Pest Management and Climate Change in New Mexico

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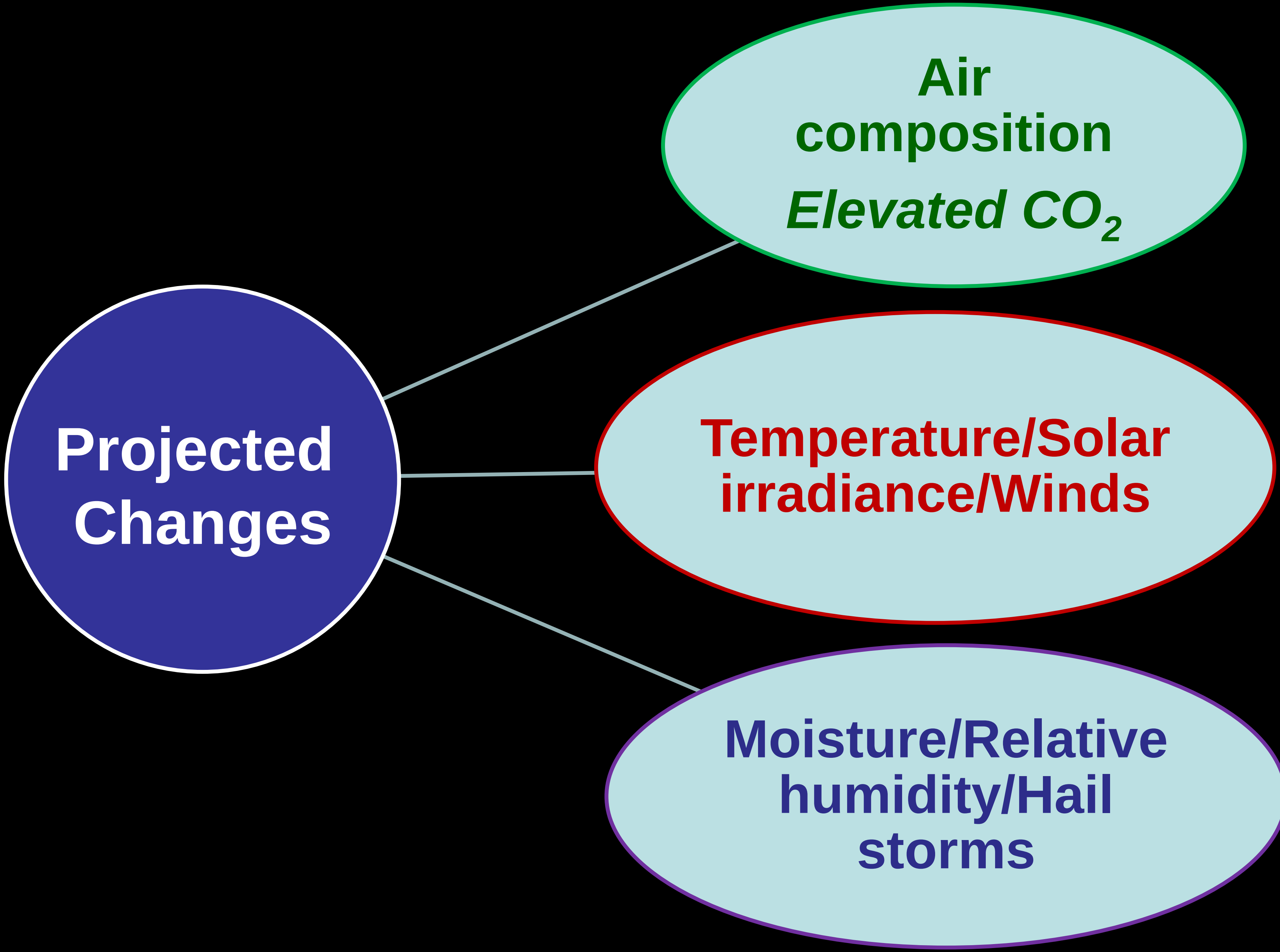
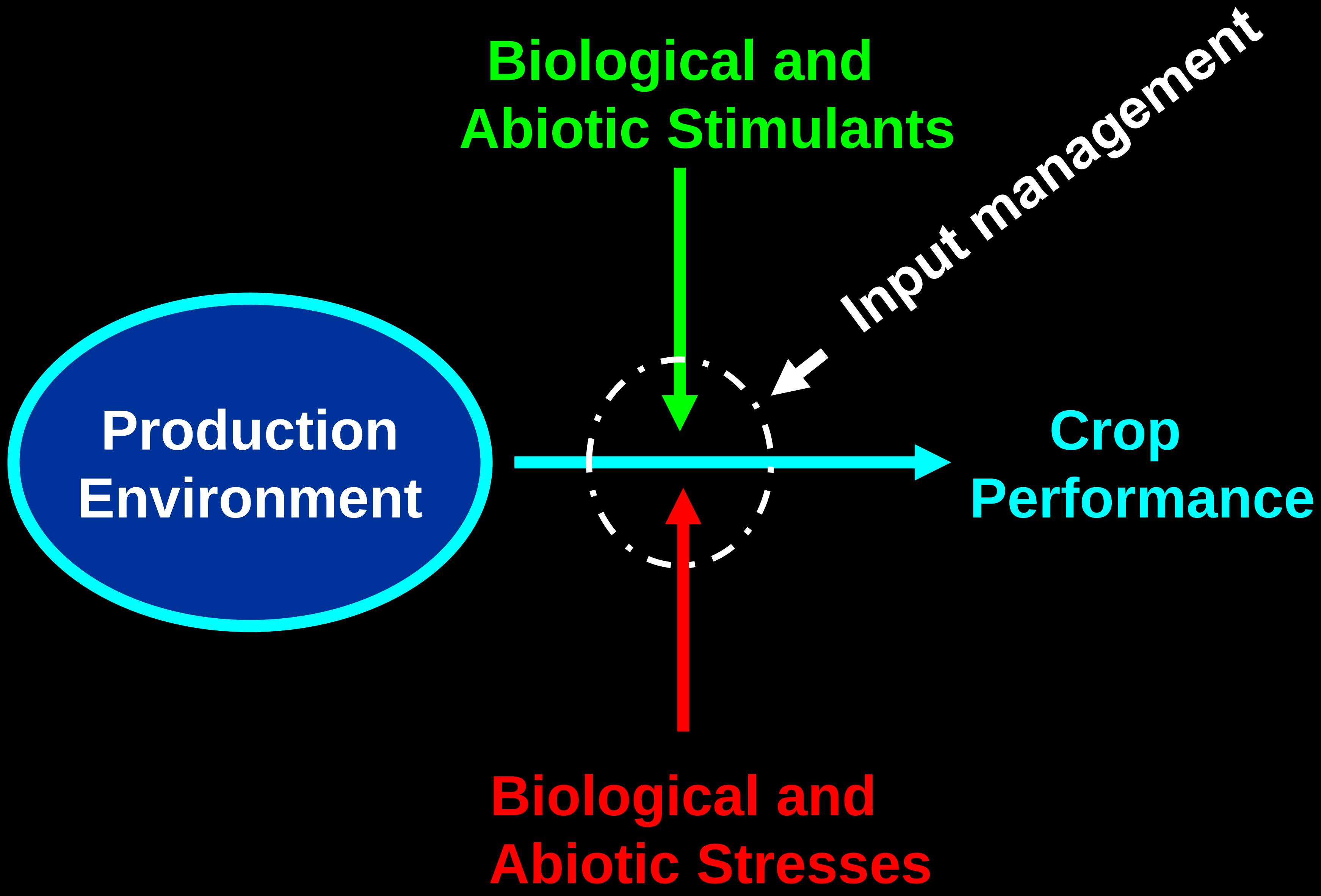
Outline

- Pathogen/Disease Management and Climate Change in New Mexico - *Dr. Soum Sanogo*
- Climate Change Effects on Weeds and Weed Management - *Dr. Brian Schutte*
- Climate Change vs. Producers vs. Insects: Who's Winning? - *Dr. Carol Sutherland*

Pathogen/Disease Management and Climate Change in New Mexico


Projected Changes
Air composition
Elevated CO_2
Temperature/Solar irradiance/Winds
Moisture/Relative humidity/Hail storms

Impacts of Climate Change



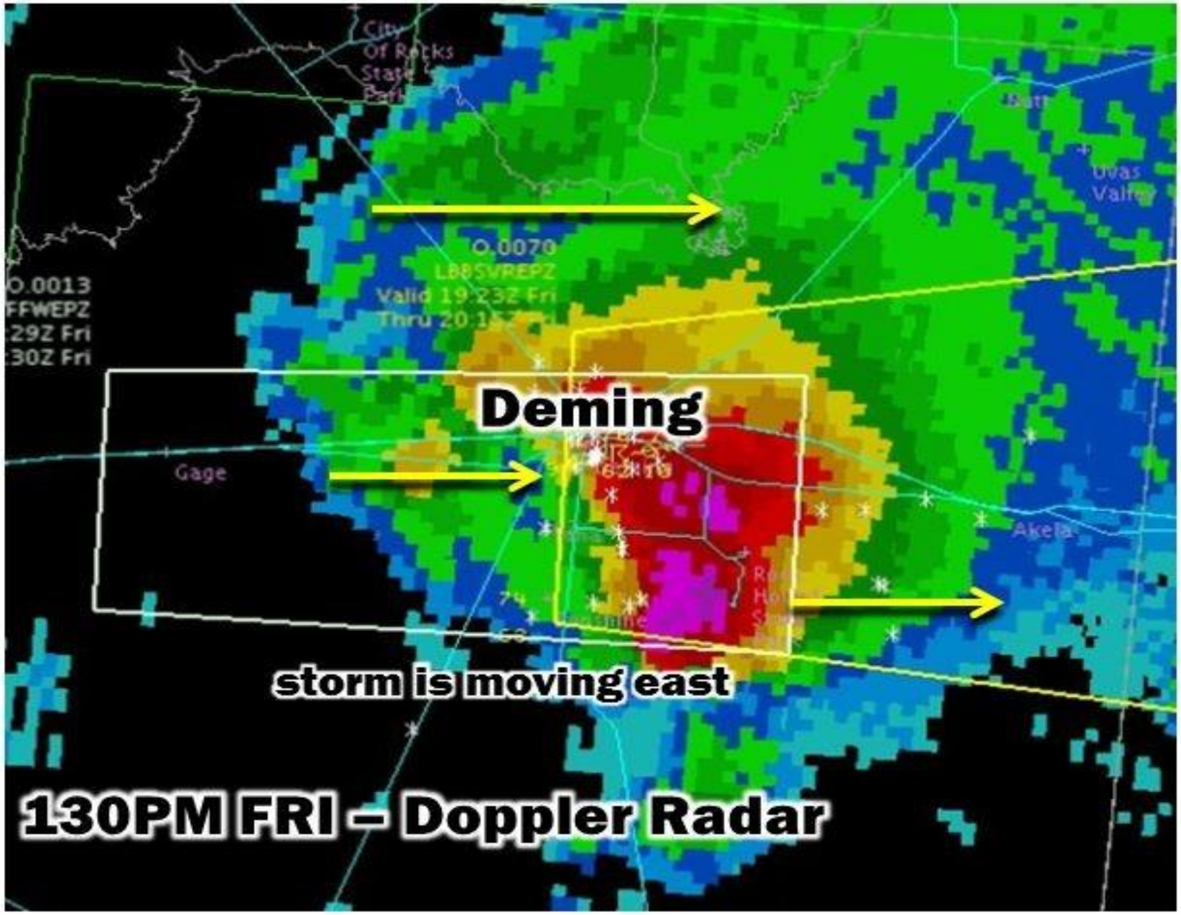
LARGE HAIL / INTENSE RAIN / FLASH FLOODING

SEVERE THUNDERSTORM IN AND SE OF DEMING, NM

Supercell Thunderstorm is moving across the Deming area at 130 pm Friday afternoon.

This is a dangerous storm. Take cover.

Seek shelter from this storm.



Courtesy: Ben Etcheverry, Mizkan Americas, Deming

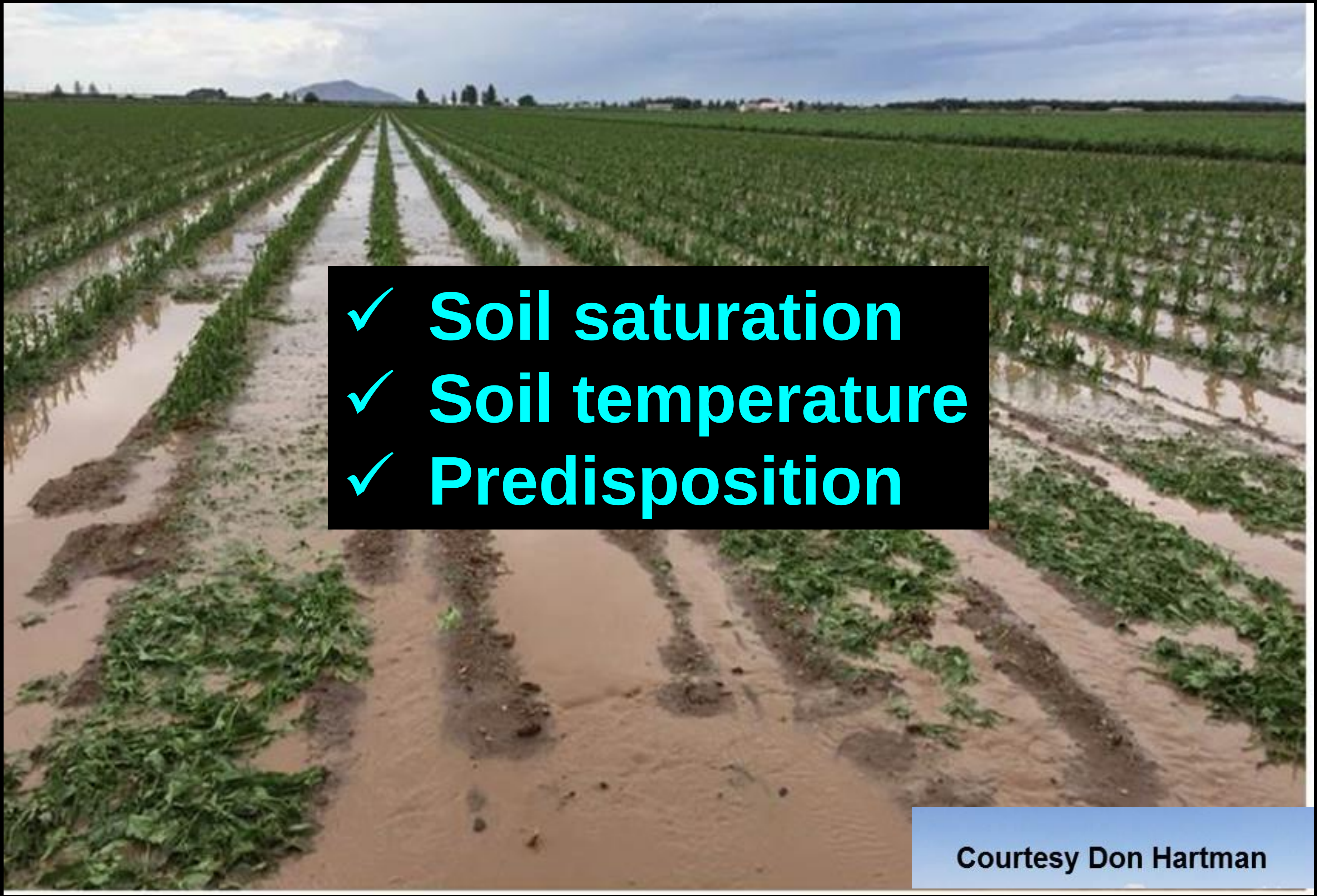
Pictorial of 2015 Hail Event

Courtesy: Ben Etcheverry, Mizkan Americas, Deming

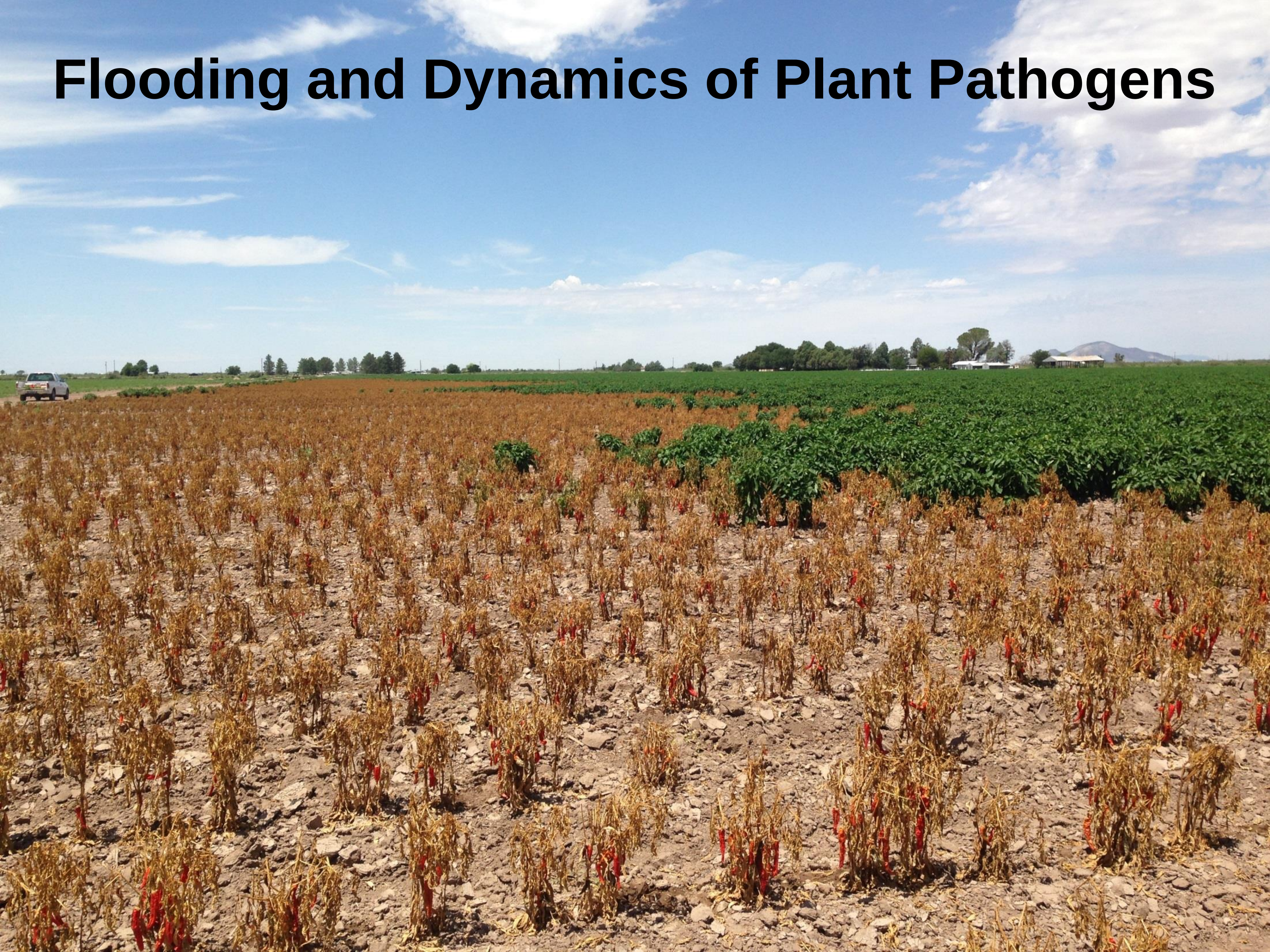
Pictorial of 2015 Hail Event

Extent of Hail Damage

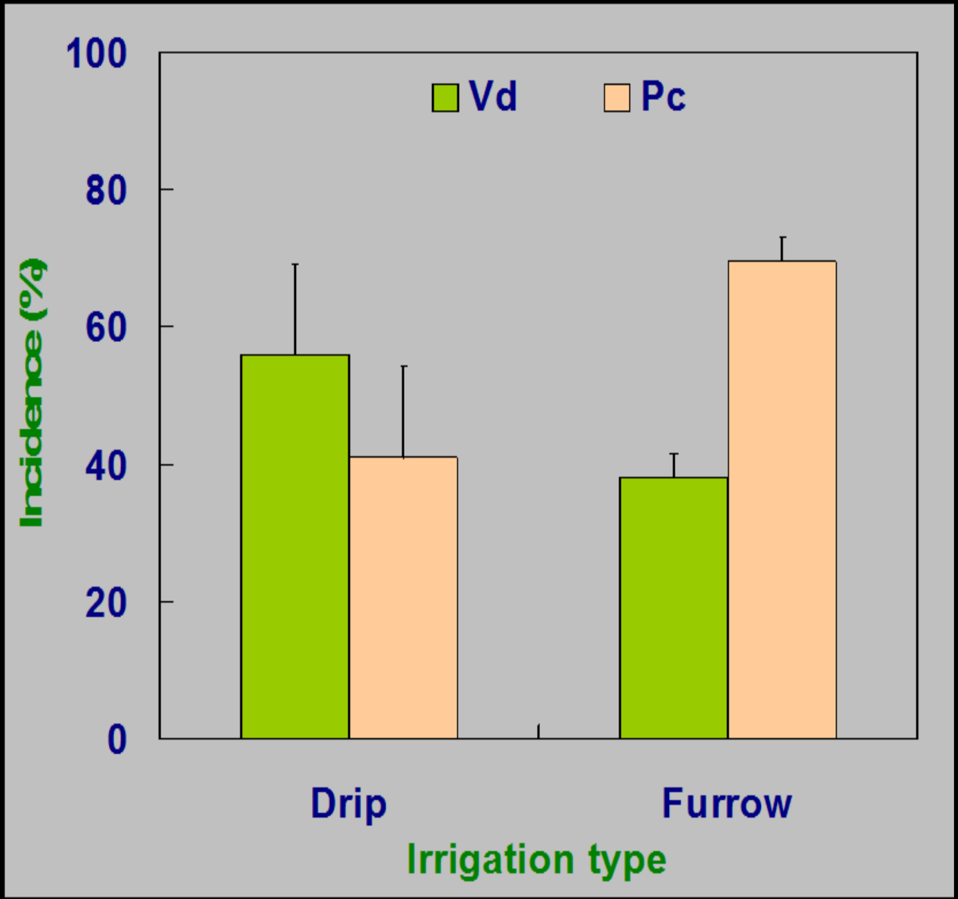
	Field 1	Field 2
Foliage damage (%)	15-30	5-10
Pods with damage (Kg)	1.85	0.98
Pods with no damage (Kg)	1.87	2.23
	~50%	~70%

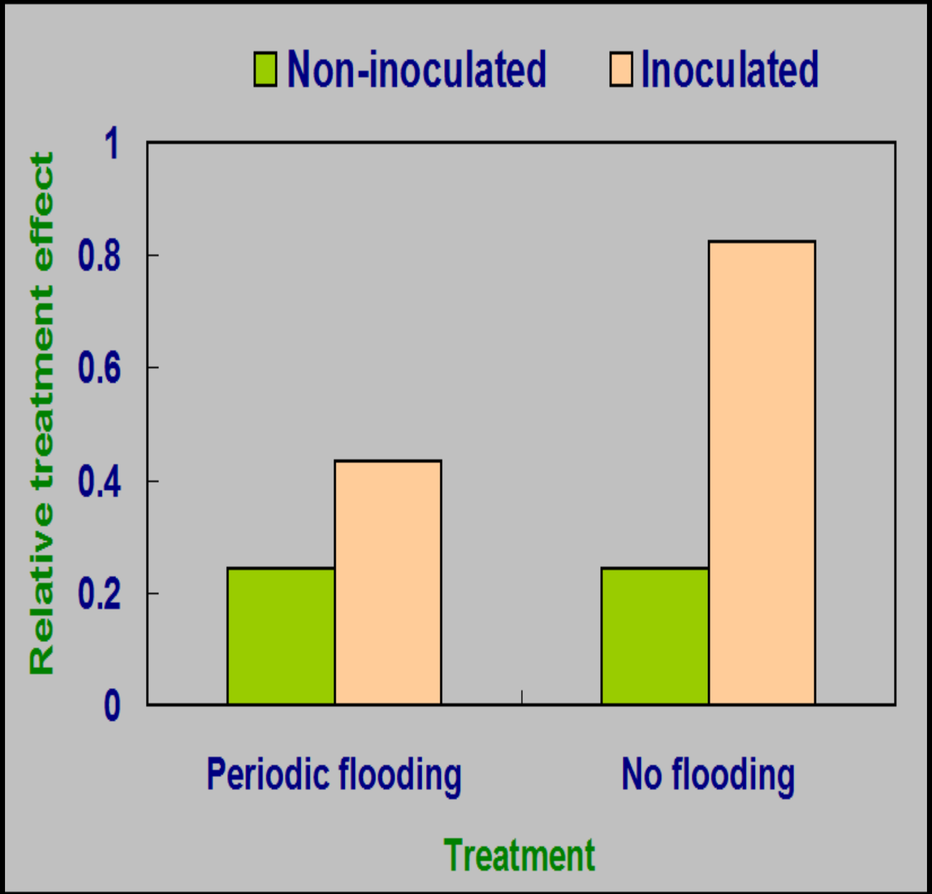

✓ Soil saturation
✓ Soil temperature
✓ Predisposition
Courtesy Don Hartman

Flooding and Dynamics of Plant Pathogens



Flooding and Dynamics of Plant Pathogens





Vd > Pc under drip; Pc > Vd under furrow

(Sanogo and Carpenter, 2006)

Vd > in no flooding

(Sanogo et al., 2008)

Hail and Disease Outbreak Relationship?

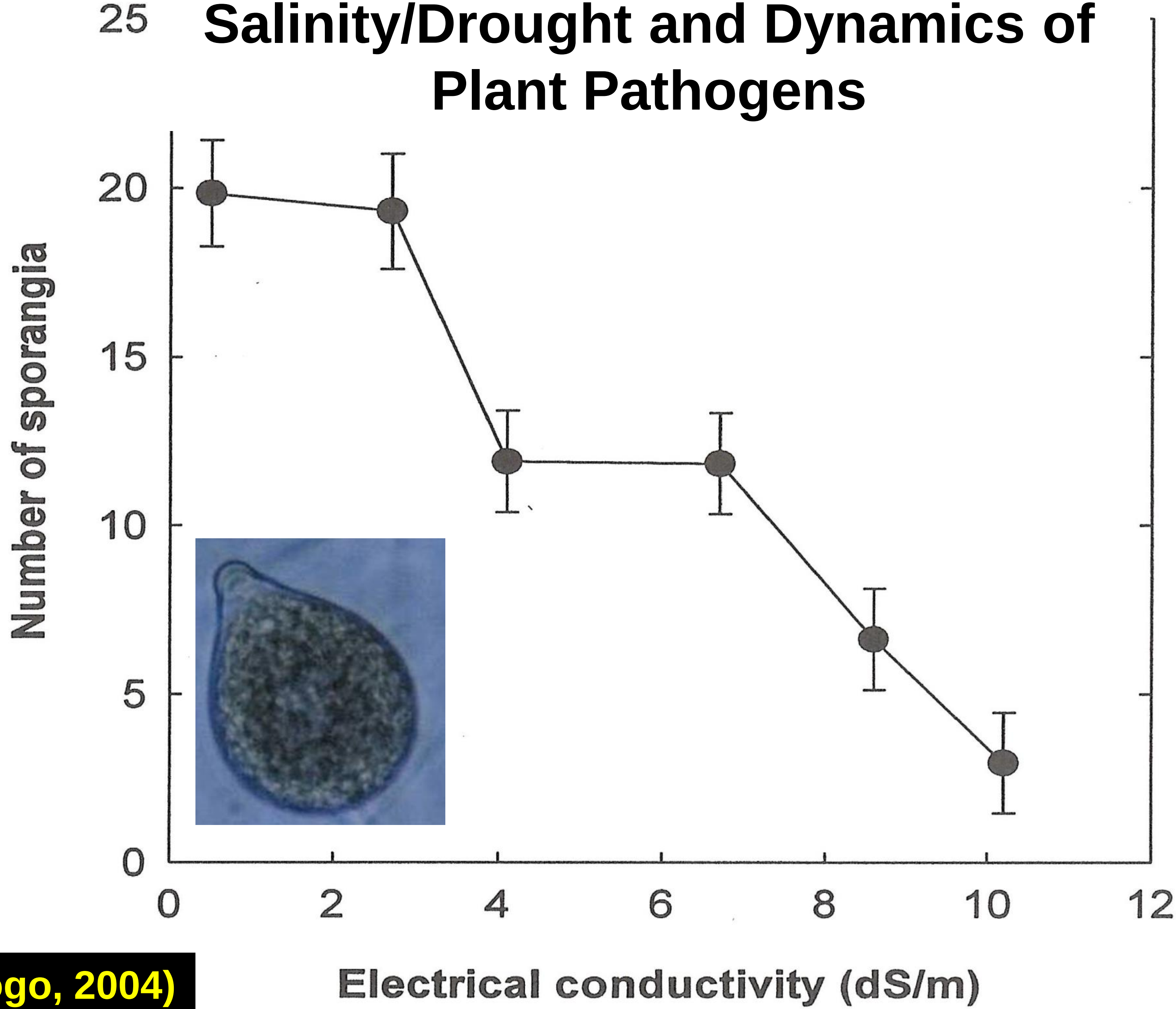
- Mowed versus not mowed
- Mowed and treated versus mowed and not treated


Not Mowed
Mowed

Projected Changes in Production Environment (Extremes)	Pathogen			
	Survival	Spread	Reproduction	Infection
Air composition				
Elevated CO_2				
Biotrophs	✓	✓	↗	↗
Necrotrophs	✓	✓	↗	↗
Temperature				
High	✓	✓	✓	↗
Low	✓	✓	✓	↗
Moisture				
High (flood)	✓	↘ ↗	✓	↗
Low (drought)	✓	↗	✓	↗
Wind and hail storms	✓		✓	↗

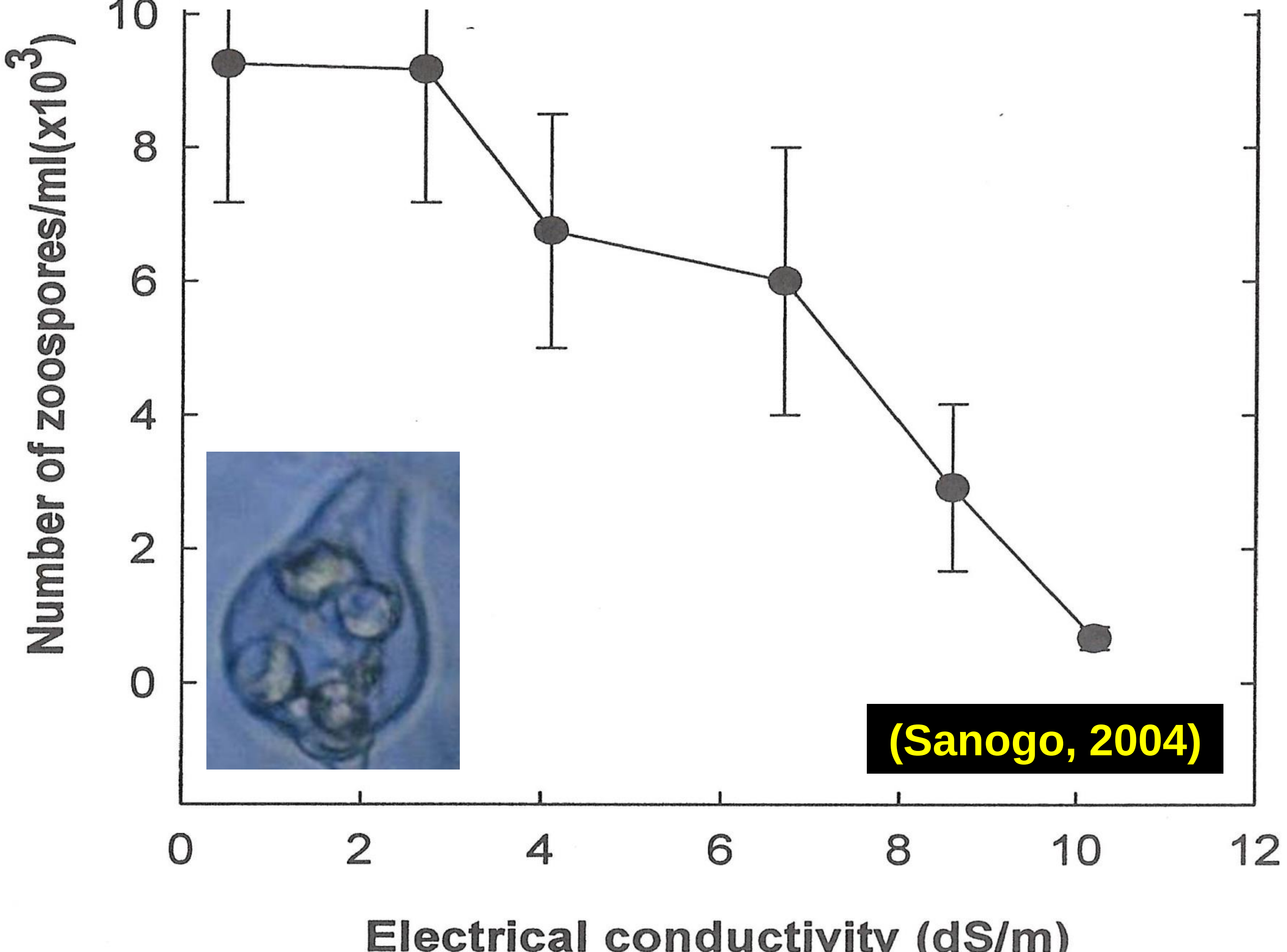
↗ **Predispositional effect**

Salinity/Drought and Dynamics of Plant Pathogens

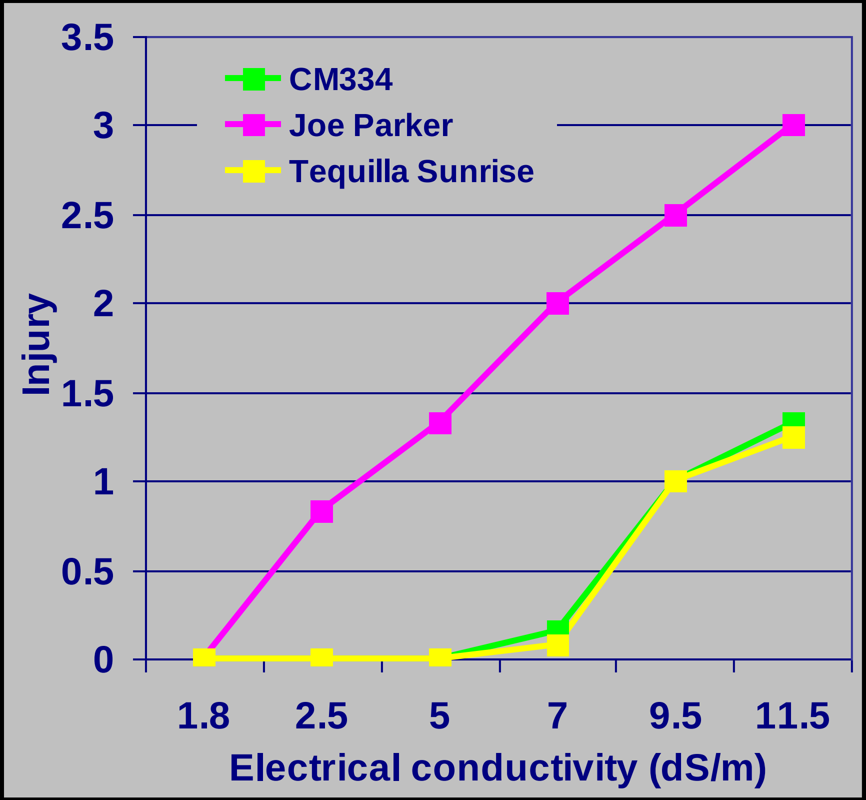


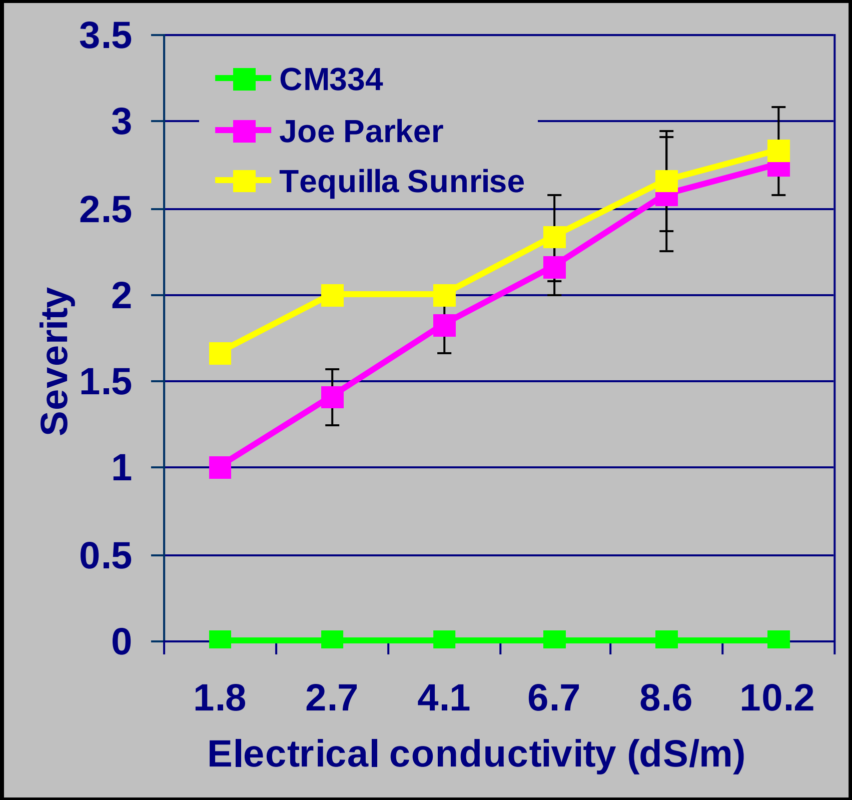
(Sanogo, 2004)

Salinity/Drought and Dynamics of Plant Pathogens



Effect of soil salinity on plant infection by *Phytophthora capsici*





(Sanogo, 2004)

- Salinity promotes disease development
- Management under saline conditions: cultivars with tolerance to salinity and resistance to *P. capsici*

Response of pathogens or diseases to salinity

Pathogen or disease	Response
Phytophthora species	↗
Fusarium oxysporum **f. sp.** ***vasinfectum***	↗
Fusarium oxysporum **f. sp.** ***radicis lycopersici***	↗
Verticillium dahliae	↗
Alternaria solani	↗
Fusarium wilt of date palm	↘
Rhizoctonia crown and root rot of table beet	↘
Fusarium crown and root rot of asparagus	↘
Fusarium wilt of cyclamen	↘

Response of pathogens to salinity

Increase in diseases, Why?

- Increase plant susceptibility
  - ✓ Changes in plant physiology
  - ✓ Disruption of water uptake
  - ✓ Decrease in tissue nutrients (like potassium)
  - ✓ Increase in root exudates
- Increase in pathogen virulence

Response of pathogens to salinity

Decrease in diseases, Why?

- Increase in manganese (Mn) levels in plant tissues, which induces disease resistance
- Increase in sodium and chloride levels in plant tissues

Resiliency through enhancement of beneficial microbiome

Endomycorrhizae associated with ~60% of terrestrial plants (comprising 80-95% of vascular plants)

Ectomycorrhizae associated with ~3-5% of seed plants

Resiliency through enhancement of beneficial microbiome

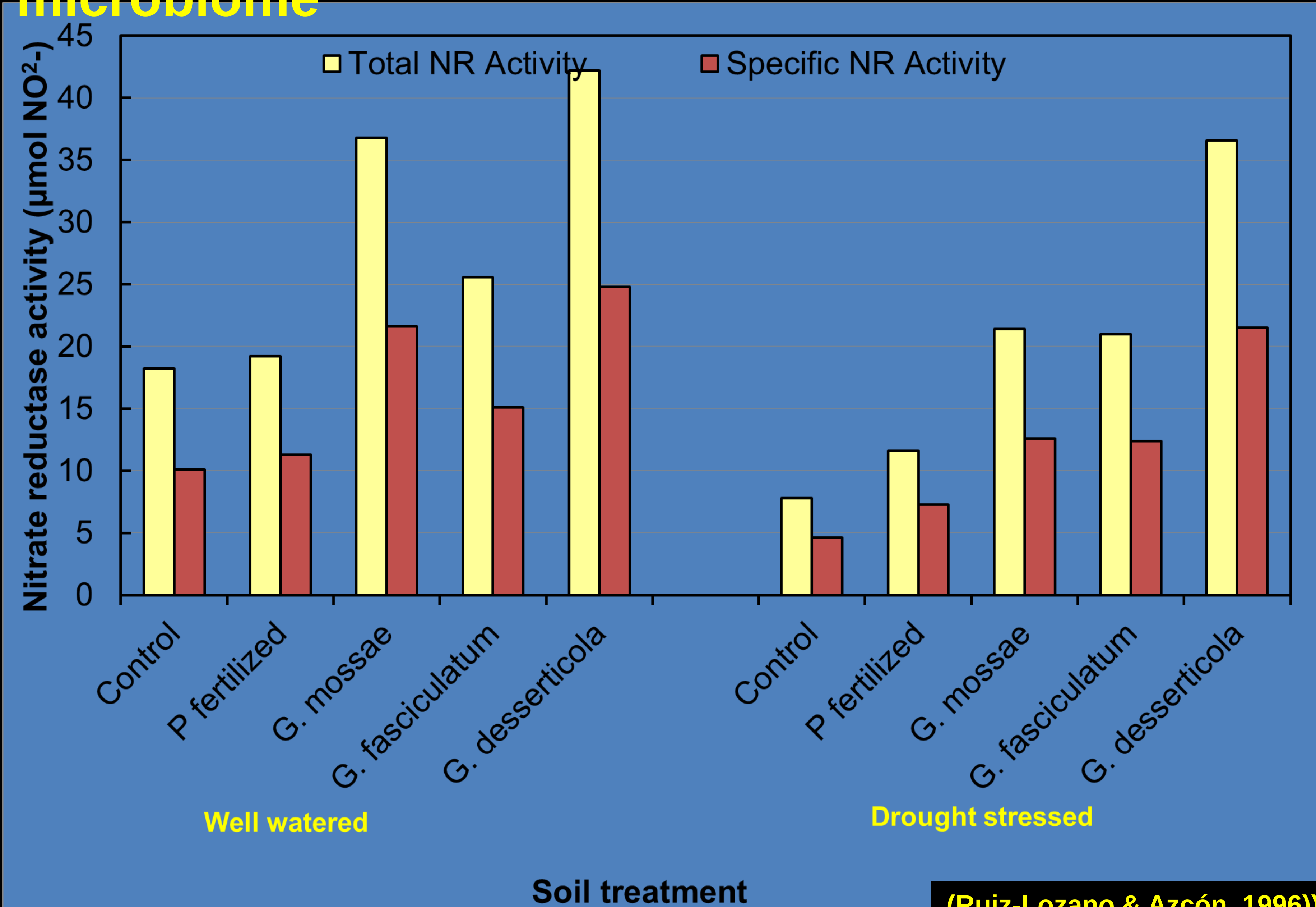
Tolerance to biological and environmental stresses

- Nutritional
- Drought
- Pathogens/Pests

Benefit to soil

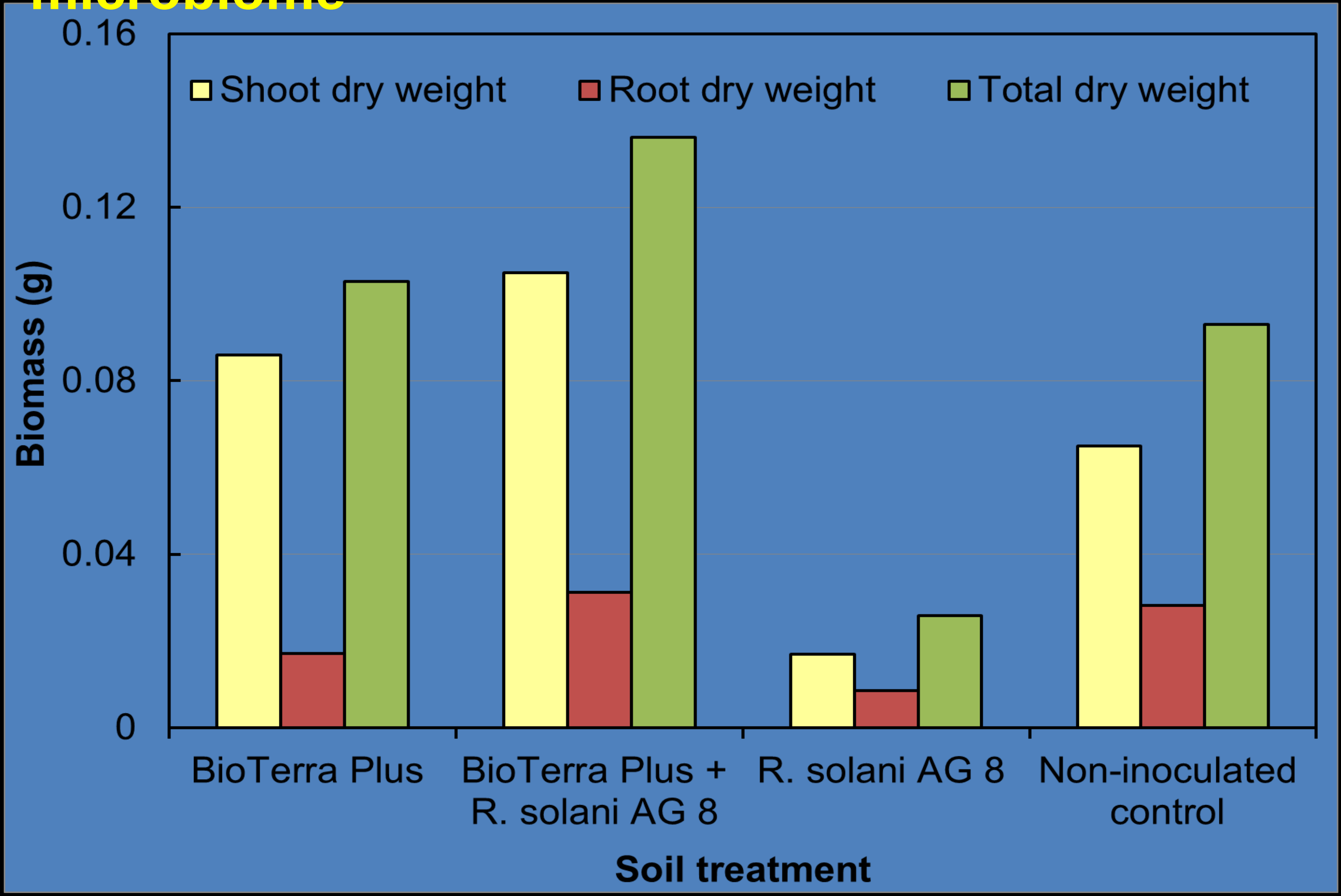
- Stabilization of soil aggregates (production of glomalin~1.5% of dry soil weight)
- Root exudation and abundance of soil bacteria

Resiliency through enhancement of beneficial microbiome



(Ruiz-Lozano & Azcón, 1996))

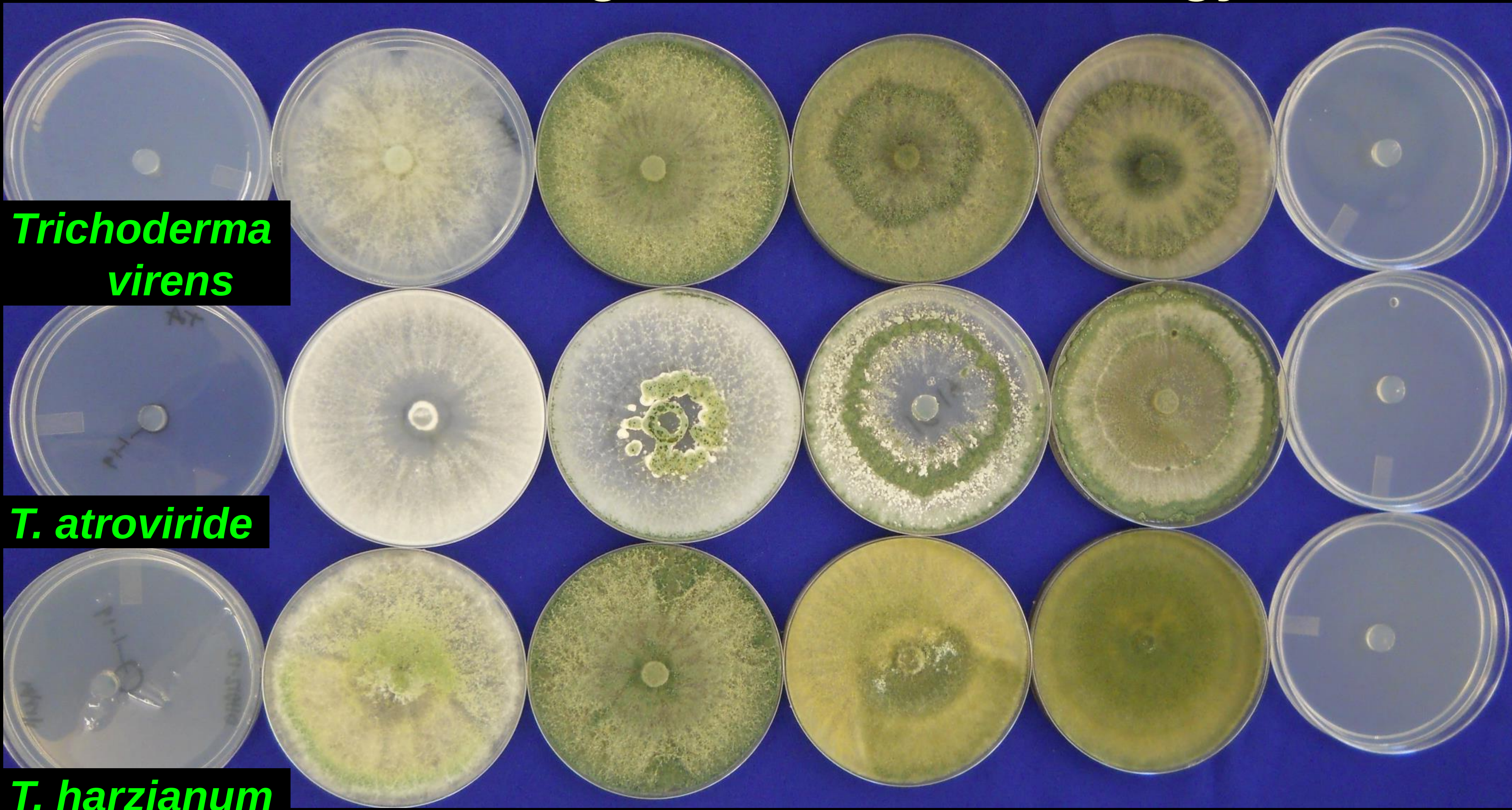
Resiliency through enhancement of beneficial microbiome



(Dipak Sharma-Poudyal et al., 2013)

Resiliency through enhancement of beneficial microbiome

- Combining function and ecology

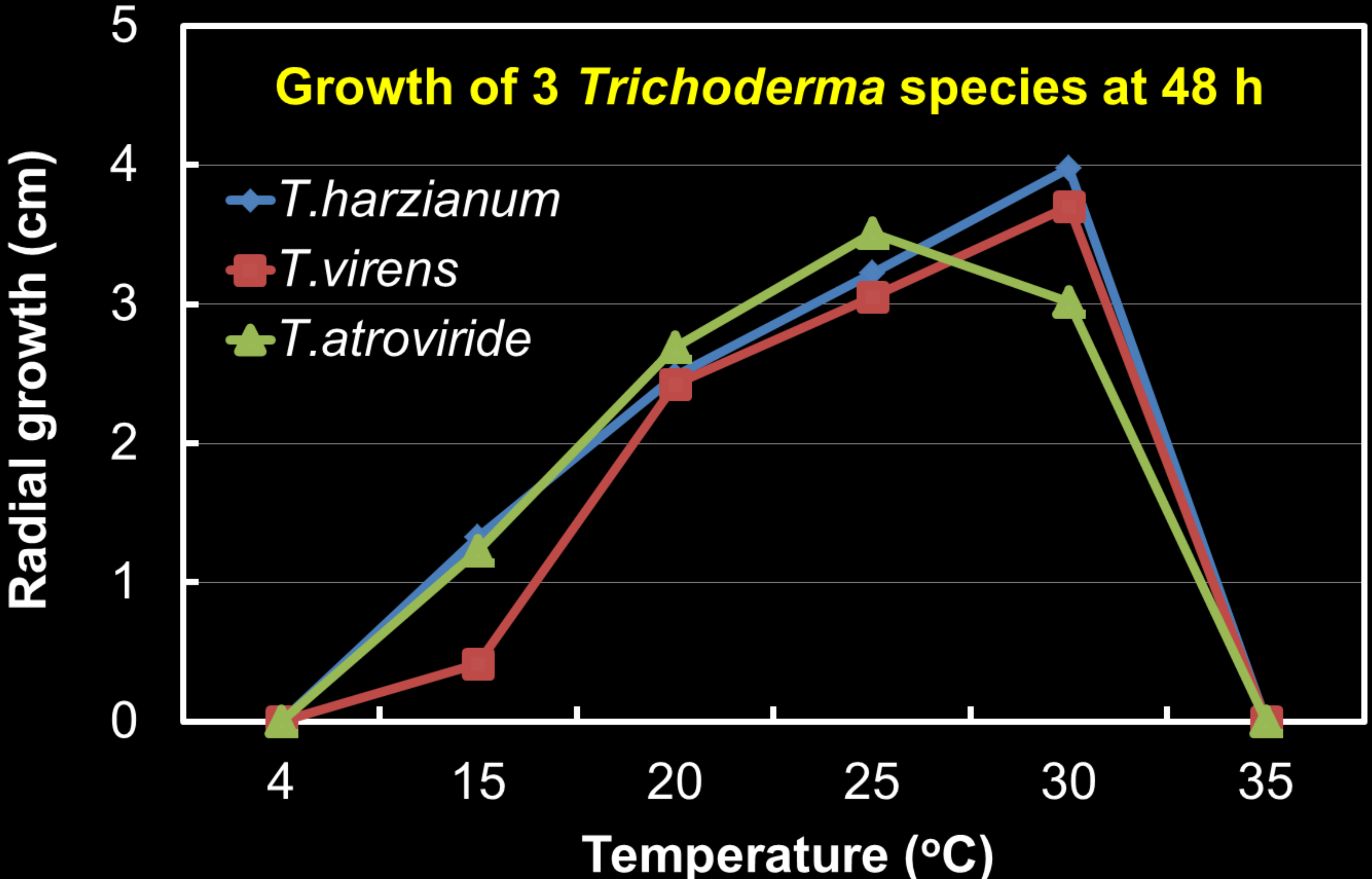


Resiliency through enhancement of beneficial microbiome

- **Combining function and ecology**

Trichoderma virens ***Trichoderma atroviride*** ***Trichoderma harzianum***

Resiliency through enhancement of beneficial microbiome



Resiliency through enhancement of beneficial microbiome

→ Crop residue / soil management

T. atroviride

T. virens

T. harzianum

T. atroviride

Fall | Spring

Climate Change Effects on Weeds and Weed Management

Climate Change Assumptions for this Talk

- Increase in atmospheric CO_2
- Increase in average annual temperature
- Increased risk of drought
- Increase in extreme precipitation events

Source:

- *Climate Change and Vegetation in Southwestern North America*, David Gutzler, 2013, NM Vegetation Management Association http://www.nmvma.com/

Climate Change Effects on Weeds and Weed Management

1. The effectiveness of weed control tactics will change
2. Existing weed threats may get worse
3. New weed threats will arise; however, predicting specific species is difficult

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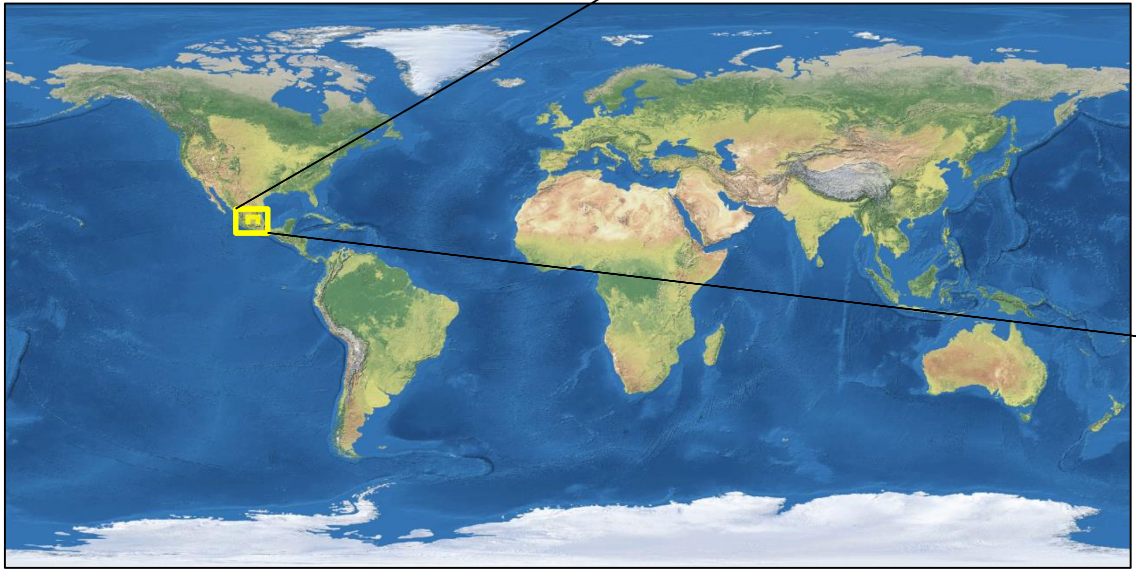
New Weed Threats – *Range Shifts*



Physalis patula Mill.
Agricultural weed in Mexico

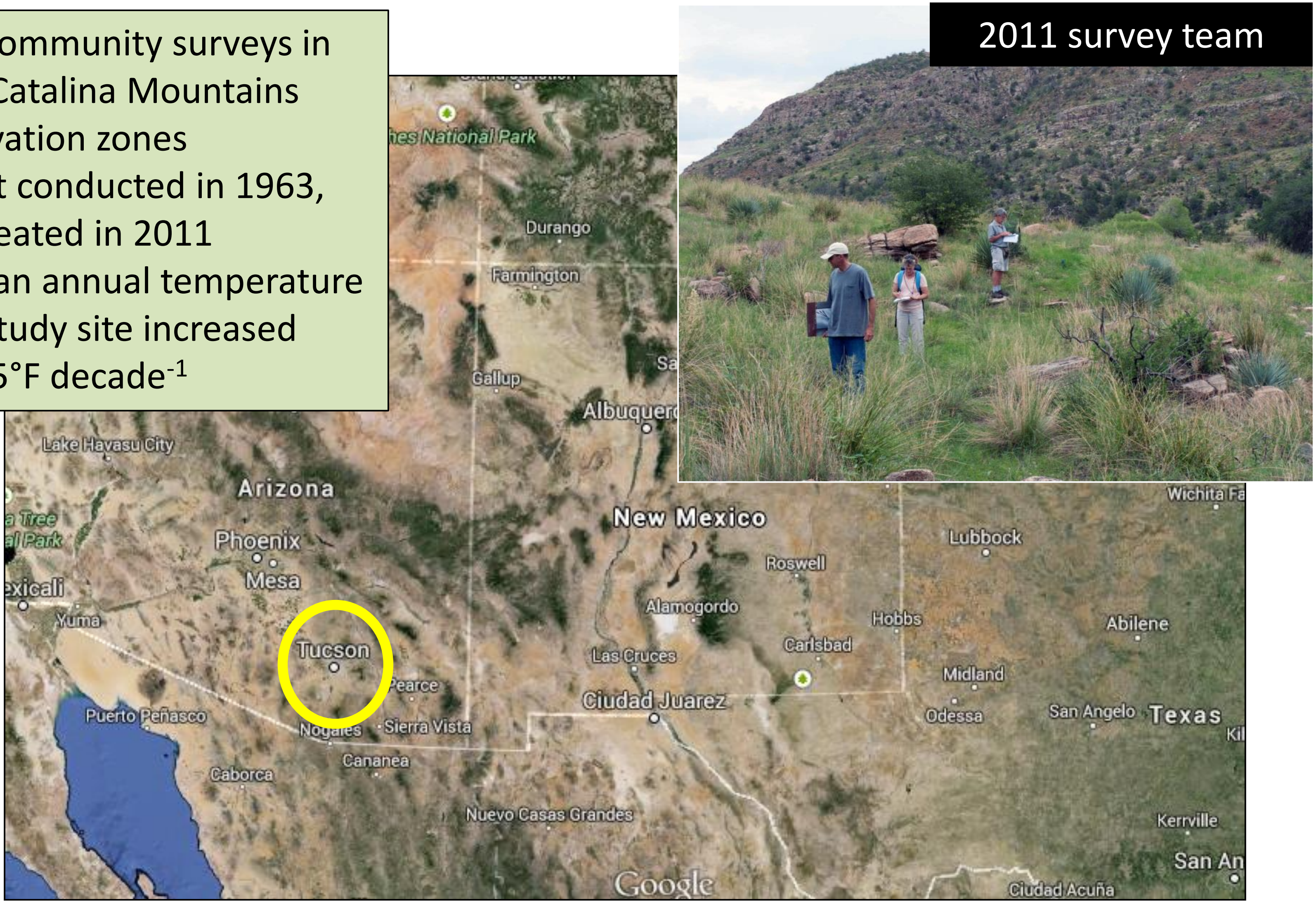
Could it become a problem in New Mexico?

http://www.boldsystems.org/index.php/Taxbrowser_Taxonpage?taxid=732255

http://bio.uaq.mx/municipioQro/fichas.php?idA=44&n_img=1&F=1

New Weed Threats Will Arise
Range Shifts in Natural Environments

Plant community surveys in Santa Catalina Mountains
- Elevation zones
- First conducted in 1963, repeated in 2011
- Mean annual temperature at study site increased 0.45°F decade^{-1}



http://uanews.org/story/warming-climate-pushes-plants-up-the-mountain

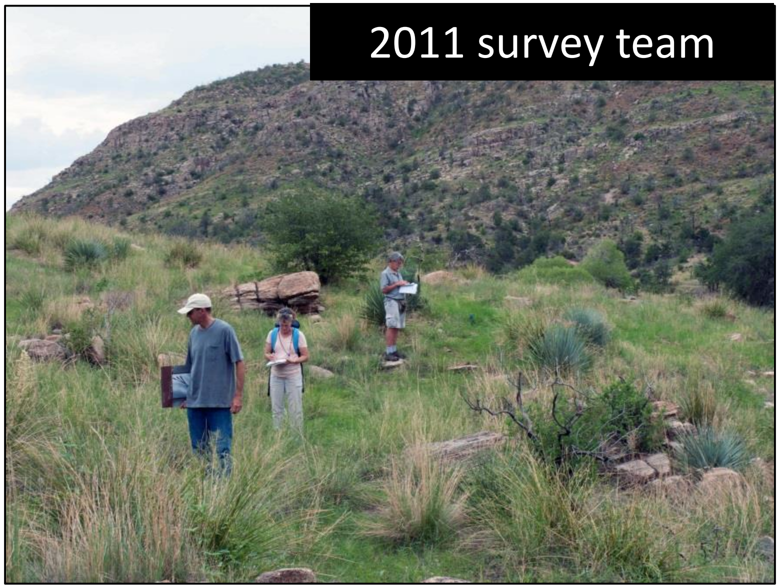
New Weed Threats Will Arise

Range Shifts in Natural Environments

- Results revealed large changes in elevation of common montane plants.

- Elevation changes were species-specific, but, in general, plant species showed significant upward movement of lower elevation boundaries.

Ecology & Evolution 3:3307-3319



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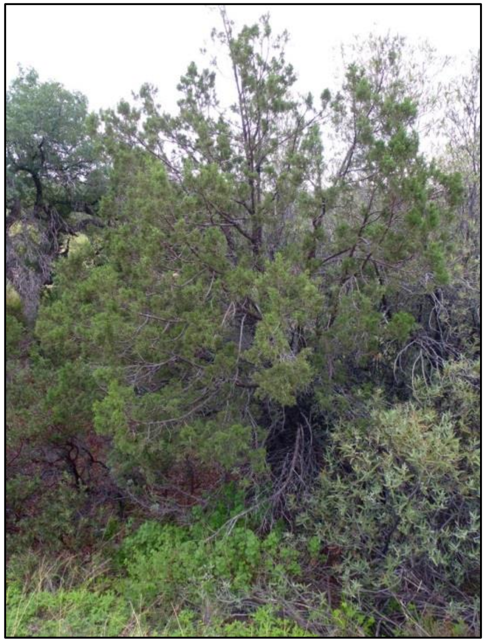
New Weed Threats Will Arise
Range Shifts in Natural Environments

Alligator juniper (*Juniperus deppeana*) elevation shifts on Santa Catalina Mountains

- 1963 – first found at 3000 ft
- 2011 – first found at 5000 ft

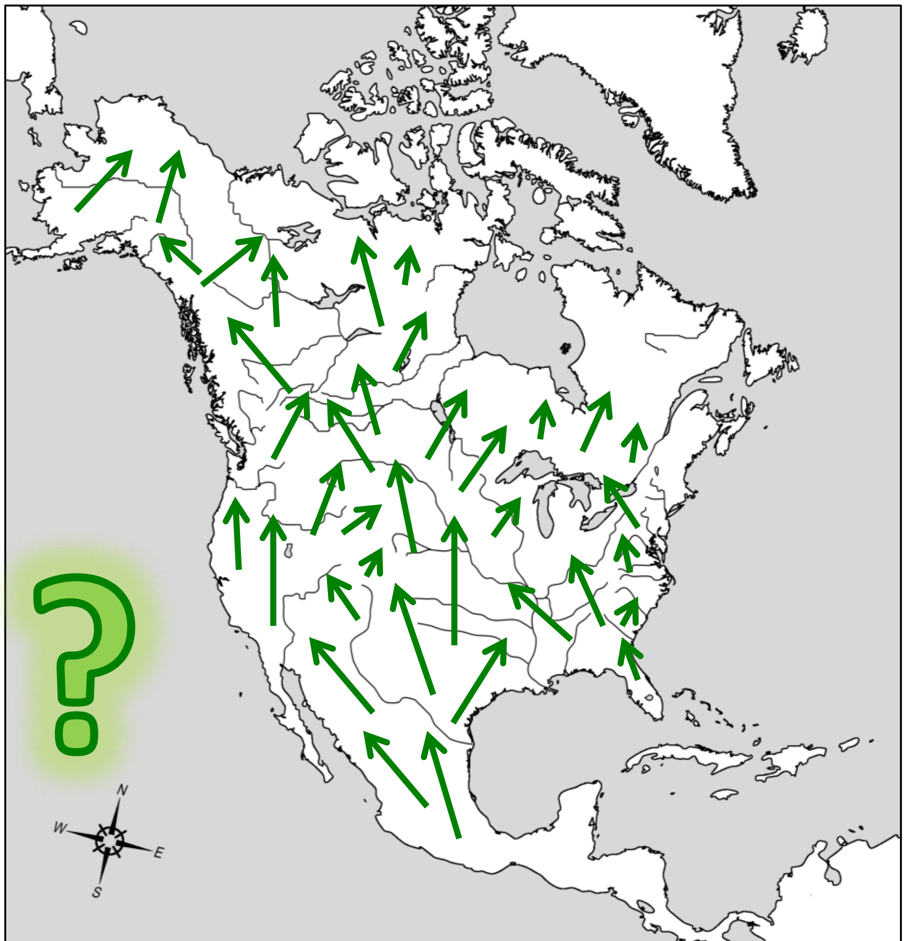


In 2011, alligator junipers first appeared at 5000 feet.

Below 5000 feet, hundreds of dead alligator junipers, reflecting the cooler conditions of the past

Ecology & Evolution 3:3307-3319

New Weed Threats – *Difficult to Predict*



Bioclimatic Niche Modeling

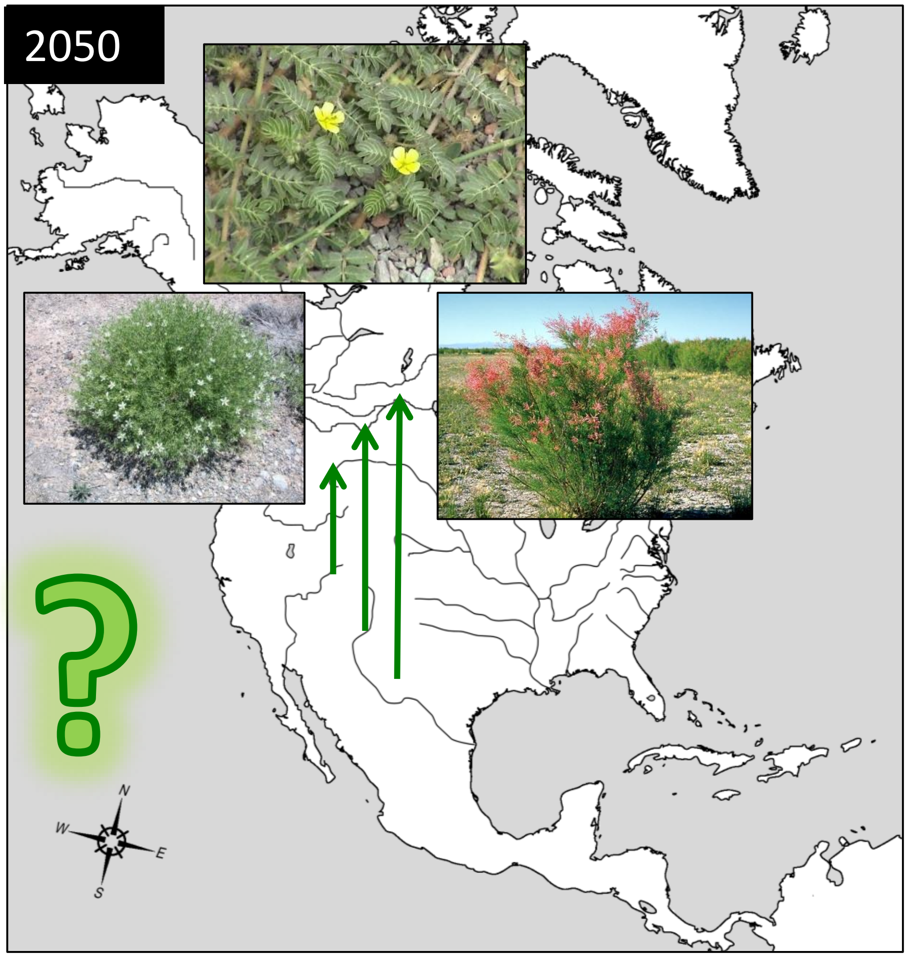
Niche – optimum environment for growth, reproduction and survival

- Soil characteristics
- Competition
- Climate

Bioclimatic niche – area where climate is suitable for a species

https://s-media-cache-ak0.pinimg.com/originals/a6/c8/d9/a6c8d9646865cd9cc7fc13ee26d26597.jpg

New Weed Threats – ***Difficult to Predict***



http://www.colostate.edu/Dept/CoopExt/Adams/ag/image/puncturevine.jpg

http://weeds.nmsu.edu/factsheet.php?weed_id=57

https://www.blm.gov/style/medialib/blm/wy/programs/invasiveplants/pics.Par.4155.Image.432.310.1.gif

BIOCLIMATIC NICHE MODELING

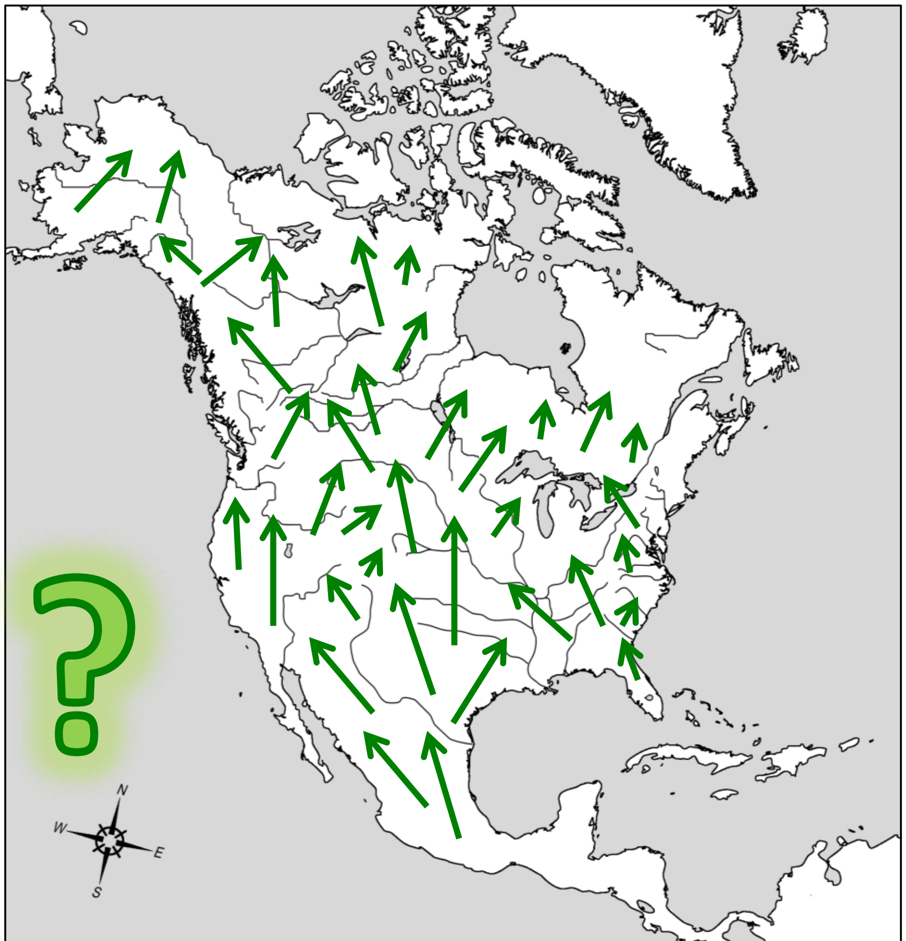
Example: Alberta in 2050 is expected to have suitable habitat for

- African rue
- puncturvine
- saltcedar

Models do not account for:

- Edaphic factors
- Competition
- Evolutionary change
- Climate change effects on management

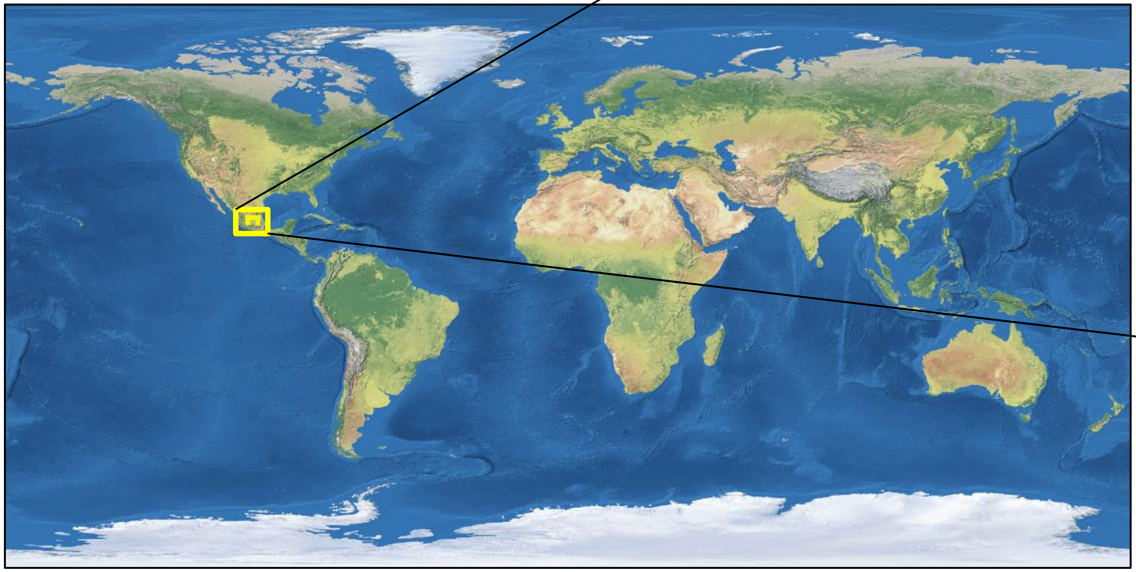
New Weed Threats – <u>*Difficult to Predict*</u>



General consensus:
Rising temperatures will cause species range boundaries to be moved further toward the poles

https://s-media-cache-ak0.pinimg.com/originals/a6/c8/d9/a6c8d9646865cd9cc7fc13ee26d26597.jpg

New Weed Threats – *Difficult to Predict*



Physalis patula Mill.
Agricultural weed in Mexico

Could it become a problem in New Mexico?

Maybe – Worth consideration

Weeds of Mexico website:
http://www.conabio.gob.mx/malezasdemexico/2inicio/home-malezas-mexico.htm

Climate Change Effects on Weeds and Weed Management

1. **The effectiveness of weed control tactics will change**
2. Existing weed threats may get worse
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Change in Weed Control Outcomes

- Climate change is expected to influence efficacy of:
  - Mechanical weed control
  - Herbicides
  - Biocontrol

Change in Weed Control Outcomes
Mechanical Weed Control

- Warmer temperatures accelerate growth and development of seedlings *Weed Science* 51:869-875
- Elevated CO_2 stimulates:
  - Tiller production in grasses *New Phytologist* 150:261-273
  - Root growth *Plant, Cell & Environment* 15:749-752
  - Leaf growth, especially in C3 plants *Global Change Biology* 5:807-837

Change in Weed Control Outcomes
Mechanical Weed Control

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Plants where the initial steps in photosynthesis builds a three-carbon compound.

Change in Weed Control Outcomes
Mechanical Weed Control

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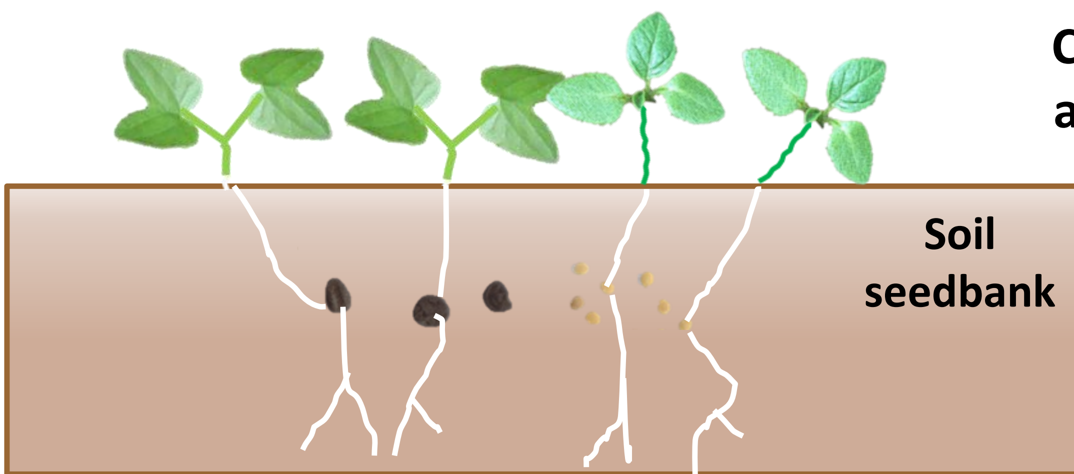
Mechanical controls are most effective against seedlings



Climate change accelerates the clock!

Change in Weed Control Outcomes

Herbicides

Mode of Action	Example	Hypothesized response to increases in CO_2 and temperature[1]
Photosynthetic inhibitor	Atrazine Bentazon	Increased efficacy
Pigment inhibitor	Clomazone Flumioxazin	Increased efficacy
Amino acid inhibitor	Glyphosate	Decreased efficacy[2]

[1] *Agriculture, Ecosystems and Environment* 231:304-309

[2] Supported by data

Change in Weed Control Outcomes
Herbicides

- Glyphosate efficacy is reduced under increased CO_2
  - Common lambsquarters and other C3 annual weeds
    Weed Science 47:608-615; *Crop Science* 46:1354-1359
  - Quackgrass *Australian Journal of Plant Physiology* 27:159-166
  - Canada thistle *Weed Science* 52:384-388

Change in Weed Control Outcomes
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Canada thistle responses to elevated CO_2
- Increase allocation to roots
- Reduced glyphosate efficacy

2-yr underground growth of Canada thistle ←

https://www.btny.purdue.edu/Pubs/WS/CanadaThistle/CanadaThistle.html

Change in Weed Control Outcomes
Biocontrol

Climate change affects[1]:

- Temporal and spatial synchrony between biocontrol agents and invasive plants
- Location cues for biocontrol agents
- Nutrition for biocontrol agents

[1] USDA Forest Service RMRS-GTR-285. 2012

Change in Weed Control Outcomes

Biocontrol

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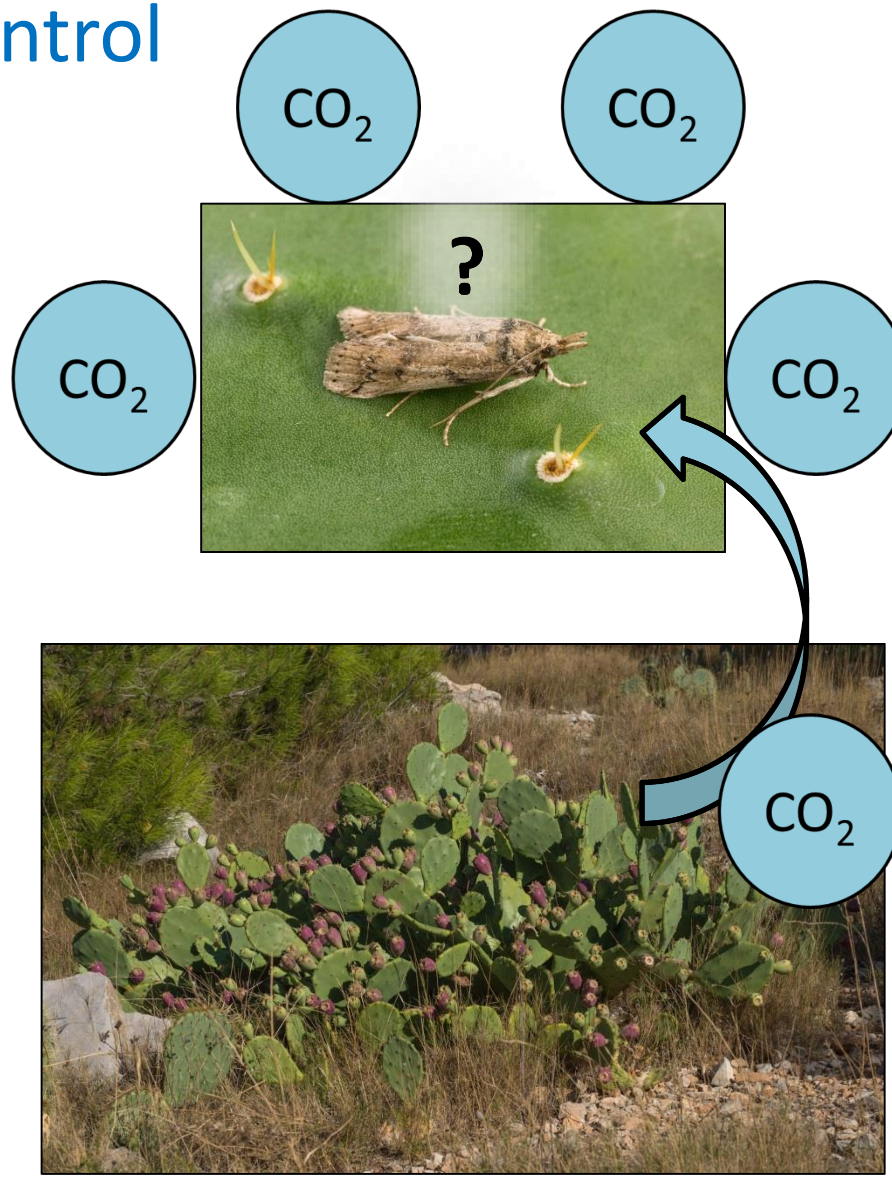
Biocontrol of prickly pear cactus in Australia



https://commons.wikimedia.org/w/index.php?curid=30044580

https://commons.wikimedia.org/w/index.php?curid=1214897

Oecologia 102:341-352

Change in Weed Control Outcomes

Biocontrol

Biocontrol of field bindweed with gall mites

icultural Research Service, Bugwood.org

How does increased temperature, altered precipitation and elevated CO_2 affect gall mite biocontrol of bindweed?

Howard F. Schwartz, Colorado State University, Bugwood.org

Bob Hammon, Colorado State University, Bugwood.org

Managing Aceria malherbae Gall Mites for Control of Field Bindweed
NMSU Cooperative Extension Service Circular 600

Climate Change Effects on Weeds and Weed Management

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Climate Change Effects on Weeds and Weed Management

- What can be done?
  - Scout for new weed threats
    PROMPT ACTION IS CRITICAL
  - Monitor growth of problem weeds
  - Evaluate weed control outcomes
    DON'T ASSUME THAT TACTICS WILL REMAIN EFFECTIVE
  - Be prepared for weed control following extreme precipitation events