



Exotic Pathogens, Resistant Seed, and Restoration of Forest Tree Species in Western North America

Richard A. Snieszko, Diana F. Tomback, Regina M. Rochefort, Ellen Goheen, Rich Hunt, Jerry S. Beatty, Michael Murray, and Frank Betlejewski

Abstract—Non-native invasive pathogens such as white pine blister rust (*Cronartium ribicola*) and Port-Orford-cedar root disease (*Phytophthora lateralis*) are killing trees and disrupting forest ecosystems in western North America. Populations of western white pine (*Pinus monticola*), sugar pine (*P. lambertiana*), whitebark pine (*P. albicaulis*), and limber pine (*P. flexilis*) are declining precipitously from damage by blister rust. Foxtail pine (*P. balfouriana*) and southwestern white pine (*P. strobiformis*) populations are also infected by blister rust in parts of their range. *P. lateralis* continues to spread and kill Port-Orford-cedar (*Chamaecyparis lawsoniana*) in Oregon and California. Because resistant individuals in all these species are rare, genetic variation may be reduced to the point where future populations may not be viable without active management. Seeds from resistant parents are now available for western white pine, sugar pine, and Port-Orford-cedar restoration for some areas. Selection and breeding programs for resistance, coupled with active ecological management, will be needed to create opportunities to restore and retain these species in forest ecosystems on federal or crown lands. Any strategy for restoration must include opportunities for natural regeneration and planting, with the goal of maintaining these species on the landscape until resistance characterizes populations. Intervention to restore more natural conditions in wilderness may be evaluated case-by-case, and weighed against other wilderness values. Organizational and implementation strategies that are developed for managing *C. ribicola* and *P. lateralis* can provide a starting point for work involving other introduced pathogens. See the poster at <http://www.fs.fed.us/r6/dorena/posters/index.shtml> for more details.

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Richard A. Snieszko is with the USDA Forest Service, Dorena Genetic Resource Center, 34963 Shoreview Road, Cottage Grove, OR 97424.

Diana F. Tomback is with the University of Colorado at Denver, Department of Biology, CB 171, P.O. Box 173364, Denver, Colorado 80217.

Regina M. Rochefort is with the USDI National Park Service, North Cascades National Park Service, 810 State Route 20 Complex, Sedro-Woolley, WA.

Ellen Goheen and Frank Betlejewski are with the USDA Forest Service, Southwest Oregon Forest Insect and Disease Service Center, 2606 Old Stage Road, Central Point, OR 97502.

Rich Hunt is with Natural Resources Canada, Pacific Forestry Center, 506 W. Burnside Road, Victoria, BC V8Z 1M5, Canada.

Jerry S. Beatty is with the USDA Forest Service, RPC 7, Forest Health, 1601 N. Kent St., Arlington, VA 22209.

Michael Murray is with the USDI National Park Service, Crater Lake National Park Service, PO Box 7, Crater Lake, OR 97604.



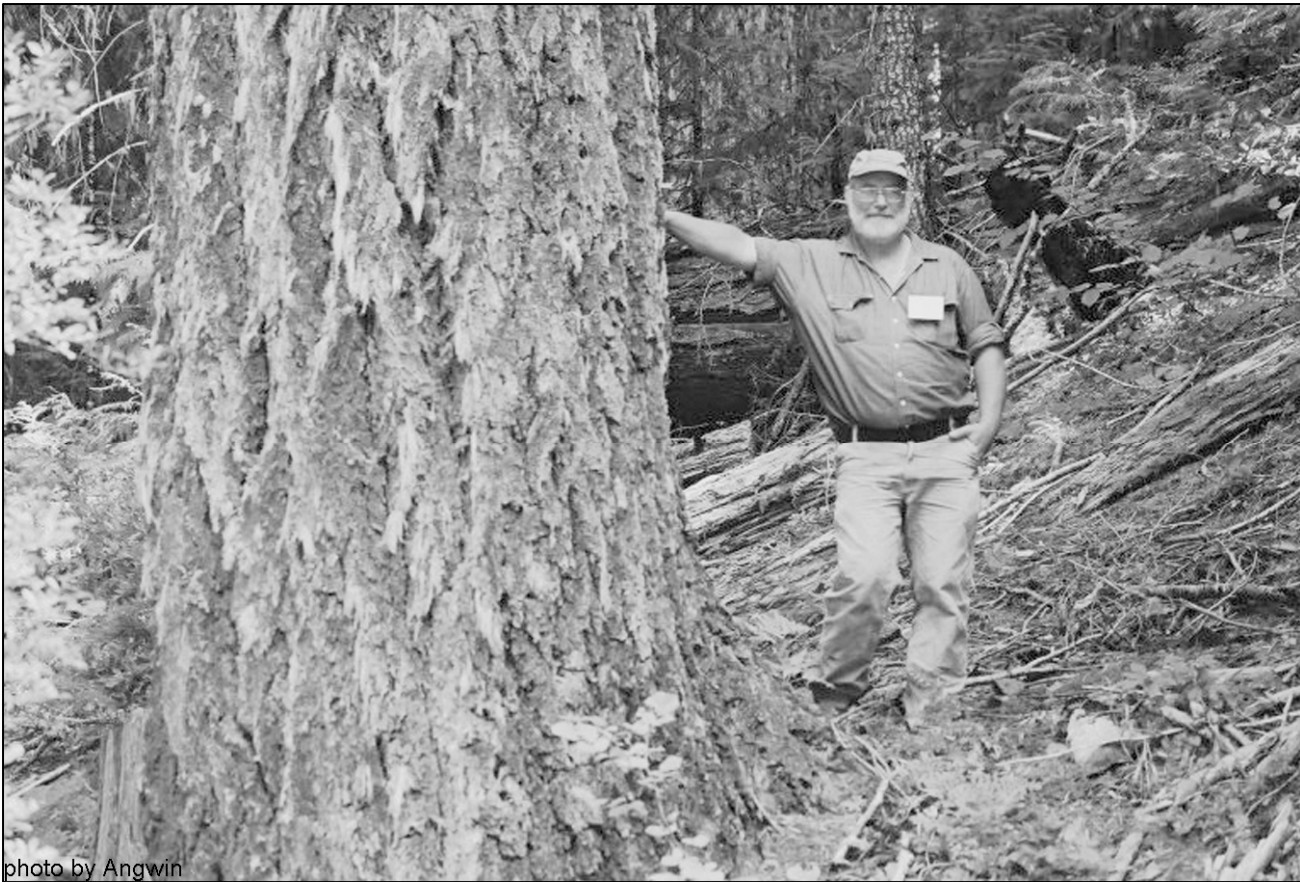


photo by Angwin



Panel: Quarantines and Problematic Genetic Exchange

Susan Frankel, Moderator

The impetus for this panel comes from two bitter and difficult experiences in California with forest pathogens and quarantines—*Fusarium circinatum* (cause of pitch canker) in the mid-1990s, and more recently, *Phytophthora ramorum* (cause of sudden oak death and other diseases).

Despite lengthy debate, *Fusarium circinatum* was never quarantined. I understand now, after struggling with the *P. ramorum* quarantine, why regulatory agencies refused to quarantine *F. circinatum*. Part of the problem with the debate was, we didn't know what we were asking for. We, forest pathologists in California, did not fully understand what a quarantine is, and how it is enforced.

Program

Our objective in today's panel is to provide a basic understanding of quarantines and how they are developed and enforced in North America. We will also suggest ways the systems used to prevent pathogen establishment may be improved. We have assembled the following speakers:

History of forest disease quarantines in the United States. Borys Tkacz, National Program Manager, Forest Health Monitoring, Arlington, VA.

The regulatory system for forest pathogens in North America, the European Union, and other parts of the world: a pop quiz! Susan Frankel, Plant Pathologist, Pacific Southwest Region, Forest Health Protection, Vallejo, CA.

***Phytophthora ramorum* quarantine: Challenges of regulating a new organism with a wide host range.** David Rizzo, Associate Professor, UC Davis, CA.

Preventing exotic pathogen threats to forests—a sideways scientific look. Clive Brasier, Pathology Branch, Forest Research, Farnham, Surrey, UK.

Current challenges in forest pathogen protection. Faith T. Campbell, Director, Invasive Species Program, American Lands Alliance, Washington, DC.

! [Should anyone ask: 1-c, 2-c, 3-c, 4-a, 5-c, 6-d, 7-a,b,c,d]

Recipe

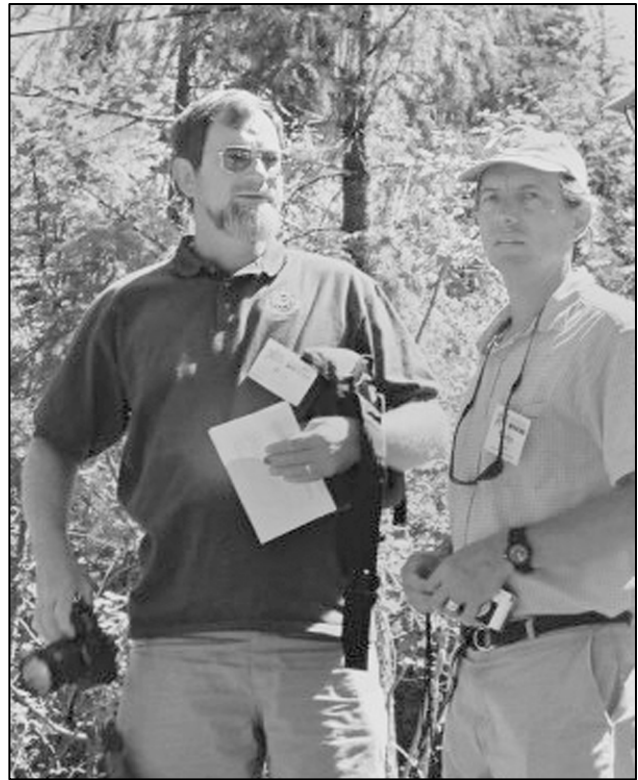
I will start off with a demonstration of how the quarantine for *Phytophthora ramorum* was formulated.

Recipe for the *Phytophthora ramorum* (Sudden Oak Death) quarantine

- ✎ Mix in a standard blender:
- ✓ 1 new red potato (forest pathologists)
- ✓ 78 peanuts (local citizens)
- ✓ 1 snack-size box raisins (media and legislators)
- ✓ 1 box, individual serving-size, Fruit Loops cereal (State regulatory agencies)
- ✓ 1 cup ice (Federal regulatory agency)
- ✓ 58 cloves garlic (California County Agricultural Commissioners)
- ✓ 1 miniature baseball bat (special interest groups)
- ✓ 1 sugar pine cone (Native American Tribal Members).
- ⌚ Puree for three years.
- ✎ Add additional spices, fruits, and nuts upon need or demand. It may be difficult to fit some items in the blender and combine them.



photo by Angwin





History of Forest Disease Quarantines in the United States

Borys M. Tkacz

Abstract—Invasive forest pathogens present significant threats to the health of forests. Previous introductions of invasive forest pathogens into new environments have resulted in severe tree diseases with long-lasting economic and environmental impacts. Quarantine regulations have been promulgated in attempts to limit the spread of established invasive forest pathogens and prevent new introductions. This paper reviews the history of quarantines against invasive forest pathogens in the United States and discusses challenges associated with preventing new introductions.

Introduction

Introductions of non-native forest pathogens into North American forests have resulted in devastating diseases affecting many native and planted forests. Some of the most damaging forest pathogens have appeared since 1900 (Hepting 1964; table 1).

Table 1—Diseases caused by exotic forest pathogens.

Disease	Hosts	Year Discovered
Chestnut blight	<i>Castanea</i>	1904
Blister rust	<i>Pinus</i> (5-needled)	1906
Beech bark disease	<i>Fagus</i>	1920
Larch canker	<i>Larix</i>	1927
Dutch elm disease	<i>Ulmus</i>	1930
Littleleaf	<i>Pinus</i>	1932
Persimmon wilt	<i>Diospyros</i>	1933
Mimosa wilt	<i>Albizia</i>	1935

The sudden appearance of these and other damaging plant pathogens led to the development of quarantine laws aimed at halting the spread of diseases to new locales. This paper summarizes the history of quarantines against invasive forest pathogens in the United States (US) and discusses the challenges associated with preventing the spread of forest diseases.

Early Quarantine Laws

Discovery of large numbers of brown tail moth and gypsy moth on fruit stock arriving in US in 1909 and 1910 led to introduction of a plant quarantine bill in the House and Senate in early 1909 (Johnson 1964). Although it was initially thwarted by strong nursery interests, the bill finally

passed on August 20, 1912 as the **Plant Quarantine Act** (PQA). The Act included the following provisions:

Required permits for imports and inspections of nursery stock;

Notification of Secretary of Agriculture of the arrival of any nursery stock at port of entry and identification of source;

Authority for Sec. of Ag. to promulgate regulations regarding international or interstate quarantine restrictions;

Penalties for violations—misdemeanor—\$500 fine and/or one year imprisonment;

Appropriated \$25,000 to Sec. of Ag. to carryout provisions of Act.

Quarantine No. 1—The first foreign quarantine promulgated under PQA was to prevent further introduction of the white pine blister rust fungus (*Cronartium ribicola*) by restricting importation of 5-needle pines from “each and every country of Europe and Asia”. Subsequent rules targeting forest trees were merely repetitions of the minimum provisions of the bill itself:

Unlimited importation of forest trees was allowed;

Foreign inspection and certification were required;

Additional re-inspection was to be done at destination in US by State inspectors;

Inspections were limited to above-ground portions of plants.

Quarantine No. 26—issued on April 21, 1917—authorized destruction of *Ribes* to control the spread of white pine blister rust. Emphasis was on cultivated European black currant, but all *Ribes* were prohibited within “infection distance” of white pine. There were no provisions for compensation to owners. This provided the basis for a large-scale wild *Ribes* eradication program—“the most extensive forest disease control effort in time, money, men, and materiel in the history of US forestry” (Maloy 1997).

Quarantine No. 37—issued on June 1, 1919—excluded most classes of nursery stock and trees from importation to the US. Admissible plants had to be free of soil and were

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Tkacz, Borys M. is National Program Manager for Forest Health Monitoring, USDA Forest Service, 1601 N. Kent St., Arlington, VA 22209.

subject to treatment as a condition of entry. This ushered in a “strengthening of our system of plant protection on a valid biological basis” (Johnston 1964). Quarantine 37 was revised on January 1, 1949 and merged a variety of rules, regulations, and appendices into one document:

Specifically listed genera were prohibited entry from certain countries;

Provisions were specified for post-entry quarantine;

Size-age limitations were specified for admissible plants—stage easiest to inspect and least likely to harbor plant pests;

Mandatory treatments were required for some plants;

Forest trees were only admissible as seeds.

Federal Plant Pest Act of 1957—broadened the definition of plant pest to include any known organism that can directly injure a plant. It allowed for restriction of “pest carriers” such as soil and provided authority to take emergency action against pests and issue regulations to prevent spread of plant pests.

More Recent Laws

Cooperative Forest Assistance Act (1978)—authorized Secretary of Agriculture to protect forests and trees from insects and diseases and provided for coordinated action by Federal and non-Federal land managers to prevent and control forest insects and diseases.

Forest & Rangeland Renewable Resources Research Act (1978)—authorized research and dissemination of information on protecting and managing forests.

Agricultural Quarantine Enforcement Act (1989)—prohibited shipment of quarantined materials via mail.

Plant Protection Act of 2000—replaced the Federal Noxious Weed Act and many other Animal and Plant Health Inspection Service (APHIS) plant protection authorities. The law consolidated and modernized all major statutes pertaining to plant protection and quarantine; permitted APHIS to address all types of weed issues; increased the maximum civil penalty for violation; and authorized APHIS to take both emergency and extraordinary emergency actions to address incursions of noxious weeds.

International Plant Protection Agreements

Greatly increased international traffic in agricultural products following World War II led to sudden and severe outbreaks of plant pests and diseases in many countries and

aroused interest in international cooperation on plant quarantines. In 1949, the United Nations–Food and Agriculture Organization (FAO) proposed the establishment of a broad international agreement on plant protection (Ling 1964). The **International Plant Protection Convention** (IPPC) was formally approved by the FAO conference in 1951. Contracting governments agreed to:

Set up satisfactory national quarantine services;

Participate in regional plant protection agencies;

Participate in international control campaigns during emergency outbreaks;

Report on occurrence, outbreak or spread of plant pests.

The IPPC specified responsibility for exporting and importing countries for the prevention of international spread of dangerous pests and diseases. It introduced a standard phytosanitary certificate as proof of duly performed export inspection.

The World Trade Organization’s **Sanitary and Phytosanitary (SPS)** agreement was ratified in April, 1996. The agreement requires that countries strive towards greater transparency and scientific basis supporting their actions with trade partners. SPS provides procedures to reveal, challenge, and eliminate unjustified phytosanitary trade barriers.

In November, 1997, the IPPC was revised to comply with SPS the agreement. The revised convention states that phytosanitary measures may be no more stringent than measures applied to same pests within importing country. Safeguards may only be applied to regulated pests: “quarantine pests”—those not yet present in importing country and “regulated non-quarantine pests”—those pests regulated within importing country. International standards are developed under the authority of the IPPC Secretariat.

Current Federal Quarantines

Quarantine 37—Current regulations governing imports of living plants into the US are listed in Title 7 of the Code of Federal Regulations (CFR), part 319.37. Specific plants and plant pests are prohibited, although the list of forest trees and associated pathogens is fairly limited (table 2). Permits are required for importation of specifically listed species from specified countries. The regulations allow imports of artificially dwarfed trees or shrubs; specify special foreign inspection and certification requirements for several types of plants; describe required post entry quarantine procedures; and specify special ports of entry. Plants must be imported without any growing media, with certain

exceptions (for example, *Rhododendron* from Europe with phytosanitary certificate).

Regulations Regarding Importation of Unmanufactured Wood—Following concerns raised about the dangers associated with importation of unmanufactured wood and a series of pest risk assessments completed by the USDA Forest Service (Tkacz 2002), APHIS issued general prohibitions and restrictions on importation of unmanufactured wood (Title 7, CFR, part 319.40). These regulations specify:

General permits for Canada and border states of Mexico;

Procedures for permit applications for wood imports;

Importation and entry requirements for wood imports, including—

Universal requirements,

Softwoods from Asia,

Wood from New Zealand and Chile;

Standards for pest risk assessments, treatments and safeguards.

Current federal domestic quarantines restrict the interstate movement of the following forest pests: gypsy moth, European larch canker, pine shoot beetle, Asian long horned beetle, and sudden oak death (Interim).

European Larch Canker Quarantine—(7 CFR 301.91)—quarantines all parts of larch (*Larix* spp.) including logs, pulpwood, branches, twigs, etc., as regulated articles. Also, any other product, article, or means of conveyance whatsoever, is restricted when it has been determined by an inspector that it presents a risk of spread of the disease. The quarantine designates parts of Hancock, Knox, Lincoln, Waldo, and Washington Counties in Maine as the

Table 2—List of prohibited forest trees and pathogens (7CFR319.37-2)

Prohibited trees	Foreign places from which prohibited	Plant pests existing in the places named and capable of being transported with the prohibited article
<i>Abies</i> spp.	All except Canada	50 or more species of rusts including <i>Chrysomyxa abietis</i> (Wallr.) Unger; <i>Phacidiopycnis pseudotsuga</i> (M. Wilson) G. Hahn (Douglas-fir canker)
<i>Acer</i> spp.	Japan Europe, Japan	<i>Xanthomonas acemea</i> (Ogawa) Burk. Maple mosaic or variegation diseases
<i>Aesculus</i> spp.	Czechoslovakia, Germany, Romania, United Kingdom	Horsechestnut variegation or yellow mosaic disease
<i>Castanea</i> spp.	All	<i>Cryphonectria parasitica</i> (Murrill) Barr (chestnut blight); <i>Dryocosmus kuriphilus</i> Yasumatsu (gall wasp)
<i>Cedrus</i> spp.	Europe	<i>Phacidiopycnis pseudotsuga</i> (M. Wilson) G. Hahn (Douglas-fir canker); <i>Fusarium fuliginosporum</i> Sibia (Seedling disease)
<i>Eucalyptus</i> spp.	Europe, Sri Lanka, and Uruguay	<i>Pestalotia disseminata</i> Thuem. (parasitic leaf fungus)
<i>Juniperus</i> spp.	Austria, Finland, and Romania Europe	<i>Stigmia deflectans</i> (Karst) Ellis (Needlecast disease) <i>Phacidiopycnis pseudotsuga</i> (M. Wilson) G. Hahn (Douglas-fir canker)
<i>Larix</i> spp.	Provinces of New Brunswick and Nova Scotia in Canada, Europe, and Japan	<i>Lachnellula willkommii</i> (R. Harteg) Dennis (European larch canker)
<i>Picea</i> spp.	Europe, Japan, and Siberia Europe	<i>Chrysomyxa ledi</i> var. <i>rhododendri</i> (de Bary) Saville (Rhododendron-spruce needle rust) <i>Phacidiopycnis pseudotsuga</i> (M. Wilson) G. Hahn (Douglas-fir canker)
<i>Pinus</i> spp. (2 or 3-leaved)	Europe and Japan Japan	<i>Cronartium flaccidum</i> (Albertini and Schwein.) Wint. (Rust causing serious stunting of hard pines) Gall-forming rust
<i>Populus</i> spp.	Europe	<i>Xanthomonas populi</i> Ride (canker)
<i>Pseudolarix</i> spp.	Provinces of New Brunswick and Nova Scotia in Canada, Europe, and Japan	<i>Lachnellula willkommii</i> (R. Harteg) Dennis (European larch canker)
<i>Pseudotsuga</i> spp.	Europe	<i>Phacidiopycnis pseudotsuga</i> (M. Wilson) G. Hahn (Douglas-fir canker)
<i>Quercus</i> spp.	Japan	<i>Sterium hiugense</i> Imazeki (White rot); a gall forming rust
<i>Salix</i> spp.	Germany, Great Britain, and The Netherlands	<i>Erwinia salicis</i> (Day) Chester (Watermark disease)
<i>Ulmus</i> spp.	Europe	Elm mottle virus

quarantined area from which movement is restricted.

***Phytophthora ramorum* Interim Quarantine**—(7 CFR 301.92)—quarantines 12 counties in California and portions of one county in Oregon and regulates the interstate movement of regulated and restricted articles: nursery stock of listed species, soil, and any other article deemed to present risk of spreading *P. ramorum* including: bark chips, forest stock, or mulch of listed species from the quarantined area. The rule also specifies conditions of interstate movement of regulated and restricted articles from quarantined areas.

Challenges in Excluding Invasive Forest Pathogens

Although quarantine laws have been in effect since 1912, new forest pathogens, such as the recently discovered *Phytophthora ramorum*, continue to appear and spread in the forests of the US. The current situation is best summarized by a quote that is as relevant today as when it was written:

The maintenance of quarantine regulations is beset with difficulties; therefore in the final analysis quarantines must be regarded as measures of delay rather than measures of exclusion. ... The present procedure in this country against introduced diseases is unsound. In general nothing is done until the foreign organism has been introduced and become more or less well established; then an eradication or control campaign is begun (John Shaw Boyce 1961)

The following are some of the major challenges we face in excluding invasive forest pathogens from our forests:

Forest pathogens can be carried on a variety of plant products;

Many diseases cannot be easily detected;

It is practically impossible to adequately inspect all commodities and methods of importation; and

It is difficult to predict which exotic pathogens will be damaging to native ecosystems.

As pointed out by Peace (1962a), there is a strong tendency to base quarantines on specific diseases and on our knowledge of their “potential danger and ...distribution”. This approach can be “highly dangerous” (Peace 1962b) because of our lack of knowledge of tree pathogens in many parts of the globe and the possibility that “a known pathogen may behave quite differently when moved to a new environment” (Peace 1962a). Our best strategy to stem the tide of new invasions is to continue and expand efforts to assess and mitigate risks associated with the major pathways for movement of invasive forest pathogens into

new ecosystems (Tkacz 2002). By focusing on known organisms traveling via these pathways, we can develop effective mitigation strategies that eliminate both known and similar unknown organisms.

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Pop Quiz on Regulating Forest Pathogens
WIFDWC, August 21, 2003
Grants Pass, Oregon!

Multiple choice—circle all the correct answers

1. NAPPO, EPPO and IPPC are

- a. part of the USDA Forest Service.
- b. characters in a Marx Brothers movie.
- c. international organizations that provide guidance for pest regulation.
- d. all of the above
- e. none of the above

2. NPAG, PERAL, and CPHST

- a. are proposed new TV networks.
- b. are headquartered in Raleigh, North Carolina.
- c. stands for New Pest Advisory Group, Plant Epidemiology and Risk Analysis Laboratory, and Center for Plant Health Science and Technology
- d. all of the above
- e. none of the above

3. NAPIS stands for the

- a. North Alberta Post Secondary Institutions Society.
- b. Navy Air Pollution Source Info System.
- c. National Agricultural Pest Information System, the database for the Cooperative Agriculture Pest Survey Program (CAPS). It is part of the Center for Environmental and Regulatory Information Systems at Purdue University.
- d. all of the above.
- e. none of the above.

4. A quarantine pest is

- a. a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled.
- b. a pest that has significant impacts on the forest ecosystem.
- c. often eradicated with help from the US military.
- d. all of the above.
- e. none of the above.

5. A pest risk assessment is

- a. the determination of whether a pest is a quarantine pest.
- b. an evaluation of a pest's introduction potential.
- c. a document that covers pathway information, likelihood of introduction, consequences of introduction and estimates unmitigated pest risk potential.
- d. all of the above.
- e. none of the above.

6. The National Plant Board

- a. is an organization of the plant pest regulatory agencies of US states.
- b. handles agricultural, horticultural and forestry pests.
- c. has a Web site at www.aphis.usda.gov/npb/.
- d. all of the above.
- e. none of the above.

7. Quarantines must be

- a. logical.
- b. necessary.
- c. legally sanctioned.
- d. valid.
- e. none of the above.

! Answers in footnote for introduction to Panel: Quarantines.





Preventing Invasive Pathogen Threats to Forests— A Sideways Scientific Look

Clive M. Brasier

Abstract—A scientific health check or risk analysis on the current global (WTO/FAO) prevention system is presented. It is concluded that the system, though often well-regulated, is fundamentally flawed, because it is not properly science-based. Possible solutions are presented.

Introduction

The progenitor of this paper was prepared in response to a request from the USDA Forest Service to critique the current global plant health protocols of the World Trade Organization (WTO) and Food and Agriculture Organization (FAO). It was written at a time of increasing international trade in plants and in the context of Sudden Oak Death (SOD) and other invasive pathogens threatening forests and natural ecosystems. The original paper was presented during the Quarantine Panel at the International Symposium on Sudden Oak Death, Monterey, December 2002. An abstract of the original text is on the Symposium website (<http://danr.ucop.edu/ihrmp/sodsymp/paper>). At Monterey, I pointed out several of my regulatory colleagues from APHIS, UK Plant Health, and Canadian Plant Health were sharing the platform with me and expressed the hope they would still be counted among my friends at the end of my presentation!

The text presented here is a rework of that original paper, and it represents a personal view, based on more than 35 years investigating the behaviour of forest pathogens. It is intended to stimulate and encourage debate in a field where debate is not only seriously lacking but at times is actively suppressed.

The Problem

We have a global prevention system that is

Systematic

International

Well-regulated and well-policed.

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Brasier, Clive M. is Emeritus Mycologist at Forest Research, Farnham, Surrey GU10 4LH, UK.

Nonetheless, SOD is just another symptom of a historical, and now rapidly growing problem. Although the current system of prevention is often excellently and expertly carried out by regulatory agencies, the system cannot succeed, because it is not yet properly science-based.

Biological Weaknesses

In its current form, the plant health system has a variety of biological weaknesses.

List-dependency—Present protocols are essentially a list-system derived from a ‘Noah’s Ark’ perspective, that is from Linnaean systematics and a morphospecies concept that if a pathogen ‘looks like’ X, it is X. This perspective is not based upon the species and genotype concepts of modern population biology. Consequently, there are both legal and identification loopholes.

Non-Darwinian—The present protocols have not yet caught up with the science of 1850. Evolutionary theory warns us that greatest threat is from organisms that have evolved in ‘other’ biogeographical zones, but have not yet ‘escaped’ and so are still ‘waiting’ to cause serious damage on new hosts. These threats need to be anticipated. I estimate from recent events that about 80 percent of the pathogens of serious threat to European or U.S. forests are not on the schedules of listed organisms, because they do not cause any notable damage in their natural habitat.

Reactive not proactive—The present schedules tend to cover mainly those pathogens that have already escaped their original evolutionary zone and are causing noticeable damage on new (that is, not co-evolved) hosts. Some examples are Dutch elm disease, North American oak wilt, SOD, chestnut blight, pinewood nematode, and jarrah dieback.

PRA over-dependency—Present protocols, encapsulated by WTA/FAO rules, are based strongly on Pest Risk Analysis (PRA). A PRA is an excellent tool for summarizing current risk information of well-characterized threat organisms that have already escaped. PRAs do not cover the estimated 80 percent of unknown or un-escaped threat organisms.

Structural rigidity—The present system, as an essentially list- not process-driven system, tends to lack the flexibility

to embrace major new risks related to or even arising directly from the system, including:

Stable-door syndrome. Potential, international, dangerous, and newly identified organisms are often not on plant health schedules nor do they have a PRA. Recognition is too slow. Part of the problem is that the organism may be perceived as benign in the country of first discovery. Another problem is lack of efficient communication between scientists and plant health regulators in country of first discovery and ‘would-be preventors’ or activists in countries of possible invasion. The new *Phytophthora* of hybrid alder in Europe and the new oak-wilt pathogen in Japan are examples of potentially dangerous organisms that should probably be on many national schedules.

Trojan horse syndrome. Fungistatic compounds are widely used in the international plant and nursery trade. These temporarily mask disease symptoms on exported stock and thereby promote effective spread of exotic pathogens (such as *Phytophthora*).

Typhoid Mary syndrome. Organisms threatening to forest trees are imported on apparently innocuous plant ‘carriers’. Consider how SOD may be transported on Rhododendron nursery stock.

Hybridization syndrome. Rapid evolution of new hybrid pathogens is promoted by the present trade practice. For example, at intensive nurseries in Europe, multiple species of exotic pathogens are brought into physical contact and treated with unusual chemicals. These emerging hybrid pathogens are neither detected nor adequately covered by the current system.

In summary—Our present system of prevention tends to respond to the ripples after a splash and not to prevent the splash. The result is that probably only 10 to 20 percent of the exotic pathogens threatening our forests are covered in current quarantine schedules. Basic evolutionary principles are insufficiently encapsulated into the current approach; whereas they should underpin the entire biological rationale. On evolutionary grounds, rapid commercial movement of large numbers of rooted nursery plants and soil between continents and countries probably cannot be carried out with a high degree of long-term safety.

Market Forces and Policy Weaknesses

In addition to the biological weaknesses, there are a number of economic and social weaknesses.

Weakest link—Within multi-state economic political units, such as the European Union (EU), the plant health protection system may tend to operate at the level of the weakest state. This promotes risk and is the very antithesis of how living organisms evolved to restrict the spread of

diseases via multiple compartments (‘fire walls’). The system itself is non-Darwinian.

Non-Keynesian—The present global system, as operated, is not properly science-based in market economics. It lacks the central, environmental, Keynesian principle that the ‘polluter pays’. In this case, neither the trade, the regulator nor the government pay. Therefore, there is no strong feedback loop on the economic system or on the regulatory system to encourage effective bioprotection.

Institutionalisation—A lack of market pressure in favour of progressive and sustainable bioprotection policy can allow governments, trade and regulators to become entrenched and conservative. Therefore, the system itself becomes part of the problem rather than the solution.

Nelsonian approach—Consequences of defensive from regulators over unspoken weaknesses of a system can generate (i) resistance to strategic thinking, (ii) resistance to funding research that expose the weaknesses and (iii) resistance to any policy change. For the regulator, the preferred action is inaction or avoidance because “I see no risks!”

In summary—Market forces don’t operate sufficiently and directly on governments, regulators, or commerce to ensure support for effective forest bioprotection measures. The result is that ‘nobody’ pays for the UK’s recent DED disaster or the current alder mortality. In fact, those who ultimately pay are the UK public and its environment.

Diagnosis

A scientific health check indicates the present global plant health system is itself a threat to bioprotection.

Treatment? _____

Evolutionary biology (science of the 1850s) argues that the present system needs to be better balanced and, in parts, reversed.

Science-process led—The system needs to be based on more environmentally realistic, market-based economics, and sounder bioscience.

Rapid reaction—We need more rapid and comprehensive reporting and assessment of newly identified potential pathogens between the country of discovery and countries at risk.

Proactive approach—A Rio-style agreement among nations should provide for scientific testing of risks posed by a newly identified potential pathogens before they escape. Modern science, technology and infrastructure permit the conduct of these tests either under international co-operation in the geographical centre of origin/discovery or under quarantine conditions in a country at risk.

Fully apply the precautionary principle—The increasing large scale commercial movement of rooted nursery stock between continents and vegetation zones (and subsequent rapid dispersal to other countries) is very high risk. We can significantly reduce the risk from plant imports by:

Regulating plant introductions as we regulate animal introductions.

Importing only meristem cultures or seed, as licensed introductions for propagation (rarely, small quantities of licensed rooted material may be imported for quarantine testing before release).

Encouraging local commercial propagation of forest trees, shrubs and ornamentals.

“Update Noah”—Risk protocols should be extended to fully cover different pathogen genotypes, varieties and unnamed taxa as well as morphospecies.

“Liberté, égalité...”—We should have regular and periodic review of plant health policies and protocols to insure they are processes based on current scientific knowledge, responsive to informed criticism, and open to public debate.

Effective intelligence—Protecting forests and natural ecosystems from invasive pathogens will always be a protracted ‘war’. If present invasion trends continue, future losses in terms of species elimination, loss of biodiversity, or ecosystem degradation will be large. Currently, we may be in danger of losing this particular war. Indeed, the increasing damage and threat to forests and natural ecosystems under present international WTO/FAO plant health protocols appears inconsistent with a policy of sustainable forestry and forest protection.

We need to accept that the majority of potential invasive pathogen threats to forests are likely to be currently ‘unknown’ or so far ‘unescaped’ organisms. Effective scientific intelligence and scientific insight need to be our first line of defense. We need to keep one at least two steps ahead of the ‘enemy’. More globally and locally correct prevention protocols, based on these scientific insights, need to be the second line of defense.

Provision of scientific intelligence in this area is presently very weak. Much of the research currently occurring alongside the formal channels of plant health regulation is too institutionalised and reactive to identify the many risk organisms and processes. Many of these risks are very dangerous but not very obvious. Greater support and encouragement is needed from research funding agencies for intuitive, insightful, and strategic research.



