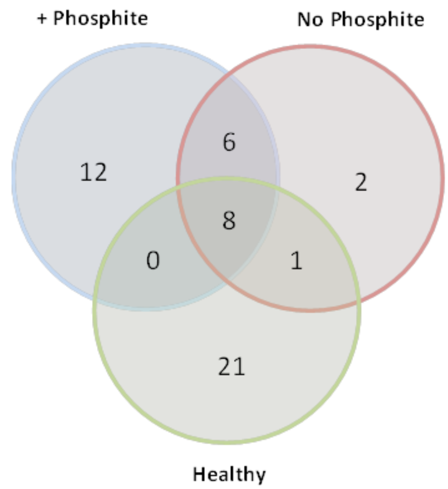

Figure 3. Venn diagram showing numbers of species restricted to or shared by each treatment at Gull Rock

Monitoring at Vancouver Peninsula

Site and treatment

The Vancouver Peninsula site (Fig. 4) is coastal woodland dominated by *Eucalyptus marginata, Banksia grandis* and the threatened *B. brownii*. The sprayed area is approximately 1ha in size (100 x 100m) on a southwest facing slope directly above the shores of Princess Royal Harbour. The site had two autumn applications (4–6 weeks apart) of phosphite, each at the rate of 12 kg ha^{-1} (or 40% Phosphite at the rate of 30 L ha^{-1}), in 1996, 1999, 2001, 2004, 2006, 2008 and 2010. In 2003, 2009, 2012 and 2014, only one autumn application of phosphite was undertaken (in 2003 60% phosphite was applied at the rate of 20 L ha^{-1}, which also equates to 12kg ha^{-1}). An unsprayed infested area of similar vegetation, also about 1ha in size, situated 200m southeast of the sprayed area was also selected for survey.

Survey method

In each sprayed and unsprayed area all macrofungal species and the number of fruit bodies were recorded on two 100m transects which ran along the contour of the slope. The two transects in each area were about 40m apart and each was 4m wide. No monitoring was undertaken on a similar but apparently uninfested site as disease expression at this location was not obvious and it couldn't be guaranteed that dieback was not present.

Results

Multi-dimensional scaling (MDS), Canonical analysis of principal coordinates (CAP) and stacked column graphs were used to examine and display differences between and within species compositions recorded in each of the treatments. Over the survey period, 80 species of macrofungi were recorded at Vancouver Peninsula (see the complete list in Appendix 2), including 35 in 2004, 42 in 2007 and 45 in 2014. Although similar numbers of species were recorded on sprayed and unsprayed sites in each survey year, their abundances were consistently higher on the sprayed site. Each year only 20–30% of species were found on both sprayed and unsprayed sites (Fig. 5), and species compositions found on each site varied considerably (Fig. 6). Overall there were similar numbers of saprotrophic and mycorrhizal species in each treatment, but as was observed for each year, abundance was considerably higher in the sprayed treatment (Table 2).

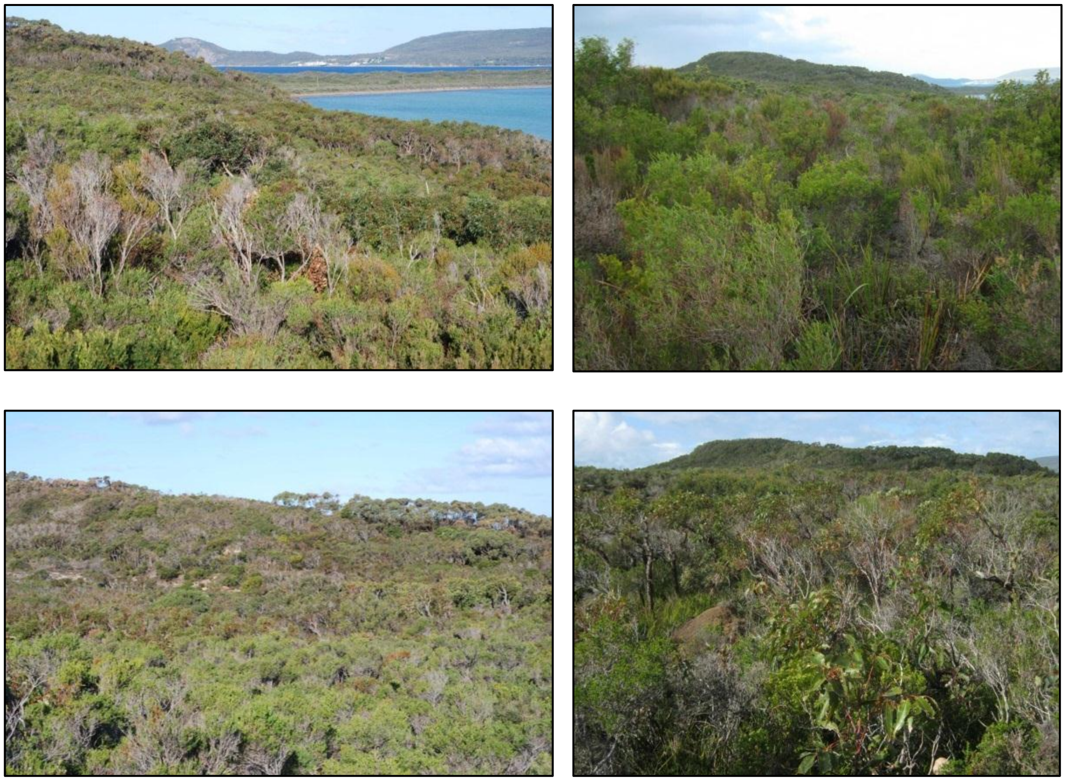

Figure 4. *Banksia grandis - Banksia. brownii* woodland at Vancouver Peninsula. Infested woodland sprayed with phosphite and photographed in 2004 (top left) and in 2014 (top right). Adjacent unsprayed woodland in 2004 (above left) and in 2014 (above right).

Table 2: Species richness and abundance of macrofungi recorded at Vancouver Peninsula in 2004, 2007 and 2014 in dieback-infected (Pc) woodland sprayed with phosphite and adjacent unsprayed woodland

	Pc + Phosphite spray			**Adjacent unsprayed**			**Total**			**Overall totals**	
	2004	2007	2014	2004	2007	2014	2004	2007	2014	Spray	No spray
Number of species	23	31	26	22	20	29	35	42	45	53	53
Number of fruit bodies	276	437	270	79	162	228	355	599	498	983	469
Number of species in each life-mode											
Coprophilous	1	2	1	1	2	1	1	3	1	1	1
Saprotrophic	10	16	17	6	10	17	13	21	28	28	25
Mycorrhizal	12	13	8	15	8	11	21	18	16	23	26
Number of fruit bodies in each life-mode											
Fruit bodies											
Coprophilous	4	27	1	3	6	5	7	33	6	32	14
Saprotrophic	101	270	245	20	126	204	121	396	449	616	350
Mycorrhizal	171	140	24	56	32	19	227	172	43	335	107

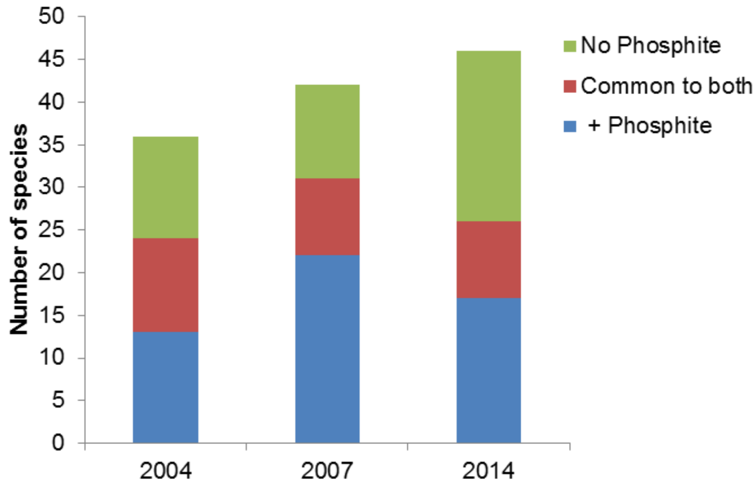

Figure 5. Graph showing numbers of species restricted to or shared by sprayed and unsprayed dieback-infested (Pc) areas at Vancouver Peninsula in each year of sampling

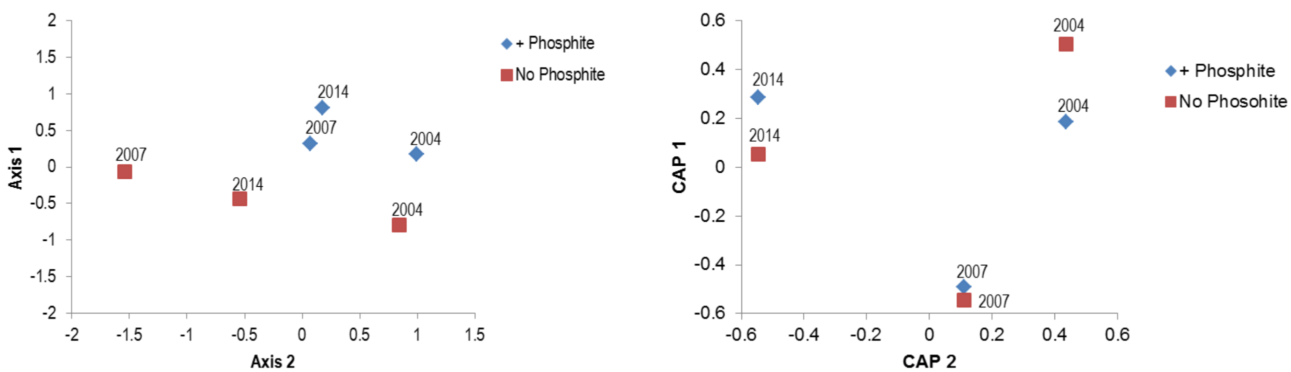

Figure 6. Output from MDS (left) and CAP (right) analysis showing relationship between species assemblages in sprayed and unsprayed dieback-infested (Pc) areas at Vancouver Peninsula at each survey date (2D stress for MDS = 0, P-value for differences between treatments within years for CAP= 0.248)

In all, 33 species of mycorrhizal fungi were recorded. Of these, nine were species of *Cortinarius*; all of which were found in the unsprayed site, but only five of them were recorded in the sprayed treatment, all in 2007. Other fungi included four species of *Russula* (more common in the unsprayed treatment) and three species each of *Inocybe* and *Amanita* , both of which were more commonly recorded in the sprayed sites) (Appendix 2).

The most common species recorded was an unnamed saprotrophic species, *Mycena* sp. 'tan dome, long slender stem', which was only recorded on the sprayed site. Just two species were recorded on both sites in all years, *Psilocybe coprophila* and *Galerina* spp. complex. *Rickinella fibula* was also common, but was not recorded on the unsprayed site in 2004. The most abundant mycorrhizal species were *Laccaria lateritia* and *Laccaria* sp. B, but they were only recorded on the sprayed site (Appendix 2).

Discussion

The Gull Rock site shows that the diversity of macrofungi is greater in healthy woodland than in woodland infested with *P. cinnamomi*, and that the assemblages of fungal communities differ in infested woodland compared to healthy woodland. The number of species recorded in the healthy woodland site, however, appears to be lower than expected; most likely due to the very thick shrub and herb cover and accompanying thick litter layer that make it difficult to find fruit bodies, or smothers any developing fruit bodies. It's not unusual to observe sparse fruiting of macrofungi on sites with dense ground-cover plants and very thick litter, but this does not imply that fungi are absent or inactive. In jarrah forest, dieback-free and infested sites were found to have significantly different macrofungal floras. Diversity was about 1.8 times greater and abundance 1.5 times greater on dieback-free sites compared to infested sites and only 20% of species occurred on both site types (Anderson 2007). Despite a paucity of species in infested woodland at Gull Rock, the abundance of *Laccaria* sp. B was exceptionally high. High abundance of a small number of species is common following disturbance, and has also been reported following fire (Robinson *et al*. 2008) and timber harvesting (Robinson & Williams 2011).

It is difficult to assess whether phosphite has had any effect on fungal communities on these sites. It would appear from the findings that dieback has a far greater impact on fungal species assemblages than does the application of phosphite, presumably through indirect impacts such as the loss of mycorrhizal host plants and litter cover (Anderson 2007) which also contributes to increased daytime soil temperatures and a decrease in soil moisture (Gochenaur 1981). Species assemblages in infested areas were more closely aligned regardless of phosphite application. At Gull Rock, species richness was similar on healthy and sprayed infested sites (although very thick litter on the healthy site hampered survey results there) but low on the unsprayed infested site. In contrast, species abundance was considerably higher in the unsprayed infested site (same result if *Laccaria* sp. B is not taken into account). At Vancouver Peninsula, species richness was the same in sprayed and unsprayed infested areas with abundance higher on the sprayed area. *Laccaria* sp. B*,* the most dominant species, was more abundant in the unsprayed infested treatment at Gull Rock and in the sprayed infested treatment at Vancouver Peninsula. Species assemblages in the sprayed and unsprayed infested areas were similar at both the Vancouver Peninsula and Gull Rock sites (but species diversity was very low at Gull Rock). The parasitic macrofungus, *Armillaria luteobubalina*, was also present at Vancouver Peninsula. Although Armillaria has the ability to cause severe disease and eventually death of trees and shrubs (Robinson 2010), it was not prevalent enough to have a visibly significant impact. However, phosphite application may also benefit shrubs infected with this pathogen.

Whether it is practical to continue monitoring fungi to satisfy permit requirements needs to be questioned, especially the need to monitor fungi utilised by native animals as a food—namely hypogeous truffle-like fungi. Surveys for such fungi require destructive sampling and the disturbance and movement of soil. Sampling on small areas such as the sites at Gull Rock and Vancouver Peninsula would cause significant disturbance, and affect subsequent sampling. Movement and disturbance of soil on dieback-infested sites is also undesirable. The benefits of phosphite for plant communities are indirectly beneficial for fungal communities, especially mycorrhizal fungi that rely on the presence of healthy and abundant hosts. Instead, the effect of dieback on fungal communities is of far greater concern and warrants further investigation.

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Appendix 1. List of species (and abundance) of macrofungi recorded at Gull Rock in 2004, 2007 and 2014 in healthy and dieback-affected (Pc) woodland either sprayed and unsprayed with phosphite

Species	Life-mode[1]	Healthy			Pc infested + Phosphite spray			Pc infested, no Phosphite spray		
		2004	2007	2014	2004	2007	2014	2004	2007	2014
Psilocybe coprophila	C							1		
Lichenomphalia chromaceae	L	9				3		1	2	
Lichenomphalia sp. 'orange'	L		3							
Amanita umbrinella	M	1								
Cortinarius fibrillosus	M		1							
Cortinarius sp. 'chestnut'	M					4				
Cortinarius lamellatus	M	3		1						
Cortinarius sp. 'pointy cap'	M		1							
Cortinarius sp. (Telemonia)	M		41							
Cortinarius sp. 'yellow fibrillose cap'	M		3							
Cortinarius spp. (unidentified)	M	1	4	3	1	1				2
Descolea maculata	M						2			
Inocybe aff. *australiensis*	M	9				24			31	6
Inocybe sp. 'large fibrillose cap'	M						3			
Inocybe sp. 'scaly cap'	M				11	6		4	21	
laccaria lateritia	M				3					1
Laccaria sp. B *sensu* T. May	M				448	610	2	106	3097	244
Lactarius sp. 'creamy yellow'	M		2							
Scleroderma cepa	M			1						
Thelephora aff. *terrestris* 'light brown'	M				2			6		
Thelephora sp. 'orange margin'	M						3			
Cordyceps sp.	P						2			
Hypomyces sp. on *Coltricia oblectans*	P		1			2		2		1
Hypomyces chrysospermus	P			1						
Alleurodiscus sp.	S			27						
Calocera sp.	S							42		
Clavulinopsis sp. 'tan'	S						3			
Coltricia cinnamomea	S		5		9	23	8	45	16	4
Crepidotus nephrodes	S					2				
Discinella terrestris	S	35	4							286
Galerina spp.	S			12			2		1	11
Gymnopilus alantopus	S			1			3		3	
Gymnopilus sp. 'slender'	S					11			5	
Lepiota cristata	S	1								
Lepiota sp. 'creamy brown'	S		1							
Marasmiellus sp.	S		53							
Mycena aff. *maldea*	S		2							
Mycena mijoii	S	3								
Mycena sp. 'grey-brown, no bleach'	S						19			
Mycena sp. 'tiny white, on soil'	S		2							

Appendix 1 continued

Species	Life-mode[1]	Healthy			Pc infested + Phosphite spray			Pc infested, no Phosphite spray		
		2004	2007	2014	2004	2007	2014	2004	2007	2014
Mycena sp. 'orange striate, viscid'	S		3							
Mycena subgallericulata	S						2			
Mycena sp. 'tiny white umbrella'	S	7								
Mycena yirakensis	S						2			
Mycena yuulongicola	S			1						
Omphalotus nidiformis	S						1	2		
Polypore. 'White resupinate'	S						5			
Protubera canescens	S						1			
Pycnoporus coccineus	S	4		2			1		2	
Resupinatus cinerascens	S		8							
Total number of species		10	16	9	6	10	16	9	9	8
Total number of fruit bodies		73	134	49	474	686	59	209	3178	555
Number of species and life-mode										
Coprophilous		0	0	0	0	0	0	1	0	0
Lichenised		1	1	0	0	1	0	1	1	0
Parasitic		0	1	1	0	1	1	1	0	1
Saprotrophic		5	8	5	1	3	11	3	5	3
Mycorrhizal		4	6	3	5	5	4	3	3	4
Number of fruit bodies and life-mode										
Coprophilous		0	0	0	0	0	0	1	0	0
Lichenised		9	3	0	0	3	0	1	2	0
Parasitic		0	1	1	0	2	2	2	0	1
Saprotrophic		50	78	43	9	36	47	89	27	301
Mycorrhizal		14	52	5	465	645	10	116	3149	253

[1] M = mycorrhizal, S = saprotrophic, P = parasitic and L = lichenised (symbiotic with algae)

Appendix 2. List of species (and abundance) of macrofungi recorded at Vancouver Peninsula in 2004, 2007 and 2014 in dieback-affected (Pc) woodland sprayed with phosphite and adjacent unsprayed woodland

Species		**Pc infested + Phosphite spray**			**Adjacent unsprayed**			**Total**	
	Life-mode[1]	2004	2007	2014	2004	2007	2014	Spray	No spray
Poronia ericii	C					2			2
Psilocybe coprophila	C	4	25	1	3	4	5	30	12
Stropharia semiglobata	C		2					2	
Armillaria luteobubalina	P	8		1		5		9	5
Amanita cf. *bruneibulbosa*	M		1		1			1	1
Amanita sp. (unidentified)	M	1			1			1	1
Amanita xanthocephala	M	2	2	1				5	
Clavulina sp. 'grey-br black tips'	M						2		2
Cortinarius filrillosus	M						2		2
Cortinarius sp. (Telemonia)	M					10			10
Cortinarius sp. 'brown with purple stem'	M		6			2		6	2
Cortinarius sp. 'chestnut'	M		2		9	7		2	16
Cortinarius sp. 'pointy cap'	M		5			4	1	5	5
Cortinarius sp. 'viscid orange'	M					1			1
Cortinarius sp. 'viscid pink-brown'	M				1				1
Cortinarius spp. (unidentified)	M		9		11		2	9	13
Cortinarius vinaceolamellatus	M		30		5		2	30	7
Descolea maculata	M		13	5				18	
Hydnum repandum	M	44			2		3	44	5
Hygrocybe cantharellus	M		2	3			1	5	1
Hygrocybe conica	M	1						1	
Inocybe australiensis	M		10	2			2	12	2
Inocybe sp. 'scaly cap'	M	5	1		4			6	4
Inocybe sp. 'tan skirt'	M	1						1	
Laccaria lateritia	M	42	37	8	3			87	3
Laccaria sp. B *sensu* T. May	M	59	22		1			81	1
Lactarius eucalyptica	M					2	1		3
Lactarius sp. 'creamy yellow'	M				2				2
Paxillus sp.	M	2						2	
Phellodon sp. 'niger slender'	M			1				1	
Pisolithus sp.	M	1						1	
Ramaria sp. 'grey-brown'	M				9				9
Russula clelandii	M					1			1
Russula floctonae	M			3	1		1	3	2
Russula neerimea	M	5			2		2	5	4
Russula sp. 'white-white-white'	M				4				4
Anthrocobia sp. 'orange'	S		100					100	
Camarophylopsis sp. 'napthalene'	S						2		2
Clavulina sp. 'grey-brown'	S			2				2	
Clavulinopsis amoena	S						4		4

Appendix 2 continued

Species		Pc infested + Phosphite spray			Adjacent unsprayed			Total	
	Life-mode[1]	2004	2007	2014	2004	2007	2014	Spray	No spray
Clavulinopsis miniata	S			6				6	
Coltricia cinnamomea	S	8	2					10	
Coprinus spp.	S		3					3	
Cystolepiota sp.	S			1			1	1	1
Discinella terrestris	S					100	82		182
Entoloma sp. 'honey'	S	1	1					2	
Entoloma sp. 'tall grey-brown, grey stem'	S	2	2	1	1		1	5	2
Fistulinella mollis	S		1	1				2	
Galerina sp. 'eccentric stem'	S						1		1
Galerina spp. complex	S	15	43	6	11	3	9	64	23
Grandinia sp. 'simple spines'	S					1			1
Gymnopilus alantopus	S					10			10
Gymnopilus sp. 'slender'	S				3				3
Hjortstamia crassa	S						3		3
Hymenochaete sp. 'yellow'	S			4				4	
Hymenochaete sp. 'yellow margin'	S						9		9
Lachnia virginatum	S			50				50	
Lepiota cristata	S			1				1	
Lepiota sp. 'light brown'	S			1				1	
Marasmius sp. '223'	S					1			1
Melenophyllum echinatum	S	2						2	
Mycena albidocapillaris	S		25	23		1	1	48	2
Mycena carmelliana	S		2					2	
Mycena mijoii	S		1					1	
Mycena sanguinolenta	S	1						1	
Mycena sp. 'tan dome, long slender stem'	S	26	14	120				160	
Mycena sp. 'grey-br, no bleach'	S						2		2
Mycena sp. 'orange striate'	S						10		10
Mycena sp. 'tiny white scaly cap'	S		6			1	15	6	16
Mycena spp. (unidentified)	S	6		1				7	
Mycena yirakensis	S		5	10		5	2	15	7
Mycoacea sp. 'brown'	S			1				1	
Peziza sp. 'hollow sphere'	S				1				1
Pluteus lutescens "yellow'	S					1			1
Polypore. 'White resupinate'	S						3		3
Psathyrella sp.	S	8		2	2			10	2
Pycnoporus coccineus	S		1			3	3	1	6
Rickinella fibula	S	32	63	15			56	110	56
Scleroderma cepa	S		1					1	
Stereum hirsutum	S				2				2
Total number of species		23	31	26	22	19	29	53	52
Total number of fruit bodies		276	437	270	79	162	228	983	469

Appendix 2 continued

Species	Life-mode[1]	Pc infested + Phosphite spray			Adjacent unsprayed			Total	
		2004	2007	2014	2004	2007	2014	Spray	No spray
Number of species and life-mode									
Coprophilous		1	2	1	1	2	1	1	1
Saprotrophic		10	16	17	6	10	17	28	25
Mycorrhizal		12	13	8	15	8	11	23	26
Number of fruit bodies and life-mode									
Coprophilous		4	27	1	3	6	5	32	14
Saprotrophic		101	270	245	20	126	204	616	350
Mycorrhizal		171	140	24	56	32	19	335	107

[1] M = mycorrhizal, S = saprotrophic, P = parasitic and L = lichenised (symbiotic with algae)