GROWING KNOWLEDGE

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Rhododendrons with symptoms of *Phytophthora ramorum* blight are quarantined pending diagnostic testing. PHOTO COURTESY OF OREGON STATE UNIVERSITY

Managing epidemics

Whether dealing with plant pathogens or COVID-19, common principles apply

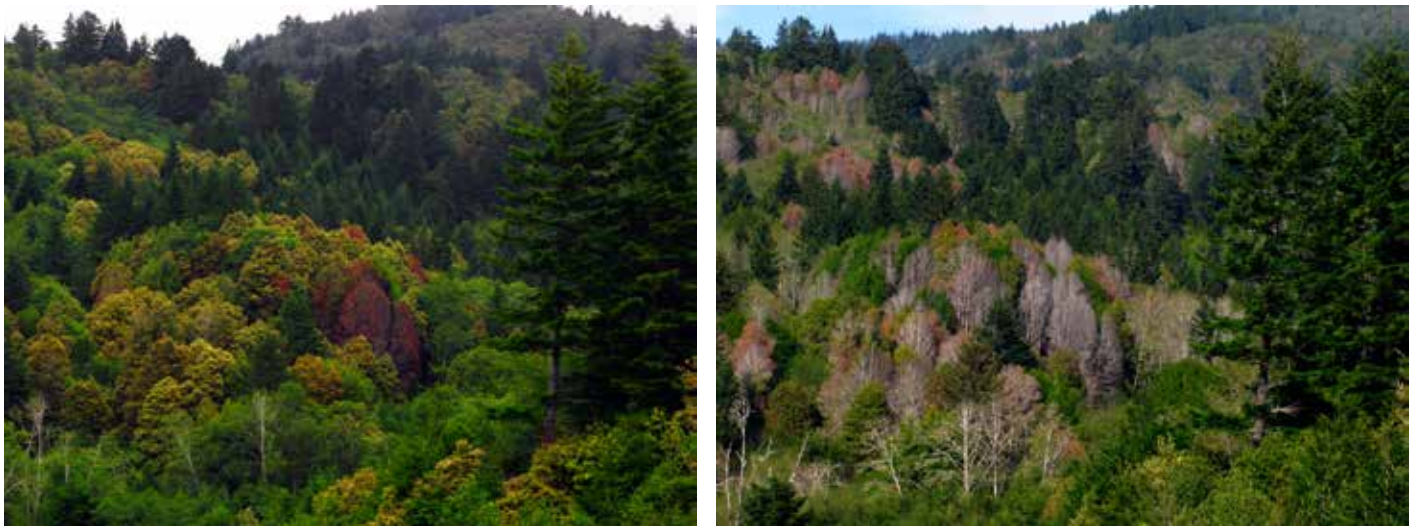
BY JENNIFER PARKE

THE COVID-19 PANDEMIC has changed life as we know it, threatening human health, causing disruption to our society, and resulting in economic challenges. While impacts of plant pests and diseases may pale in importance compared to COVID-19, they still cause large-scale ecological and economic damage to forests, and urban and suburban landscapes.

We can learn some important lessons from the current human pandemic, and apply them to managing plant pest infestations and plant disease epidemics. The converse is also true: our experience with plant diseases and pest infestations can also inform our response to COVID-19.

For this article, I will be drawing from my 19 years of experience working with the sudden oak death (SOD) organism, *Phytophthora ramorum* — a pathogen that has killed more than 30 million trees in California and Oregon. It has threatened both the timber industry and the nursery industry with reduced markets.

Changes to a forest near Brookings, Oregon from 2011 (left) to 2013 (right) caused by sudden oak death. Dead and dying trees are tanoak. PHOTO COURTESY OF EBBA PETERSON, OREGON STATE UNIVERSITY.



Pathways of entry

Although COVID-19 is caused by a virus and SOD is caused by a water mold, both diseases result from new, exotic pathogens whose spread is exacerbated by the global transportation of people and goods. While international travelers initially drove the spread COVID-19, the movement of imported goods spreads plant pests and pathogens.

It is estimated that 69% of the insects and pathogens that damage American forests and urban landscapes enter the country on imported live plants. More than 3 billion live plants are imported into the U.S. annually, an increase of 500% from 1967–2009.

A secondary entry pathway consists of wood packaging materials, such as crates and pallets used in shipping (Lovett et al. 2016). Imported pests include emerald ash borer (EAB), Asian longhorned beetle, and balsam wooly adelgid; imported diseases include Dutch elm disease, chestnut blight, and SOD. While some regulations have been put in place to limit imports of high-risk plant material and require heat or chemical treatments on wood packaging material, we need to consider more effective strategies for preventing new pests and pathogens from arriving on our doorstep.

Preventative strategies cost significantly less than the work needed to control the spread of pests and pathogens once they have established. Now that the EAB is in the U.S., it has killed hundreds of millions of ash trees. The cost of responding to the damage through 2020 is estimated to be $12.7 billion.

Quarantines that prevent shipments of live plants and treatments of wood packaging from known infested areas can exclude many pests and pathogens. Points of entry, such as shipping ports, should be monitored closely to intercept new pests and pathogens. However, pests and especially microscopic pathogens are difficult to detect.

An alternative strategy is to require source countries to abide by "clean stock" production practices. A successful example of this is imported geranium cuttings, which must be produced according to strict phytosanitary guidelines required by the USDA Animal and Plant Health Inspection Service (APHIS).

The "clean stock" certification program prevented the spread of the select agent *Ralstonia solanacearum* Race 3 Biovar 2 into the U.S. from 2004–2020. It is a bacterial pathogen that causes a deadly disease for potatoes and tomatoes.

Ideally, the health of human travelers should similarly be monitored prior to travel, including testing and certifying individuals do not have COVID-19 before boarding planes and cruise ships.

Preventing transmission

Once a pathogen or pest has arrived in the U.S., early detection is key to preventing spread; pest identification, recognition of disease symptoms, and development of rapid diagnostic tests are needed.

Rapid testing and reporting of the results are key to identifying disease outbreaks. As is the case with COVID-19, diagnostic tests based on the polymerase chain reaction (PCR) are commonly used to identify of *P. ramorum* and other plant pathogens.

Eradication of novel pests and pathogens is possible, but only in the earliest stages when the outbreak is small and localized. Bold, swift action — similar to the actions of New Zealand to stop the spread of COVID-19 — is necessary to eradicate pests and pathogens before they begin to spread. The effort to stop SOD from proliferating through the forests of Curry County, Oregon did not succeed because the areas around infected trees that were cleared and burned were initially too small. These efforts did significantly slow the spread of the disease, however.

If exclusion and eradication fail, the disease must then be managed over a long time frame. Effective disease management requires an understanding of how the pathogen is transmitted from one infected individual to another. For newly discovered pathogens such as COVID-19, it takes time for researchers to determine how it spreads. In time, researchers develop strategies that specifically target transmission.

For COVID-19, person-to-person transmission was initially attributed to large droplets and contaminated surfaces. As of the writing of this piece, it is now known that the virus primarily spreads by aerosols and large droplets — particularly in indoor environments. Wearing face masks has been shown to drastically reduce person-to-person transmission of COVID-19.

For *P. ramorum*, the initial focus was on preventing the localized movement of contaminated soil. Subsequent research indicated that *P. ramorum* produces spores in the tree canopy foliage, which are then carried by rain or turbulent air.

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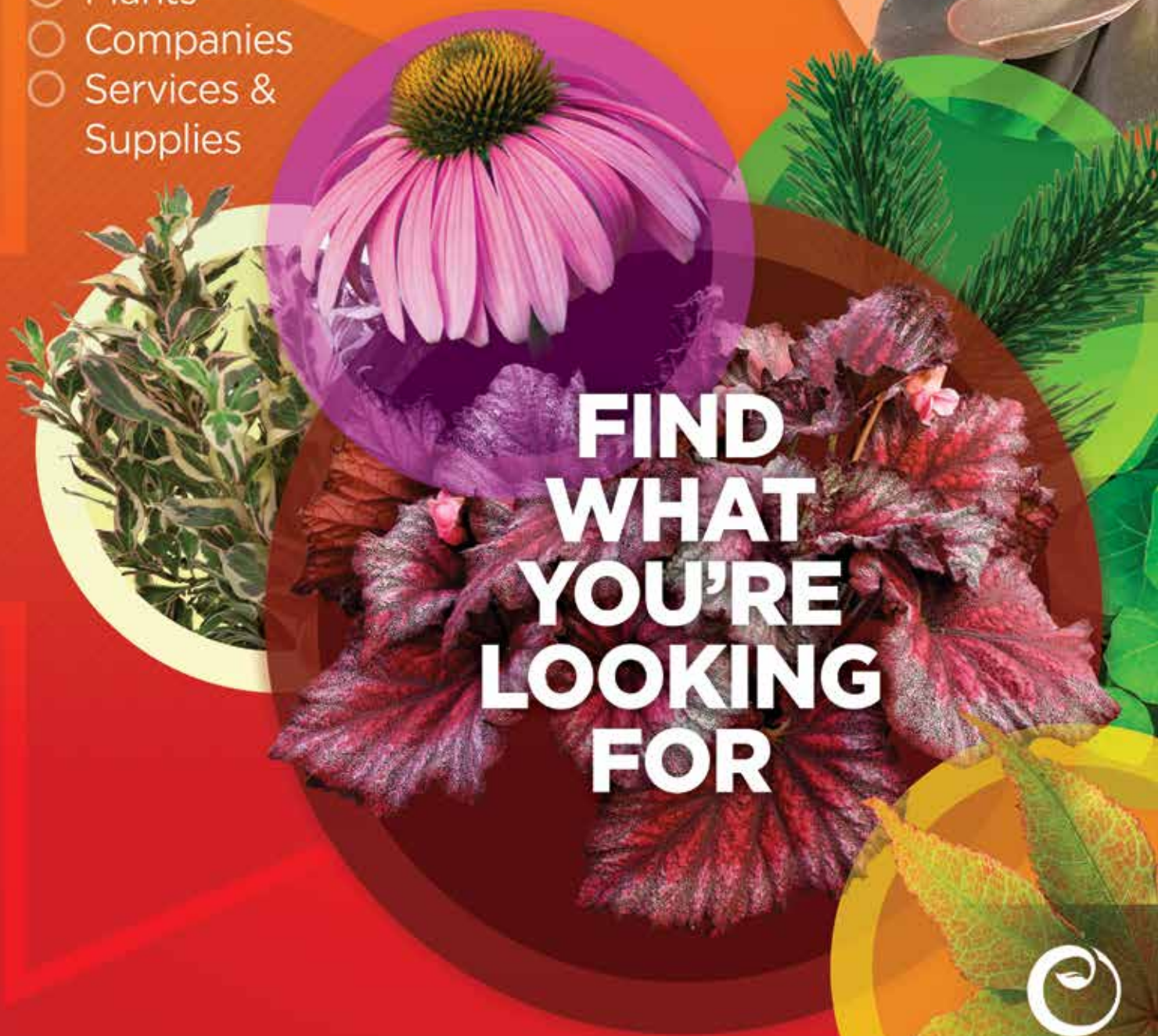

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These findings explain the occasional, sporadic spread over distances of a few miles. Plus, this feature of its epidemiology makes it very difficult to predict when and where the spores will initiate new infections in the forest.

Aerial surveys are currently being used to spot early signs of infected trees and play a critical role in managing the disease. The long-distance spread of the pathogen across state lines was also traced to shipments of infected nursery plants.

Superspreader events

As with COVID-19, "superspreader" events can result in large outbreaks. Superspreader events for *P. ramorum* can consist of a single nursery that sends contaminated plants to multiple locations across the country — something that has occurred several times since 2003.

Most recently in 2019, one nursery in Washington and two in Canada shipped *P. ramorum*-infested rhododendrons to their customers, and the plants were eventually distributed to 18 midwestern and eastern states.

When superspreader events occur, it is vital to conduct trace-forwards and trace-backs (analogous to contact tracing for COVID-19) in a timely way to identify the source of infection. We must follow-up on potential new infestations before they spread to established vegetation.

As with COVID-19, where certain sectors of the human population are more susceptible to disease than others, *P. ramorum* also affects certain plant species more than others. Rhododendron, *Camellia*, *Viburnum*, *Kalmia*, *Pieris* (in nurseries) and tanoak and coast live oak (in forests) are all susceptible to SOD infection. Asymptomatic hosts exist for both pathogens, confounding disease detection and interfering with efforts to limit disease spread.

For example, with COVID-19, up to 30% of infected individuals do not develop symptoms, but they may still carry high loads of virus inoculum that infect other people.

In an interesting parallel, Oregon myrtlewood (also known as California bay laurel) is not killed by *P. ramorum,* and this species only develops inconspicuous leaf spots. However, infested trees will produce abundant levels of spores which can infect and kill nearby oak and tanoak trees. We have much to learn about why certain individuals or plant species are at higher risk than others.

Strategies for control

Sanitation and physical distancing are strategies which reduce disease transmission for both COVID-19 and *Phytophthora ramorum*. For COVID-19, sanitation involves handwashing, wearing face masks, cleaning of high-touch surfaces, and filtering of contaminated air.

For *P. ramorum,* sanitation in nurseries involves removing fallen infested leaves; solarization, steam-treating, or fumigating contaminated soil and containers; and disinfecting contaminated irrigation water.

Social distancing with humans means staying at least 6 feet apart, avoiding physical gatherings (especially indoors), and staying within household "bubbles" or small-group "pods" to limit exposure. Nursery managers are similarly encouraged to employ plant spacing between blocks of plants. That way, in case an infection arises, only plants within a continuous block need to be destroyed.

Moreover, just as visitors from certain states with high COVID-19 infection rates are urged to quarantine themselves temporarily, recent plant acquisitions from other nurseries should be isolated in a separate area and monitored for symptoms.

One significant difference in the treatment of human diseases and plant diseases is the availability of therapeutic agents and vaccines. Therapeutic agents for human diseases focus on medicines administered to sick people to cure disease or reduce symptom severity. In contrast, few pesticides applied to plants have curative properties; most act as chemical protectants and are most effective when applied to healthy plants to prevent infection or infestation.

While developing an effective vaccine is the goal to control COVID-19, it is highly unlikely that there will be vaccines for any plant diseases because of the prohibitive research and production costs. However, plant scientists have a tremendous tool that medical practitioners

For more information

SOD, sudden larch death, and ramorum blight
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***Phytophthora* Online Course: Training for Nursery Growers**
J. Parke, J. Pscheidt, R. Regan; J. Hedberg; N. Grunwald
tinyurl.com/y3wson2o

must go without: the genetic manipulation of hosts to develop disease resistance through traditional breeding and selection, or through transgenic methods. (Although it is now possible to modify human genes to cure or prevent certain genetic diseases such as sickle cell anemia, this is fraught with many ethical considerations and therefore not an option in the forseeable future.)

The overall approach

Outbreaks of novel diseases and pests require a coordinated, multi-agency approach to monitor, manage and remedy each incident using the best available science. In the case of COVID-19, this is the federal Center for Disease Control (CDC), the National Institutes of Health, and state and local departments of health. In the case of plant pests and diseases, USDA-APHIS is the lead agency, coordinating with the state departments of agriculture and forestry (or natural resources).

Researchers at universities and state and federal labs are central to generating the scientific knowledge base. Approaches to disease and pest management must evolve to reflect advances in our scientific understanding of the pathogens or pests.

In conclusion, the global movement of people and goods will continue to deliver new diseases and pests, presenting new challenges to nurseries. We must be able to mobilize quickly to identify new threats to plant health and to quickly limit disease and pest outbreaks before damaging natural resources, agriculture, and forestry.

A robust, coordinated national strategy of monitoring and early detection is paramount. COVID-19 has increased the public's awareness of the power of microbes and taught us to think more broadly about epidemiology.

The lessons we learn can be applied to cope intelligently with new pests and diseases — those affecting humans as well as those affecting plants.

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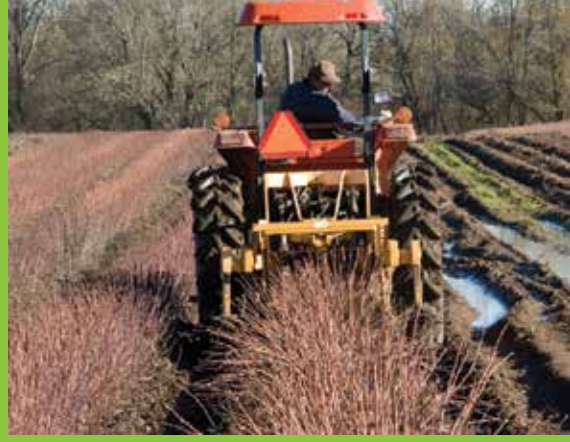

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