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School of Environmental and Biological Sciences

Plant diseases in cultivated and native habitats of the New Jersey Pine Barrens

Peter V. Oudemans
Associate Professor
Department of Plant Biology and Pathology

National Center for Vaccinium Research

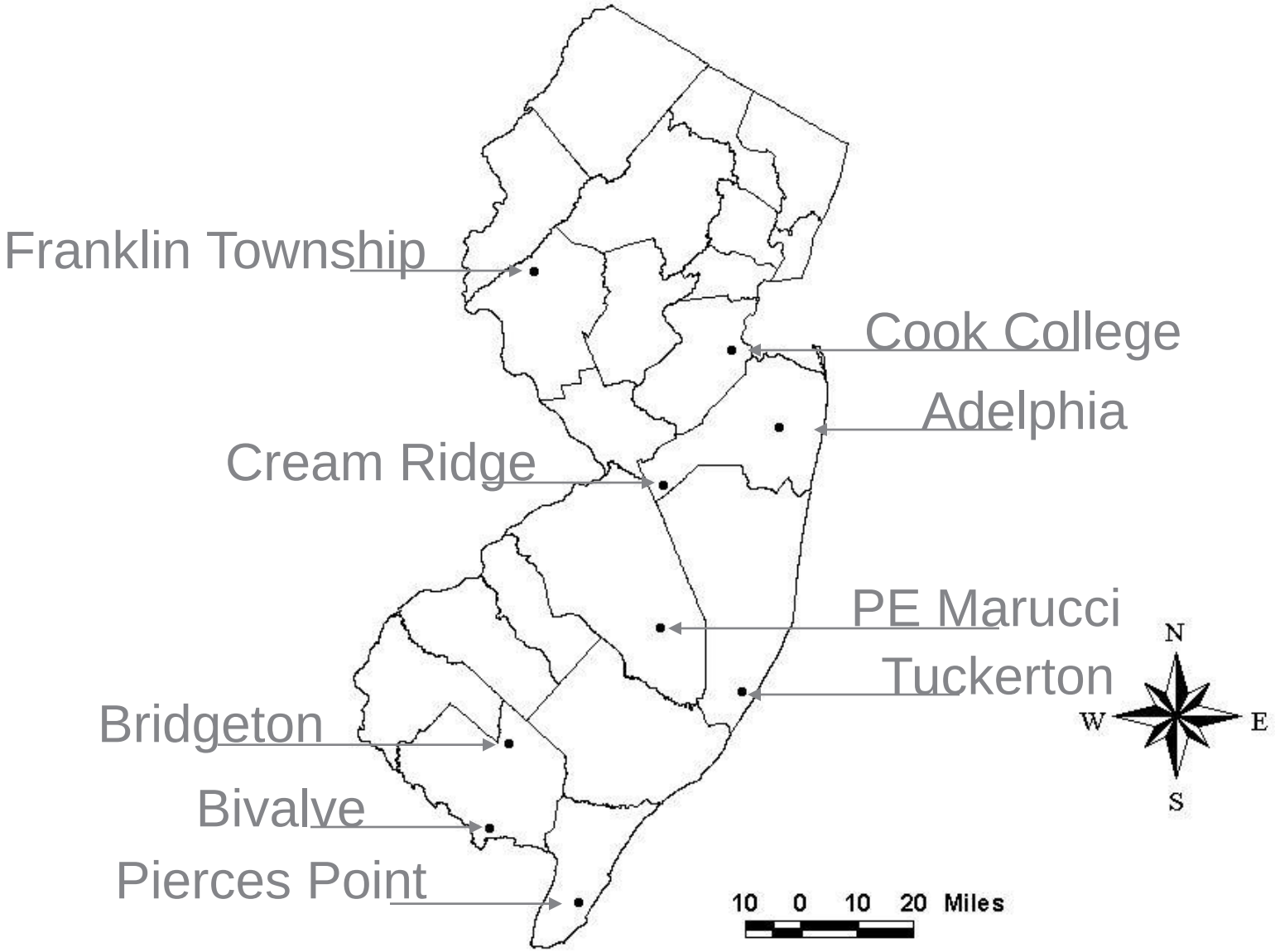
- New Jersey Pine Barrens covers over 2000 square miles
- Landscape is flat coastal plain
- Soils are sandy, acidic and low in nutrients

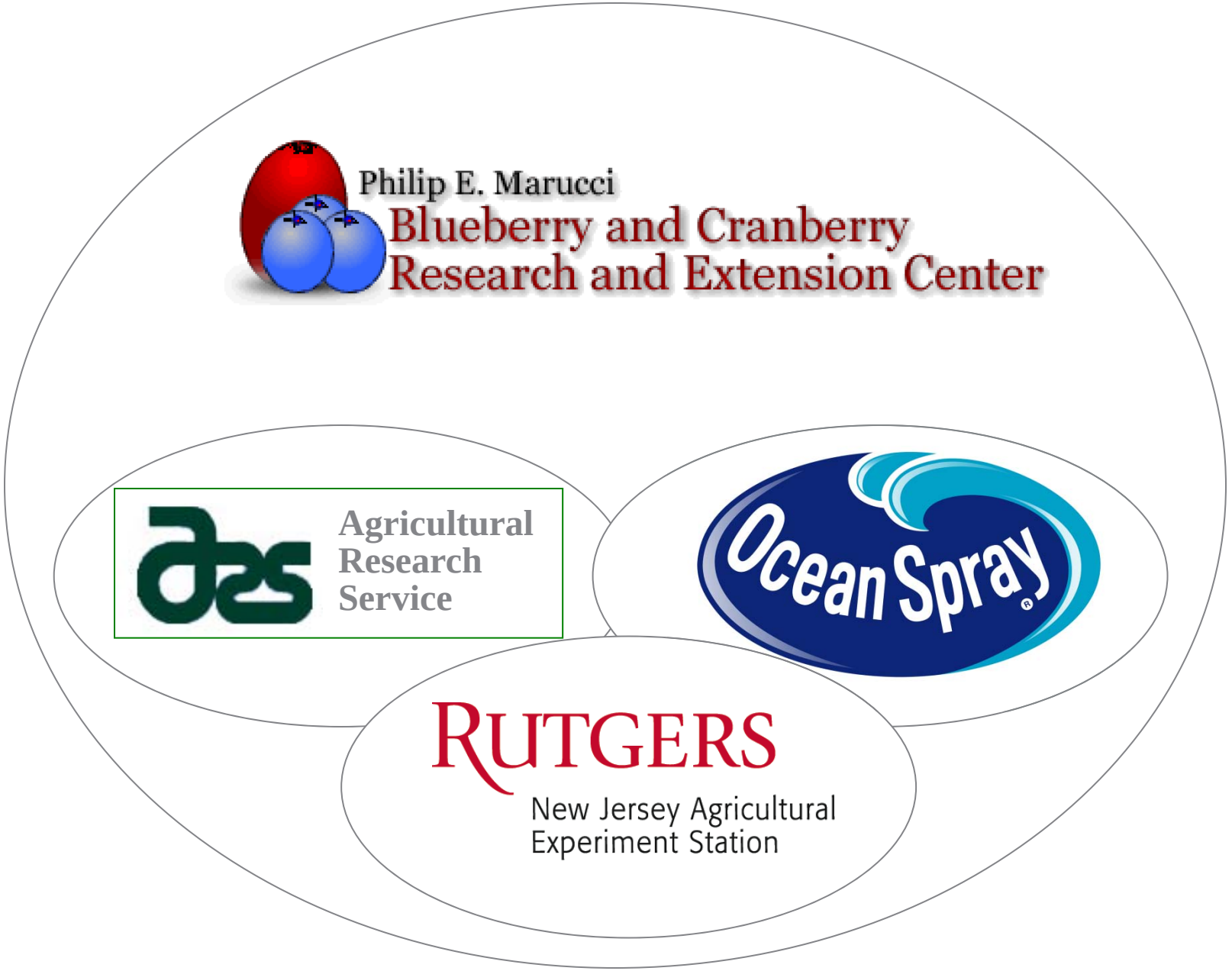
Highbush Blueberry
Vaccinium corymbosum L.

Large American Cranberry
Vaccinium macrocarpon Ait.

- Leading fruit crop in New Jersey
- Berries contain compounds thought to be beneficial to human health
- Two of three native American fruits

The New Jersey Agricultural Experiment Station




Philip E. Marucci
Blueberry and Cranberry
Research and Extension Center
Agricultural
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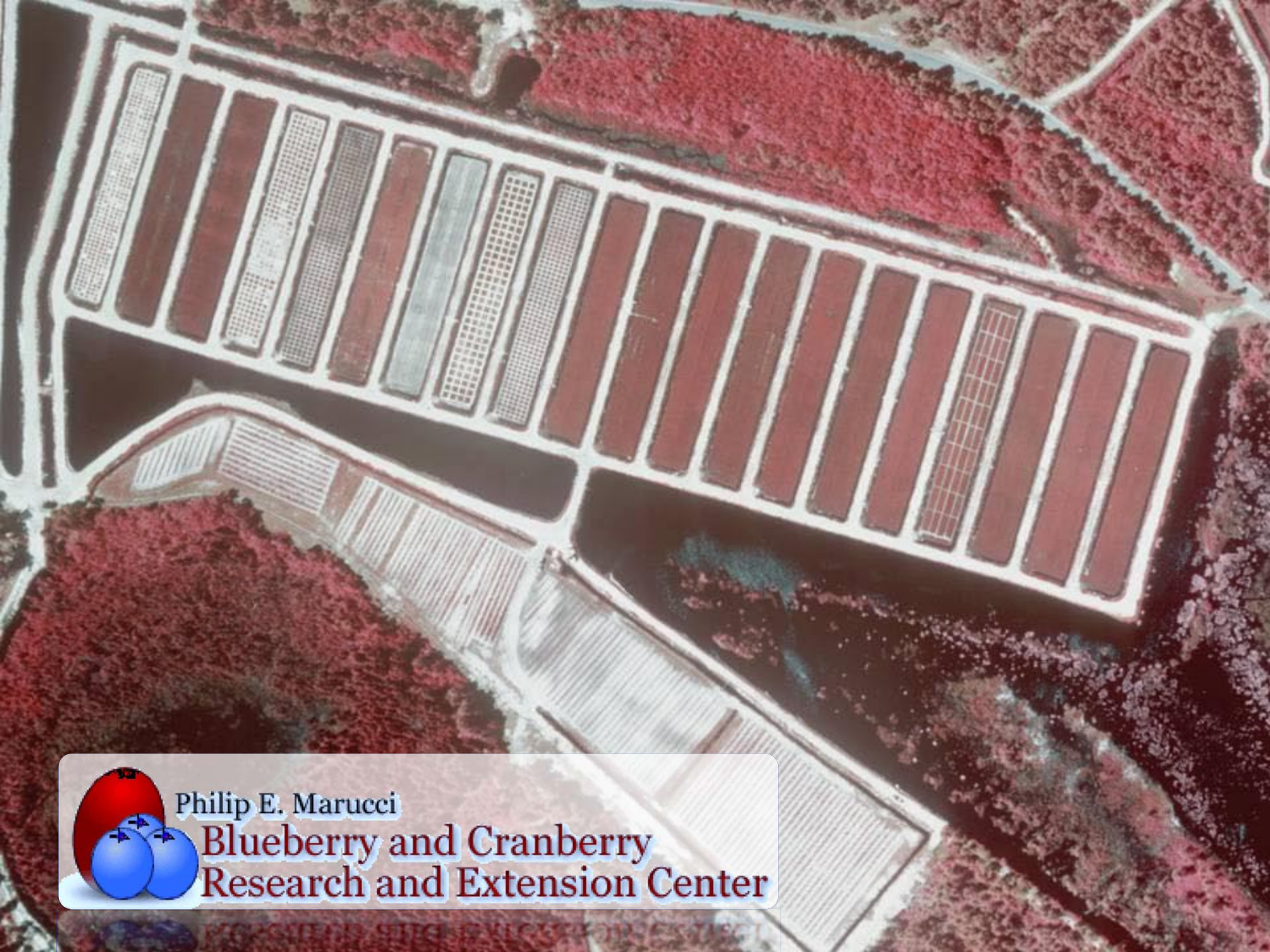
Service
Ocean Spray
RUTGERS
New Jersey Agricultural
Experiment Station

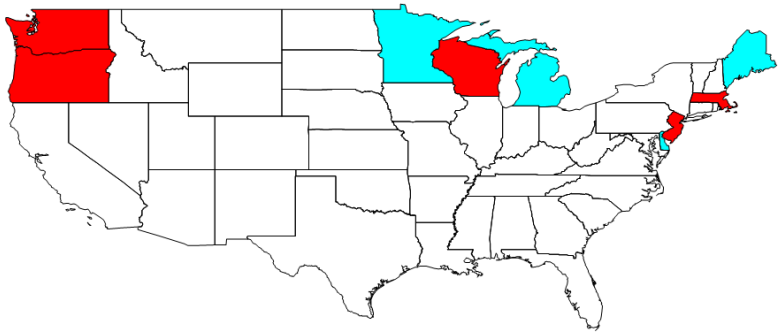

Philip E. Marucci
Blueberry and Cranberry
Research and Extension Center

Research and Extension Programs

- Entomology
  - Dr. Cesar Rodriguez-Saona – Rutgers University
- Health Benefits
  - Dr. Amy Howell – Rutgers University
- Integrated Pest Management
  - Mr. Dean Polk – Rutgers University
  - Mr. Dan Schiffhauer – Ocean Spray Cranberries
- Plant Breeding
  - Dr. Mark Ehlenfeldt – USDA-ARS
  - Dr. Nick Vorsa – Rutgers University
- Plant Pathology
  - Dr. James Polashock – USDA-ARS
  - Dr. Peter Oudemans – Rutgers University

Native and Cultivated Status: *Vaccinium macrocarpon* Aiton

In Canada:
British Columbia,Quebec
Maritime Provinces



2011	MA	NJ	OR	WA	WI
Area Harvested	13,000	3,000	2,800	1,700	18,000
Total yield (10^6 bbl)	2.35	0.51	0.36	0.12	4.4
Total value (1000 $)	103,955	26,316	14,105	6,461	193,382

History of Cranberry Pathology

- 1835 - Benjamin Thomas of Burrs Mills, NJ
- 1869 - Theodore Budd forms American Cranberry Growers Association
- Elizabeth White of Whites Bog collaborates with Francis Coville
- Important scientists:-
  - R. B. Wilcox, C.S. Beckwith,
  - P. E. Marucci
- 1979 passage of Pineland Preservation Act

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CRANBERRY FRUIT ROT

Barclay White - 1870

Such has been my experience in the cultivation of the cranberry, and unless I can find a remedy for this rotting of the berry, I must abandon the business as unprofitable. If this can be avoided, there is an excellent opportunity here to cultivate them extensively and profitably. They begin to rot about the commencement of their ripening or coloring, on the side touching the ground, presenting the appearance of having been scalded. I have thought it might be owing to the hot sun shining on them after rain, scalding the part touching the earth. Possibly, when the vines become thicker, shading the ground more thoroughly, it may be corrected.

Halsted, B. D. 1889. Some Fungus Diseases of the Cranberry. N.J. Agric. Coll. Exp. Stn.,New Brunswick. Bull. 64.

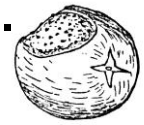

Fig. 5. A Berry Partly Scalded.

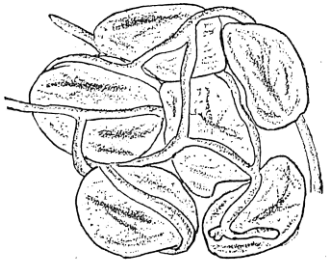

Fig. 6. Cells with Fungus Threads.

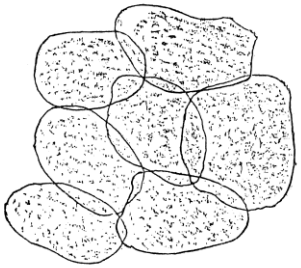

Fig. 7. Healthy Cranberry Tissue.

Fig. 8. A Pustule upon the Cranberry.

Fig. 10. A Leaf Half Scalded.

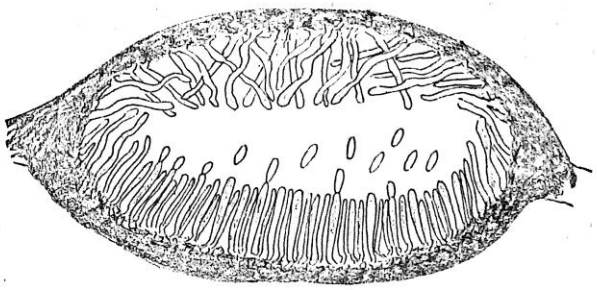

Fig. 9. Section of a Pustule

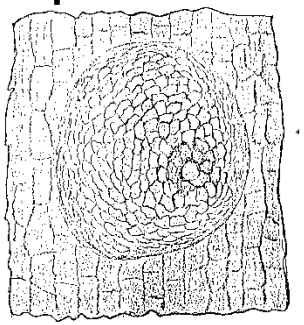

Fig. 11. A Pustule upon a Leaf.

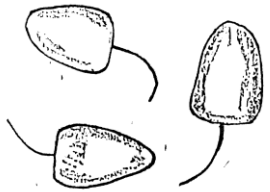

Fig. 13. Three of the Spores.

Fig. 15. One of the Sacs Bearing Eight Spores.

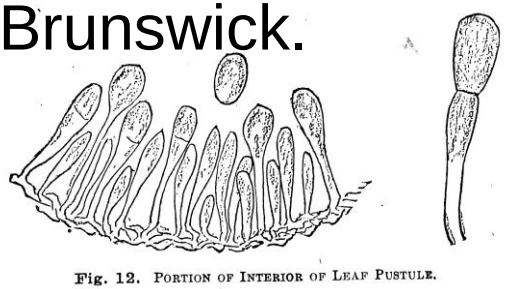

Fig. 12. Portion of Interior of Leaf Pustule.

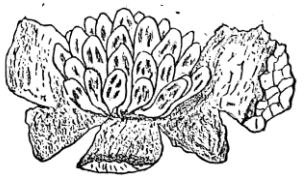

Fig. 14. A Pustule Broken Open.

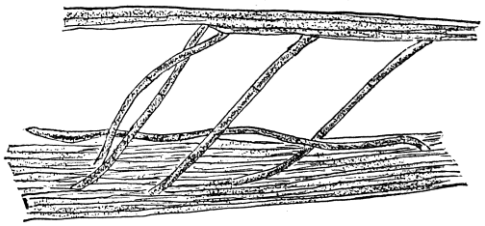

Fig. 16. Fungus Filaments in the Stem.

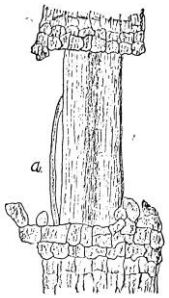

Fig. 17. Fungus-Infested Root.

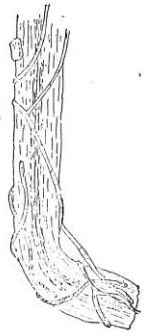

Fig. 18. The Fungus upon Young Root.

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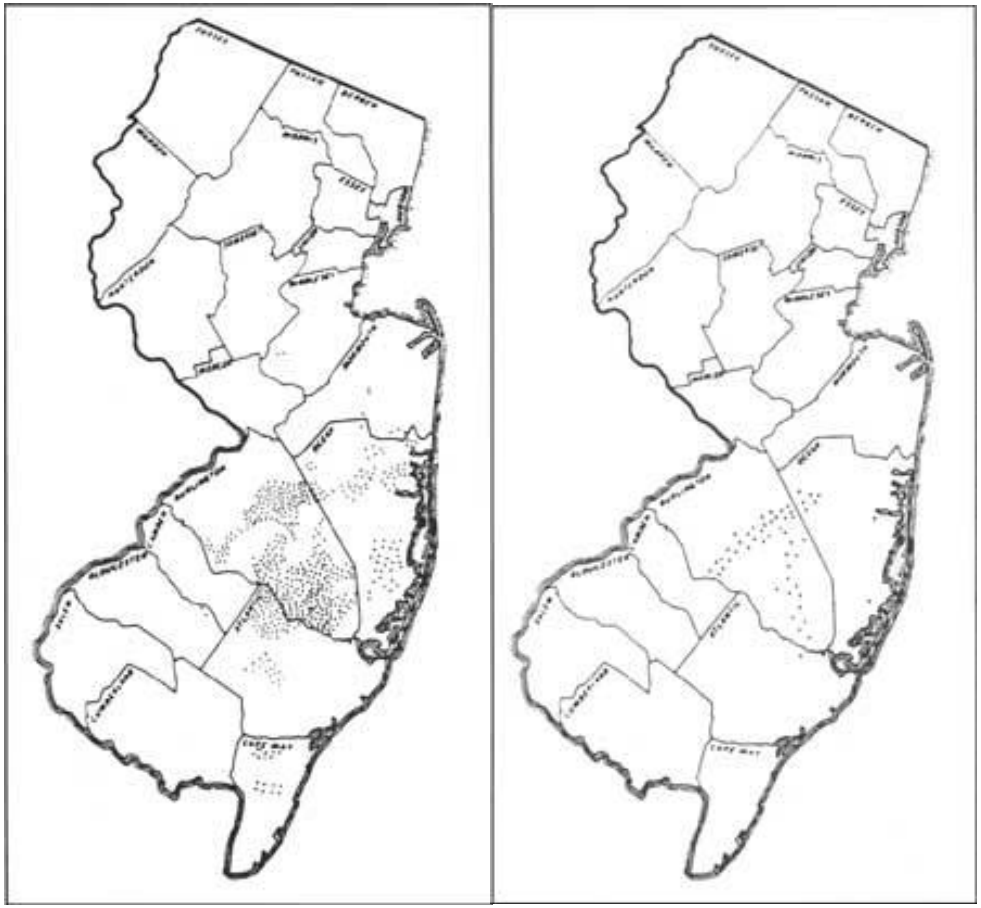
Domestication of Highbush Blueberry

The Impact of False Blossom Disease on Cranberry Production



Map showing the distribution of New Jersey Cranberry acreage for 1955. Each dot represents ten acres.

Map showing current distribution of New Jersey cranberry acreage. Each dot represents fifty acres.

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  - C. Doehlert
  - P. E. Marucci
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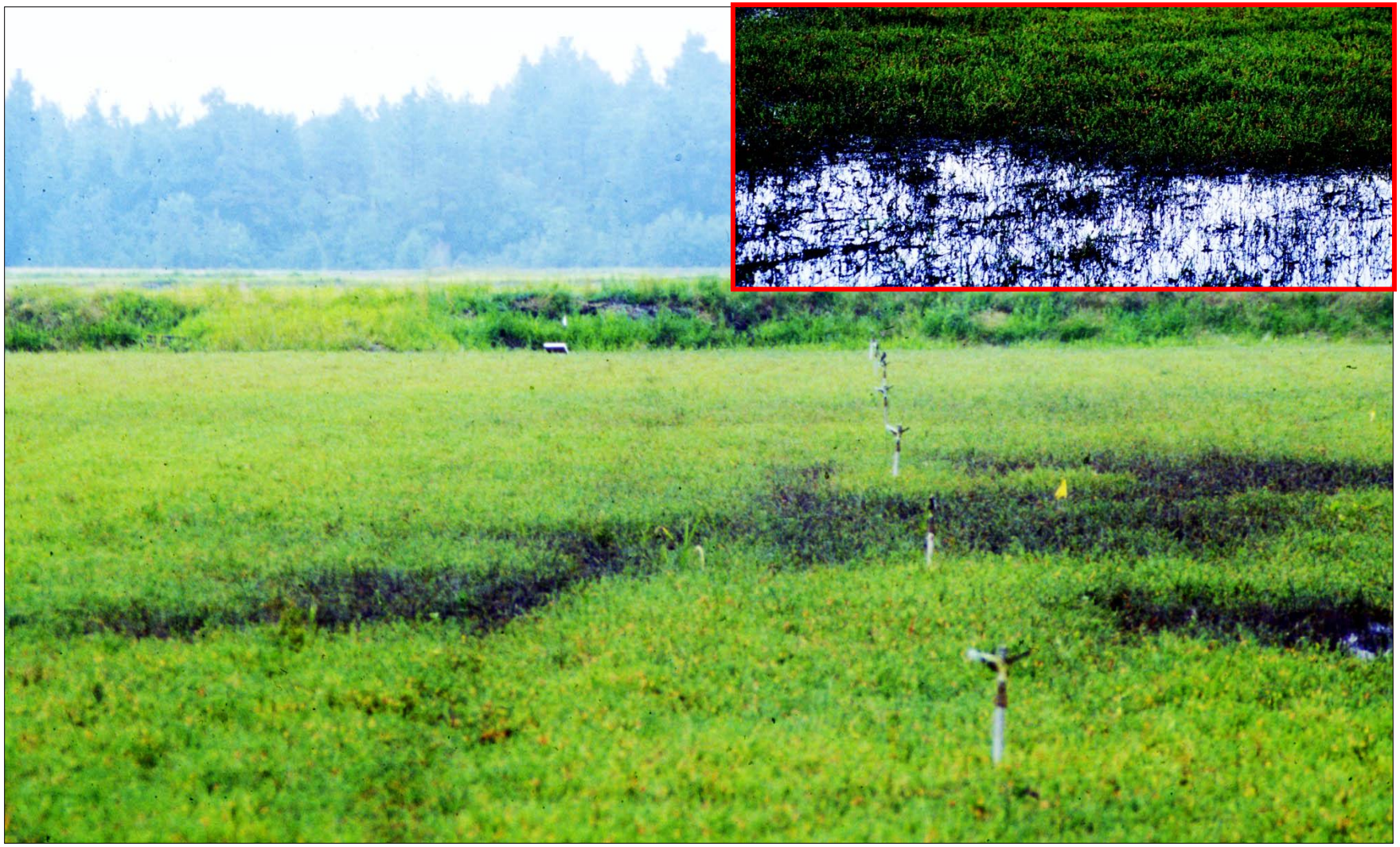
Phytophthora root rot of cranberries

Phytophthora root rot of cranberries



Decreased root mass

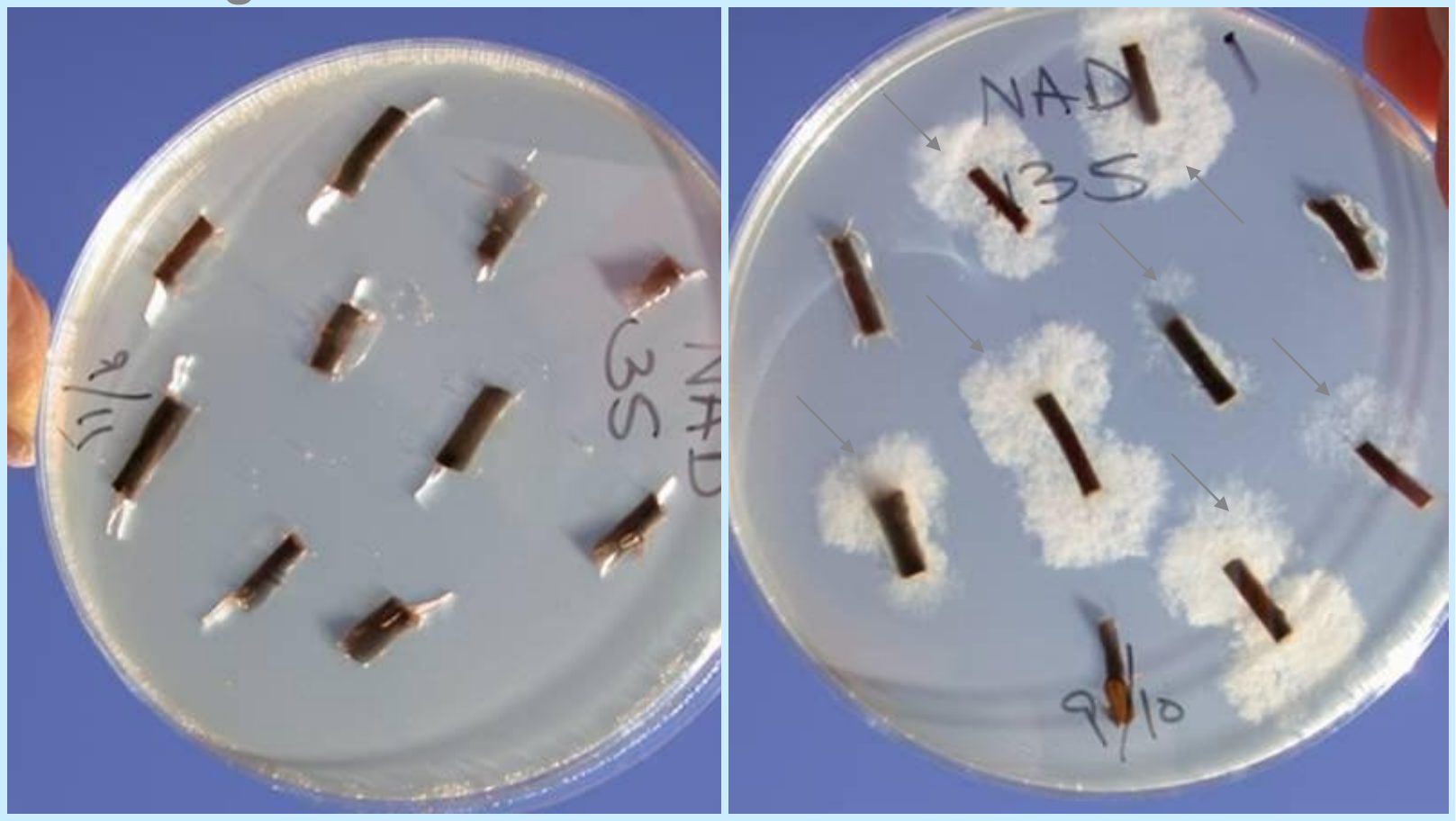
Upright dieback

Decreased fruit load

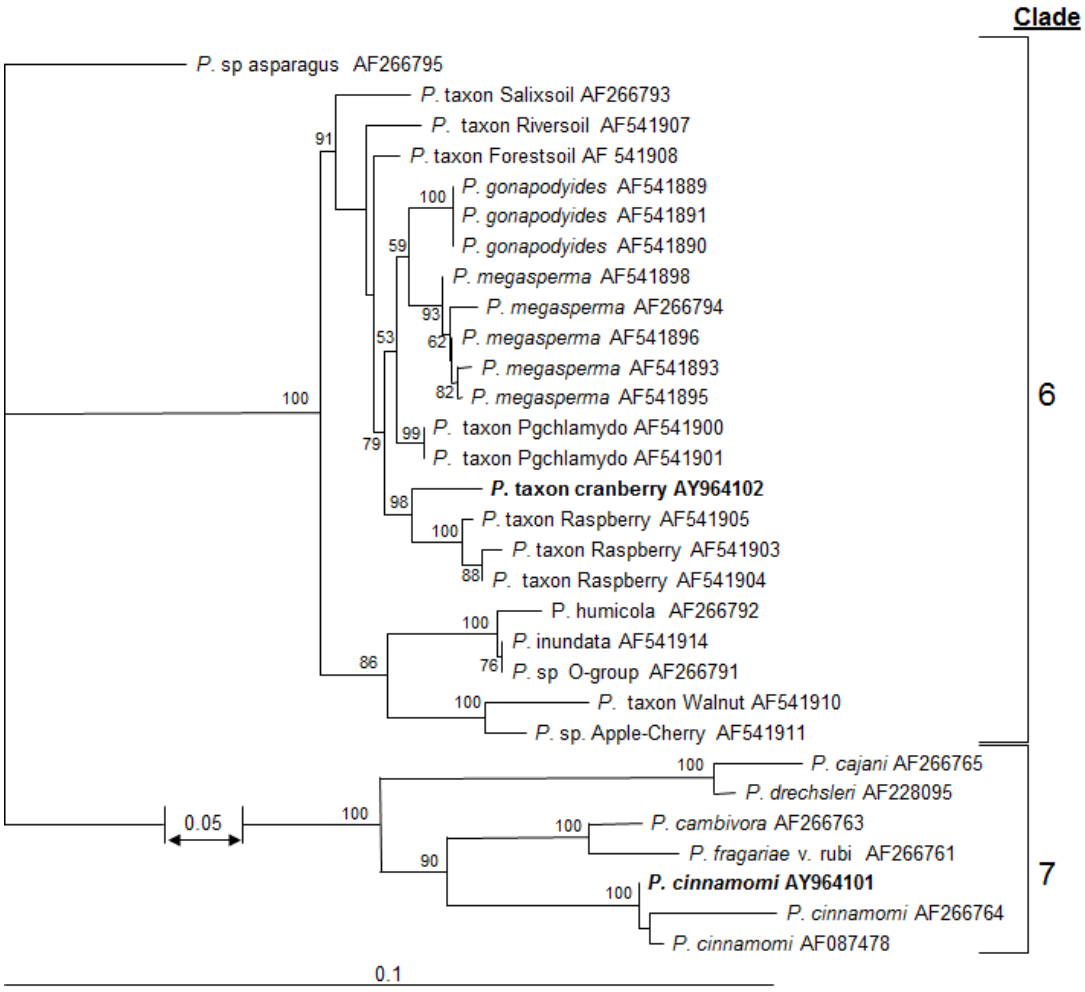
Phytophthora isolation using PARPH selective medium

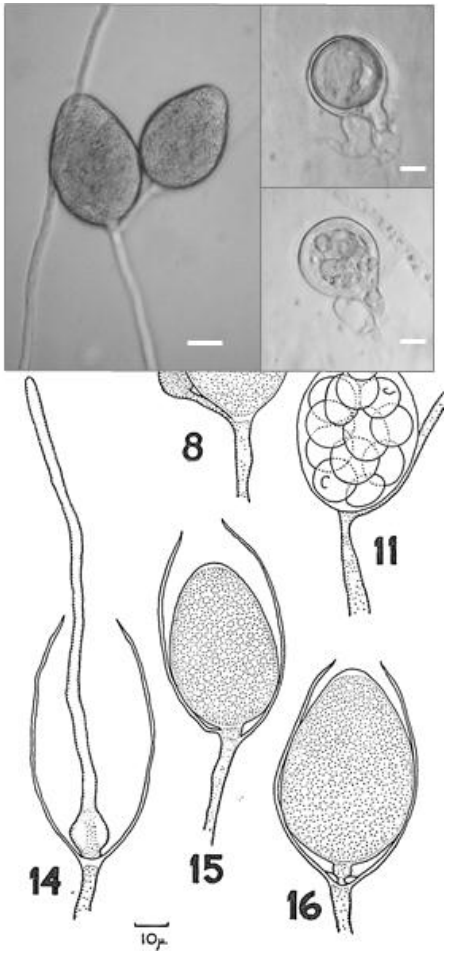
Negative

Positive

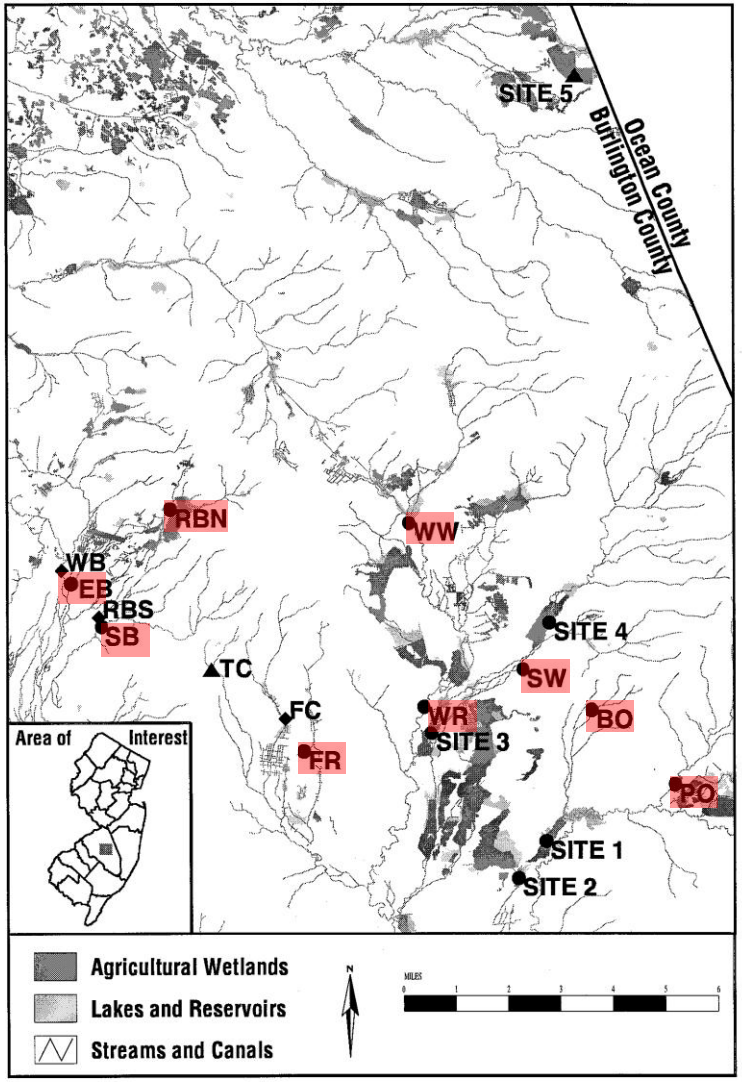


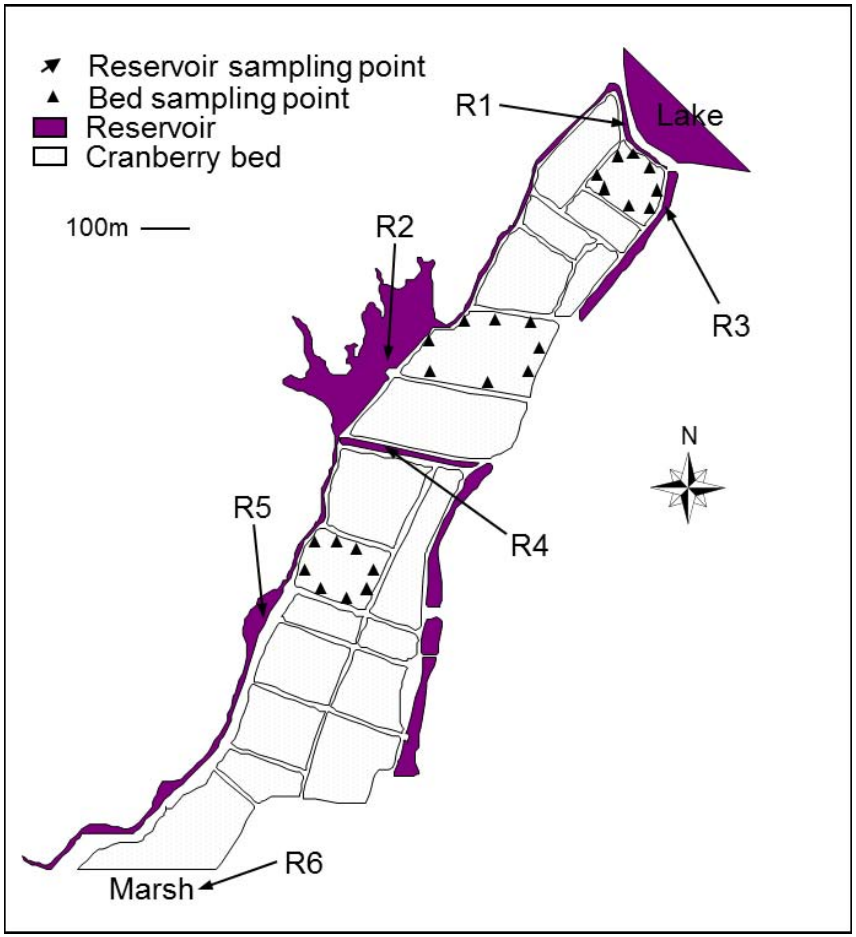
Identification of *P.taxon* Cranberry and distinction from *P. cinnamomi*





Trapping of Phytophthora species New Jersey cranberry growing area





Results of Phytophthora trapping

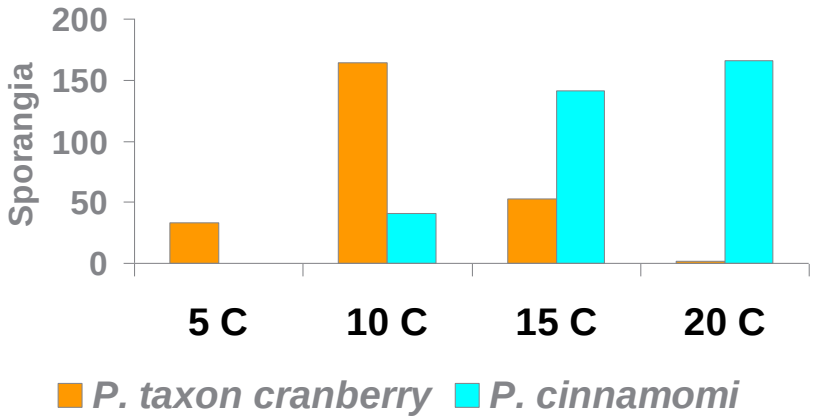
Table 2. Recovery of *Phytophthora cinnamomi* from lupine bait sampling of native streams tested in 1995[a]

Code[b]	Location	18 July	15 August	22 August	18 September
PO	Papoose Branch, Oswego River	3/16	0/16	nt[c]	nt
BO	Breeches Branch, Oswego River	3/16	0/16	nt	nt
SW	Shoal Branch, Wading River	14/16	16/16	nt	nt
WW	West Branch, Wading River	nt	nt	2/8	3/8
RBN[d]	Roberts Branch, Batsto River, north	nt	nt	4/8	4/8
WB	West Batsto River	nt	nt	0/8	0/8
EB	East Batsto River	nt	nt	5/8	2/8
RBS[d]	Roberts Branch, Batsto River, south	nt	nt	0/8	0/8
SB	Skit Branch, Batsto River	nt	nt	2/8	0/8
TC	Tulpehocken Creek	nt	nt	0/8	0/8
FC	Featherbed Creek	nt	nt	0/8	0/8
FR	Friendship Reservoir	nt	nt	4/8	4/8
WR	Wading River	nt	nt	5/8	7/8

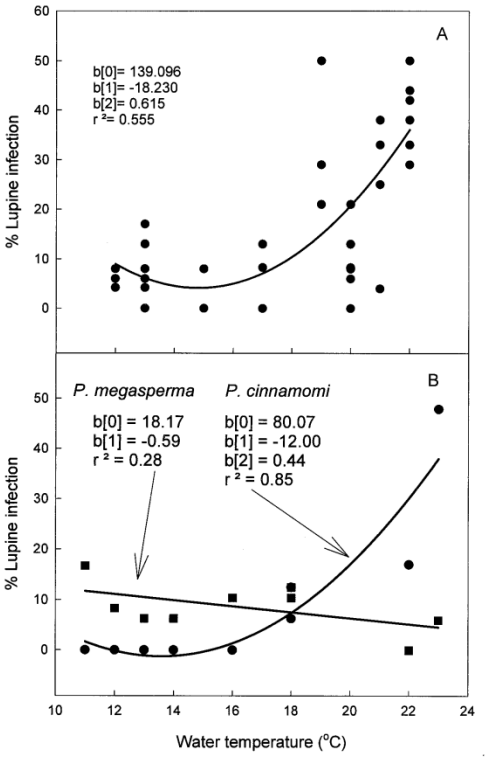
[a] Values represent the number of lupine baits infected out of the total number placed in stream.
[b] This code is used for locations on the map in Figure 1.
[c] Not tested.
[d] RBN and RBS are the same stream with northern and southern sampling locations.

Comparison of P. taxon cranberry and P. cinnamomi

Lab studies



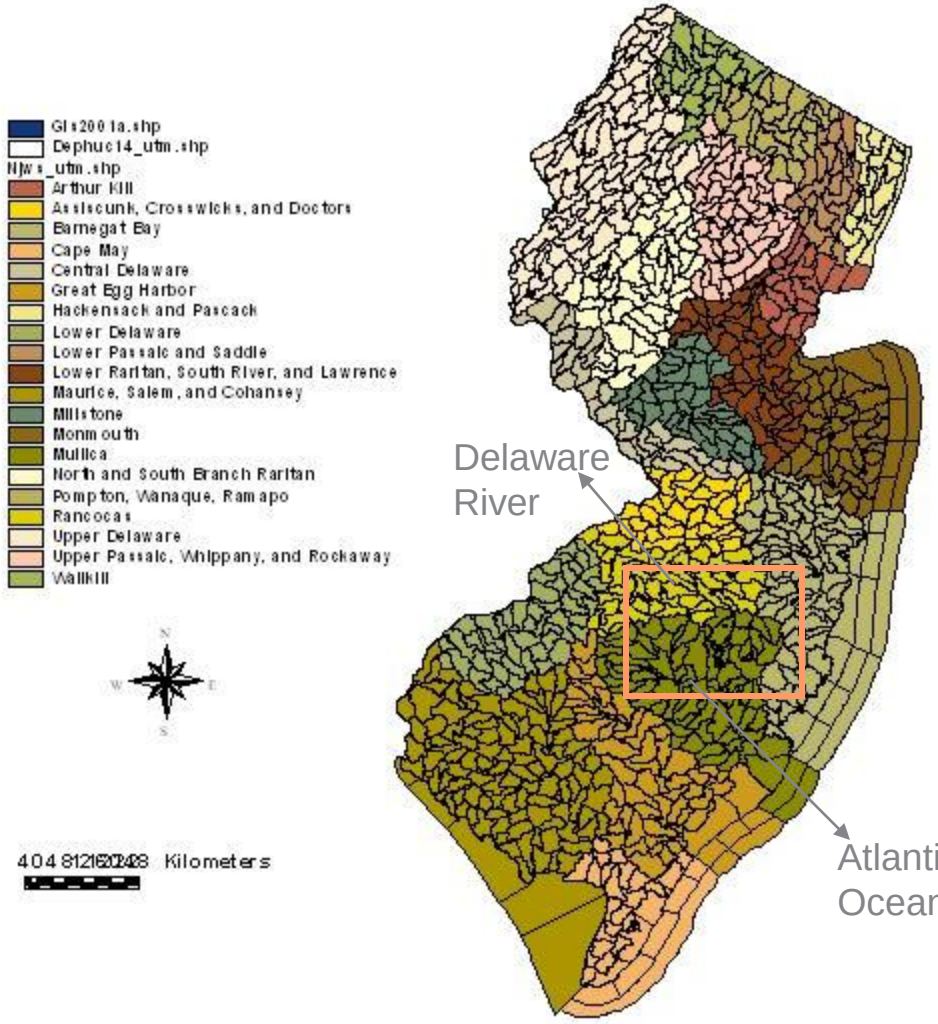
Field results

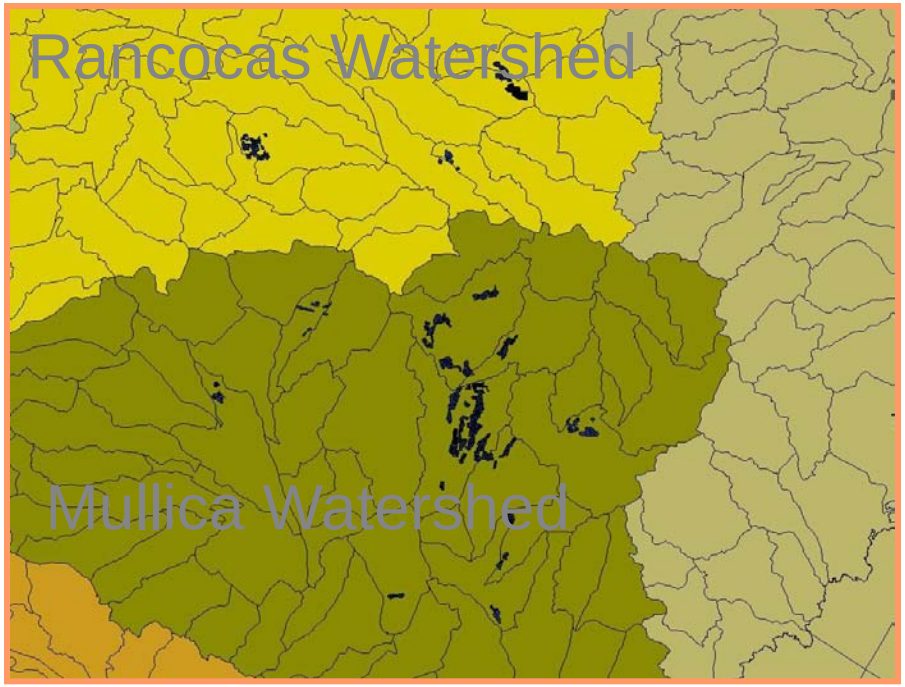


Distribution of *Phytophthora* species from cranberry in New Jersey.

Species	Recovery
P. cinnamomi	182 beds (842 acres)
P. taxon cranberry	none
Both species	52 beds (197 acres)
None	56 beds (259 acres)

New Jersey Watersheds with Cranberry Production





Areas with cranberry production

Comparison of P. Taxon cranberry and P. cinnamomi

- PTC has a narrow distribution in NJ.
- PC is widely distributed in NJ and MA
- PTC has a lower temperature optimum than PC
- PTC is less pathogenic than PC
- PC and PTC have different fungicide sensitivities

Phytophthora cinnamomi

- >3000 host species
- Soilborne
- Heterothallic BUT mating types separated
- Diagnostic character

Impact of *Phytophthora cinnamomi* on Jarrah Forests in Australia

IMPACT

1. Death of trees-45%
2. Death of 50- 75% different species
3. Decline in abundance of plants
4. Decline in plant diversity
5. Extinction of endangered species
6. Increase in % of bare ground
7. Change to sedges and rushes
8. Loss of birds, marsupials, and insects


A


B

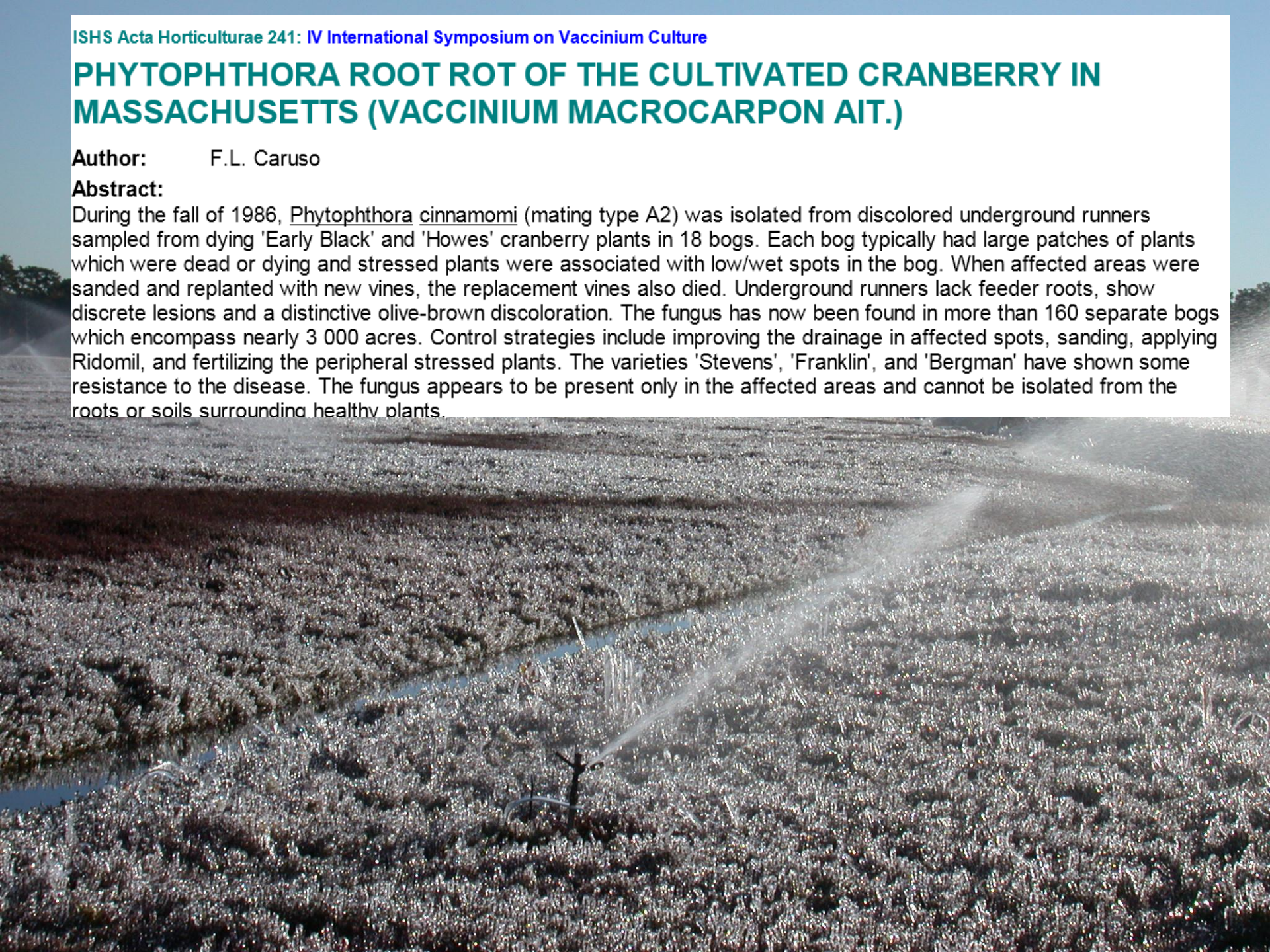
ISHS Acta Horticulturae 241: IV International Symposium on Vaccinium Culture

PHYTOPHTHORA ROOT ROT OF THE CULTIVATED CRANBERRY IN MASSACHUSETTS (VACCINIUM MACROCARPON AIT.)

Author: F.L. Caruso

Abstract:

During the fall of 1986, Phytophthora cinnamomi (mating type A2) was isolated from discolored underground runners sampled from dying 'Early Black' and 'Howes' cranberry plants in 18 bogs. Each bog typically had large patches of plants which were dead or dying and stressed plants were associated with low/wet spots in the bog. When affected areas were sanded and replanted with new vines, the replacement vines also died. Underground runners lack feeder roots, show discrete lesions and a distinctive olive-brown discoloration. The fungus has now been found in more than 160 separate bogs which encompass nearly 3 000 acres. Control strategies include improving the drainage in affected spots, sanding, applying Ridomil, and fertilizing the peripheral stressed plants. The varieties 'Stevens', 'Franklin', and 'Bergman' have shown some resistance to the disease. The fungus appears to be present only in the affected areas and cannot be isolated from the roots or soils surrounding healthy plants.



Observed range of *P.cinnamomi* on Castanea species

Crandall and Gravatt, 1945

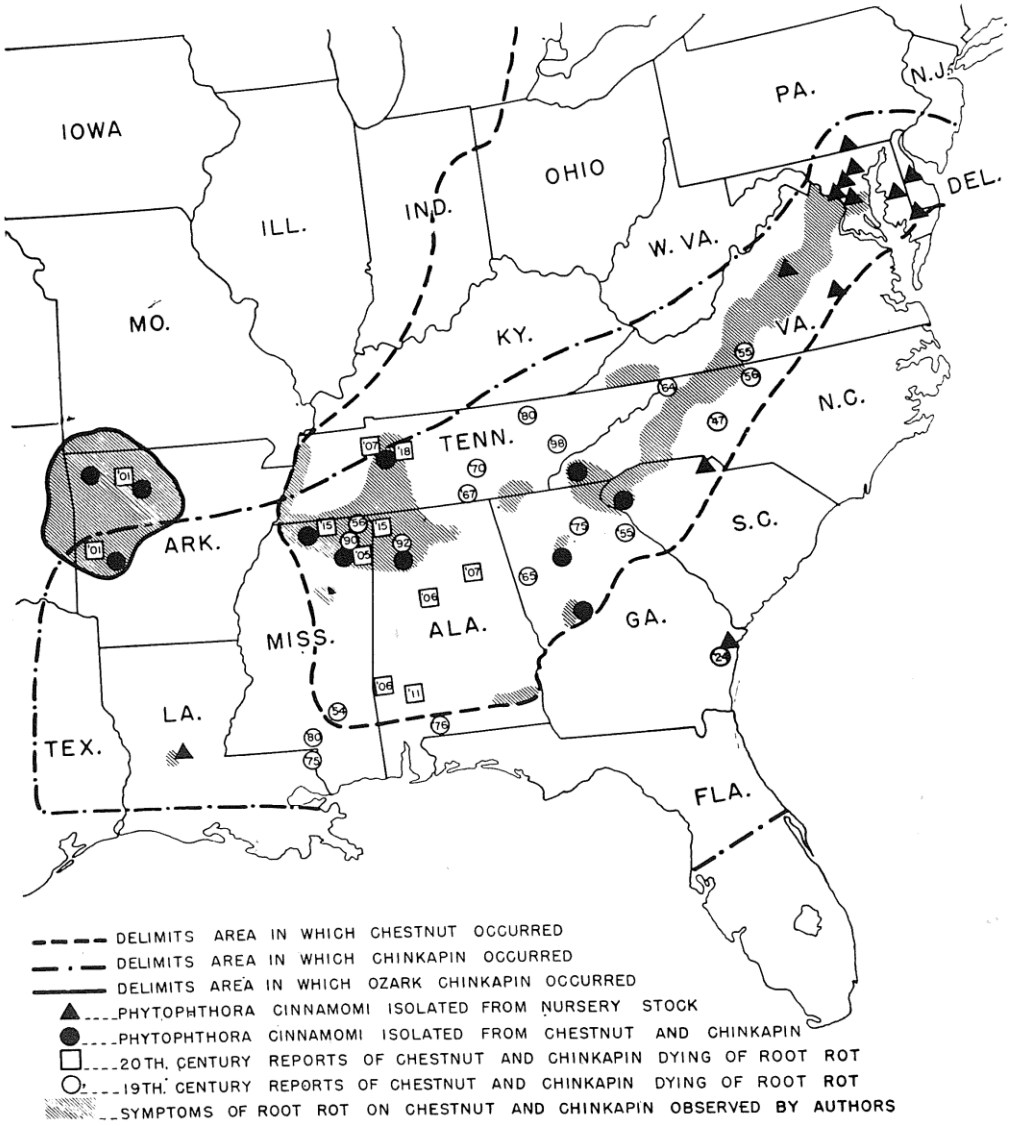


FIG. 2. Observed range of root rot caused by *Phytophthora cinnamomi*.

Phytophthora spp. Associated with Forest Soils in Eastern and North-Central U.S. Oak Ecosystems

Balci et al., 2007

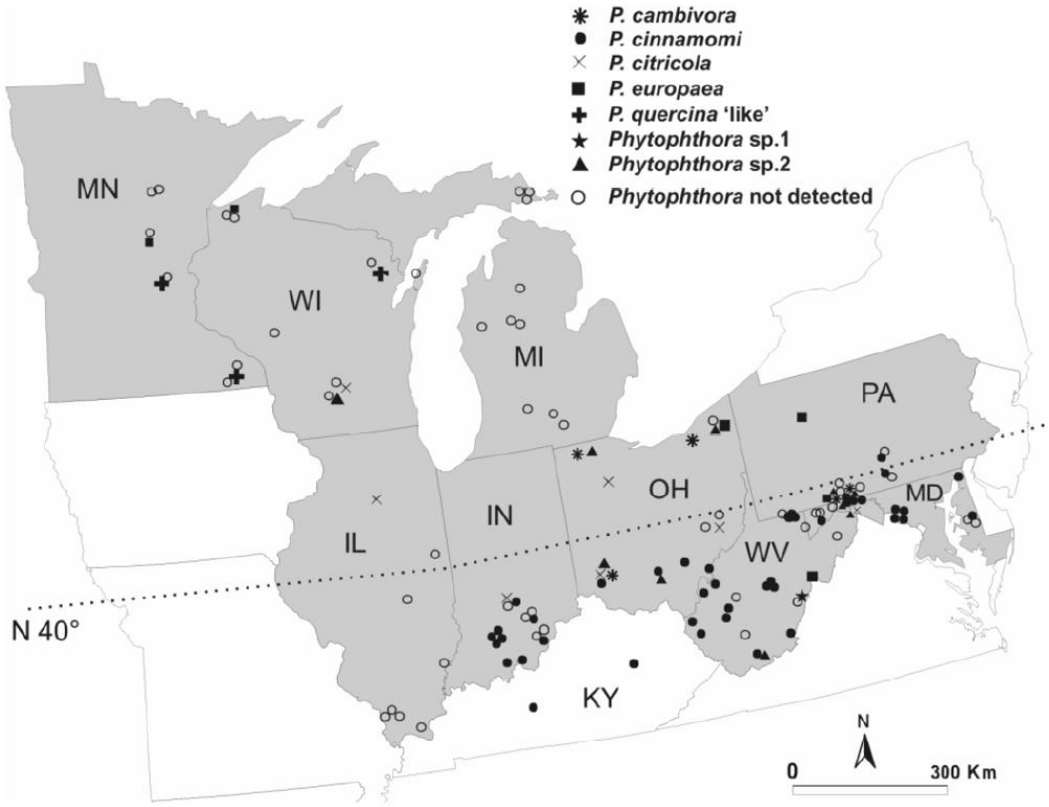
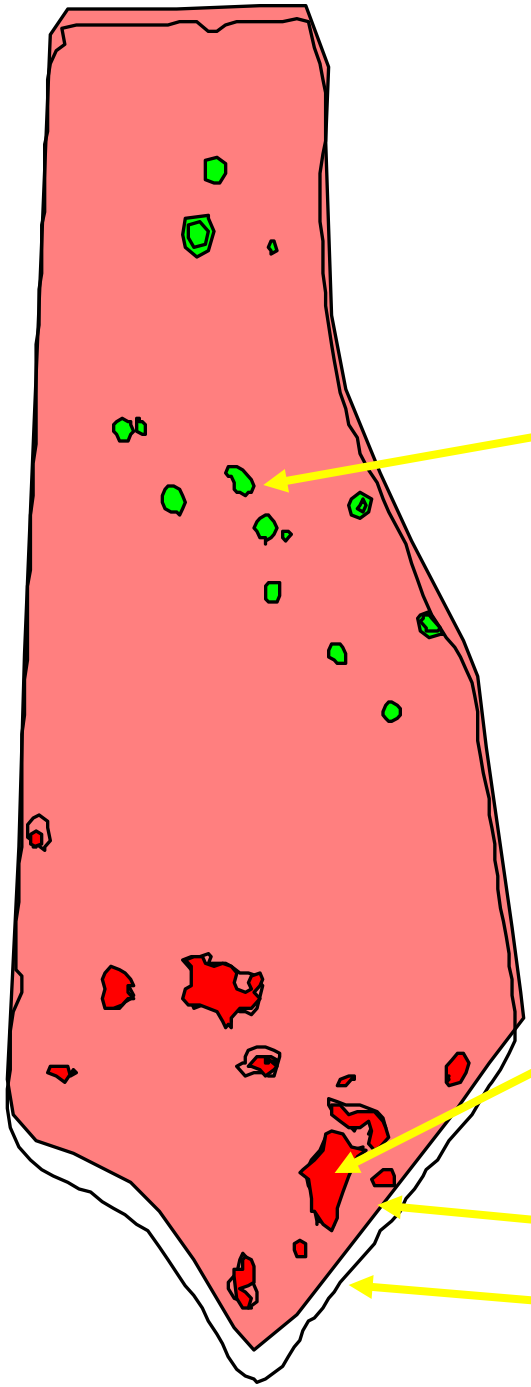


Fig. 1. Distribution of *Phytophthora* spp. isolated from soil throughout the survey area.



Fairy Rings

Phytophthora root rot

Bed boundary

GPS

DOQQ

GPS based maps include features such as be boundaries and disease symptoms.

Fairy Ring

0.017 acres

loss 7.8 barrels

Root Rot

0.1 acres

loss 45.8 barrels


Fairy Ring on a cranberry bed

Fairy Ring on a cranberry bed

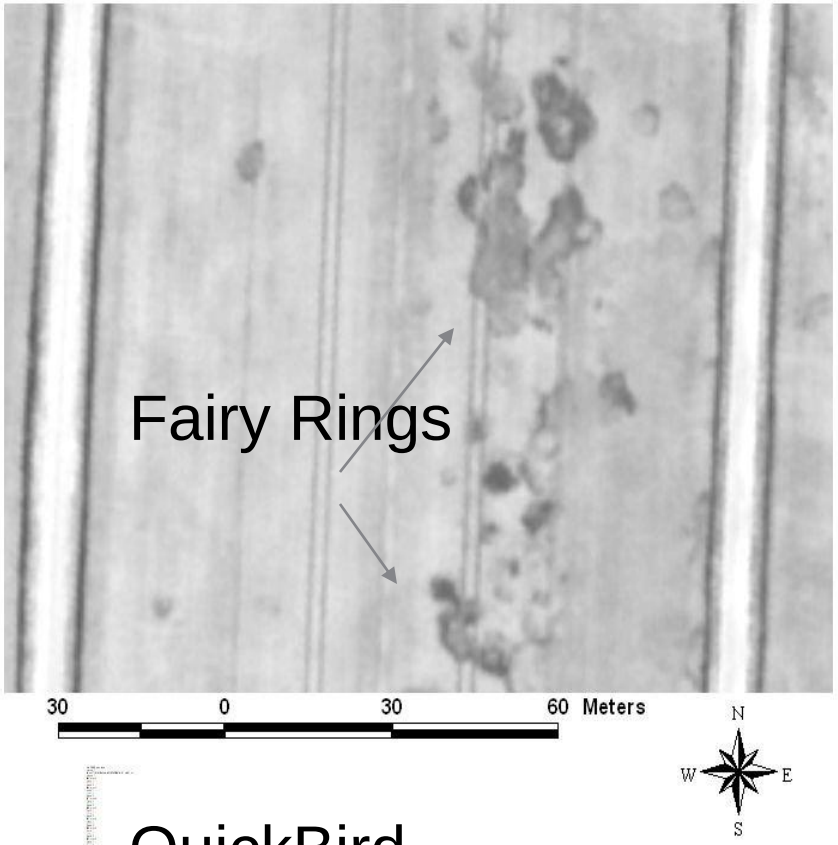
Estimated economic impact of disease on cranberry yield of a single bed in New Jersey

Yields and yield loss were estimated by counting berries in 200 cm^2 areas. The areas occupied by each disease as well as the area of the entire bed were measured using a GPS. The crop values are based on 2008 figures and the fungicide and management costs are current.

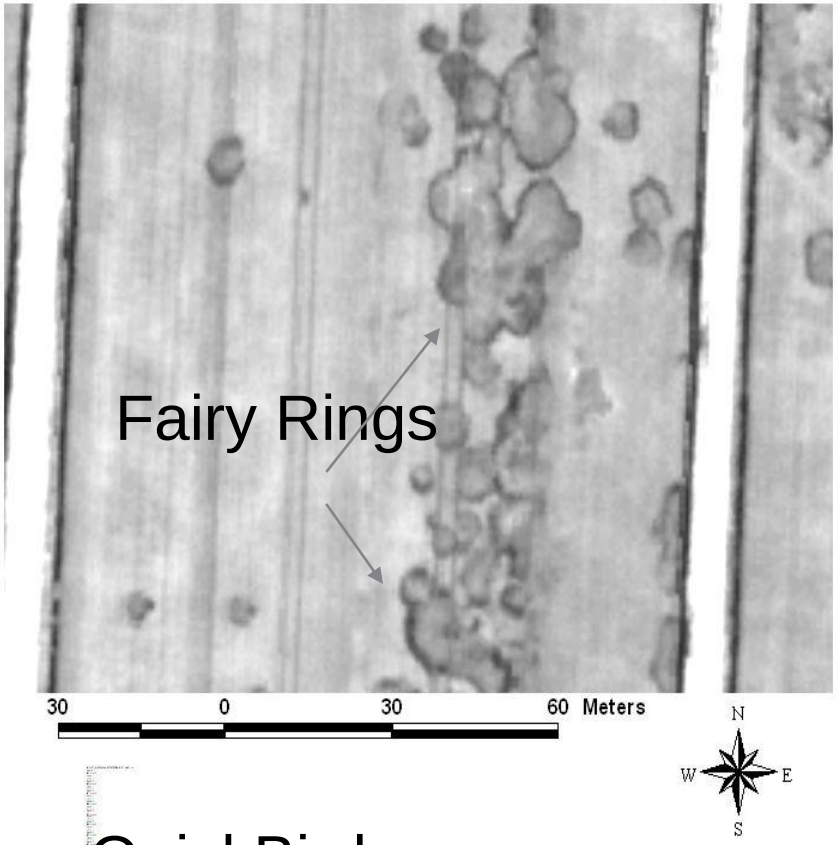
	Yields/ Losses	Value	Fungicide costs/year	Cost to eradicate[1]	Cumulative 10-yr loss[2]
Bed	89,454 kg	$118,464			
PRR	-2081.8kg	- $2748	$45	$1,000	unknown
FR	-354.3kg	- $468	$179	unknown	$84,775

[1]Cost to eradicate PRR includes fungicide costs, drainage enhancement and replanting.
[2]Ten-year losses were observed increases in fairy ring.

Spread of Fairy Ring Disease 2006 - 2008

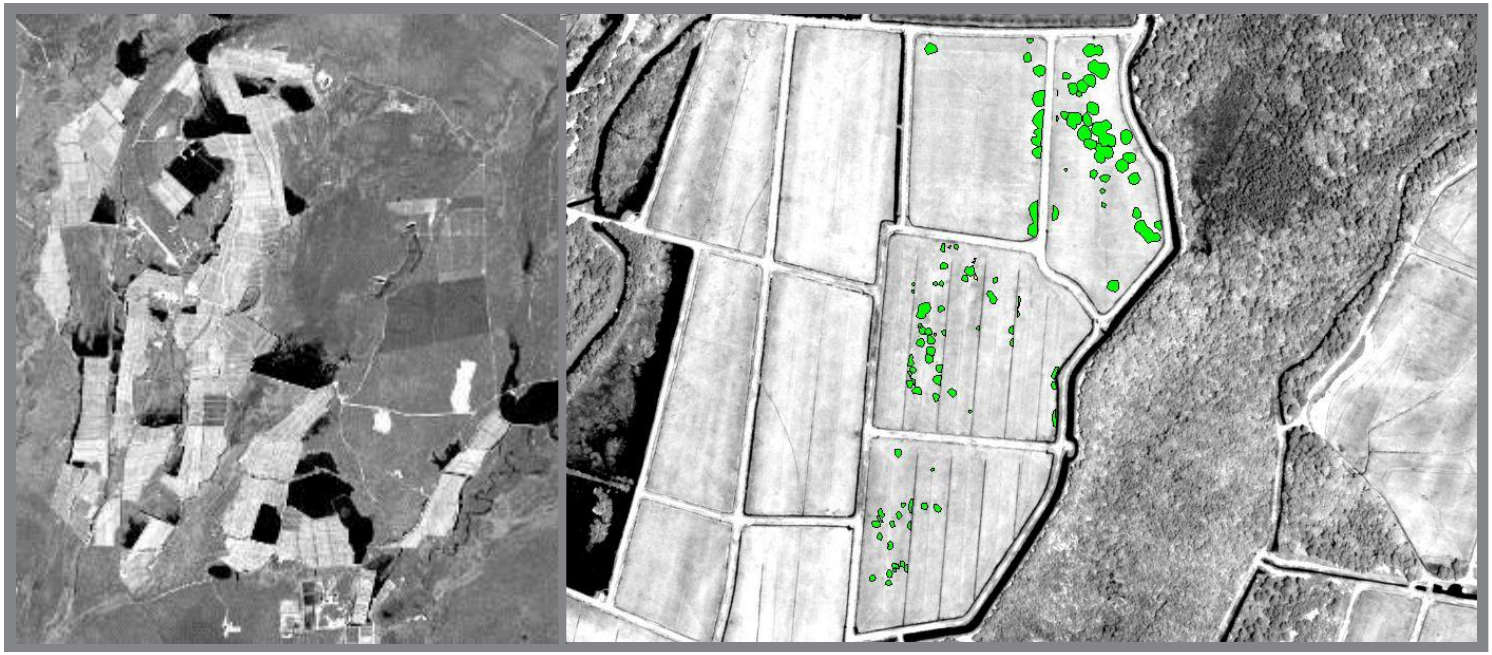


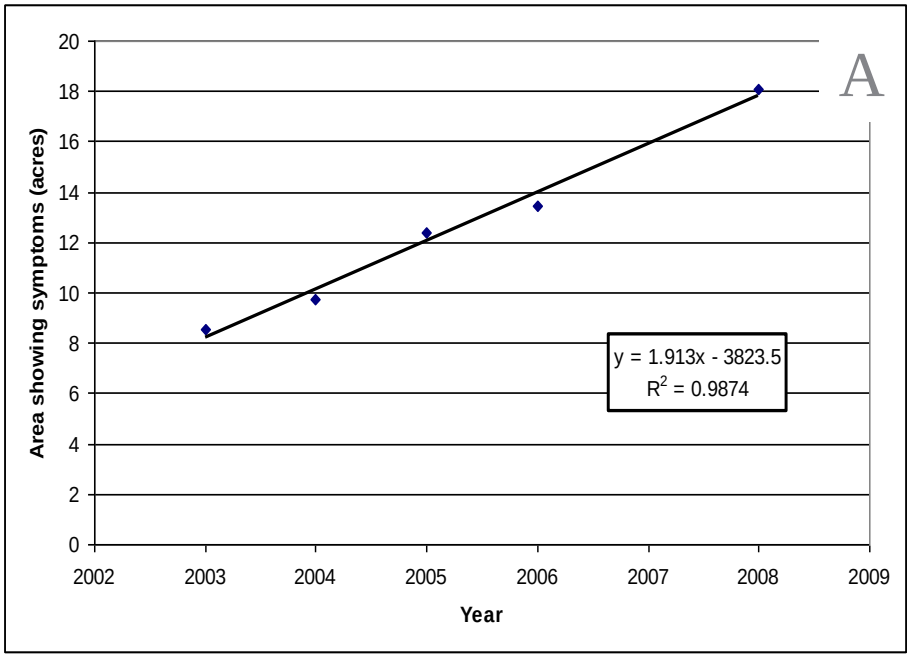
QuickBird Panchromatic image taken July 18, 2006

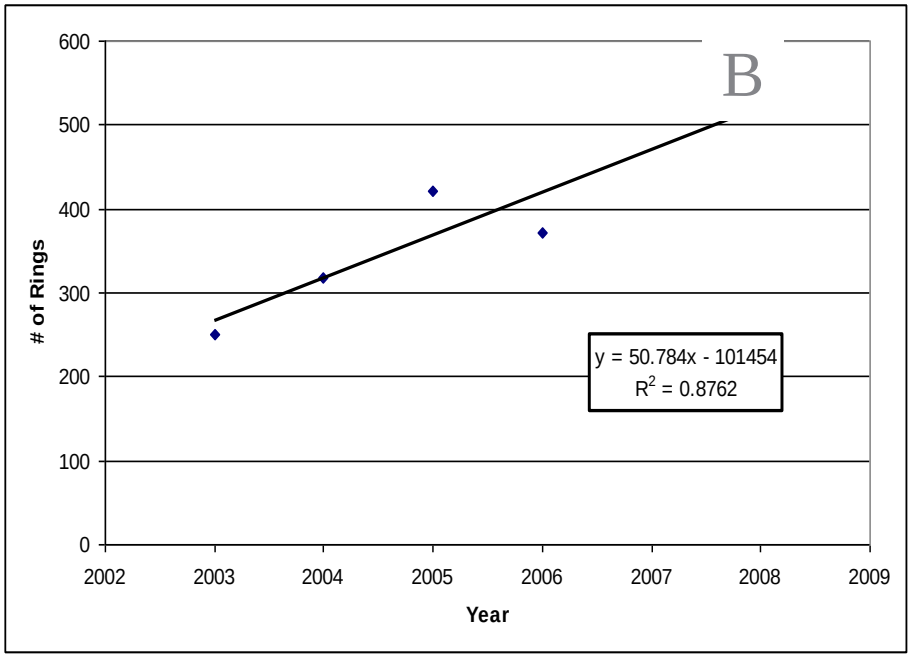


QuickBird Panchromatic image taken June 27, 2008

Incidence and severity of fairy ring disease on cranberry fields near Chatsworth, NJ in 2006				
Cultivar	Area Sampled (ha)	Number of rings	Area Infected (ha)	Fields infected (Total fields)
Ben Lear	49	163	2.33	15 (30)
Early Black	290	105	1.88	29 (165)
Stevens	126	63	0.48	12 (83)







Change in fairy ring severity across a study area of ~1300 acres. A) Increase in acreage affected by the disease from 2003 – 2008. B. Shows the increase in the number of rings over the same time period. Data was collected from satellite imagery taken just following the bloom period each year.

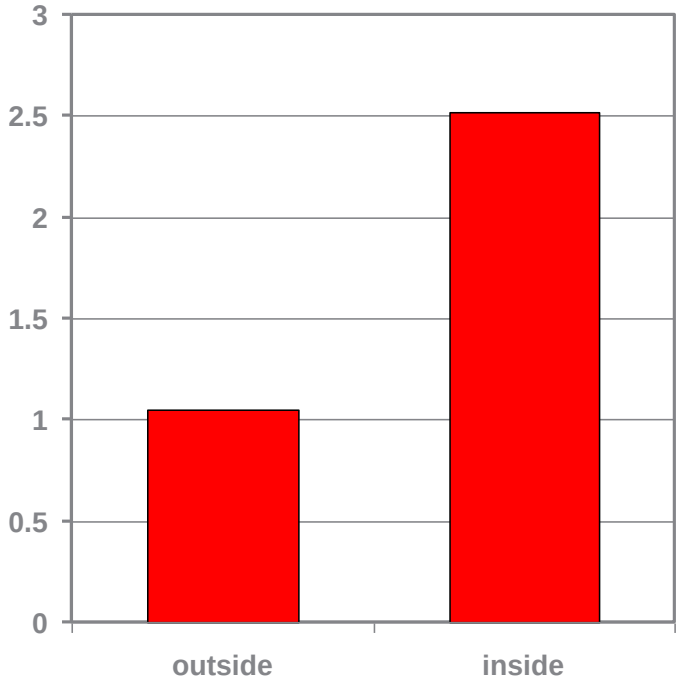
Yield Effects of Fairy Ring on Cranberry Yield

Condition	Yield 2002 (kg/ha)	Yield 2003 (kg/ha)	Yield 2004 (kg/ha)
Inside	8730	10500	13270
Outside	18420	25500	37140
	p<0.001	p<0.001	p<0.001


‘Ben Lear’
(Healthy)
‘Ben Lear’
(Fairy Ring-affected)

Genetic Diversity

- Genetic diversity is 2-4 times higher in the affected areas.
- Calculated AMOVA (Analysis of MOlecular VAriance).

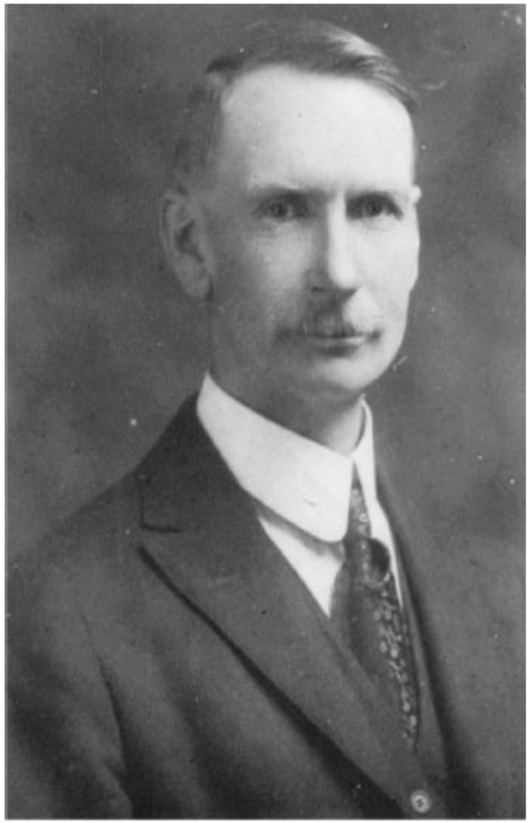


- Stand opening diseases have the potential to increase genetic diversity and reduce longevity of productive beds
- Economical control measures are necessary
- Causal agent

Importance and Economic Impact

- Distribution limited to the northeast region
- Once considered minor now impacting high yielding cultivars such as Stevens and Ben Lear
- Reduces yield (50-60%)
- Increases fruit rot
- Opens canopy to weed invasion
- Increases genetic diversity of cranberry crop
- Increases need for replanting

Isolation and identification of the causal agent has proven



C. L. Shear

The fungus rarely fruits on the bog under natural conditions, but fruiting bodies are readily produced on sods from certain rings if the sods are kept moist and shaded. Or, if a sod is removed from the active zone in June or early July and the hole shaded and kept moist, fruiting bodies are often produced along the vertical walls.

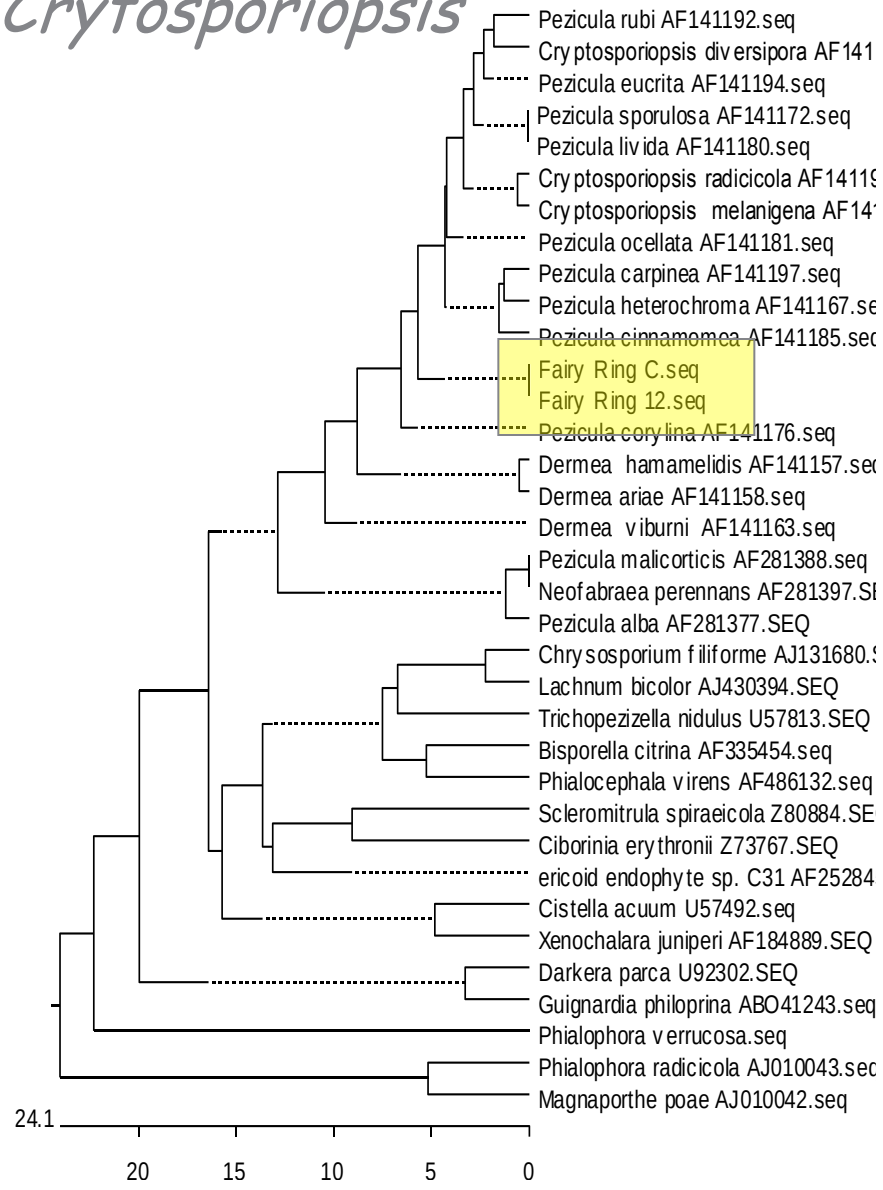
Psilocybe agrariella
Shear et al., 1931. USDA Agric. Tech. Bull.

***Phialophora* sp.**
Hlubik, 1988. Rutgers University M.S. thesis

***Rhizoctonia* sp.**
Chang, 1989. Rutgers University M.S. thesis

Causal Agent: Part 1

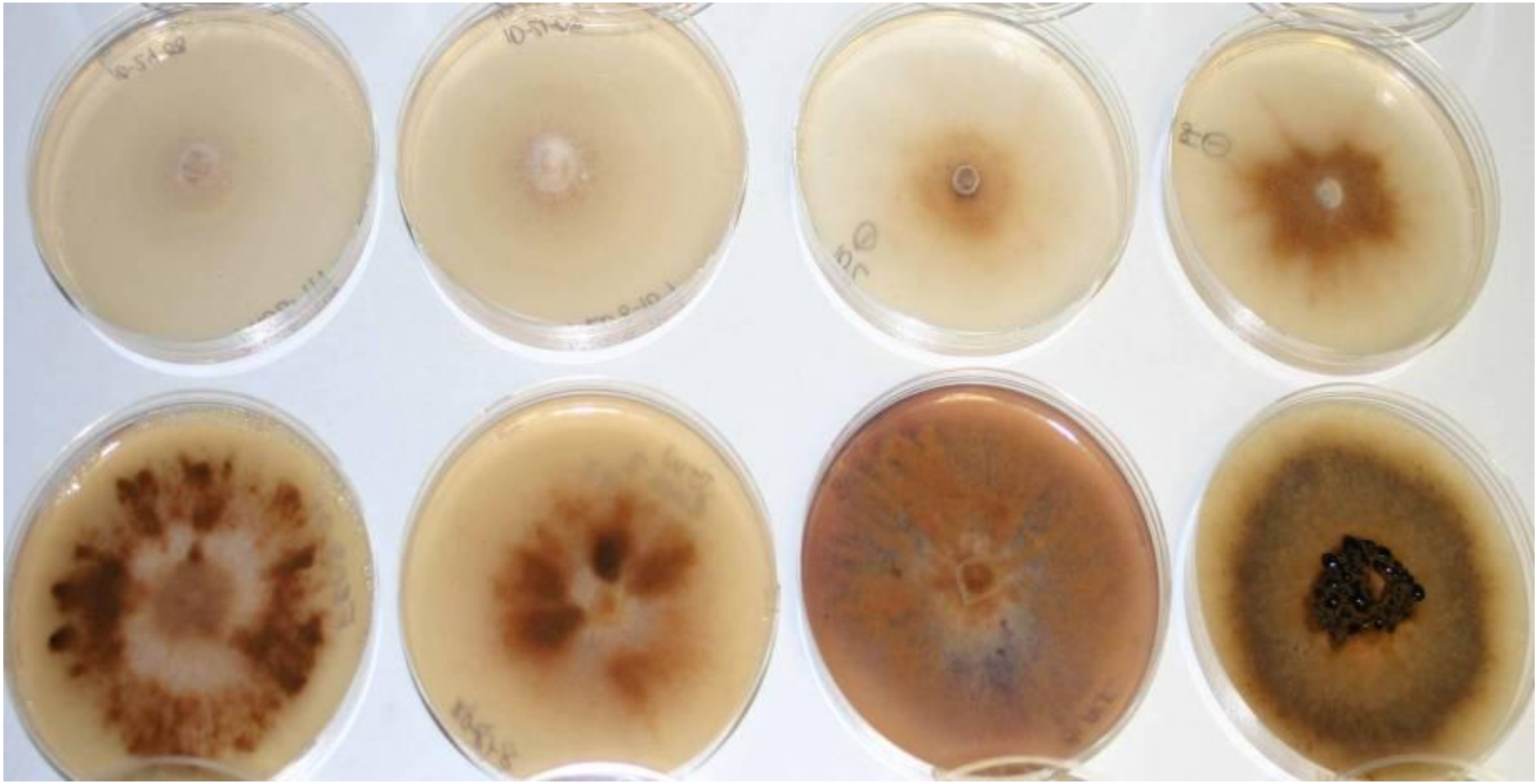
Pezicula, Dermea, Neofabraea, Crytosporiopsis



Fairy Ring Causal Agent: Part 2

- Koch's Postulates failed on two counts
  - Inconsistent isolation
  - Failure to re-infect
- Isolation approach changed
  - Observed dark structures on some stolons
  - External mycelium evident
  - Difficult to isolate

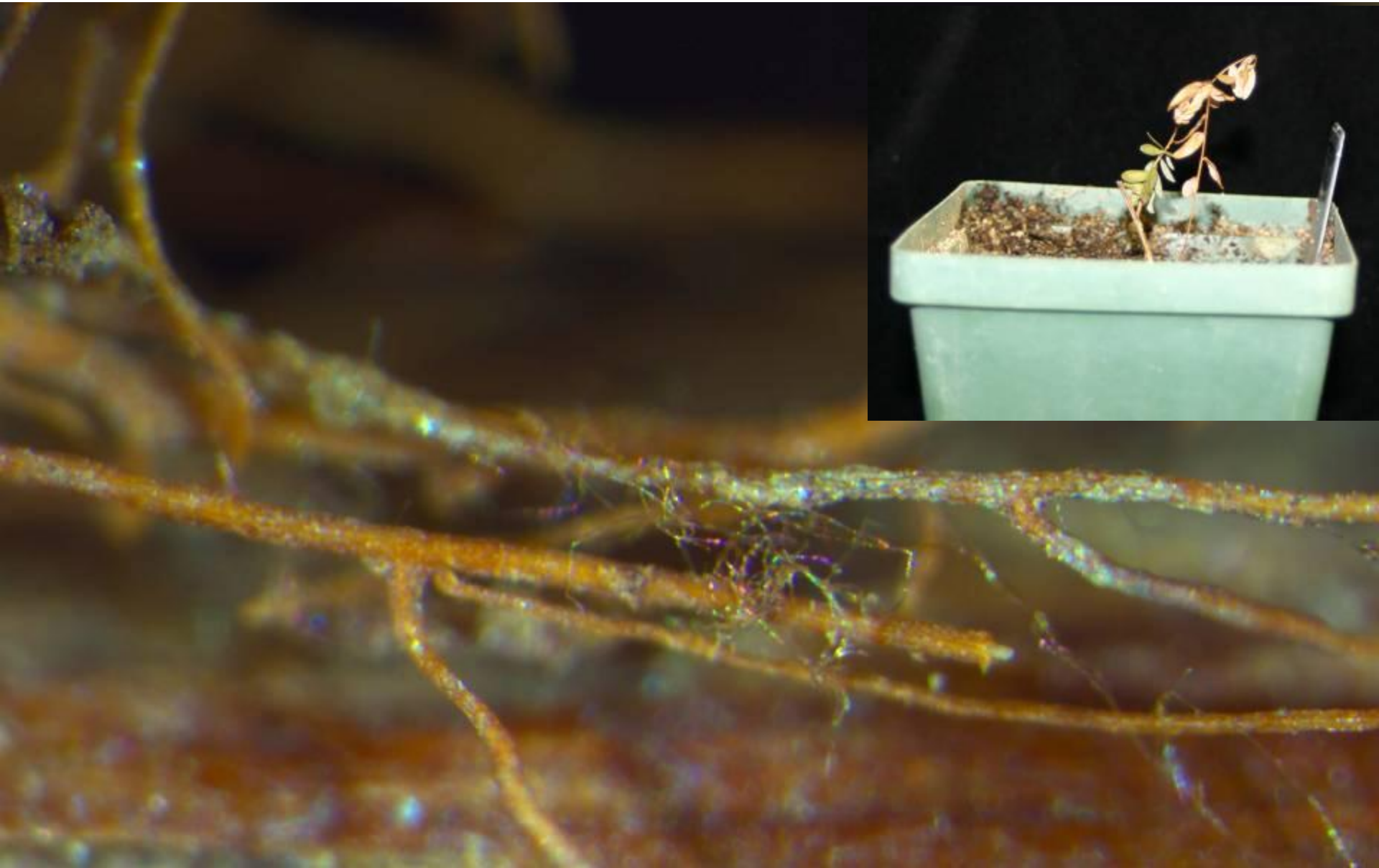
Isolated Cultures



*No sporulation in culture

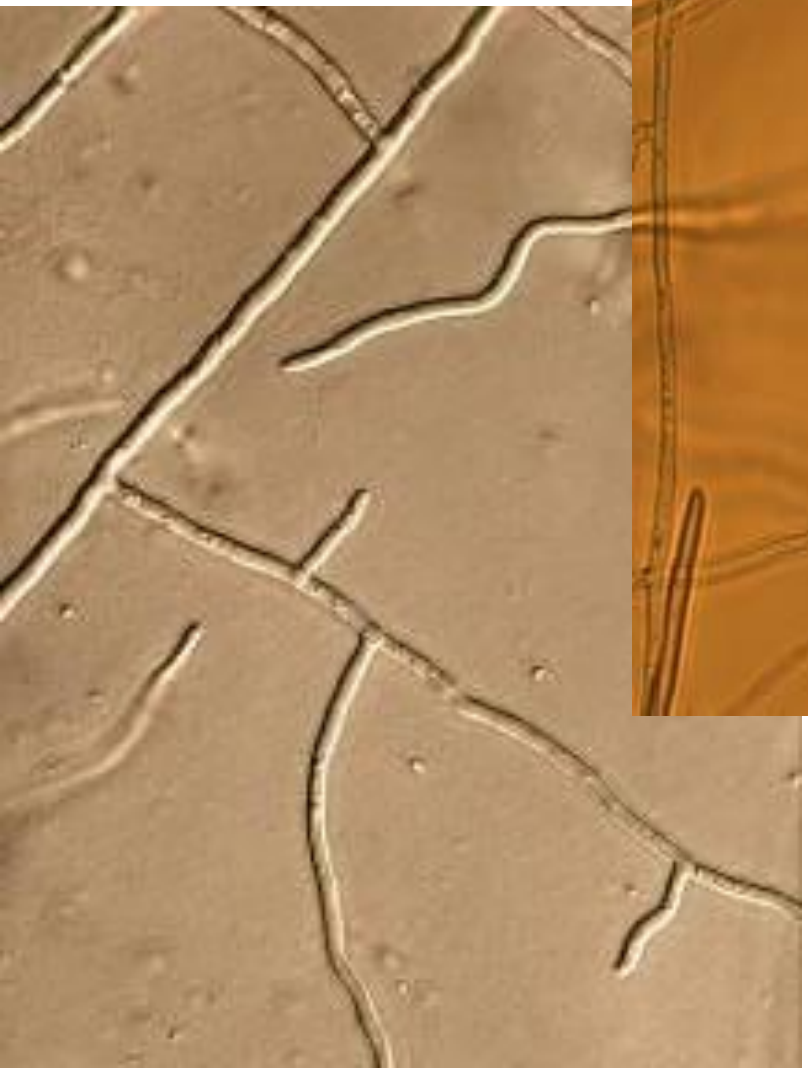
Inoculations

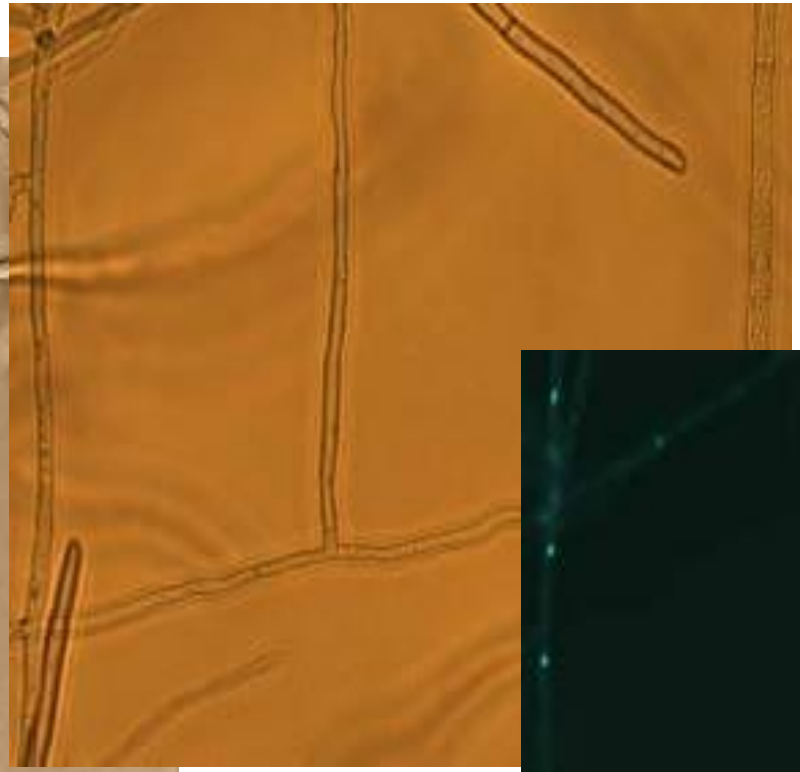
Infection and Plant Death

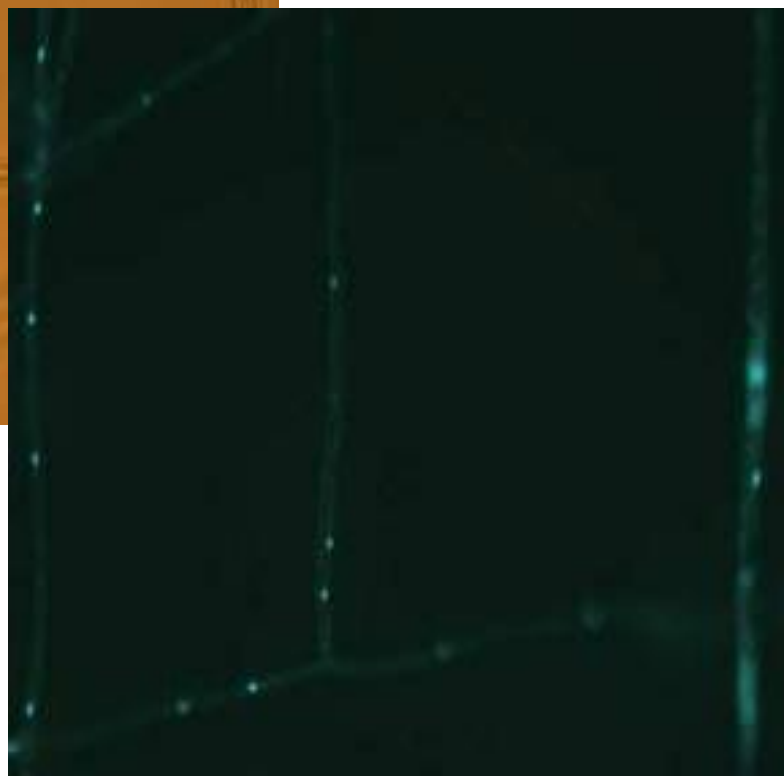


Fairy Ring Causal Agent: Part 2

Rhizoctonia spp.??







Sequence Analysis for Identification

AY292443.1	Helicobasidium longisporum I voucher M 5803 18S ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, complete sequence; and 28S ribosomal RNA; amplified by primers ITS1 gene, partial sequence	652
AY292427.1	Helicobasidium longisporum I voucher GZU 74-99 18S ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, complete sequence; and 28S ribosomal RNA; amplified by primers ITS1 gene, partial sequence	652
AY460155.1	Tuberculina persicina isolate ml73 18S ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, complete sequence; and 28S ribosomal RNA gene, partial sequence	652
AY460153.1	Tuberculina persicina isolate ml324 18S ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, complete sequence; and 28S ribosomal RNA gene, partial sequence	652
AB056725.1	Helicobasidium purpureum genes for nuclear small rRNA, ITS1, 5.8S rRNA, ITS2, nuclear large rRNA	652
AB044140.1	Rhizoctonia violacea gene for nuclear small rRNA, ITS1, 5.8S rRNA, ITS2, nuclear large rRNA, partial and complete sequence	652
AY292426.1	Helicobasidium longisporum II voucher CBS 296.50 18S ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, complete sequence; and 28S ribosomal RNA; amplified by primers ITS1 gene, partial sequence	645

ITS BLAST Results

Tuberculina – Thanatophytum/Rhizoctonia crocorum – Helicobasidium: a unique mycoparasitic–phytoparasitic life strategy†

Matthias LUTZ*, Robert BAUER, Dominik BEGEROW and Franz OBERWINKLER

Mycol. Res. **108** (3): 227–238 (March 2004).

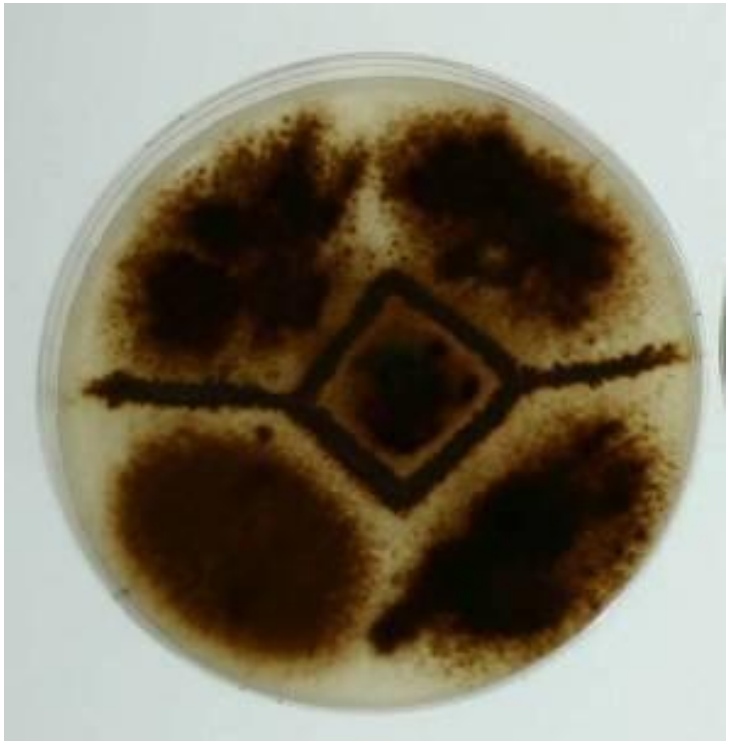
DOI: 10.1017/S0953756204009359 *Printed in the United Kingdom.*

Key Points: *Tuberculina* a rust hyperparasite is synonymous with *Thanatophytum*

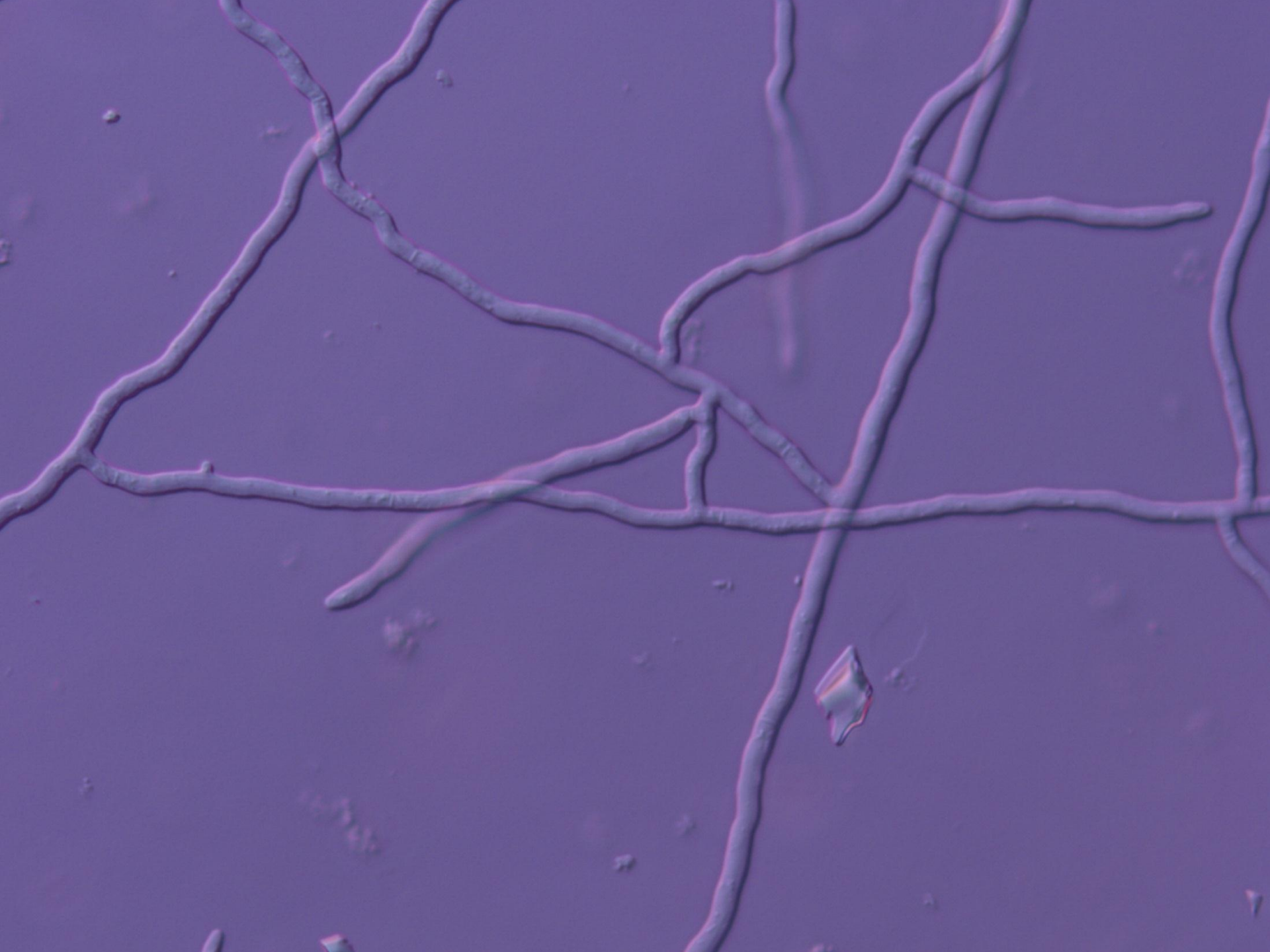
The described stages are linked in a relatively complex life-cycle

Vegetative Incompatibility

	R1a	R1b	R2a	R2b
R1a	+			
R1b	+	+		
R2a	-	-	+	
R2b	-	-	+	+



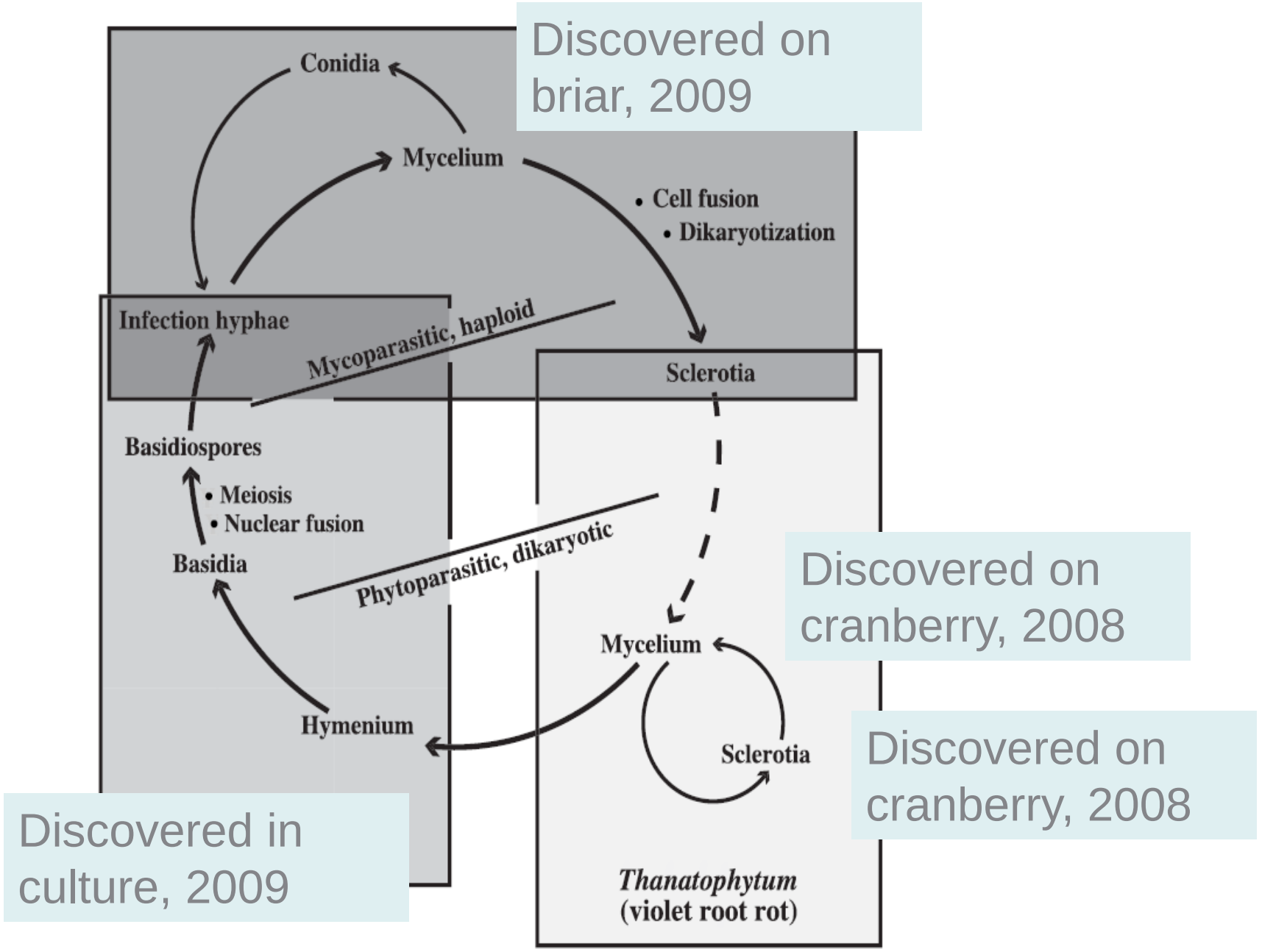
- Same ring = same VC
- Different rings = different VC



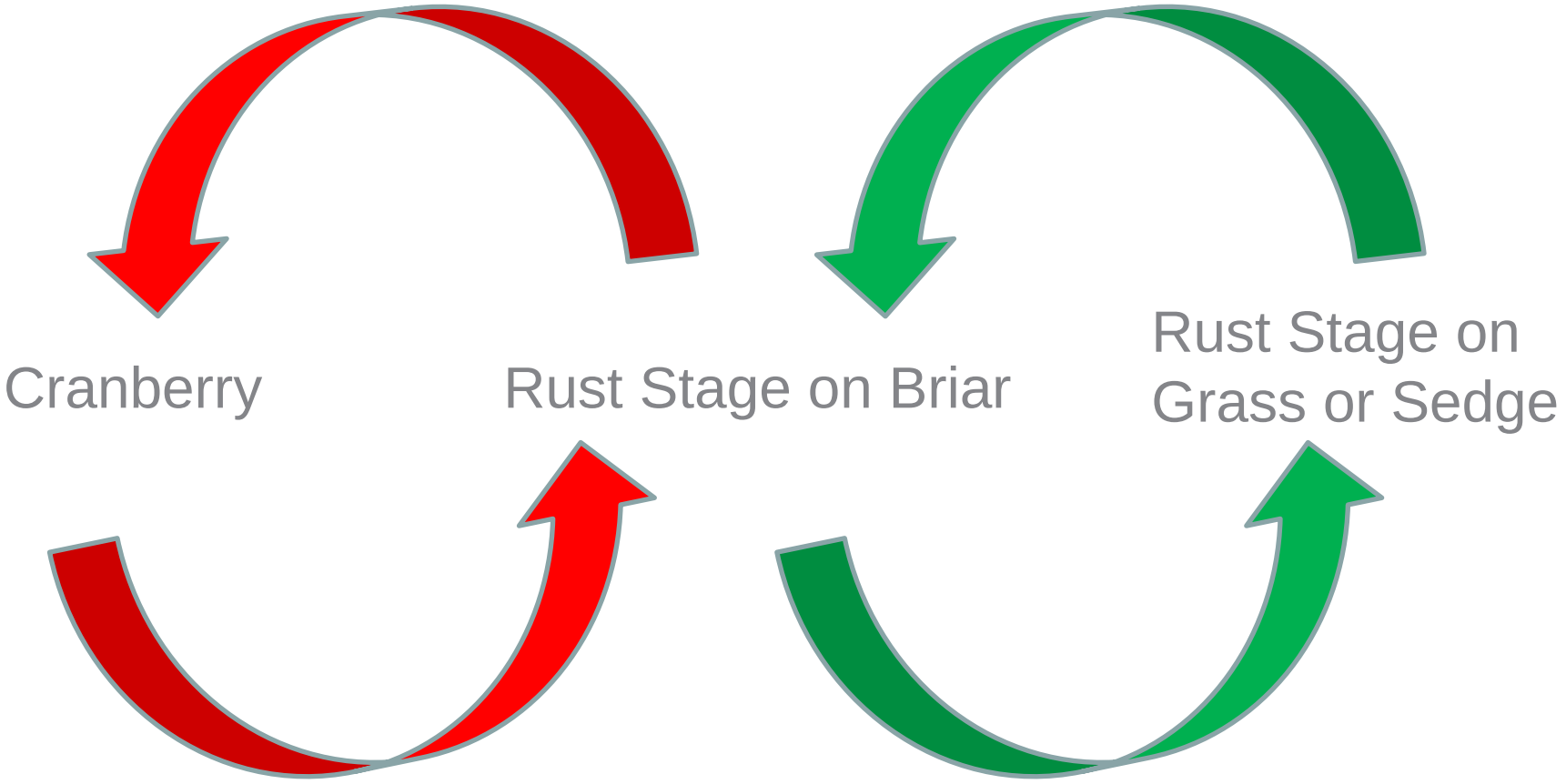
Vegetative Incompatibility

- Isolates have been obtained from 36 rings
- From those we have found 26 VCGs
- Duplicate VCGs are always found in the same bed
- Five rings with five isolates each confirm a single VCG per ring

Sclerotia found in an fairy ring

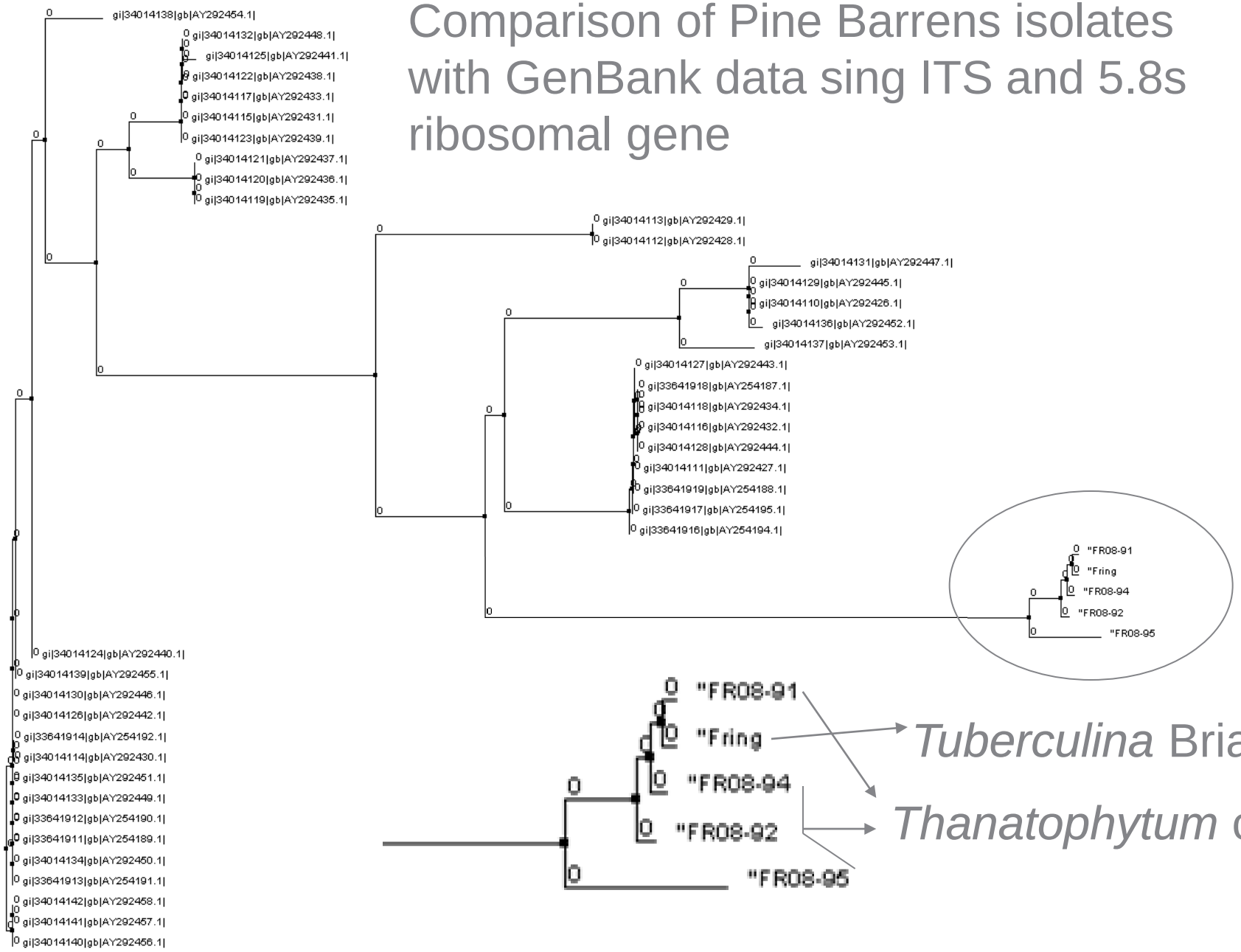

Conidia
Mycelium
• Cell fusion
• Dikaryotization
Infection hyphae
Mycoparasitic, haploid
Sclerotia
Basidiospores
• Meiosis
• Nuclear fusion
Basidia
Phytoparasitic, dikaryotic
Mycelium
Hymenium
Sclerotia
Thanatophytum
(violet root rot)
Discovered on briar, 2009
Discovered on cranberry, 2008
Discovered on cranberry, 2008
Discovered in culture, 2009

Fairy Ring – Controlling the Spread



THE ALTERNATE HOST: RUST

Comparison of Pine Barrens isolates with GenBank data sing ITS and 5.8s ribosomal gene



Rust Lifecycle

Briar

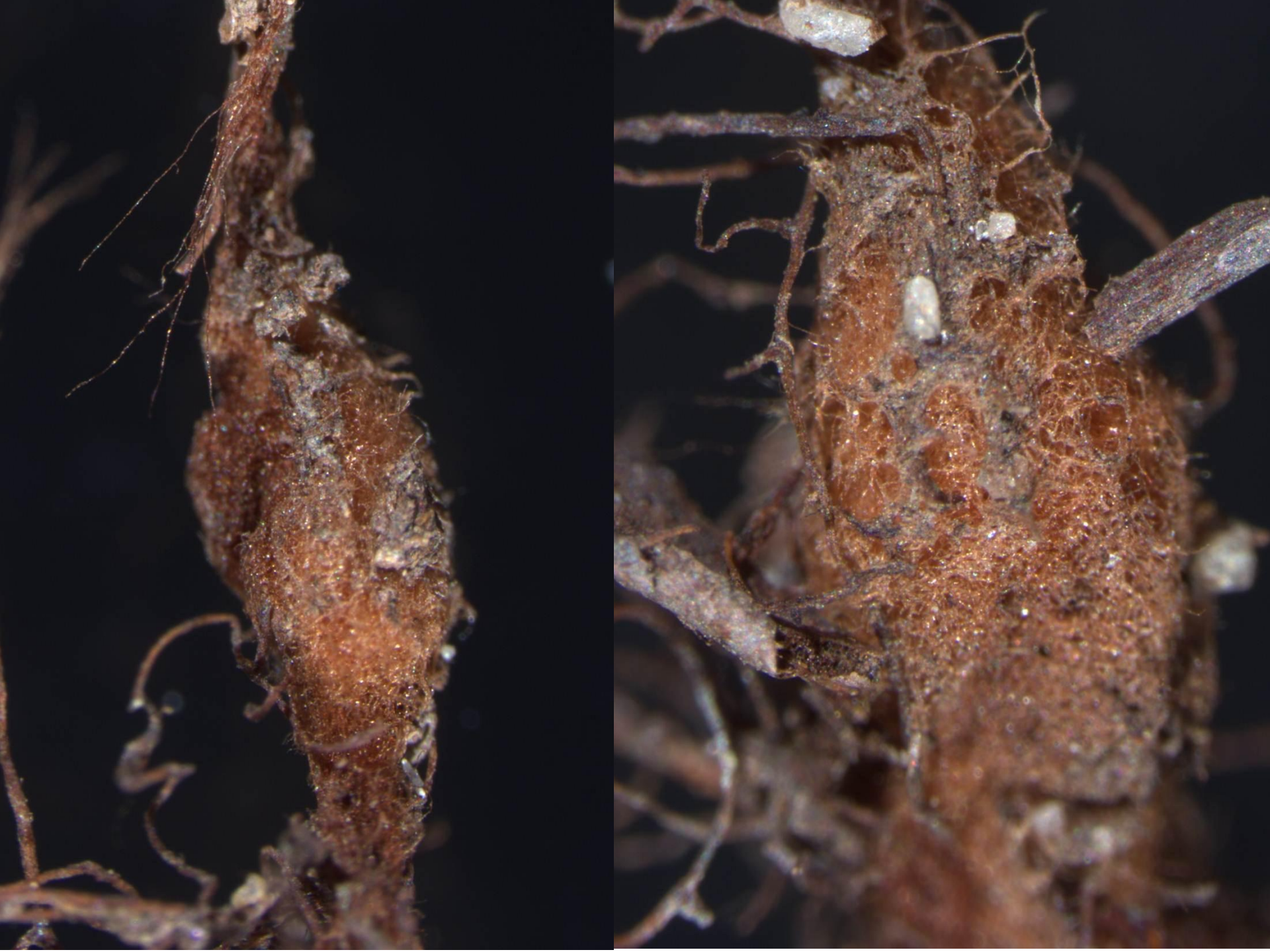
Early summer

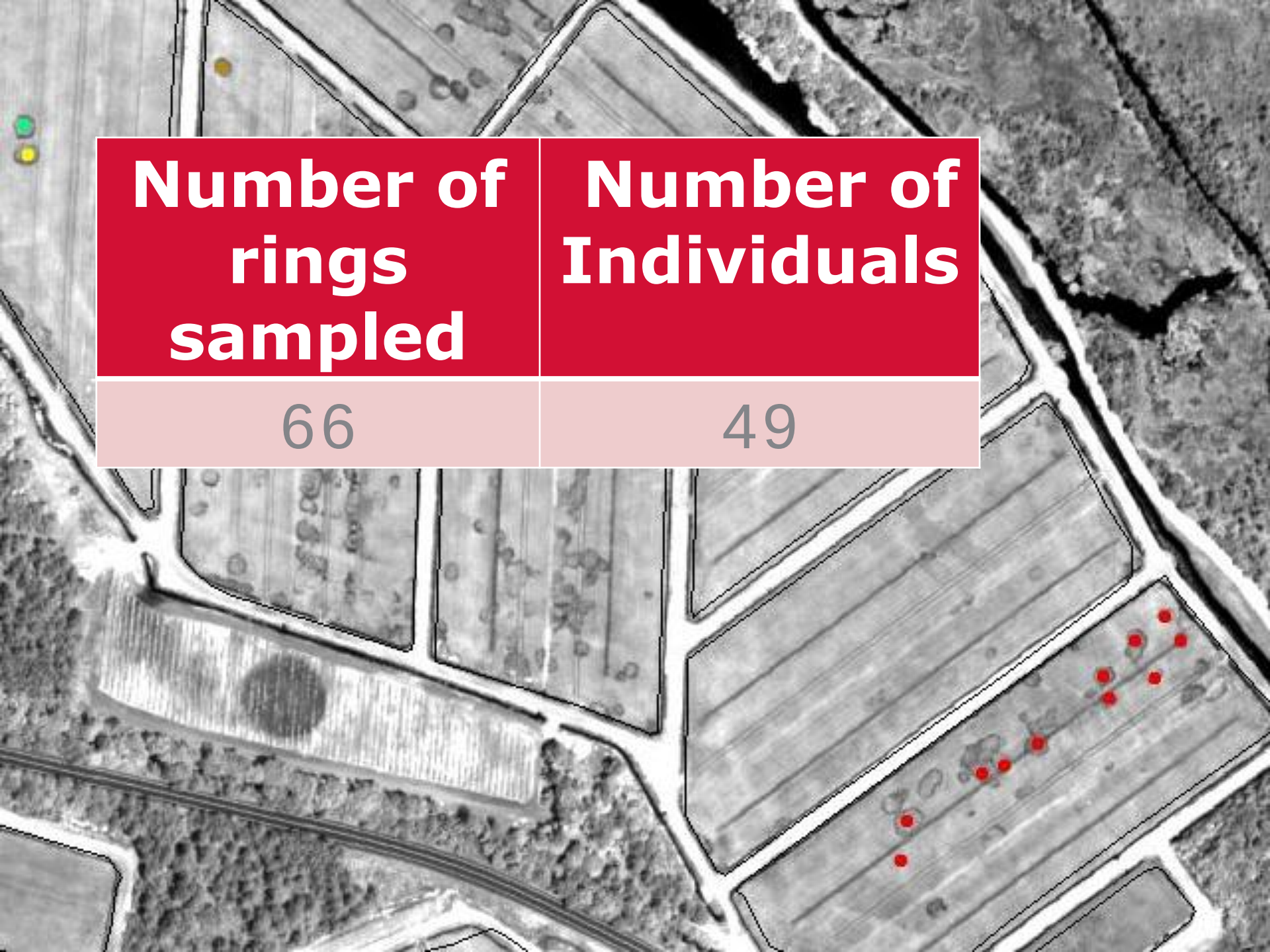
Grass

Summer and fall

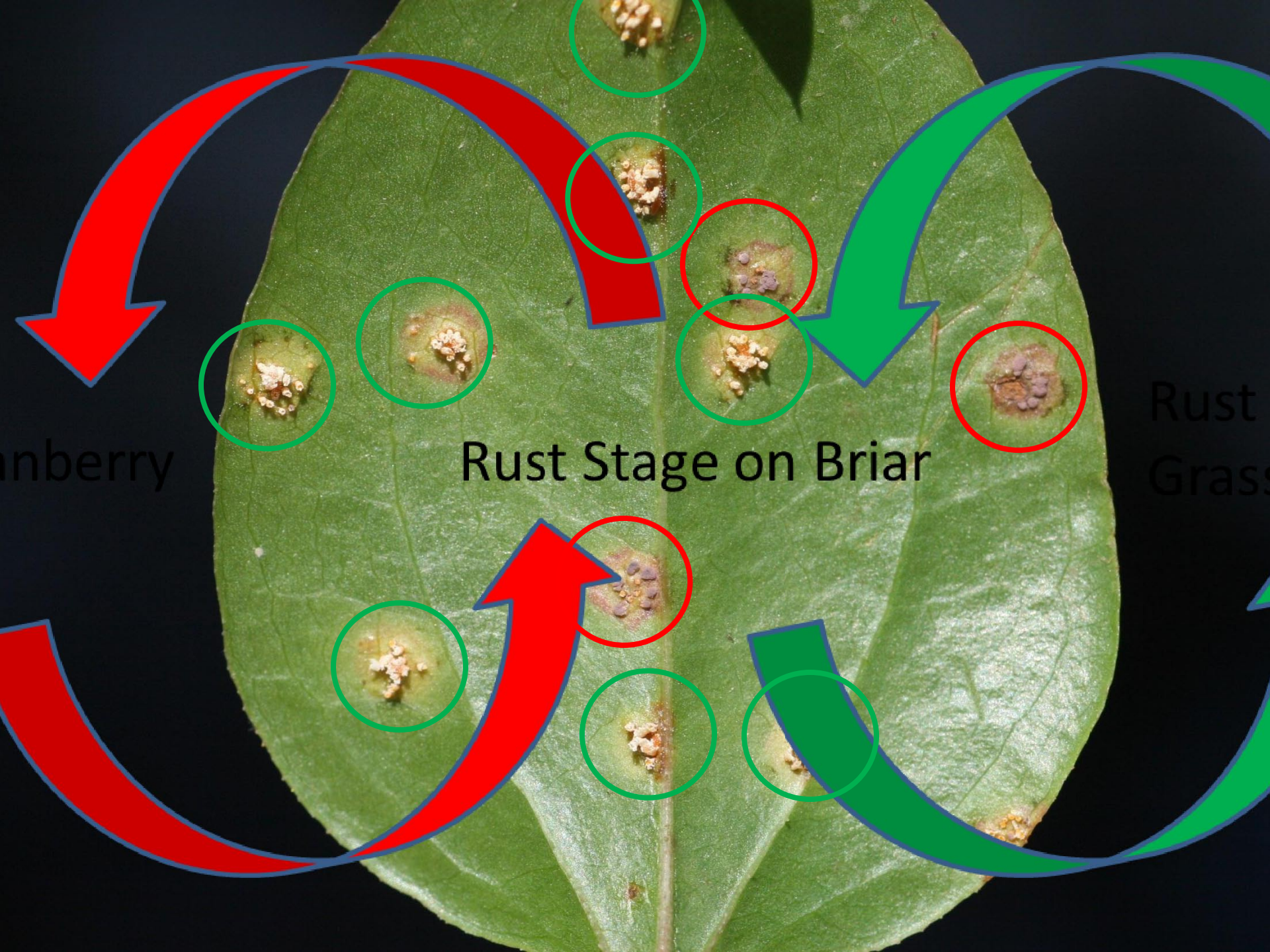
FAIRY RING


2
3
4
5
6
7
8
Compliments of the
Vegetable Growers Association
PHONE/FAX PHIL TRAINO
609-985-4382
PHONE/FAX ROCKY DIGEROLAMO

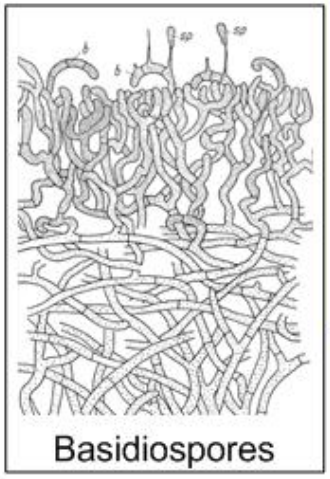




Number of rings sampled	Number of Individuals
66	49


nberry
Rust Stage on Briar
Rust
Grass

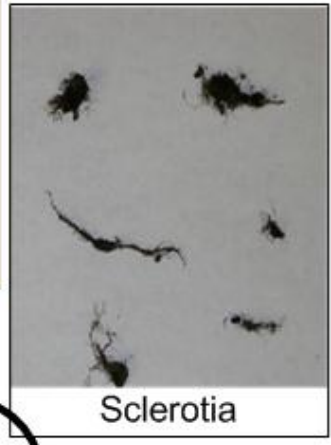
The Life Cycle of Fairy Ring Disease on Cranberry



Basidiospores

Infected Rust

Conidia



Sclerotia

Tuberculina

Basidiospores

Sclerotia

Helicobasidium

Meiosis

Thanatophytum

Conclusions

- Causal agent of fairy ring is a species of *Thanatophytum/Helicobasidium/Tuberculina*
- Spread of this pathogen likely involves the hyperparasitic phase on at least one rust species
- Control options may now target one or more alternate hosts
- The pathogen genetic structure suggests a large population size and one that is supported by multiple host species

2010 Summer Program

- August 3: Meet the Woodland Township Historical Society and visit historic Whites Bog
- August 4: Experience bee keeping and cranberry farming from a hands on perspective
- August 5: Visit the historic ghost towns of the New Jersey Pine Barrens
- September 13*: Meet the cranberry entomologist and the bugs that destroy this crop
- September 20*: Meet the cranberry scientist who studies health benefits
- September 27*: Tour a cranberry harvest operation
- October 4*:Hear about the history of cranberry farming in Chatsworth
- October 11*: Prepare for the cranberry festival
- October 16: Chatsworth Cranberry Festival
- October 17: Chatsworth Cranberry Festival

The Cranbassador Community

- Middle School Students: Mullica Township School in Atlantic County NJ is the first school to take part in the program.
- Chatsworth Community Cranberry Festival: The cranberry festival is held annually on the 3rd weekend of October. Cranberry harvest tours are provided to the public.
- The American Cranberry Growers Association: The association will provide organizational structure and help organize tours on the commercial cranberry farms.
- About Harvest: A for profit social enterprise using media in formats dedicated to informing, educating and celebrating agricultural history, development, and food (http://aboutharvest.com/about/).
- Rutgers University: The PE Marucci Center is located in Chatsworth NJ and is uniquely located to provide experiential learning for the cranbassador program