Three aspects of resistance to white pine blister rust in California

D. R. Vogler, A. Delfino Mix, P. E. Maloney

USDA, Forest Service, PSW–IFG, & University of California, Davis, CA

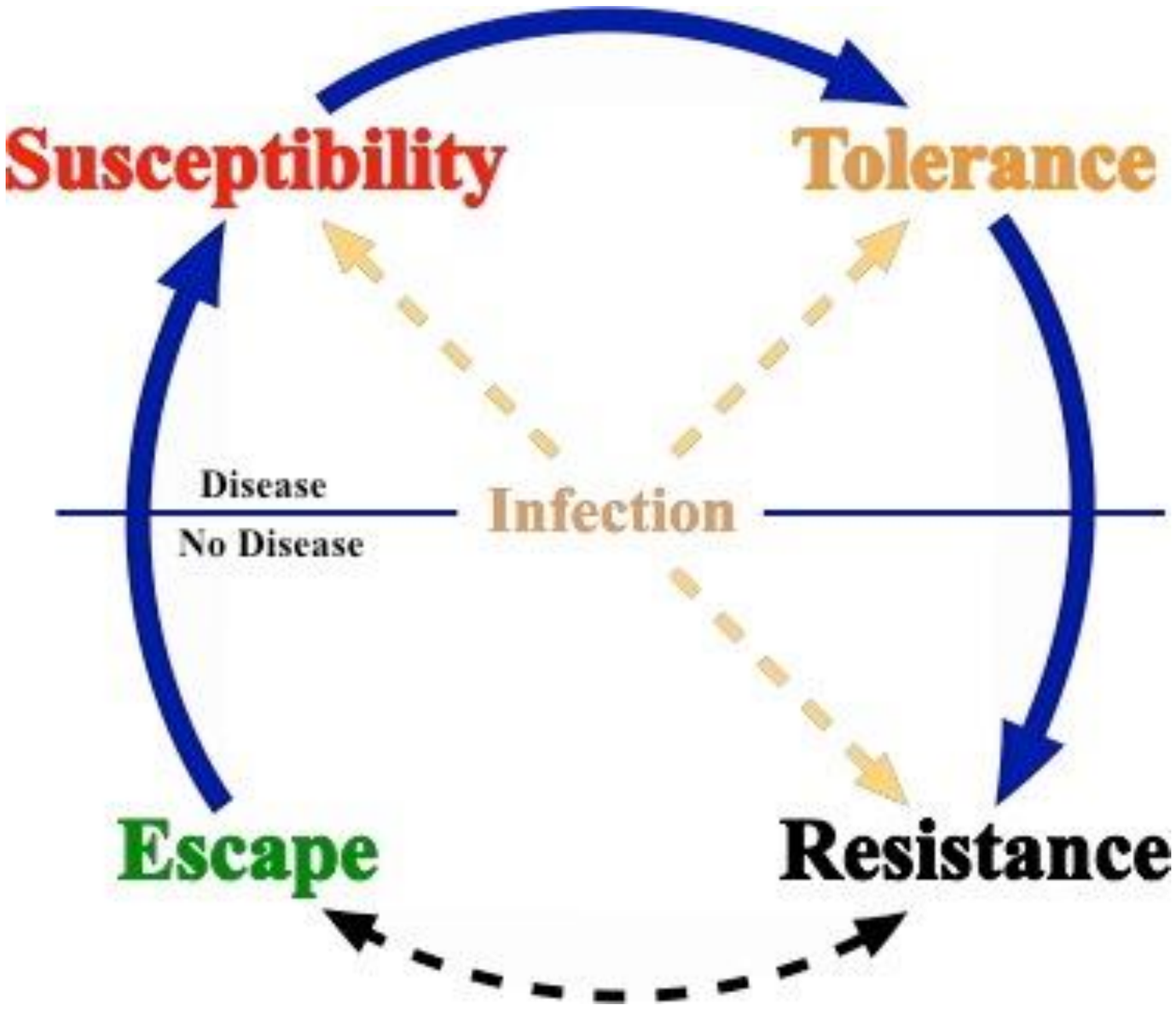
Topics

- The nature of disease resistance in pines: An array of “behavioral” traits
- Mechanisms of resistance to white pine blister rust in the California white pines
- How can a gene for resistance to a recently introduced pathogen arise in a host population without direct selection by the pathogen itself?

Nature of Disease Resistance in Long-Lived Woody Plants

Varieties of “resistance”

- **Escape**
  - Host and pathogen fail to encounter each other
- **Susceptibility**
  - Infection and disease proceed without hindrance
- **Tolerance**
  - Early stages of disease occur, but the pathogen develops slowly and eventually ceases to grow
- **Resistance**
  - Host responds rapidly, killing the pathogen



Modes of resistance

Mechanisms of Disease

Resistance in Long-Lived Woody Plants

Specific host-pathogen interactions

- The needle spot is a classic specific interaction
  - A virulent genotype of a pathogen bypasses recognition by the resistant host and hence develops normally
  - An avirulent genotype is recognized by a resistant host and is rendered impotent
  - The consequence of the latter is that the avirulent genotype *fails* to reproduce, while the virulent genotype *does*

Hypersensitive reaction (HR) in needles

Sugar pine (*Pinus lambertiana*), western white pine (*Pinus monticola*), southwestern white pine (*Pinus strobiformis*), and limber pine (*Pinus flexilis*)

Non-specific or systemic host-reactions

- Susceptible needle spots occur, and infection proceeds normally into the stem
  - Discoloration and swelling develop in the stem at the site where infection invades from the needle
  - Initially, infection seems to grow unchecked
  - Lesions develop at the site of infection, often at the base of an infected needle, which can remain attached. The pathogen grows no further.
  - The line between tolerance and resistance is blurry, but the pathogen is eventually encased

Stem reaction (pitchy lesion)

Eastern white pine (*Pinus strobus*)

Cork cambium develops into wound periderm, serving as a barrier that blocks further fungal growth (Struckmeyer and Riker, 1951)

Stem reaction (pitchy lesion)

Great Basin bristlecone pine (*Pinus longaeva*)

Stem Reaction (pitchy lesion)

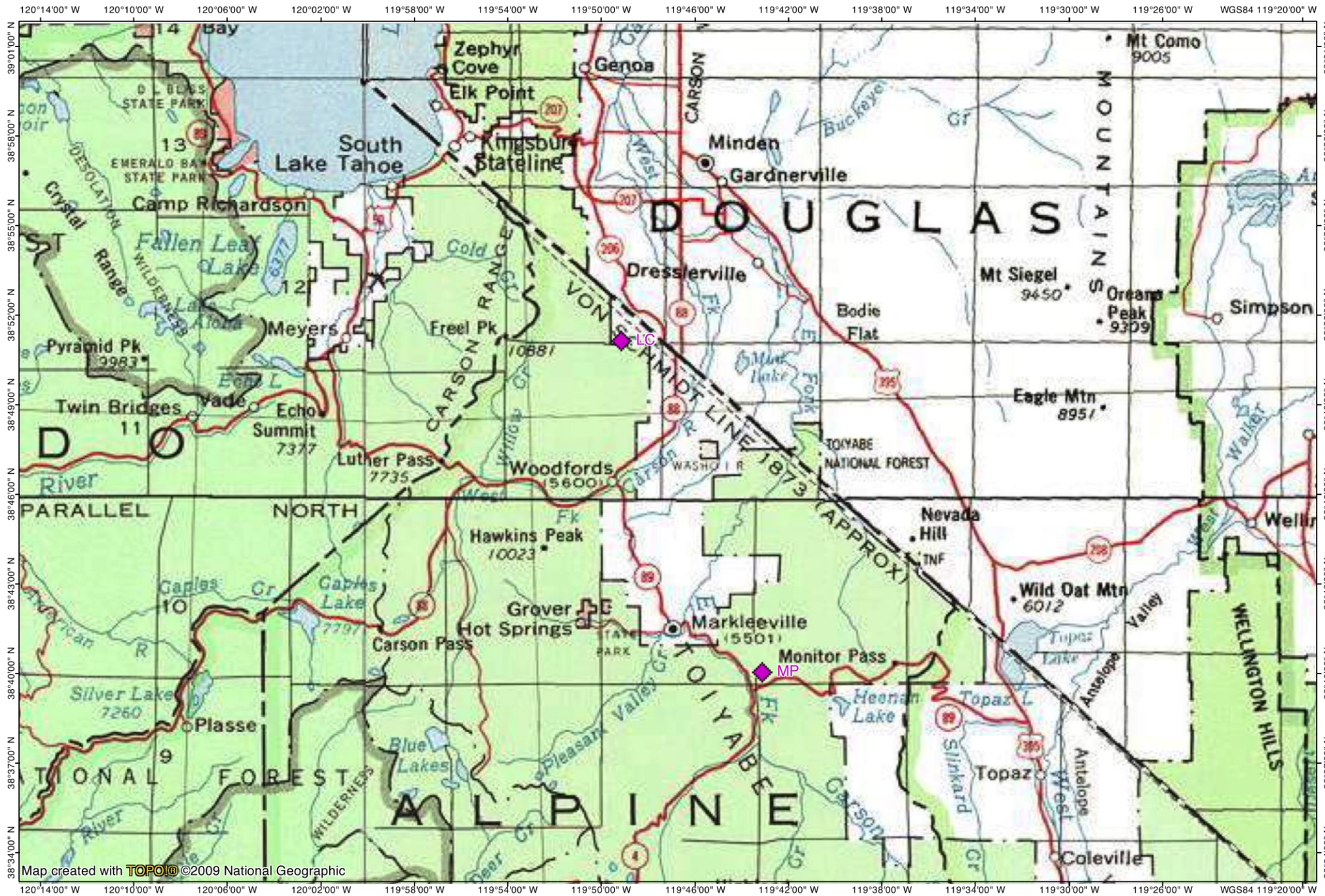
Rocky Mountain bristlecone pine (*Pinus aristata*)

Can a gene for resistance to *Cronartium ribicola* arise in a host population without direct selection by the pathogen itself?

An example from the southeastern Sierra Nevada

- Study locations: Luther Creek and Monitor Pass
- No infection by *Cronartium ribicola* in this region of the eastside of the Sierra Nevada
- Pinyon pine is near to and within the sugar pine stands
- Goal: to determine frequency of the sugar pine resistance gene *Cr1* in these stands

TOPO! map printed on 10/24/14 from "LutherCanyon&MonitorPass.tpo"



NATIONAL GEOGRAPHIC

0 2 4 6 8 10 miles
0 2 4 6 8 10 12 14 16 km

TN MN 13.5°

10/24/14

Results for frequency of *Cr1*

- Luther Creek (14 SP families)
  - Mean frequency: 0.075
- Monitor Pass (25 SP families)
  - Mean frequency: 0.141
- These would be high frequencies of the resistance for Cr1 in sugar pine where there has historically been rust; but there is no disease!

So why?

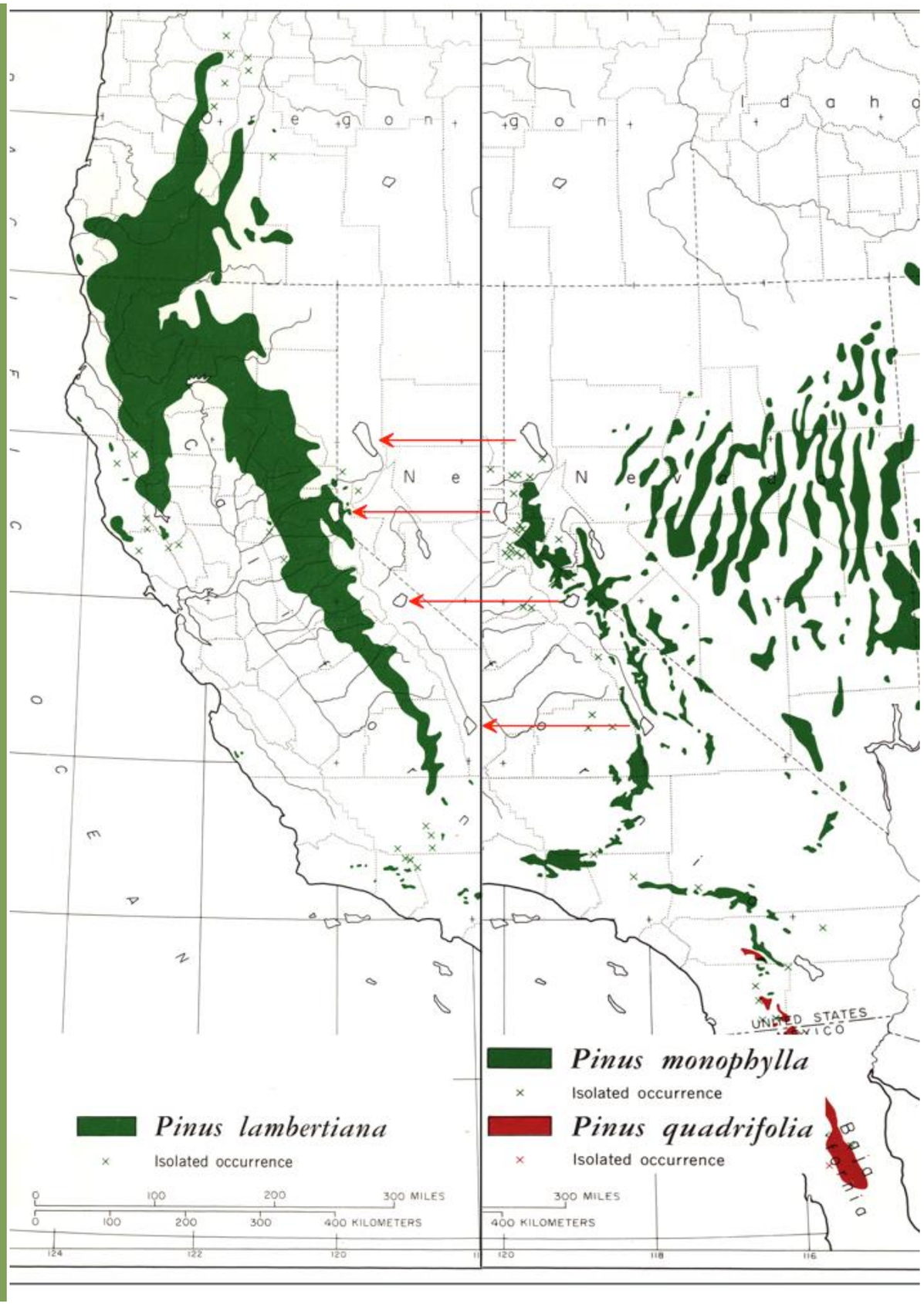
- Bro Kinloch showed in 1992 (*Can J. Bot.* 70:1319) that the frequency of *Cr1* is highest in sugar pine where pinyon pine (*Pinus monophylla*) occurs nearby or is co-located.
- *P. monophylla* is infected by a blister rust similar to WPBR.
- Pinyon blister rust infected & established in sugar pine in greenhouse trials at IFG

Support for Kinloch's conclusion

- When sugar pine and pinyon pine grew within the same stands in the past, both species may have been infected by pinyon rust
- Thus sugar pine was pre-conditioned for resistance to WPBR by past challenge from a related native rust
- Our results lend new support to this hypothesis

Current ranges of sugar pine & pinyon pine

Note the regions of range overlap on the east side of the southern Sierra Nevada.



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Rust-inoculated high-elevation white pines

Institute of Forest Genetics, Placerville, CA

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