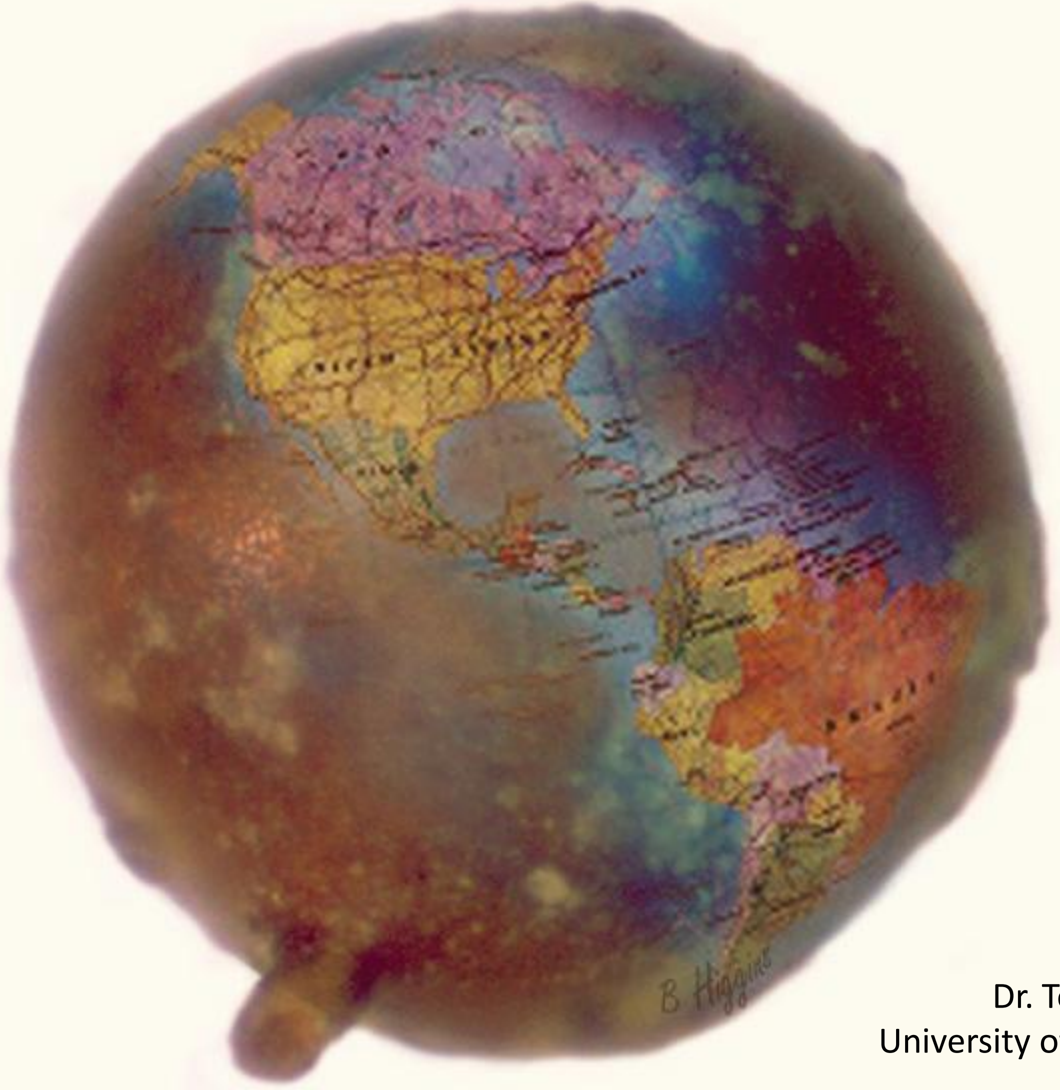
Recovery Plan for

Root-knot and Cyst Nematodes

Parasites of Agronomic and Horticultural Plants throughout North America



Dr. Tom Powers
University of Nebraska-Lincoln

Number of Species Worldwide :

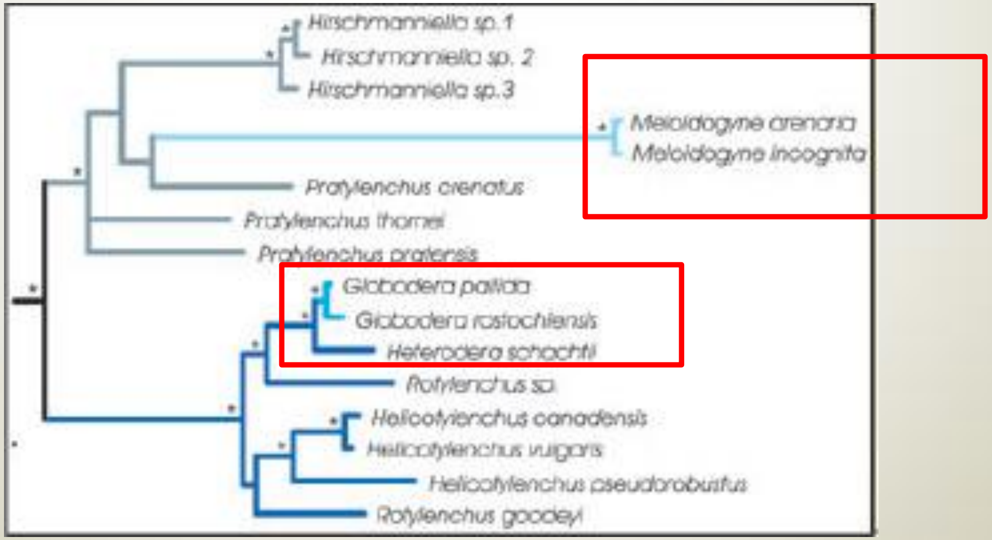
Root-knot Nematodes: ~100

Meloidogyne- 44 species in GenBank

Cyst Nematodes: ~100

Heterodera- 48 species in GenBank
Globodera- 10 species “ “

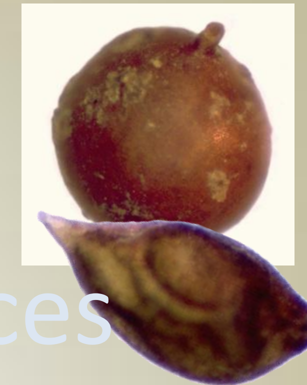
Evolutionary divergence- from early Cenozoic?



Holterman *et al*., 2006

Similarities and Differences

between Root-knot Nematodes and Cyst Nematodes



Similarities

Large females

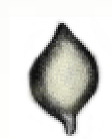
Cannot migrate very far under their own power

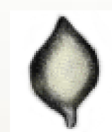
Must establish feeding sites within the plant root

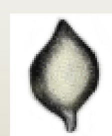
Subject to many antagonistic and predatory organisms in the soil pore space (“suppressive soil”)

Include both males and females (although many *Meloidogyne* species are parthenogenetic)









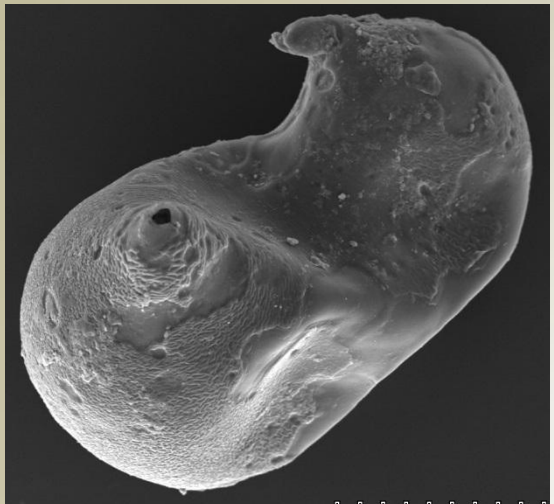

Differences

Eggs
RKN- deposited in the soil
Cyst- encased in the cyst

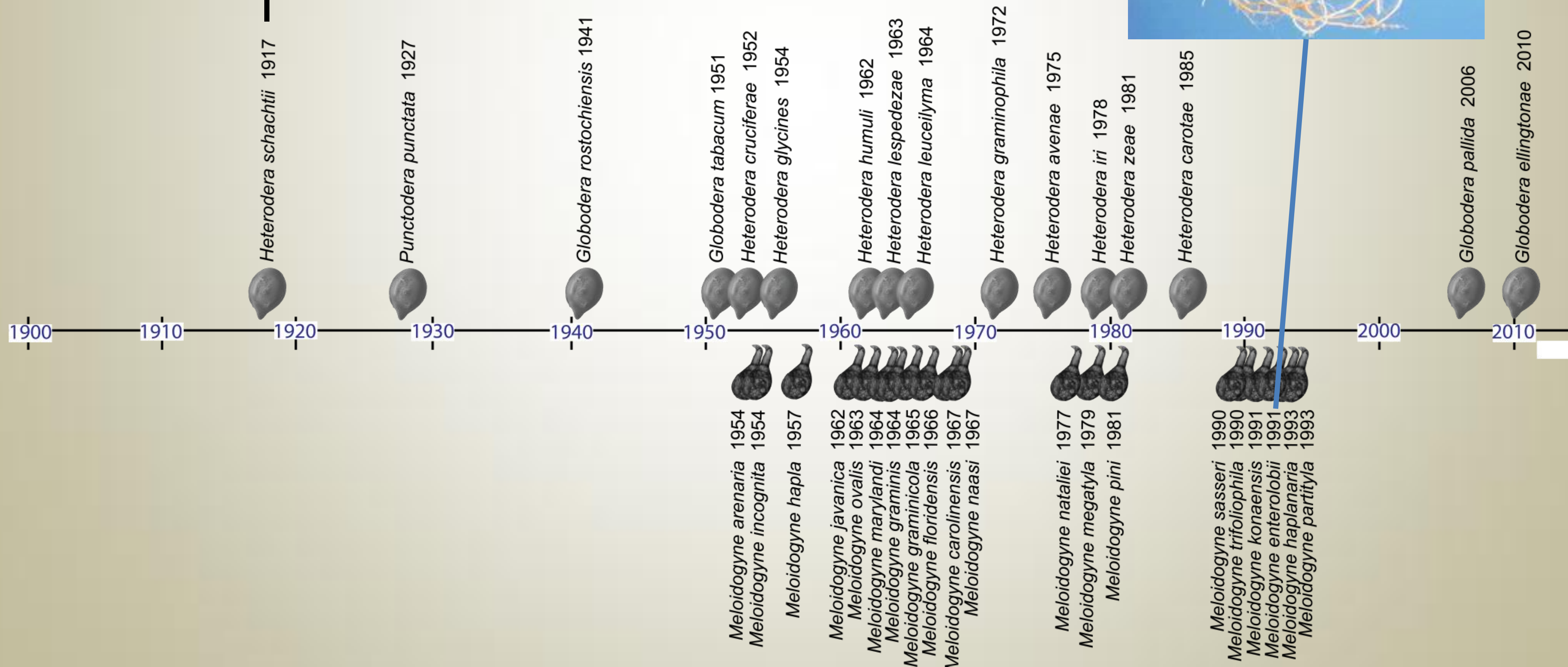
Hatch
RKN- readily hatch in the soil
Cyst- require presence of hatch-inducing chemicals

Survival
RKN- no specialized structures
Cyst- highly resistant casing

Host range
RKN- wide (400+) host range
Cyst- limited host range (ie: *H. carotae* exists only on carrot)

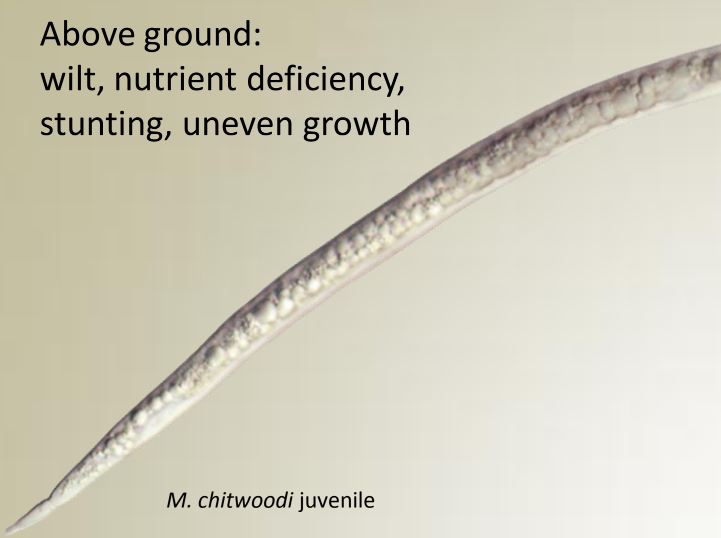


Timeline of first Record in the U.S.



Symptoms
Root-knot Nematode

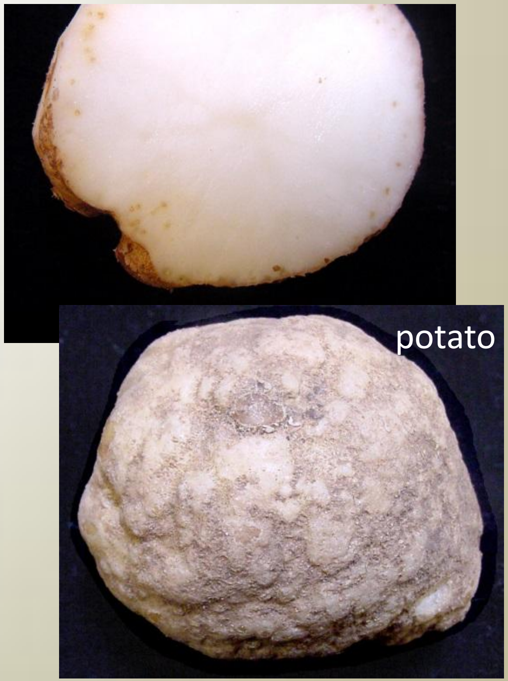
Above ground:
wilt, nutrient deficiency,
stunting, uneven growth



M. chitwoodi juvenile

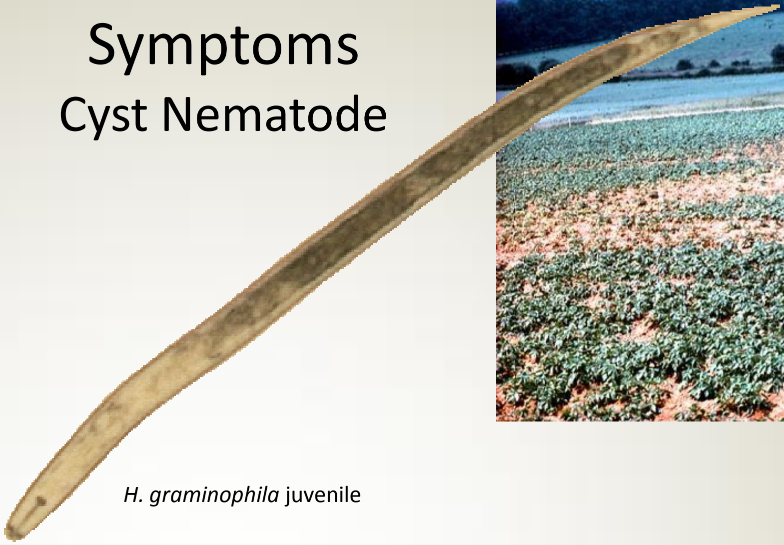
Below ground:
galls, egg masses

Tomato roots:
RKN galls (left)   healthy (right)



Above ground:
wilt, nutrient deficiency, stunting, uneven growth

Symptoms
Cyst Nematode



H. graminophila juvenile

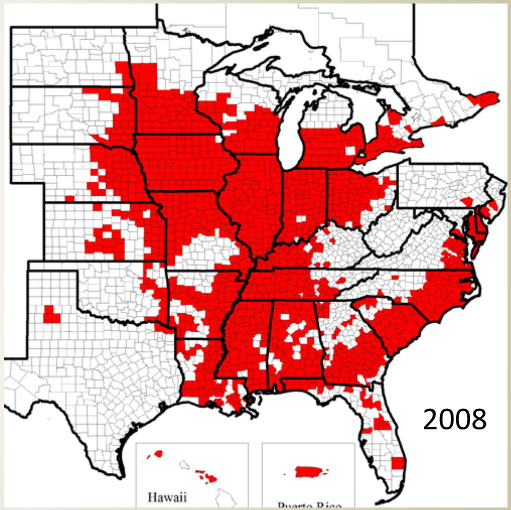
Below ground:
cysts

Historical Case Studies

Golden Potato Cyst Nematode *G. rostochiensis* (New York)

- Post WWI on military equipment
- NY 1934 observation
- State/Federal quarantines
- Quarantine success story

Mitigation point #1. There generally exists a significant lag-time between nematode introduction and nematode detection.



2008

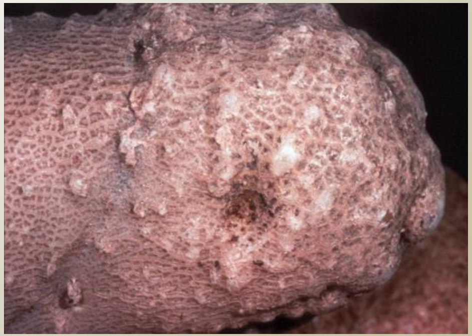
Soybean Cyst Nematode *H. glycines* (Eastern and Central U.S.)

- NC 1954 observation
- Turn of century importing of Asian soil
- East of Rockies distribution

Mitigation point #2. Once established, it is extremely difficult to prevent further spread of plant-parasitic nematodes.

Columbia Root-knot Nematode *M. chitwoodi* (Western U.S.)

- 1981 Washington state
- Asymptomatic infected seed pieces



Mitigation point #3. Endoparasitism and asymptomatic infections by root-knot nematodes emphasize the need for soil surveys to detect infective juvenile stages.

Newly Emergent Case Studies

Cyst nematodes on potato *G. pallida* and *G. ellingtonae* (Idaho and Oregon)

- 2006- Immediately closed markets in Canada, Mexico, Korea, Japan
- To date 17 infected fields, 2015 acres
- Discovered as part of a CAPS survey, in a non-standard tare sample
- *G. ellingtonae* status?

Mitigation point #4. Eradication, if possible, will require an expensive, highly regulated, large-scale operation that will include multiyear applications of general biocides.

Meloidogyne enterolobii (syn. *M. mayaguensis*) (Atlantic coast)

- Discovered in 1991 through reproduction on Mi gene
- Cryptic species, highly aggressive
- Reproduces on nematode resistant germplasm

Mitigation point #5. The next major nematode pest may emerge from populations already resident in the U.S.

M. enterolobii on gardenia

Poll Results of Professional Nematologists with field experience (43 Respondents of 56 contacted)

Question #1. Do you think it is likely that within 5-10 years, novel species or races of nematodes will be encountered in the U.S. that are capable of causing economic damage to our agricultural or horticultural crops?

- 100% of respondents felt it was likely or highly likely or inevitable that U.S. agriculture will be confronted with new economically damaging nematodes.
- Over 50% of respondents expressed the opinion that the development of new races or pathotypes, or the redistribution of species currently in the U.S. was of equal concern to exotic introduction.

Question #2. If a new potentially damaging species is introduced, do you think we have the knowledge, infrastructure, and resources to limit its damage?

- Several respondents identified the rapid and comprehensive actions be APHIS following the 2006 discovery of *G. pallida* in Idaho, as a model for addressing a potentially destructive nematode species.
- States that lack a trained field nematologist will impair early detection and management efforts.
- Lack of training opportunities

Question #3. In managing the existing pest nematode species in the U.S., would you say we are winning the battle, staying even, or losing the battle?

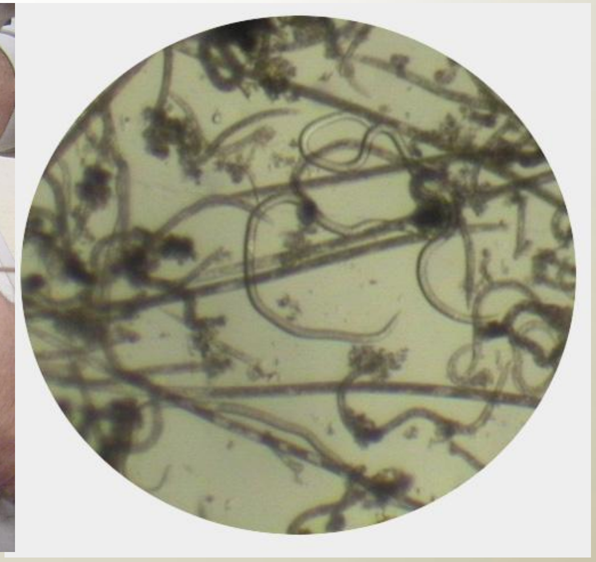
- 18 Respondents thought we are losing the battle
- 19 Respondents said we are staying even
- General frustration with post-nematicide era management options

Recovery Plan Realities

1. Recent history clearly indicates that new species will be introduced into the U.S.
2. It is highly likely that new species or genotypes already exist in the U.S. presently undetected.
3. There will be a significant lag time between nematode introduction and detection.
4. Early detection of established infestations is critical for mitigation success.
5. Many states to not have personnel trained to act as nematode infestation "first responders."
6. Opportunities for training in nematology are decreasing.
7. USDA APHIS/PPQ has the incidence command structure to rapidly respond to new nematode detections. States do not.
8. Once a nematode species is widely established it is practically impossible to eradicate.
9. The management tools of 2013 are essentially the same as they were 50 years ago, minus the variety of chemical nematicides.
10. The current management tools have greater precision but require an increased understanding of the site-specific nematode problem.
11. Genetic resistance is available for some crops and some regions and effective against some nematode genotypes.
12. No one knows how climate change will affect future nematode management.

Detection, surveys and identification - Recommendations

1. Expand the nematode survey component of the CAPS program.
2. Build reference databases to facilitate rapid identification and geographic location of species.
3. Increase taxonomic resolution of ongoing surveys to accurately record endemic species, regional diversity, host-races, and resistance-breaking genotypes.
4. Encourage the development of more SOPs for nematode identification.
5. Increase Nematology training of diagnostic “first responders.”
6. Increase resources for pest risk assessment models and establish linkages between modelers and nematologists through Multistate projects.
7. Support the generation of biological, developmental, physiological, and environmental parameters for model development and improvement of management tactics .



Management tools- Recommendations

1. Provide incentives for participants in Multistate/Regional Nematology projects to work jointly on specific integrated management approaches.
2. Just as nematode “first-responders” require training, field-savvy nematologists need to educate the next generation of nematologists to facilitate the implementation of integrated management.
3. Establish a nationwide program of field nematology internships.
4. Support broad-based approaches nematode management, if only as a backup for potential failure of “silver-bullet” solutions.
5. Use the Society of Nematologists as organizing body to facilitate recommendations.

Selected Nematology poll respondents
and sources for Nematology information

George Abawi, Cornell University

Byron Adams, Brigham Young University

Ole Becker, University of California

George Bird, Michigan State University

Janete Brito, Division of Plant Industry, Florida

Lynn Carta, USDA-ARS Beltsville, Florida

William Crow, University of Florida

Eric Davis, North Carolina State University

Donald Dickson, University of Florida

Patricia Donald, USDA-ARS Jackson, Tennessee

Jonathan Eisenbeck, Virginia Tech

Axel Elling, Washington State University

Robin Giblin-Davis, University of Florida

Howard Ferris, University of California-Davis

John Halbrendt, Penn State University

Russell Ingham, Oregon State University

Tamra Jackson-Ziems, University of Nebraska

James Kotcon, West Virginia University

Gary Lawrence, Mississippi State University

Kathy Lawrence, Auburn University

Mike McClure, University of Arizona

Michael McKenry, University of California-Riverside

Robert McSorley, University of Florida

Haddish Melakeberhan, Michigan State University

John Mueller, Clemson University

Deborah Neher, University of Vermont

James Noe, University of Georgia

Joe Noling, University of Florida

Andrew Nyczepir, USDA-ARS Byron, Georgia

Charles Overstreet, Louisiana State University

Antoon Ploeg, University of California-Riverside

Robert Robbins, University of Arkansas

Brent Sipes, University of Hawaii

James Starr, Texas A&M University

Steve Thomas, New Mexico State University

Patricia Timper, USDA-ARS Tifton, Georgia

Tim Todd, Kansas State University

Greg Tylka, Iowa State University

Inga Zasada, USDA-ARS Corvallis, Oregon