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Distribution and occurrence of *Phytophthora cinnamomi* at Middle Head and North Head, Sydney Harbour

R. Daniel[A,B], *J. Taylor*[A] *and D. Guest*[A]

[A]Faculty of Agriculture, Food and Natural Resources, The University of Sydney, NSW 2006, Australia.
[B]Corresponding author. Email: danielr@agric.usyd.edu.au

Abstract. Dieback due to *Phytophthora cinnamomi* has significant impacts on susceptible native Australian vegetation communities and dependent fauna. Here we report the occurrence and distribution of *P. cinnamomi* at North Head and Middle Head, Sydney Harbour.

The soilborne oomycete *Phytophthora cinnamomi* infects plant roots, penetrating the stele to cause tissue necrosis, root rot and vascular disruptions, which result in dieback and death of susceptible plant species. Studies in the Geriwerd (Grampian) Ranges and Brisbane Ranges National Parks, Victoria, report losses of 45% of overstorey and up to 75% of understorey plant species due to *P. cinnamomi* (Weste 1997, 2003). In Western Australia, an estimated 2000 of the 8000–9000 species are susceptible to *P. cinnamomi* (Wills 1993). As a consequence of disease, plant community structure is disrupted, resulting in a significant disturbance to the ecological balance of natural systems. The inclusion of dieback caused by *P. cinnamomi* as a Key Threatening Process in the Commonwealth's Environment Protection and Biodiversity Conservation Act 1999 and in the New South Wales Threatened Species Conservation Act 1995 highlights the destructive nature of the pathogen and the continuing threat posed to Australia's native ecosystems.

Until recently, *P. cinnamomi* has not been regarded as a serious pathogen of native vegetation in NSW (McDougall *et al*. 2003). It is now known to be widely distributed and has been identified in natural systems including Barrington Tops National Park, Jervis Bay, Royal National Park, the Blue Mountains and Sydney Harbour National Park (Summerell 2002; McDougall *et al*. 2003). Dieback of native plant species has been recognised on the Sydney Harbour foreshore since the 1950s. However, its association with the soilborne pathogen *P. cinnamomi* was first confirmed in 2000 (Summerell 2002; Jensen 2005).

The public lands around Sydney Harbour are a significant recreation and conservation resource. Much of the lands at Middle Head and North Head, on the north-eastern foreshore of Sydney Harbour, are managed by the Sydney Harbour Federation Trust (SHFT) and National Parks and Wildlife Service NSW (NPWS). North Head forms the northern entrance to Sydney Harbour. The headland is characterised by sandstone cliffs capped by high level sand dunes (NSW Department of Environment and Conservation 2004). The area comprises species-rich coastal heath and the endangered sclerophyllous Eastern Suburbs Banksia Scrub (ESBS) fragmented by various infrastructures and land tenures (NSW Department of Environment and Conservation 2004). Middle Head, a peninsula located between North and South Heads in Sydney Harbour, extends from Balmoral in the north-west to Chowder Bay in the east. The area is bordered by urban development and intersected by ex-military infrastructure. At least 199 native flora species occur on the two land masses, including the rare and endangered *Acacia terminalis* subsp. *terminalis* and *Rulingia hermaniifolia* (Anon. 2003). Species believed to be susceptible to *P. cinnamomi* include *Angophora costata, Eucalyptus botryoides* and *Banksia ericifolia* (NSW Department of Environment and Conservation 2004).

Historically, North Head and Middle Head were largely closed to the public and restricted for military use. The lands are highly disturbed as a result of land clearing, military construction activities and, more recently, urban development. The presence of *P. cinnamomi* presents a significant obstacle to managers responsible for regenerating the landscape for return to the public (Anon. 2003; Jensen 2005). The full extent to which *P. cinnamomi* occurs around Sydney Harbour is unknown and land managers are currently conducting surveys to determine the distribution of the pathogen. This report describes the occurrence and distribution of *P. cinnamomi* at Middle Head and North Head on the northern shores of Sydney Harbour.

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Soil samples were collected from Middle Head and North Head and placed in sealed plastic bags for analysis. Locations from which soil samples were taken were georeferenced with a Haicom (HI-302CF) Global Positioning System receiver attached to an iPaq (Hewlett-Packard, Blackburn, Vic.) running ArcPad 6.0 (ESRI, Redlands, CA) software.

A lupin (*Lupinus angustifolius*) bioassay was used to assess the presence of *P. cinnamomi* (Pratt and Heather 1973). Approximately 50 g of soil were placed into a plastic cup, the cup filled with distilled water and the soil and water mixed to form a slurry. Three replicate cups were prepared for each soil sample. Lids were placed on the cups, and they were left to settle overnight. The following day four 2-day-old lupin seedlings were placed through holes in the lids so that the root tips touched the soil/water slurry. Roots were examined macroscopically for wilt and root rot symptoms each day, and symptoms were examined microscopically for the presence of *P. cinnamomi*. *P. cinnamomi* was identified based on morphological characteristics (Erwin and Ribeiro 1996). After 5 days, the seedlings were replaced by freshly germinated lupin seeds and the assay was repeated.

The results of the lupin assay were joined to a shape file of the sample site GPS coordinates. Cadastral information for Middle Head (SHFT) and North Head (Department of Lands, NSW) was acquired and the results of the lupin bioassay displayed in ArcMap 9.0 (ESRI, Redlands, CA).

P. cinnamomi occurred across Middle Head, in the areas known as Georges Heights, 30 Terminal and along the Penguin Walking Track corridor adjacent to HMAS Penguin (Fig. 1). Sampling for *P. cinnamomi* has primarily been conducted along walking tracks (that tend to follow contours) and in grid patterns within project sites prior to development. No distinct relationships between drainage lines or contours and the occurrence of *P. cinnamomi* were noted. However, given the nature of the pathogen and its use of surface water flow as a vector, it is likely that these features would be a course for spread of *P. cinnamomi*.

In addition, there appears to be a pattern of tree dieback in drainage areas at Middle Head and Georges Heights, Mosman, particularly where there has been prior disturbance

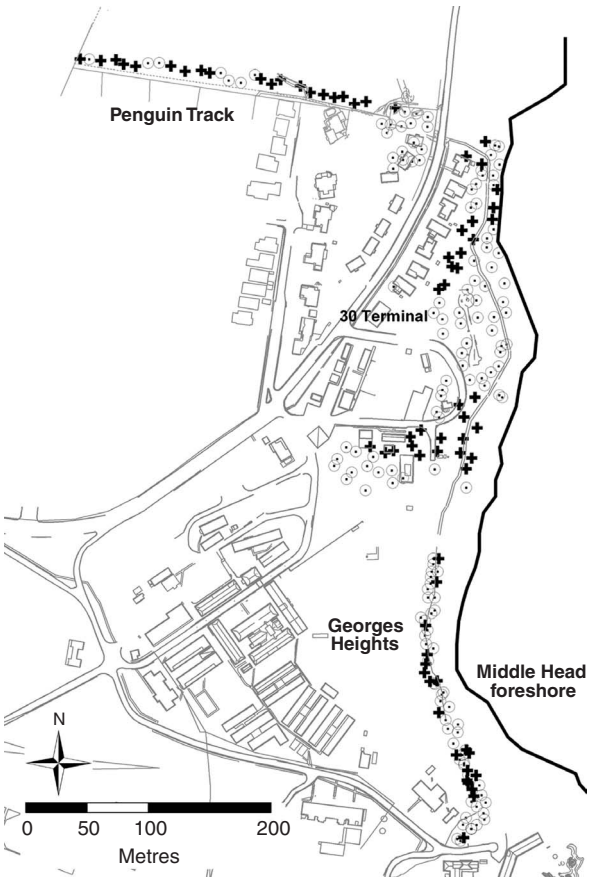

Fig. 1. Distribution of *Phytophthora cinnamomi* at Middle Head, Sydney Harbour, 2004. *P. cinnamomi* was detected by lupin baiting soil sampled from 30 Terminal, Georges Heights and the Penguin Walking Track. +, *P. cinnamomi* present; ⊙, *P. cinnamomi* not detected.

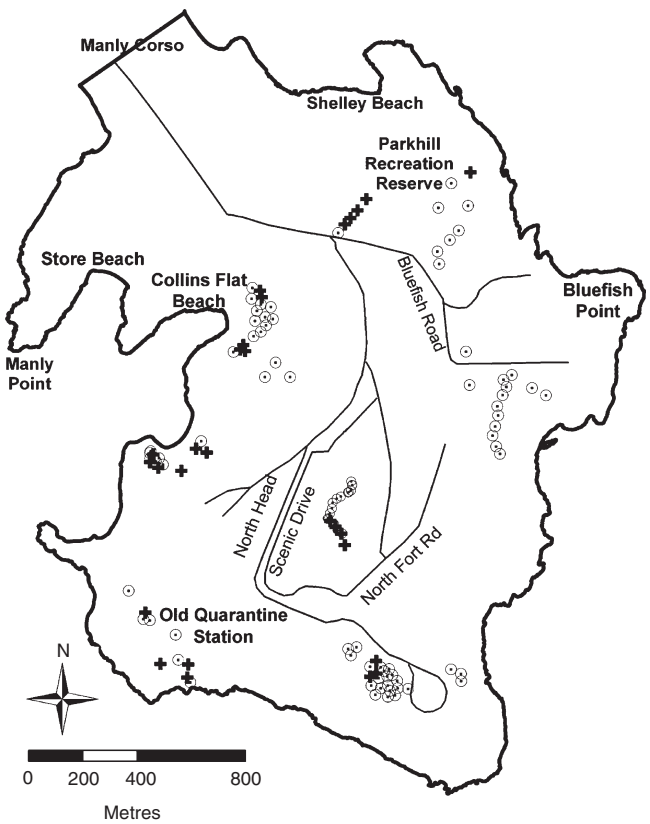

Fig. 2. Distribution of *Phytophthora cinnamomi* at North Head, Sydney Harbour 2005. *P. cinnamomi* was detected by lupin baiting soil sampled from near Bluefish Road, the Old Quarantine Station, uphill of Store Beach and Collins Flat Beach and below the two car parks at the end of North Head Scenic Drive. +, *P. cinnamomi* present; ⊙, *P. cinnamomi* not detected.

in the upper part of the catchment (for example from altered drainage in built areas along the ridge, deposition of fill and nutrient influx from household gardens). This is supported by aerial photographs from 1965 and 2003 that indicate vegetation changes along drainage lines at Middle Head (Jensen 2005). Such observations suggest that dieback in the drainage areas may not be attributable to *P. cinnamomi* alone.

P. cinnamomi was also detected at North Head. In Sydney Harbour National Park, the pathogen was isolated from soil sampled from near Bluefish Road, the Old Quarantine Station, uphill from Store Beach and Collins Flat Beach and the area below the two car parks at the top of North Head Scenic Drive (Fig. 2). Many of these areas are on slopes and often have a history of disturbance or development uphill. The area below the car park at the top of North Head Scenic Drive has been colonised by *Phytophthora*-tolerant rushes and sedges, a characteristic identified as part of the dieback cycle (Weste 2003) following death of susceptible species.

P. cinnamomi was also isolated from SHFT-managed land at Gun Park, North Head. The occurrence of *P. cinnamomi* at Gun Park may be associated with recent dieback in a drainage area to the west of Gun Park. Sampling is continuing to verify the association between *P. cinnamomi* and dieback symptoms in the drainage area. Sampling conducted by other land managers at North Head has also detected *P. cinnamomi* (Sydney Harbour Dieback Working Group, pers. comm.).

It is evident from this study that *P. cinnamomi* is at least partially involved in the dieback of plant species at Middle Head and North Head. Given the extensive historical disturbances and urban influence on the land areas, it is likely that *P. cinnamomi* is not the only factor affecting tree decline in some areas. The incursion of weeds, drought, pollution and additional stresses such as excess nutrients in storm water runoff may affect the expression and effect of dieback due to *P. cinnamomi*. Further studies could determine the role of nutrient loads from storm water runoff, pollution and other environmental influences on plant health and the expression of disease due to *P. cinnamomi*.

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