

The Colorado River Basin States  
Cooperative Weather Modification Programs  
and  
Study of Tamarisk Evapotranspiration at the  
Cibola National Wildlife Refuge

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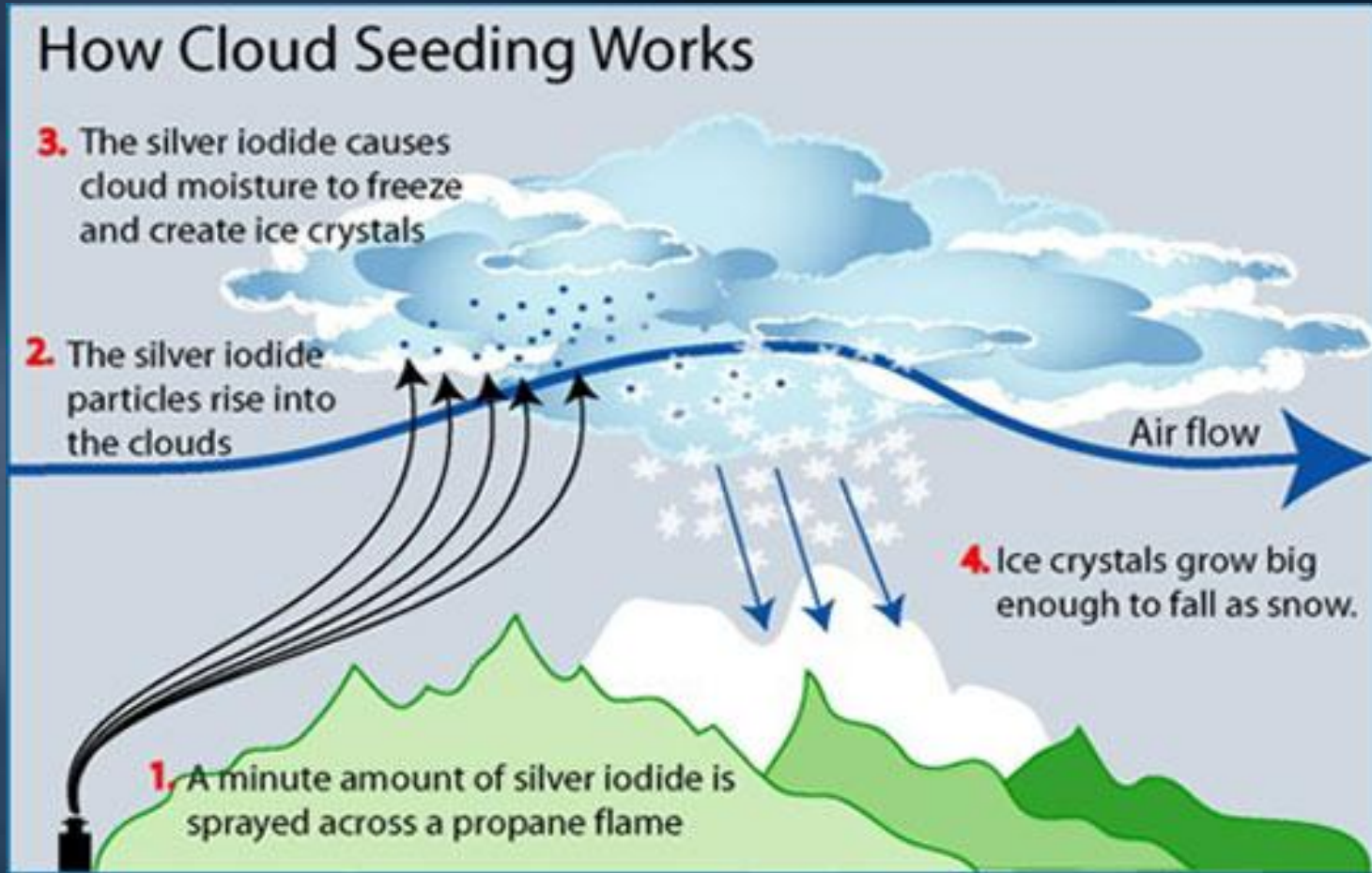
Grand Junction, Colorado

November 5, 2014

# Presentation Outline

- Weather Modification Programs
  - Agreements and Funding
  - 2006-14 Operations
  - Conclusions and Next Steps
- Tamarisk Evapotranspiration Study
  - Background and Objectives
  - Study Methods
  - Results and Conclusions

# Winter Conceptual Model



# Agreements

- Principles

- Among Lower Basin and CO, UT, WY
- Local control, regulatory safeguards
- Local, regional, basinwide benefits
- Yield is Colorado River system water

- Mechanics

- Cost-shared, maintain local funding
- Data sharing, deliverables

# Lower Basin Funding

(dollars, actual)

- 2006 - 45,000
- 2007 - 117,562
- 2008 - 246,965
- 2009 - 306,465
- 2010 - 356,334
- 2011 - 394,526
- 2012 - 399,869
- 2013 - 430,470
- 2014 - 448,950

Equal contributions by  
AZ, CA, NV

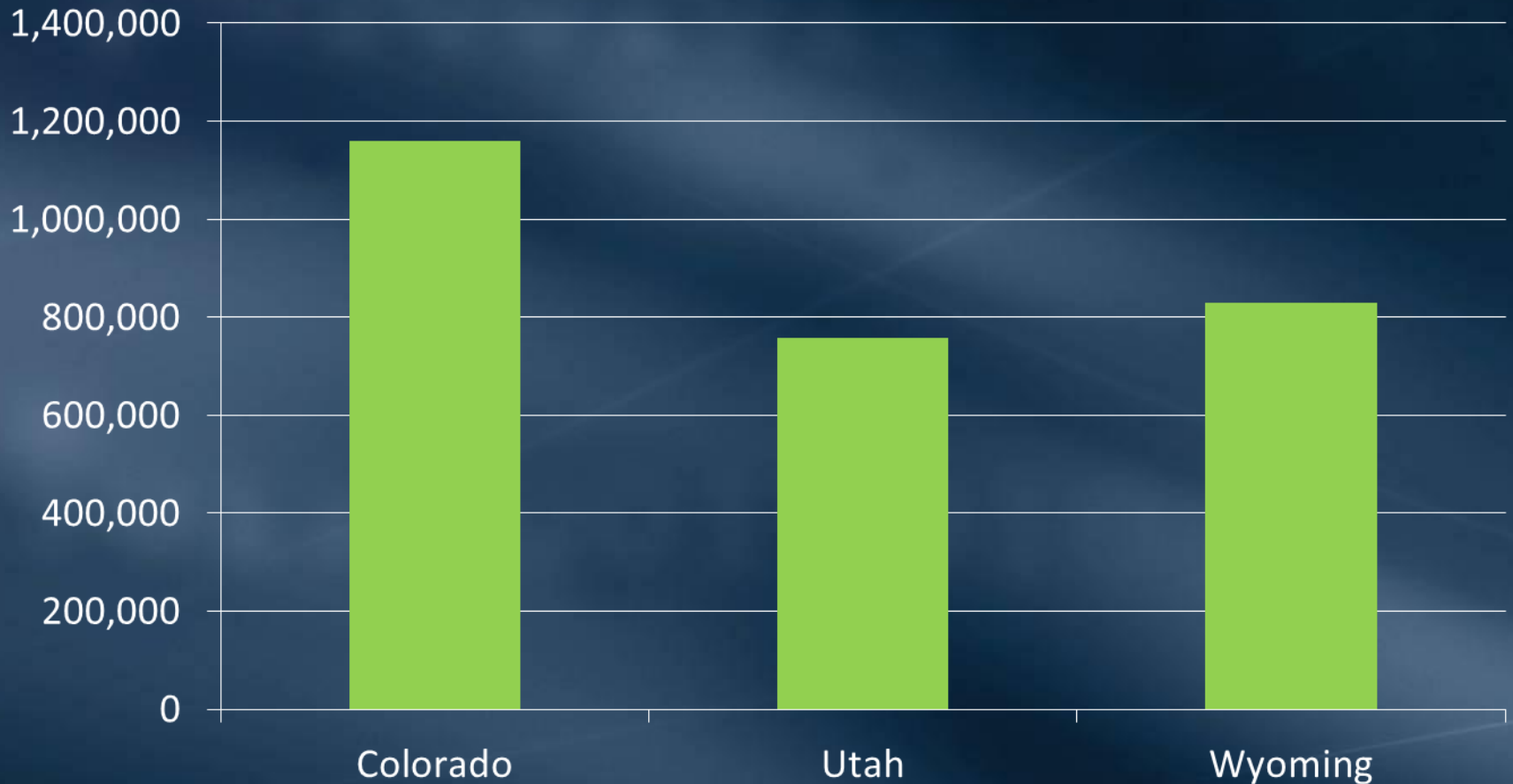
Total Lower Basin =  
**\$ 2,746,141**

- 2015 - 760,000  
(proposed)

# Locations of Expenditures

Totals by State 2006-2014

Dollars



# Target Areas



# Recent Activities

- Utah

- 6 new propane tanks and trailers
- 3 icing rate sensors

- Wyoming

- Instrumentation and Modeling
  - Radiometer and generator leases
  - K-band radar, ceilometer
  - Cloud particle imager
  - High-resolution Agl plume dispersion
  - WRF-Hydro modeling

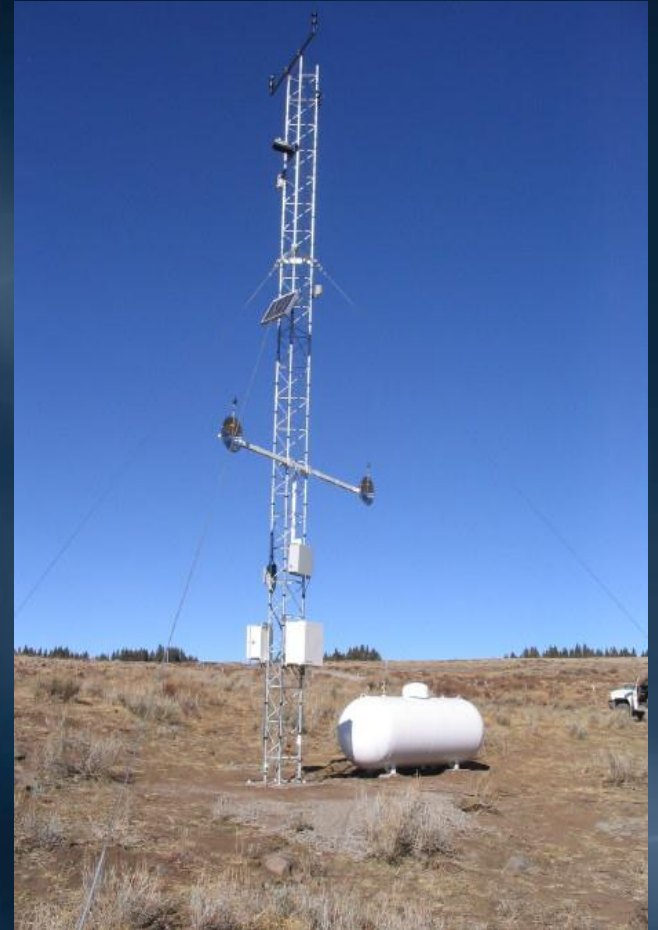


# Recent Activities

- Colorado
  - New Project
    - Central Mountains
  - Instrumentation
    - 4 WX stations: Telluride, Durango, Vail, C-Butte
    - Icing sensor Gunnison
    - 4 new generators in San Juans
  - Target/Control Evaluations Statewide

# Grand Mesa

- 2 new generators, 1 liquid propane, WX, icing
- Technology transfer



# Next Steps - Long-Term Plan

- Additional 1,000,000+ AF yield
- NCAR and DRI big picture review
- Flexible menu of activities
- Incremental expansion
- Optimization
  - Evaluate, refine programs
- Success with grass-roots, local leadership
- 2015 - radiometer, new generator design

# Conclusions

- 2015 is 10<sup>th</sup> season
- Total \$3.5 million expenditure
- 20 projects, 15 pieces of equipment
- Collaborating with 30+ partners
- Considering alternatives for Wyoming
- Long-Term Plan provides future options



# Questions?



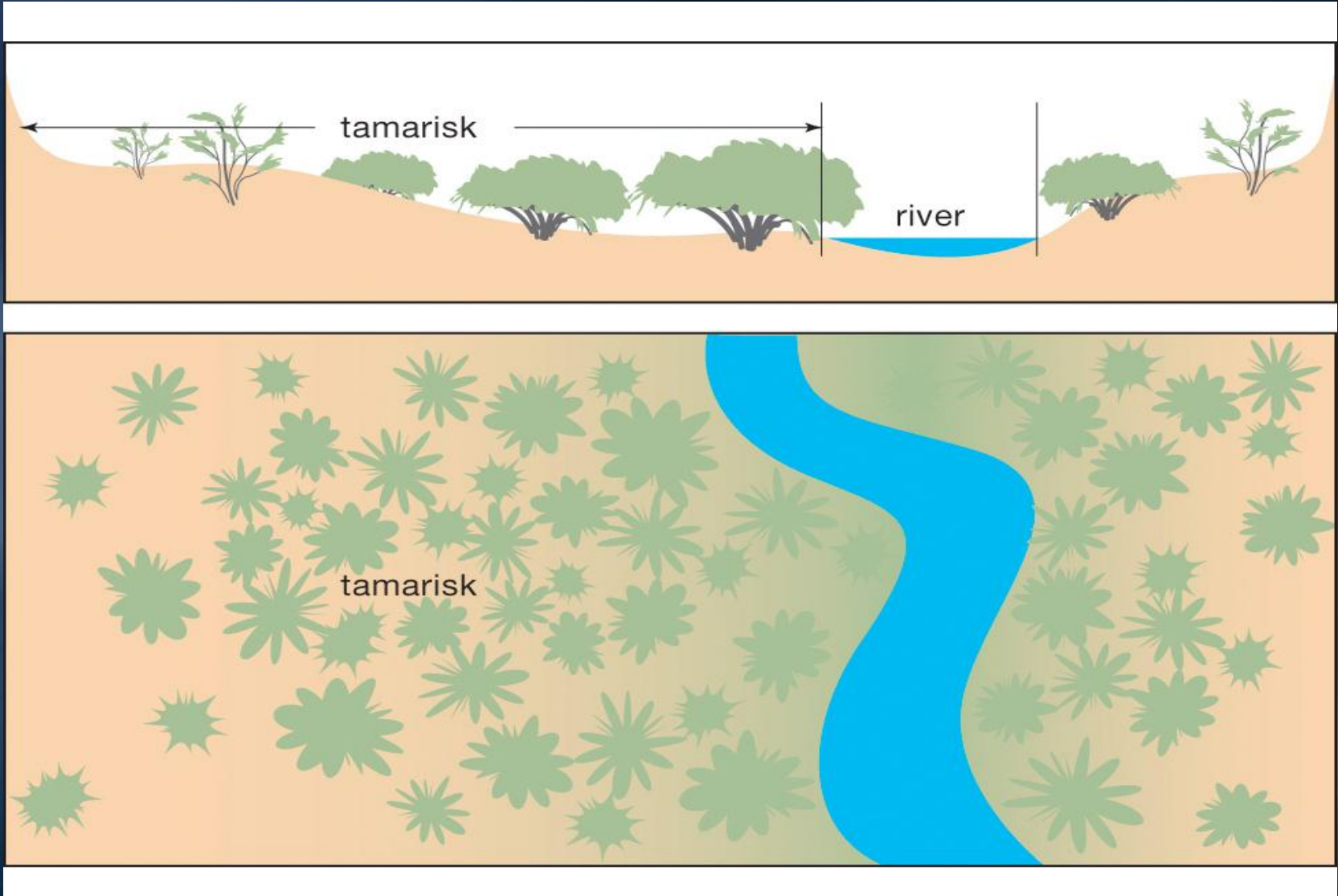
# Study of Evapotranspiration at the Cibola National Wildlife Refuge

- 2009 Colorado River Basin Tamarisk Assessment
  - Can water be saved by managing Tamarisk?
  - Is controlling Tamarisk to save water cost-effective?
  - Can saved water be recovered, i.e. will it appear in the river?

# Funding Partners

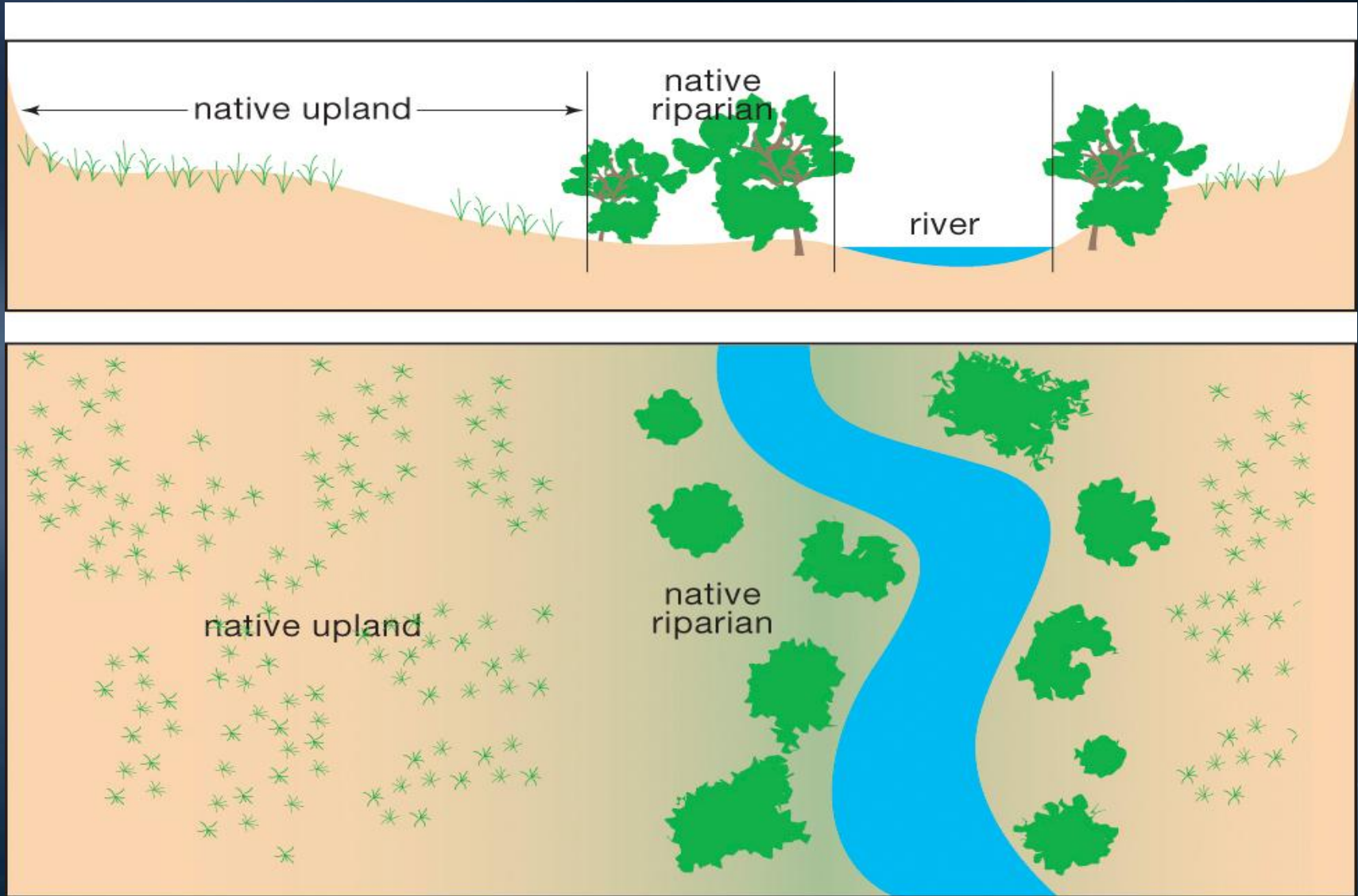
- Central Arizona Project
- Colorado Water Conservation Board
- New Mexico Interstate Stream Commission
- Six Agency Committee of California
- Southern Nevada Water Authority
- Utah Division of Water Resources
- Wyoming State Engineer's Office

# Water Savings Approach (before)





# Water Savings Approach (after)



# Findings

- Basis for further expenditures to begin demonstration, pilot, management
- Normalized basin-wide average
- Savings from ET reduction
  - 1 AF per 1.85 ac. managed (.54 AF/ac.)
- Cost per AF
  - 6 of 7 methods <\$400/AF; (\$260-1,050)
- Water will be saved, amount which might appear in river cannot be predicted

# Study of Evapotranspiration at Cibola

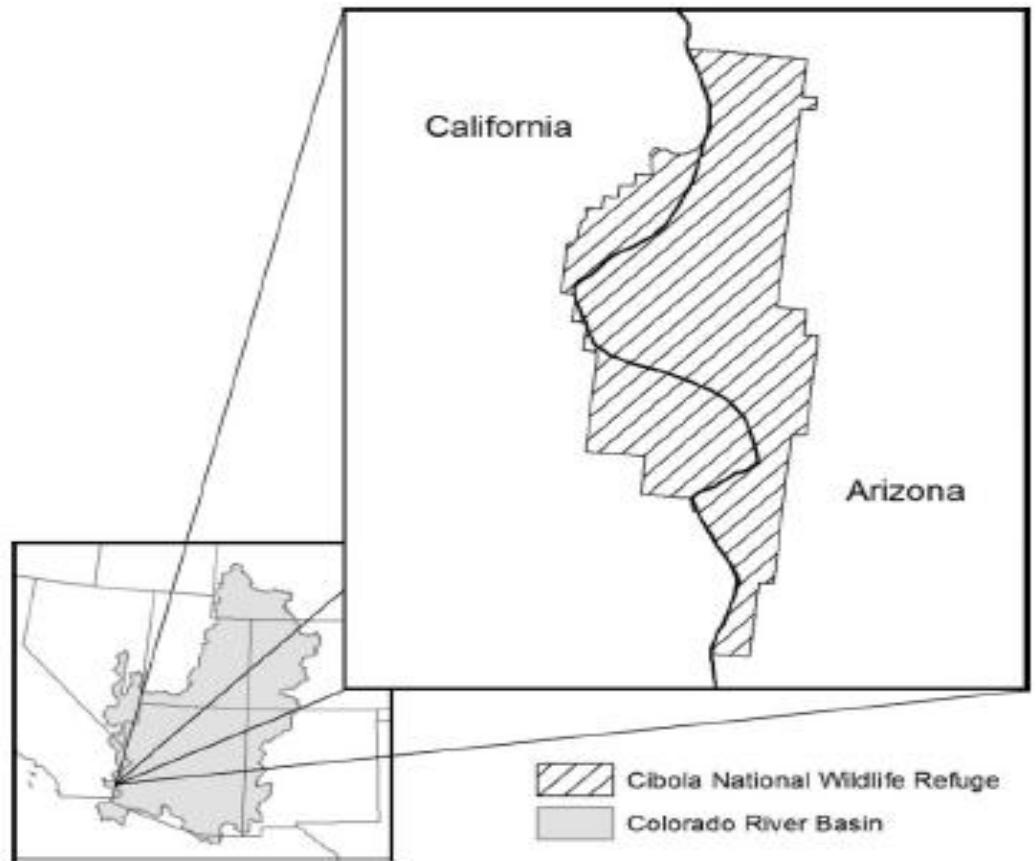
- Background

- "Proof of Concept"
- Contribute to USBR for ongoing academic study of ET fluxes over tamarisk forest
- Baseline data since 2006, fire in 2011

- Basin States Question

- Utah State University
- Does groundwater respond to significant change in ET of surface vegetation
- Consideration of river stage

# Study Area



Source: Utah State University

# Equipment – Slitherin Site

Source: Utah State University

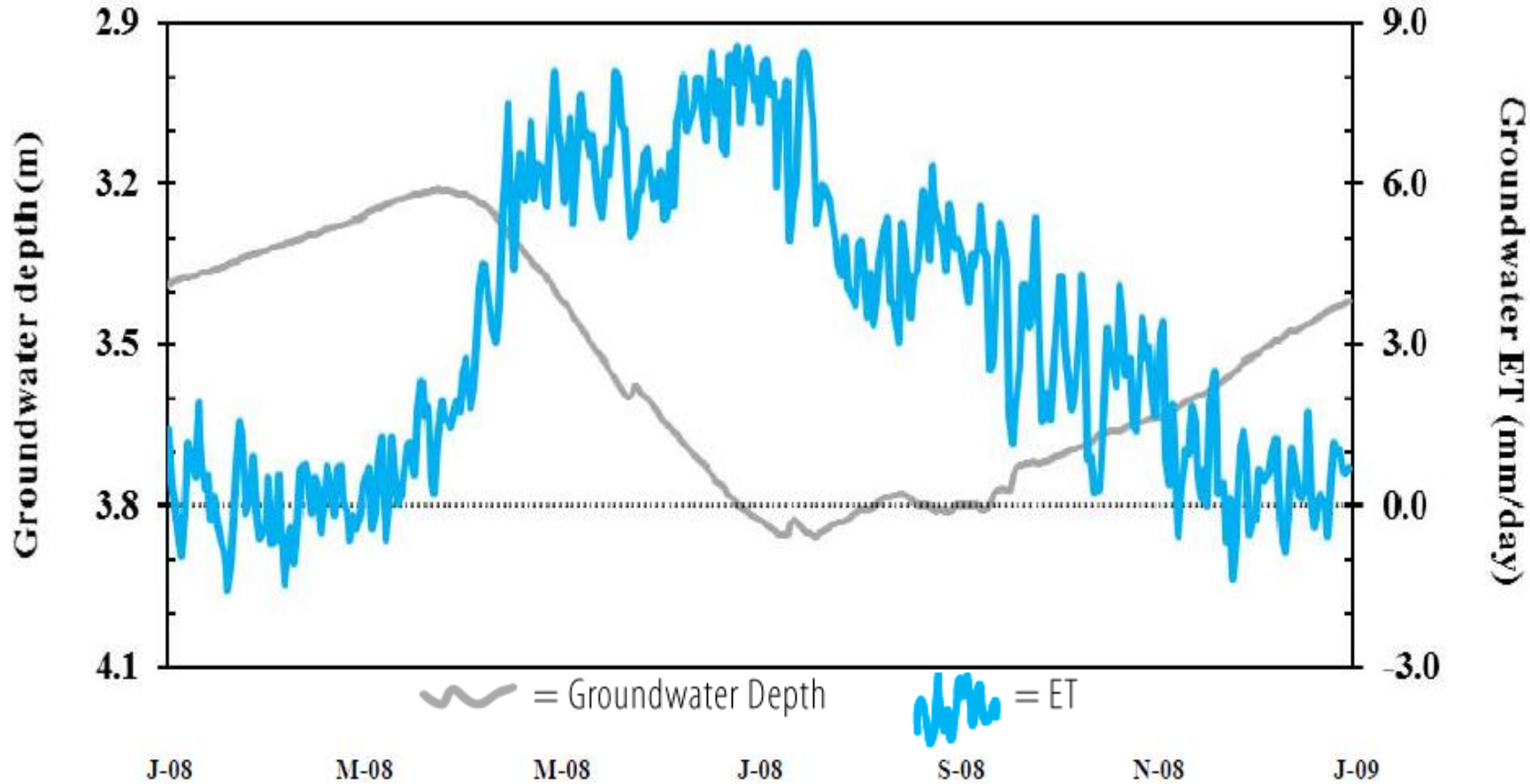


# Methods

- Eddy covariance and Bowen ratio
- Scintillometer
- Airborne multispectral/thermal IR system
- LANDSAT 5
- LiDAR
- MODTRAN algorithm
- Two-source energy balance model
- SEBAL
- Model of groundwater

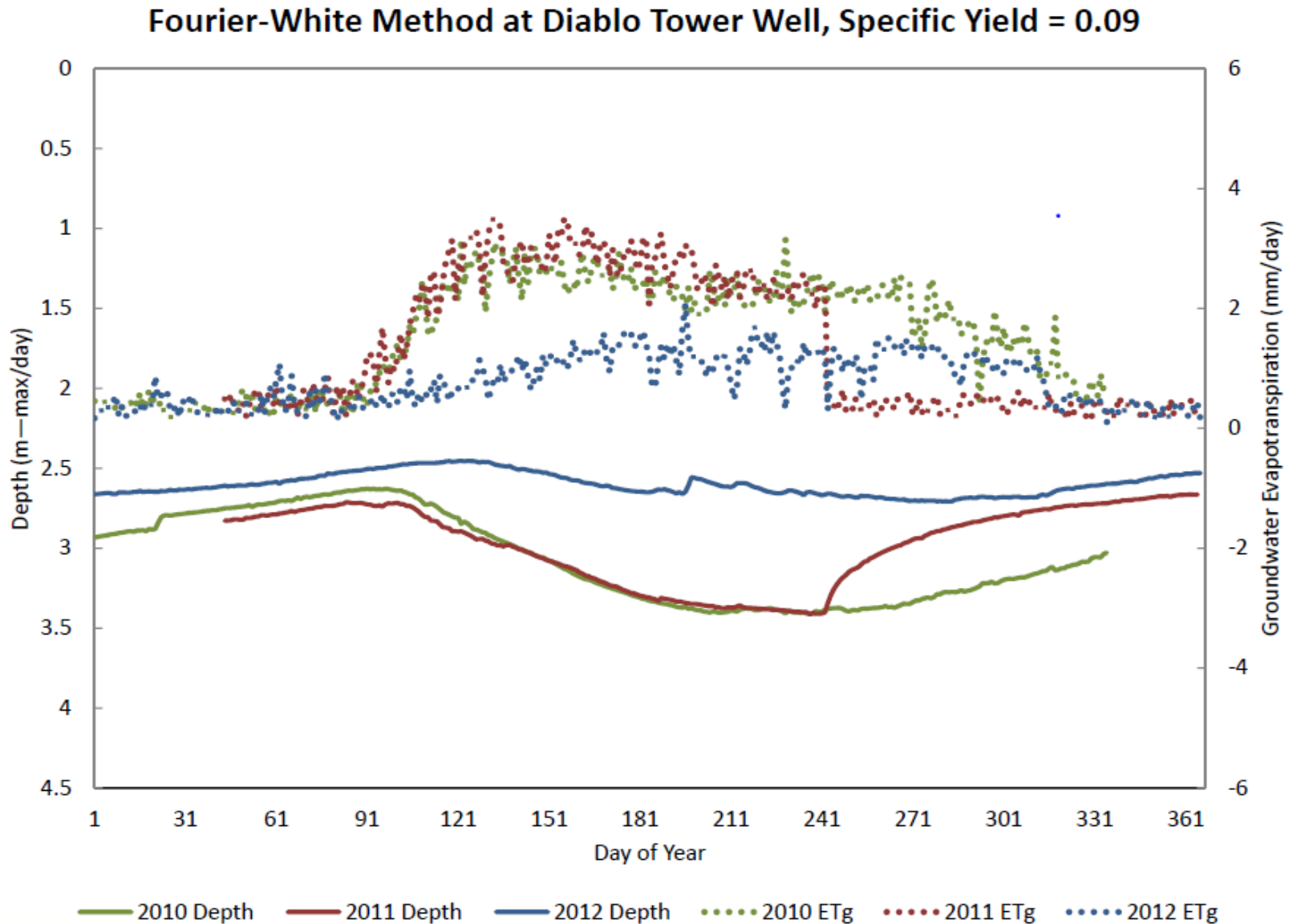
# Baseline – Bowen Ratio/Slitherin

Source: Utah State University



# Results (cont')

Source: Utah State University





# Results

- Consistent results among 3 ET methods
- Consistent behavior between sites pre- and post fire
- Remote sensing of ET with ground truthing can work for large areas
- As ET decreased, groundwater rose
- Recovered to winter level within 60 days
- 2013 (2<sup>nd</sup> year post-fire) groundwater extraction also lower

# Conclusions and Next Steps

- Unaware of another study that demonstrates this connection
- Good site and extreme event was beneficial
- Sets the stage for future water balance work that would quantify the amount made available to the system
- Possible Year 2 work on site or use same method at new potential management sites

# Questions?

