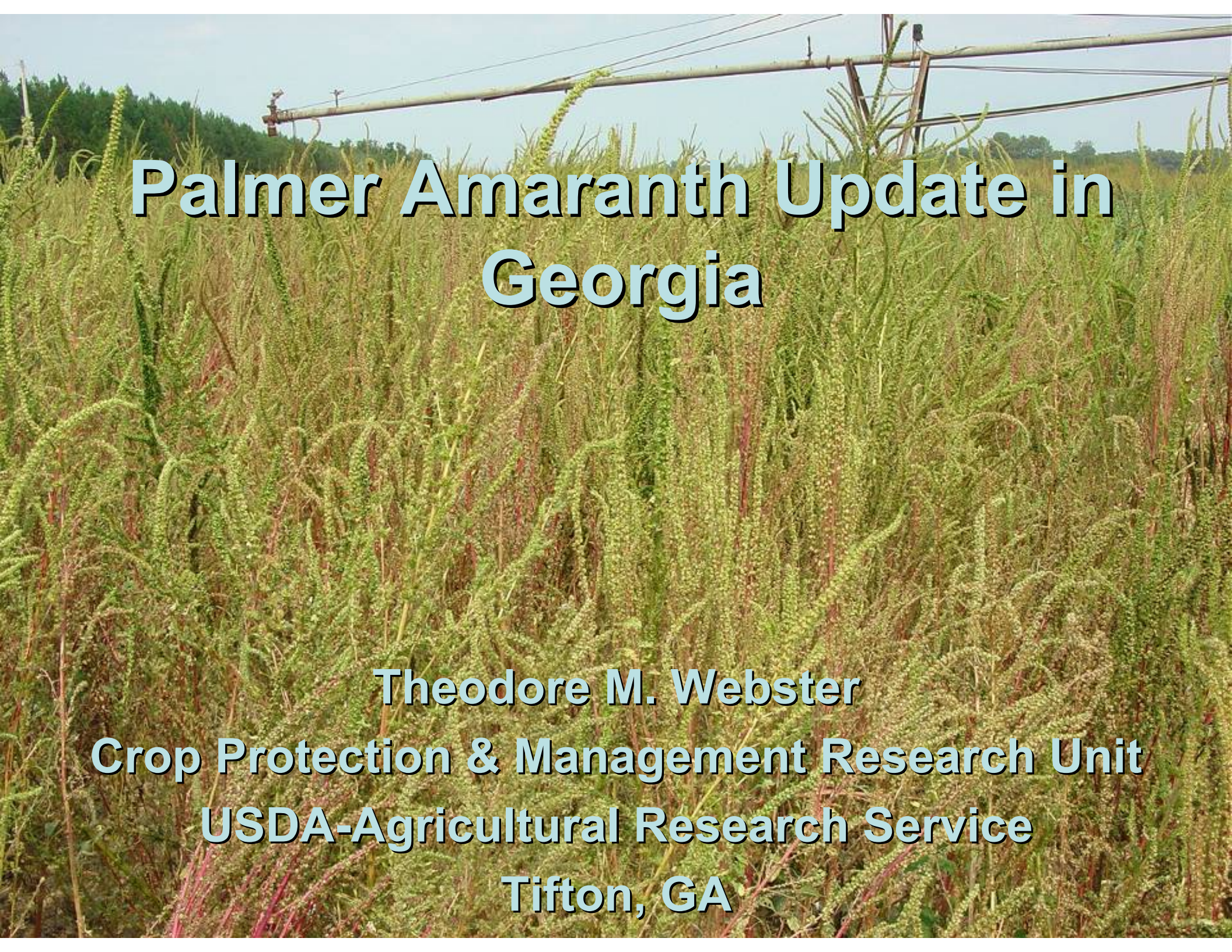
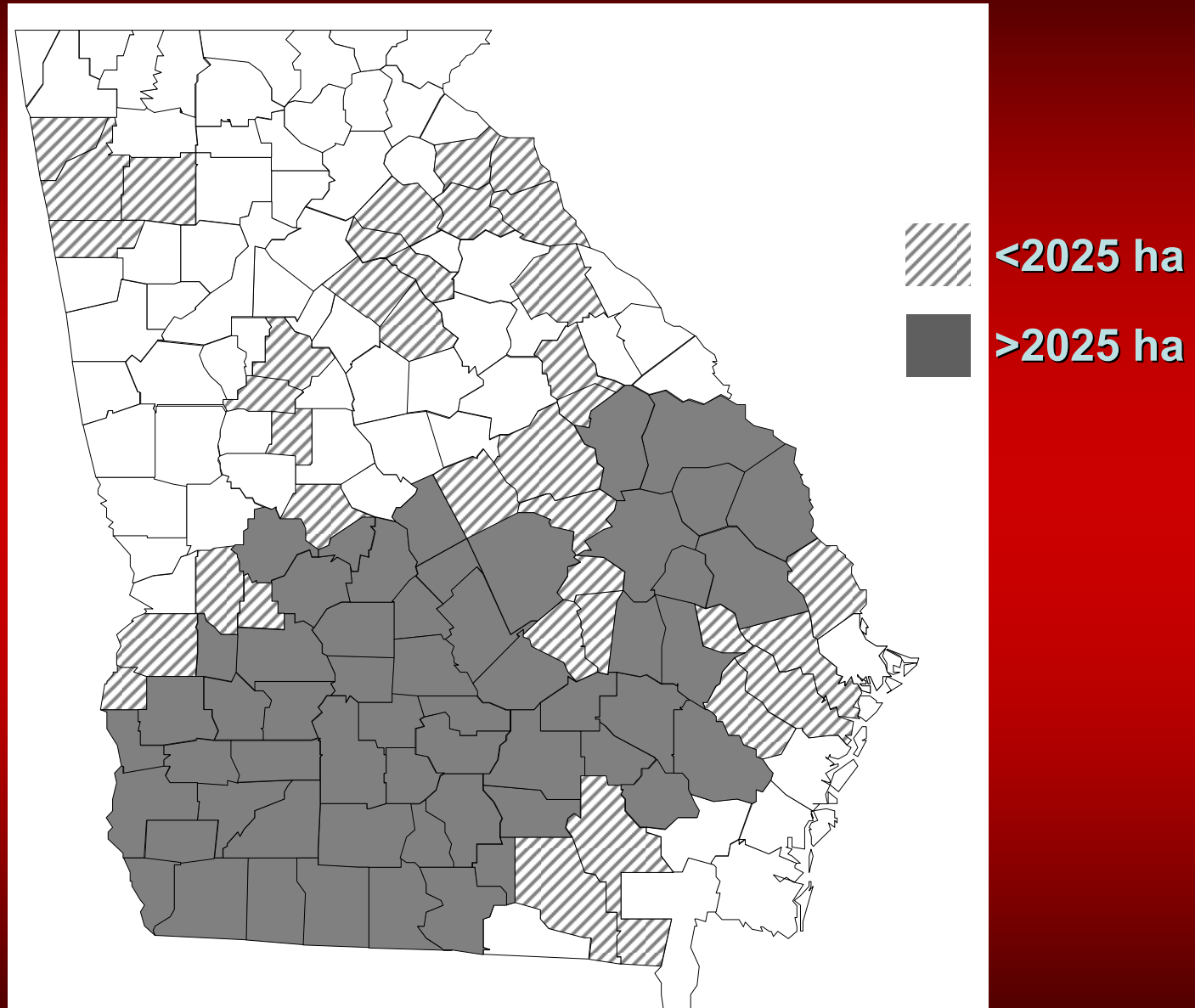




Palmer Amaranth Update in Georgia

Theodore M. Webster
Crop Protection & Management Research Unit
USDA-Agricultural Research Service
Tifton, GA

Georgia Cotton Production



Webster, USDA-ARS; Culpepper,
Sosnoskie, Grey, Vencill, UGA



**Palmer amaranth is becoming a more
common weed in Georgia cotton**

This is a grower's field in Macon County (not a test plot)



**Populations like this were observed in other fields
throughout the state**

Palmer amaranth in unusual areas



Not only is it becoming more common, but it's more troublesome too

Most Troublesome Weeds in Georgia Cotton

1995

1. Nutsedges
2. Sicklepod
3. Coffee senna
4. Texas panicum
5. Pigweeds
6. Cocklebur
7. Morningglories
8. Wild poinsettia
9. Bristly starbur
10. Bermudagrass

Dowler 1995. Proc. South. Weed
Sci. Soc. 48: 290-305

2005

1. Benghal dayflower
2. Palmer amaranth
3. *Ipomoea* morningglories
4. Florida pusley
5. Nutsedges
6. Asiatic dayflower
7. Smallflower morningglory
8. Texas millet
9. Wild poinsettia
10. Bermudagrass

Webster 2005. Proc. South. Weed
Sci. Soc. 58: 291-306

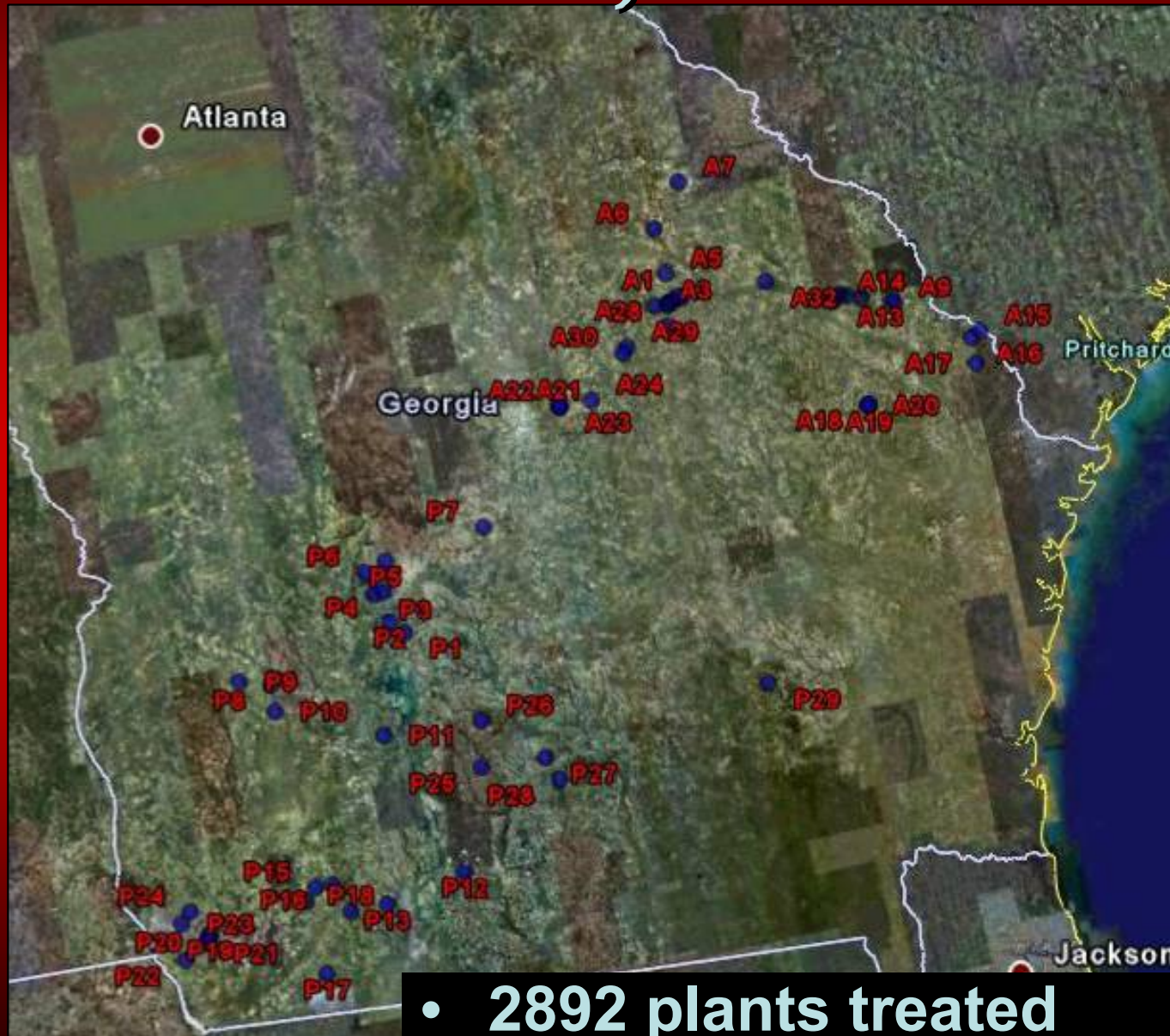
Webster, USDA-ARS; Culpepper,
Sosnoskie, Grey, Vencill, UGA

Palmer amaranth in cotton

- Other forms of herbicide resistance (DNAs and ALS inhibitors) are present in the species.
 - Possible for multiple resistance genes to become stacked, limiting control options for some growers.

2005 ALS-Resistant Pigweed Survey

61 locations, 21 counties

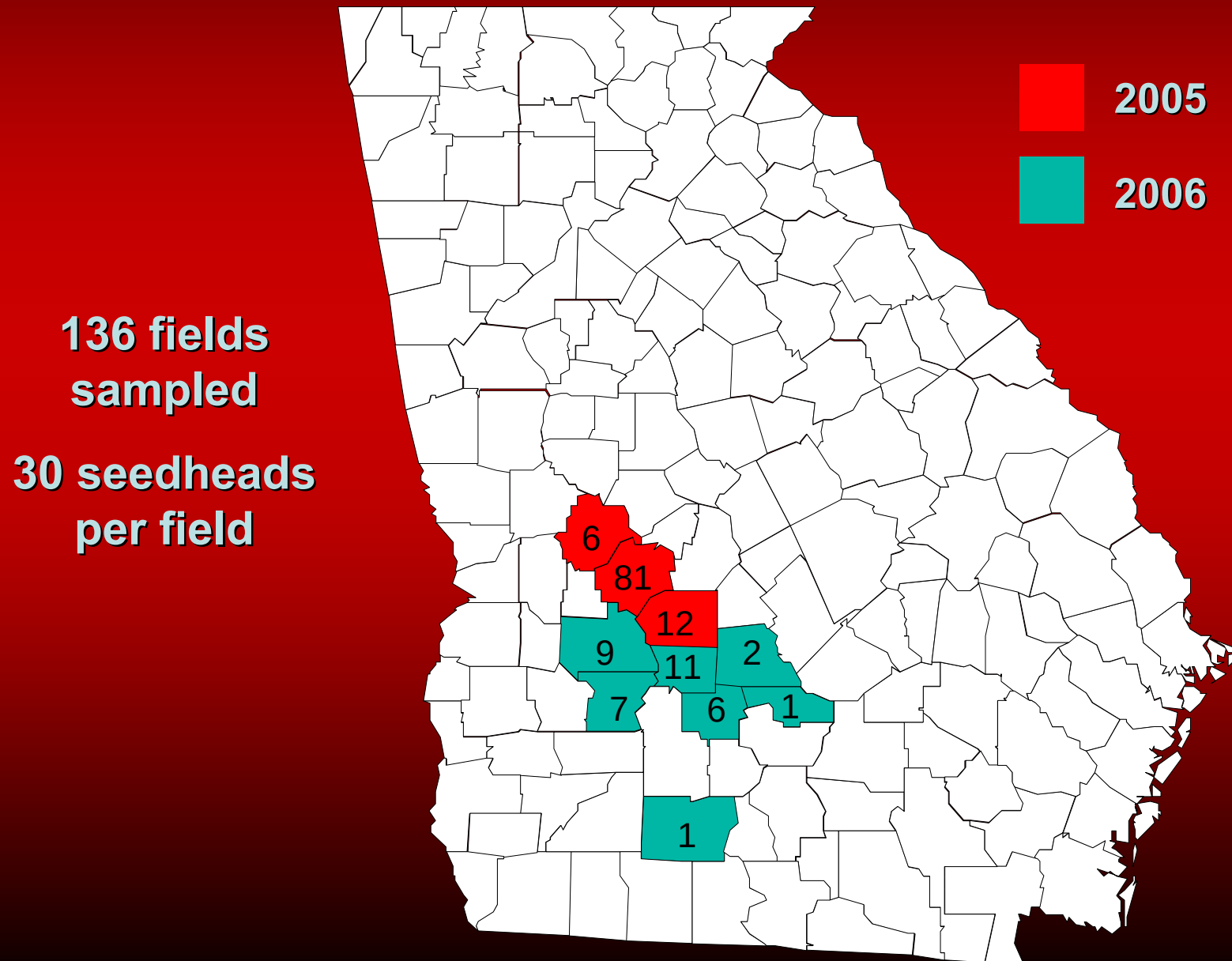


- 2892 plants treated
- 2442 plants survived (84%)

Palmer amaranth in cotton

- **Other forms of herbicide resistance (DNAs and ALS inhibitors) are present in the species.**
 - **Possible for multiple resistance genes to become stacked, limiting control options for some growers.**
- **The species is dioecious and wind pollinated.**
 - **A resistance gene may be transferred to susceptible populations via obligate out-crossing.**

Georgia counties sampled for glyphosate-resistant Palmer amaranth.

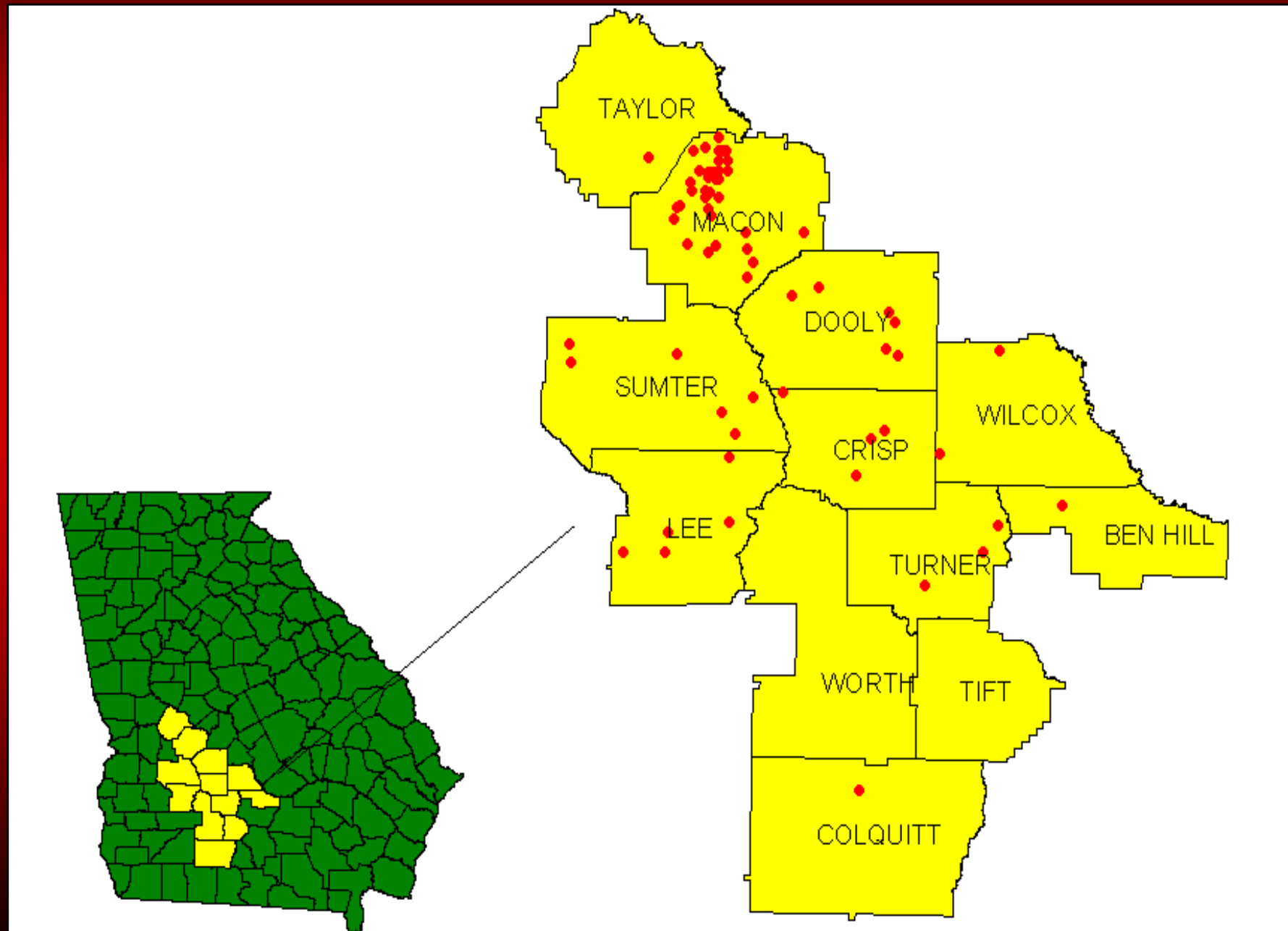


Level of Palmer amaranth resistance to glyphosate in GA

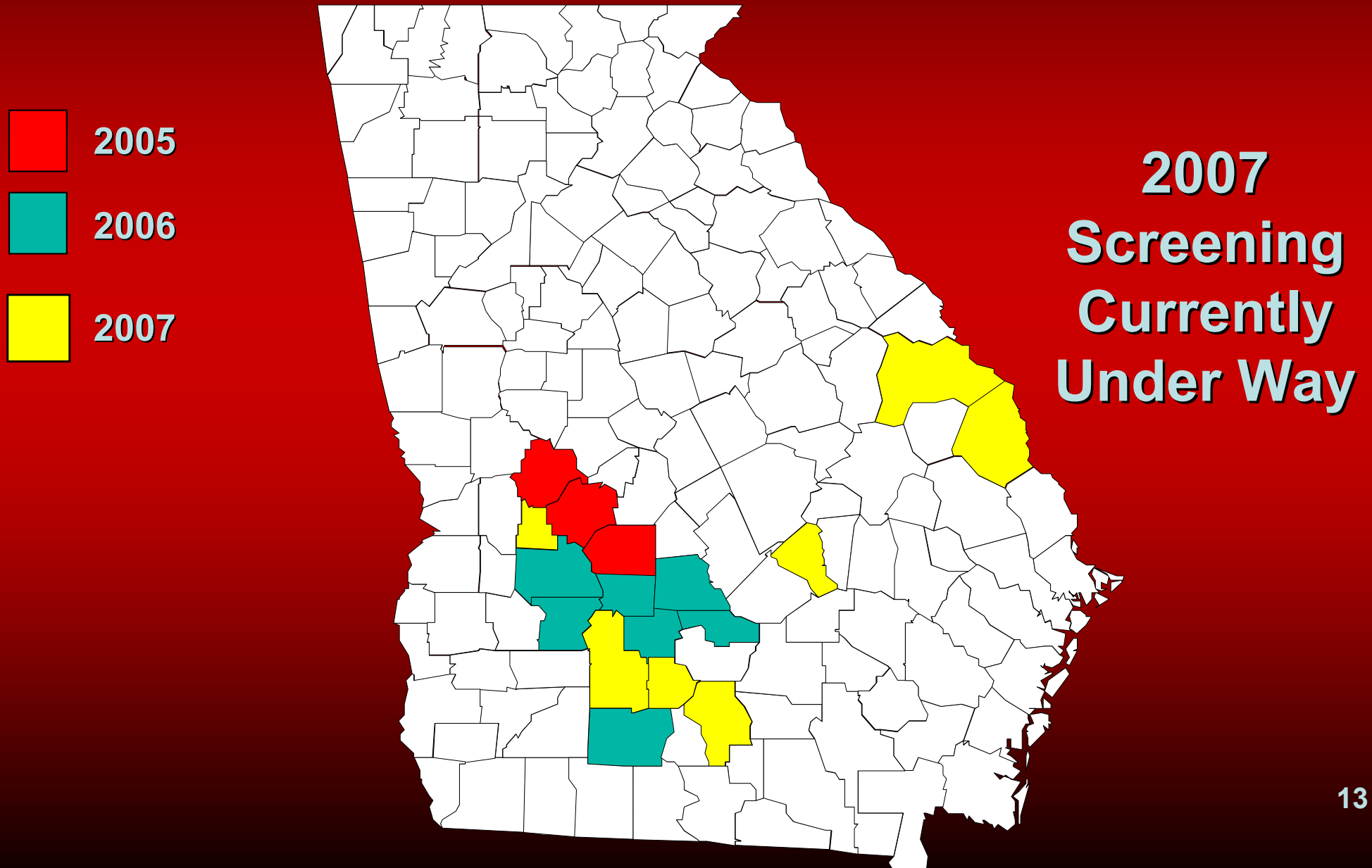
49%		High	Low	Mixed	None
2005		23	20	6	50
2006	62%	10	3	10	14

- < 50% control with 840 g ha = high level
- < 50% control with 280 g ha = low level
- Few plants poorly controlled and rest dead = mixed pop

Location of 72 fields infested with glyphosate-resistant Palmer amaranth.



Georgia counties sampled for glyphosate-resistant Palmer amaranth.



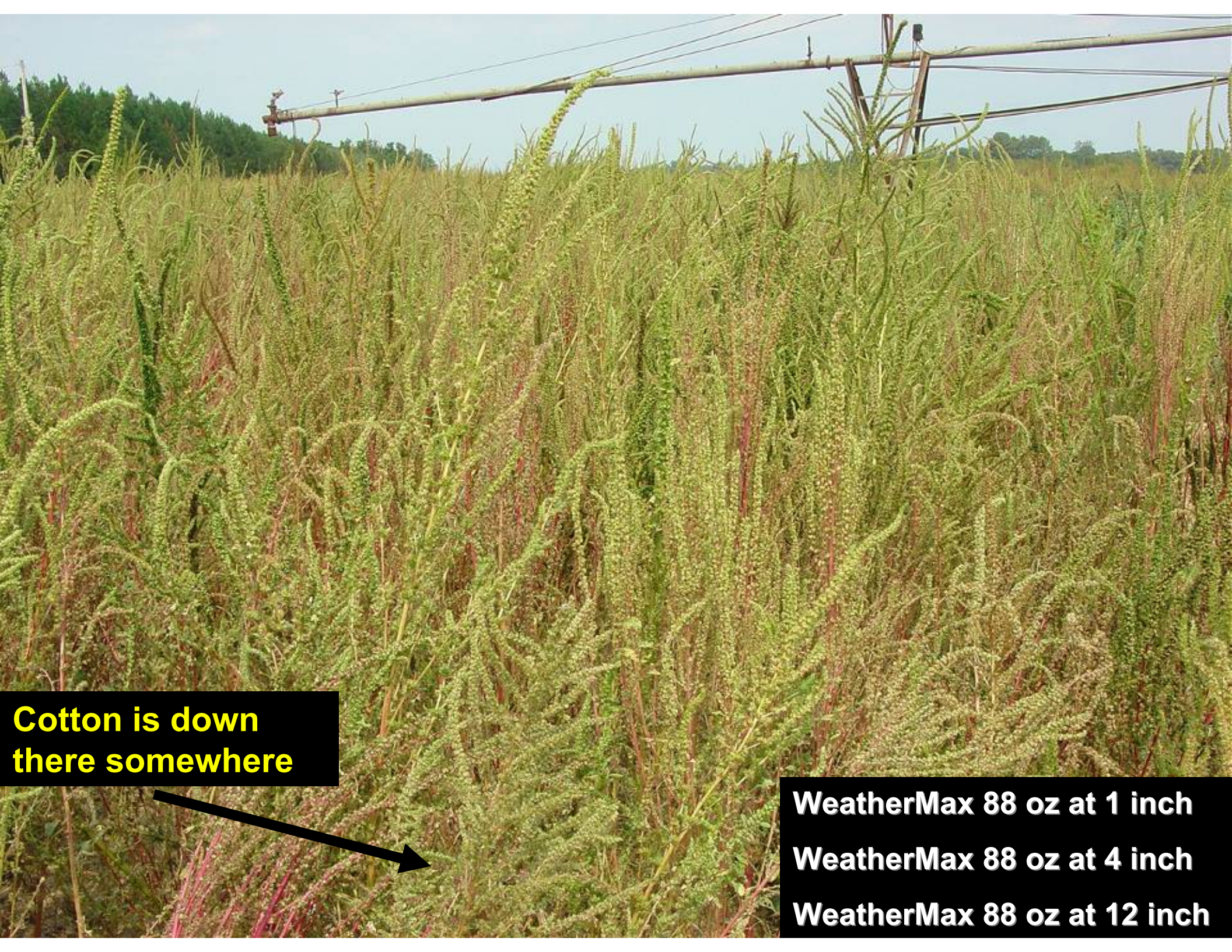
Resistant Palmer amaranth response to Glyphosate



WeatherMax 66 oz/A

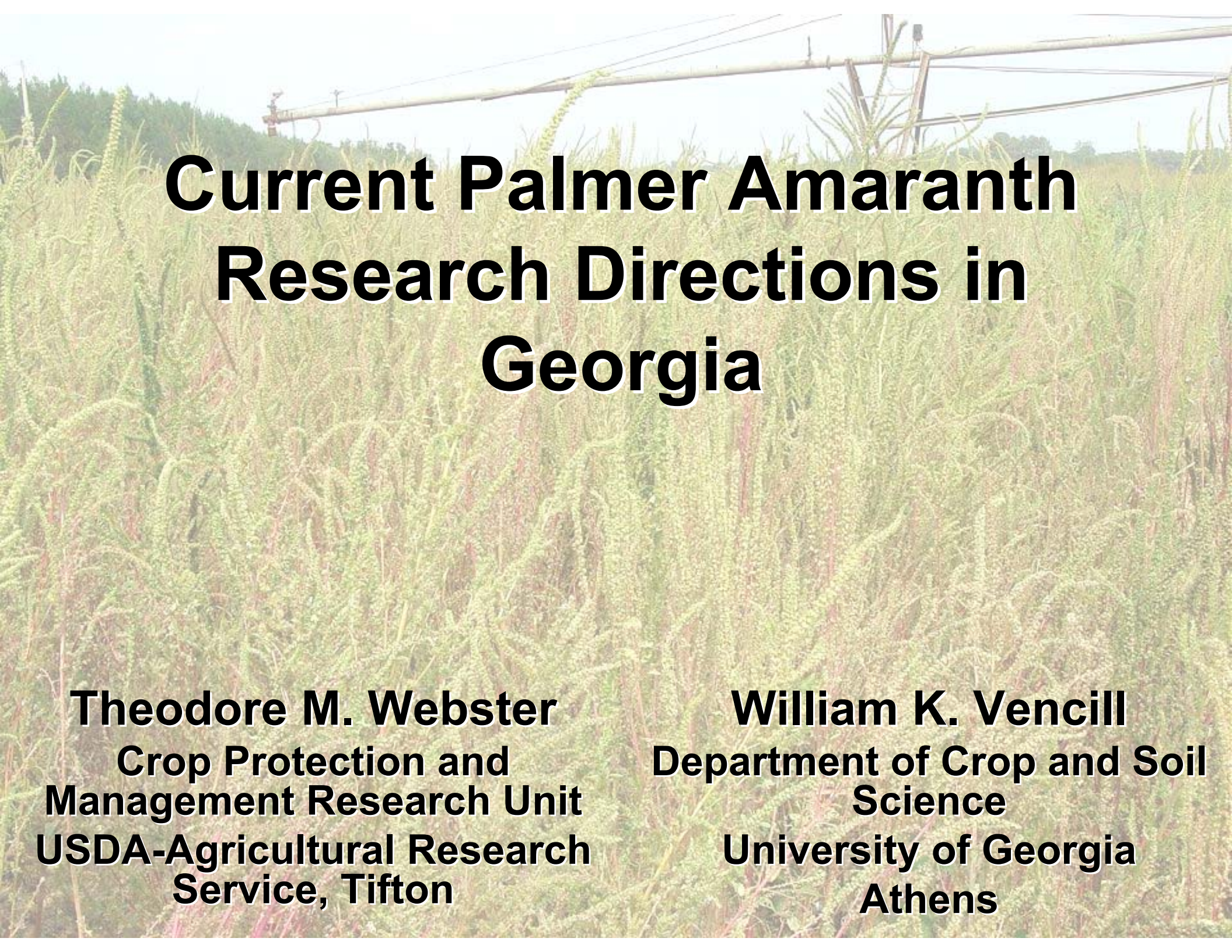


WeatherMax 264 oz/A

A photograph of a field filled with tall, dense weeds. The weeds have green, feathery foliage and reddish-brown stems. In the background, there are power lines and a clear sky. A black arrow points from the text box on the left towards the weeds.

**Cotton is down
there somewhere**

WeatherMax 88 oz at 1 inch
WeatherMax 88 oz at 4 inch
WeatherMax 88 oz at 12 inch



Current Palmer Amaranth Research Directions in Georgia

Theodore M. Webster
**Crop Protection and
Management Research Unit**
**USDA-Agricultural Research
Service, Tifton**

William K. Vencill
**Department of Crop and Soil
Science**
University of Georgia
Athens

Georgia Weed Science

A man in a white polo shirt and a green baseball cap is kneeling in a field, examining a small plant specimen in his hands.

**Stanley
Culpepper**

A man in a white lab coat and safety glasses is working in a field, using a tool to handle a plant specimen.

Tim Grey

A man in a blue long-sleeved shirt and a red baseball cap is standing on a wooden deck or walkway, looking towards the camera.

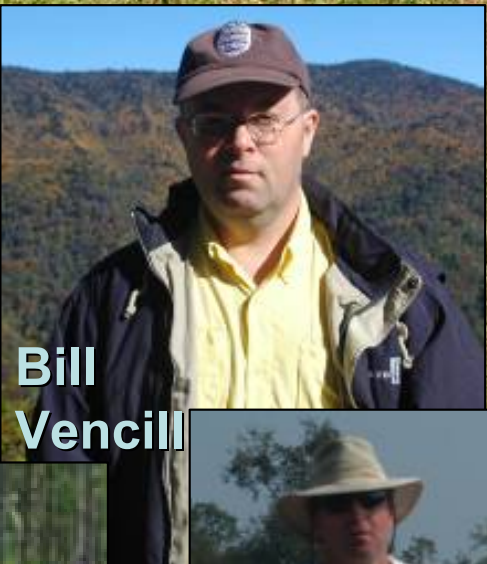
**Ted
Webster**

A man in a grey t-shirt and dark pants is kneeling in a field, working with a red bucket and some equipment.

Andrew MacRae

A man in an orange polo shirt is standing in a field, holding a small plant specimen in his hands.

**Tim
Murphy**

A man in a yellow polo shirt and a dark jacket is standing in a field, looking towards the camera.

**Bill
Vencill**

A woman in a grey polo shirt and blue jeans is standing in a field, smiling at the camera.

Lynn Sosnoskie

A man in a light blue polo shirt and a white bucket hat is working in a field, using a tool to handle a plant specimen.

Aaron Wise

A man in a light-colored polo shirt and a tan cowboy hat is standing in a field, holding a small plant specimen in his hands.

Carroll Johnson

A man in a white polo shirt and khaki shorts is standing in a field, looking towards the camera.

Eric Prostko

Some of the Georgia Studies

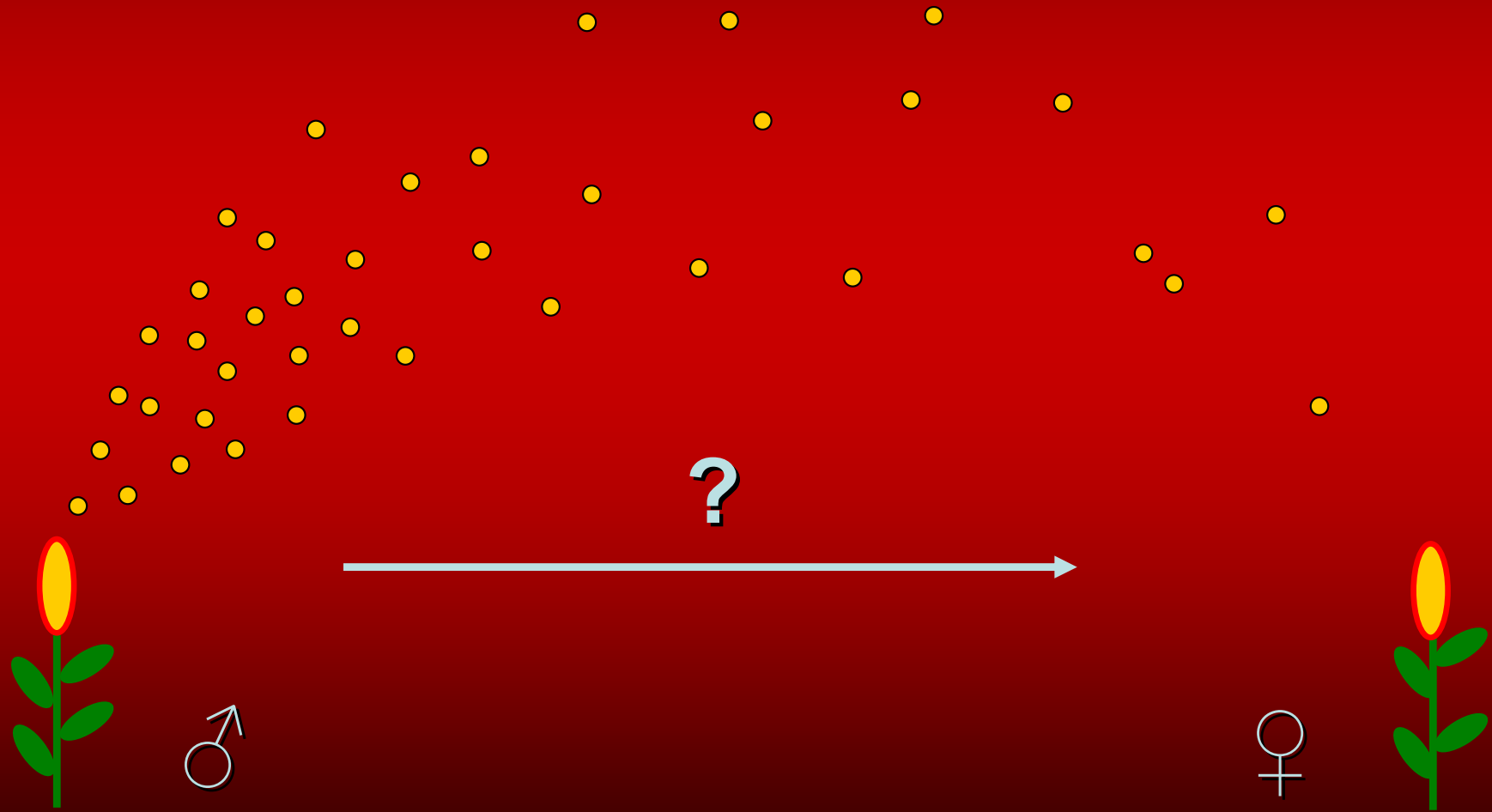
- **Potential for movement of the resistance trait in pollen (Sosnoskie)**
- **Interference of Palmer amaranth in cotton (MacRae)**
- **Movement of glyphosate in susceptible and resistant populations; where does it go? (Sosnoskie, Grey, Vencill)**

Movement of the glyphosate-resistance trait in pollen



Webster, USDA-ARS; Culpepper,
Sosnoskie, Grey, Vencill, UGA

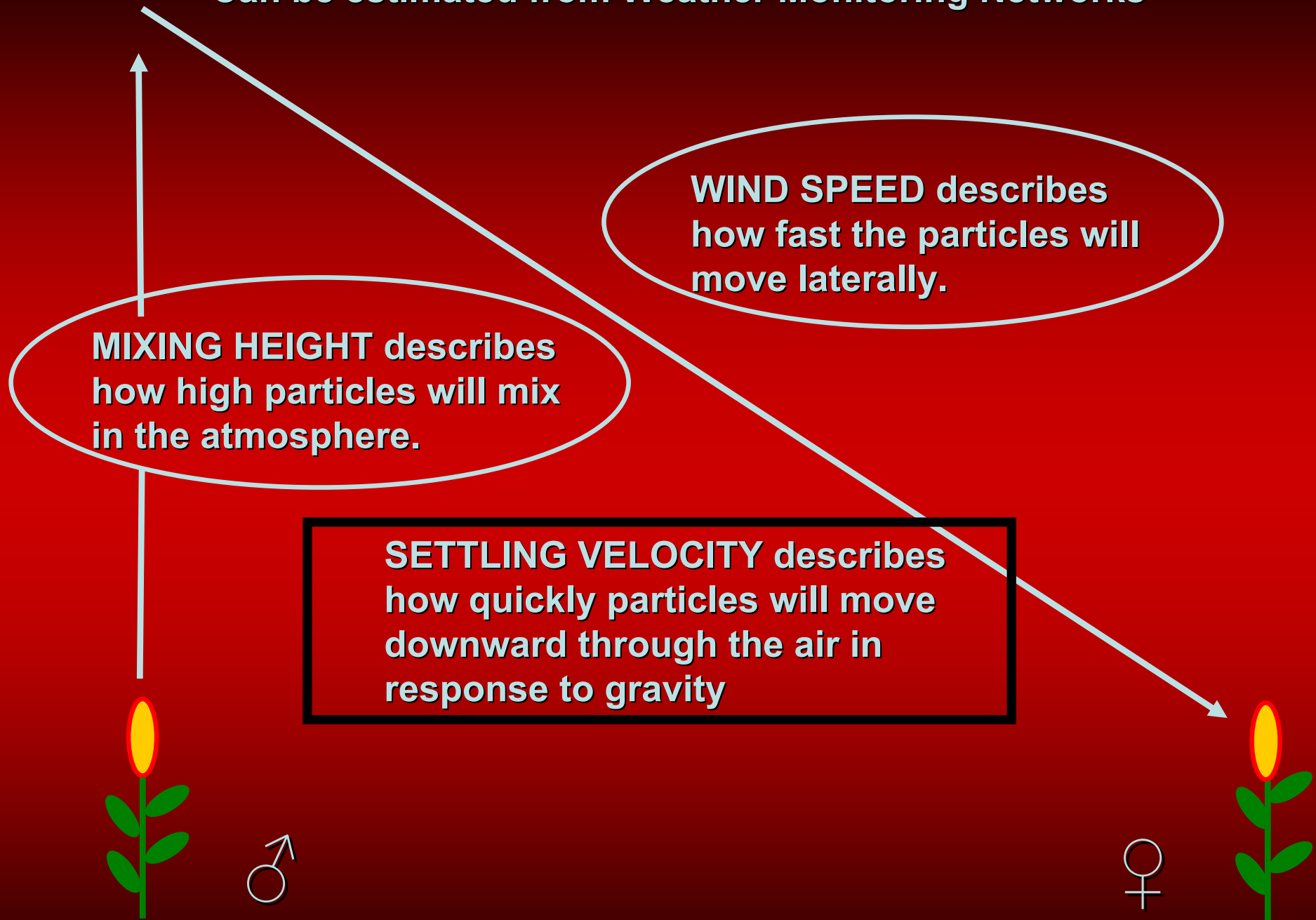
How far (theoretically) can pollen grains travel?



Theoretical maximum flight distance is a function of three factors: mixing height, settling velocity and wind speed

$$\frac{(\text{Mixing height}) (\text{Wind speed})}{\text{Settling velocity}}$$

Can be estimated from Weather Monitoring Networks



**Very Small
Seeded**



Approximately 1 mm

**However, settling
velocity can be
readily measured
with the naked eye**

X= 034.6 Y= 035.3 M S/U SF3=0040

**We are not so
fortunate with
Palmer amaranth
pollen grains,
which have a
mean diameter of
28-32 μm**

Freshly collected pollen was used in these studies to determine the distribution of pollen settling velocity

Conducted this study in the summer of '07

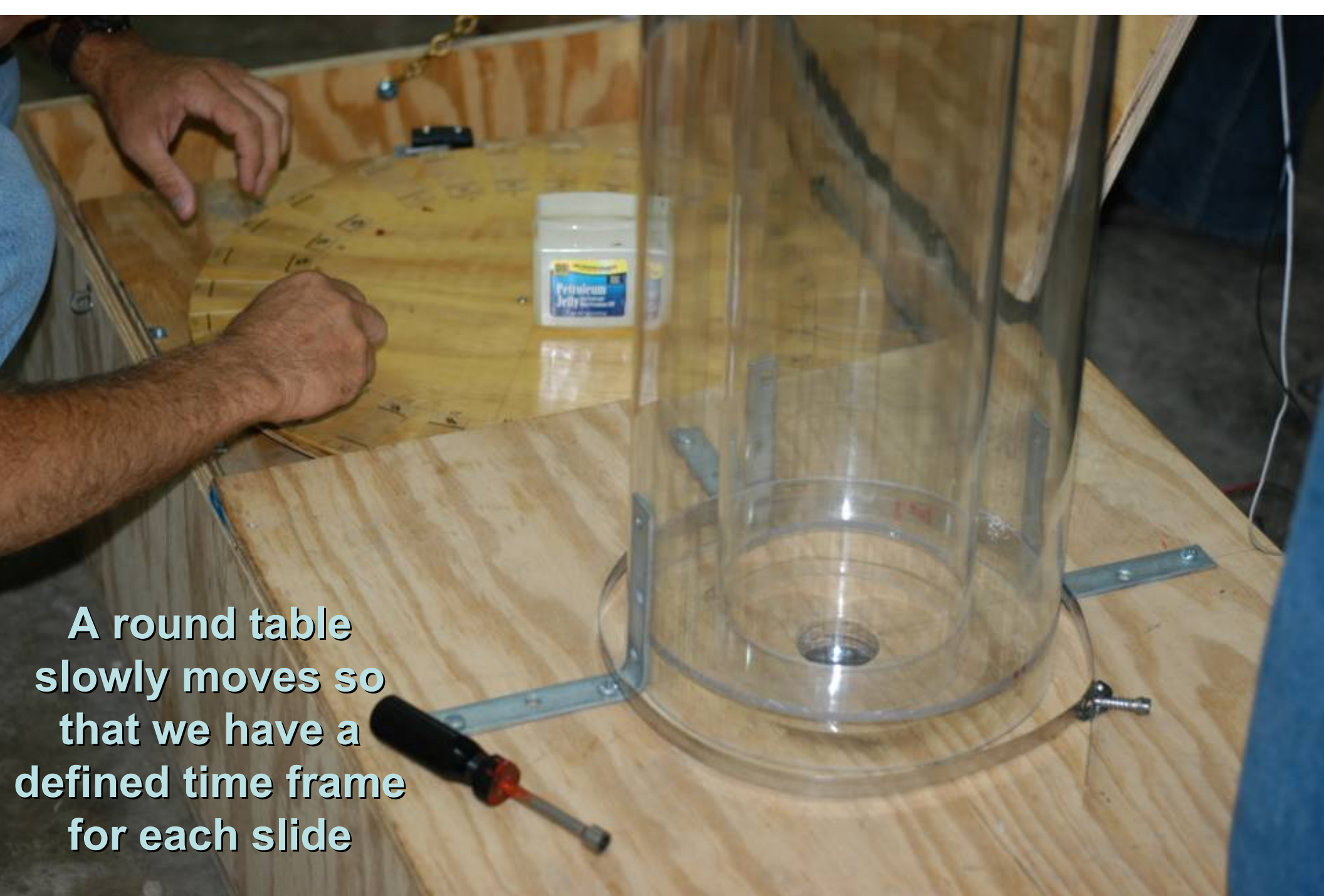
Generated a pollen settling velocity distribution for Palmer amaranth

Also have a pollen size distribution for Palmer amaranth for several locations throughout the pollination season.

Pollen Settling Chamber



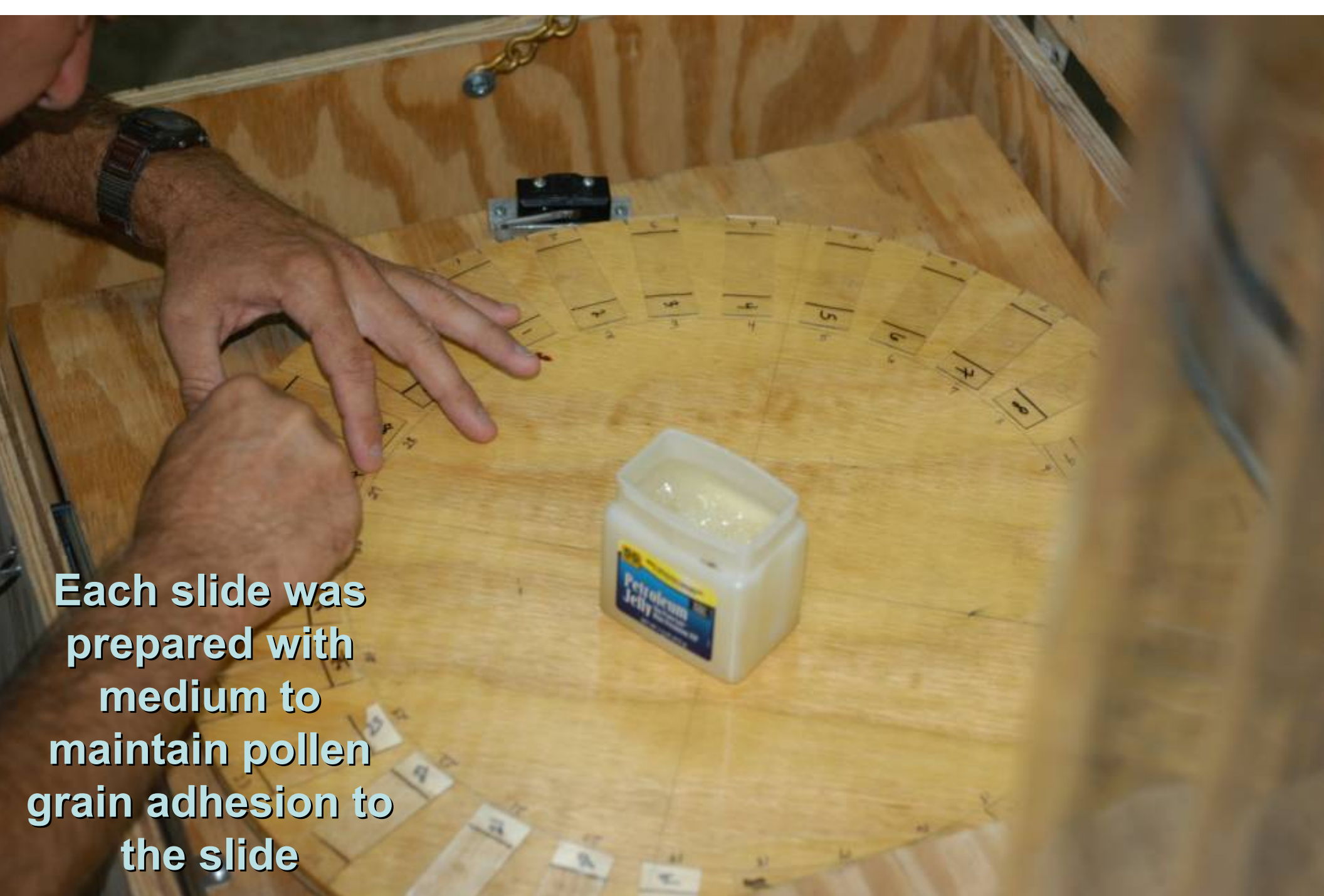




A round table
slowly moves so
that we have a
defined time frame
for each slide



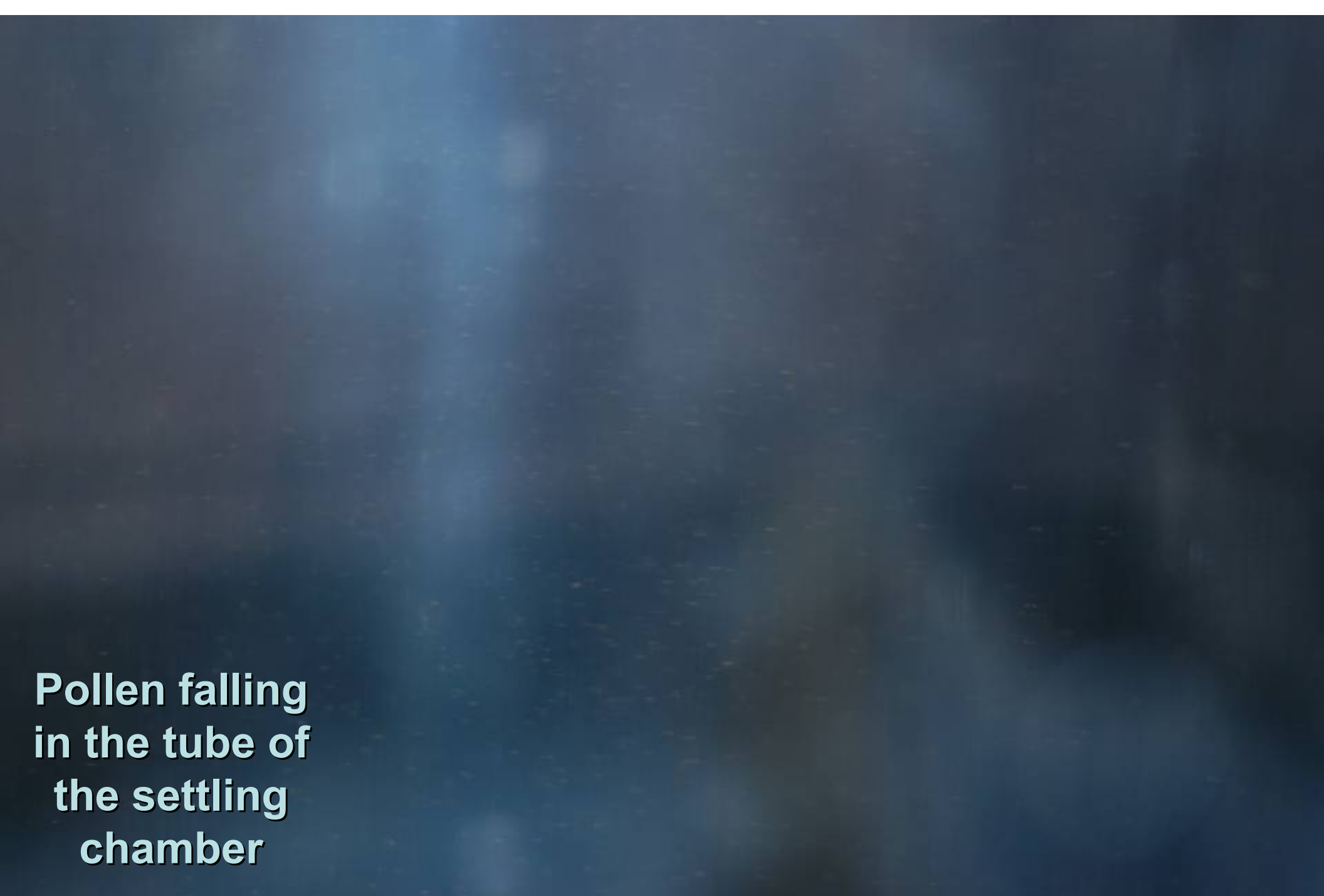
**The slide is visible
at through the hole
in the bottom of the
settling chamber**



Each slide was
prepared with
medium to
maintain pollen
grain adhesion to
the slide

**We tried
several pollen
release
mechanisms**





**Pollen falling
in the tube of
the settling
chamber**



**Pollen filled
microscope
slide**

X= 227.2 Y= 158.1 M S/U SF3=0040



The number of pollen grains on each slide were quantified and a settling velocity estimated

Also interested in Pollen Longevity

- Pollen movement is necessary in estimating potential dispersal, but...
- Movement of viable pollen is the key factor
- We evaluated longevity of field-grown Palmer amaranth pollen:
 - Time in full sun
 - Temperature
 - Osmotic potential
 - Interactions between these factors

Alexander's Stain

Fully developed cytoplasm

Aborted pollen grain
(no cytoplasm)



Measures mature pollen, but cannot quantify viability



IKI

Fully developed cytoplasm
(stains starch)

Aborted pollen grain
(no cytoplasm)

Indicates dehydrogenase activity,
need functioning enzymes (deep
pink/purple)

Less metabolically active

MTT

Stains in response to peroxidase activity

Light sensitive
and \$\$\$

Peroxidase

At what distances will resistance be transferred, successfully, to populations derived from susceptible females?



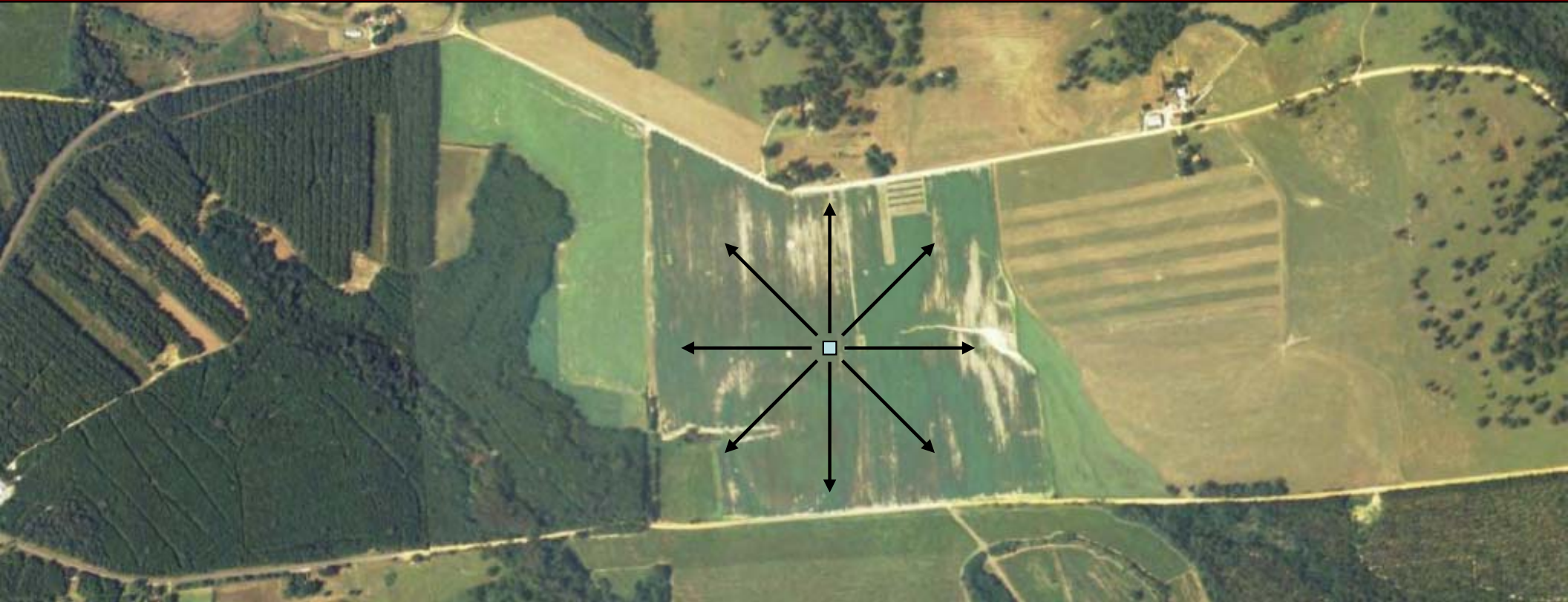


Our study field in 2006 and 2007

Garden Valley, Georgia

**Webster, USDA-ARS; Culpepper,
Sosnoskie, Grey, Vencill, UGA**

**Cotton 2006
Soybean 2007**



- **Confirmed glyphosate-resistant males were transplanted in the center of the field**
- **Glyphosate susceptible females were transplanted at 9 distances ranging from 1 to 200 m ('06) and 5 to 300 m in ('07)**



Webster, USDA-ARS; Culpepper,
Sosnoskie, Grey, Vencill, UGA



Webster, USDA-ARS; Culpepper,
Sosnoskie, Grey, Vencill, UGA



Webster, USDA-ARS; Culpepper,
Sosnoskie, Grey, Vencill, UGA



Webster, USDA-ARS; Culpepper,
Sosnoskie, Grey, Vencill, UGA

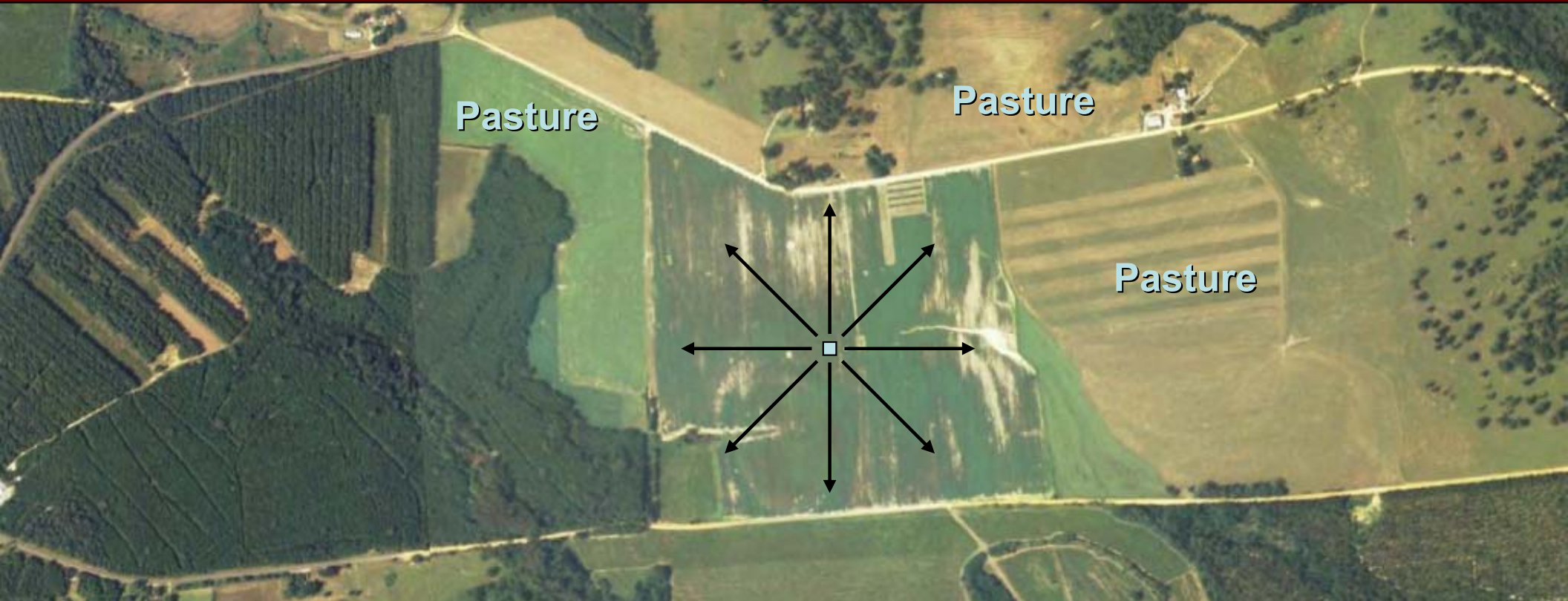
Keeping Palmer amaranth transplants alive in a 75 acre dryland field in the middle of a drought, was a challenge



How far can resistance be transferred under field conditions?

- The interior of the field and surrounding acreage (200 m from field edge in each direction) were kept free of *A. palmeri* by chemical and physical means.

Cotton 2006
Soybean 2007



How far can resistance be transferred under field conditions?

- The interior of the field and surrounding acreage (200 m from field edge in each direction) were kept free of *A. palmeri* by chemical and physical means.
- Seed was harvested from over 300 mature, susceptible female *A. palmeri* plants.
- Seed was stored in an unheated greenhouse until the samples could be hand-cleaned.
- Seed from each location was/is being screened for glyphosate resistance in the greenhouse

Palmer amaranth interference in cotton

MacRae, Webster, Sososkie, and Culpepper



Treatments

- **Density – 0, 2, 3, 5, and 10 / 20ft of row**
- **Establishment times**
 - **3-lf cotton - mimics escape from PRE application of herbicides**
 - **8-lf cotton - mimics escape from 4-lf POST application**
 - **12-lf cotton - mimics escape from 8-lf POST application**
 - **2 wk after layby (17-lf cotton) - mimics escape from layby application**

Prowl @ 1qt/A



**3-If Cotton
5 Palmer/row**



**3-If Cotton
10 Palmer/row**



**8-If Cotton
5 Palmer/row**



No Palmer

**8-If Cotton
10 Palmer/row**



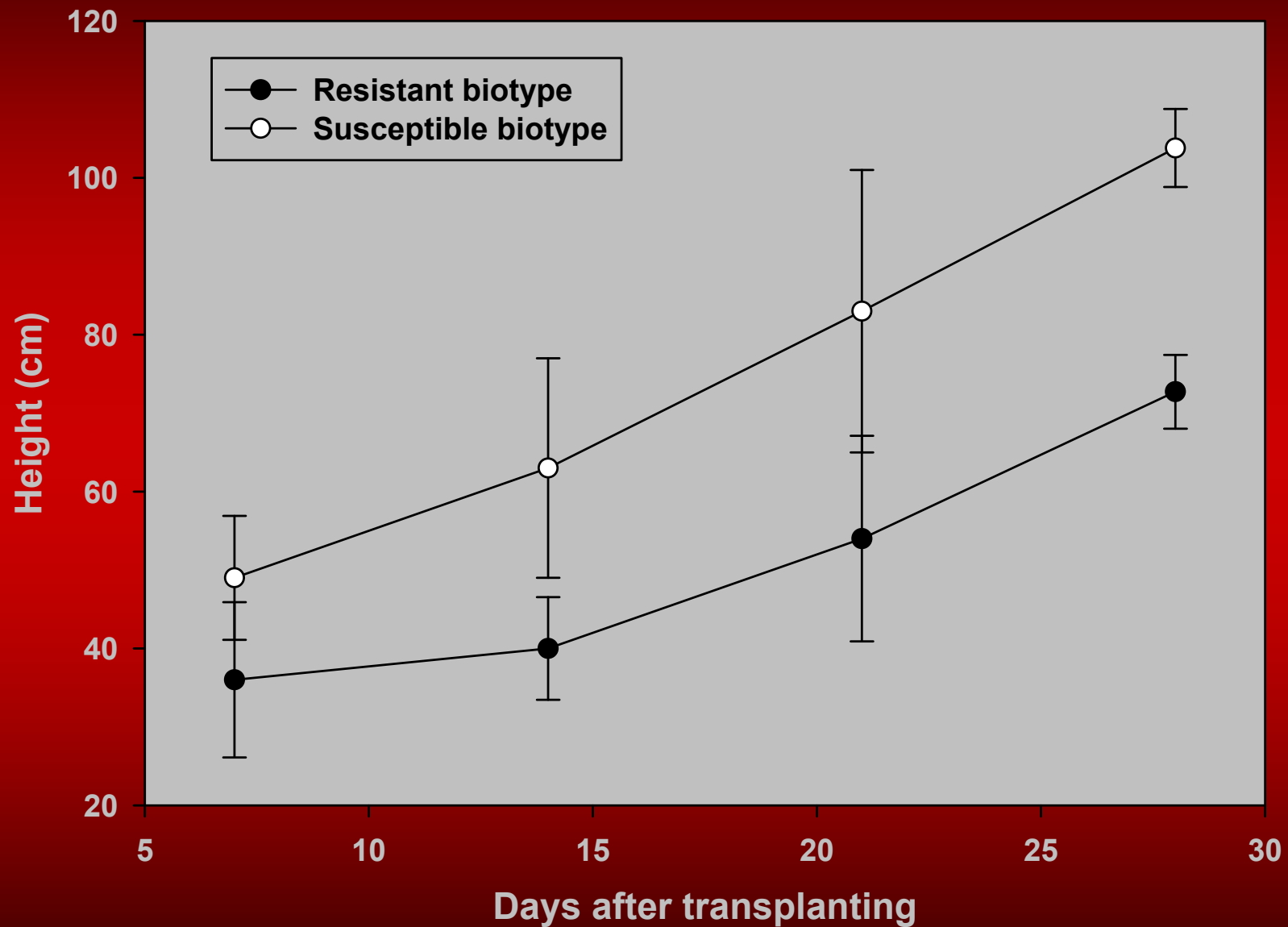
^{14}C -glyphosate: mobility and potential sequestration



Greenhouse Growth Studies

- GR and GS PW seeded in flats and transplanted to 1 L pots at 2 cm high.
- Cecil loam soil
- 2 replications (third to follow), 6 pots/rep with 4 plants in each
- Dose response: R sprayed at 3 cm tall
- Measurements taken at 15 and 30 DAT (1st rep), weekly through 42 DAT

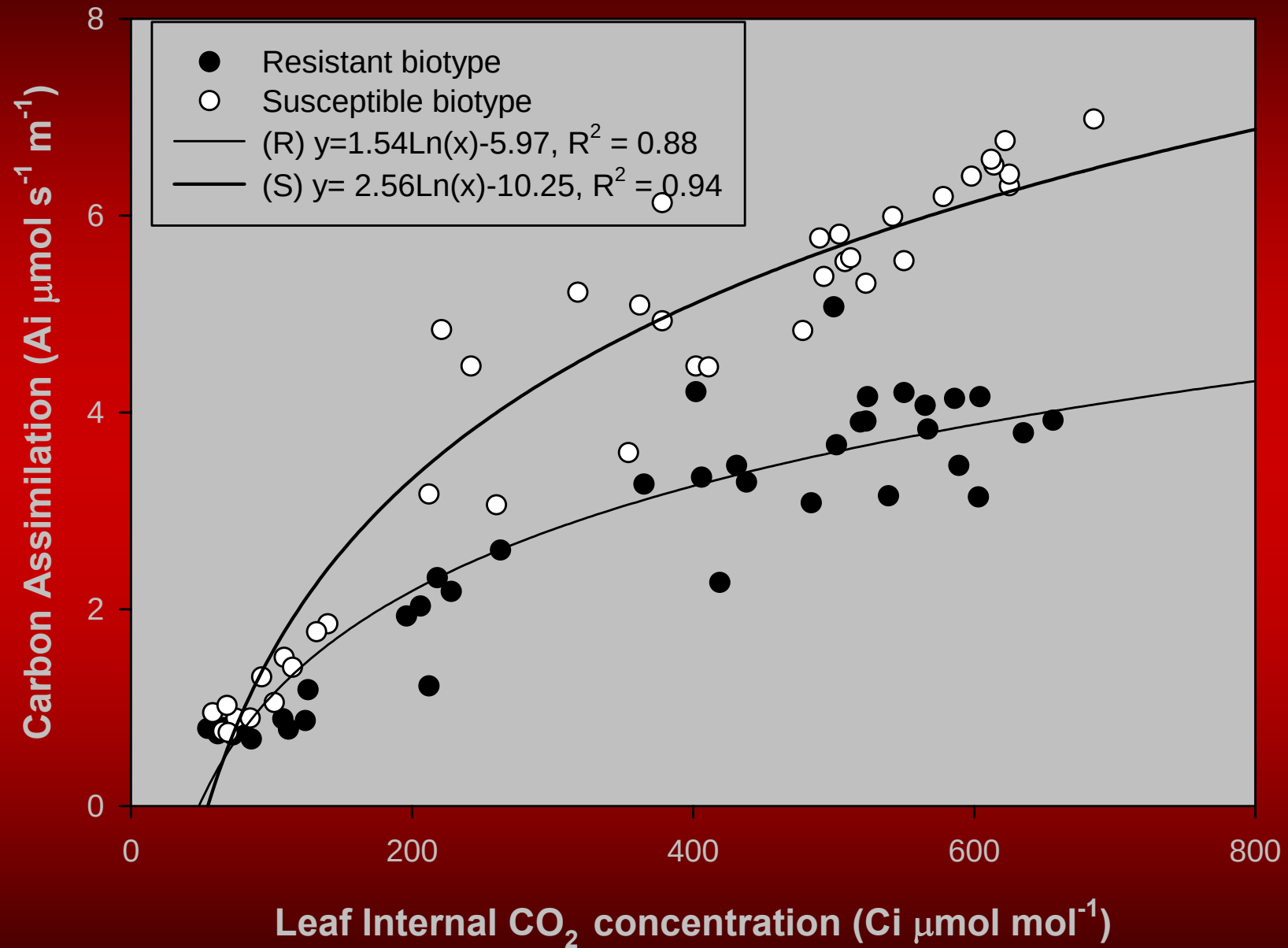
Comparison of R&S Plant Height



Gas Exchange Measurements

- Plants grown as described in greenhouse growth experiment
- Taken using an open gas exchange system (Li-Cor LI-6400)
- Calibration with Li-Cor
- Carbon assimilation measured at seven PAR levels (shown on graph)
- Leaf temperature controlled via thermocouple
- Air flow rate was $500 \mu\text{mol s}^{-1}$
- CO_2 concentration held at $400 \mu\text{mol mol}^{-1}$

Photosynthetic Carbon Assimilation



Acknowledgements

Staff and Students at USDA-ARS, ABAC and UGA

Mr. Sutton

Georgia Cotton Commission, Cotton Incorporated

Bayer, BASF, DuPont, Monsanto, Syngenta, Valent