

Hidden treasures: gourmet truffles in pecan orchards

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Lots of collaborators!

And many
pecan
growers..!





Hypothesis:

Gourmet truffles can be co-cultivated with pecans with low interference or additional costs to growers.

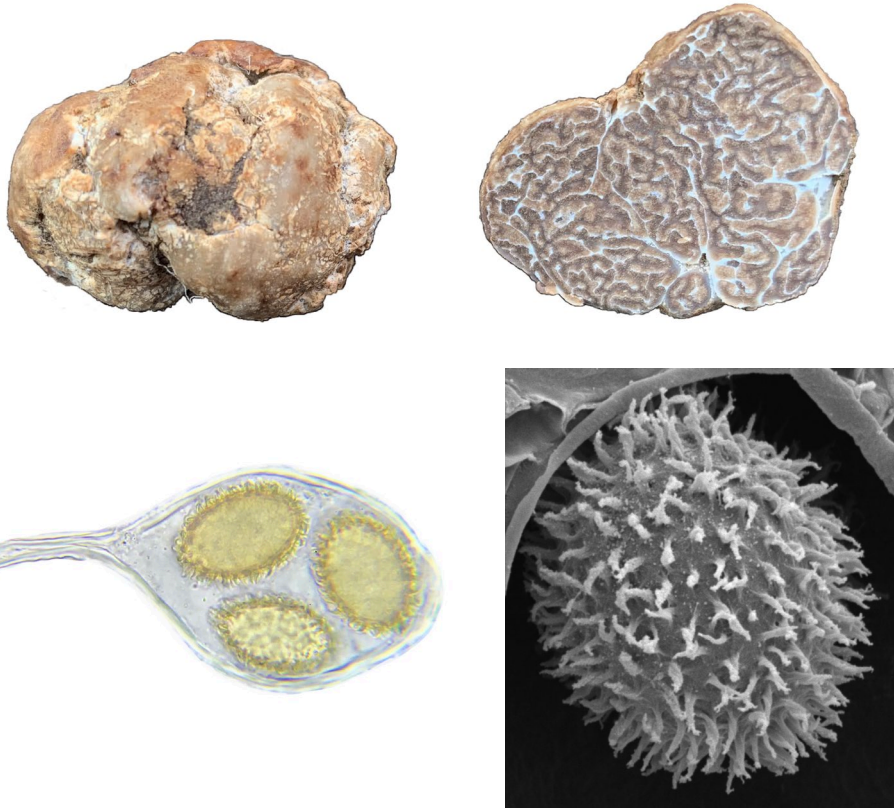
Background: What are truffles, and how can they be grown?

Setting the scene: Naturally-occurring gourmet truffles in pecan orchards

Research: Basic and applied research (past, present, future)

Get involved: We need grower involvement!

Truffles are the fruiting bodies of some fungi



Ephemeral reproductive structures, containing spores

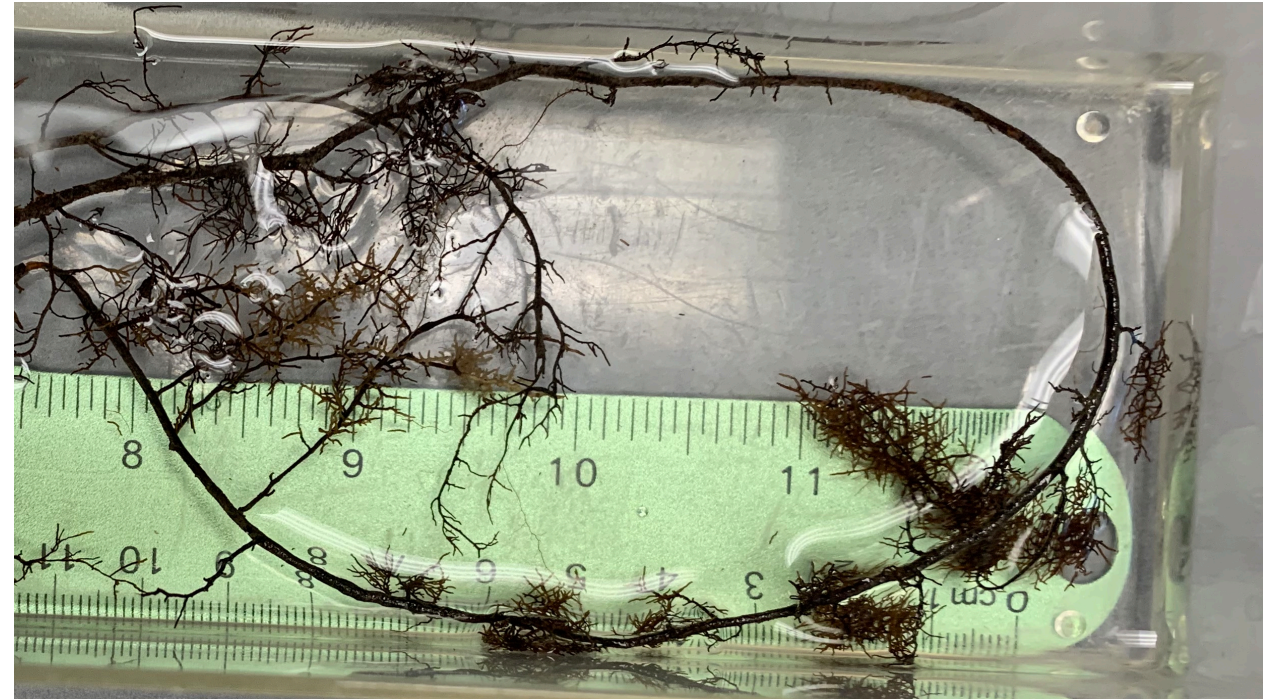


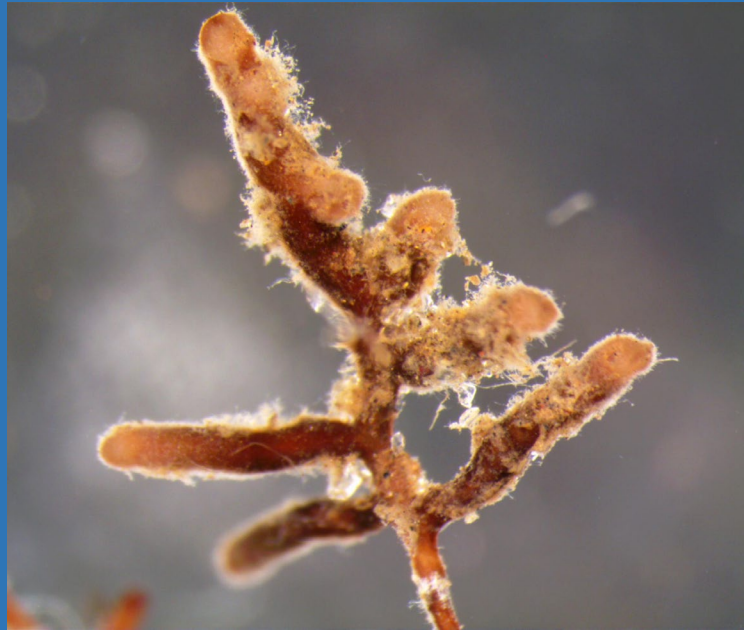
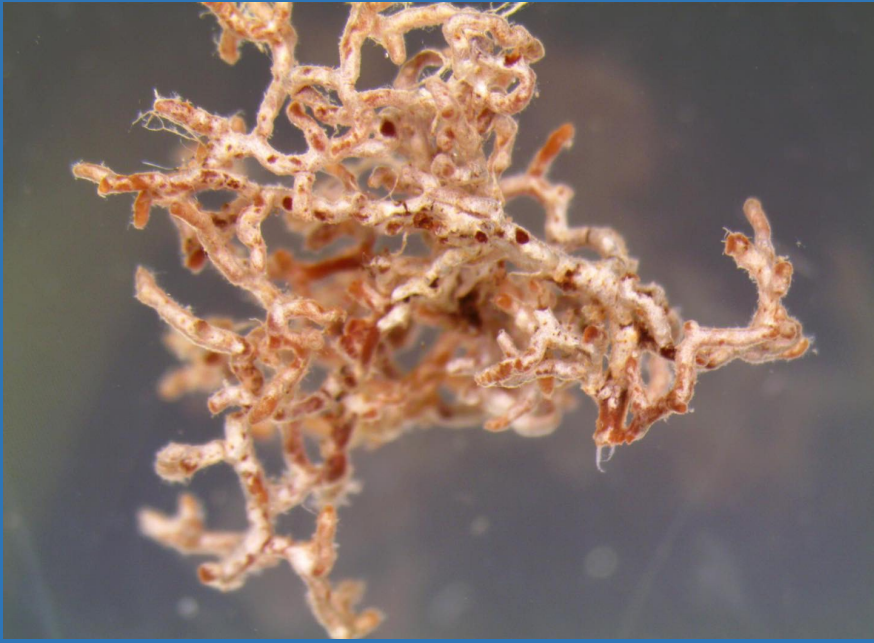
Temporary structures, produced under the right conditions by an organism

What does the truffle organism look like?

Most truffles are ectomycorrhizal (ECM) fungi

- Attached to tree roots and growing in the soil
- Exchange nutrients (N,P) with trees for carbon (sugars)
- Most tree species (**pecans!**) are **obligate hosts** of ECM fungi...
- **They cannot thrive without ECM fungi**





Ectomycorrhizal (ECM)
fungi live on root tips

Cultivating ECM fungi = cultivating this symbiosis

This is why some edible fungi are so \$\$\$



ECM symbioses are complex

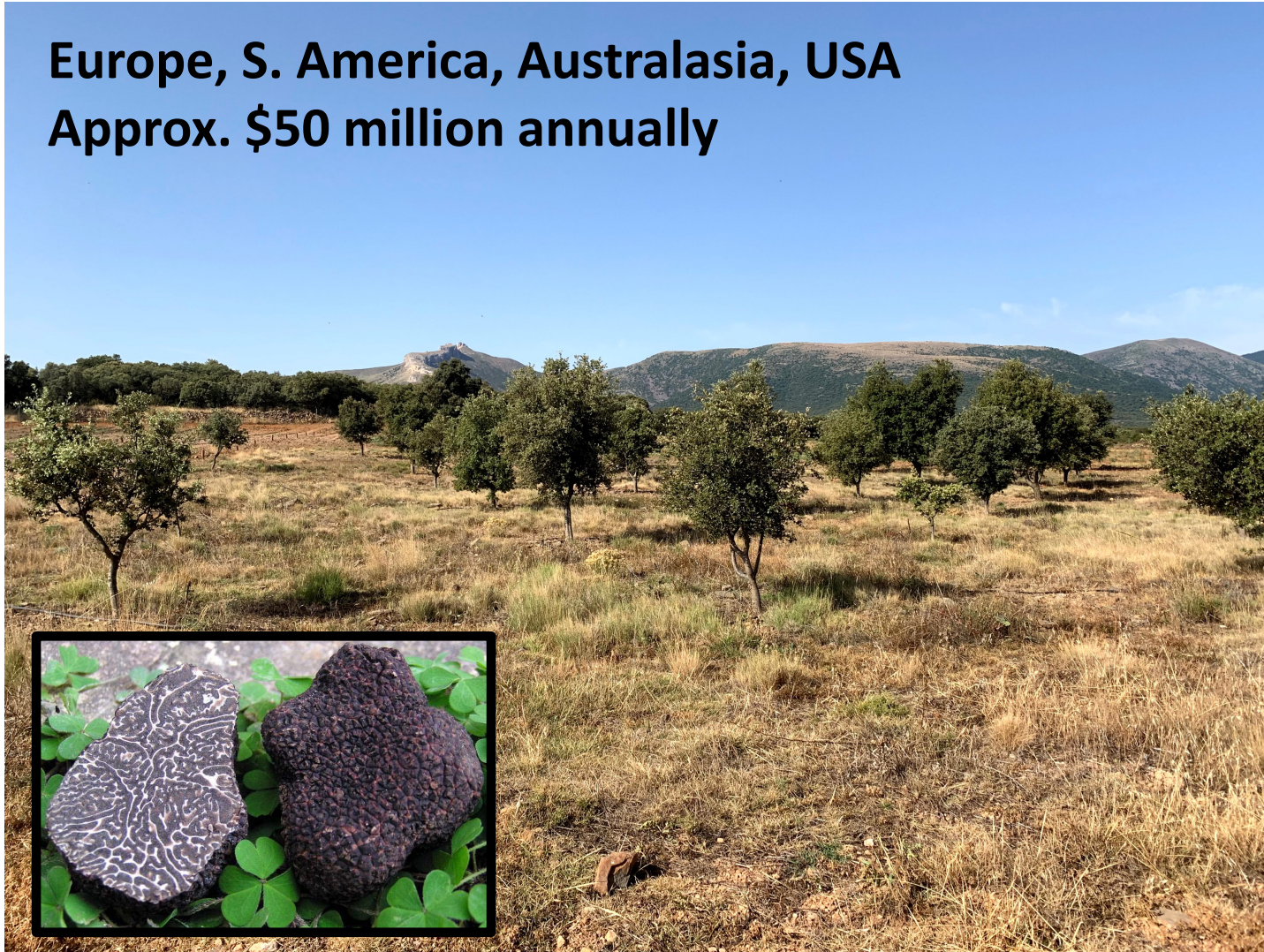
- Most cannot be cultivated
- Others take years to mature and start produce
- Constantly in flux (competition, succession, etc.)



Truffles are one of the few successfully cultivated ECM fungi

Tuber melanosporum – global cultivation success

Europe, S. America, Australasia, USA
Approx. \$50 million annually



“Model” of truffle cultivation

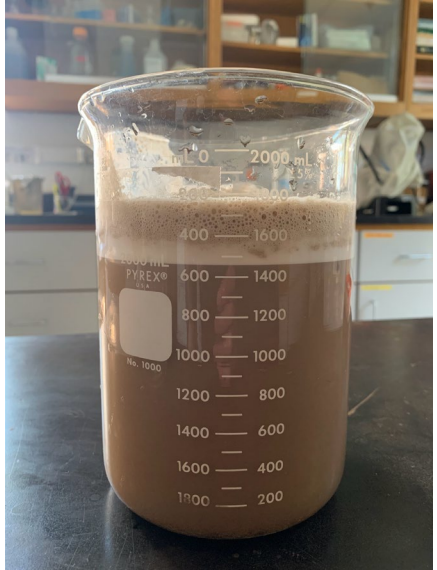
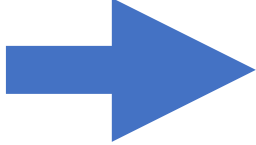


Holm Oak (*Quercus ilex*) – hardy Mediterranean oak species

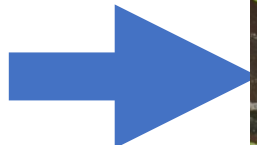
How to grow truffles 101!



Inoculum



Spore slurry

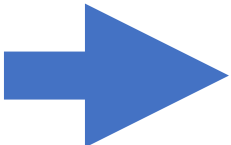
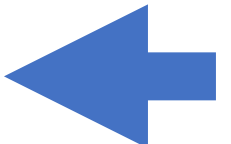


Greenhouse

Transplant

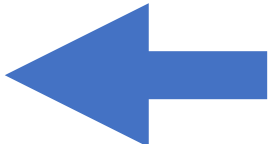


Time! (>7-10 yrs... more?)



Management

- Irrigation
- Raise pH
- weed control
- **Lots of ???s!**



7-10 years, what can possibly go wrong??

- Poor inoculum quality (contamination)
- Competition from other species
- Drought
- Disease



B.C.'s hazelnut crops hit hard by blight

Drought-induced decline in Mediterranean truffle harvest

[Ulf Büntgen](#), [Simon Egli](#), [J. Julio Camarero](#), [Erich M. Fischer](#), [Ulrich Stobbe](#), [Håvard Kauserud](#), [Willy Tegel](#), [Ludger Sproll](#) & [Nils C. Stenseth](#)

Global trade in truffles: \$300 million (more?)



Species	Price per lb	Harvest method
<i>Tuber magnatum</i> Italian white truffle	\$1,000–6,000	Almost all wild-harvested
<i>Tuber melanosporum</i> Périgord black truffle	\$800–3000	Almost all cultivated
<i>Tuber aestivum</i> Burgundy truffle	\$100–400	Mix of cultivation and wild harvest

Demand for North American truffles is rising...



Species	Region	Price
<i>Leucangium carthusianum</i> Oregon black truffle	Pacific Northwest USA/Canada	\$400–800/lb
<i>Tuber canaliculatum</i> Appalachian truffle	Eastern and Midwest USA	\$400–800/lb
<i>Tuber lyonii (sensu lato)</i> Pecan truffle	Southeastern USA (primarily) Also: N. Mexico, Midwest, Northeastern USA	\$400–650/lb

Travel back in time....



Discovery of the “pecan truffle” – 1980s/1990s

The Occurrence of *Tuber texense* in Georgia

Authors:

Richard T. Hanlin and Mei-Lee Wu
Department of Plant Pathology, University of Georgia
Athens, GA 30602

Timothy B. Brenneman
Department of Plant Pathology, Coastal Plain Experiment Station
Tifton, GA 31793

MYCOTAXON

Volume LX, pp. 365-372

October-December 1996

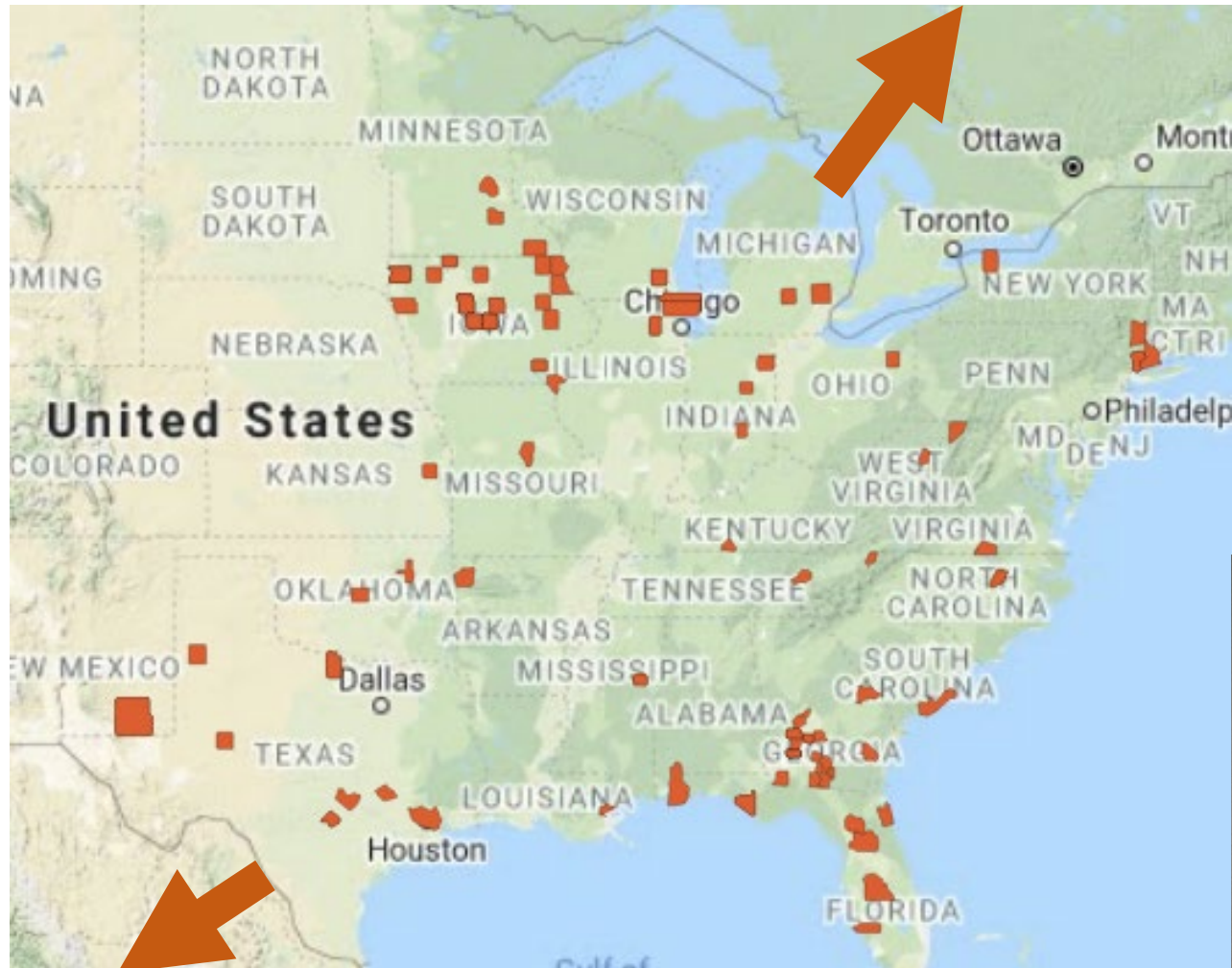
**NATS TRUFFLE AND TRUFFLE-LIKE FUNGI 5: *TUBER LYONII*
(= *T. TEXENSE*), WITH A KEY TO THE SPINY-SPORED *TUBER*
SPECIES GROUPS**

JAMES M. TRAPPE, ARI M. JUMPPONEN AND EFRÉN CÁZARES

Early days: Academic study... not yet commercial...

Set the stage for this research

The Pecan Truffle today: *Tuber lyonii* (*sensu lato*)



- Several species (= *s.l.*)
- Widespread
- Locally abundant in some pecan orchards
- Common ECM fungus on pecans and oaks
- High quality = \$400-650/lb

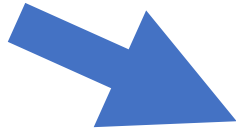




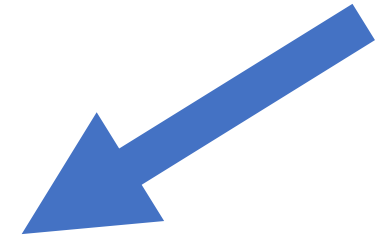
Now regarded as an excellent gourmet truffle! (Quality is key)

What do you mean, quality?

**Immature, no spores
= WEAK ODOR**



**Mature, spores
developed
= STRONG ODOR**



Quality through improvements in harvest technology



Rakes: Mixed quality and lots of time



Leaf Blower?: Mixed quality, less time



Dog: High quality, very fast

But why are pecan orchards a good habitat?

Plant Soil (2017) 418:493–505
DOI 10.1007/s11104-017-3312-z



REGULAR ARTICLE

Soil pH and mineral nutrients strongly influence truffles and other ectomycorrhizal fungi associated with commercial pecans (*Carya illinoensis*)

Zai-Wei Ge  · Timothy Brenneman · Gregory Bonito · Matthew E. Smith



Higher pH (liming)



Removing litter after harvest
(Low organic matter)

- Disturbance
- No plant competition

Can you grow truffles on pecan trees?



=



?

>>> Has led to basic and applied research ...

Q1: Can you inoculate pecans with truffles?

- Mimicking “traditional” truffle-growing approach
- Product is the **symbiosis**
- Tested *Tuber lyonii*, but also: *T. borchii*, *T. aestivum*, *T. indicum*, and *T. macrosporum*

A: YES! Many kinds!



The Asian black truffle *Tuber indicum* can form ectomycorrhizas with North American host plants and complete its life cycle in non-native soils

Gregory BONITO^{a,*}, James M. TRAPPE^b, Sylvia DONOVAN^c, Rytas VILGALYS^a

^aDepartment of Biology, Duke University, Durham, NC 27708 0338, USA

^bDepartment of Forest Ecosystems and Society, Oregon State University, Corvallis, OR 97331 5752, USA

^cNorth American Truffling Society, PO Box 296, Corvallis, OR 97339, USA

Bonito et al. 2010

Mycorrhization of Pecan trees (*Carya illinoensis*) with commercial truffle species: *Tuber aestivum* Vittad. and *Tuber borchii* Vittad

Gian Maria Niccolò Benucci • Gregory Bonito •
Leonardo Baciarelli Falini • Mattia Bencivenga

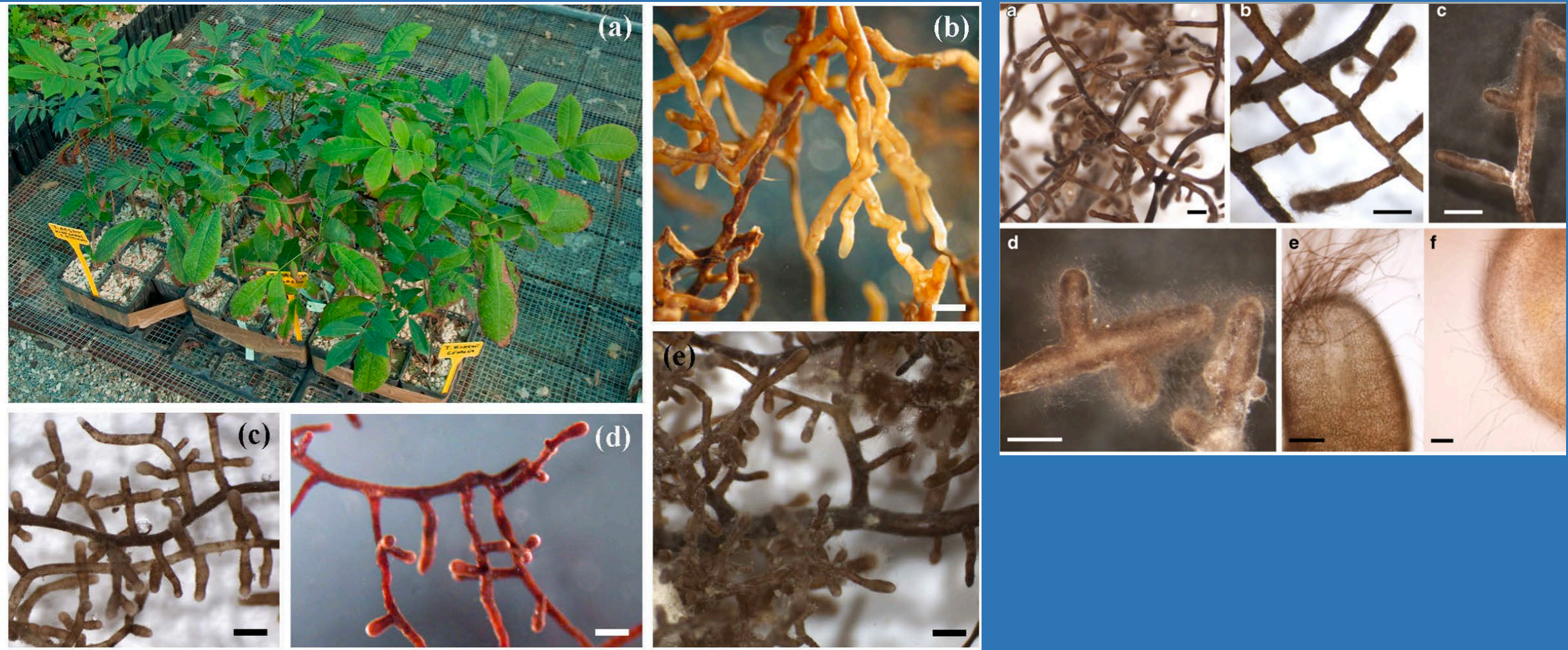
Benucci et al. 2012

Mycorrhizal inoculation of pecan seedlings with some marketable truffles

GIAN MARIA NICCOLÒ BENUCCI¹, GREGORY BONITO², LEONARDO BACIARELLI
FALINI¹, MATTIA BENCIVENGA¹ and DOMIZIA DONNINI¹

Benucci et al. 2010

***Tuber lyonii*, *T. borchii*, *T. aestivum*, *T. indicum* 40-60% colonization in 6 mos**



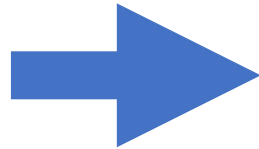
Takeaway: Pecans can be inoculated with truffles through ‘traditional’ methods

Q2: What impact does soil fumigation and inoculation dose have on colonization?

- How would inoculation of pecans look in 'real world'?
- Is inoculation compatible with pecan nurseries?
- Unique to pecans – NOT 'traditional'



**Less control...
But less cost**



Could it work?



Q: Could it work?

- Tested fumigation + inoculation treatments (separately, combined, and controls)
- Tested varying levels of inoculum
- 3 orchards in GA
- 5-year experiment: 2013 – 2018

Effects of Field Fumigation and Inoculation With the Pecan Truffle (*Tuber lyonii*) on the Fungal Community of Pecan (*Carya illinoensis*) Seedlings Over 5 Years

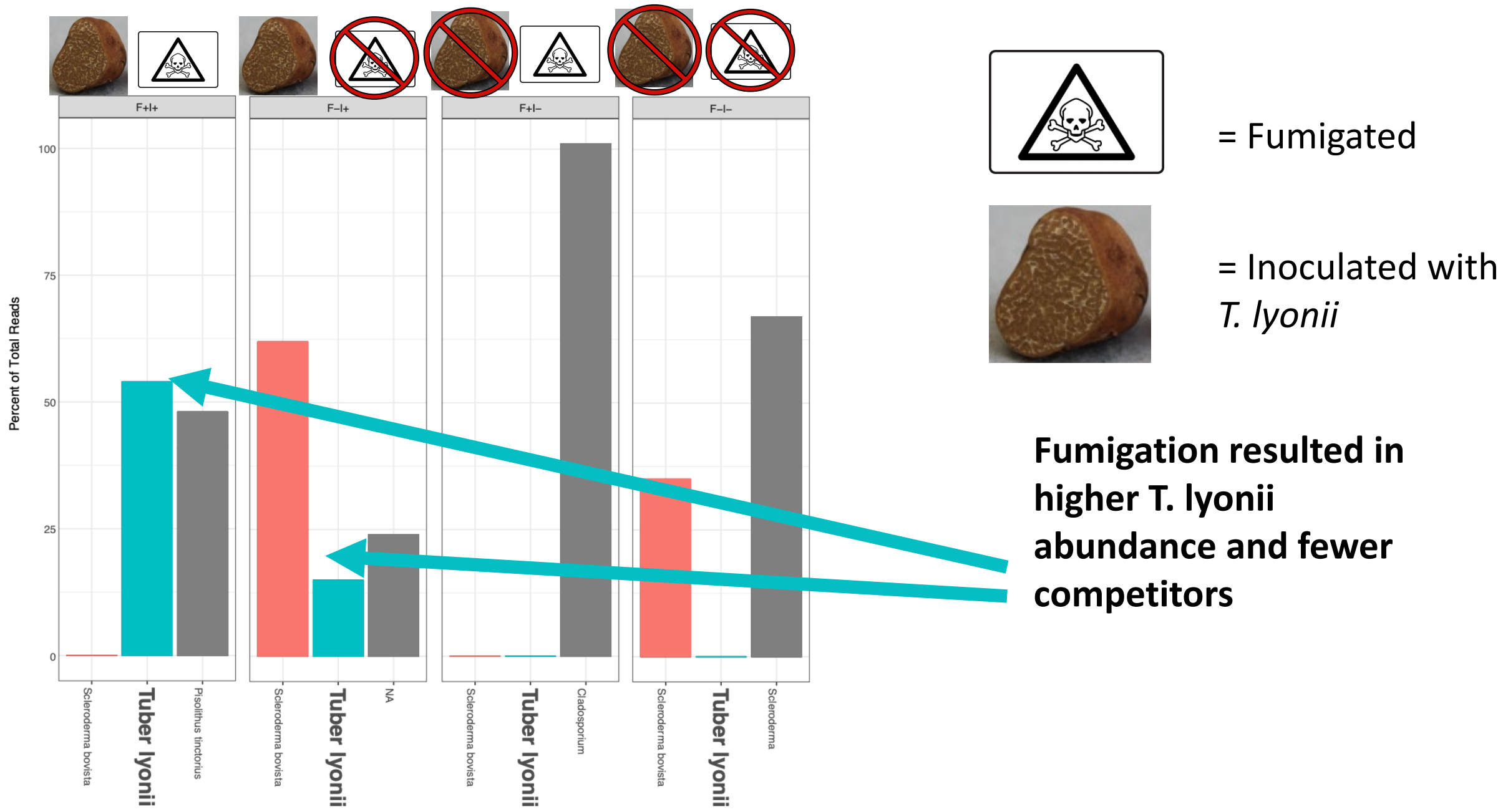
Arthur C. Grupe II¹, Michelle A. Jusino^{1,2}, Alija B. Mujic^{1,3}, Brantlee Spakes-Richter¹, Gregory Bonito⁴, Tim Brenneman⁵ and Matthew E. Smith^{1}*

Grupe et al. 2021

Inoculation



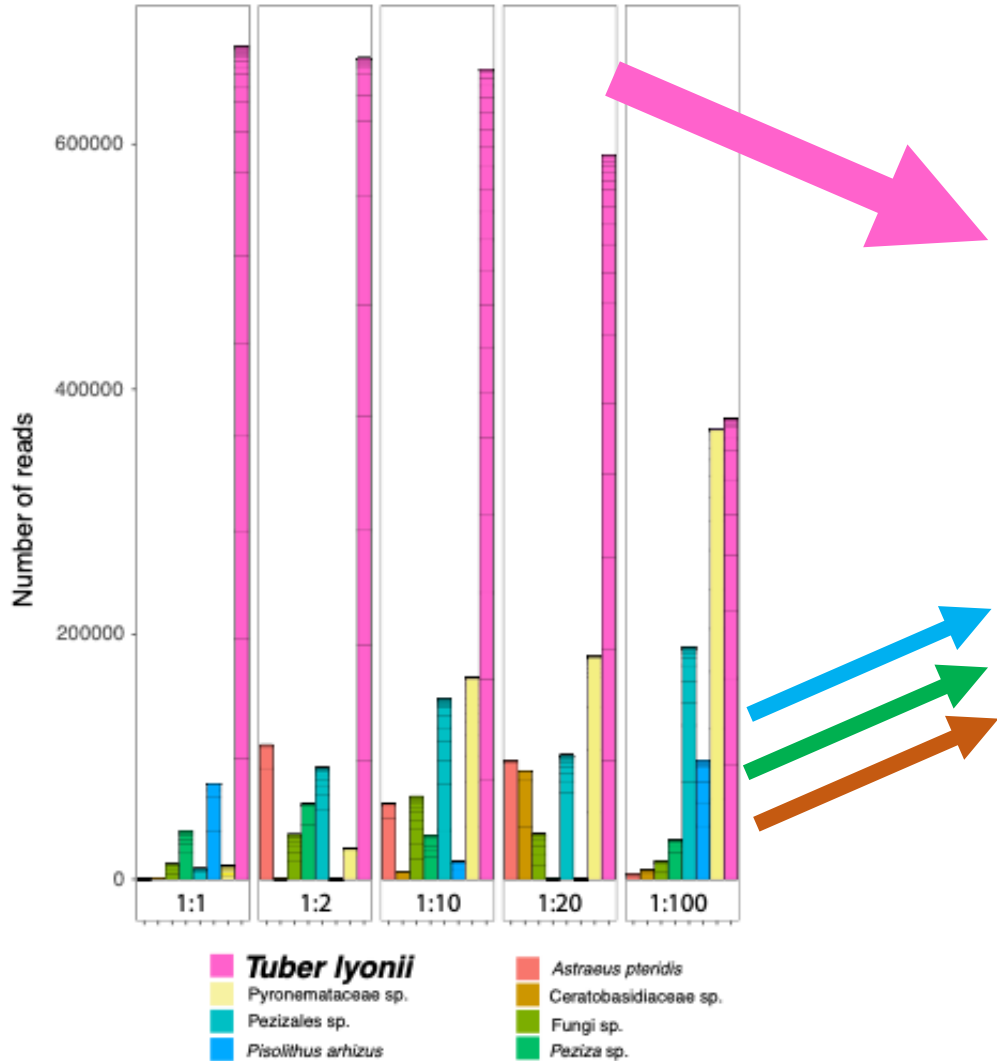
Fumigation & inoculation Experiments (Year 3)



Grams of *Tuber lyonii*



1g	0.5g	0.1g	0.05g	0.01g
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Q: How much inoculum (\$\$) do you need?

- Less truffle = more competitors
- Low doses still provided good colonization

A: Not as much as we thought! (0.5g?)

Q: Are there management conflicts between pecans and truffles?

- New experiment: Test impacts of phosphite fungicide application on *T. lyonii* colonization
- 0x, 1x, 2x standard application rates of phosphites (K-phite) on inoculated seedlings
- Other work: Reproductive dynamics of *T. lyonii*



To summarize

- YES you can inoculate pecans with truffles (all kinds!)
- Fumigation+Inoculation in open-air settings = good colonization
- Potential for management conflicts? Unknown
- More study!



Travel FORWARDS in time....



The dream!



- Inoculation, outplanting, track outcomes
- Multiple *Tuber* species
- Different management approaches – irrigation duration/intensity
- Correlate management and productivity – even for ‘accidental’ truffles

You can help!

Do you have truffles in your orchard?



We Want Your Specimens!

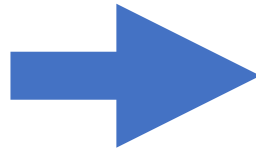
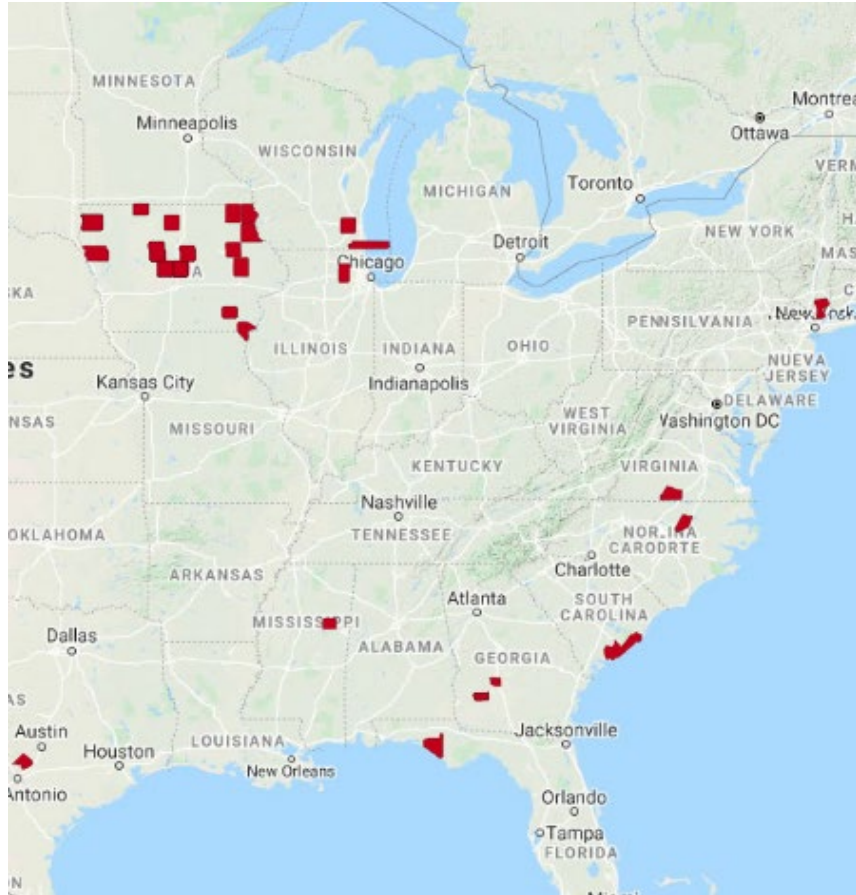
blemmond@ufl.edu

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Your specimens impact our science!

2012



2019



Thank you!

*Big thanks to all collaborators,
pecan growers, and contributors!*



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Department of Plant Pathology

