

Human Activity and the Spread of *Phytophthora ramorum*

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Increasing numbers of studies are finding that humans can facilitate the spread of exotic plant species in protected wildlands. Hiking trails commonly serve as conduits for invaders and the number of exotic plant species occurring in protected areas is often correlated positively with visitation rates. Despite such evidence linking human activity to the spread of exotic plants, few studies have addressed this possibility for plant pathogens.

Over the past four years, we have been evaluating the role that humans play in promoting the spread of *P. ramorum* and the disease it causes. Our previous research has suggested that human activity is hastening the spread of *P. ramorum* in northern California's Sonoma County: the pathogen was more commonly found in soil on hiking trails than from soil in adjacent areas off trails; public lands open to recreation had higher proportions of diseased host trees than private lands; and the chance that host trees were infected by *P. ramorum* increased as the density of human populations increased in the surrounding area. Collectively, these data suggest that human activity can inadvertently disperse *P. ramorum* throughout the landscape, further spreading the pathogen into already infected areas and introducing it into previously uninfected areas.

More recently, we have conducted additional studies that further link two forms of human activity - hiking and mountain biking - to the dispersal of *P. ramorum*. First, at a nature preserve in Sonoma County, we have shown that hikers can disperse *P. ramorum* in soil on their shoes at least 60-100 m into areas that lack local sources of inoculum. Second, we found that 5-10 % of the visitors entering a recreational area in Marin County had the pathogen in soil on their shoes and tires, and 20-30 % carried it out with them. Although hikers and mountain bikers did not differ significantly in the capacity to transport *P. ramorum*, there was a trend indicating that during dryer conditions, the further a person

traveled along a trail, the more likely they were to pick up and transport the pathogen. In addition, although our data suggest that humans can serve as effective dispersal agents, the temporal window for doing so is constrained, as the pathogen could not be cultured from soil on hikers' shoes after 24 hours, although this time was extended to at least 72 hours if the soil on hiking shoes was kept moist. These results suggest that human dispersal of *P. ramorum* may be limited to certain kinds of situations: further spread of the pathogen in already infected areas or instances in which visitors move rapidly from one region to another, especially when hiking shoes or mountain bikes have been stored in moist conditions.

In summary, our research suggests that there may be conflicts between human activities and disease spread, and that efforts to address this epidemic may require aggressive management, which may be logistically and politically challenging to implement.