

# Principles of Emergent Forest Diseases

**Gregory S. Gilbert**

Environmental Studies

University of California Santa Cruz

Key Collaborators

Ingrid M. Parker (UCSC)

Cam Webb (Yale)

# The disease triangle

**Virulent  
Pathogen**

Create novel  
plant-pathogen  
interaction

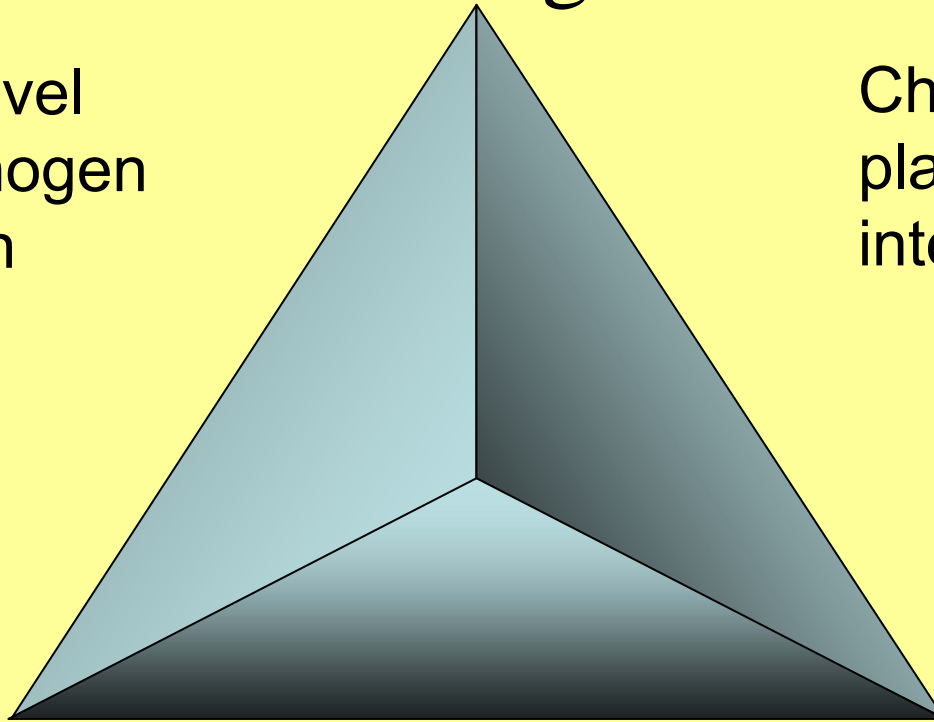
Change in existing  
plant-pathogen  
interaction

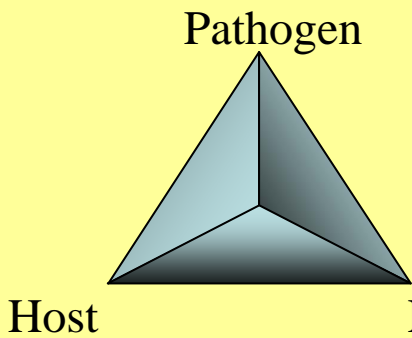
**Host**

**Susceptible**

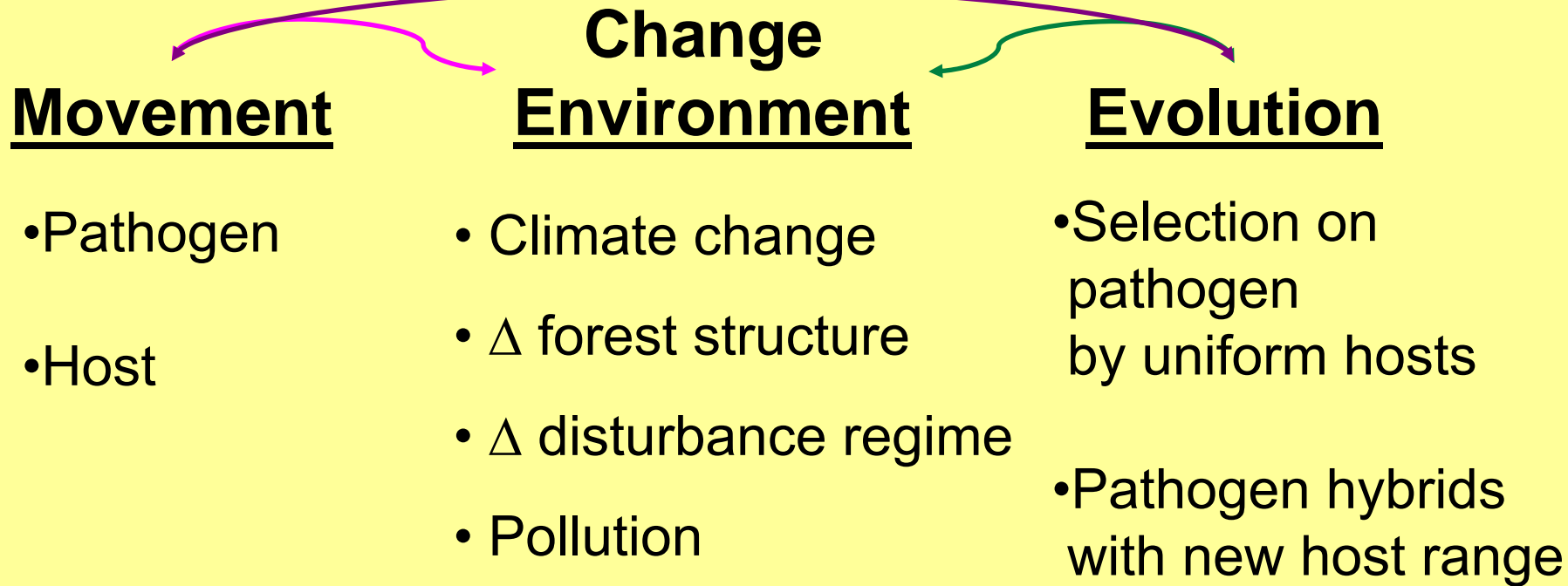
**Environment**

**Conducive**





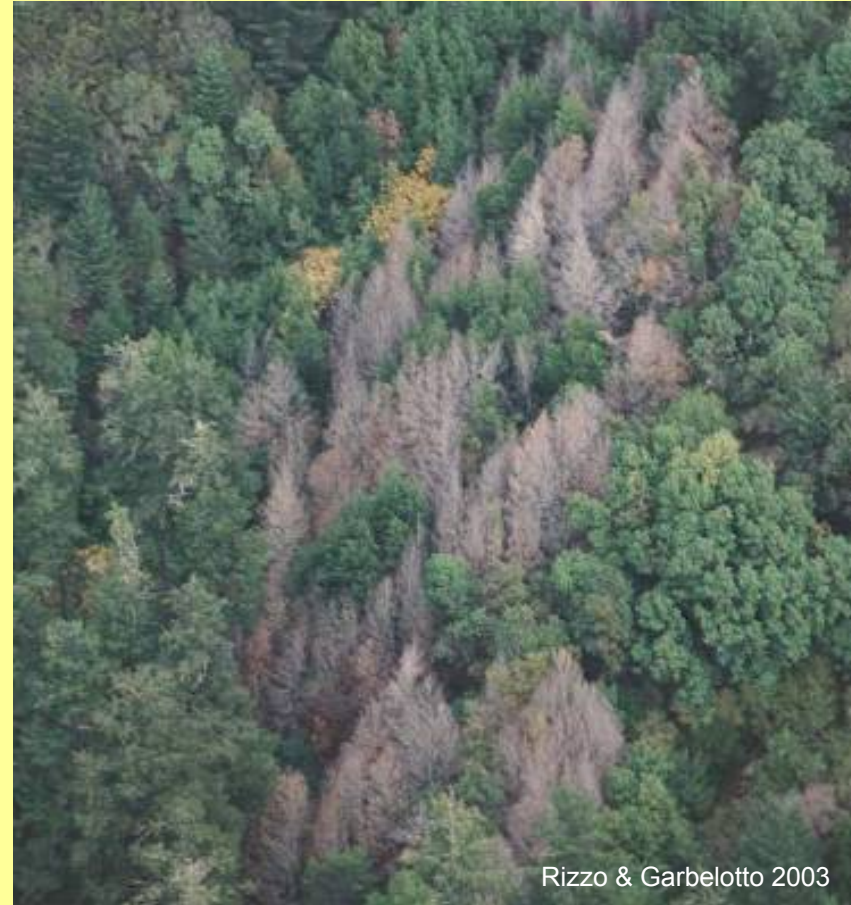
- Change in existing plant-pathogen interaction
- Create novel plant-pathogen interaction



- *All can create emergent disease epidemics.*
- *When and where are each more important?*



**Pitch canker**



**Sudden Oak Death**

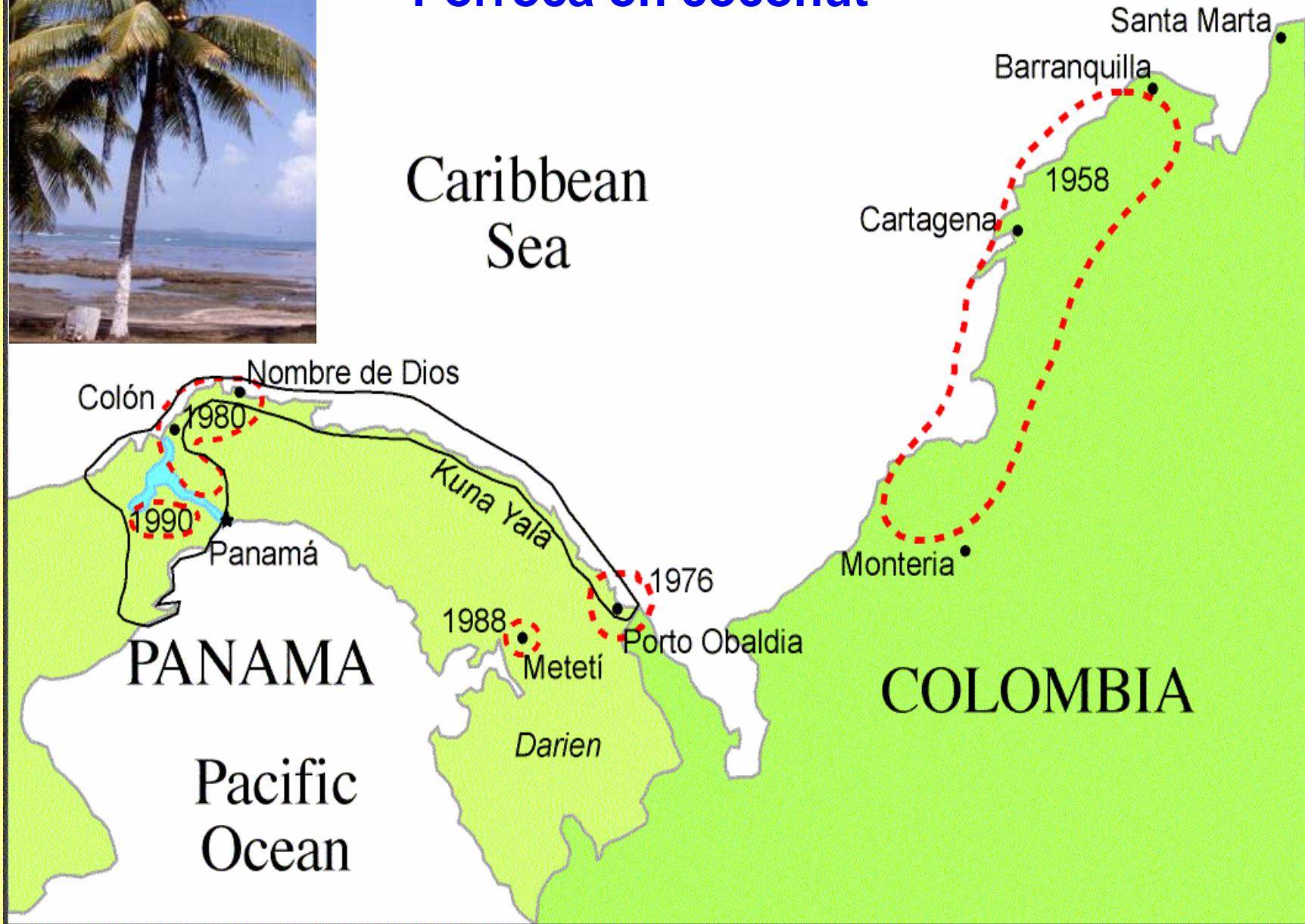


**Faramaea rust**



# Porroca on coconut

Caribbean Sea



PANAMA

COLOMBIA

Pacific Ocean

## Pathogen needs

- Reproduce
- Disperse
- Find more suitable hosts

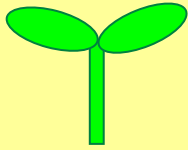
## Modes of change

- Ecological (movement)
- Evolutionary
  - host acquisition
  - environmental conditions

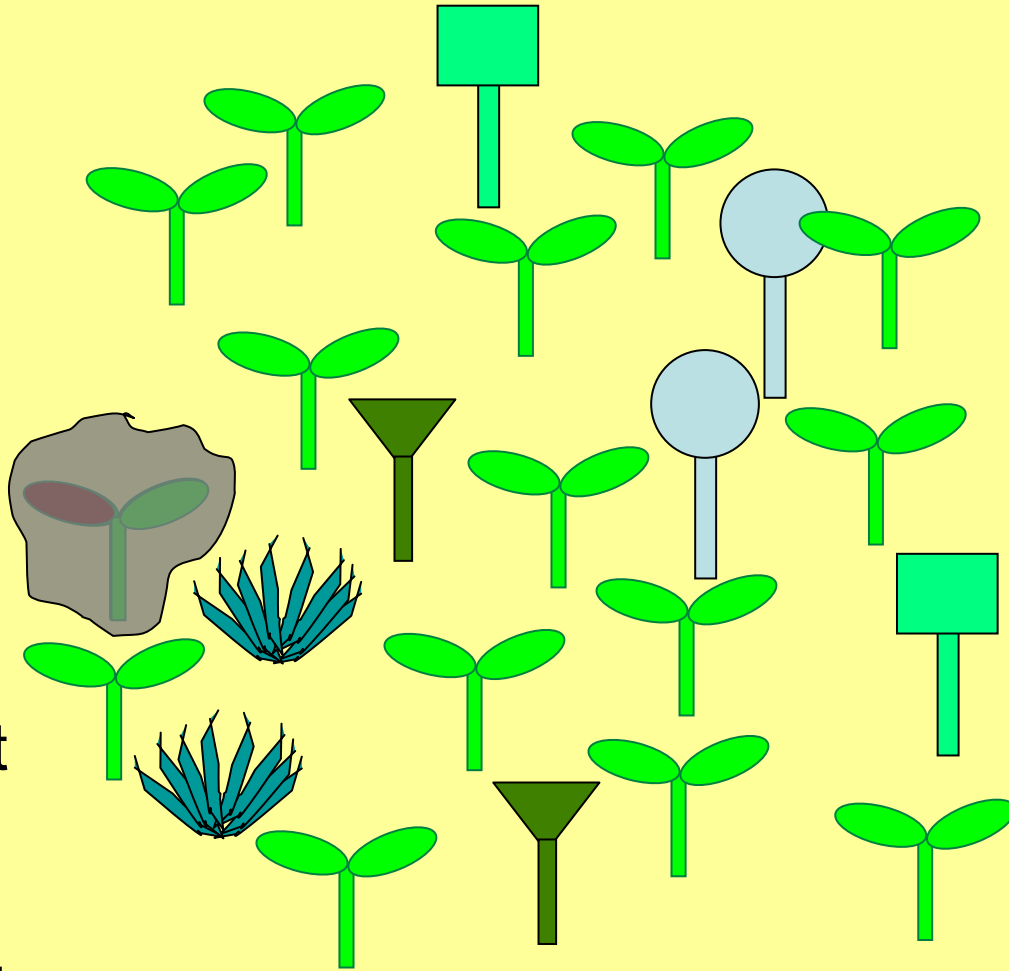
## Emergent disease scenarios

### Introduced pathogen

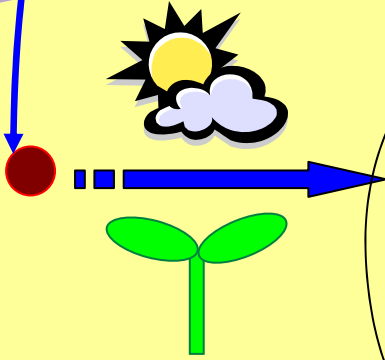
- specialized on a common host
- specialized on a rare host
- with broad host range
- restricted by environmental conditions



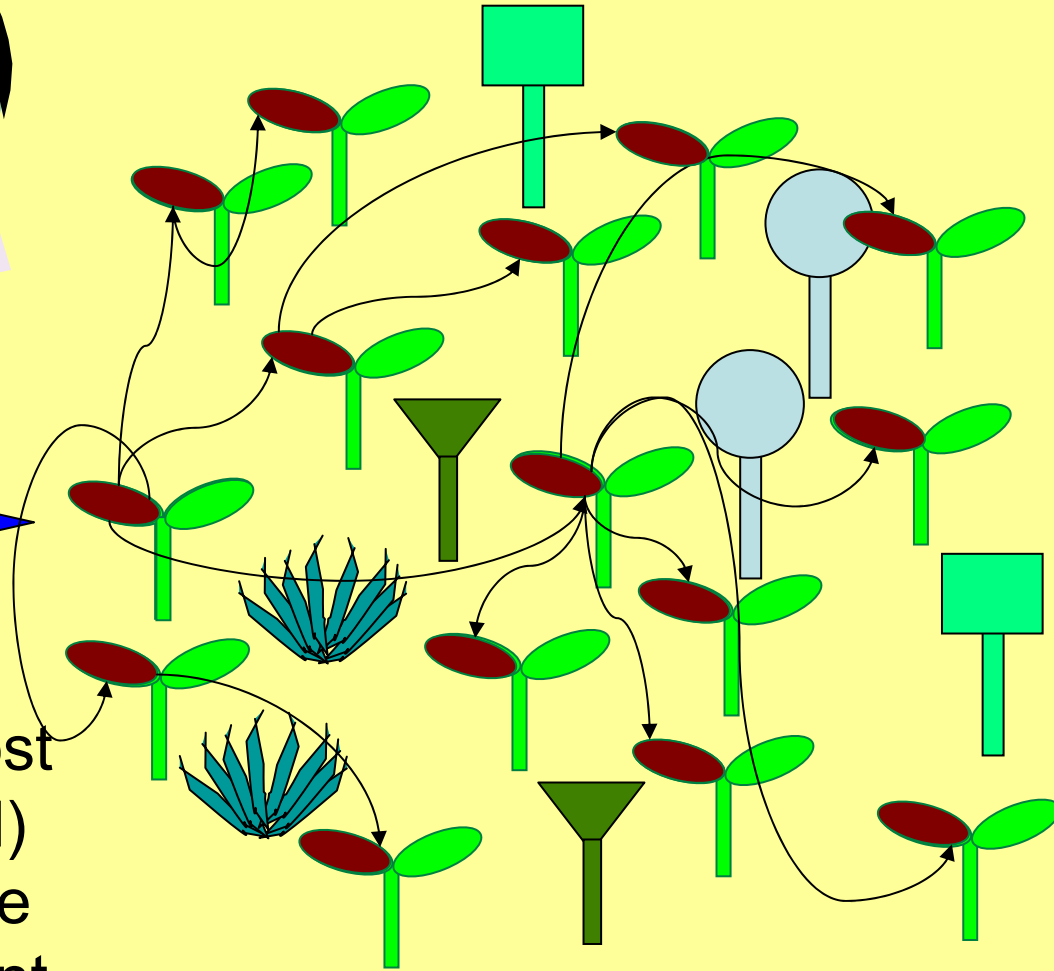
- Suitable host (preadapted)
- Appropriate environment



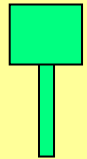
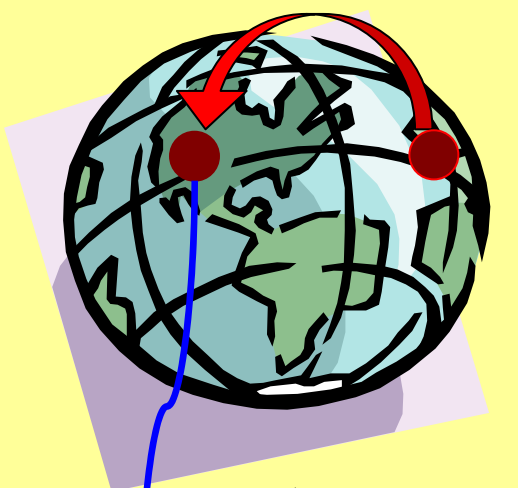
**Specialist on a common host**



- Suitable host (preadapted)
- Appropriate environment

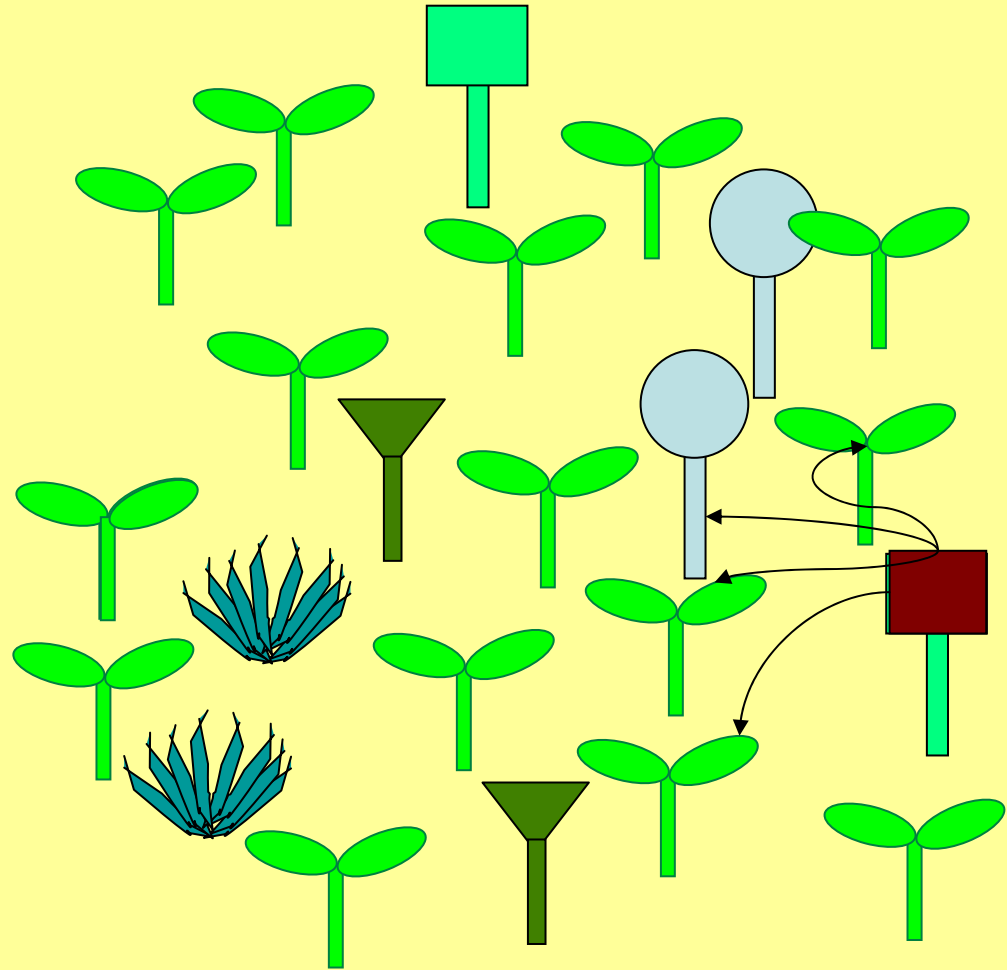


**Specialist on a common host**

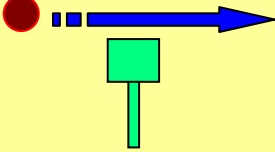


- Suitable host (preadapted)
- Appropriate environment

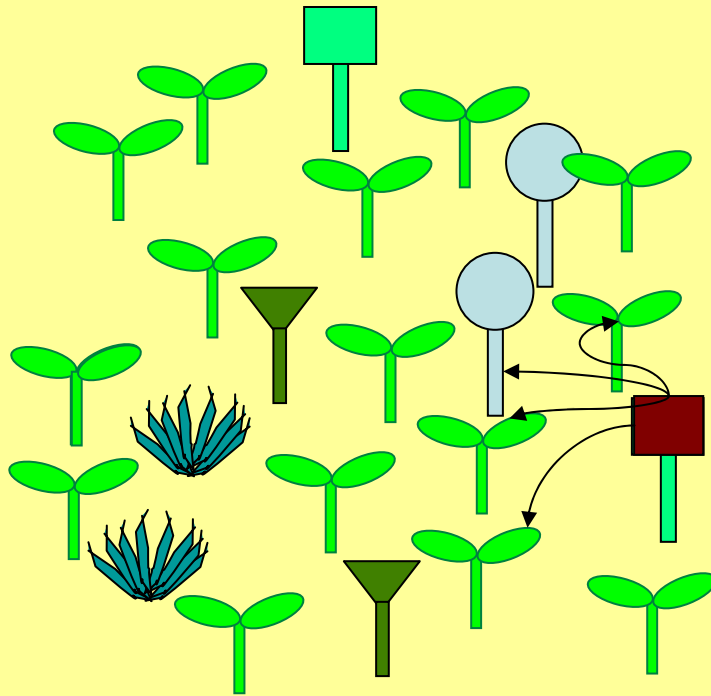
Strong selection pressure to acquire new hosts



**Specialist on rare host**



- Suitable host (preadapted)
- Appropriate environment



### Narrow host range

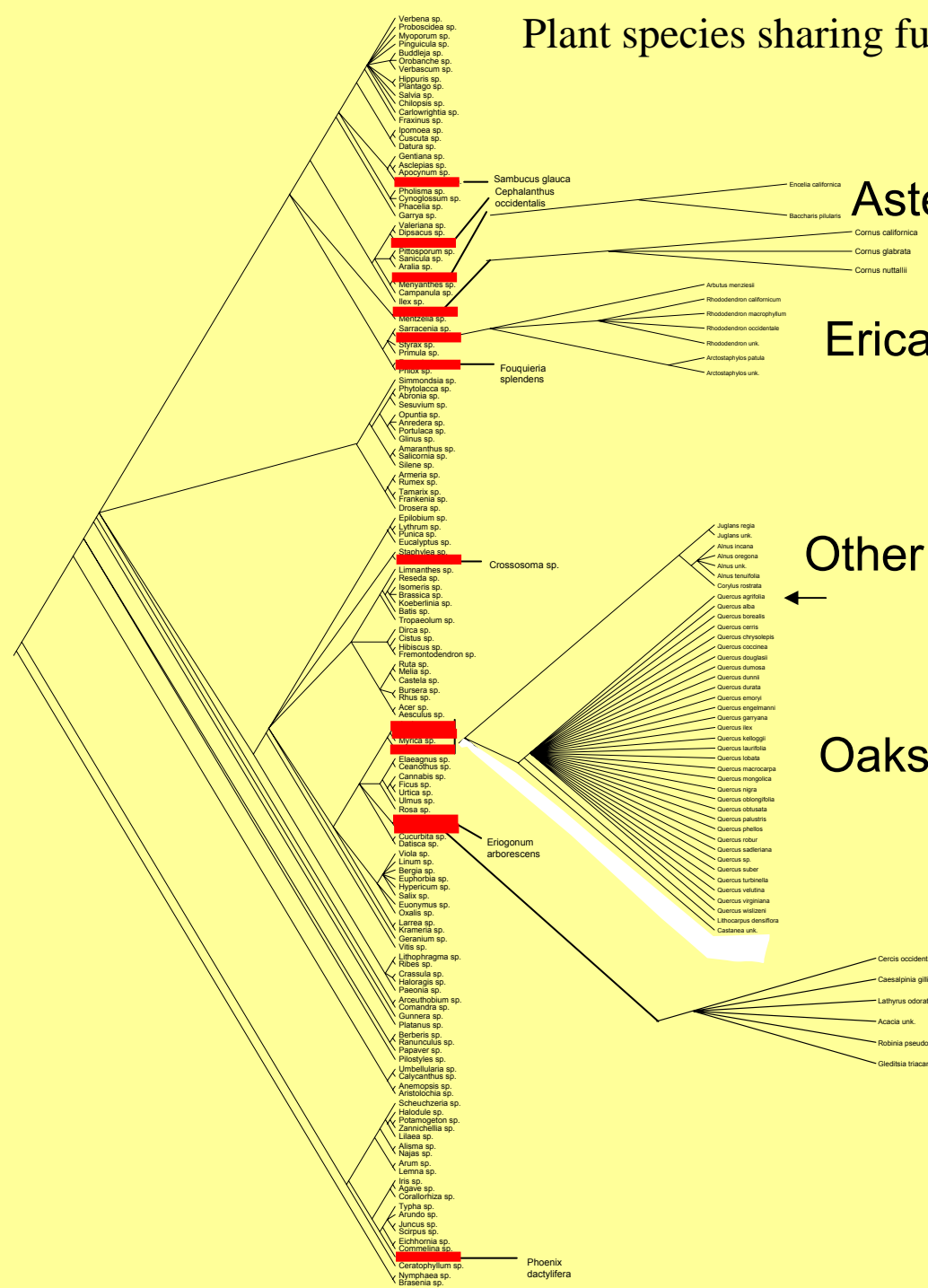
- dispersal ability of pathogen
- density of susceptible host
- environmental heterogeneity

• Strong selection pressure to acquire new hosts

- More likely to acquire:
  - closely related hosts?
  - abundant hosts?

- USDA database for fungi
- all fungi on Coast Live Oak
- all recorded host spp. for those fungi in CA coastal forests
- phylogenetic distance among hosts

# Plant species sharing fungi with *Quercus agrifolia* in California



Asterids

Ericales

Other Fagales

Oaks

Legumes

Of 70 fungal spp. on coast live oak: -80% close relatives -of remainder, most on common associates

An introduced pathogen with a broad host range may be preadapted to an unpredictable set subset of local hosts, depending on what taxa were common in its original range.

- Enocella californica*
- Baccharis pilularis*
- Cornus californica*
- Cornus glabrata*
- Cornus nuttallii*

- Artalus menziesii*
- Rhododendron cationicum*
- Rhododendron macrophyllum*
- Rhododendron occidentale*
- Rhododendron unkl.*
- Arctostaphylos patula*
- Arctostaphylos unkl.*

- Juglans regia*
- Juglans unkl.*
- Alnus incana*
- Alnus oregona*
- Alnus unkl.*
- Alnus tenuifolia*
- Corylus rostrata*
- Quercus agrifolia*
- Quercus alba*
- Quercus borealis*
- Quercus dens*
- Quercus chrysolepis*
- Quercus coccoloba*
- Quercus douglasii*
- Quercus dumosa*
- Quercus dumii*
- Quercus durata*
- Quercus emoryi*
- Quercus engelmannii*
- Quercus garryana*
- Quercus live*
- Quercus kelloggii*
- Quercus laurifolia*
- Quercus lobata*
- Quercus macrocarpa*
- Quercus mongolica*
- Quercus nigra*
- Quercus otoregibolia*
- Quercus obtusata*
- Quercus palustris*
- Quercus phellos*
- Quercus robur*
- Quercus sadleriana*
- Quercus sp.*
- Quercus suber*
- Quercus turbinata*
- Quercus velutina*
- Quercus virginiana*
- Quercus wislizeni*
- Lithocarpus densiflora*
- Castanea unkl.*

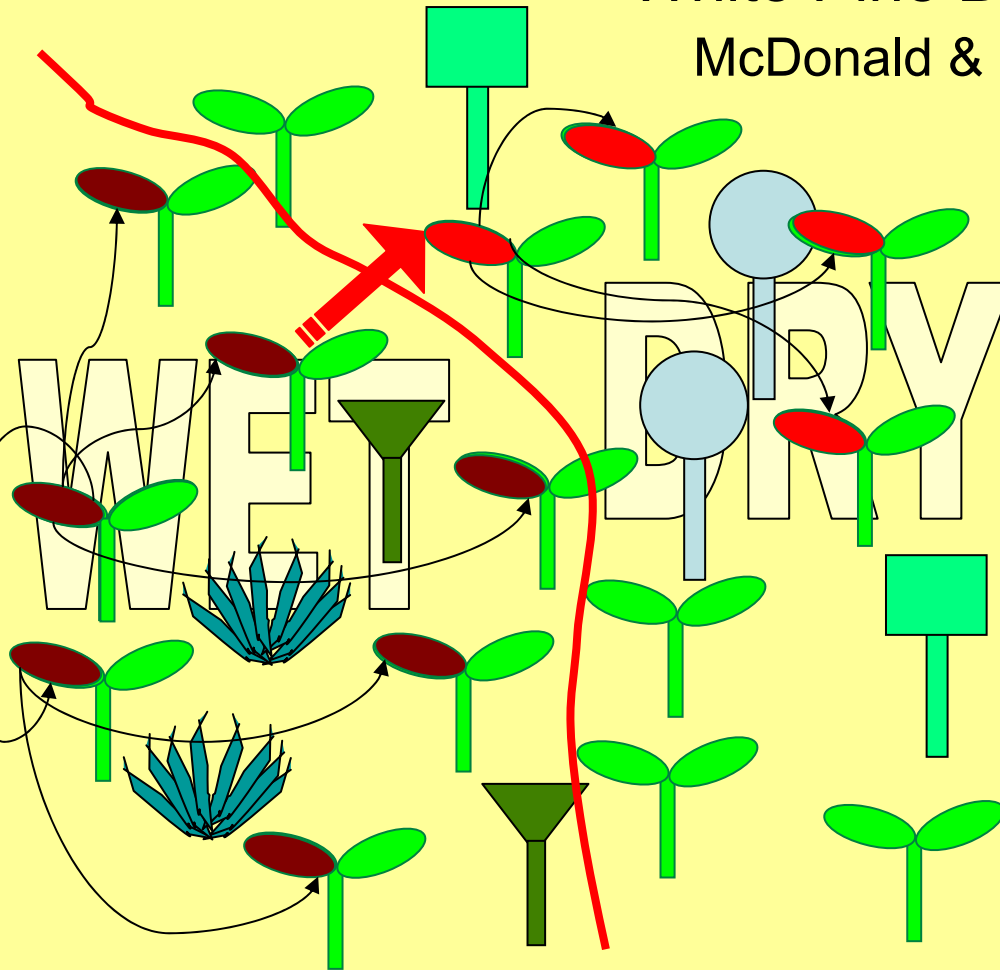
- Cercis occidentalis*
- Caesalpinia gilliesii*
- Lathyrus odoratus*
- Acacia unkl.*
- Robinia pseudoacaci.*
- Gleditsia triacanth.*

# Selection for environmental tolerance

White Pine Blister Rust  
McDonald & Hoff 2001



- Suitable host (preadapted)
- Appropriate environment



**Restricted by environmental conditions**

# Movement

## Change Environment

### Evolution of host range

Parker, I.M. and G.S. Gilbert. 2004. The evolutionary ecology of novel plant-pathogen interactions. *Annual Review of Ecology, Evolution, and Systematics*. 35: 675-700.

G.S. Gilbert and I.M. Parker. 2005. Invasion and the regulation of plant populations by pathogens. *In* M.W. Caddotte, S.M. McMahon, and T. Fukami. *Conceptual ecology and invasions biology: reciprocal approaches to nature*. Kluwer Academic Press.

Gilbert, G.S. 2002. Evolutionary ecology of plant diseases in natural systems. *Annual Review of Phytopathology* 40:13-43.