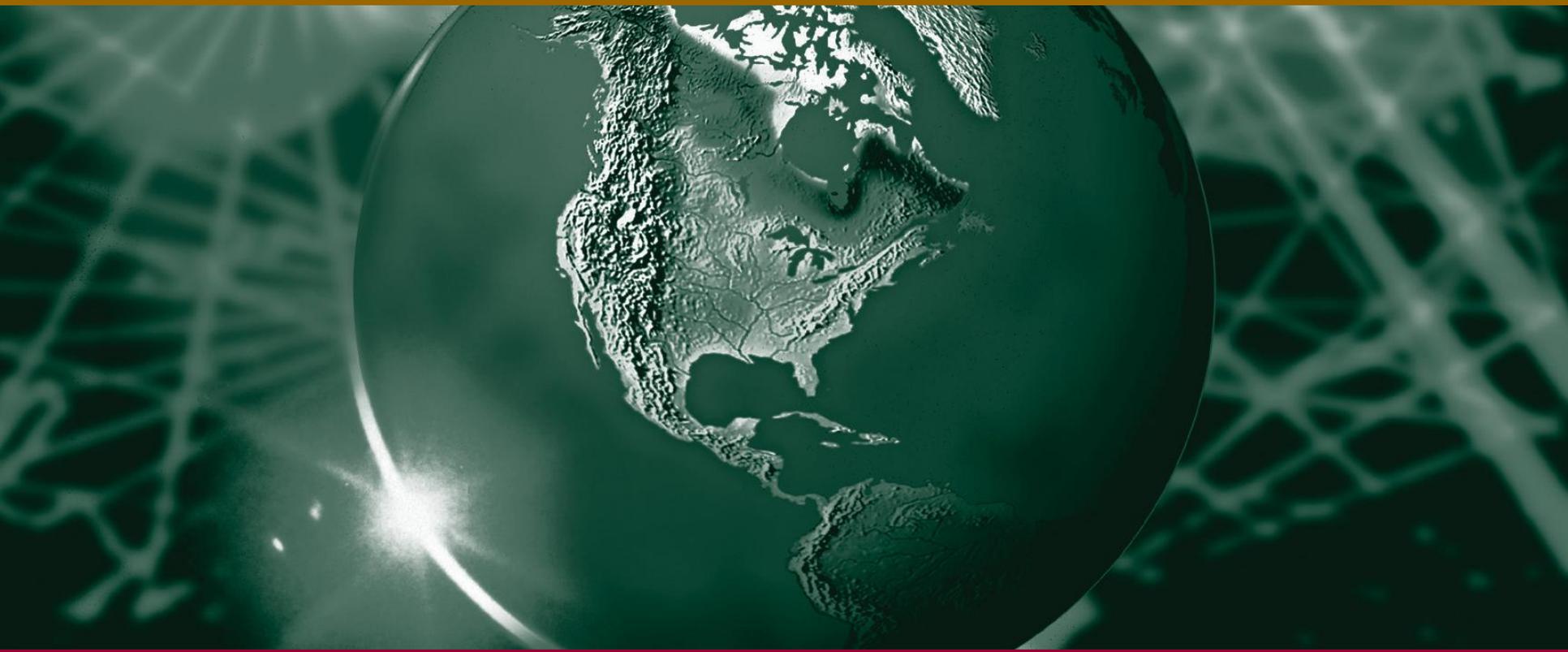


NATIONAL STATES GEOGRAPHIC INFORMATION COUNCIL



**NSGIC**



2105 Laurel Bush Rd.  
Bel Air, MD 21015  
443-640-1075 [www.nsgic.org](http://www.nsgic.org)

NSGIC



# Mapping Evapotranspiration in Idaho with Landsat

William J. Kramber, Idaho Dept. of Water Resources  
in partnership with  
Dr. Richard G. Allen, University of Idaho

Partners and Collaborators: Dr. M. Tasumi, Univ. Miyazaki, Japan; Dr. R. Trezza, Univ. Idaho; Anthony Morse, Spatial Analysis Group; Dr. Jeppe Kjaersgaard, Univ. Idaho; Clarence Robison, Univ. Idaho; Dr. Magali Garcia, Univ. LaPaz, Bolivia; Dr. Wim Bastiaanssen, WaterWatch, Netherlands; Dr. J. Wright, USDA-ARS; Dr. Allan Wylie, IDWR; Morgan Case, IDWR.



# Why is Evapotranspiration (ET) important

- ET is the water consumed by irrigated agriculture
- 3.4 million acres of irrigated agriculture in Idaho
- Over 90% of the water consumed is for irrigation
  
- Important for: water administration, water planning, and hydrologic modeling

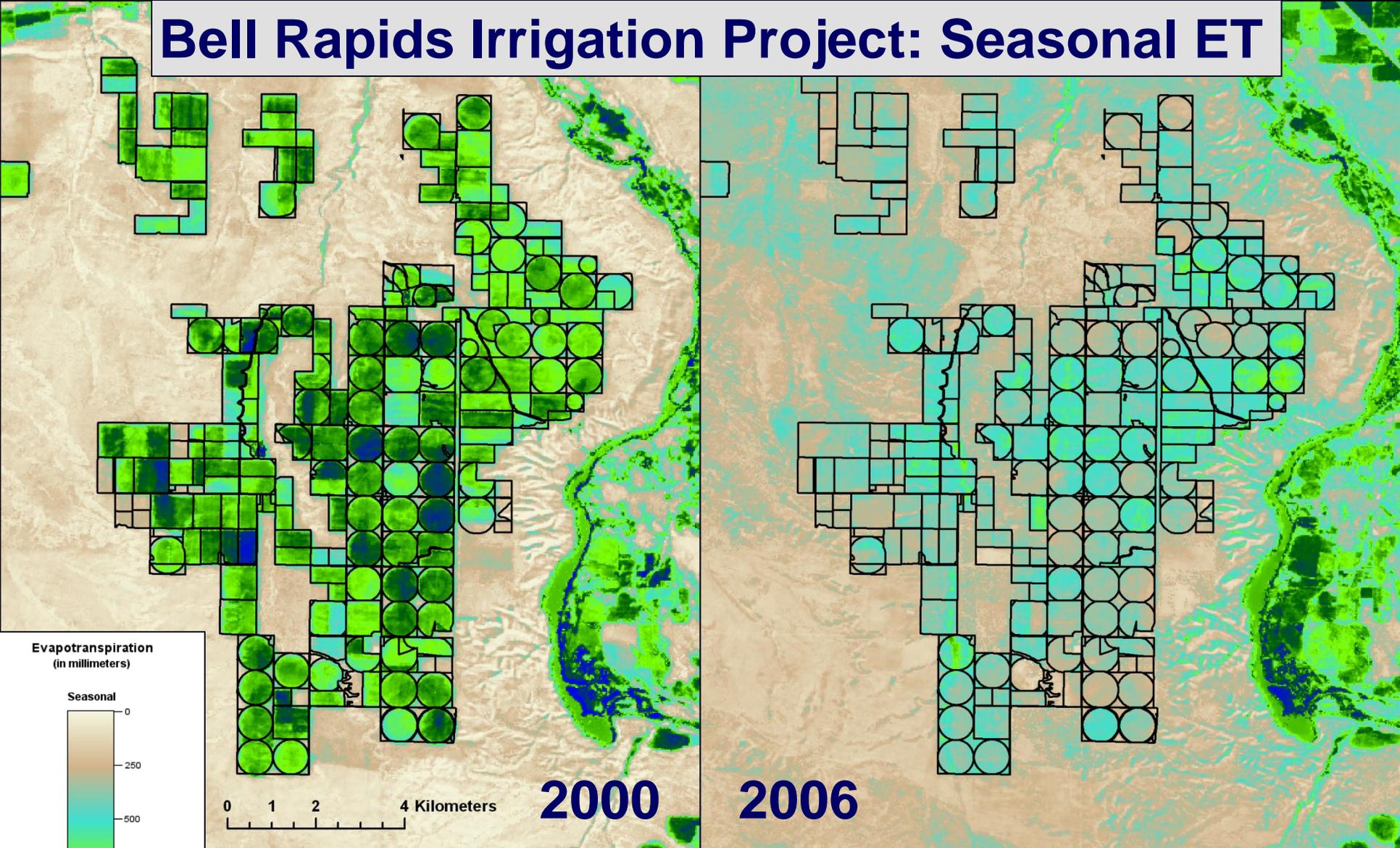
# Ground-based ET

- Potential ET using crop coefficients
  - Needs crop type acres and stage of growth
  - Produces one ET value per county

# Satellite-based ET

- Actual ET from Landsat using METRIC
  - No crop information required
  - ET per pixel can be summed by field

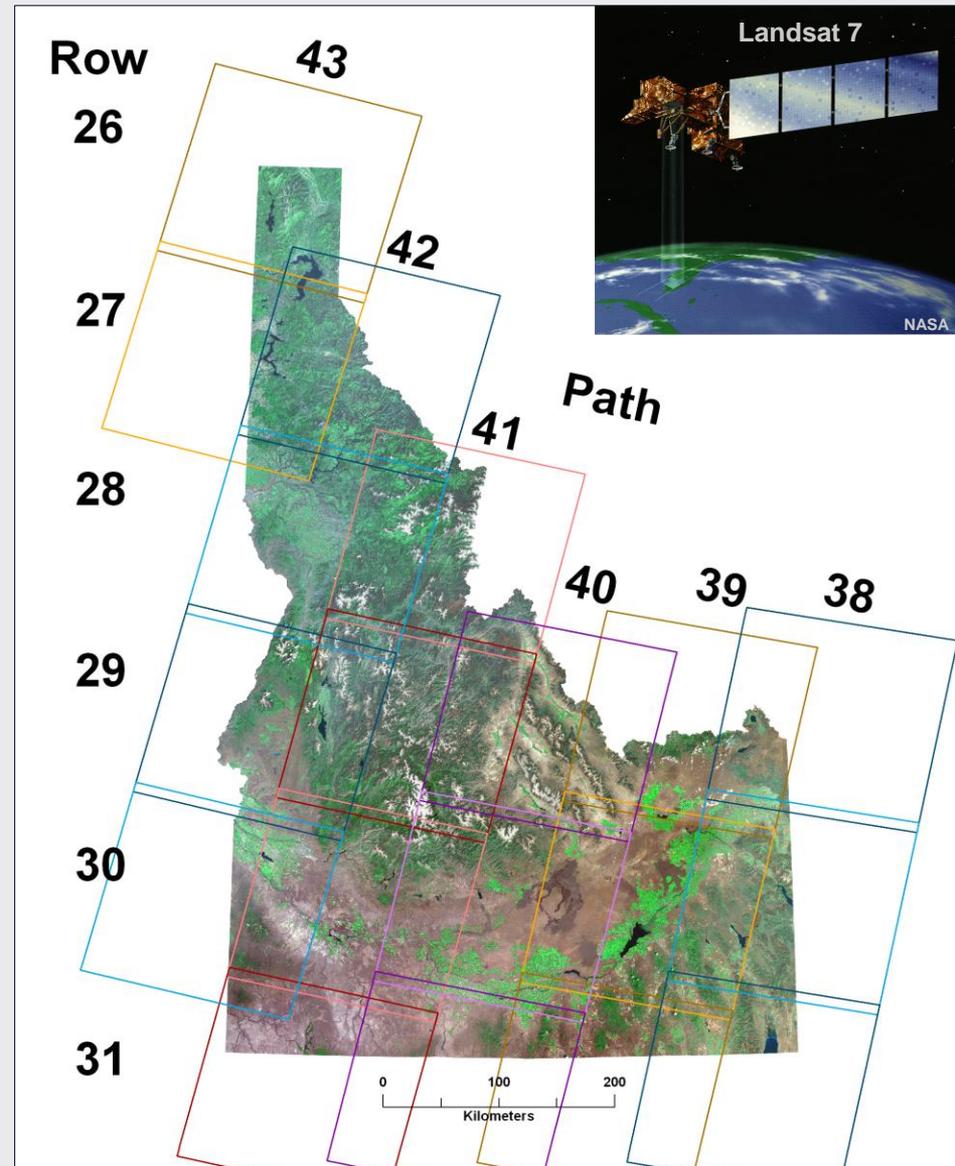
# Bell Rapids Irrigation Project: Seasonal ET



- High lift pumps irrigated 25,000 acres
- State purchased water rights in 2005
- Supports endangered salmon

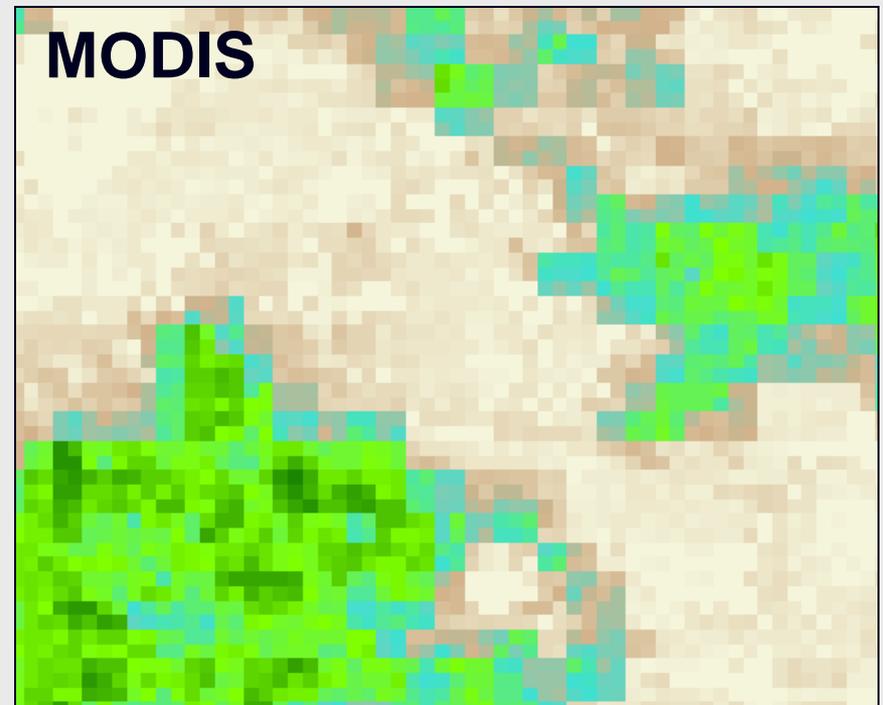
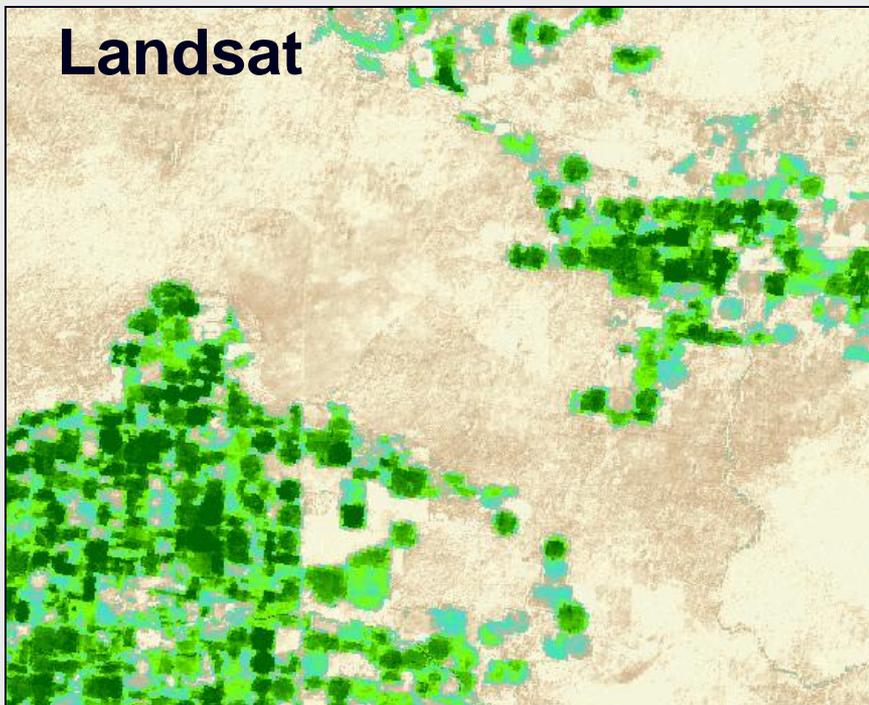
# Landsat

- USGS/NASA mission
- L5 launched 1984
- L7 launched 1999  
(damaged May, 2003)
- 30 meter pixels
- 16 day cycle
- 100 by 100 miles
- *Free*
- Landsat 8 will launch in  
December 2012
- Landsat 9?



# Why not use other satellites

- MODIS: 500 meter pixels
- AVHRR: 1000 meter pixels
- SPOT: no thermal band
- IRS AWiFS: no thermal band
- Aster: for research



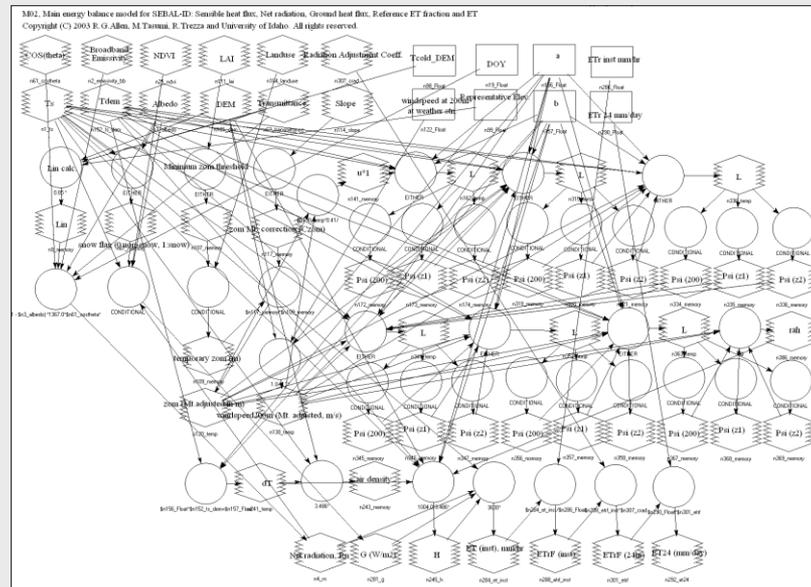
# Landsat Thermal Band

- Required for surface temperature
- Landsat is the only **operational** satellite with a “**thermal band**” and a pixel size small enough to map ET for **individual fields!**

# METRIC

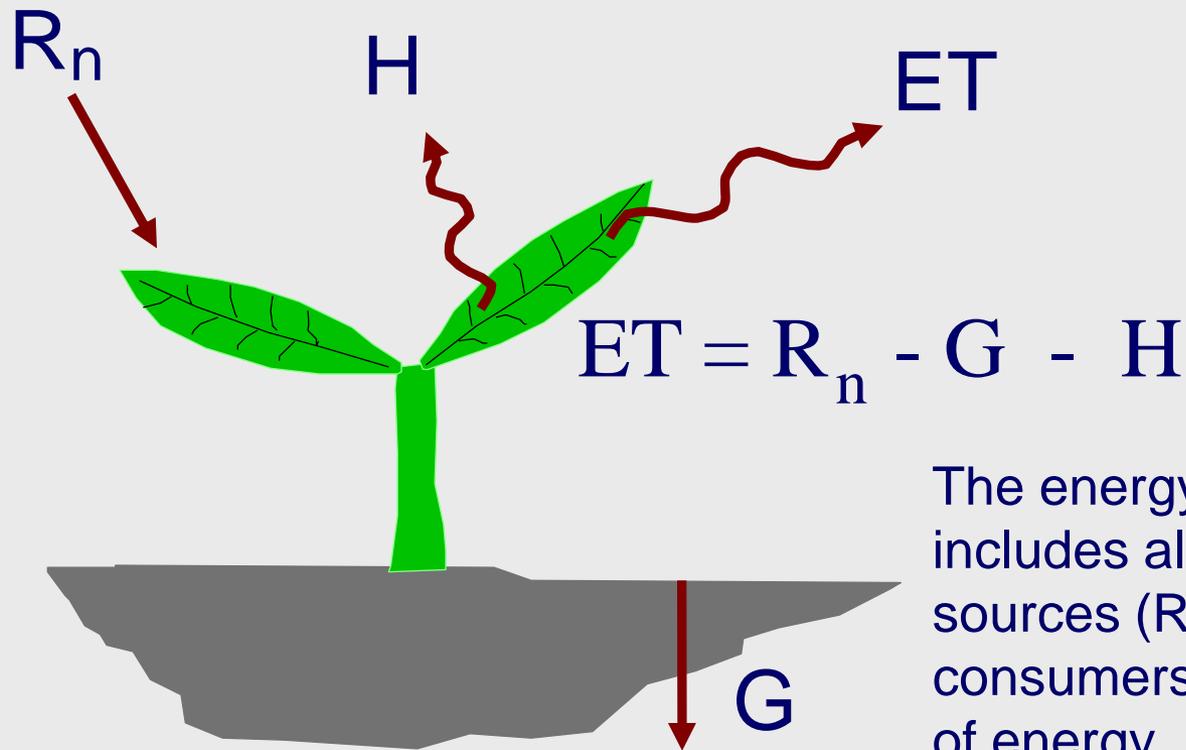
## Mapping EvapoTranspiration at high Resolution with Internalized Calibration

- Satellite-based energy balance model that computes and maps actual ET
- Internalized Calibration ties down ET to weather data



# Energy Balance for ET

- ET is calculated as a “residual” of the energy balance



The energy balance includes all major sources ( $R_n$ ) and consumers ( $ET$ ,  $G$ ,  $H$ ) of energy

# Energy balance computes “actual” ET

Can ‘see’ impacts on ET caused by:

- water shortage
- disease
- crop variety
- planting density
- cropping dates
- salinity
- management



# Weather Data

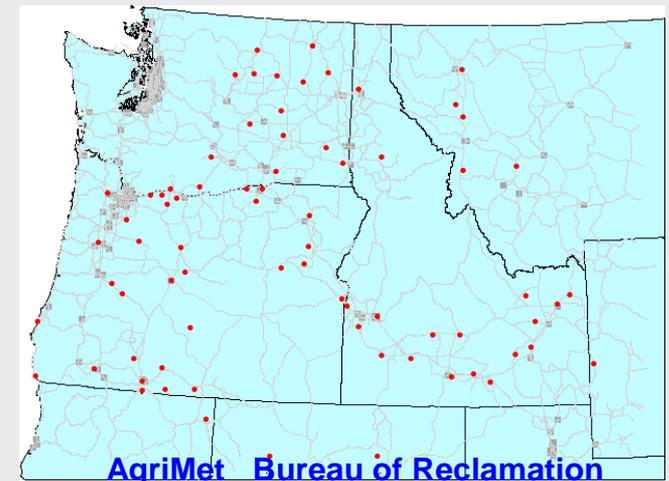
In METRIC, Weather Data are used for:

Wind speed for sensible heat flux calculation

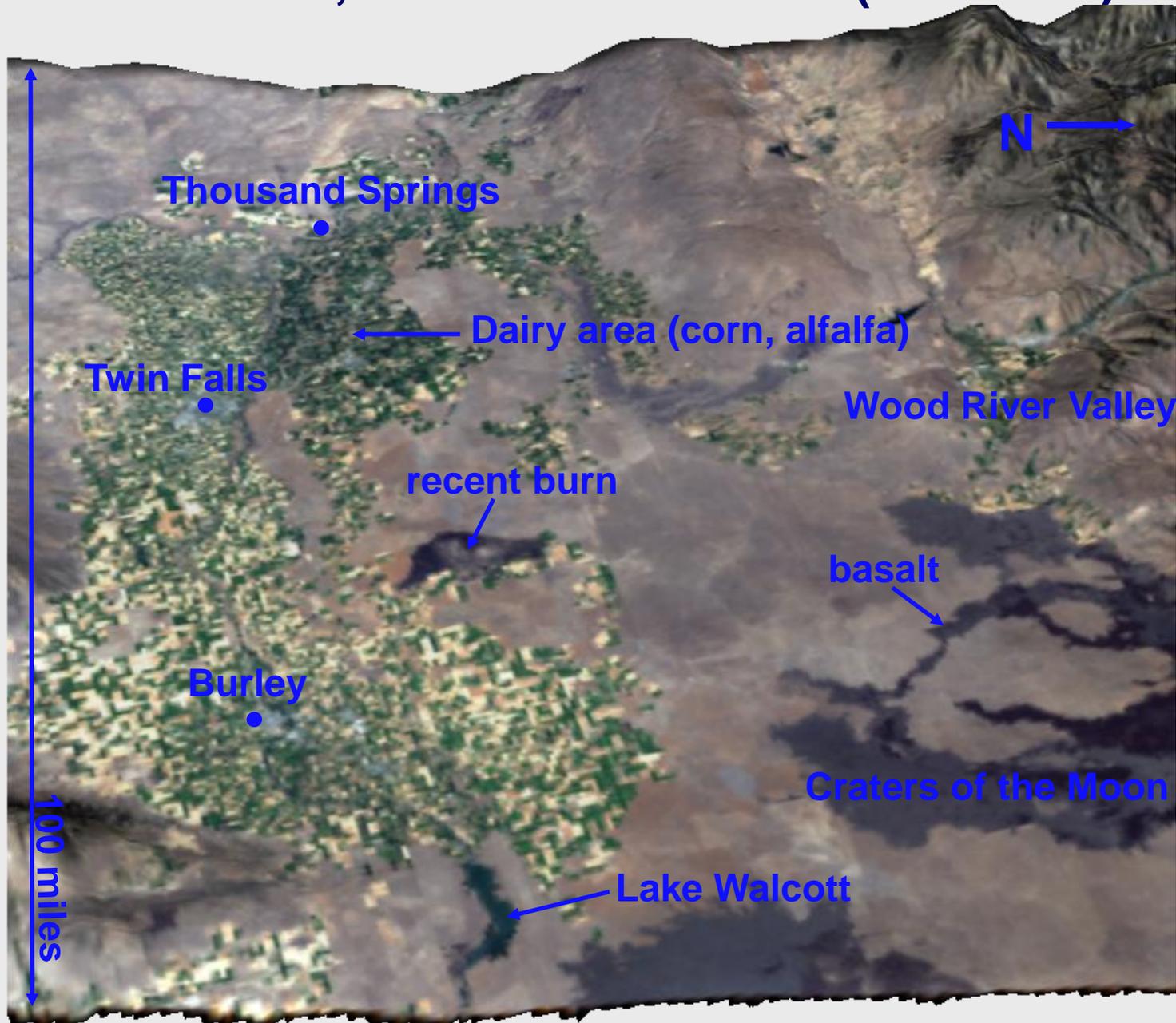
Reference ET for calibrating the Energy Balance

Reference ET to extrapolate ET

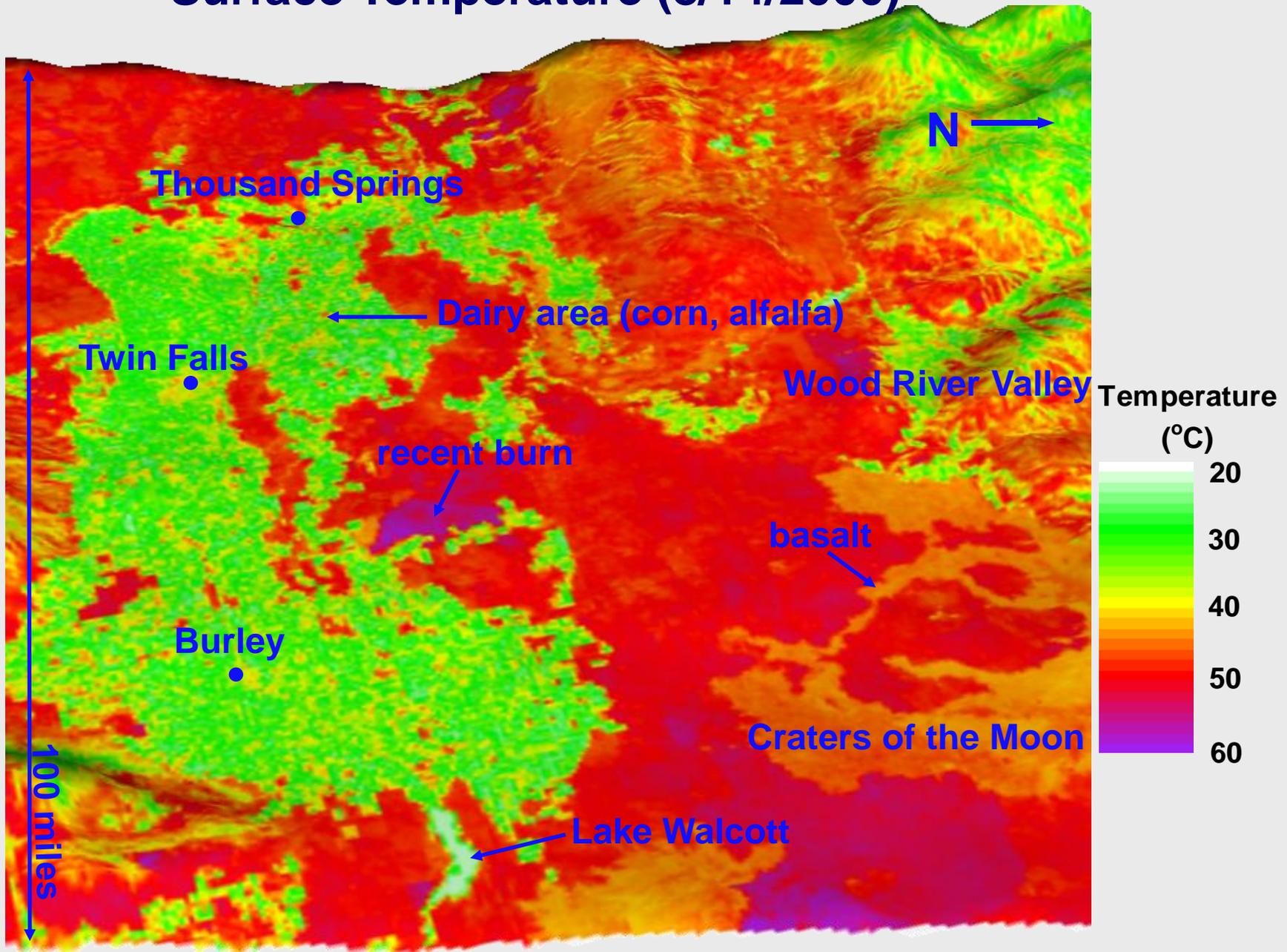
- 24-hour period
- Days between images



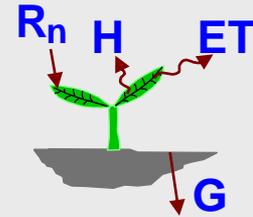
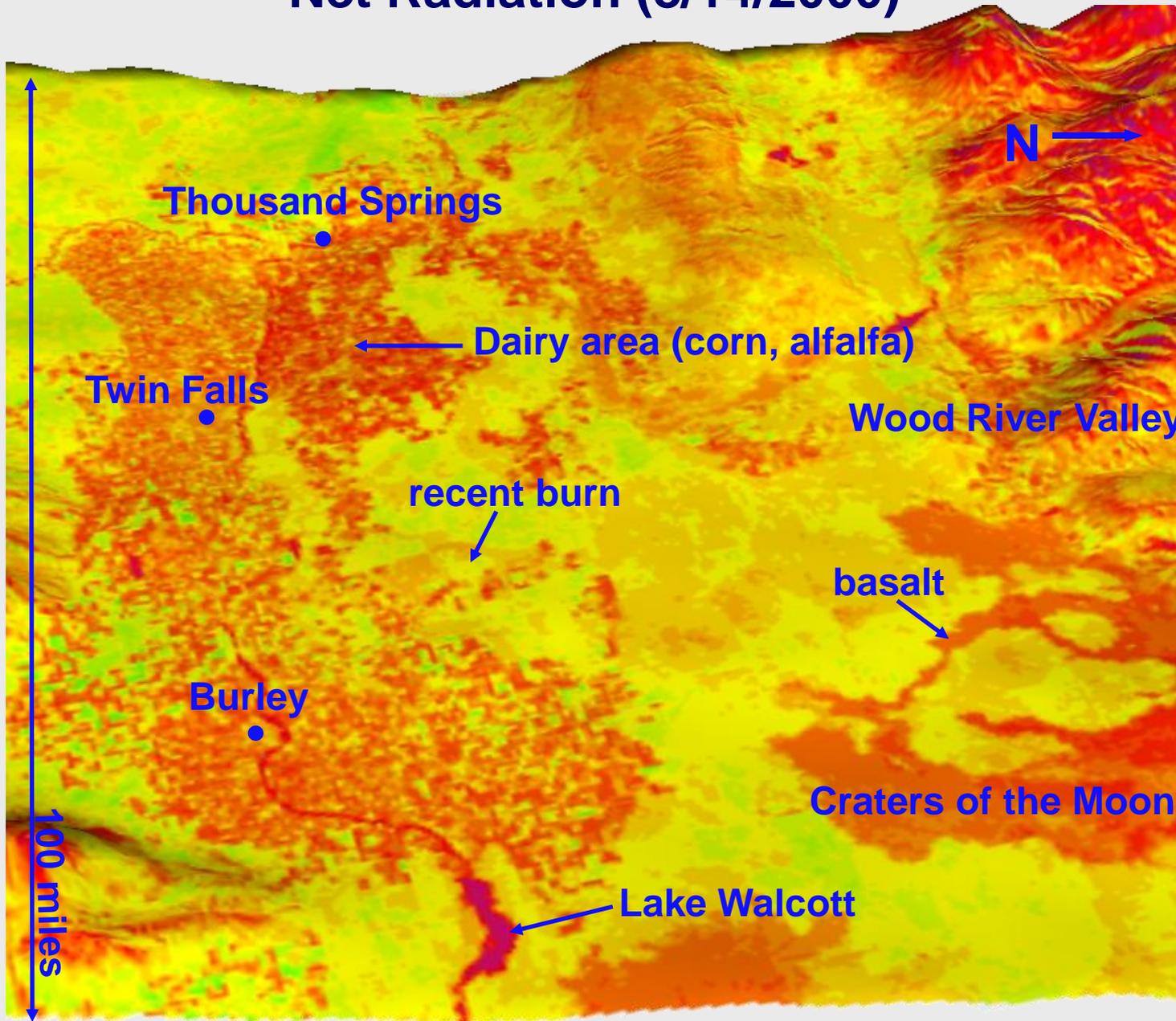
# Landsat, south-central Idaho (8/14/2000)



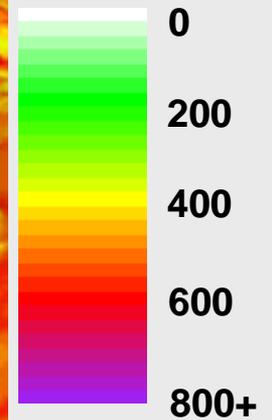
# Surface Temperature (8/14/2000)



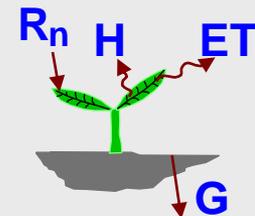
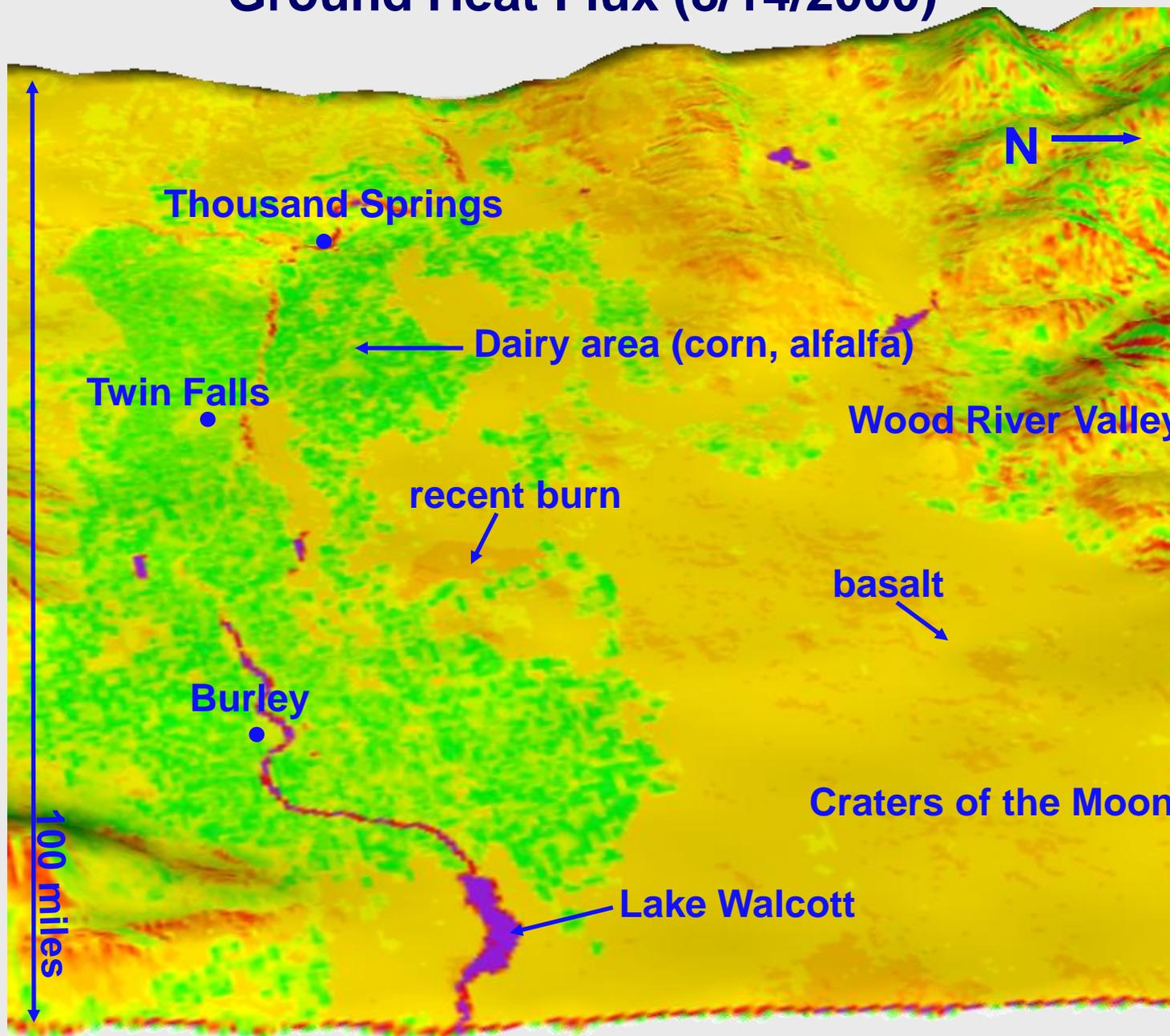
# Net Radiation (8/14/2000)



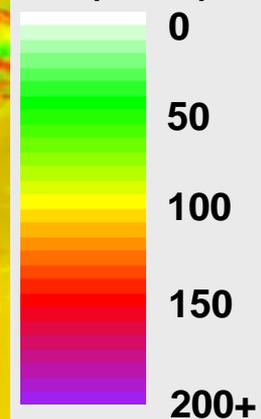
Net Radiation  
( $W/m^2$ )



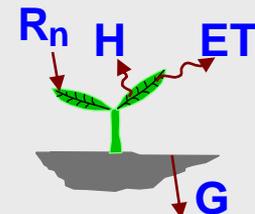
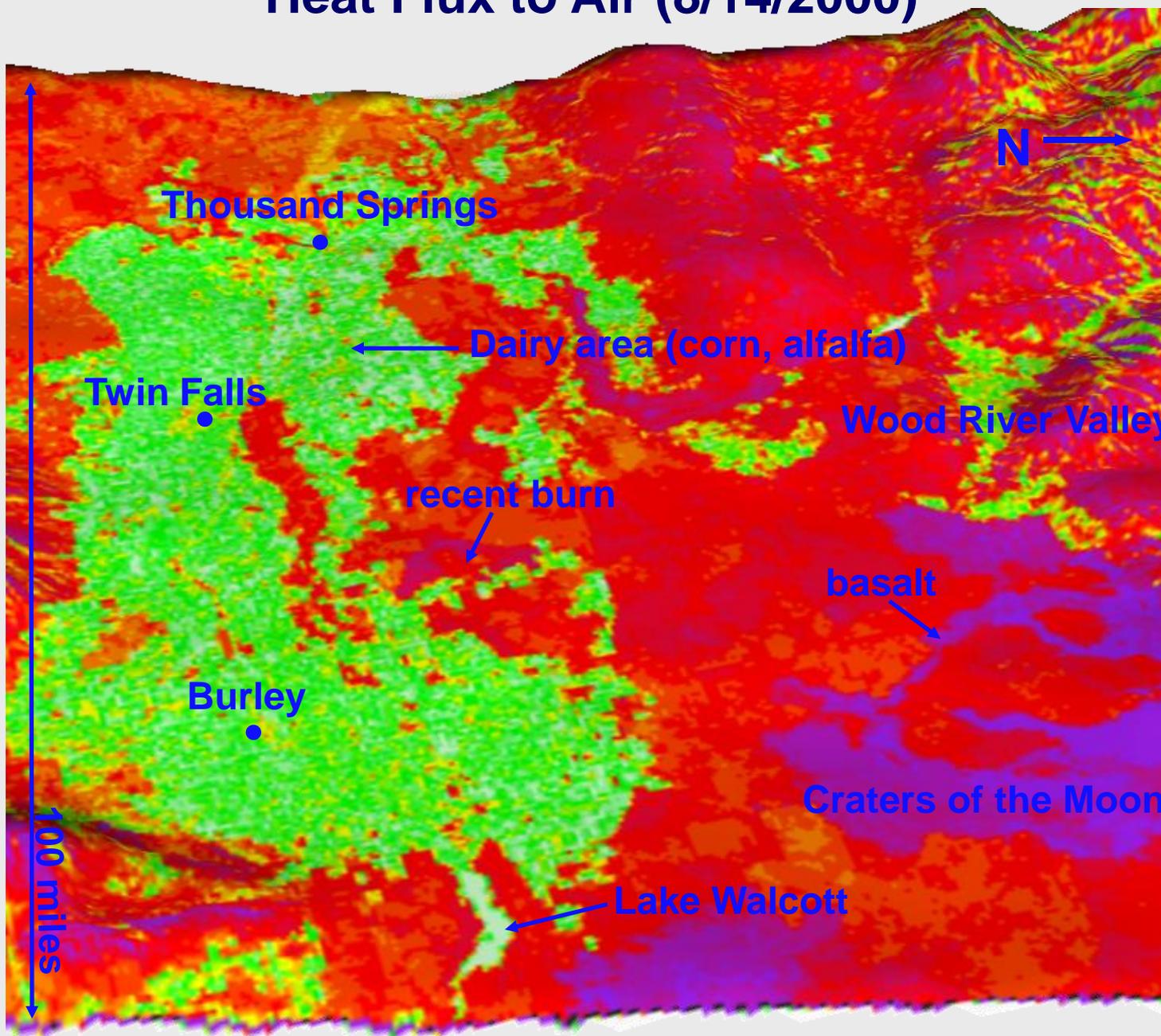
# Ground Heat Flux (8/14/2000)



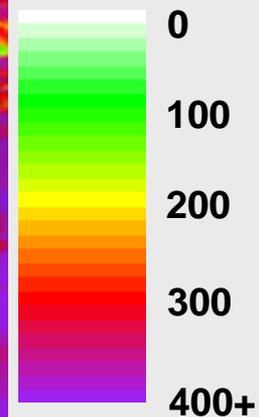
Soil Heat Flux  
( $W/m^2$ )



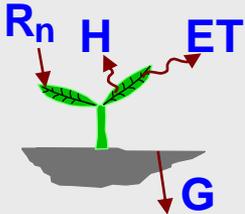
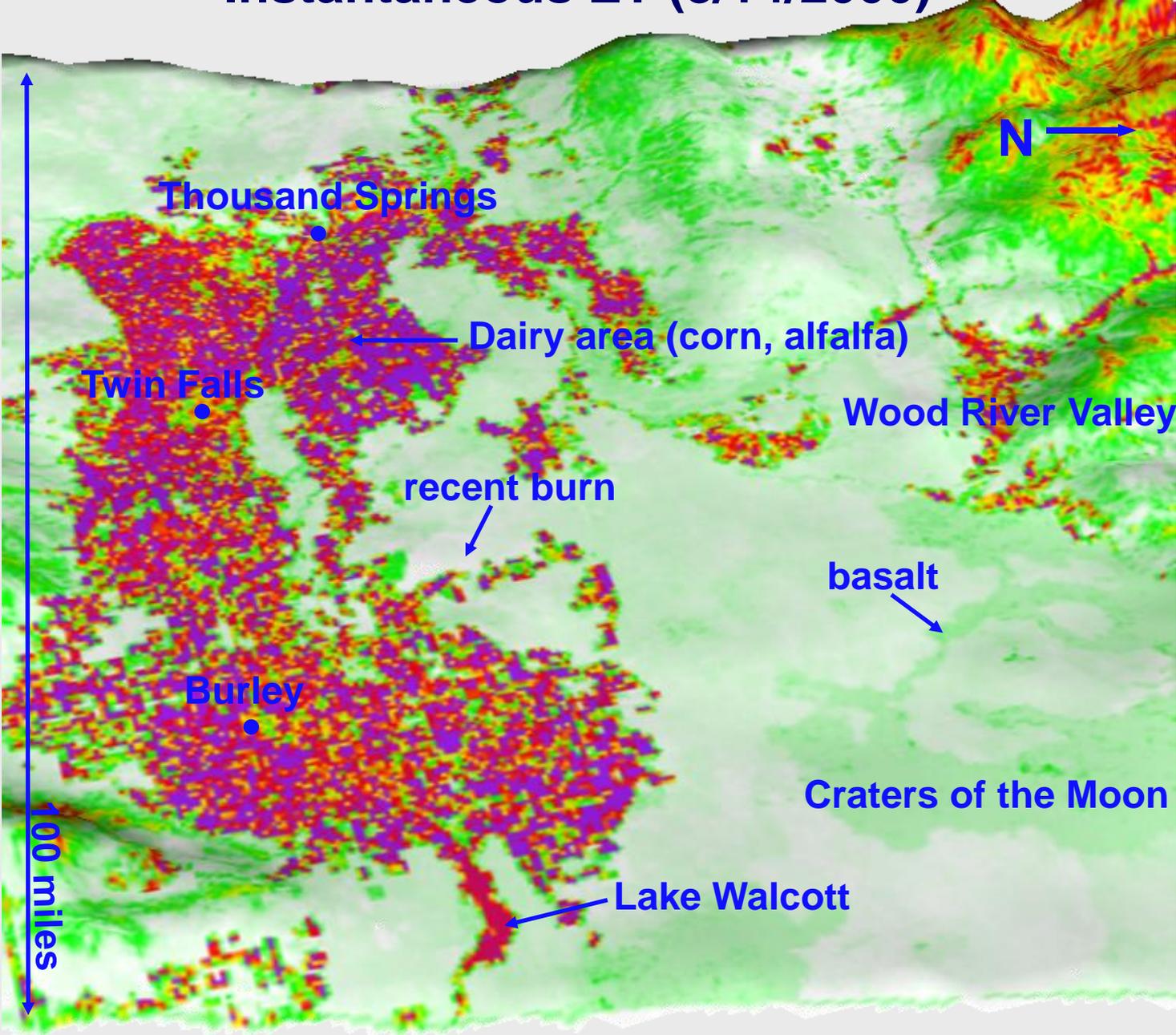
# Heat Flux to Air (8/14/2000)



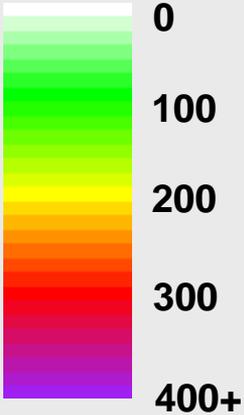
Sensible Heat  
( $W/m^2$ )



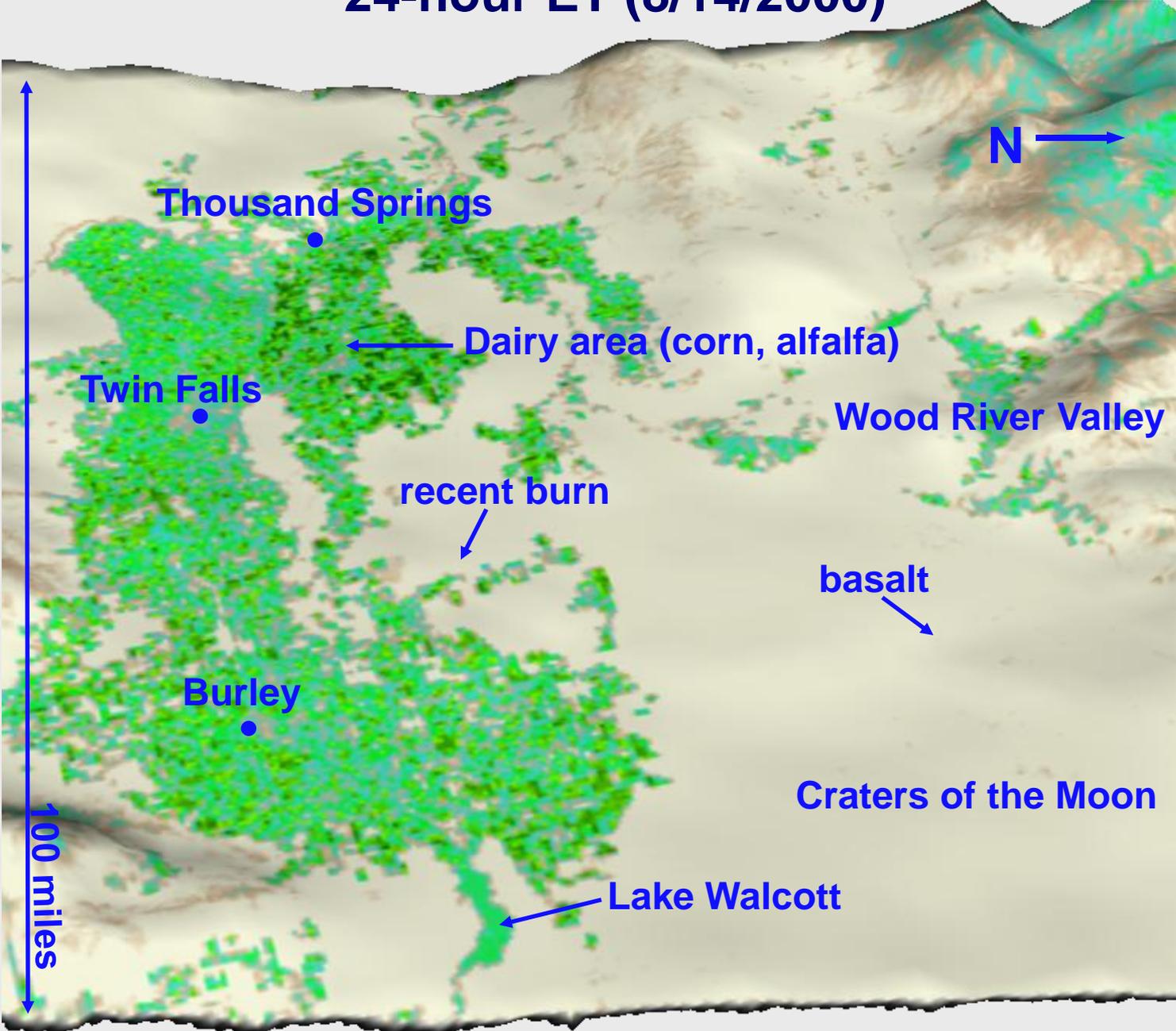
# Instantaneous ET (8/14/2000)



Latent Heat  
( $W/m^2$ )



# 24-hour ET (8/14/2000)



Evapotranspiration  
(mm/day)



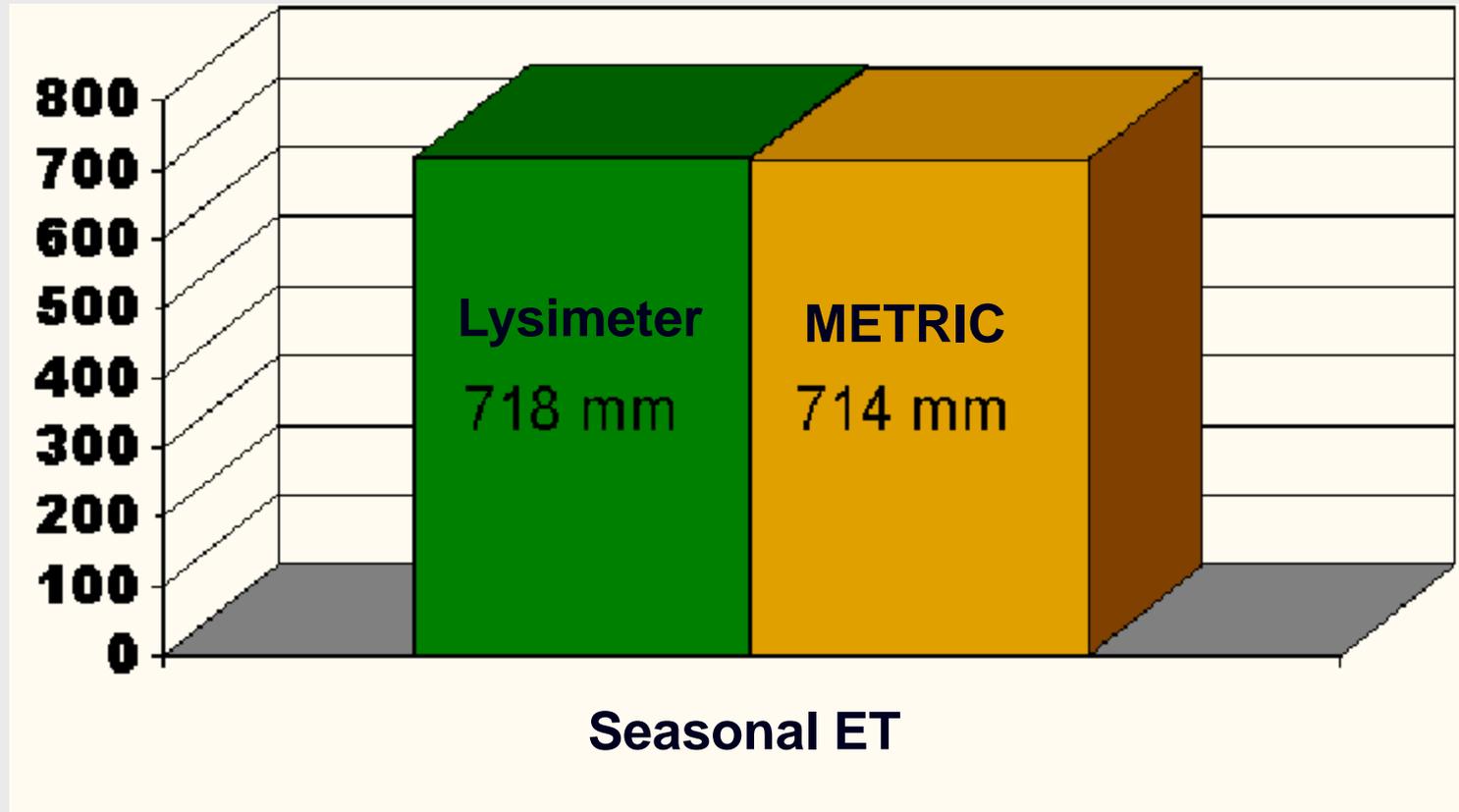
# Comparison with Lysimeter Measurements



1968-1991



Lysimeter at Kimberly (Wright)



Comparison of seasonal ET as measured by lysimeter and computed by METRIC for sugar beets at the Kimberly Research Station, for April to September, 1989.

# Applications in Idaho

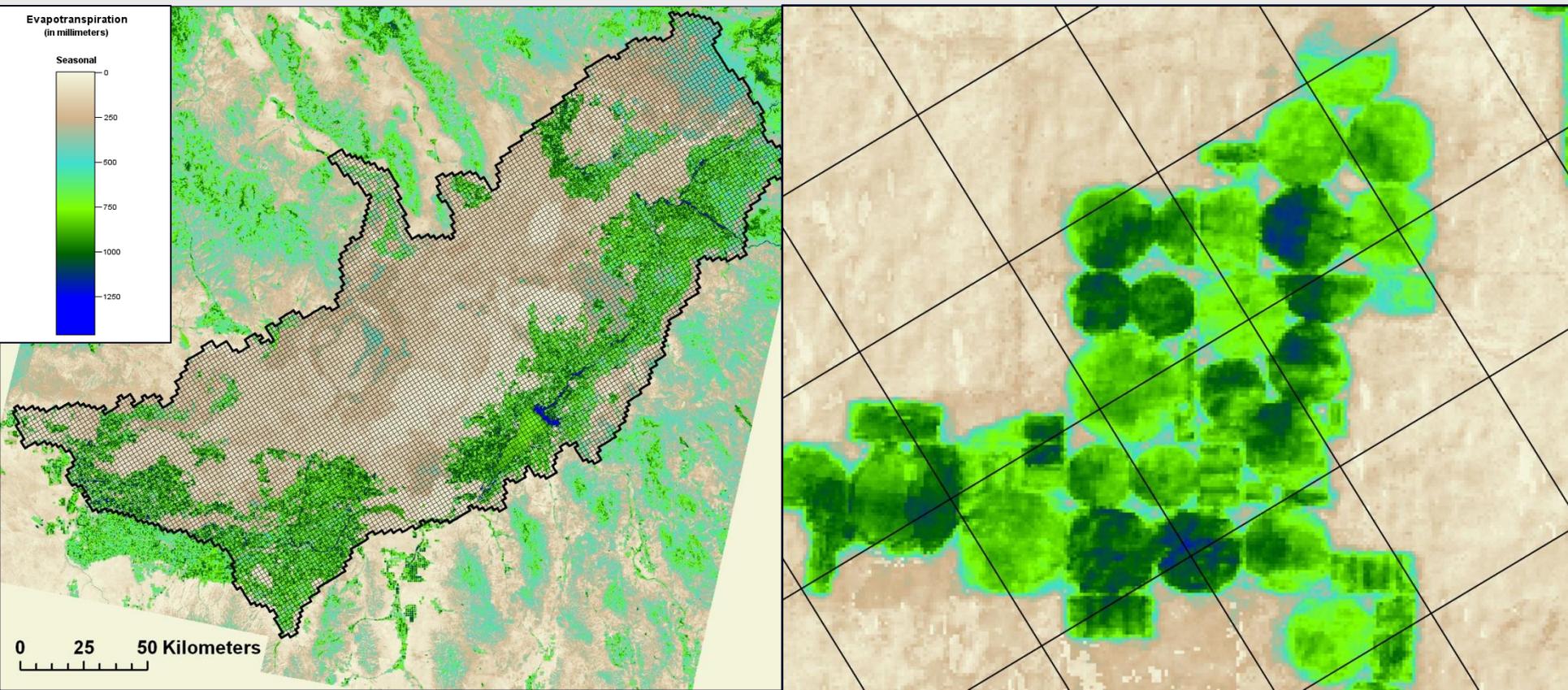
- Hydrologic modeling
- Water planning
- Water administration



# Hydrologic Modeling

## Eastern Snake Plain Aquifer Model

- Developing ET data from 1986 to present
- More accurately calibrate the groundwater model
- Completed for: 1996, 2000, 2002, and 2006



# Water Planning

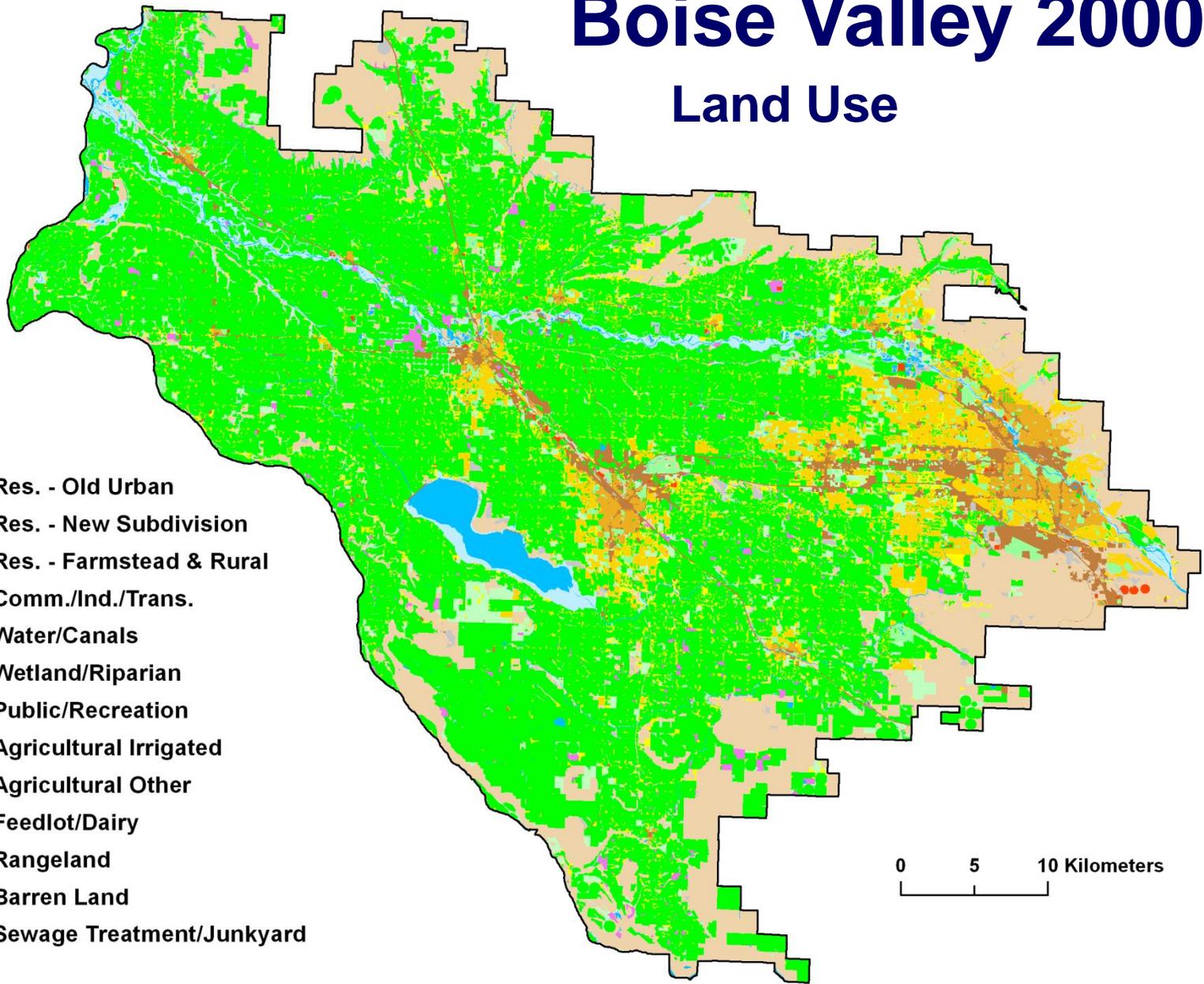
## ET by Land Use

- Used for estimates of future water demand
- Year 2000 land use data analyzed with year 2000 seasonal ET data

# Boise Valley 2000

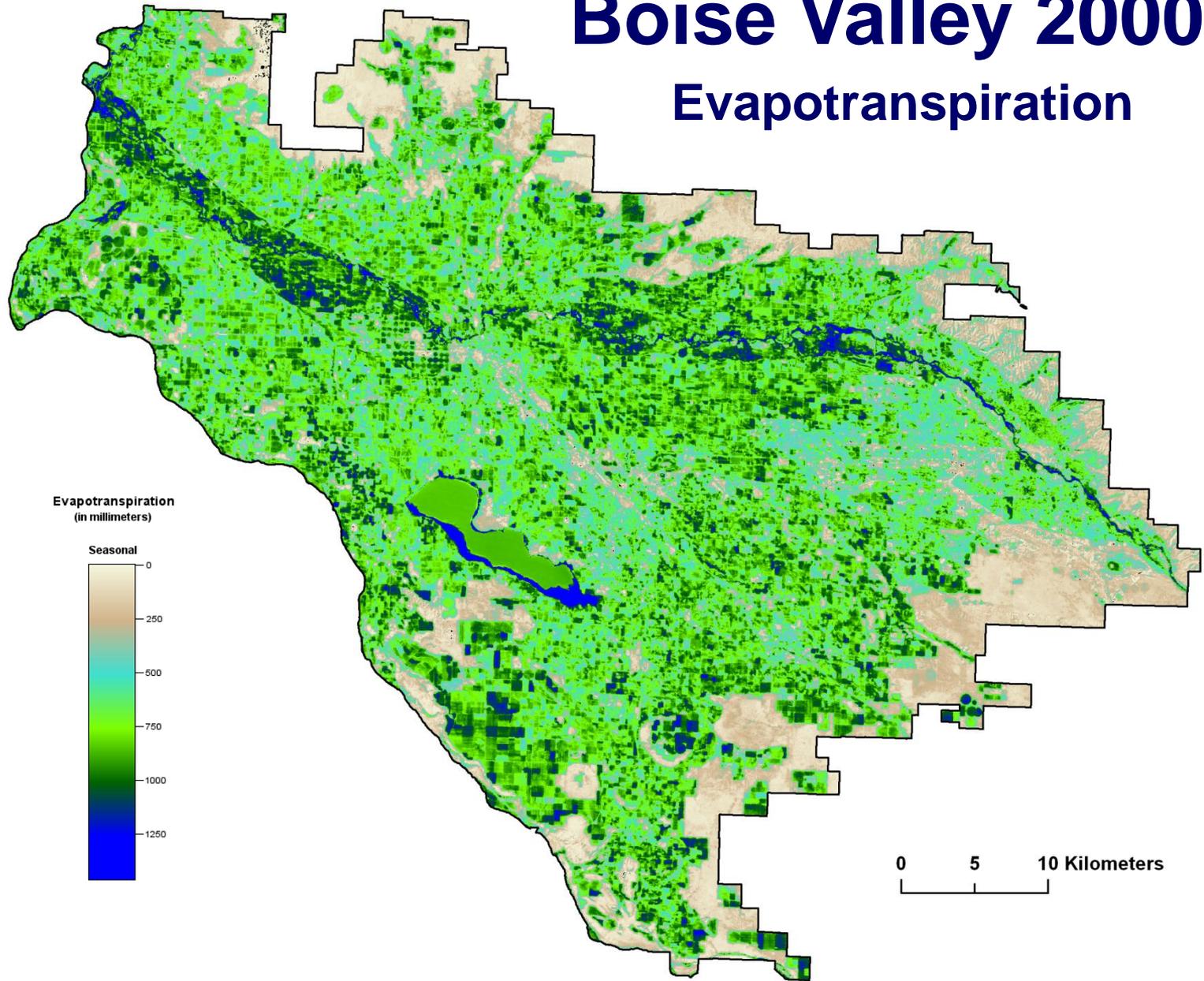
## Land Use

- Res. - Old Urban
- Res. - New Subdivision
- Res. - Farmstead & Rural
- Comm./Ind./Trans.
- Water/Canals
- Wetland/Riparian
- Public/Recreation
- Agricultural Irrigated
- Agricultural Other
- Feedlot/Dairy
- Rangeland
- Barren Land
- Sewage Treatment/Junkyard

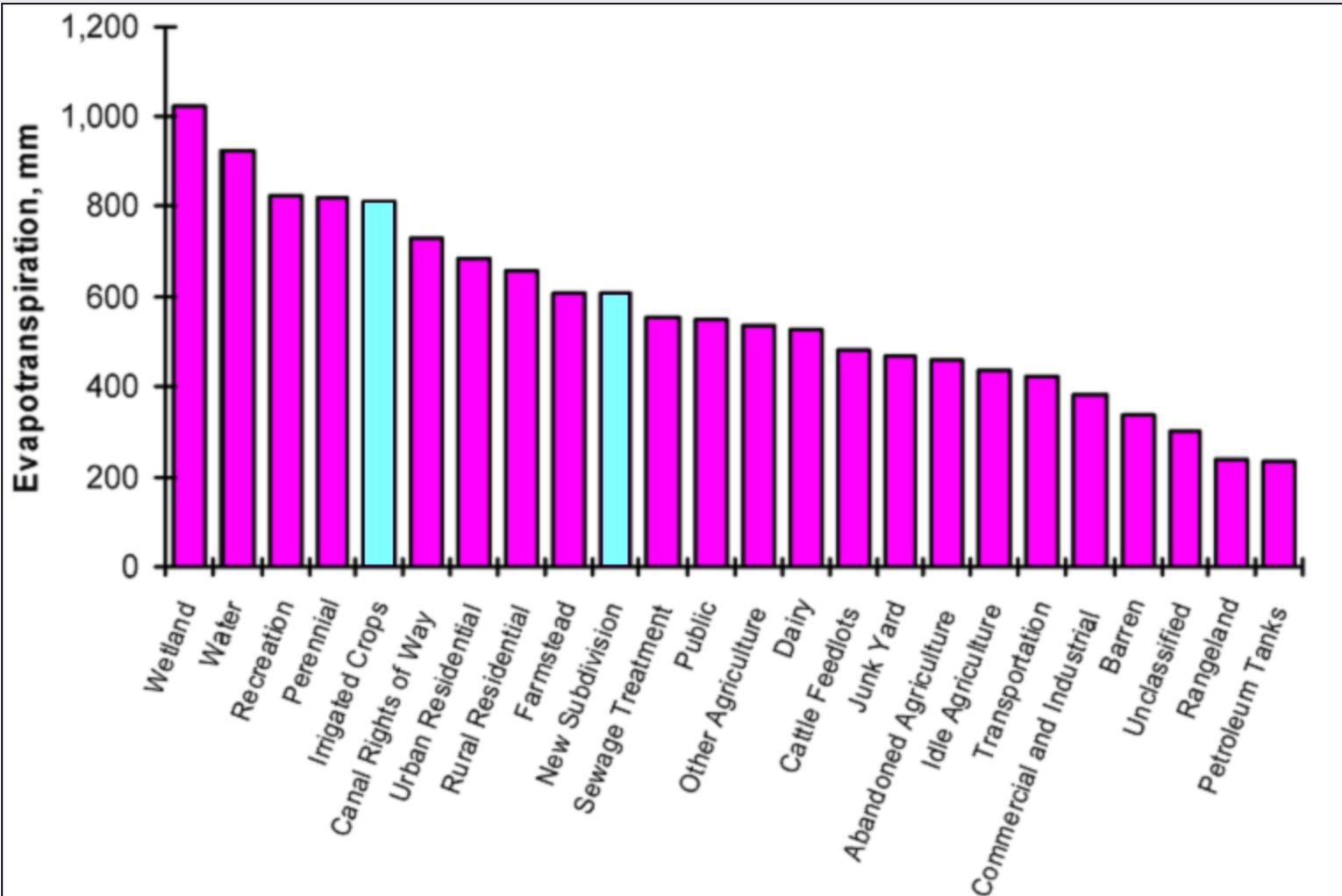


# Boise Valley 2000

## Evapotranspiration



# ET by land use

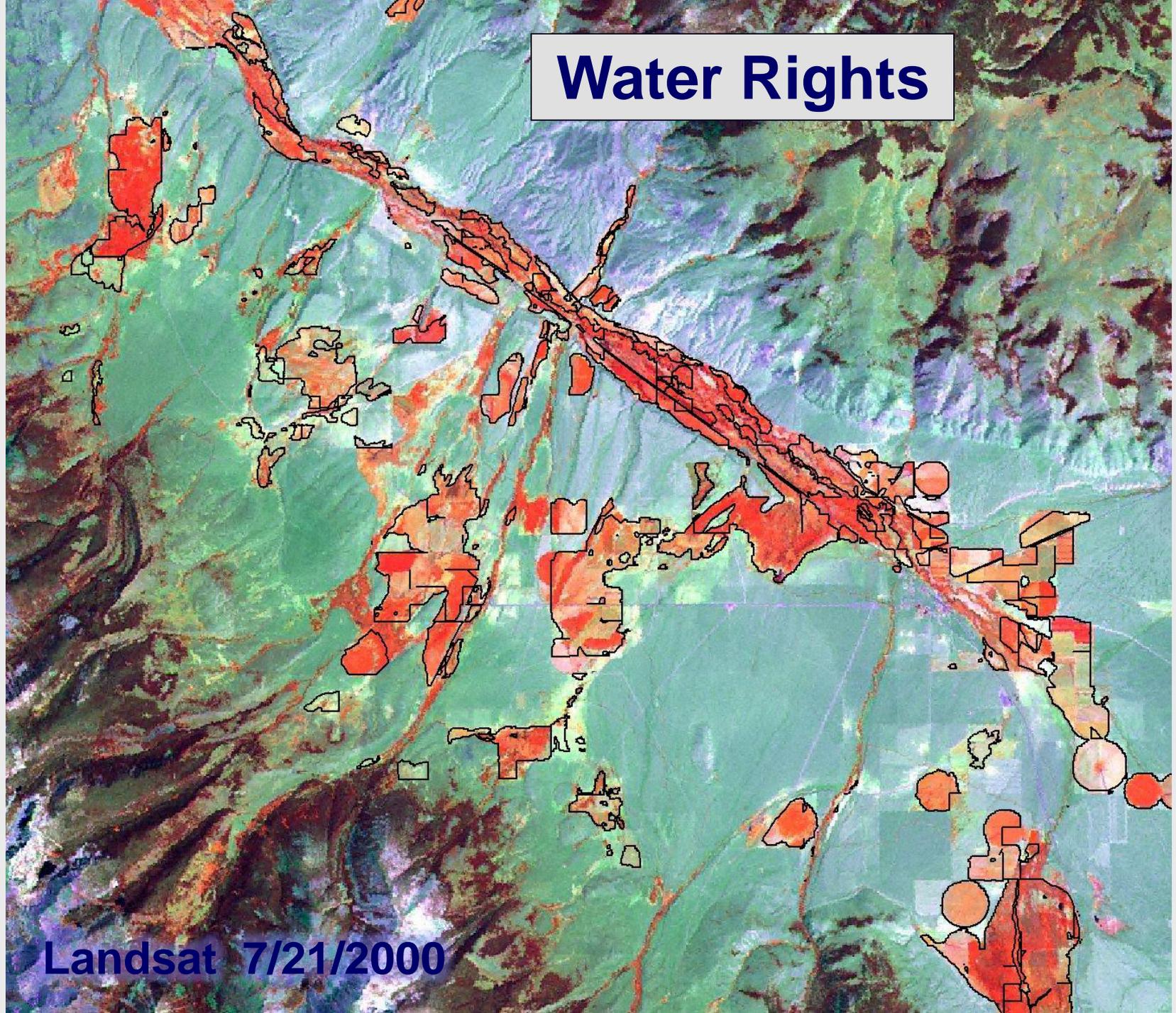


# Water Planning

## Endangered Species

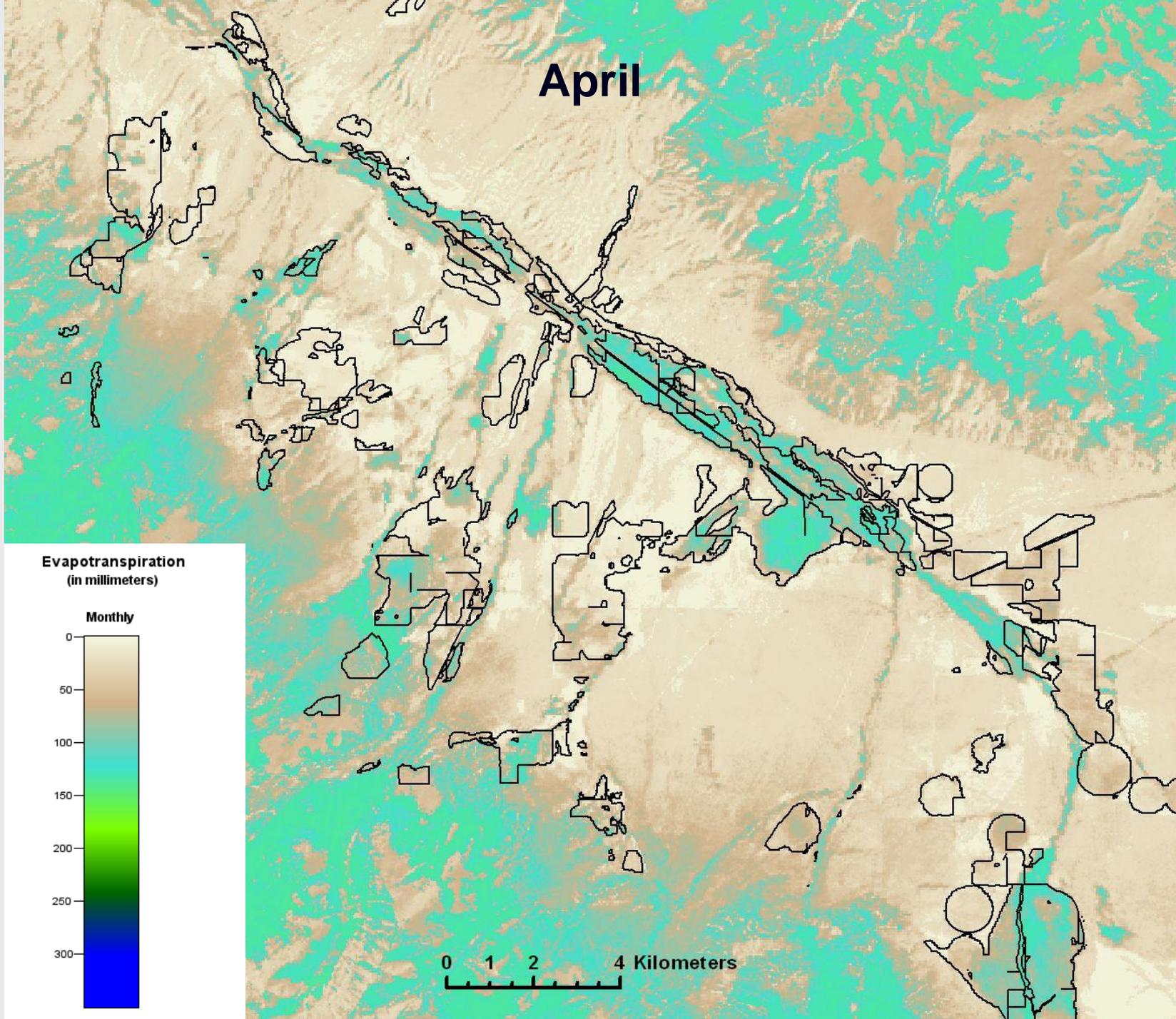
- Landsat-based ET estimates volume of water consumed for irrigation of specific water rights
- Used to negotiate leases with irrigators to increase flows for endangered fish

# Water Rights



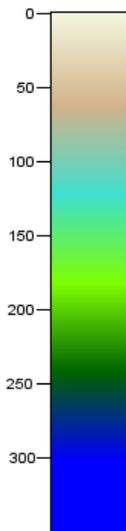
Landsat 7/21/2000

**April**



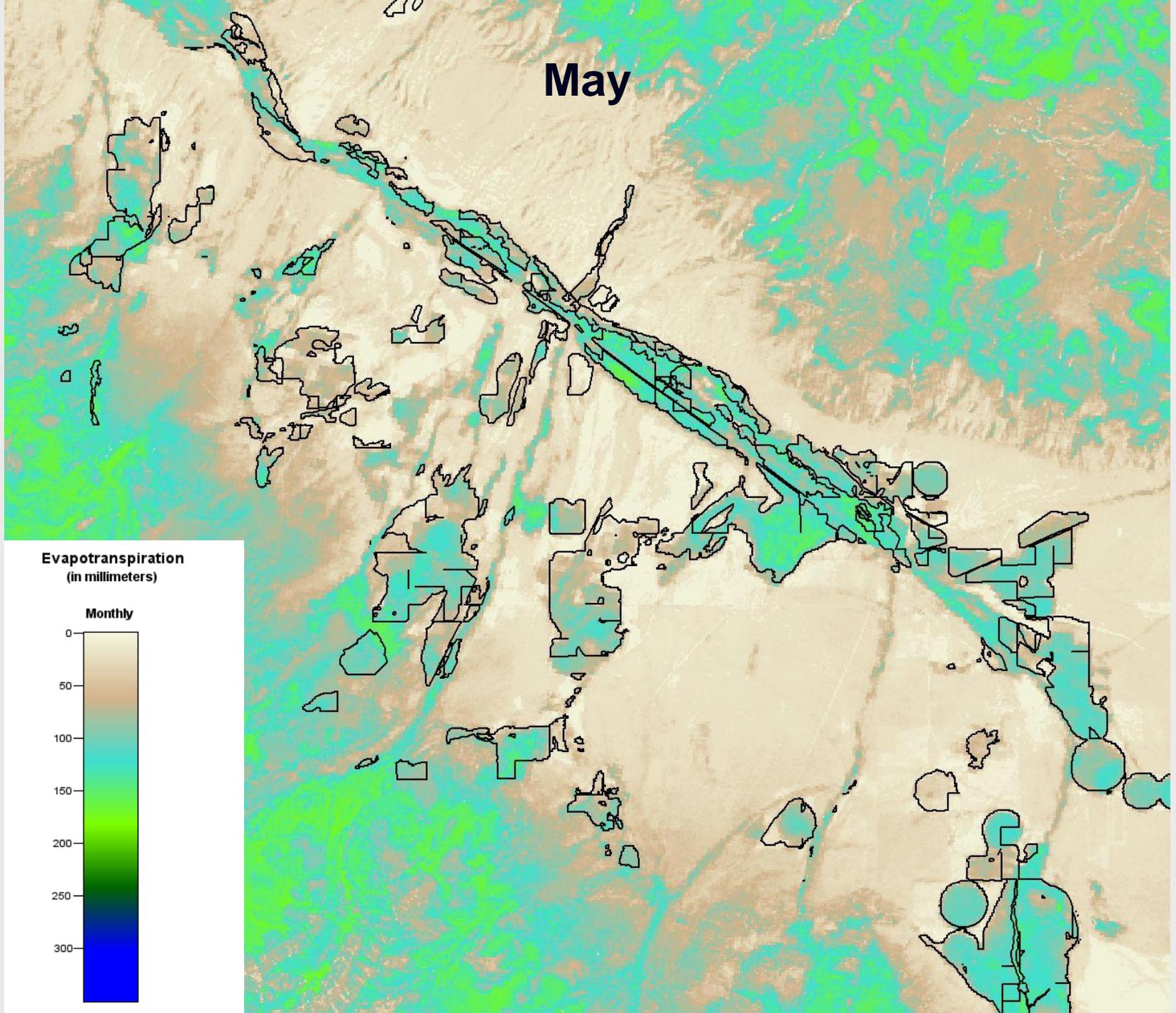
**Evapotranspiration  
(in millimeters)**

**Monthly**



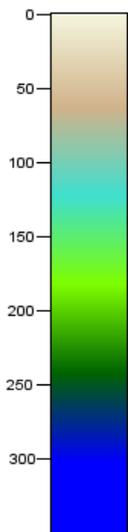
0 1 2 4 Kilometers

May

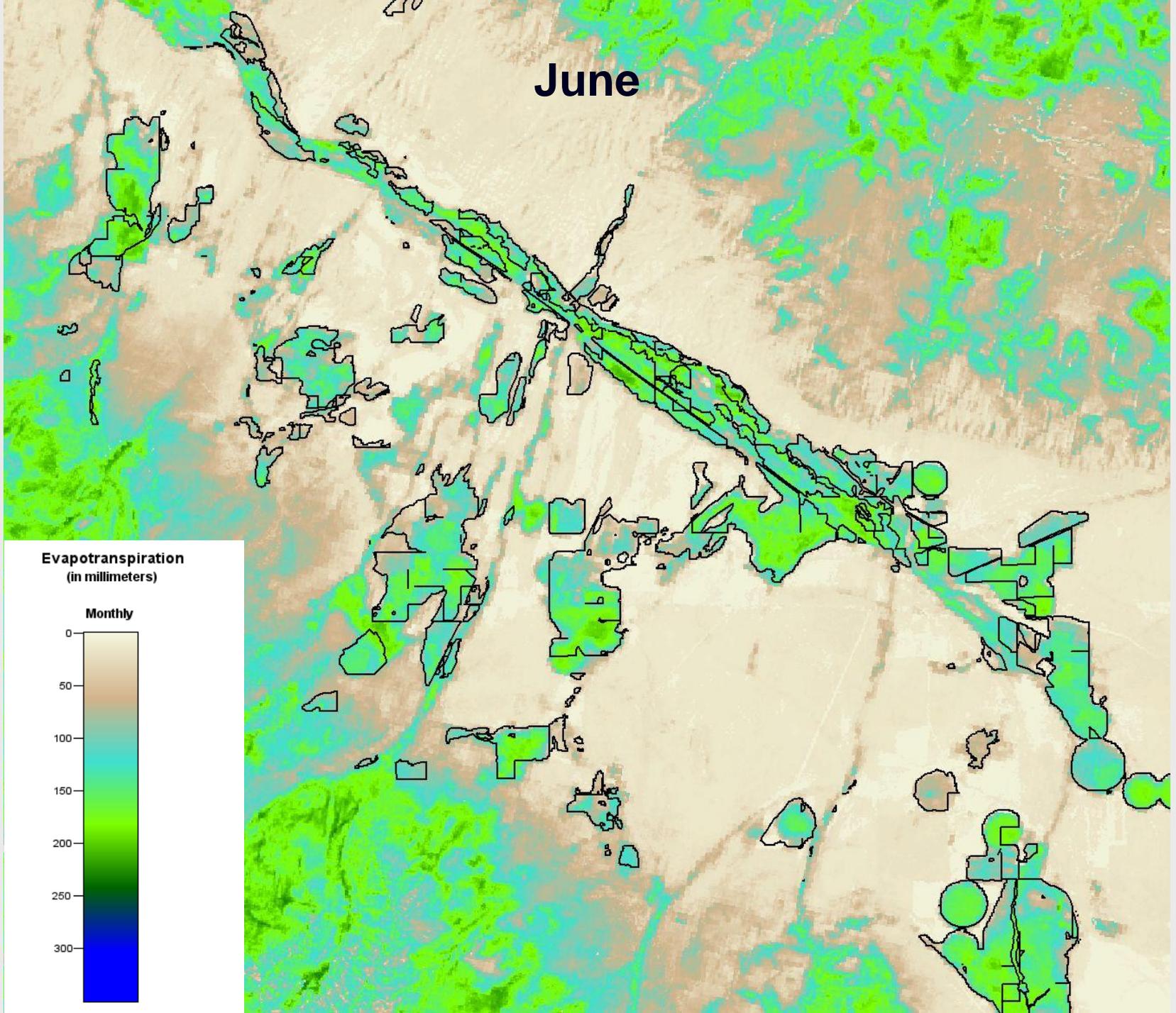
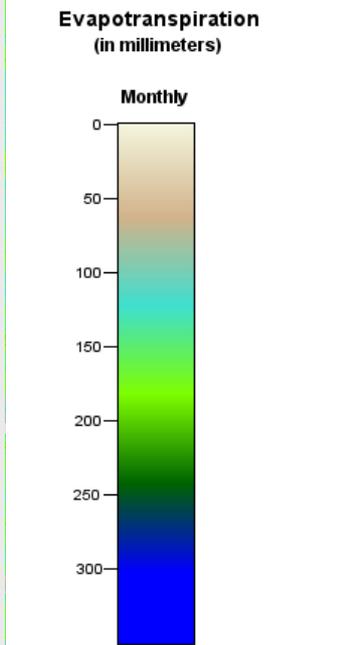


Evapotranspiration  
(in millimeters)

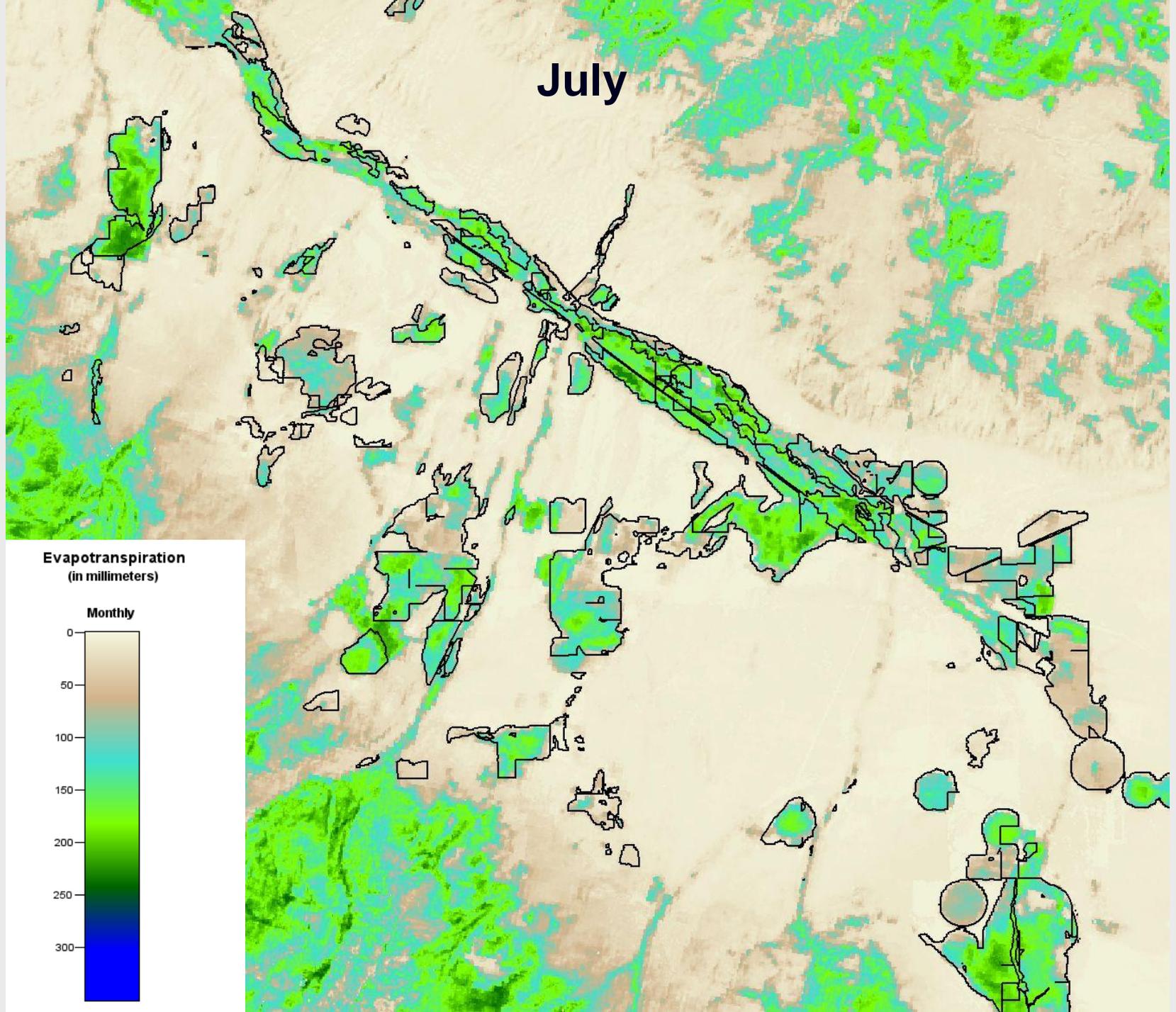
Monthly



June

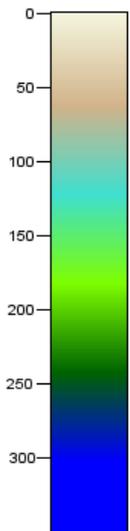


July

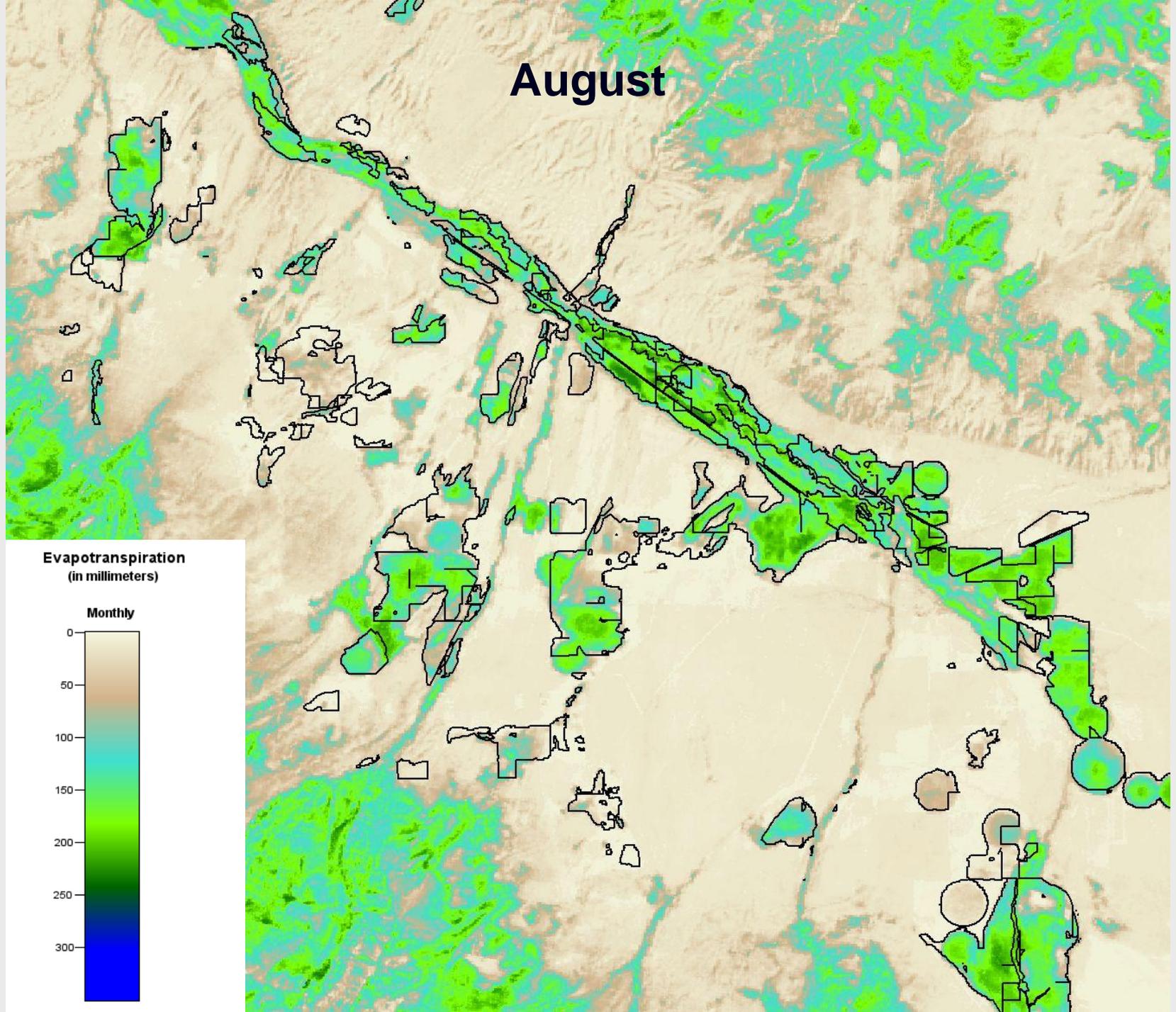


Evapotranspiration  
(in millimeters)

Monthly

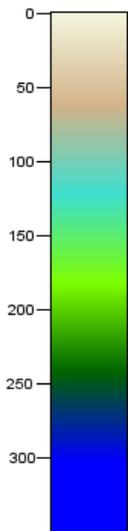


# August

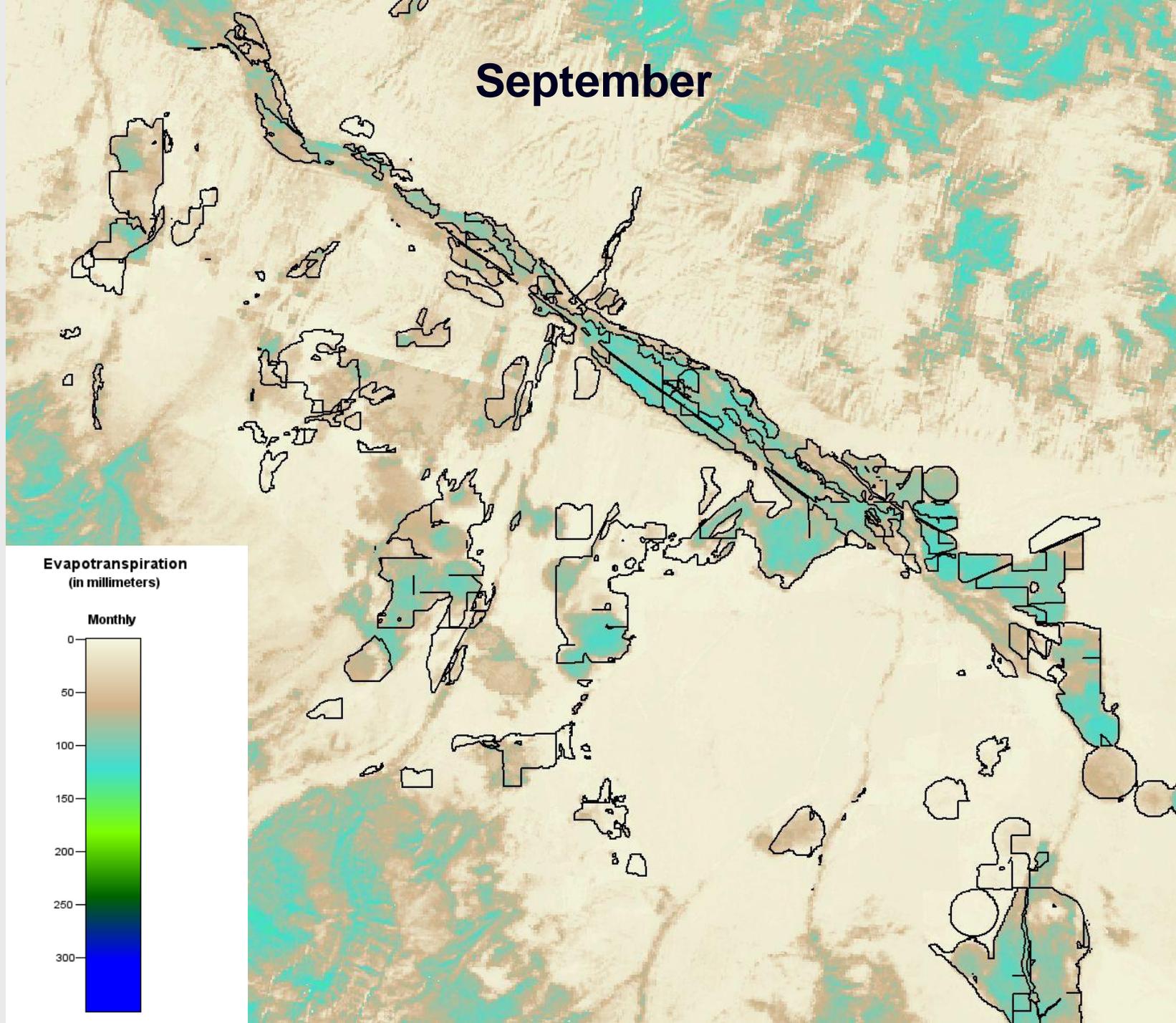


Evapotranspiration  
(in millimeters)

Monthly

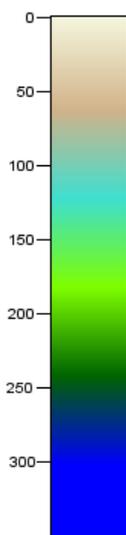


# September

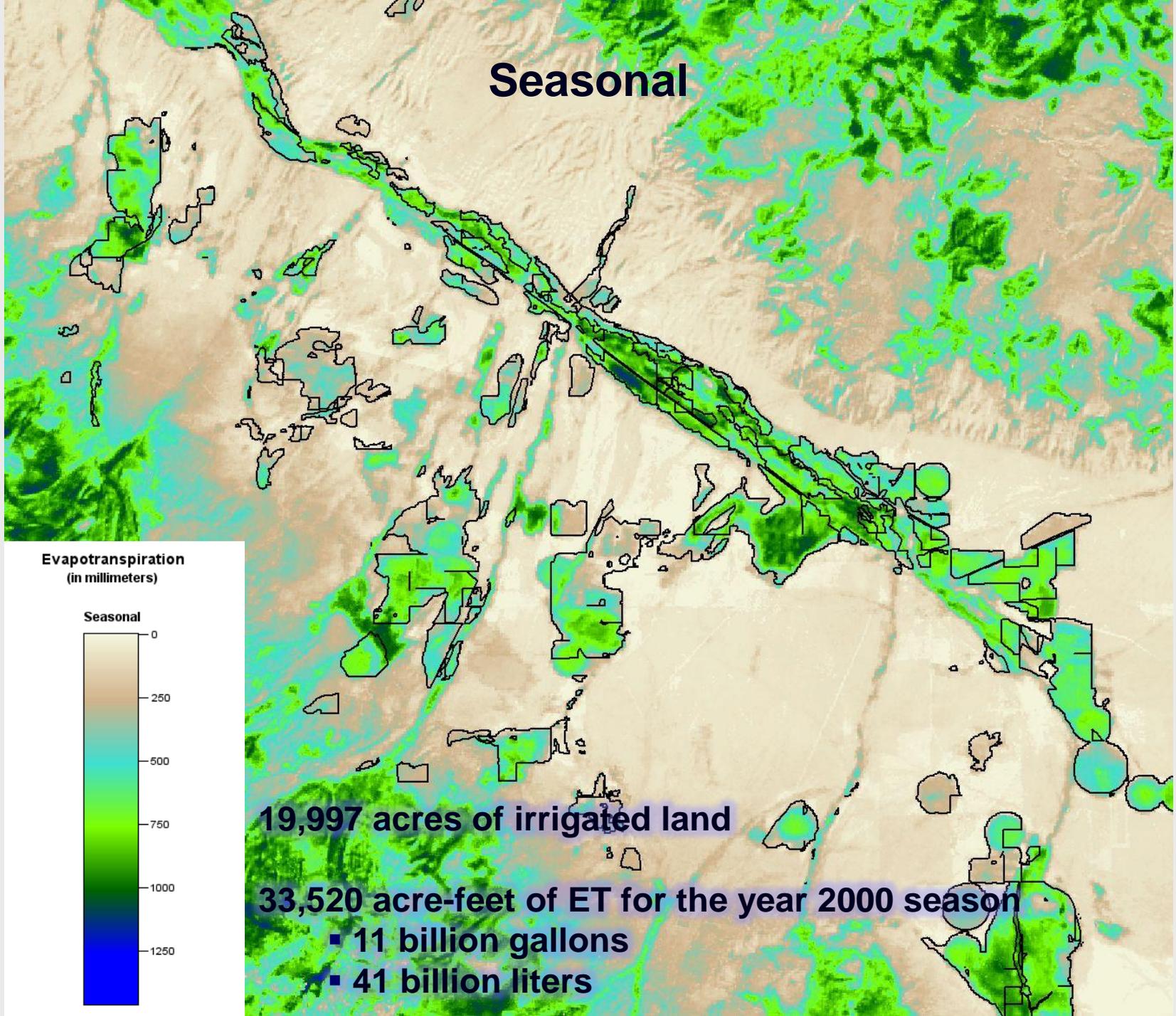


Evapotranspiration  
(in millimeters)

Monthly



# Seasonal



# **Water Administration Litigation**

- Clear Springs Foods water call
- A&B Irrigation District water call

# Water Law Terms

- **Water Right**
  - Authorization to use water
  - Includes priority date
- **Call**
  - When a senior water right holder experiences a water shortage they may place a call
- **Curtailment Order**
  - Defines how the state directs junior water right holders to stop diverting water in response to a call
- **Mitigation Plan**
  - Junior users response to a curtailment order

# Clear Springs Foods Water Call

Idaho *Business News*

## Water curtailment ordered in Magic Valley

POSTED: 11:13 MDT Thursday, July 23, 2009

by IBR Staff

Idaho Department of Water Resources Interim Director Gary Spackman on July 22 issued a **curtailment order** to about 250 holders of 315 junior water rights in south central Idaho's Magic Valley. The curtailment order is part of a continuing response to a water delivery call made in 2005 by senior water right holder Clear Springs Foods.

## State goes ahead with first large-scale well closure of more than 300 water rights in M.V.

7/31/2009

Water districts have limited options, could file a stay

By Nate Poppino

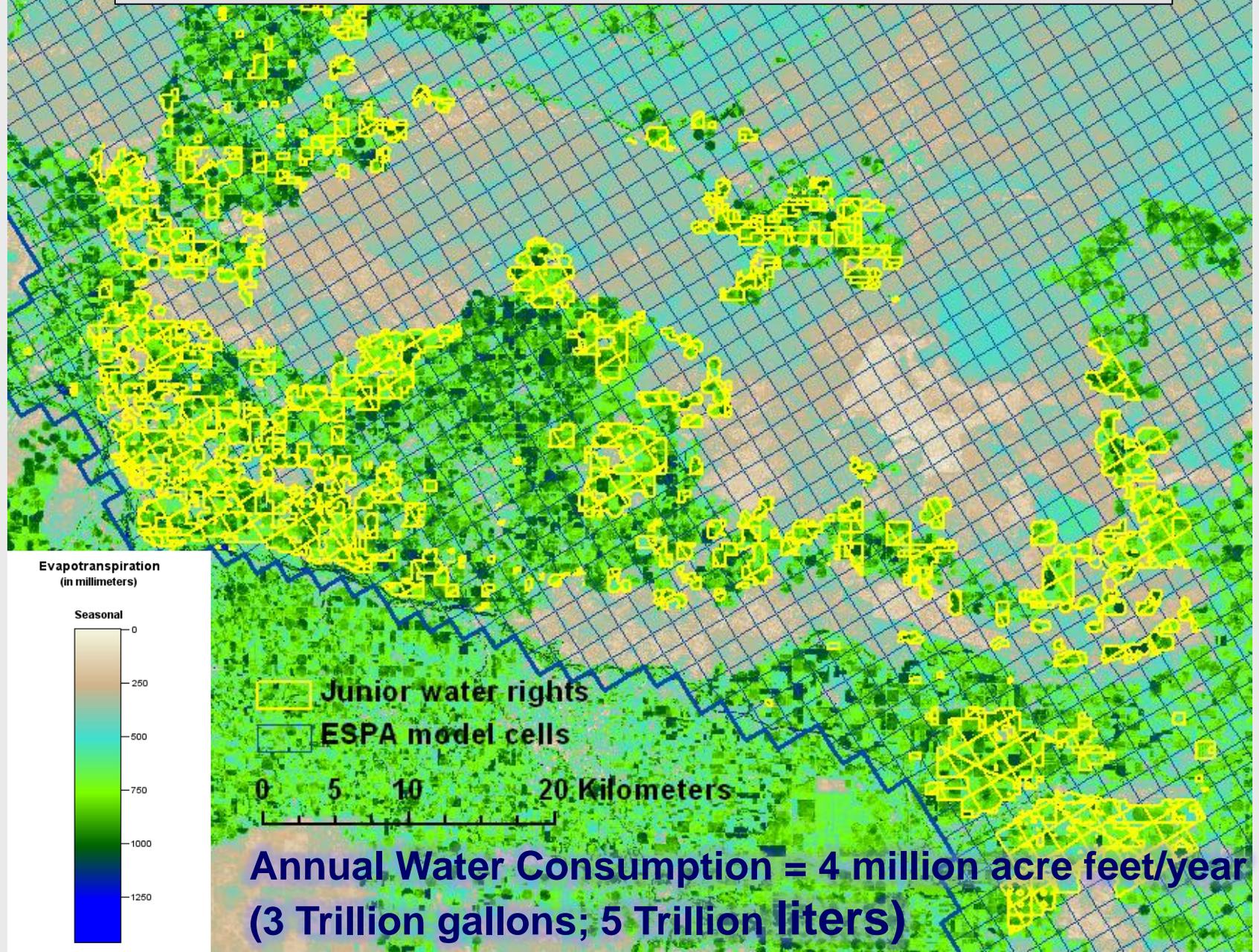
Times-News writer

The Idaho Department of Water Resources will go forward this morning with a plan to shut off more than 300 water rights irrigating just less than 9,000 acres of Magic Valley farmland, the first wide-scale well curtailment to actually be carried out by the state.

# Clear Springs Foods, Inc.



# METRIC ET 2006 April to October



# Clear Springs Foods Water Call

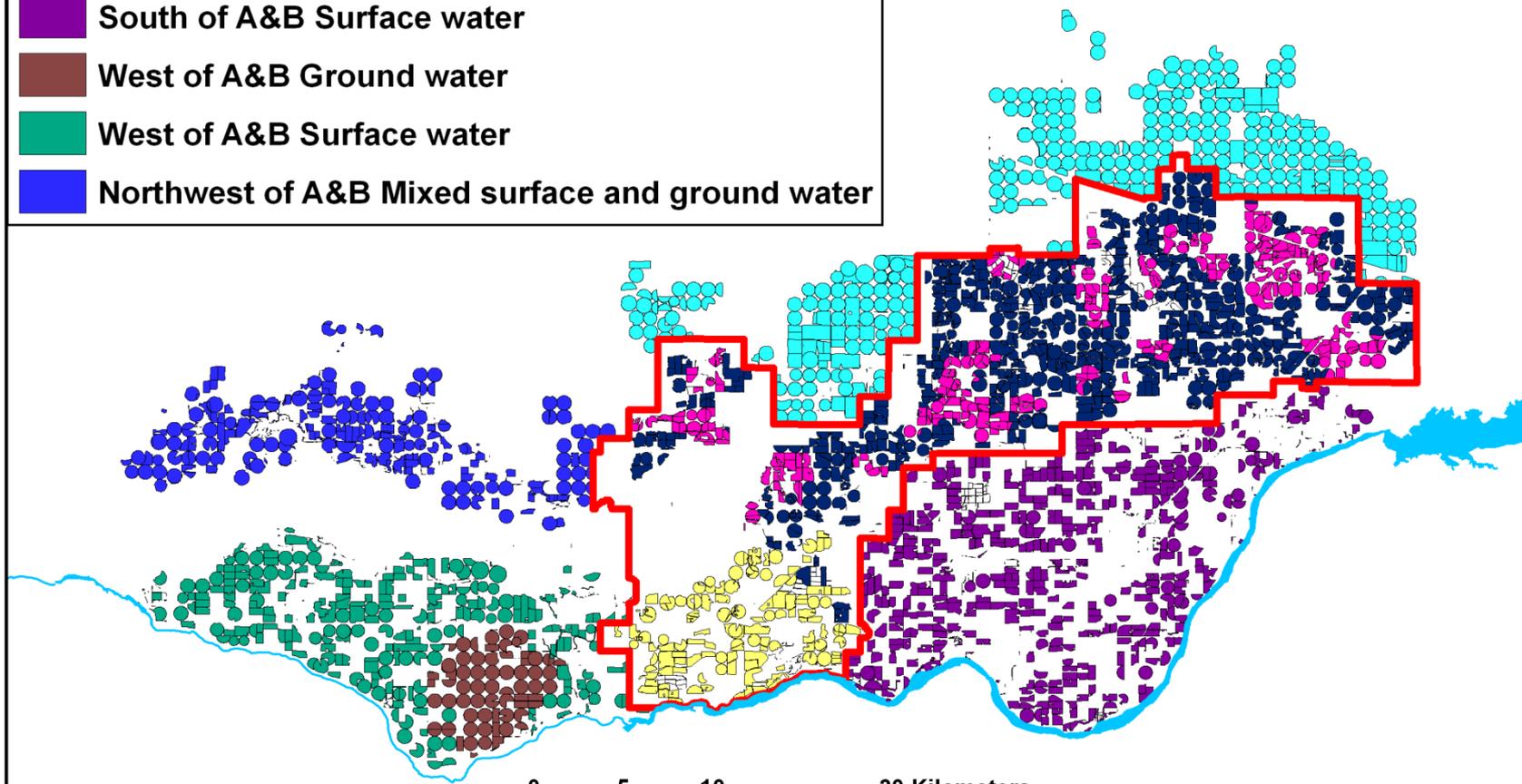
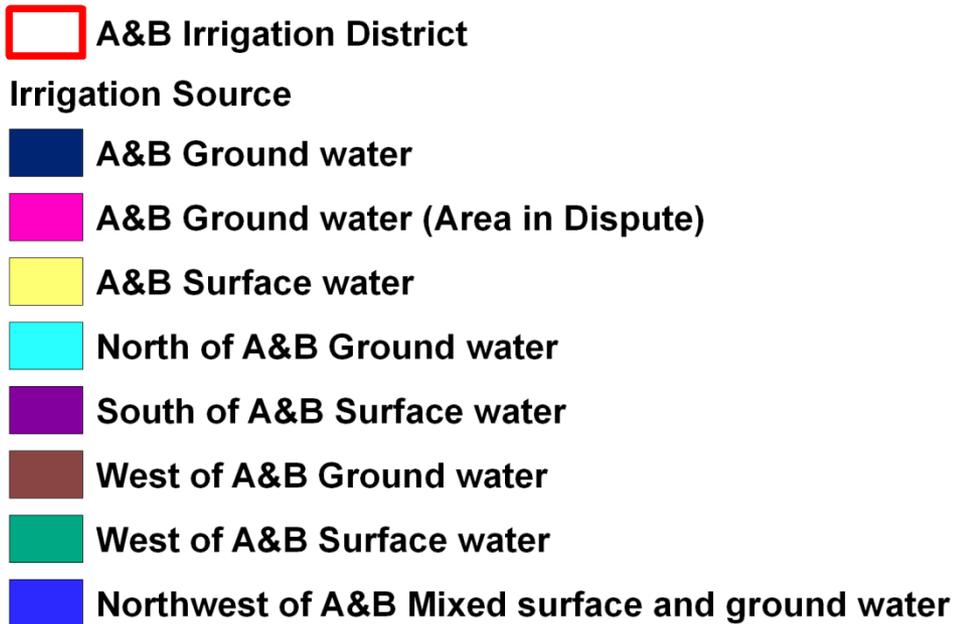
## Summary

- ESPA GW model used METRIC ET data
  - For model calibration
  - To select water rights to curtail
- No complaints from junior users about GW model or METRIC ET data

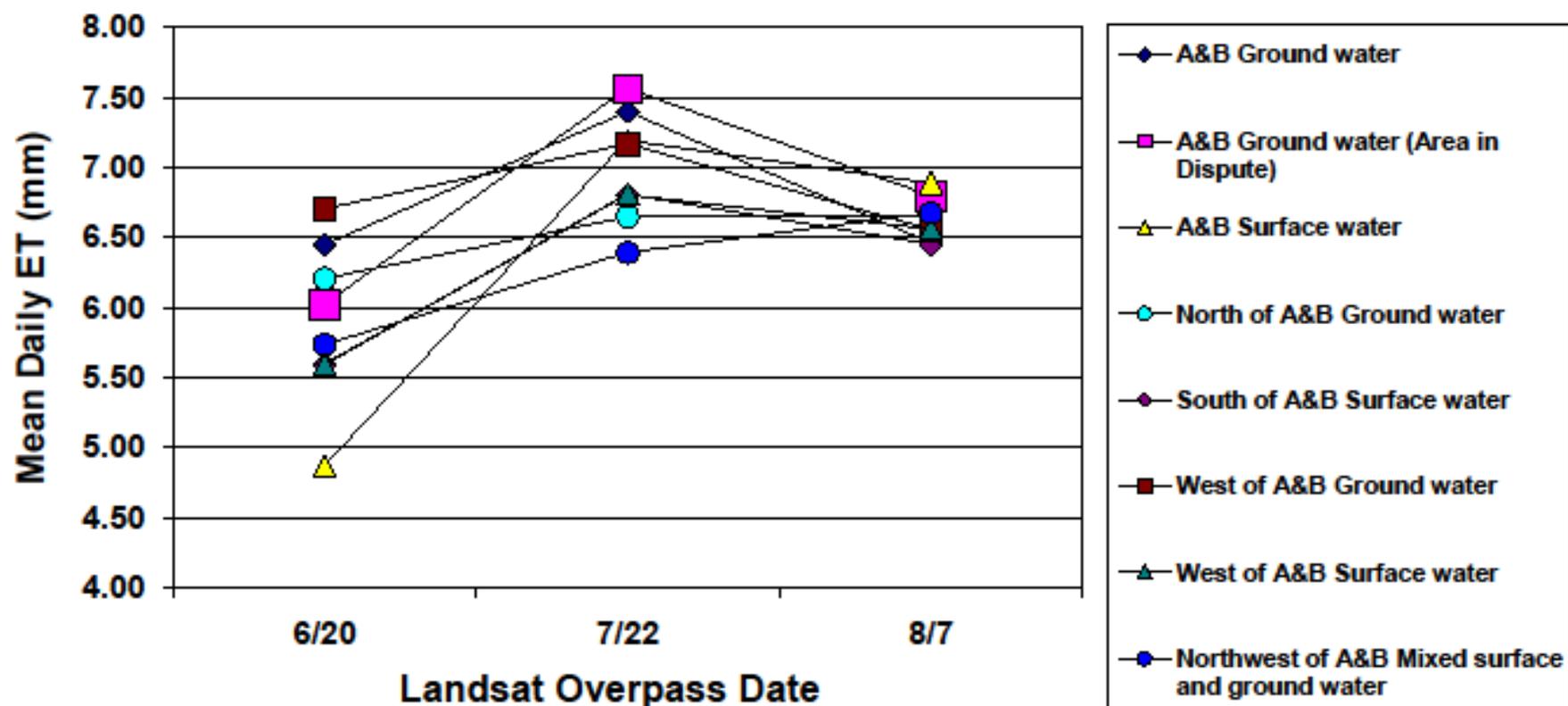
# A&B Irrigation District Water Call

- A&B claimed that certain fields were short of water due to diversions from junior ground water users
- METRIC ET showed that the fields had ET rates as high as surrounding fields that were not identified as water short

# A&B Irrigation District and adjacent land



## Year 2006: Mean Daily Evapotranspiration (ET)



# Other states using or gearing up to use METRIC

- Nevada
  - Water transfers to Reno and Las Vegas
- Nebraska
  - Over pumping of the Ogallala Aquifer
- Colorado
  - Kansas vs. Colorado over Arkansas River
  - Nebraska vs. Colorado over S. Platte River
- Wyoming
  - Nebraska vs. Wyoming over N. Platte River
- Oregon
  - Klamath Basin water shortages
- California
  - Imperial Irrigation District: water consumption by irrigation
- New Mexico
  - Middle Rio Grande: water consumption by agriculture and riparian systems
- Montana
  - Flathead Indian Reservation and ground water areas east of Helena: for improved irrigation water management and management of total depletion

# Concern about Landsat's future

- Landsat 5 is 27 years old
- Landsat 7 is 12 years old
- Landsat 8 is scheduled for launch in Dec. of 2012
- Funding for Landsat 9 is uncertain

# **Landsat used in Idaho**

## **since 1975**

- Water rights monitoring
- Adjudication
- Land use and land cover mapping
- Conservation Reserve Enhancement Program

# How Mapping ET started

- NSGIC meeting in 2000
- Conversation between Hal Anderson (IDWR) and Rita Bergman (Raytheon)
- IDWR partnered with Dr. Rick Allen (U of I) to apply for a NASA Synergy grant
- Received 5 years of funding
- Won Harvard's Ash Institute Innovations in American Government Award in 2009

# More Information

[www.idwr.idaho.gov/GeographicInfo/METRIC/et.htm](http://www.idwr.idaho.gov/GeographicInfo/METRIC/et.htm)

[www.kimberly.uidaho.edu/water/metric](http://www.kimberly.uidaho.edu/water/metric)

[www.idwr.idaho.gov/geographicinfo/landsat/LandsatConcerns.htm](http://www.idwr.idaho.gov/geographicinfo/landsat/LandsatConcerns.htm)

[http://landsat.gsfc.nasa.gov/news/news-archive/soc\\_0023.html](http://landsat.gsfc.nasa.gov/news/news-archive/soc_0023.html)

0 25 50 100 Kilometers