The presence of *Phellinus noxious* on many islands in the Pacific and observations that may lead to an effective control of this pathogen

Presented by: Dr. Phil Cannon

8th Seminar on Best Practices for Urban Tree Management

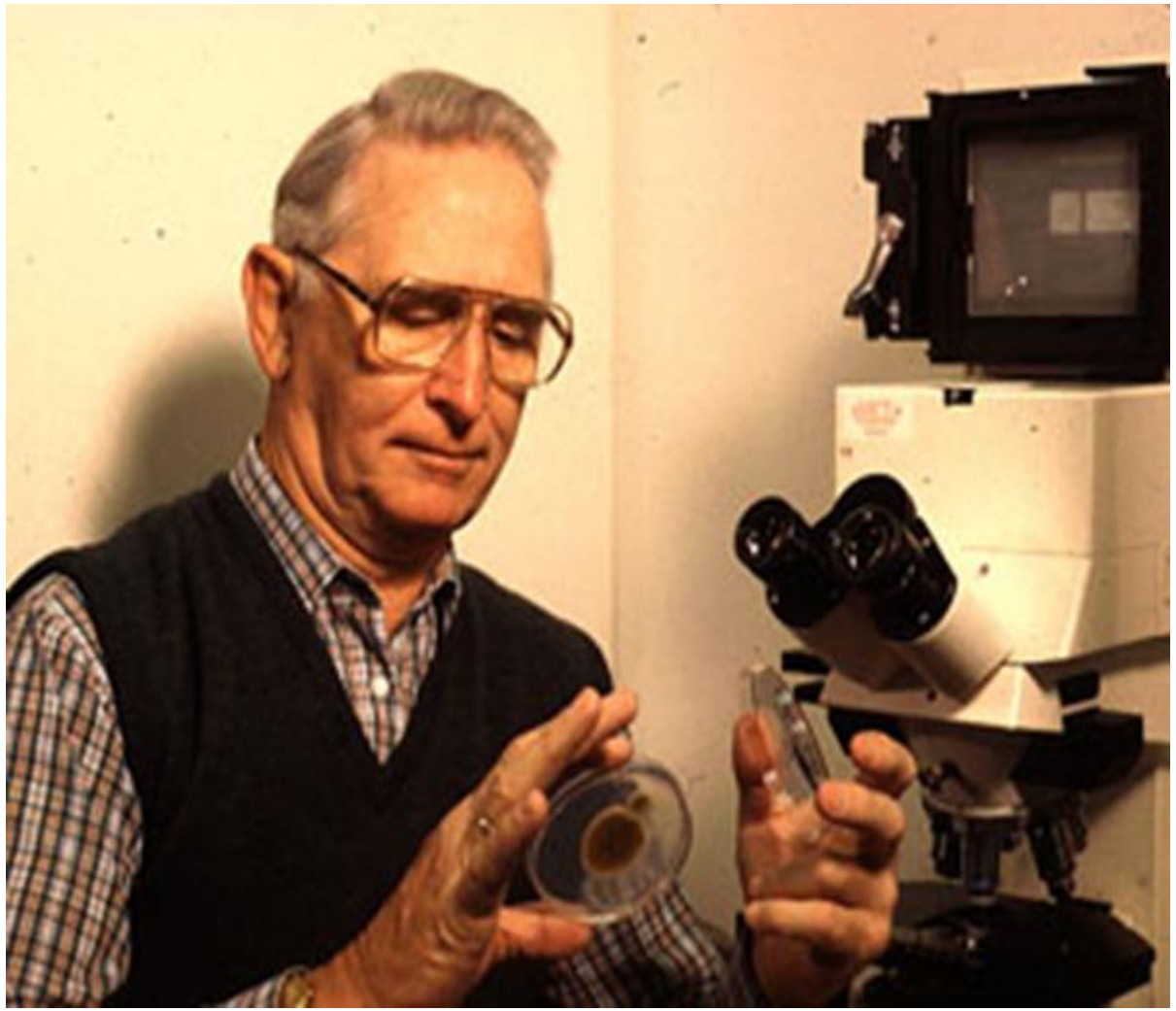
第8屆都市樹木優化作業研討會

Hong Kong, March 18, 2017

What we will talk about in this presentation

- 1) **The discovery of *Phellinus noxius*** (BRRD) on islands in the Pacific.
- 2) **The nature of *P. noxius*** on the islands of the Pacific and some observations about its spread, build up and break-down.
- 3) Basic approaches for **managing root rot pathogens**
- 4) Some **attempts to control *Phellinus noxius*** in the Pacific
- 5) **Management practices** for *P. noxius* **that deserve further testing**

In 1984, Chuck Hodges and Juaquin Tonorio find *Phellinus noxius* on flame trees (*Delonix regia*) in Saipan



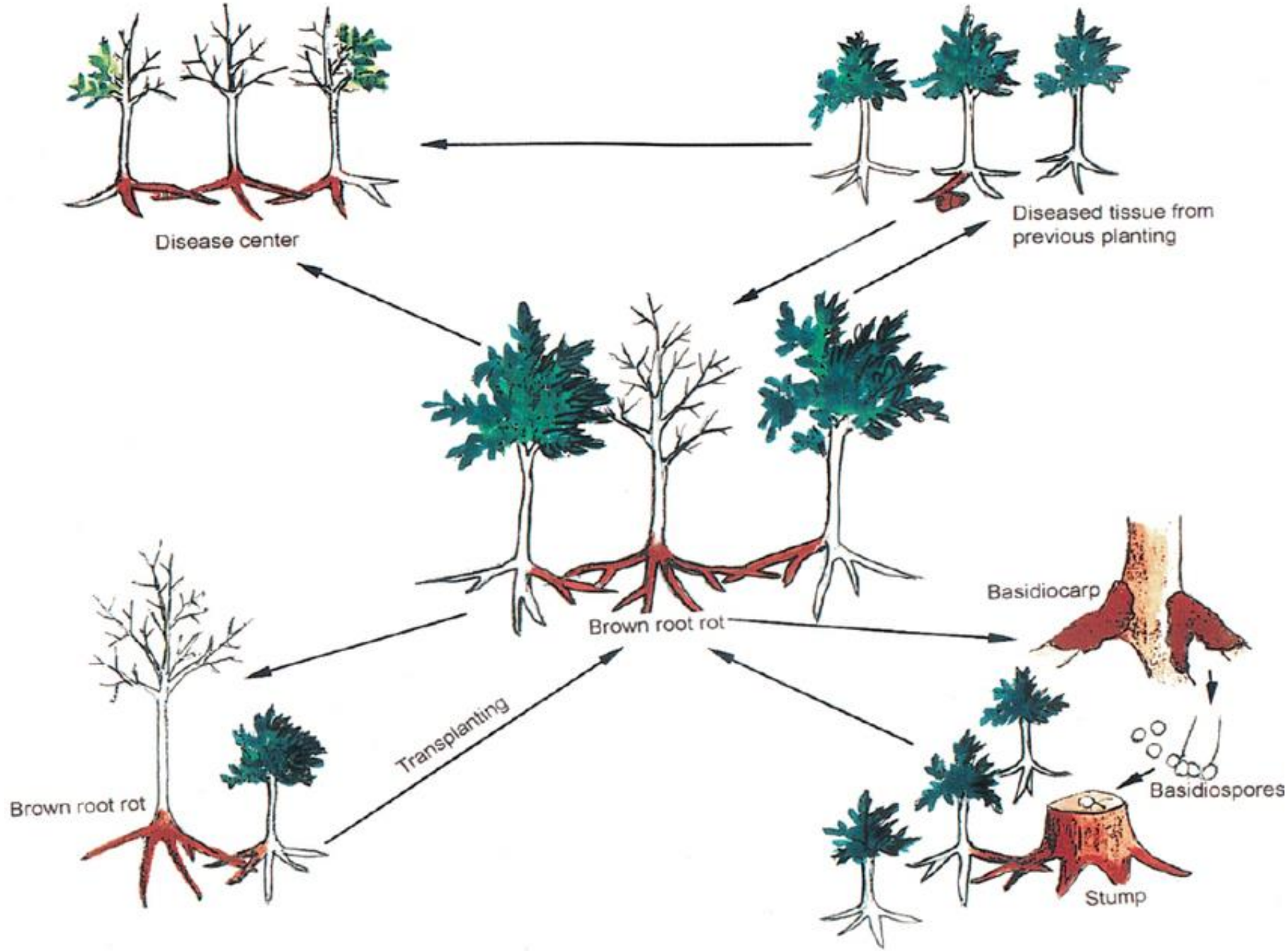
Chuck Hodges

Saipan Airport, 2016

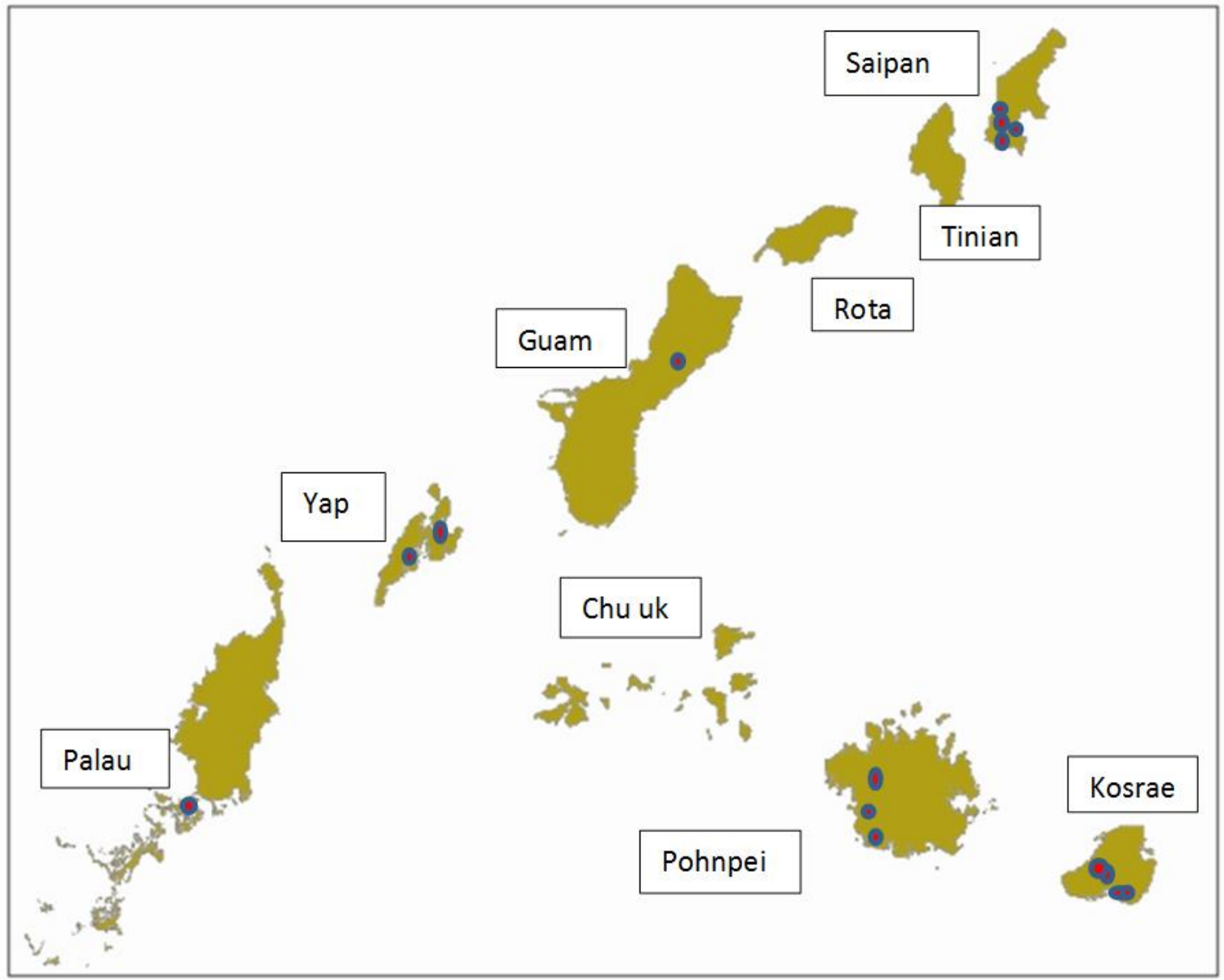
Saipan Airport

Rota Airport


Brall


Disease center
Diseased tissue from previous planting
Brown root rot
Basidiocarp
Transplanting
Brown root rot
Basidiospores
Stump

Dr. Fred Brooks finds *P. noxius* on kapok trees (*Ceiba pentandra*) in American Samoa; it has grown through root systems at 20’ per year for the past 15 years.



Over 2000 islands

Phellinus noxius: the notorious black sock

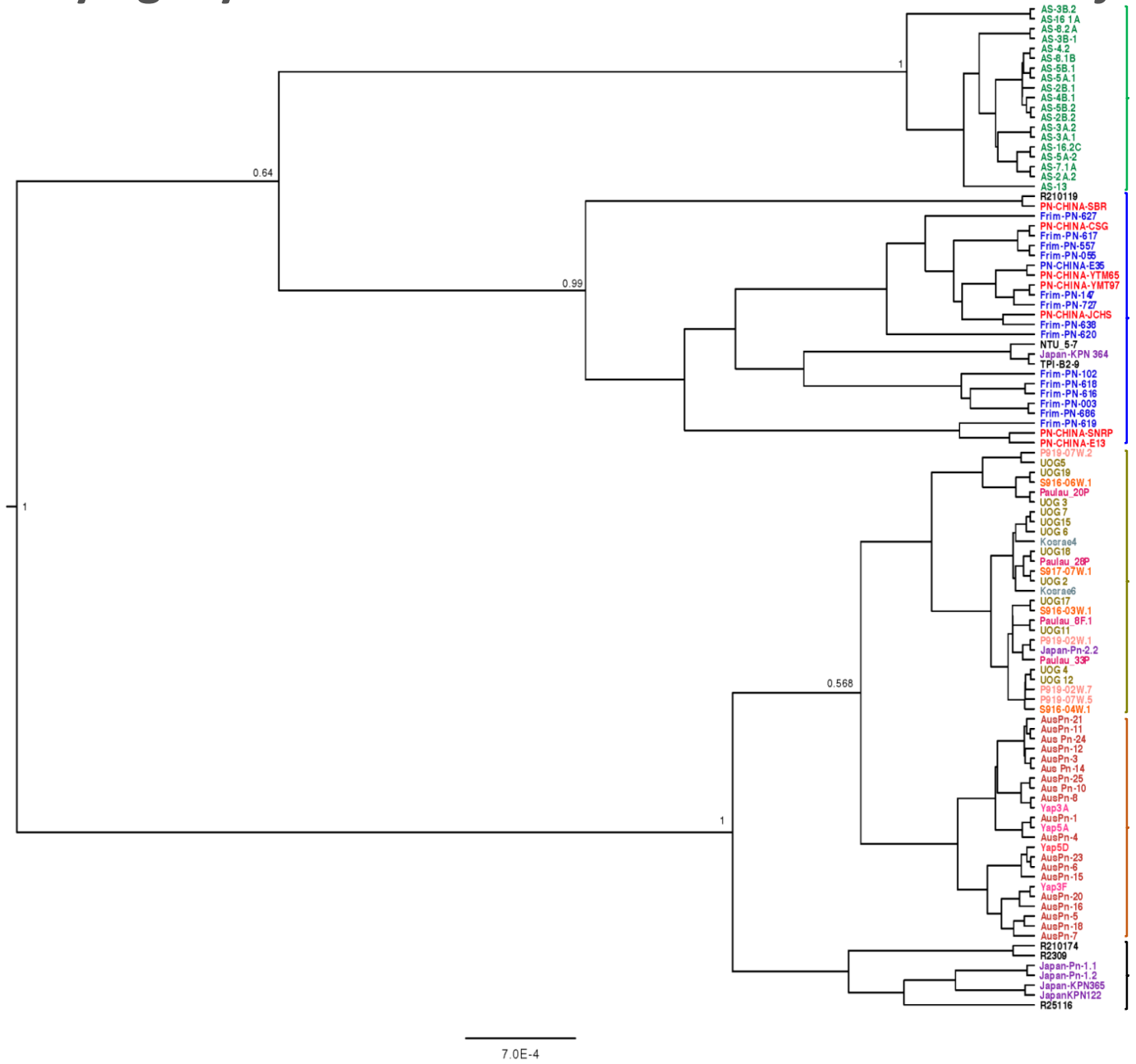
Picture Used for Wanted Poster !!

Map of *P. noxius* isolate collections

American Samoa (19)
China-Hong Kong (8)
Malaysia (14)
Taiwan (6)
Japan (3 for Ogasawa Is and 3 for Ryukyu Is)
Saipan (5), Guam (12),
Yap (4), Palau (4),
Pohnpei (4), Kosrae (2)
Australia (19)

M.-S. Kim et al.

Phylogeny of *Phellinus noxius* isolates based on *tef-1a* sequences



American Samoa

China (Hong Kong)**/Malaysia/**
Japan (Ryukyu)**/Taiwan**

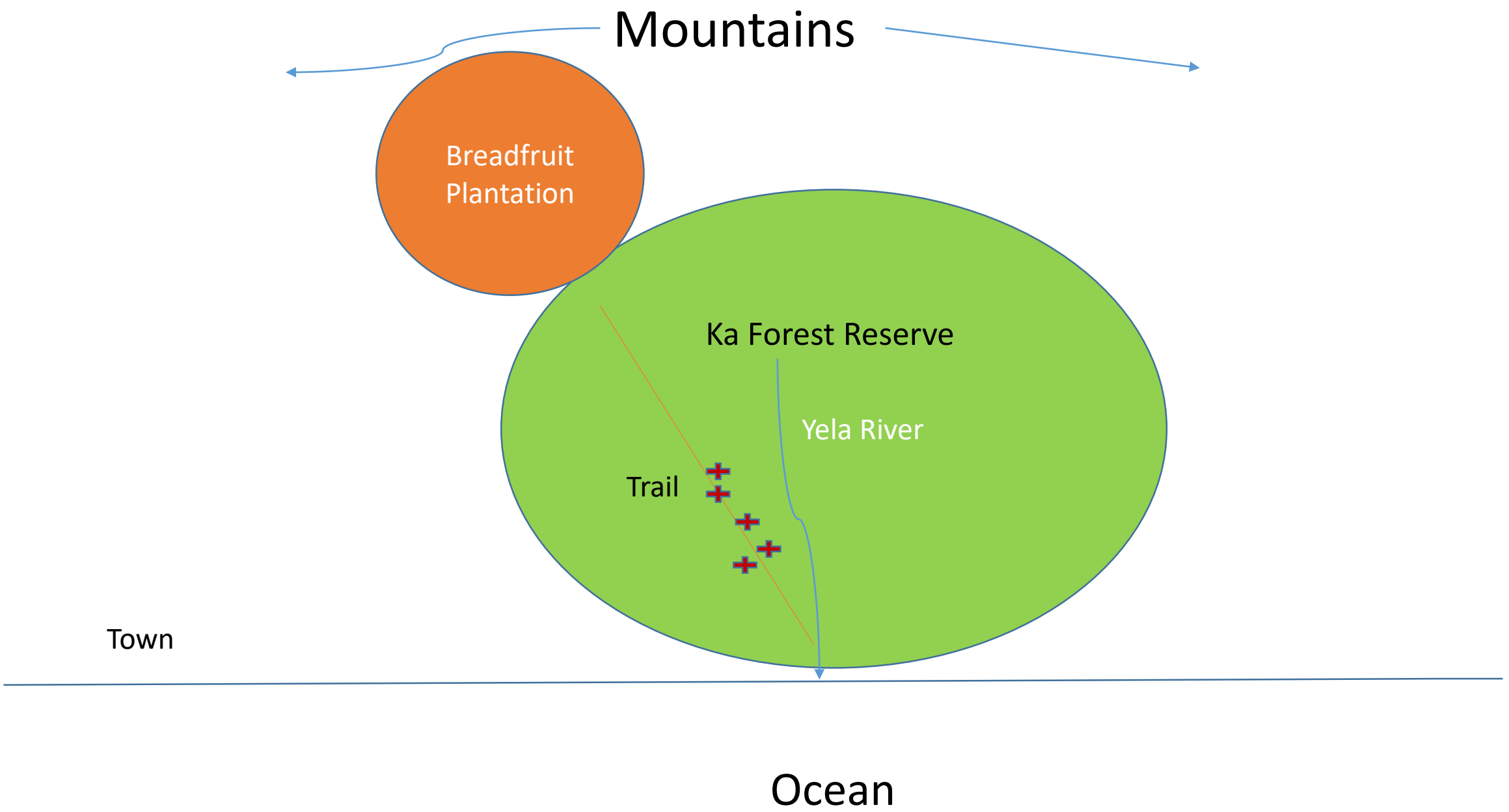
Guam/Saipan/Palau/Kosrae/
Pohnpei/Japan (Ogasawara)

Australia/Yap

Taiwan
Japan (Ryukyu and Ogasawara)

How Has the Disease Spread on Kosrae ?

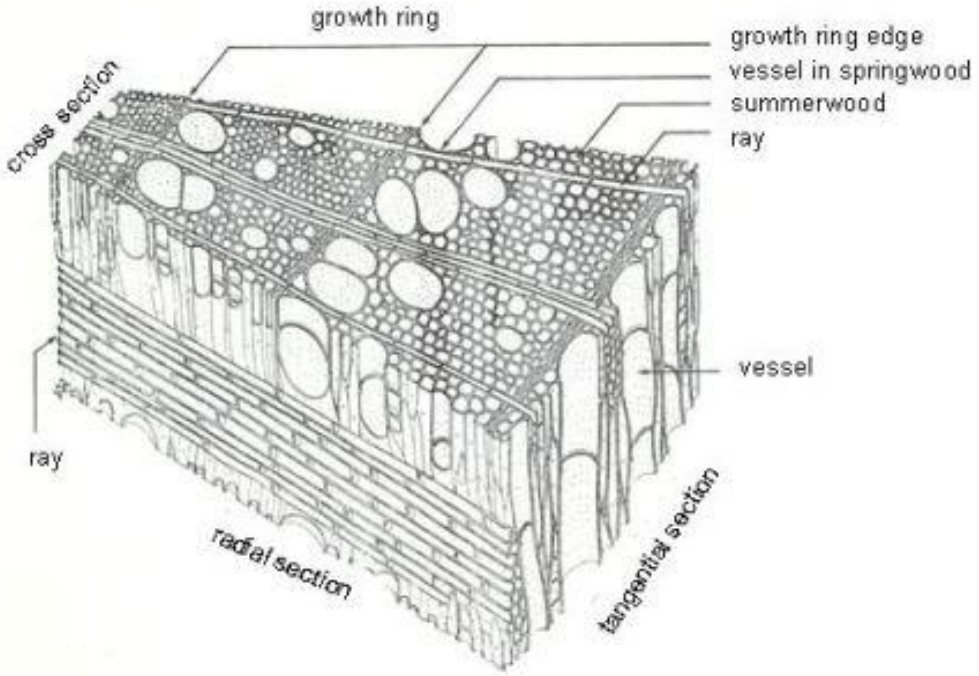
The Giant Ka Forest (*Terminalia carolinensis*) in the Yela Conservation Area of Kosrae, Micronesia


Mountains
Breadfruit Plantation
Ka Forest Reserve
Yela River
Trail
Town
Ocean

Terminalia amazonica

66% Cellulose and Hemicellulose

31% Lignin



Enzymes found in *Phellinus noxius* that help it decompose wood

- Lignin peroxidase
- Mn-dependent peroxidase
- Hemicellulase
- Xylanase
- Laccase

- Impact of *Phellinus pini* on wood of Betula sp.
- 17% overall dry weight loss
- 54% weight loss of the lignin component
- 5% weight loss of the glucose component (=cellulose)
- 13% of the xylose component

Information from Blanchette, 1991

Maxson With Invasive Vine


Local Motion


NORTH SHORE·HAWAII
Hawaiian
PREMIUM SURFING

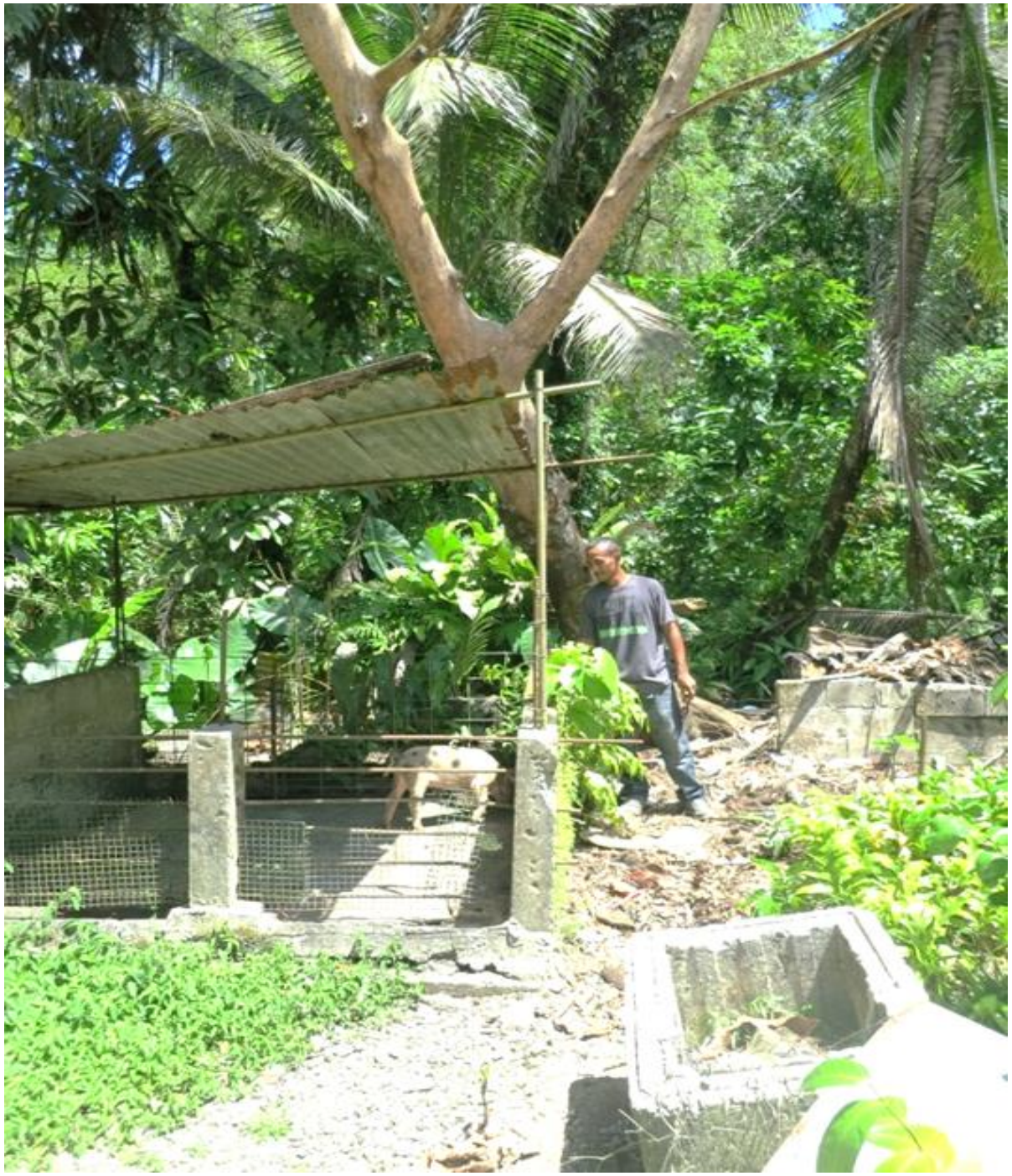
BREADFRUIT

Breadfruit (*Artocarpus altilis*) is an important staple on most islands

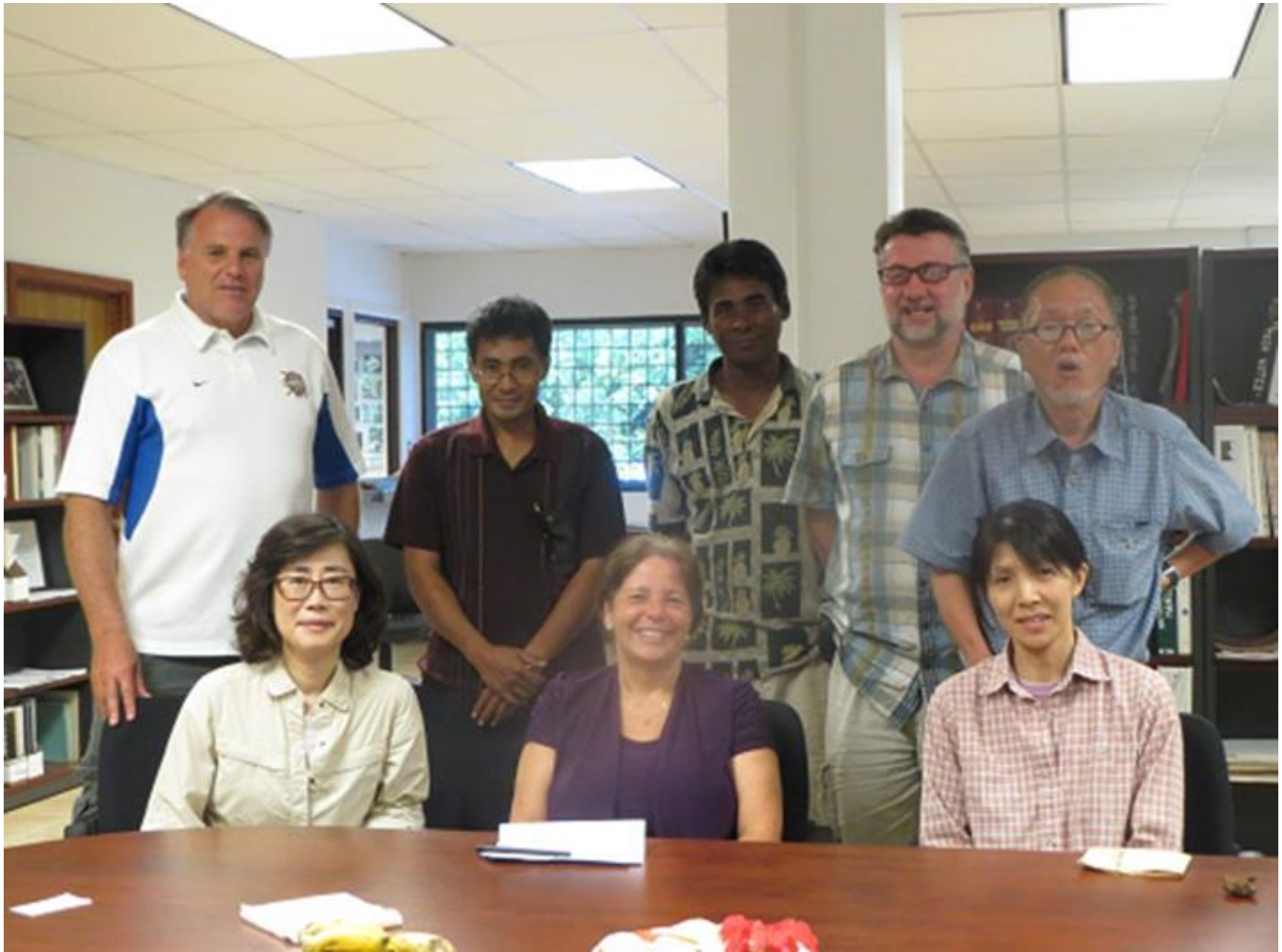
Infected
Root
Sprout


Kosrae Int. Airport
Tafunsak Village
Mt. Mutante
James Palisis Marine Park
Okat Harbour
Pacific Ocean
Lelu
Tofol
Lelu Ruins
Lelu Village
Lelu Harbour
Yela Valley Ka Forest
Tafunsak
Mt. Finkol
Mt. Oma
Utwe
Cascade Waterfall
Walung Village
Menka Ruins
Japanese Relics
Malem Village
Malem
Sipyen Waterfall
Saolung Waterfall
Utwe Village
Pacific Ocean
WWII Japanese Shelter
WWII Japanese Radio Station
WWII Japanese Monument
Walung Mangrove Channel
Utwe Harbour
N

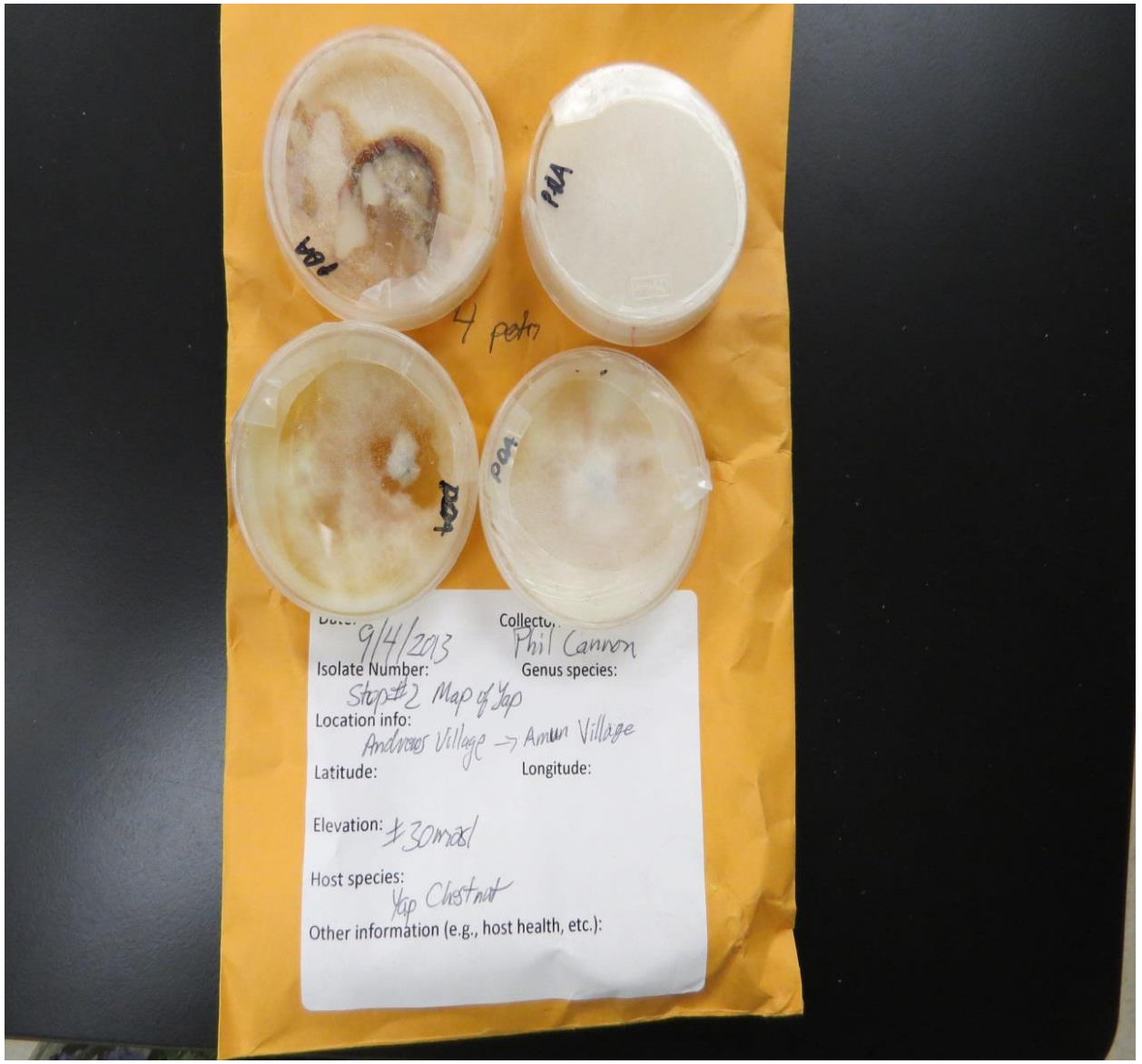
Hazard tree-
Phellinus killed tree,
could smash pig



Phellinus noxius: Dream Team

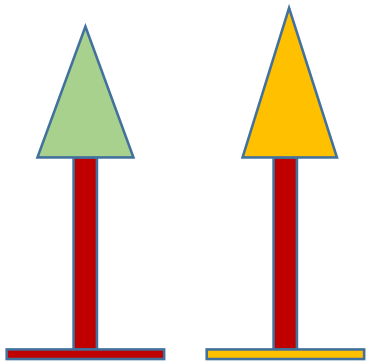


Yuko Ota

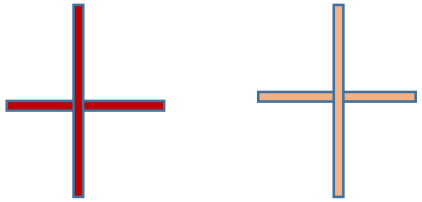


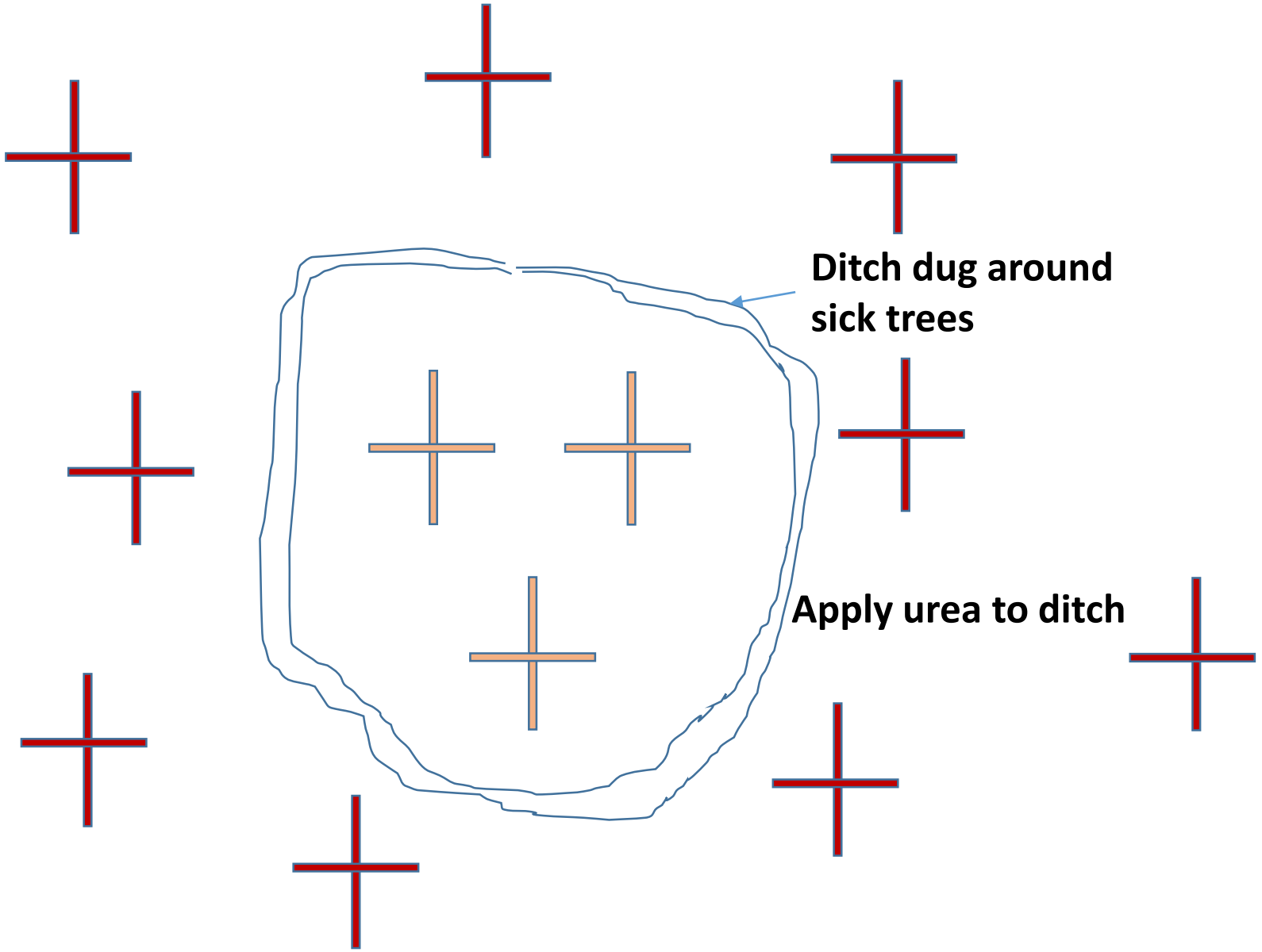
Phellinus isolates in Idaho

Shampoo ginger
Zingiber zerumbet



Healthy Diseased






12/2015
PHENOX
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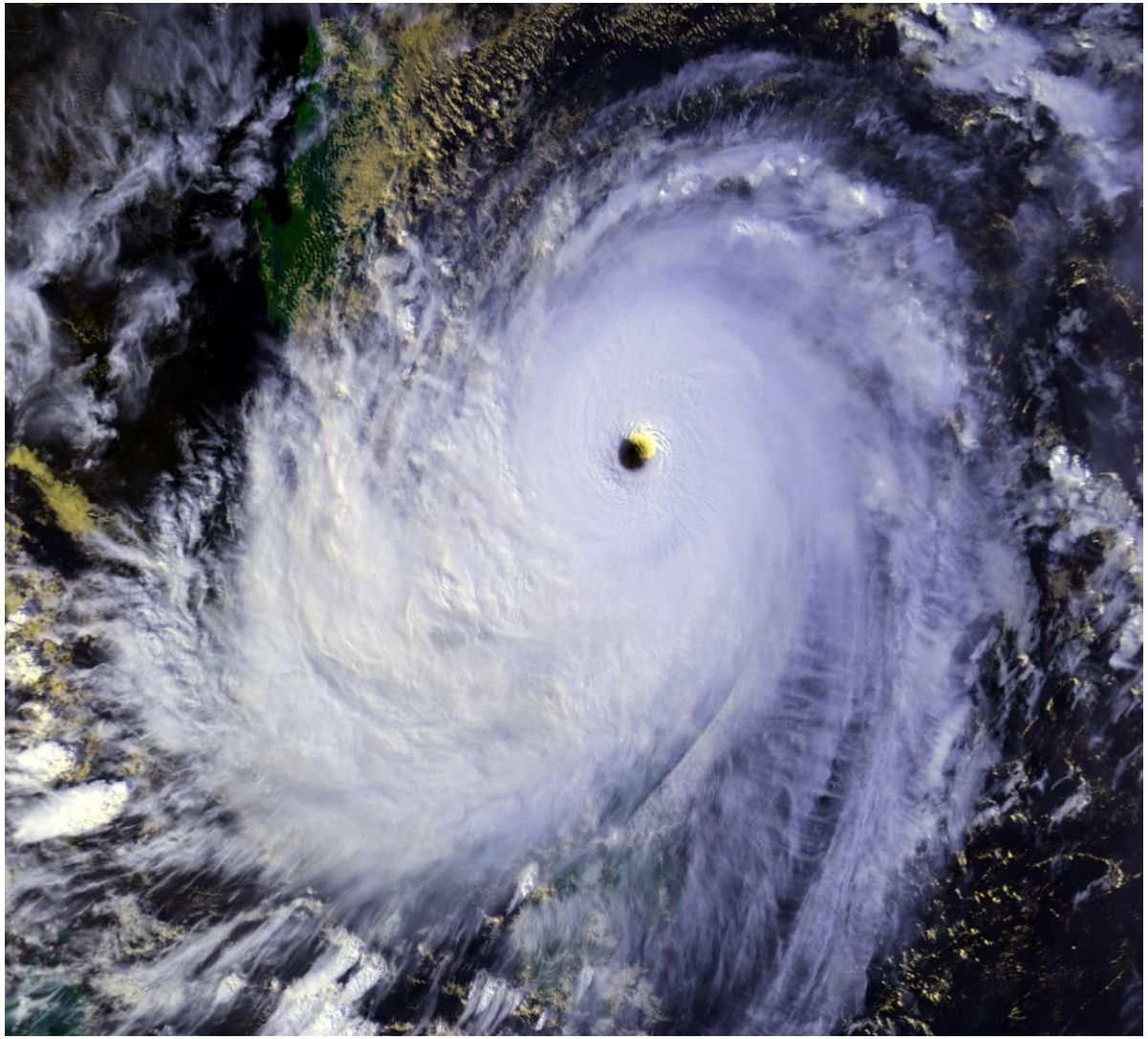
PHENOX211
PHELINUS NOXIOUS3
PHENOX
PHENOX162
PHELINUS NOXIOUS
PHENOX
PHENOX62
PHENOX91
PHENOX92
PHENOX71
PHELINUS NOXIOUS1
PHENOX61
PHENOX111
Image © 2015 CNES / Astrium
Image © 2015 DigitalGlobe

Typhoons can cause a triple whammy

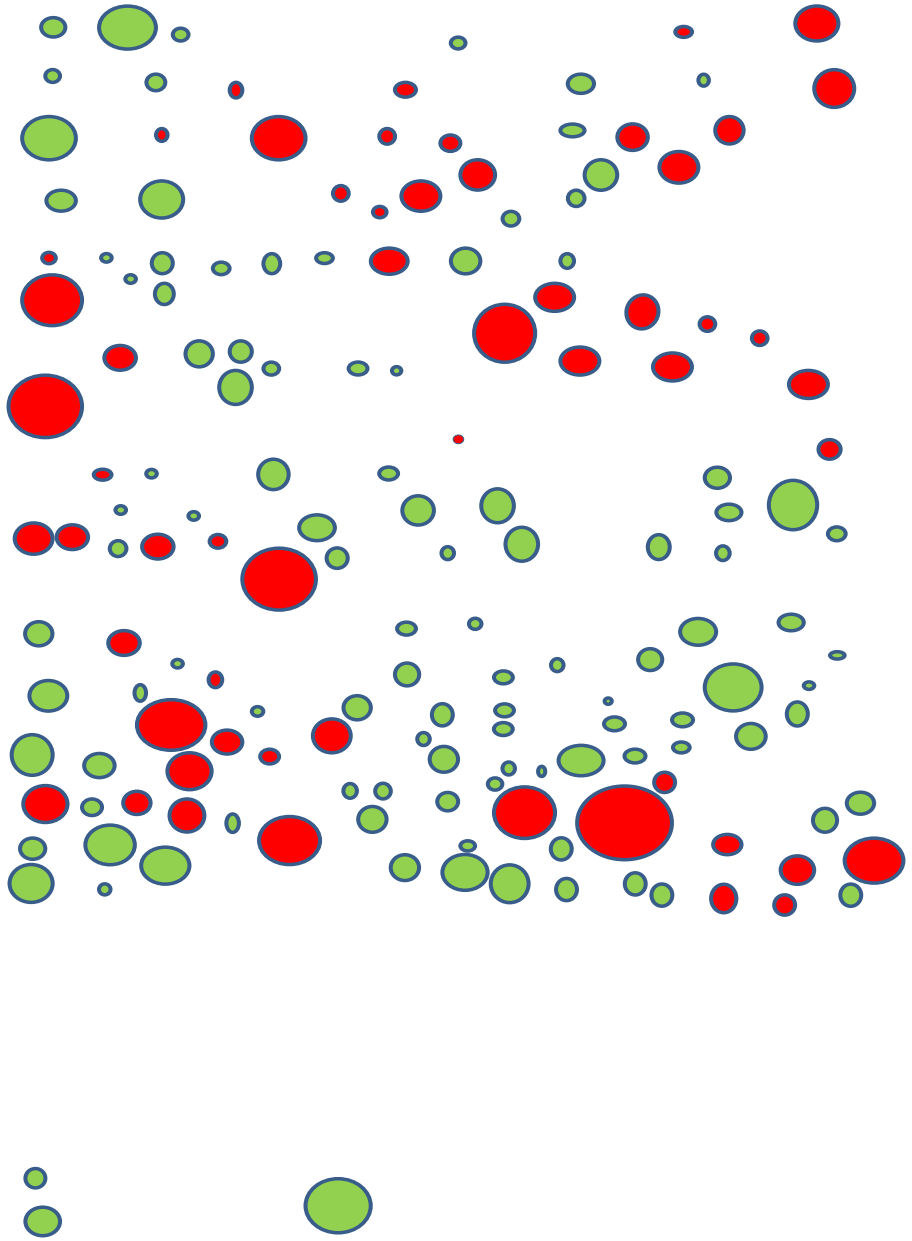
1) Push trees around causing breakage of limbs and boles and the wounding of roots.

2) Provide lots of moisture which will increase sporulation and infection rates.

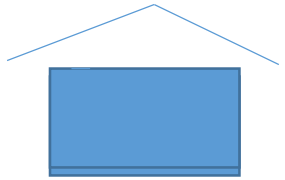
3) Promote growth of the mycelial sheath (Black sock)



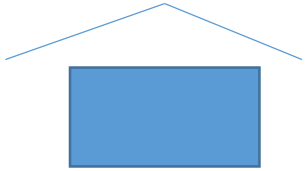
Distribution of trees with and without Phellinus noxius sign/symptoms at the Ada Estate Saipan
(smallest circles are 4”dbh trees; largest circles represent 36” dbh trees)



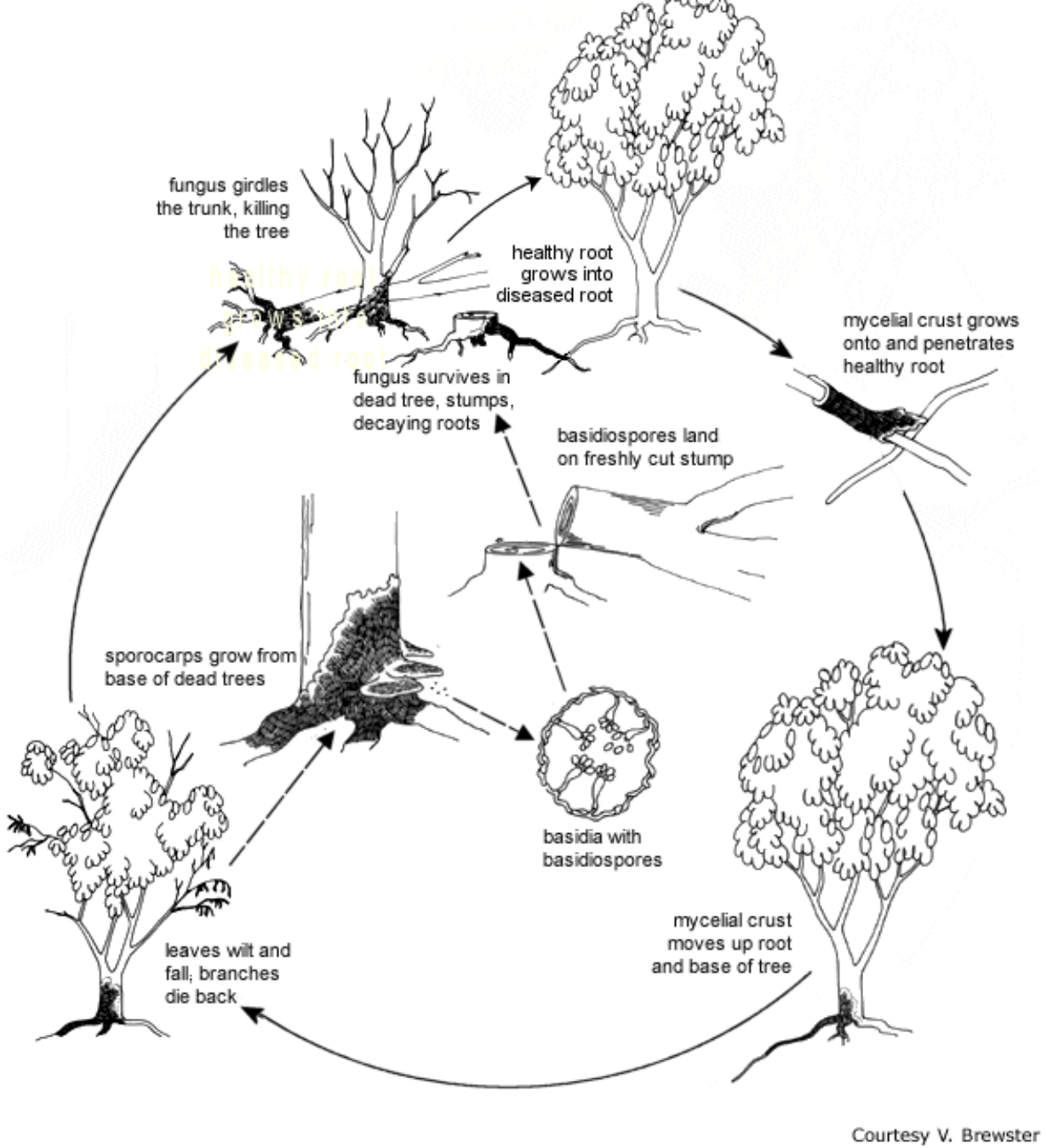
THE ANGRY SISTERS



One sister



The other sister



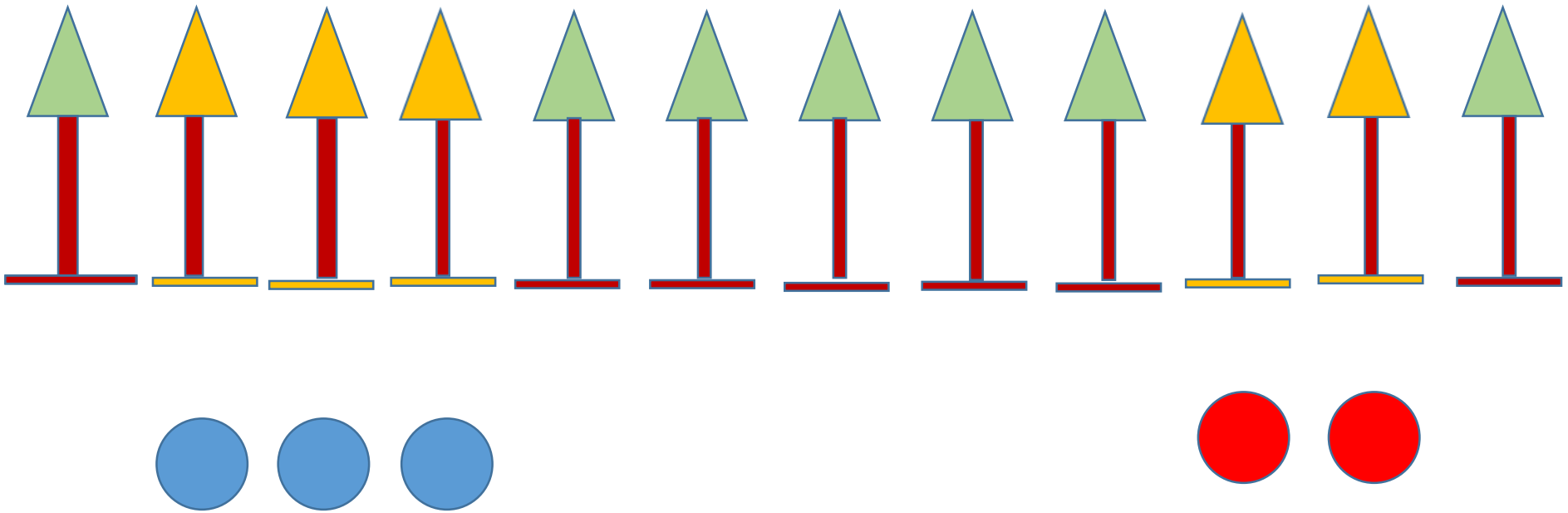
Courtesy V. Brewster

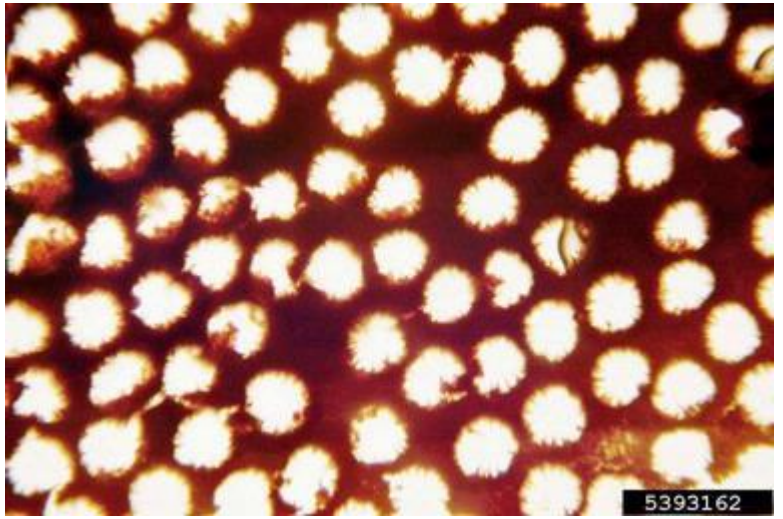
Disease Control =

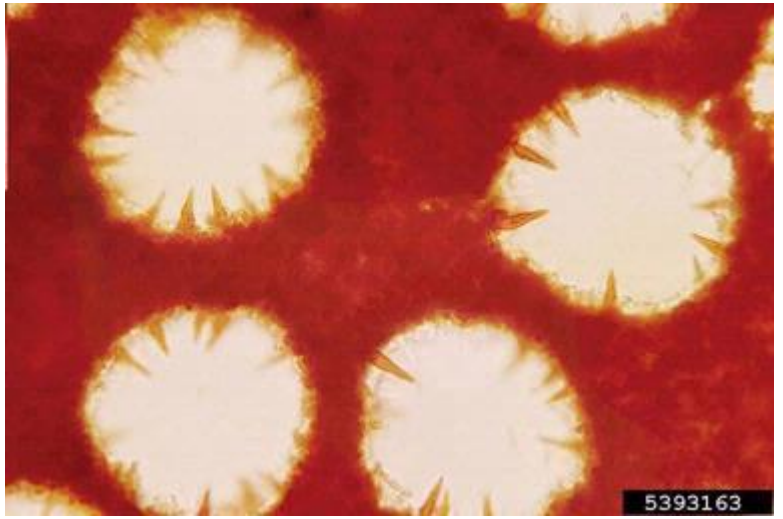
Use of cost-effective ways to break the disease cycle.

PREVENT INTRODUCTIONS INTO NEW AREAS

Was the fungus transmitted root to root or by spores? Genetics can tell.
And, it is important to know this in order to control the pathogen.

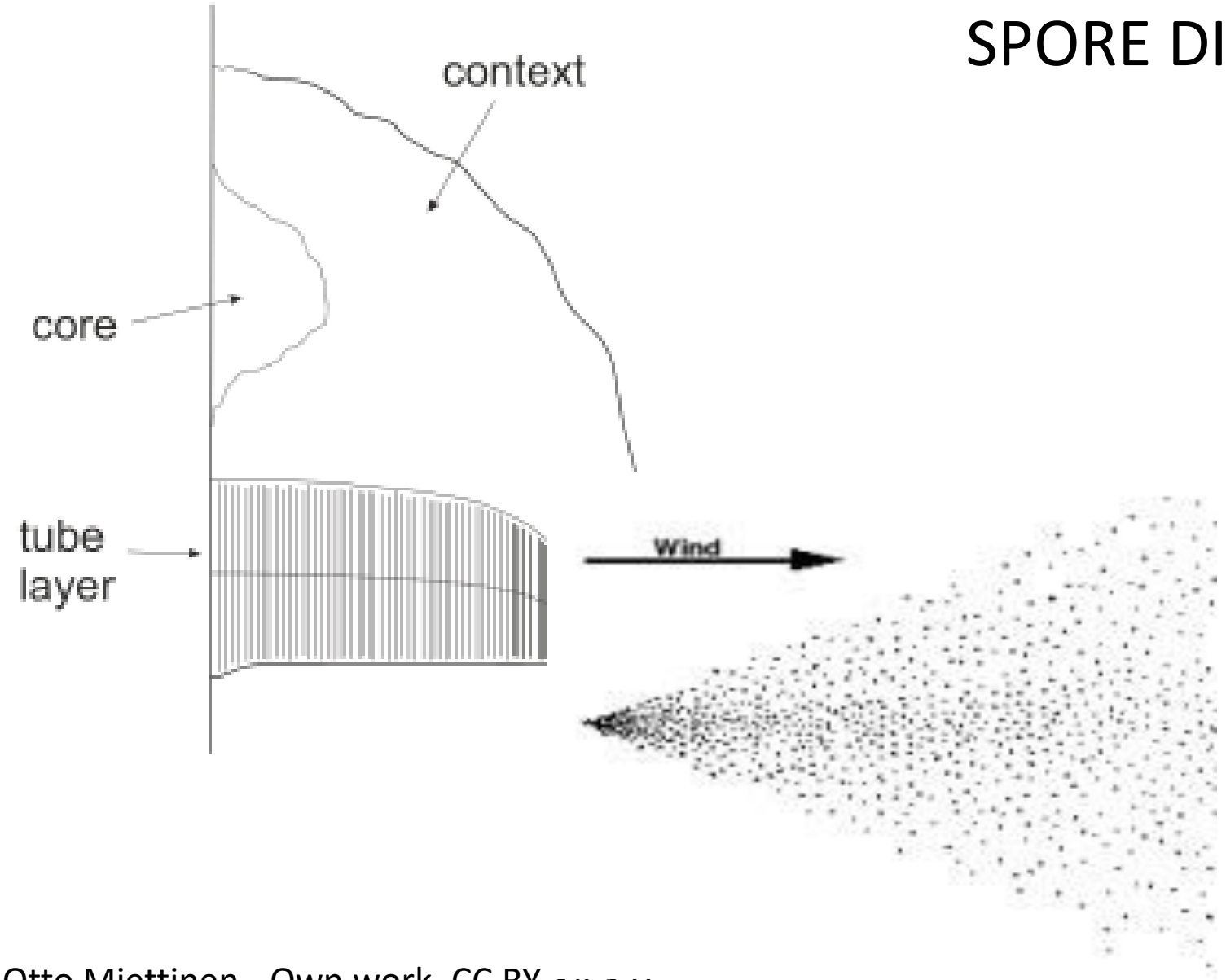






Sporocarp of Phellinus noxius

SPORE DISTRIBUTION



By Otto Miettinen - Own work, CC BY-SA 3.0,
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Root rot disease after stump treated with some chemicals at 18 months

Treatments	Root rot disease (%)
Lime	0
Borax	0.18
Urea	0.11
Round up 480 AS	0
Tordon 101 M	0.58
Garlon 480 EC	0.4
Control	0.68

From Indrayadi and Lian

Weed Whackers

Don’t Cause Wounds Because they can provide Courts of Infection

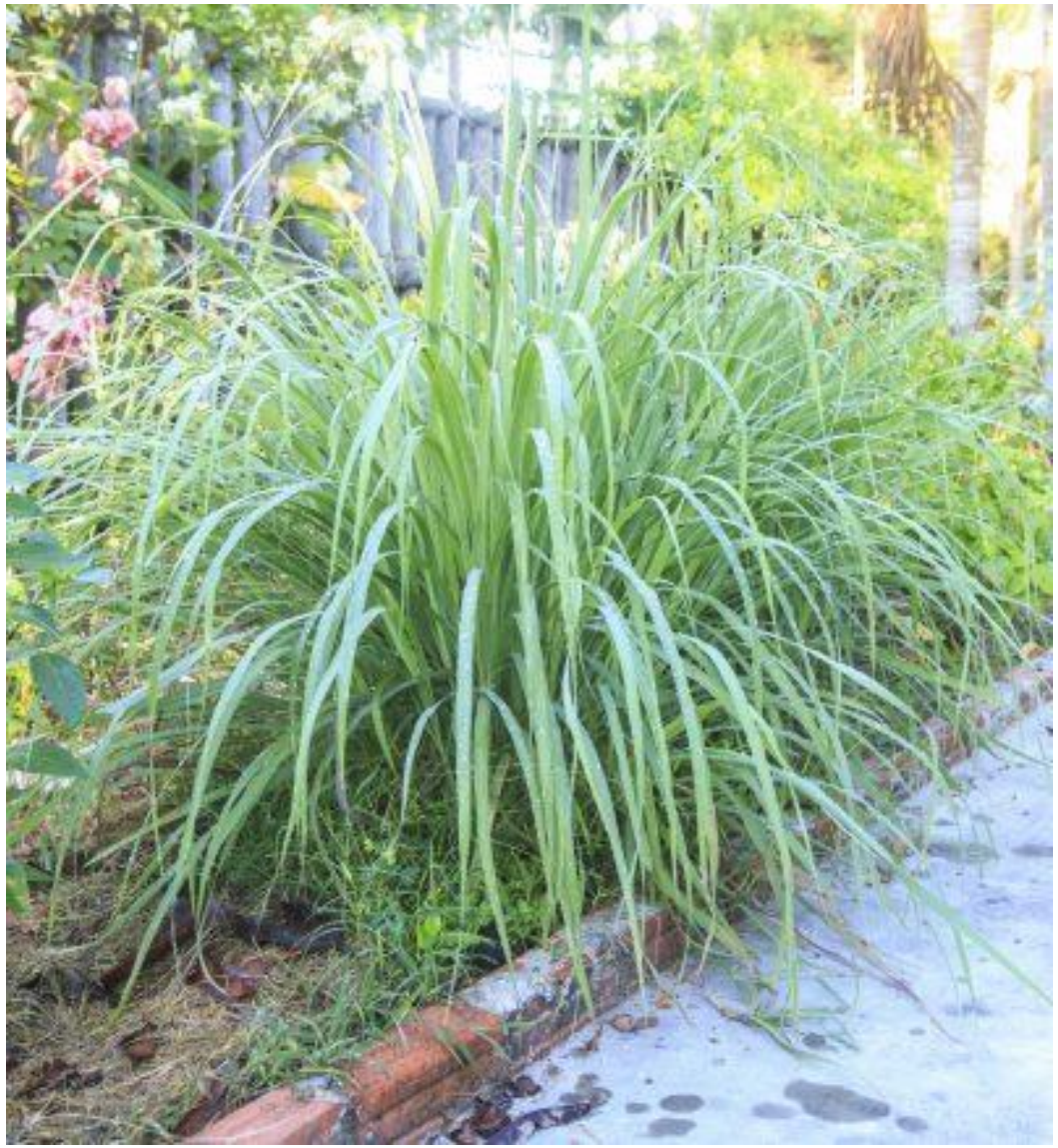
If a wound is caused there are a few things that can be applied

Fungicides
Rally 40WSP
Topsin M

Physical Barriers
B- Lock
Viti Seal

Need to be applied within 24 hours of wounding

No Guarantees: need to do some experiments!!!!



lemongrass

Cover Crops

In American Samoa lemongrass (*Cymbopogon citratus*) is planted to discourage *Phellinus noxius* from growing through the soil.

To determine the effectiveness of some chemicals to prevent spreading root rot disease via root contact.

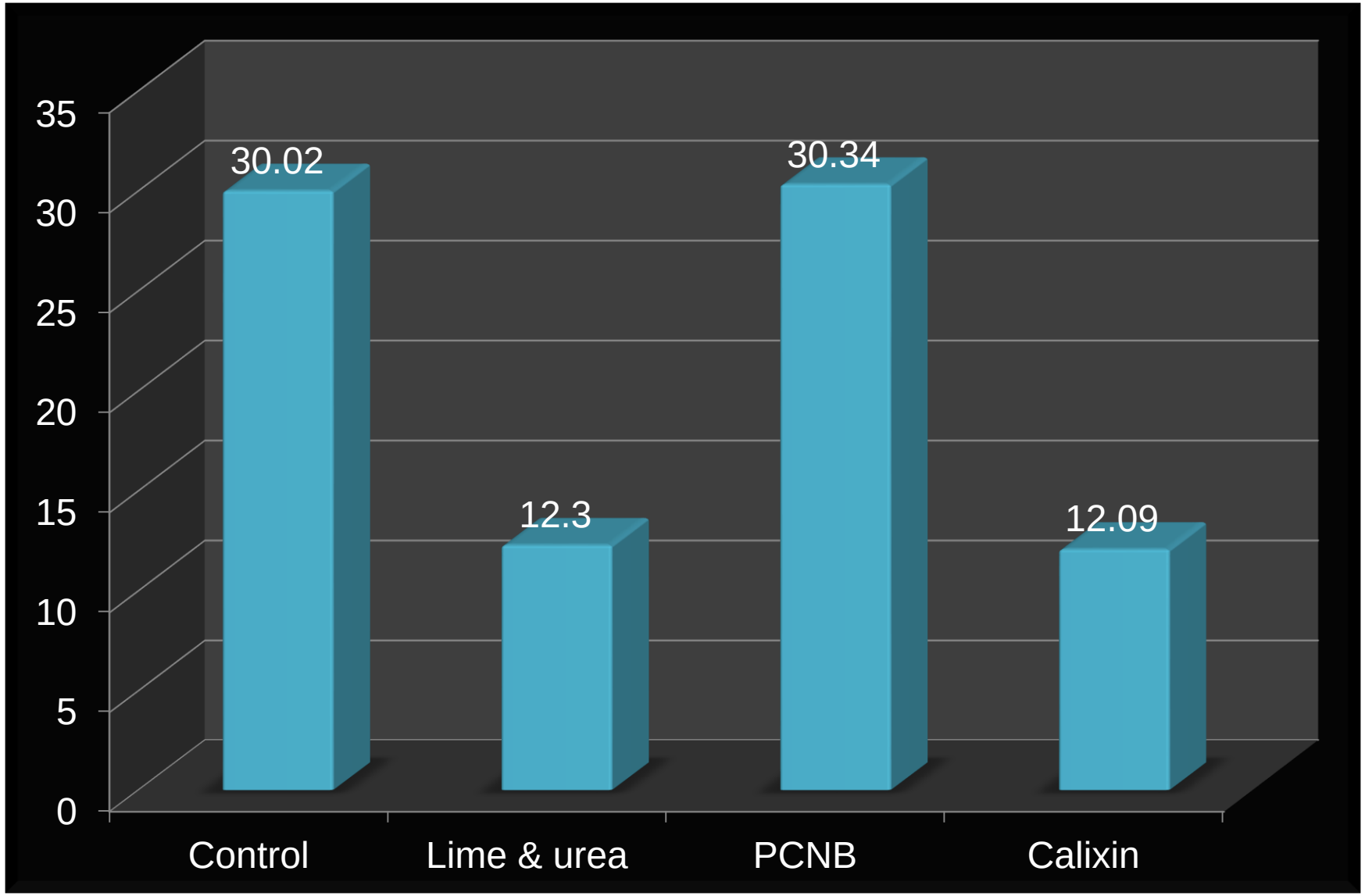
Materials Lime & urea, Calixin (tridemorph), PCNB,

Method:
Each chemical was poured or drenched into 30 diseased patches.

Patch disease : central disease, 1 row direct neighbour trees and 1 row indirect neighbour trees

From Indirayadi et al: Sinar Mas Forestry, Indonesia

Root rot disease percentage on neighbour trees at 18 months after treatment.



However, *P. noxius* failed to survive in infested wood when more than 3000 p.p.m. of urea was added to non-autoclaved soil (Note: this = 6,000 lbs urea/acre)

The concentrations of NH3 produced in the air were proportional to the amount of urea added to the soil.

The data suggest that soil microorganisms convert urea into NH3 and this is toxic to Phellinus noxius.

This only happens when the soil conditions are acid

The longer explanation

Phellinus noxius was not recovered from pieces of artificially infested wood placed in or on soil amended with urea $(NH_4)_2CO_3$ or aqueous ammonia. High concentrations of volatile NH_3 were detected in these treatments, indicating that NH_3 generated from these chemicals was fungicidal to *P. noxius*. A high concentration of volatile NH_3 was detected from non-autoclaved soil amended with urea, but not from amended autoclaved soil, indicating that soil microorganisms were involved in NH_3 generation.

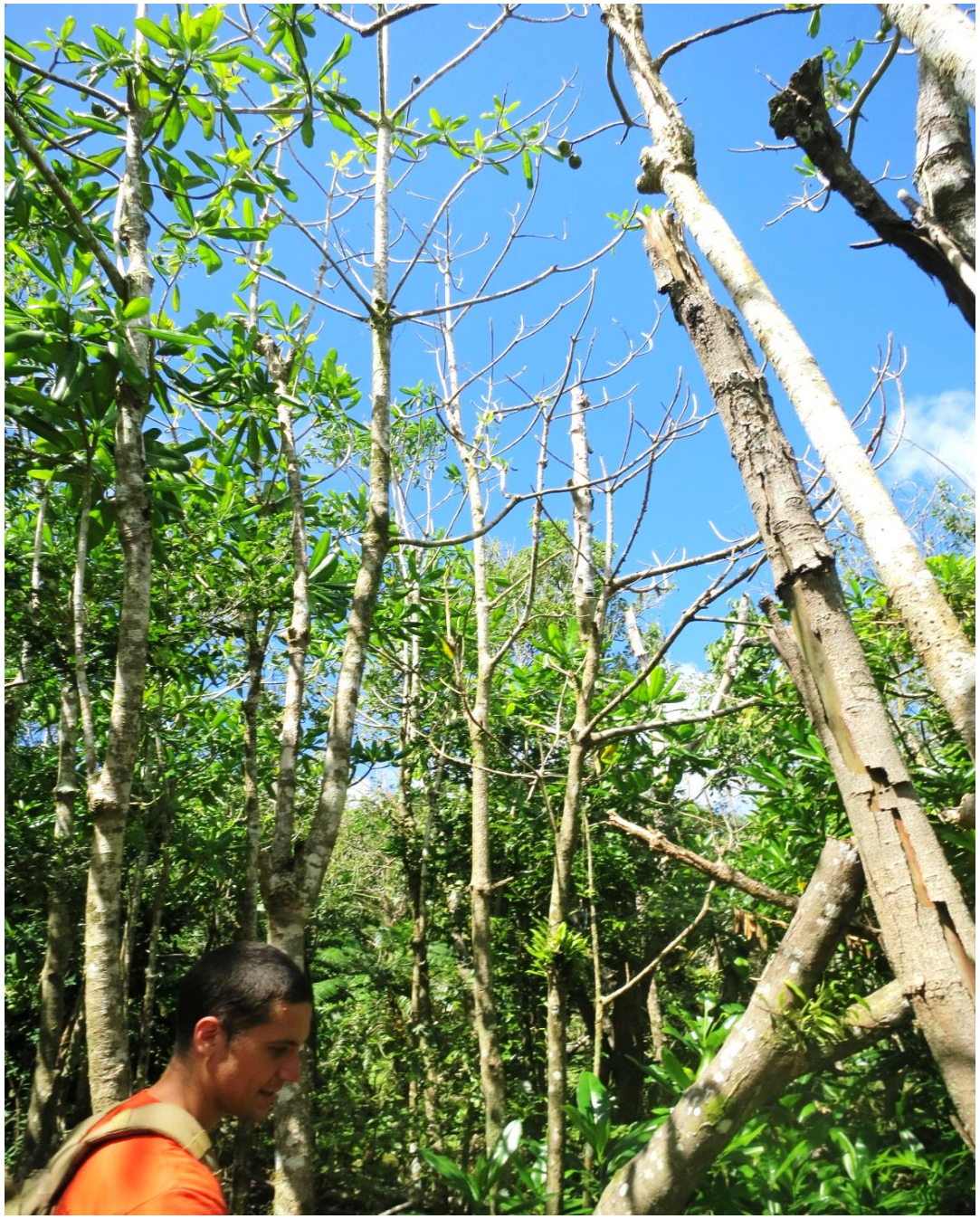
To kill *P. noxius* completely required 3000 p.p.m. urea in soil. Volatile NH_3 was generated from urea in alkaline soil, but not in acidic soil. In acidic soil 1 month after urea amendment, populations of both fungi and bacteria, and the concentration of NH_4^+ (but not of NH_3 in the air), were significantly greater than in the no urea treatment and in the urea treatment 3 days after amendment, indicating that NH_4^+, generated from urea in the soil enhanced the activity of soil microorganisms From Chang et al 2002

Phellinus weirii in Oregon

Chloropicrine injection works, but yikes!


JOHN DEERE


BX25
KUBOTA



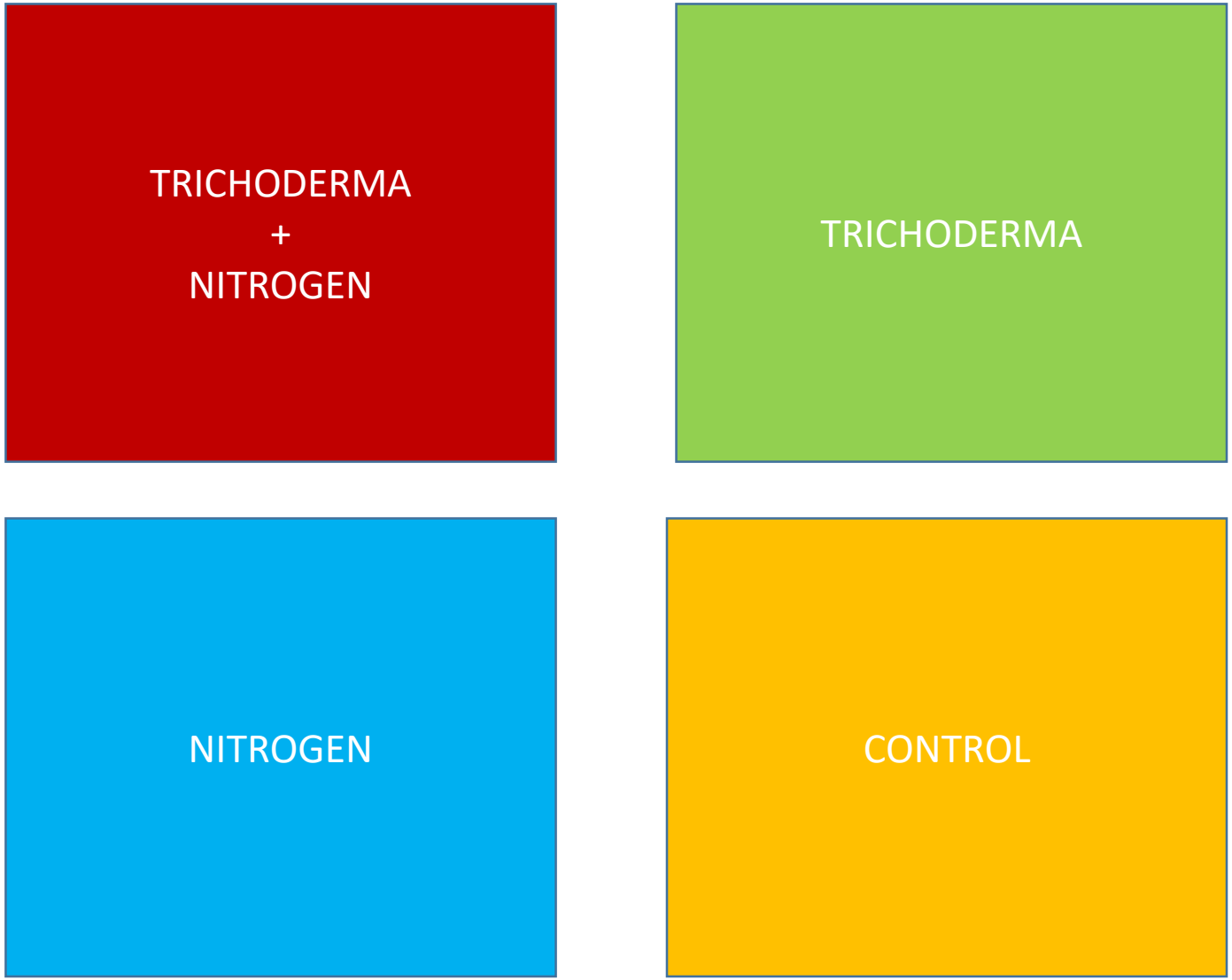
picaroon

pulaski

How small…. It looks like the pieces can’t be more than ½ an inch thick.


Vermeer
208-591-0330

A Possible Experiment



Possibilities of Biocontrol of *Phellinus noxius* using different Trichoderma spp.

Inhibition of radial growth of wood decay fungi by VOCs* of Trichoderma

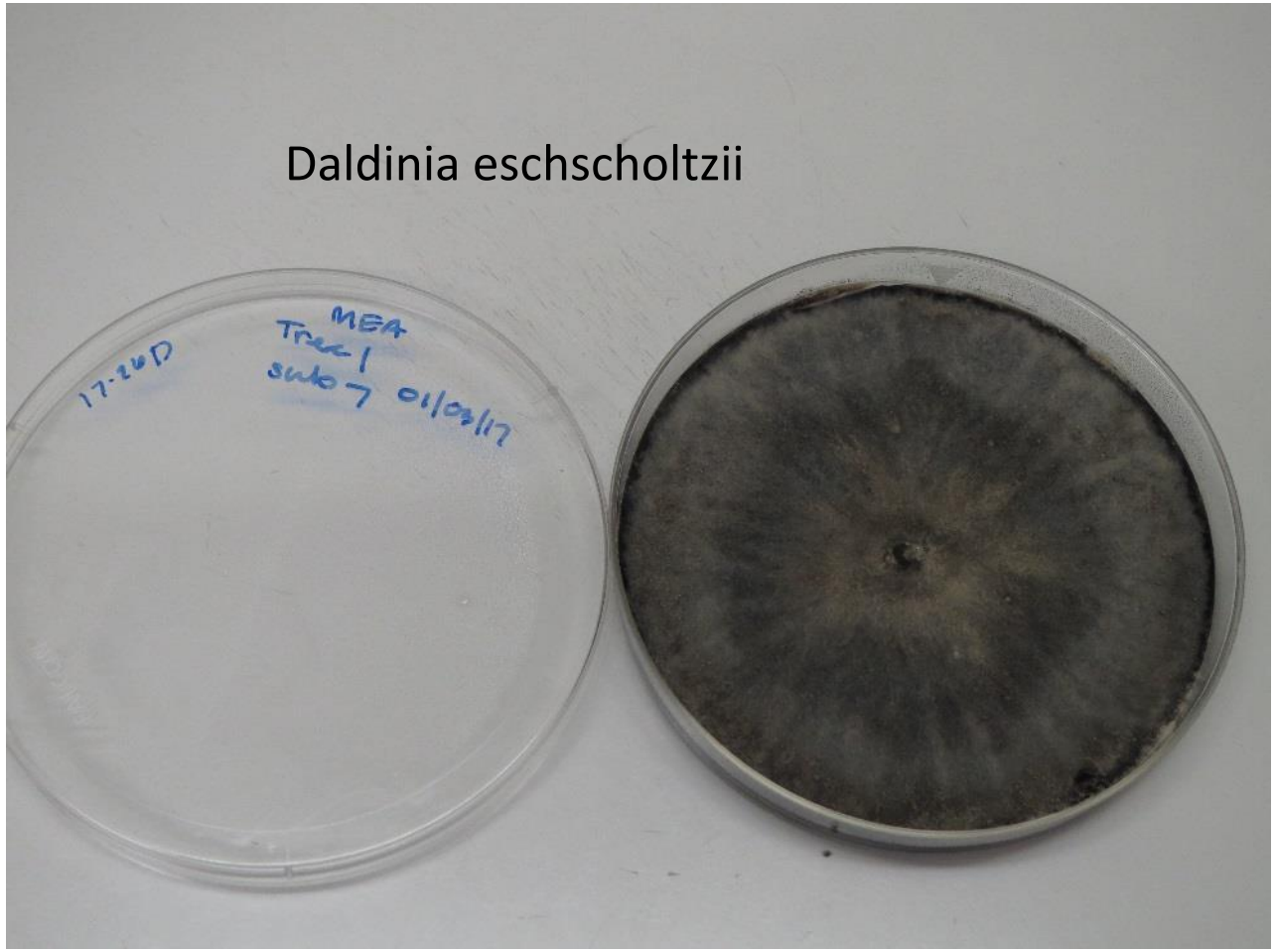
Trichoderma Strain	*Phellinus noxius* strain			
	133	144	169	178
Control	9.3 ± 2.0	6.5 ± 1.3	6.9 ± 2.6	7.7 ± 2.6
*T. atroviride*15603.1	2.2 ± 1.4	1.9 ± 2.0	1.0 ± 1.2	1.4 ± 1.5
T. ghanense 4510	11.0 ± 2.4 n.s.	6.3 ± 1.5 n.s.	6.1 ± 2.4 n.s.	8.4 ± 3.0 n.s.
T. harzianum 4428	5.3 ± 0.5 n.s.	5.3 ± 0.5 n.s.	4.4 ± 1.1 n.s.	3.6 ± 1.1

*VOC= Volitile Organic Compound

From: Schwarze et al 2012

Bob Schlub's isolates of 2/13/2017 in Guam; DNA extraction and ID's by Mee Sook Kim

- Phellinus noxius 5 x
- Annulohypoxylon stygium 5 x
- Daldinea eschscholtzii 1 x
- Pestalotiopsis theae 10 x
- Schwanniomyces sp. 3 x
- Ogataea trehalo abstinens 1 x
- Coniothyraceae sp. 1 x
- Ascomycota sp. 2 x
- Other 14 x



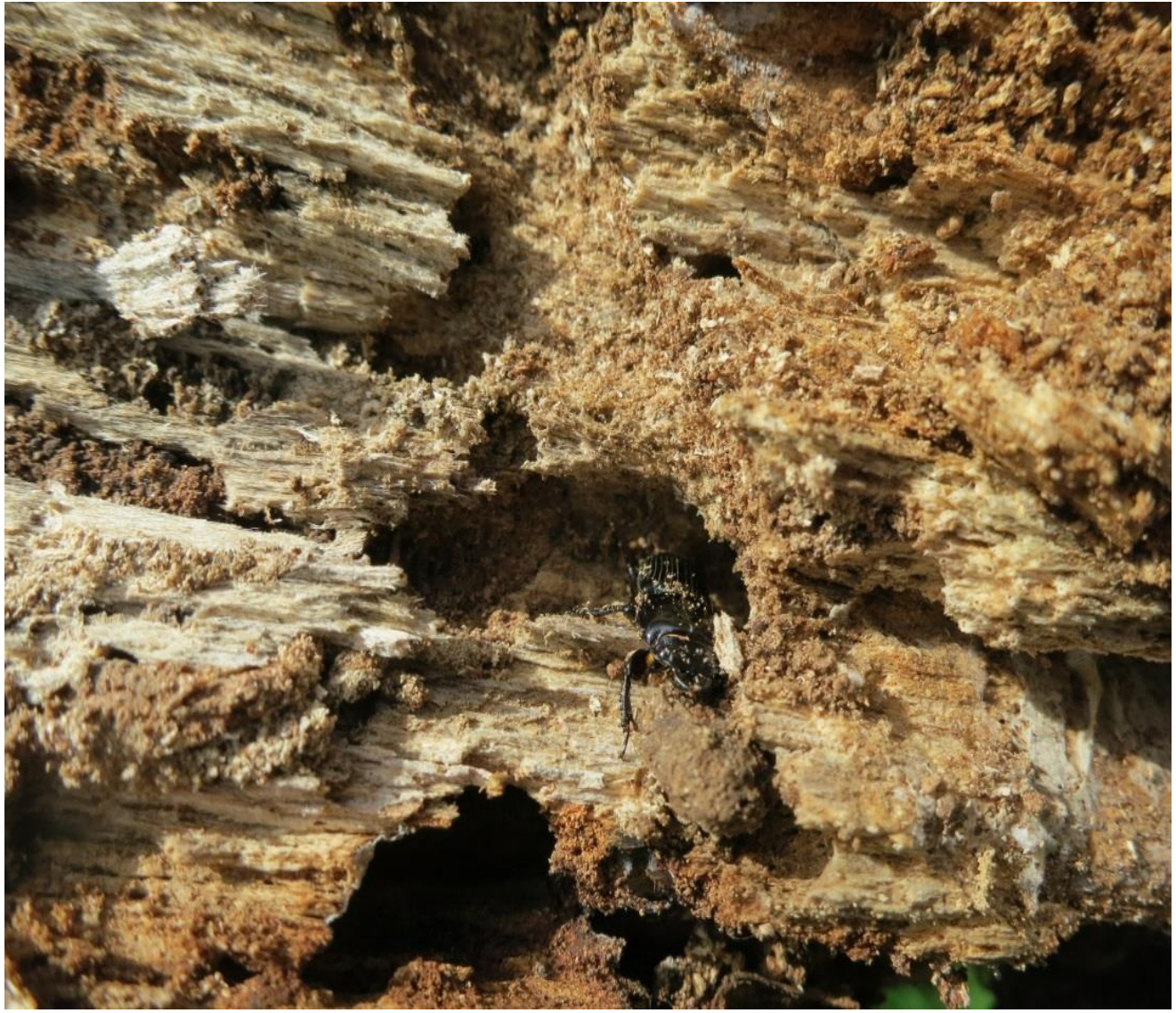
Flame tree in Saipan killed by P. noxius but now showing fructifications of another fungus.

This flame tree was killed by Phellinus, but termites have totally displaced the Phellinus.

Termites can often be found in trees that have been killed by *P. noxius*. There are 2,000 species of termites in the world. 435 of these are in Asia and mainly China.

Carpenter ants:

Scrounge around in rotten wood and build their nests



Flame tree in Saipan killed by *Phellinus noxius* but now the rotten wood is overrun by Carpenter ants.

Plant only Resistant Tree Species

Determine if there are species preferences for the *Phellinus noxius* strains in Hong Kong. This example comes from Sahashi et al 2010.

Table 2. Mortality results for nine different host species inoculated with nine different isolates of *Phellinus noxius*

	Isolate used and percentage of seedling killed									
Host plant species	**KPN100**	**KPN81**	**KPN92**	**KPN89**	**KPN78**	**KPN54**	**KPN83**	**KPN77**	**KPN85**	**Average[y]**
Bischofia javanica	30[w]	30	10	40	10	0	0	0	0	13.3 bc
Calophyllum inophyllum	40	10[w]	10	0	10	0	10	0	0	8.9 c
Casuarina equisetifolia	50	0	50[w]	0	20	0	10	0	20	16.7 abc
Cinnamomum japonicum	70	20	0	0[w]	30	0	20	0	0	15.6 abc
Garcinia subelliptica	50	10	0	0	20[w]	0	10	0	10	11.1 c
Machilus thunbergii	30	0	70	30	10	0[w]	10	0	0	16.7 abc
Melia azedarach var. *subtripinnata*	50	20	40	20	0	0	10[w]	10	0	16.7 abc
Podocarpus macrophyllus	50	60	80	0	10	0	20	0[w]	30	27.8 ab
Rhaphiolepis indica var. *umbellata*	30	40	80	0	10	0	50	20	40[w,x]	30.0 a
Average[z]	44.4 a	21.1 b	37.8 a	10.0 bc	13.3 bc	0 c	15.6 bc	3.3 c	11.1 bc	

[w] Isolate of *P. noxius* inoculated onto its source plant species.
[x] Significantly higher than the average mortality by the isolate (chi-square test, $P = 0.004$).
[y] Means followed by the same letter in a column are not significantly different (Fisher's PLSD test, $\alpha = 0.05$).
[z] Means followed by the same letter in a row are not significantly different (Fisher's PLSD test, $\alpha = 0.05$).

Important to note that Chang (1995) found no host specificity between 12 different P. noxius strains in Taiwan

Flooding of the soil for one month was very effective for killing Phellinus in small blocks of wood.

Flooding infested fields may help control Phellinus noxius in the field. T.T. Chang, 1996

Byron Bay, Australia

Phellinus noxius management techniques & Their Effectiveness

1) Don't use infected planting stock*****
2) Don't disseminate infected wood***
3) Prevent wounding ****
4) Prevent colonization of cut stump surfaces using borax or other compounds***
5) Make soil unfavorable for Phellinus (lemon grass, fertilizers (urea, lime), fungicides)***
6) Treat trees recently attacked by Phellinus with: mangrove mud, ginger shampoo, smoke*
7) Prevent infection foci from expanding using urea, lime, pig manure, other***
8) Remove infected stumps ****
9) Use genetically resistant tree species **
10) Flood the soil for at least 1 month
11) Use biocontrol agents:

    9a) Other fungi associated with Phellinus noxius***; 9b)Trichoderma strains****

12) Destroy zone lines in infected residuals so they can be decomposed*****.
13) Ridding the soil of tiny units of inoculum (5 pictures)*****
14) Other agents that help destroy *P. noxius*: termites, carpenter ants**
15) Flooding to suffocate Phellinus : * to ***** depending on conditions.
16) Use combinations of the above practices **= Integrated Pest Management*******
17) Just live with Phellinus.

* A little bit effective; *** kind of effective; ***** very effective; *******most effective

Integrated Phellinus Management (IPM)

A) Remove infected stumps and root systems

B) Rid the soil of tiny units of inoculum

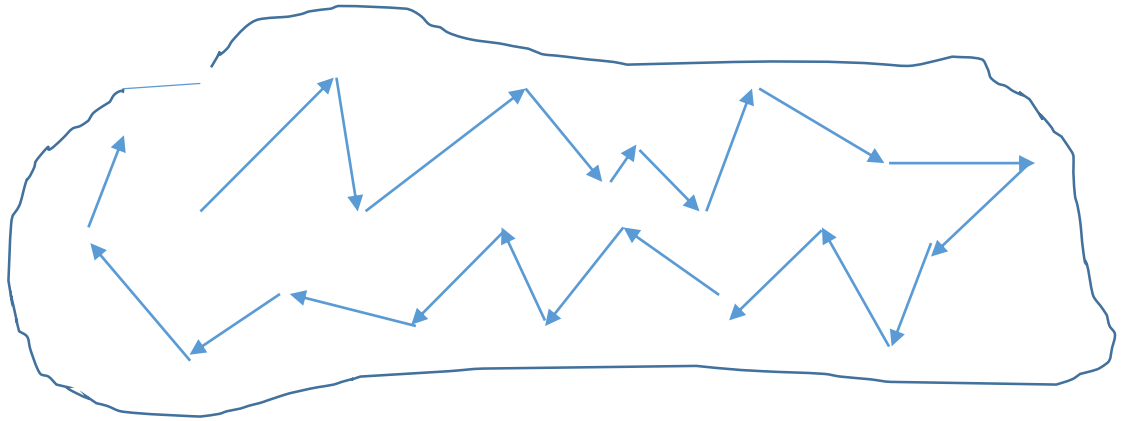
C) Use Chemicals (Urea)

D) Use *Trichoderma atrovirde*

Experiments needed

Use a Bioassay

Or use metagenomics to determine amount of Phellinus still in soil



ZIG ZAG Sample

Hong Kong Institute of Horticultural Science

Palau Forestry

Yap Forestry

Guam Forestry

Saipan Forestry

Rota Forestry

Pohnpei Forestry

Kosrae Forestry

Chu’uck Forestry

American Samoa Forestry

Rocky Mountain Res. Station

Mee Sook Kim

Colorado State Univ.

Forest Pathology Japan

University of Guam

NRCS Micronesia and Guam

S&PF Region 5 USDA Forest Service

FIA USDA Forest Service

US Embassy Micronesia

Australia Forest Pathology

Arbor Global

Pacific Root and Butt Rot Club

The presence of *Phellinus noxious* on many islands in the Pacific and observations that may lead to an effective control of this pathogen

Presented by: Dr. Phil Cannon

8th Seminar on Best Practices for Urban Tree Management
第8屆都市樹木優化作業研討會

Hong Kong, March 18, 2017

Phellinus noxious on islands in the Pacific and possible controls of this pathogen

Presented by: Phil Cannon at the April, 2017 PIFC in Guam