Longevity of Phytophthora ramorum in terminal tree hosts after removal of primary sporulating hosts

Introduction
The Forestry Commission managed public forest estate in Plym, Devon (south west England), was one of the first locations in late summer 2009 where trees of Larix kaempferi (Japanese larch) were found to be infected with Phytophthora ramorum (EU1 lineage). The 398 ha forest had a high proportion (>30%) of L. kaempferi affected by P. ramorum infection, some with very significant crown dieback. Trees of all ages were affected. The Phytophthora ramorum disease in Plym was also significant as it was the first location where infected trees were found without associated infected Rhododendron ponticum – the latter had been identified as a sporulating host and up until 2009 was considered the main driver of disease spread in the wider environment. The findings in Plym also led to the discovery that L. kaempferi could be both a sporulating and bole host.

As part of disease management, all larch trees were removed from Plym forest between 2009-2011. Prior to removal however, P. ramorum spores released from infected larch foliage had already initiated die back and bole cankers in a wide range of non-sporulating coniferous and broadleaved trees that were either part of the understorey or present in stands adjacent or nearby to the infected L. kaempferi.

Approach
In March 2015, forest areas adjacent to now removed but previously infected larch were re-surveyed. Trees with symptoms of crown dieback and typical P. ramorum bole cankers could be readily identified. A sub-set of the trees now had cankers that almost entirely girdled the stem; in some conifers the upper crown had also been entirely killed. What appeared to be actively expanding lesions were identified on some affected trees. Lesions occurred at near ground level to c. 5m in height on the stems; active lesions were tested for presence of P. ramorum.

Results
Broadleaved hosts Mature beech (Fagus sylvatica) were identified with active bleeding cankers (Fig.1c). Bark removal revealed extensive aerial lesions typical of P. ramorum (Fig. 1a). In addition, beech trees previously sampled and confirmed infected by P. ramorum were re-inspected; in some the sunken and callused appearance of the cankers indicated that active P. ramorum infection ceased (Fig. 1b).

Coniferous hosts Several symptomatic semi-mature Abies grandis (grand fir), Pseudotsuga menziesii (Douglas fir) and Tsuga heterophylla (western hemlock) were found in immediate proximity to the previously felled infected larch. Many of them had signs of recent, profuse resin exudation (Fig. 2). Investigation under the resinous bark revealed discoloured necrotic lesions typical of P. ramorum infection. However, infection progression in other trees appeared to have ceased – the resin exudations had darkened and dried, cankers were sunken and in many cases had healthy callus growth around the edges (Fig. 2).

Conclusions
Our observations suggest that even when the opportunity for successive years of re-infection is eliminated by removal of spore generating larch, P. ramorum can remain viable and continue to cause expanding stem lesions in some terminal (non-sporulating) tree hosts for at least 5 years. This has biosecurity implications for the processing of infected timber from sites with a history of infection. It also raises the question of why larch trees succumb so rapidly to disease, often in just 2-3 years, while other susceptible conifer terminal hosts remain alive for much longer despite sustaining active and potentially lethal stem infections.