Invasive Ambrosia Beetle Conference

The Situation in California

August 12 – 14, 2012

Meeting sponsored by:

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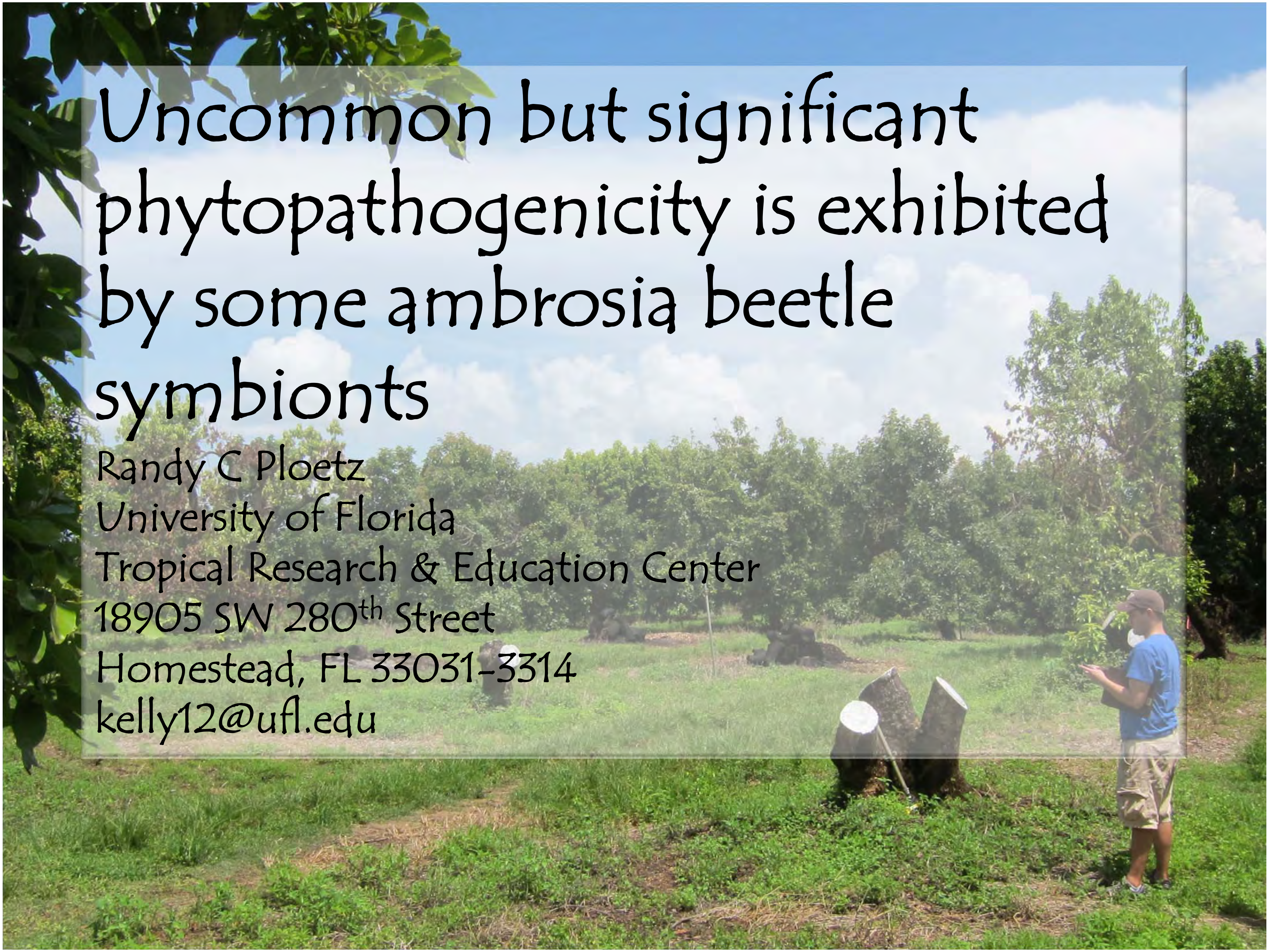
Session 4

Biology of the Fungal Symbiont



Uncommon but significant phytopathogenicity is exhibited by some ambrosia beetle symbionts

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- Due to their uncommon attributes, they are unpredictable
- Although they are abnormal, they can have extreme impacts on forest, landscape and agricultural trees

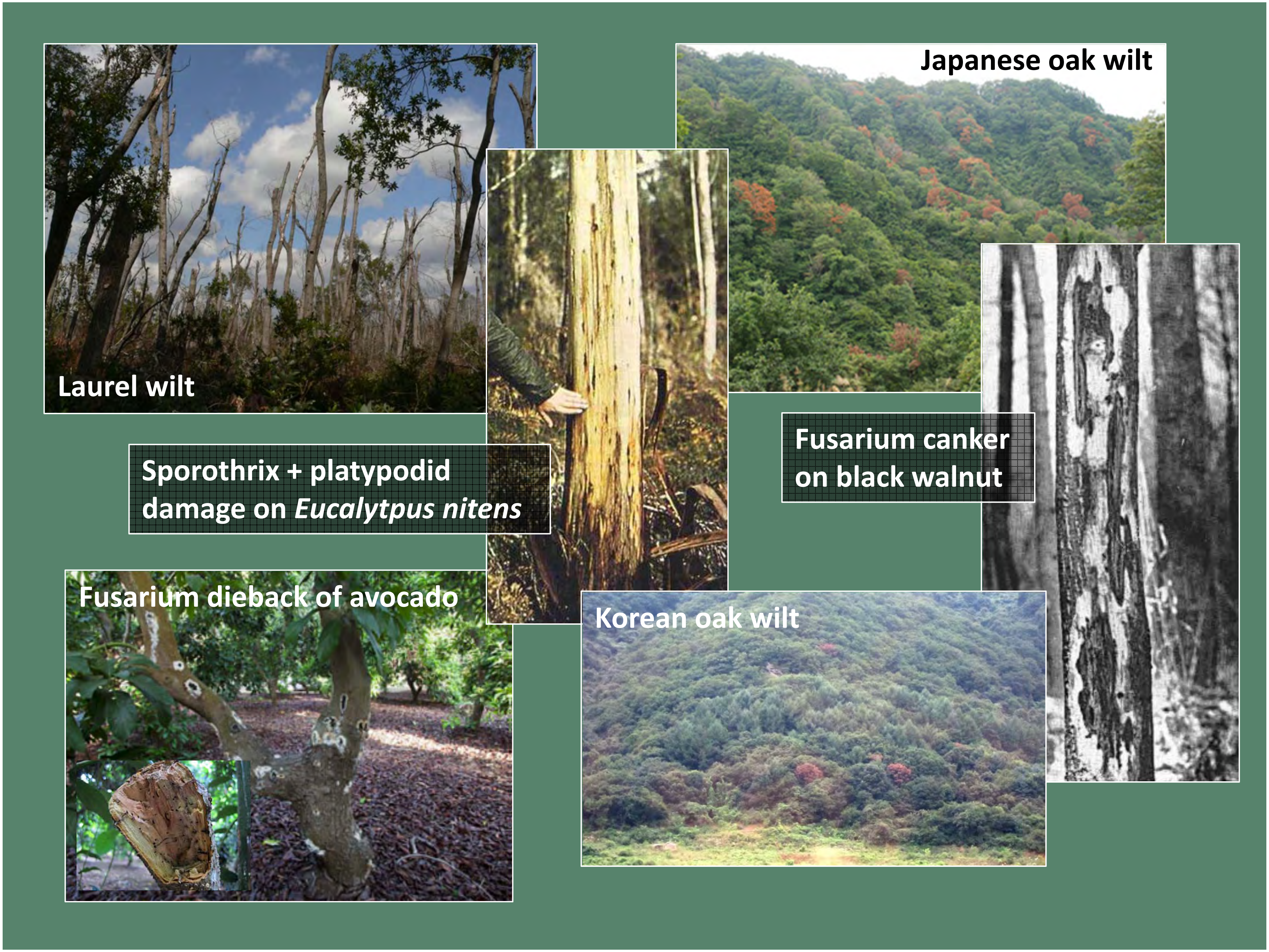

Laurel wilt
Japanese oak wilt
Sporothrix + platypodid damage on *Eucalytpus nitens*
Fusarium canker on black walnut
Fusarium dieback of avocado
Korean oak wilt

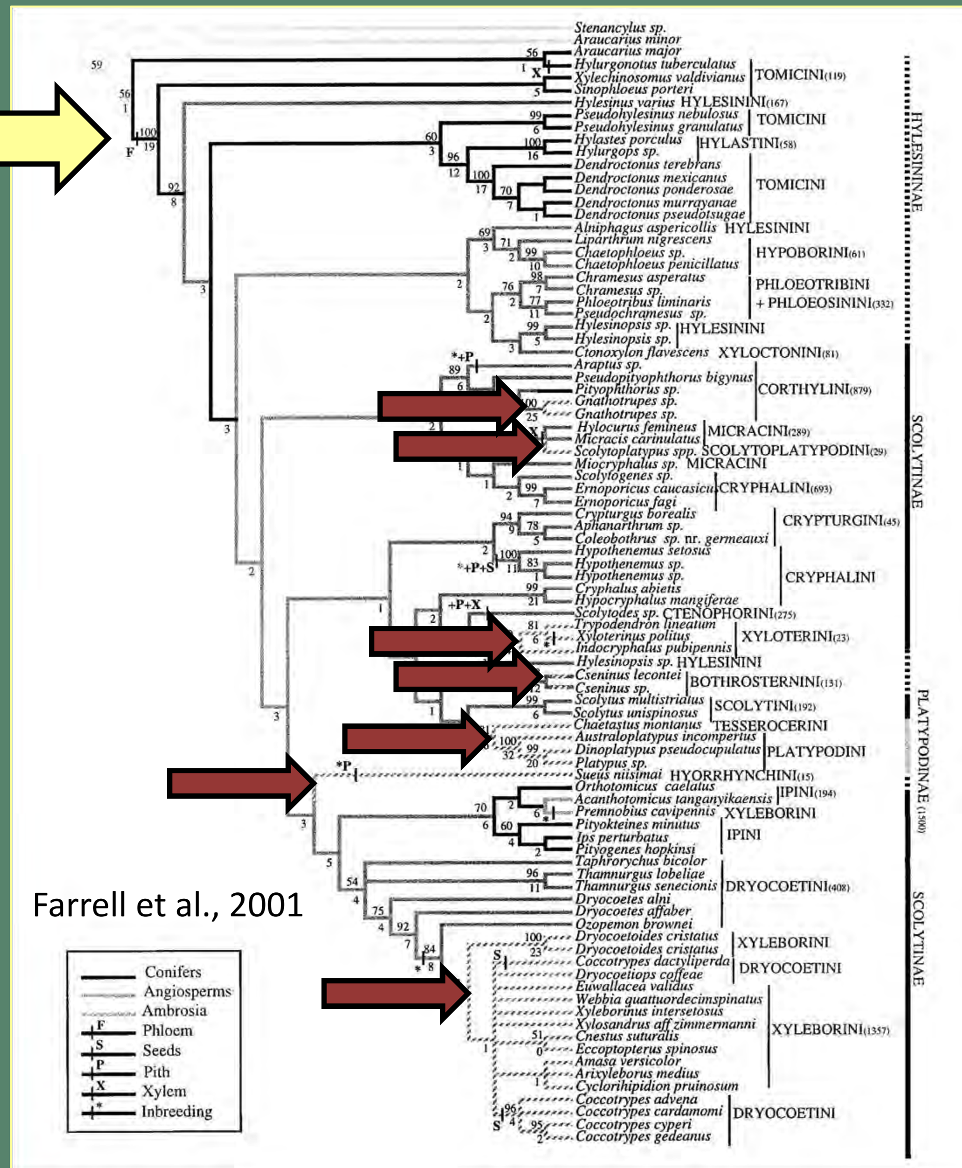
Table 1. Examples of ambrosia beetle-associated damage to trees

Species	Host tree(s)	Symbiont(s). Host impact	Leach's rules?	References
Platypodinae: Platypodini				
Austroplatypus incompertus	*Eucalyptus*	*Ambrosiella* sp. Wood quality degraded in living trees with an unclear involvement of symbiont or other fungi	No	Kent, 2008; Finnegan, 1967; Baker, 1972
Euplatypus parallelus	*Pterocarpus indicus*	*Fusarium oxysporum*. Lethal wilt. Symbiotic relationship with beetle suggested, but Leach's rules not fulfilled	No	Bumrungsri et al., 2008
Megaplatypus mutatus	numerous	*Raffaelea santoroi*. Mortality with no symbiont impact reported	n/a	Alfaro et al. 2007; Smith, 2009
Platypus quercivora	*Quercus crispula, Q. serrata*	*Raffaelea quercivora.* Japanese oak wilt. Mortality in susceptible species after mass attack by vector	Yes	Murata et al., 2009; Kinuura and Kobyashi, 2006; Kamata et al., 2002; Urano, 2000
Platypus koryoensis	*Quercus mongolica, Q. aliena* and *Q. serrata*	*Raffaelea quercus-mongolicae*. Korean oak wilt. Mortality in susceptible species after mass attack by vector	Yes	Kim et al., 2009; Lee et al. 2011
Platypus cylindrus	*Quercus suber*	*Ophiostoma quercum* and other Ophiostomatales recovered from beetle, but Koch's postulates and Leach's rules not fulfilled	No	Belhoucine et al. 2011
Platypus apicalis, Platypus gracilis, Treptoplatypus caviceps **(formerly *Platypus caviceps*)**	*Nothofagus menziesii, N. solandri* var. *cliffortioides, N. fusca* and *N. truncata*	*Sporothrix nothofagi*. Mortality and/or reduced wood quality caused by symbiont	Yes	Milligan, 1972; Faulds, 1977; Wiser et al. 2005
Scolytinae: Xyleborini				
Corthylus columbianus	Numerous angiosperms in eastern U.S.A. Prefers vigorous living hosts.	No apparent role for symbiont or other fungal associates. Causes significant economic degrade of timber.	n/a	Baker, 1972; Kabir and Giese, 1966; Kuhnholz et al., 2003; Nord and McManus, 1972
Corthylus punctatissimus	Diverse angiosperms in eastern North America	No apparent role for symbiont. Lethal to young Acer saccharum, which is girdled at root collar	n/a	Baker, 1972; Finnegan, 1967; Kuhnholz et al., 2003
***Corthylus* sp.**	*Alnus* plantations in Colombia	Pathogenicity documented for associated fungi, *Fusarium solani* and *Ceratocystis* sp.	No	Zulma et al., 2004
Euwallacea fornicatus	*Camellia sinensis* and other angiosperms	*Fusarium ambrosium*	Yes	Anonymous, 2012; Brayford, 1987; Sivapalan, 1978
"Euwallacea fornicatus"	*Persea americana* and other angiosperms	*Fusarium* sp. causes branch dieback and is disseminated by what may be distinct relatives of *E. fornicatus*	Yes	Eskalen et al., 2012; Mendel et al., 2012
Xyleborus glabratus	*Persea americana, P. borbonia, P. humilis, P. palustris,*	*Raffaelea lauricola*. Laurel wilt. Lethal development in susceptible species after a single inoculation	Yes	Fraedrich et al., 2008; Harrington et al., 2008; Ploetz et al., 2012
Xylosandrus germanus	*Juglans nigra, Liriodendron tulipifera, Quercus rubra*	*Fusarium lateritium, F. solani* (*Ambrosiella hartigii* may be primary symbiont). Cankers and severe damage on trees in nurseries, but Leach's rules not fulfilled.	No	Alamouti et al., 2009; Anderson and Hoffard, 1978; Dochinger and Seliskar, 1962; Kessler, 1974

There are more species of beetles (the Coleoptera) than any other order in the animal kingdom (25% of all known life-forms)

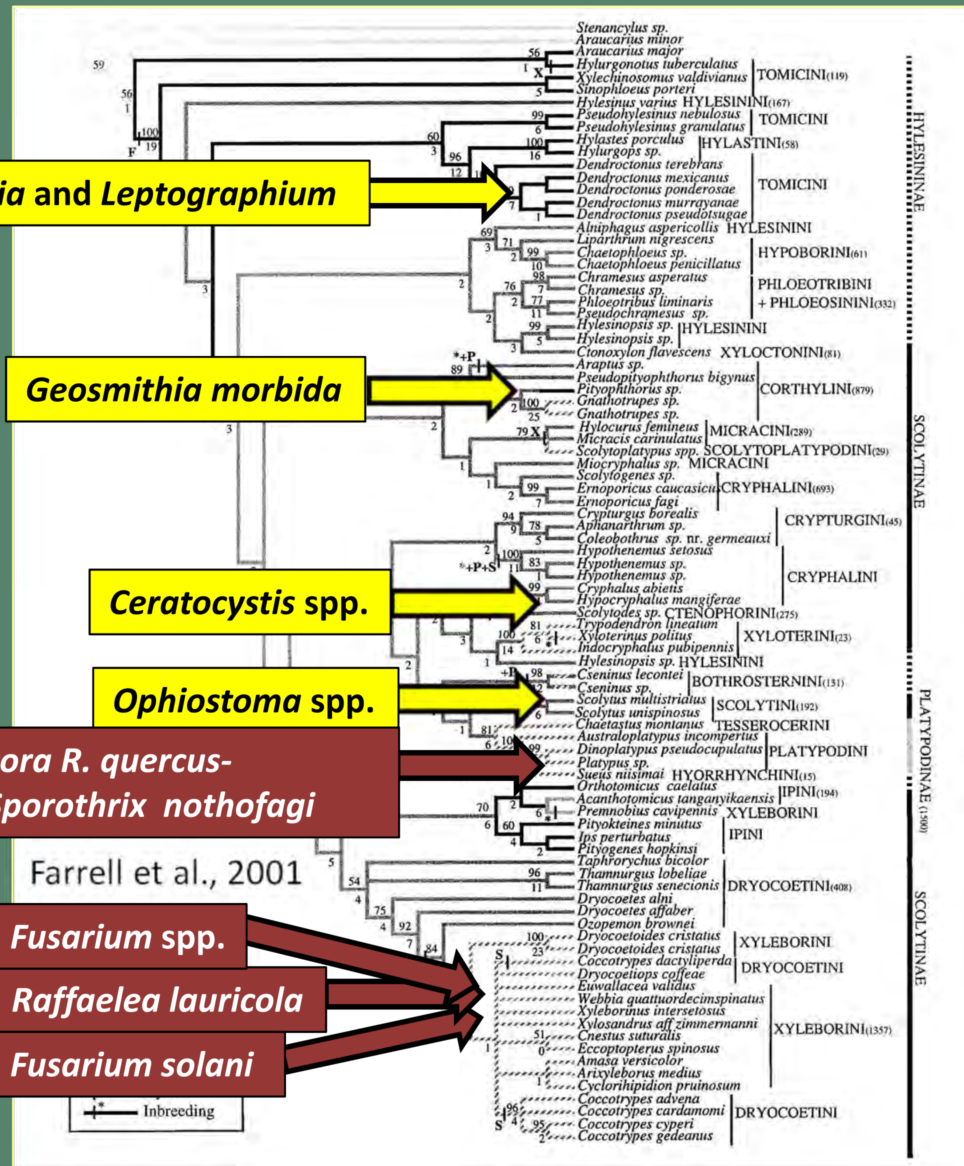
Bark beetles are phloem feeders

Bark beetles are phloem feeders – they are ancestral to the ambrosia beetles, which reside in the xylem

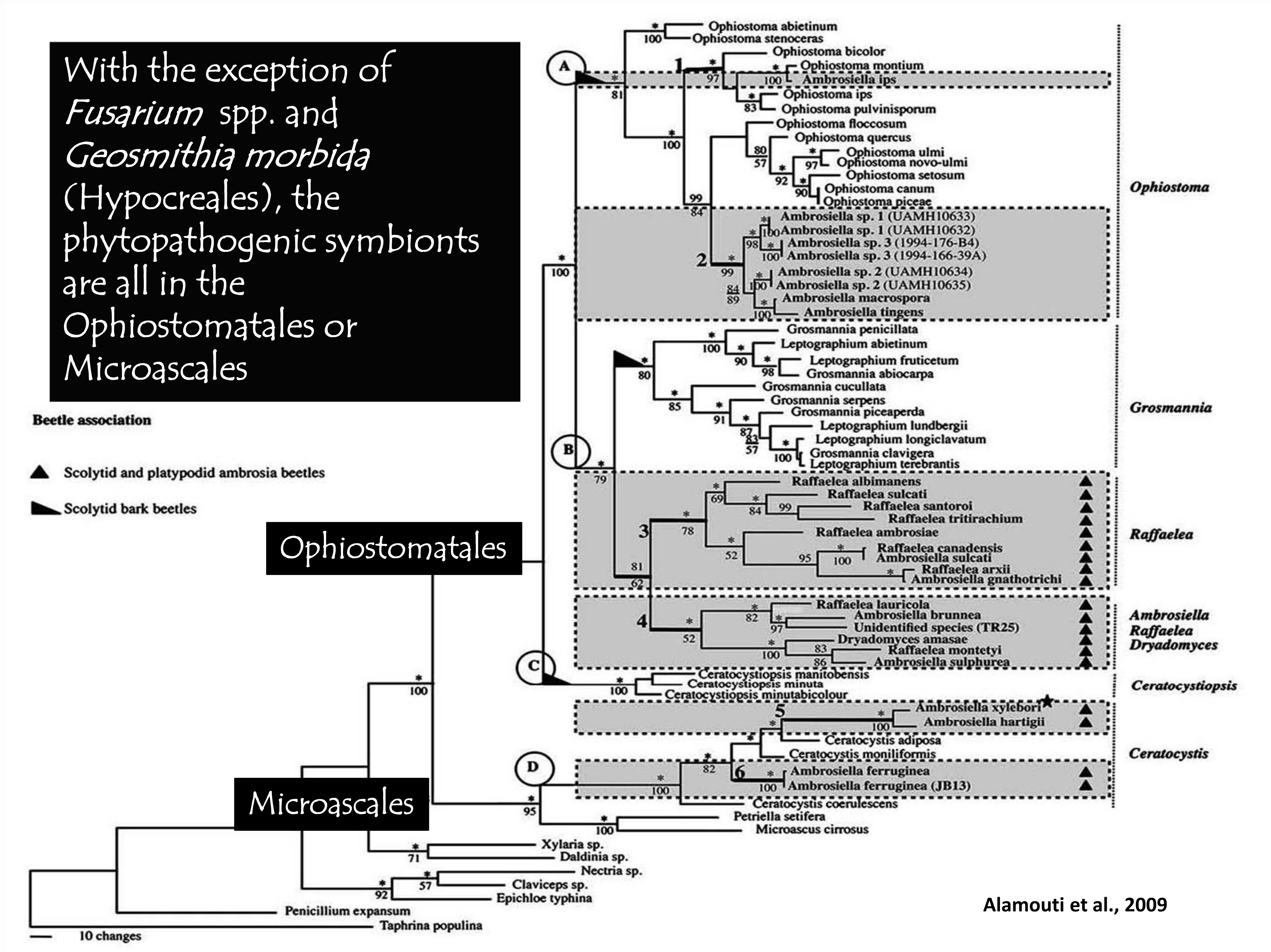


Farrell et al., 2001

Bark beetle and ambrosia beetle vectors of pathogenic fungi are nested throughout this phylogeny

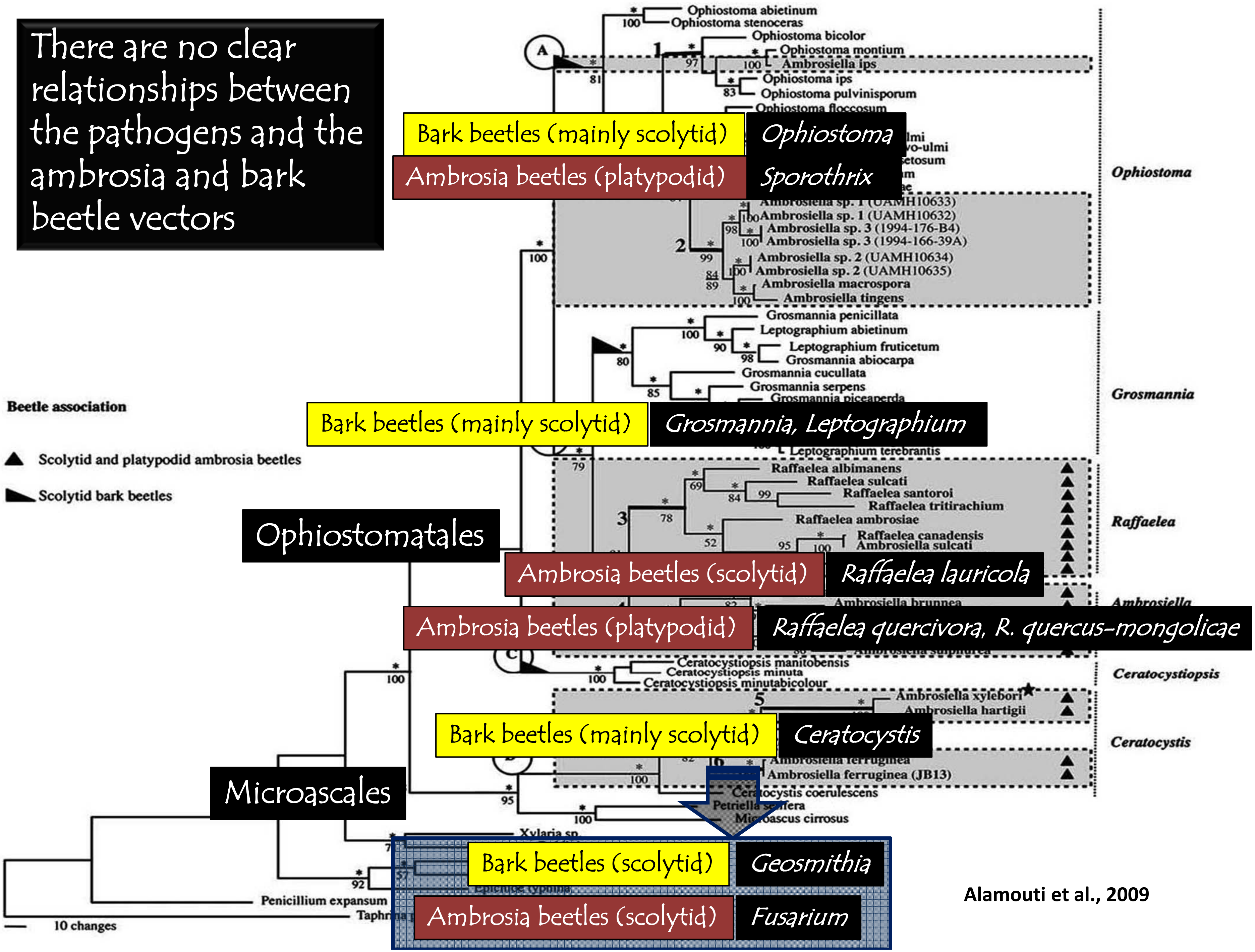


With the exception of *Fusarium* spp. and *Geosmithia morbida* (Hypocreales), the phytopathogenic symbionts are all in the Ophiostomatales or Microascales



Alamouti et al., 2009

There are no clear relationships between the pathogens and the ambrosia and bark beetle vectors



Alamouti et al., 2009

The amount of disease that is associated with beetle activity varies greatly

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For ambrosia beetle-associated tree mortality, significant to no damage is caused by the symbionts

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Laurel wilt: Systemic and lethal damage after a single infection. *Xyleborus glabratus* attempts natal galleries in healthy trees, but colonies are not established – however, these initial interactions are sufficient to start lethal, vascular infections

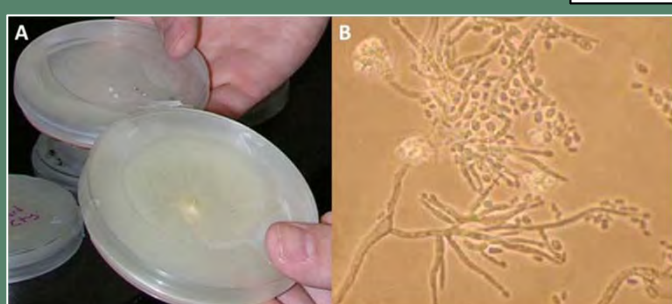

Figure 1. A) Colonies of *Raffaelea lauricola* on CSMA (Ploetz), and B) conidia and cpnidiophores of the fungus produced in culture (courtesy of S. Fraedrich).

Platypodid-associated damage of diverse trees in New Zealand
Sporothrix nothofagi

Platypus **damage, 10-year-old *Eucalyptus nitens***

Treptoplatypus caviceps

Nothofagus fusca **(red beech)**
***T. caviceps*-associated damage**

Platypus apicalis

Platypus gracilis

At the other extreme, some ambrosia beetles cause serious damage by themselves, apparently without symbiont impact

At the other extreme, some ambrosia beetles cause serious damage by themselves, apparently without symbiont impact – prominent examples in the literature include *Corthylus columbianus* (Scolytinae: Scolytini: Corthylina), *C. punctatissimus* , and *Megaplatypus mutatus* (Platypodinae: Platypodini)

Acer, Citrus, Eucalyptus, Fraxinus, Laurus nobilis, Magnolia grandiflora, Malus domestica, Platanus, Populus, Prunus persica, Persea americana, Pyrus communis, Quercus, Robinia pseudacacia, Salix, Tilia, Ulmus, Corylus avellana, Prunus cerasus, Pyrus communis and *Malus domestica*

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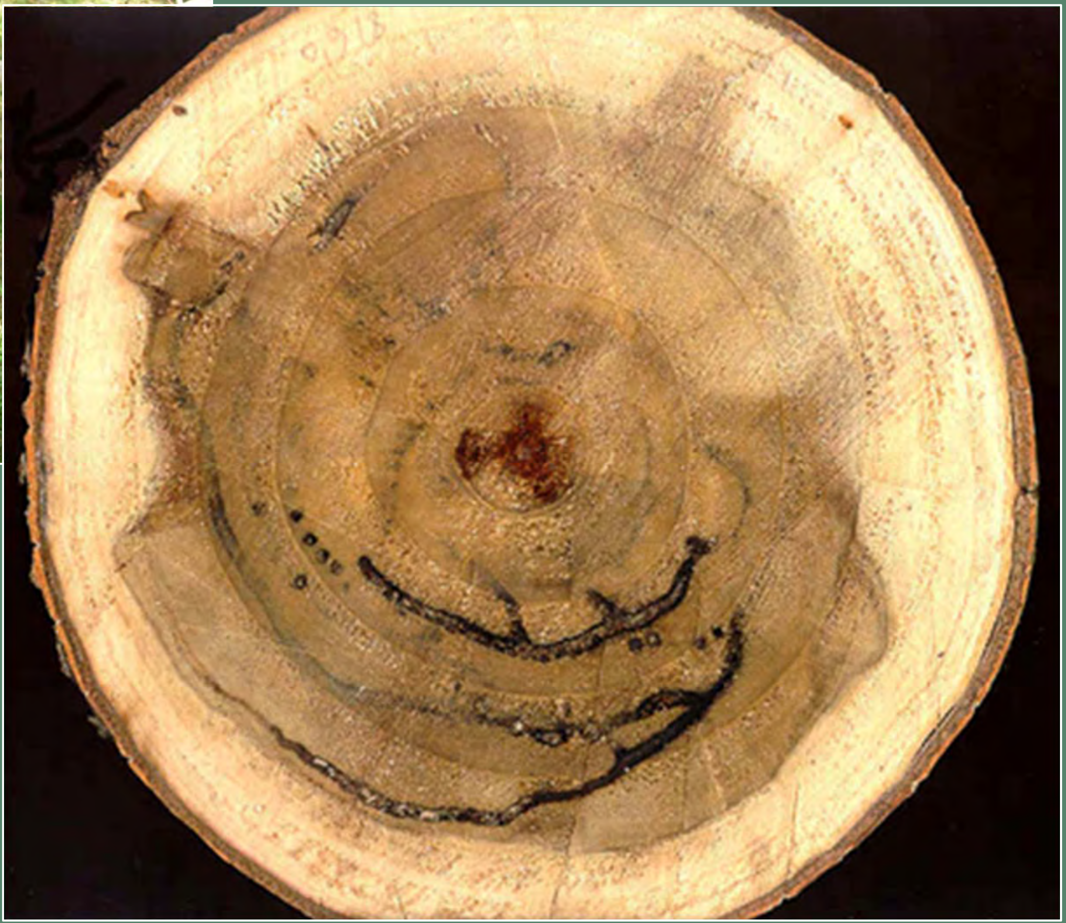
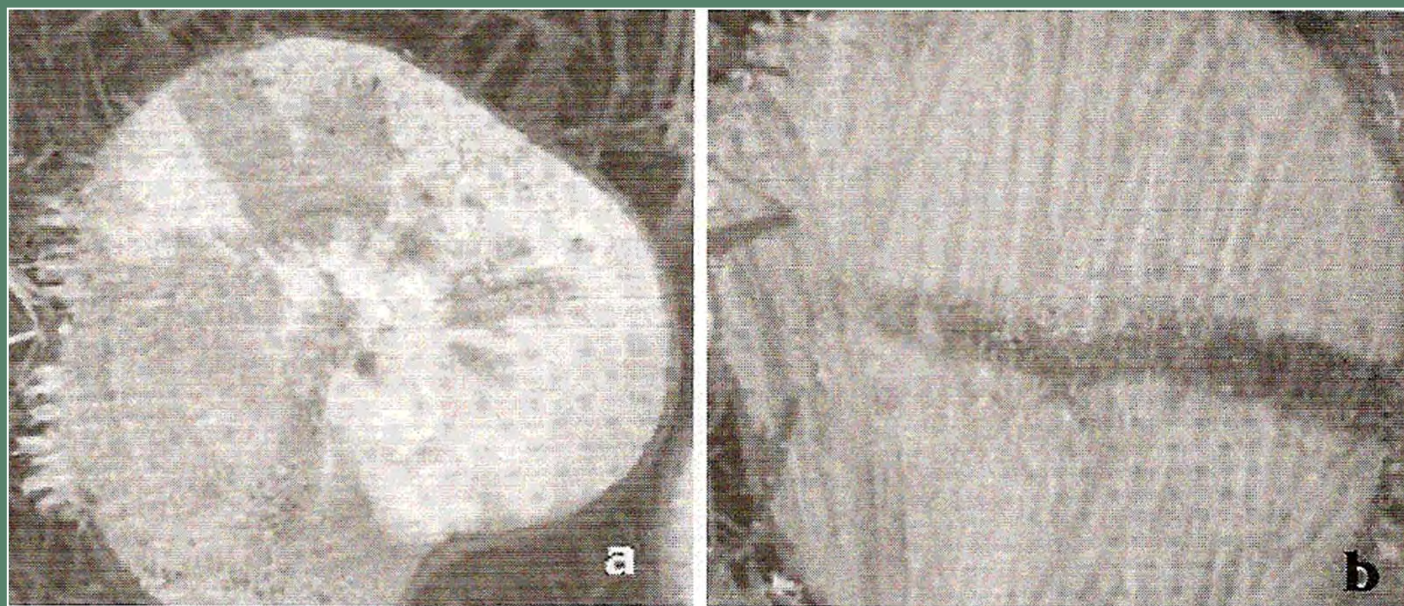
However…



"*Megaplatypus mutatus* damage" on *Populus*



Corthylus sp.
a) *Ceratocystis* sp. and b) *Fusarium solani*
Alnus, Colombia

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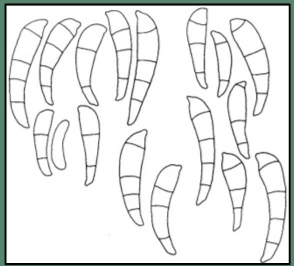
These include scolytid x *Fusarium* interactions

Cankers/dieback caused by *Fusarium* sp., associated with mass attack by *Euwallacea fornicatus.* Avocado, etc. Israel, Australia, California

Mendel et al.



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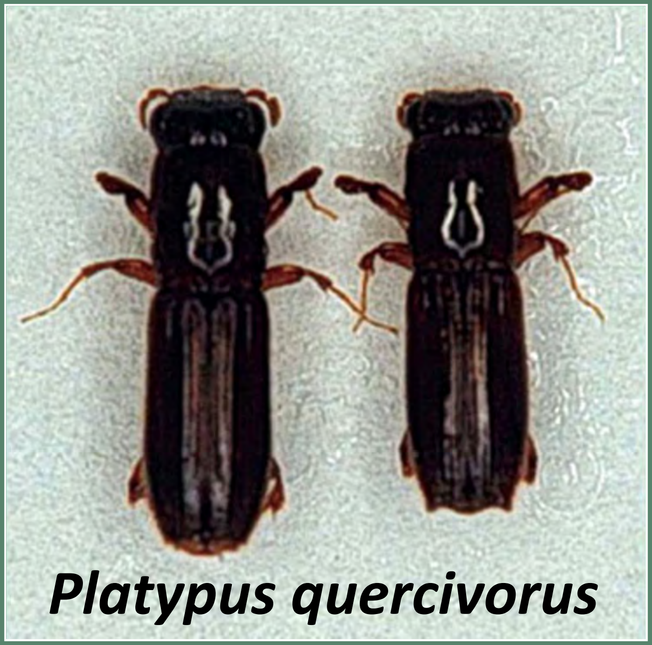
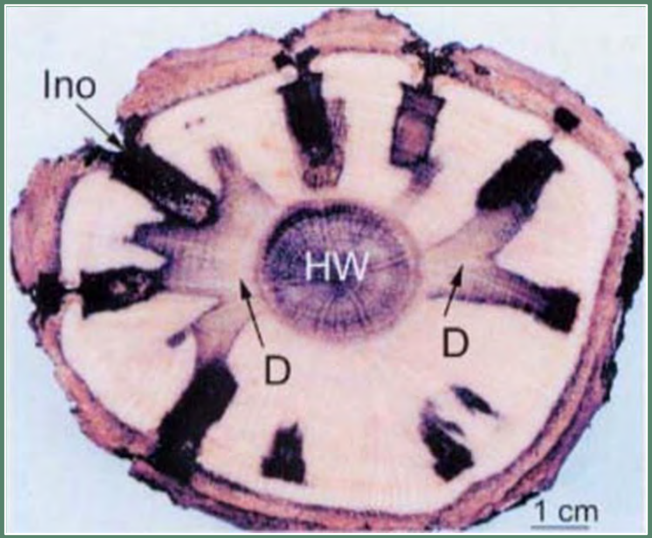
These include scolytid x *Fusarium* interactions, as well as platypodid interactions

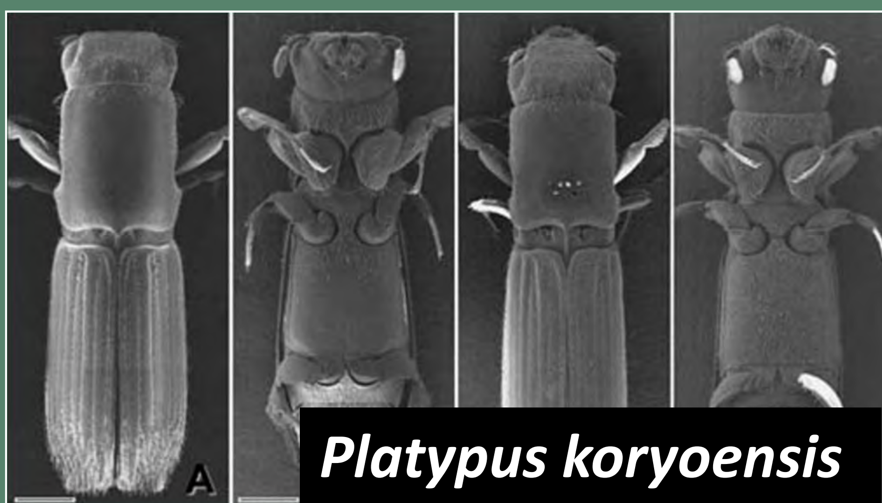
Japanese oak wilt

Raffaelea quercivora





Korean oak wilt
Raffaelea quercus-mongolicae



Platypus koryoensis

Why has the incidence of ambrosia and bark beetle-associated problems increased worldwide?

Why?

Climate change

Why?

Climate change

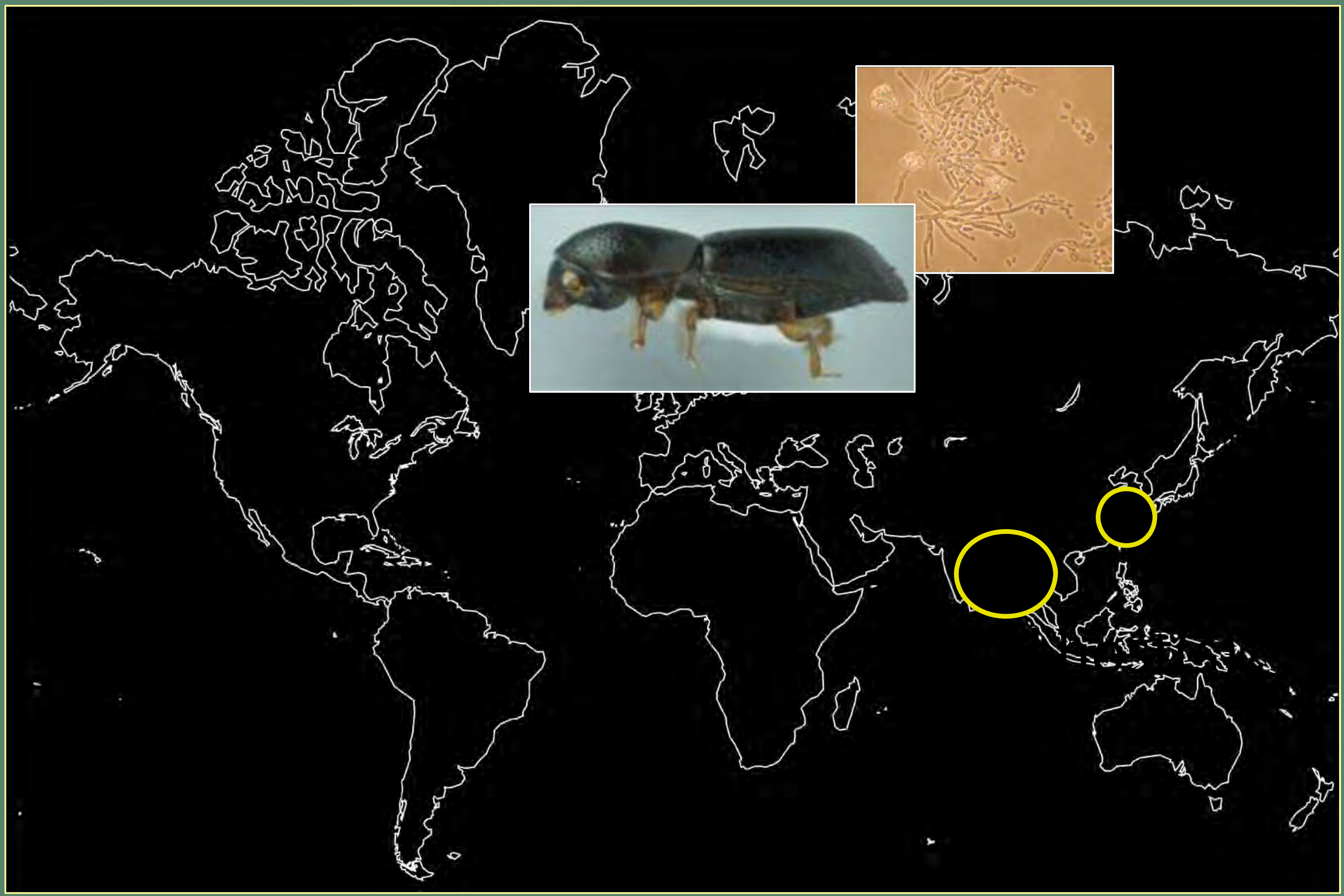
Global warming has been proposed as a reason for the development of both Japanese and Korean oak wilt, as the beetles have extended their geographic ranges into the ranges of previously unencountered host species (Kamata et al., 2002; Kim et al. (2009).

Why?

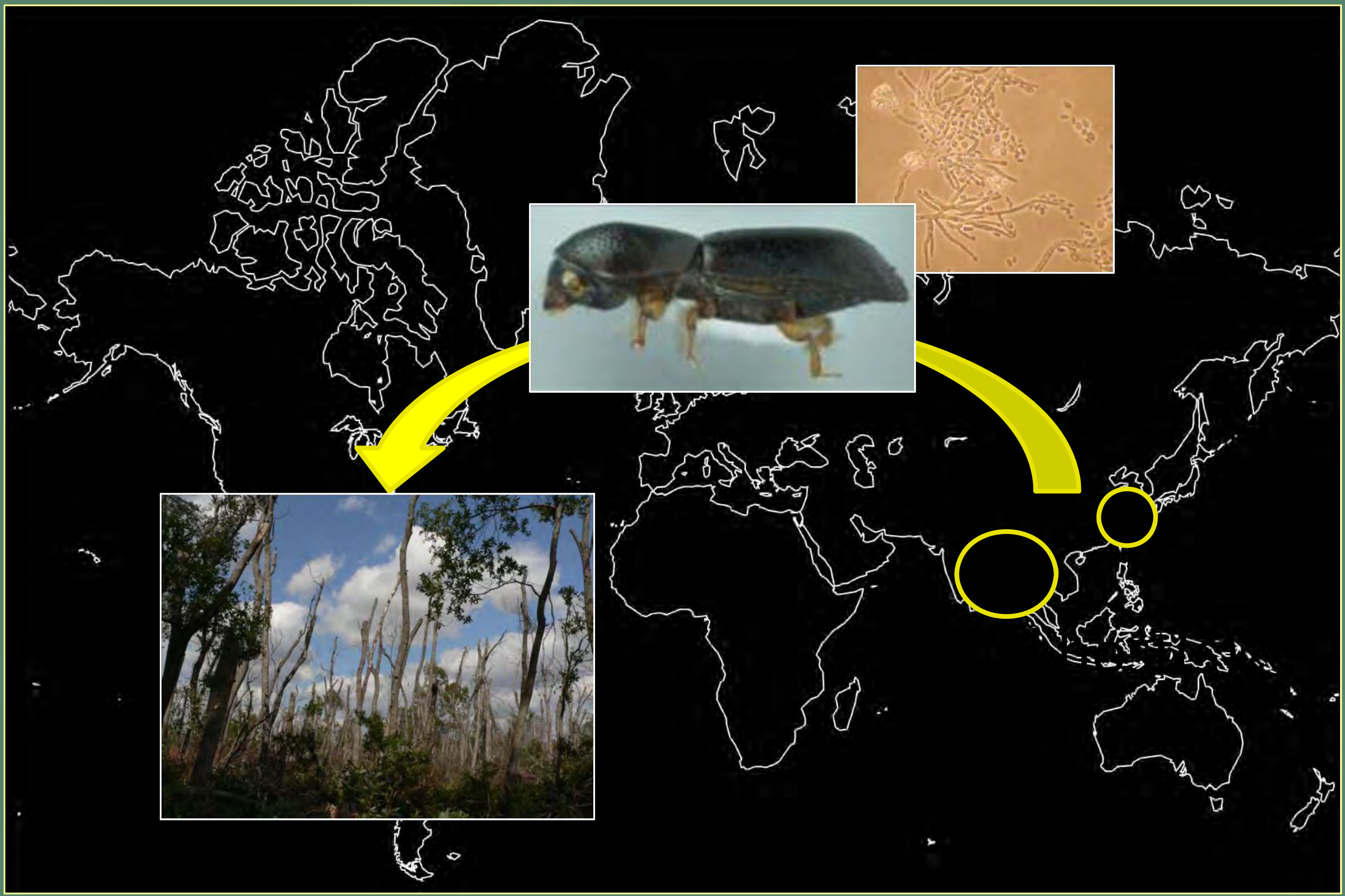
Climate change

New encounters (no evolutionary history between host tree and beetle/fungus)

Laurel wilt.



Laurel wilt. Vector and pathogen moved to SE USA where they encounter new, susceptible hosts



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Olfactory miscues (mistakes in vector behavior) (Hulcr and Dunn 2011)

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New encounters coupled with predisposing conditions (Faulds, 1977; Kessler, 1974; Payton, 1989)

Why?

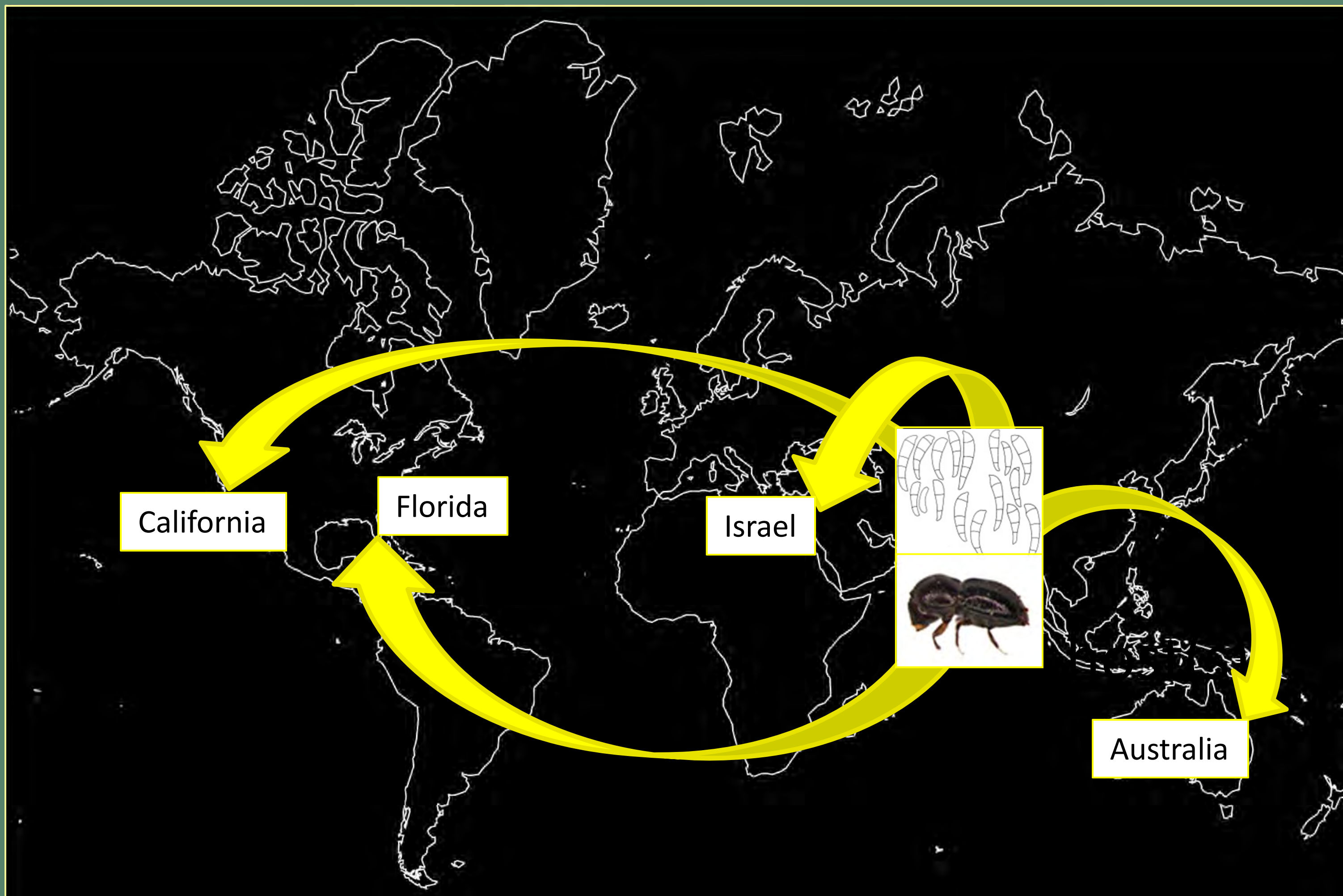
Climate change

New encounters

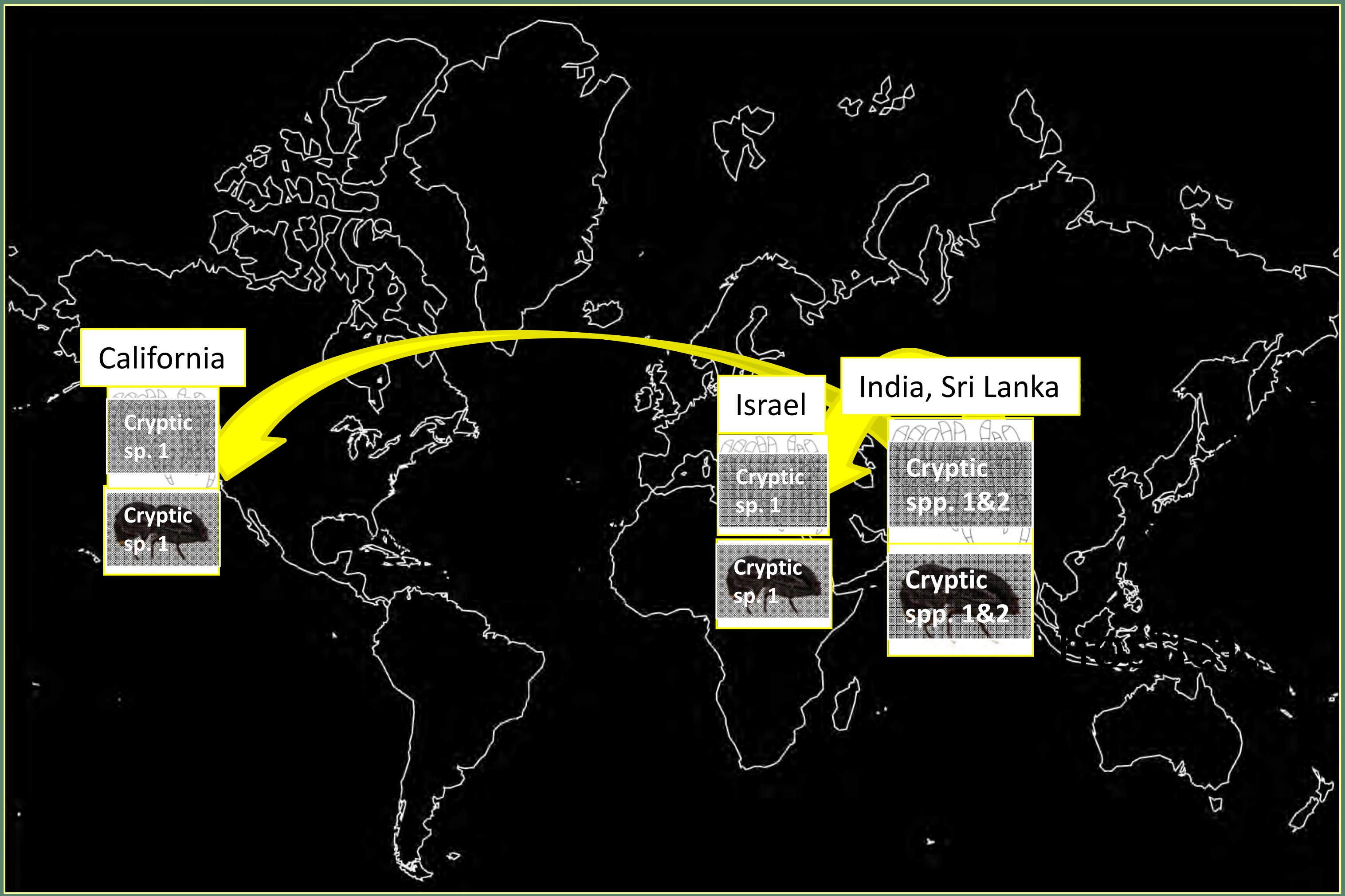
Increased virulence/fitness in fungus (evolution, hybridization or selection of rare pre-existing genotypes)?

Evolution or selection? *Euwallacea fornicatus/ Fusarium ambrosium.*

Evolution or selection? *E. fornicatus/ F. ambrosium.* Is the simple story incorrect?



Evolution or <u>selection</u>? *E. fornicatus/ F. ambrosium.* i.e., diverse insect and fungus in Asia…



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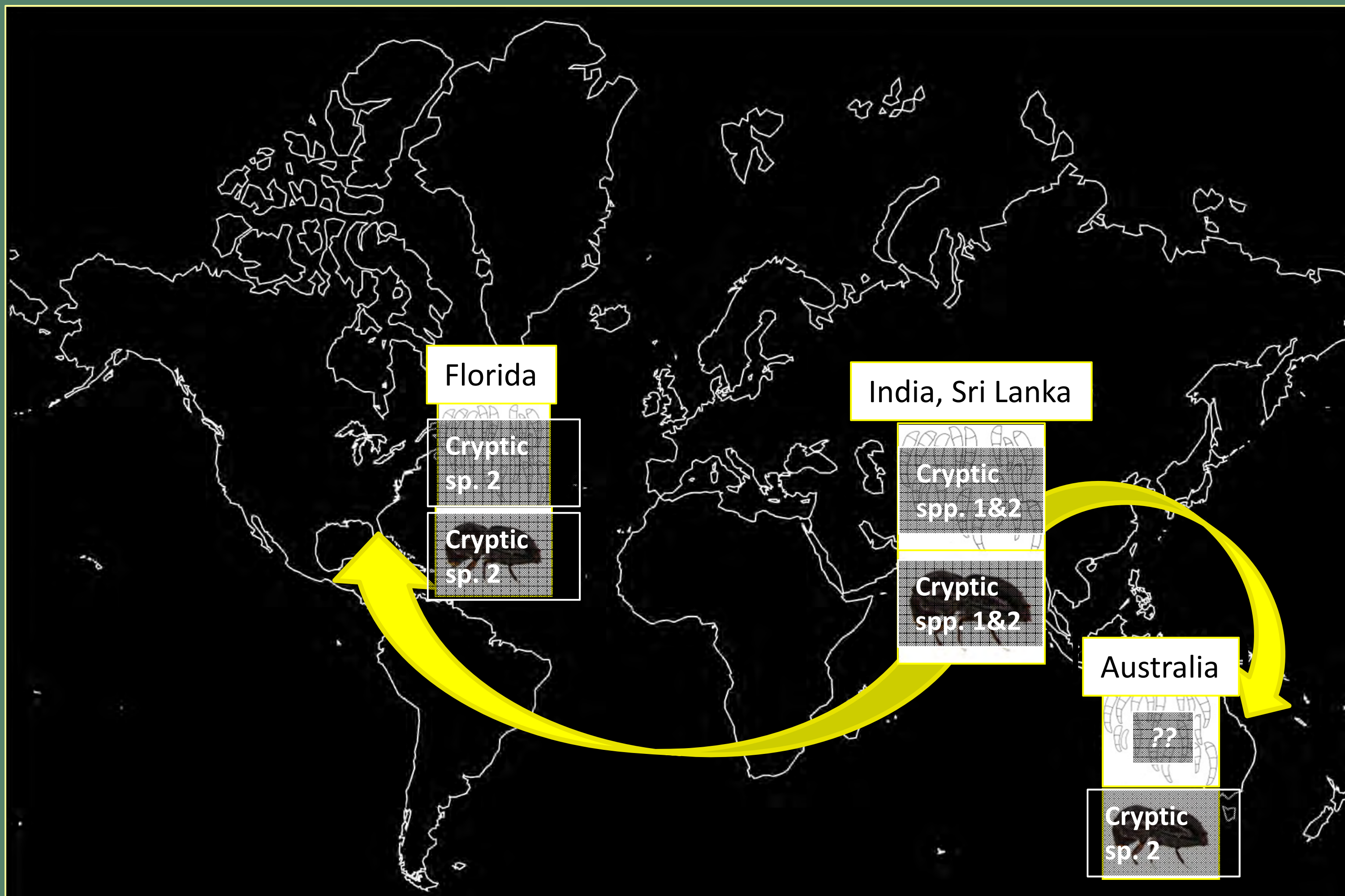
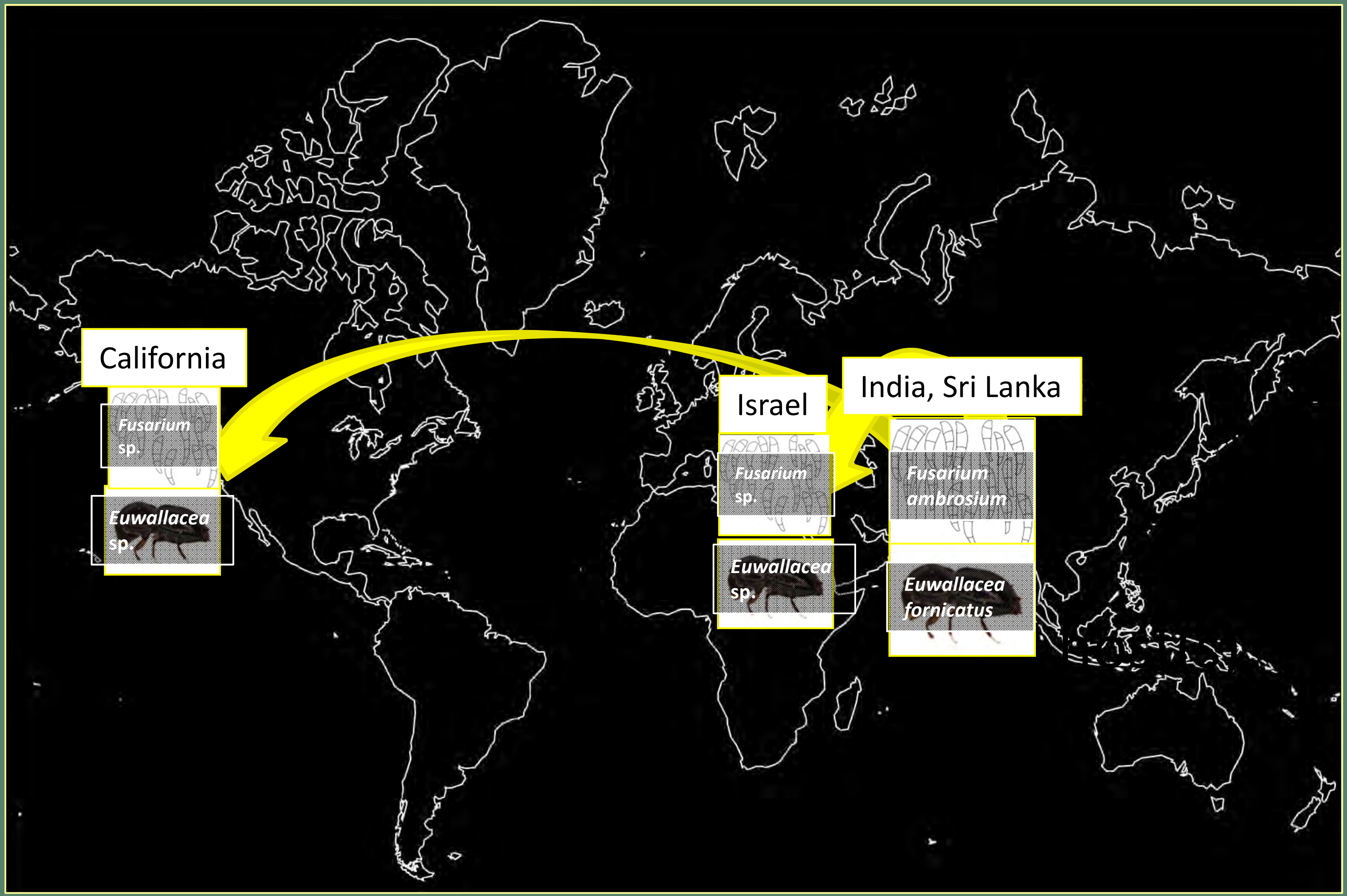
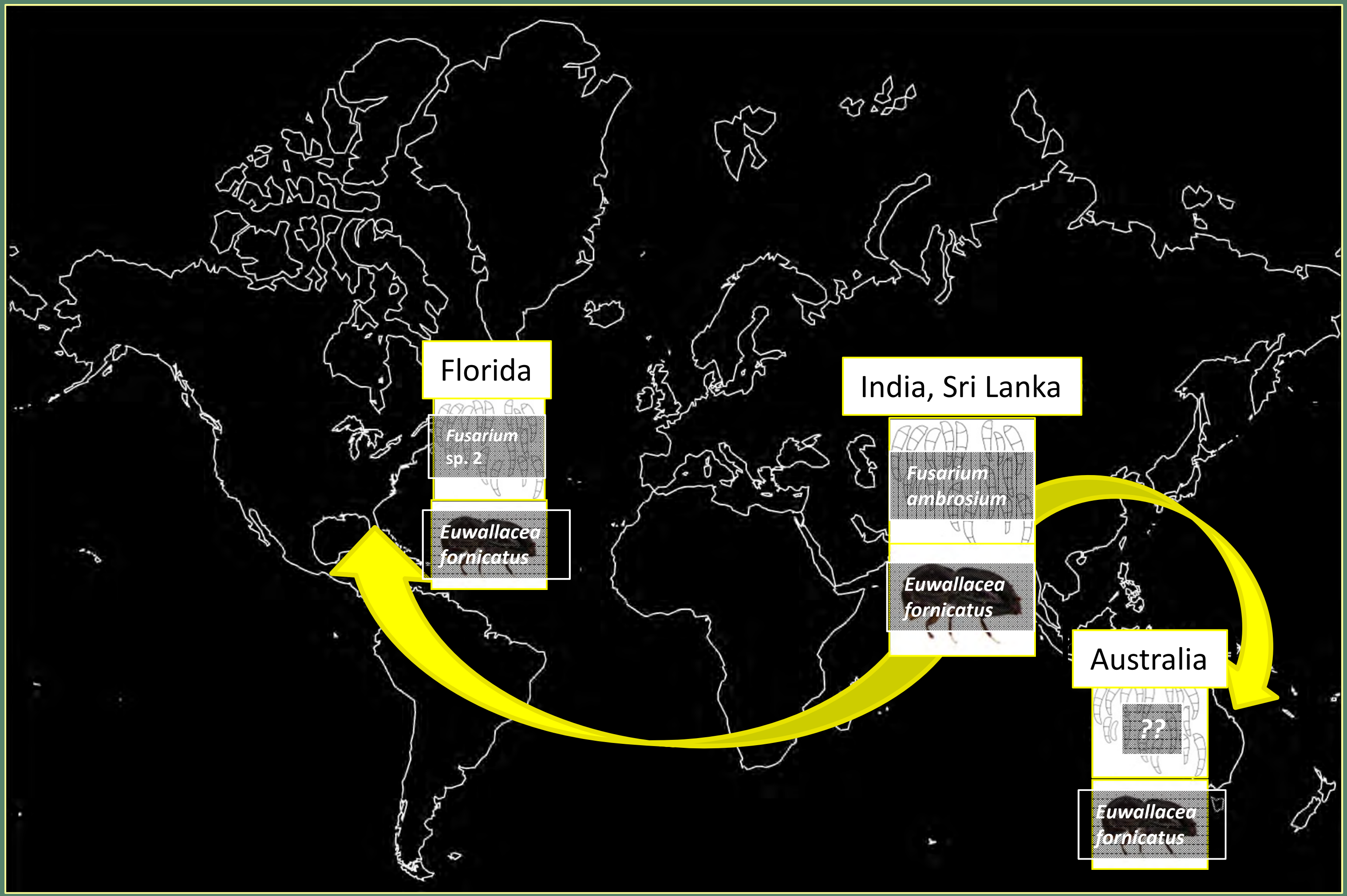


Evolution or selection? Or are the California and Israel …



Evolution or selection? … and Florida and Australia situations caused by evolved beetles and/or fungi?



What can be done?

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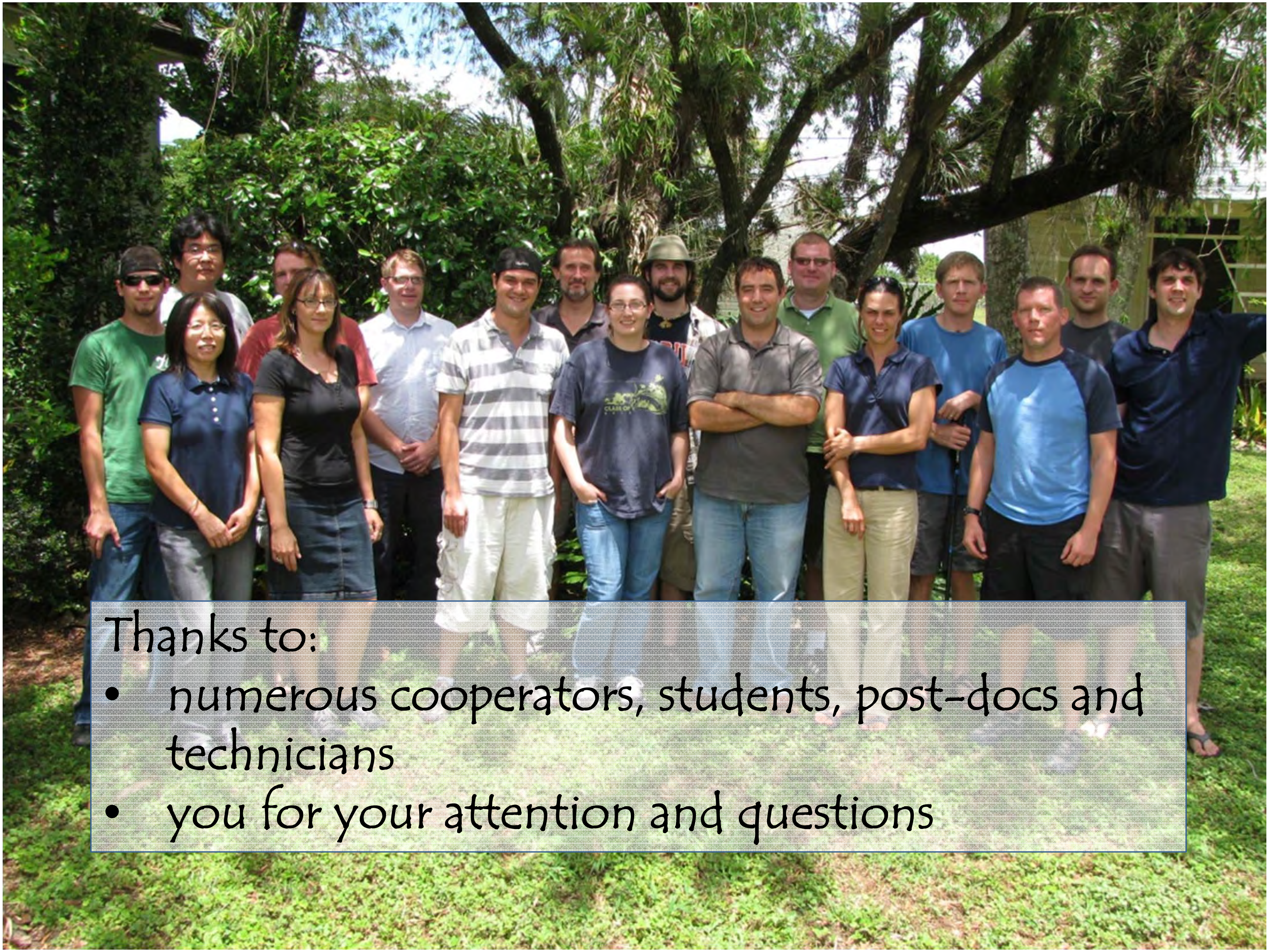
Interdiction, management and prediction will be discussed at the end of this session



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- you for your attention and questions