

# Mapping Evapotranspiration for Water Rights Litigation in Idaho

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# Why is measuring Evapotranspiration (ET) important

- ET is the water consumed by irrigated agriculture
- Important for administration, management, and planning of water resources
- Irrigated agriculture in Idaho
  - 3.4 million acres
  - Accounts for over 90% of the water consumed
- Irrigation in the US
  - 50 million acres agriculture, 32 million acres recreational
  - Accounts for over 80% of the water consumed



# Ground-based ET

Potential ET using crop coefficients

- Needs crop acres and stage of growth
- Produces one ET value per county

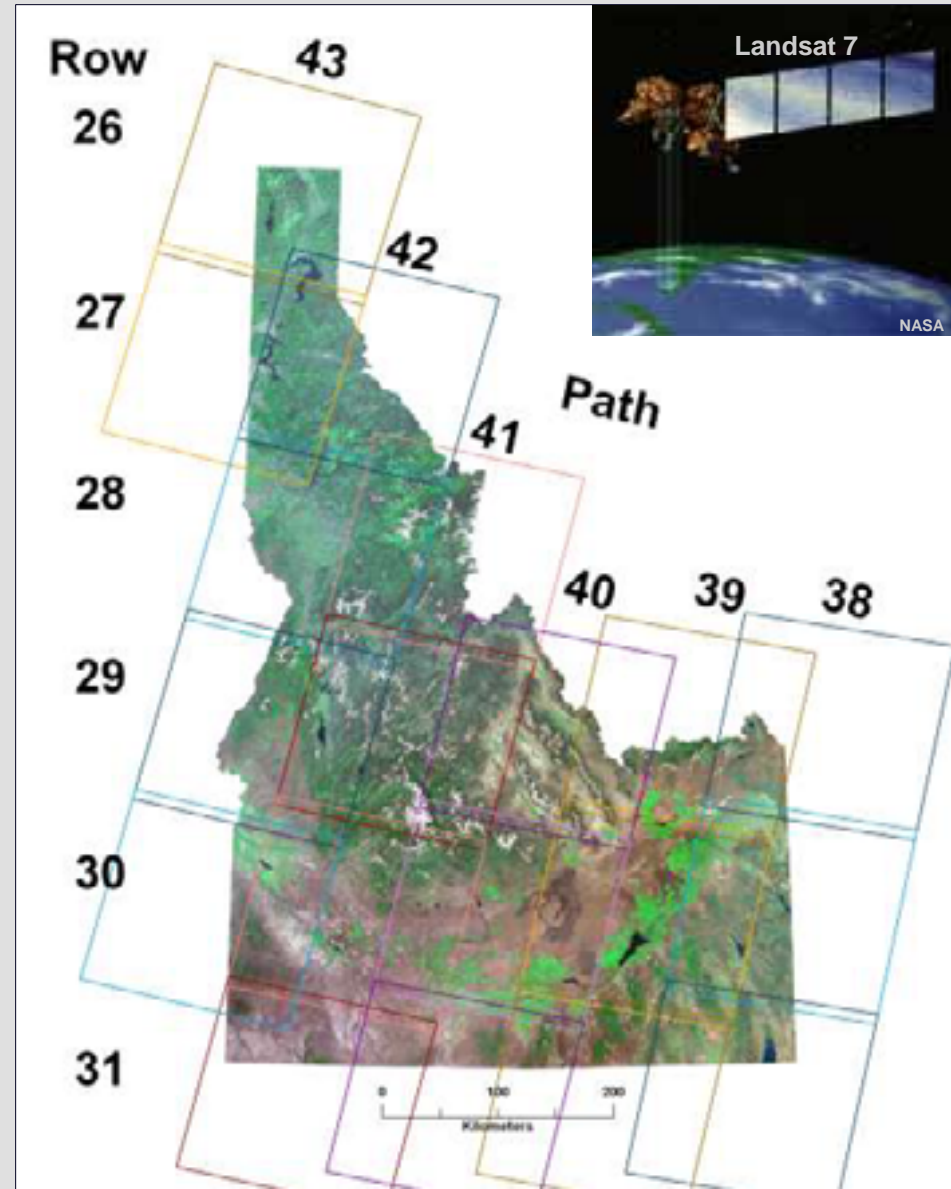
# Satellite-based ET

Actual ET from Landsat using METRIC

- No crop information required
- ET per pixel can be summed by field

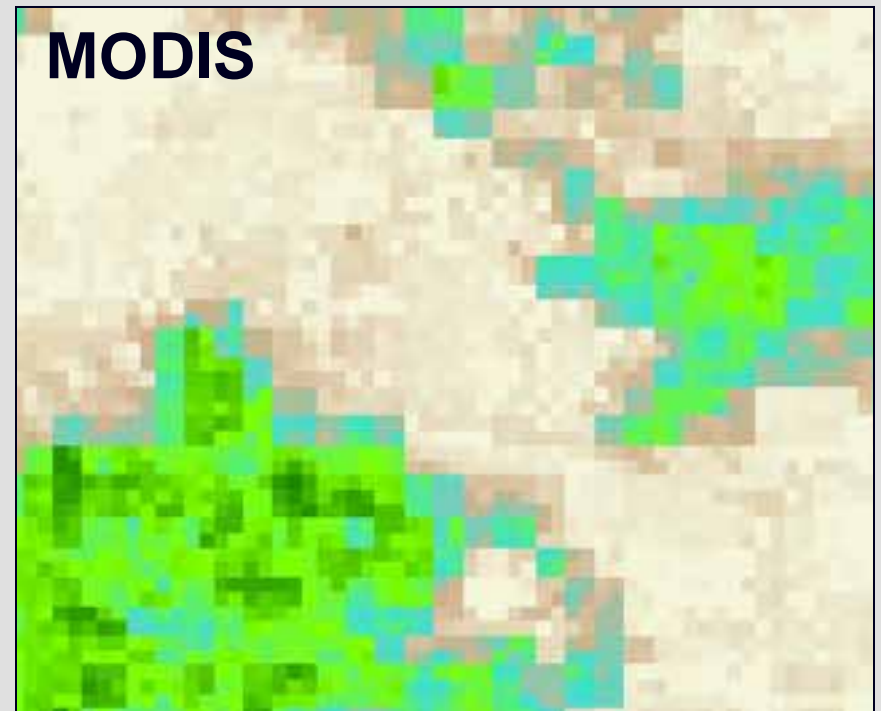
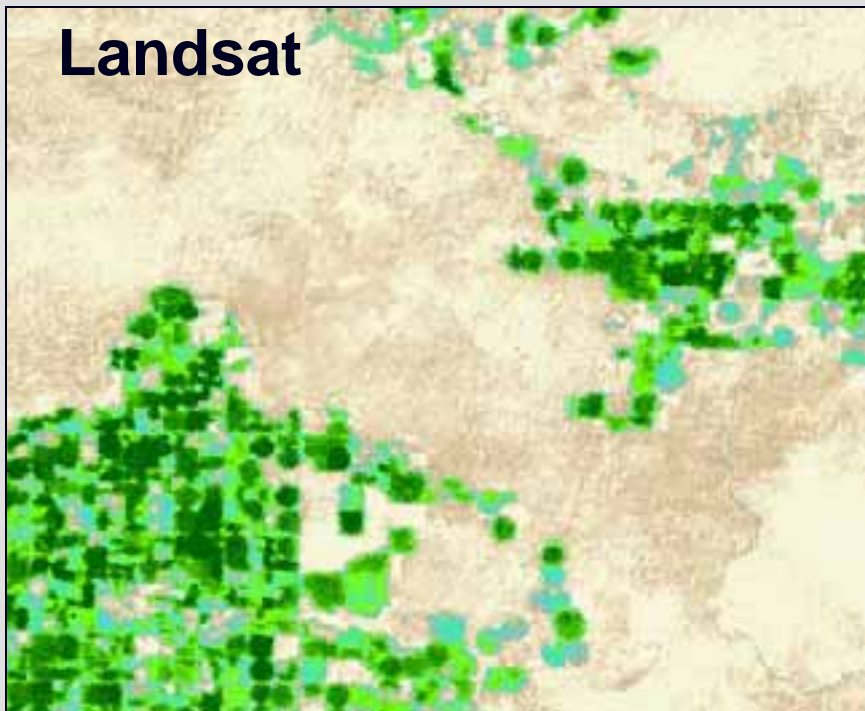
# Landsat

- USGS/NASA mission
- L5 launched 1984  
(halted November 2011)
- L7 launched 1999  
(anomaly May 2003)
- 30 meter pixels
- 16 day cycle
- 100 by 100 miles
- *Free*
- Landsat 8 will launch in  
January 2013
- 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



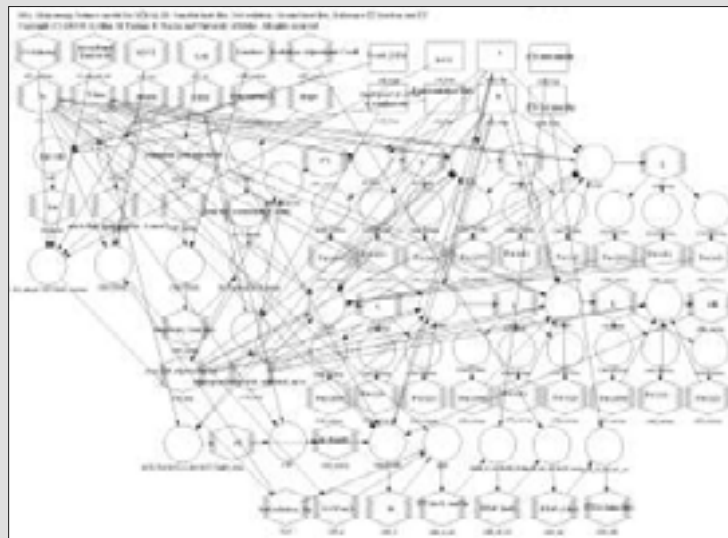
# Landsat Thermal Band

- 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

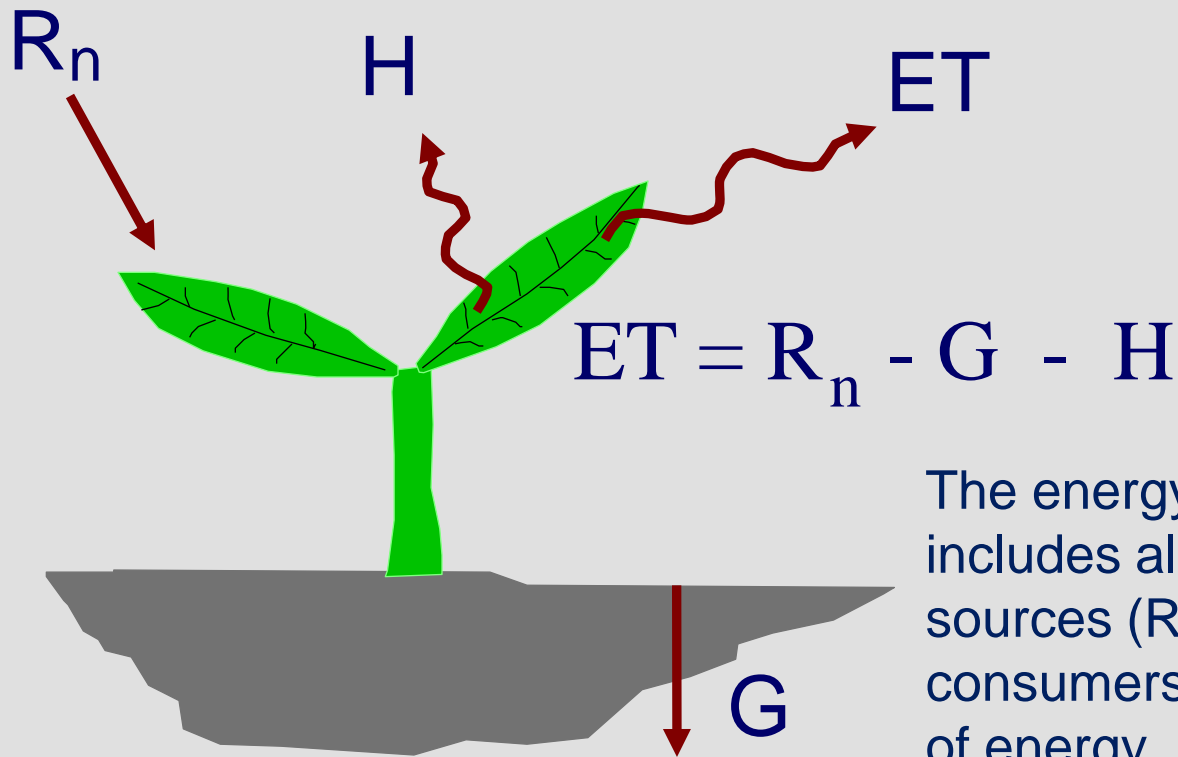
## Mapping EvapoTranspiration at high Resolution with Internalized Calibration

- Satellite-based energy balance model that computes and maps actual ET
- Internalized Calibration ties down ET to weather data
- Over 90% accurate compared to precision weighing lysimeter



# 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
- wet soil



# Weather Data

In METRIC, Weather Data are used for:

Wind speed for sensible heat flux calculation

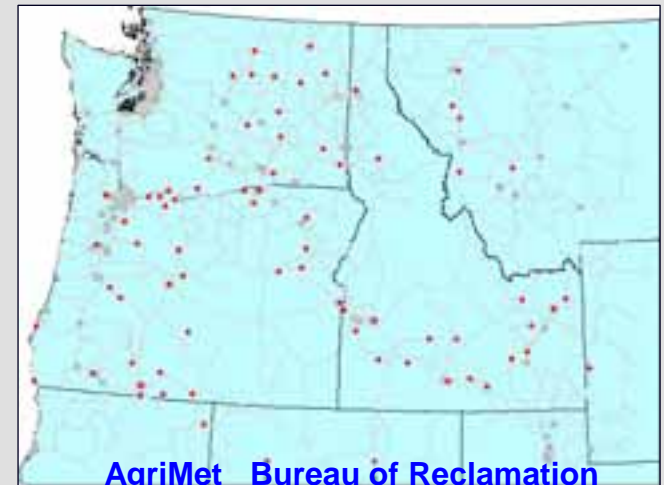
Reference ET for calibrating the Energy Balance

Reference ET to extrapolate ET

- 24-hour period
- Days between images



AgriMet Twin Falls



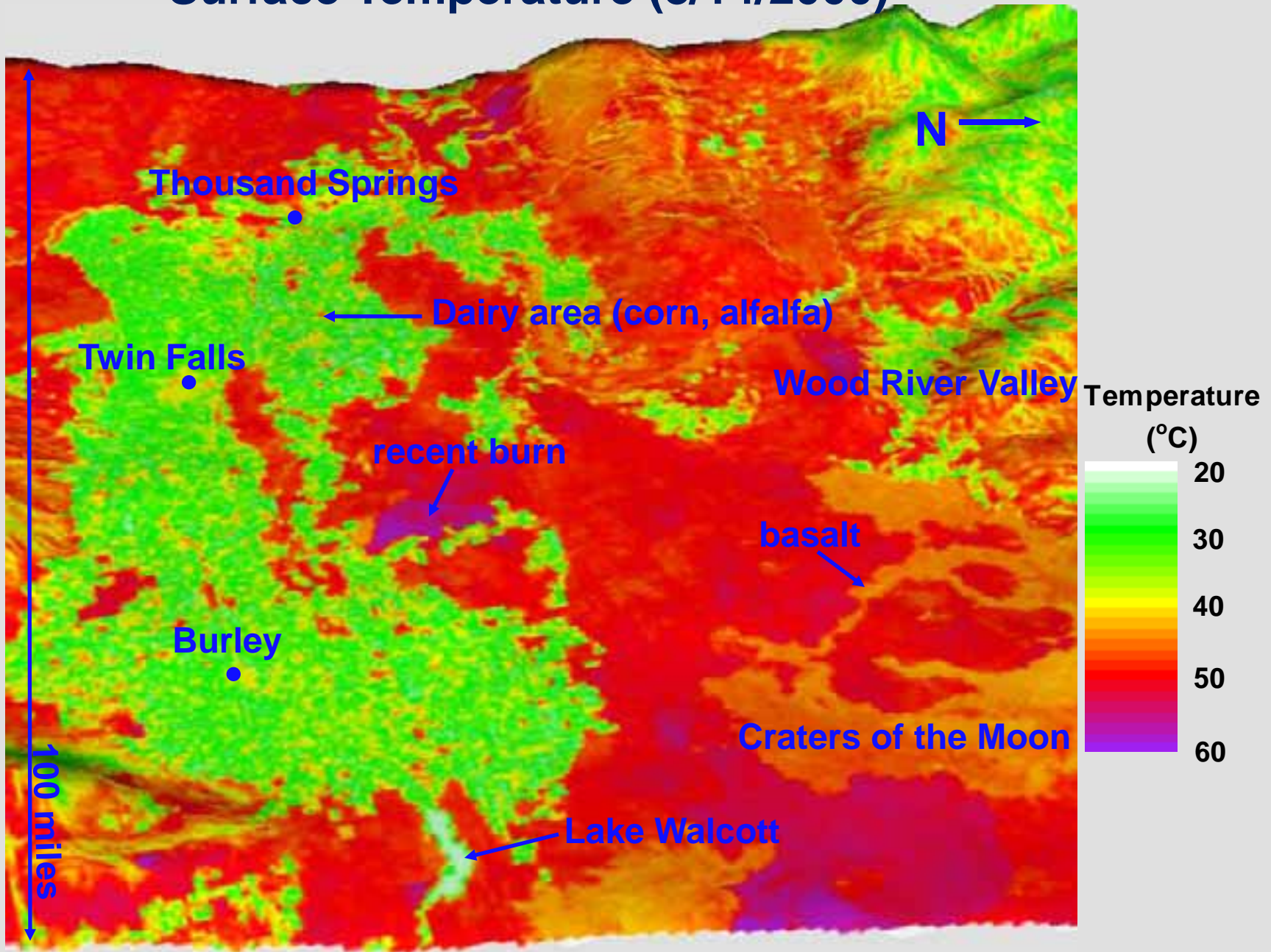
AgriMet Bureau of Reclamation

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

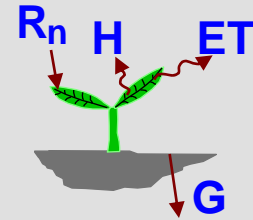
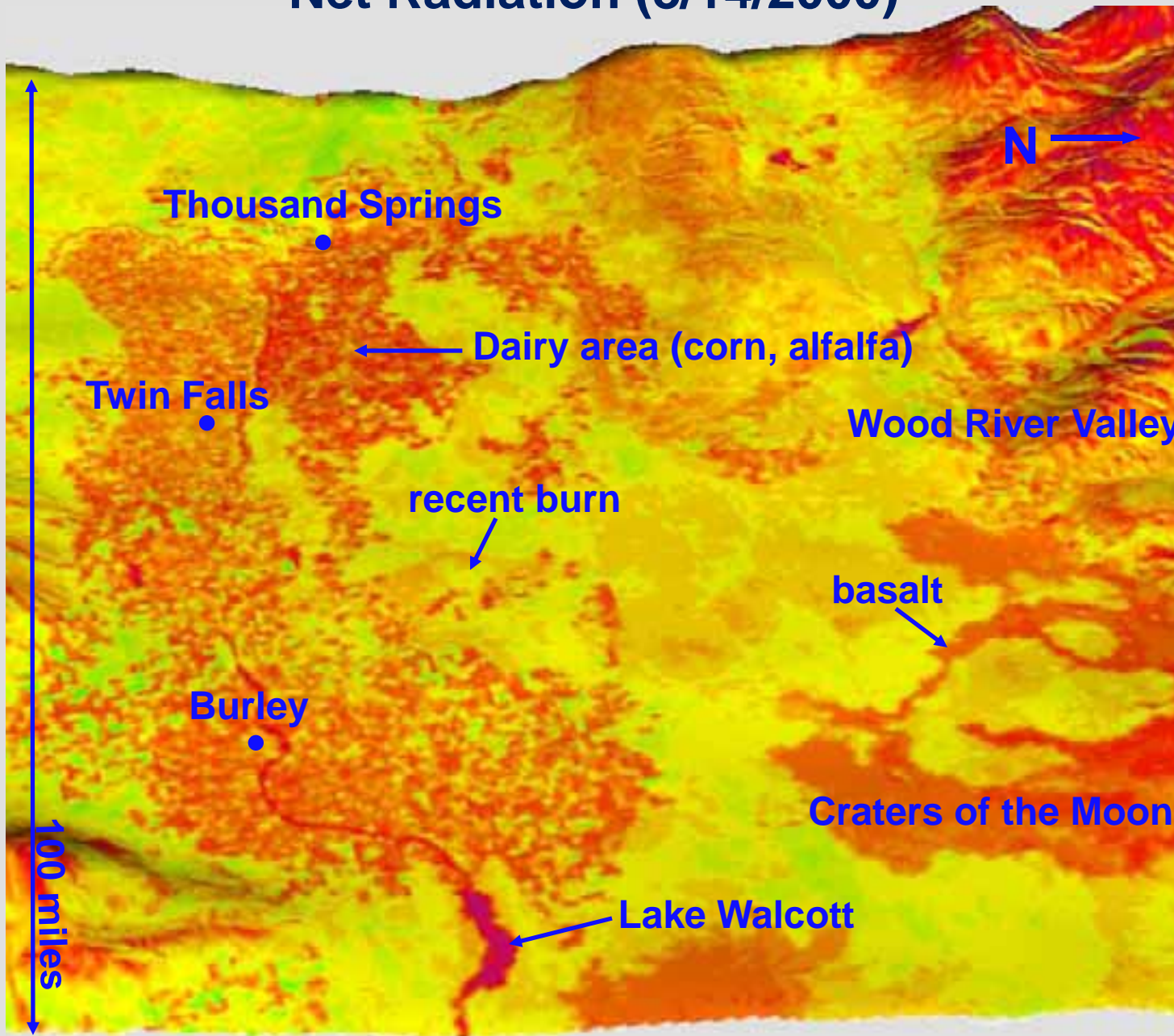




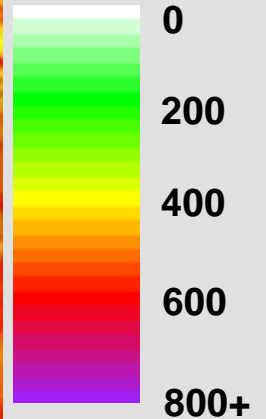
# Surface Temperature (8/14/2000)



# Net Radiation (8/14/2000)

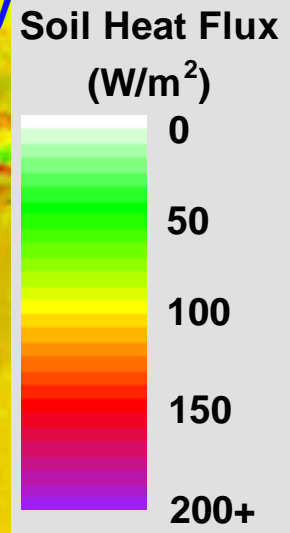
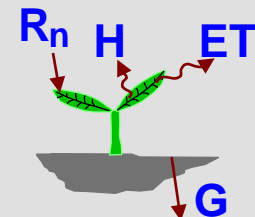
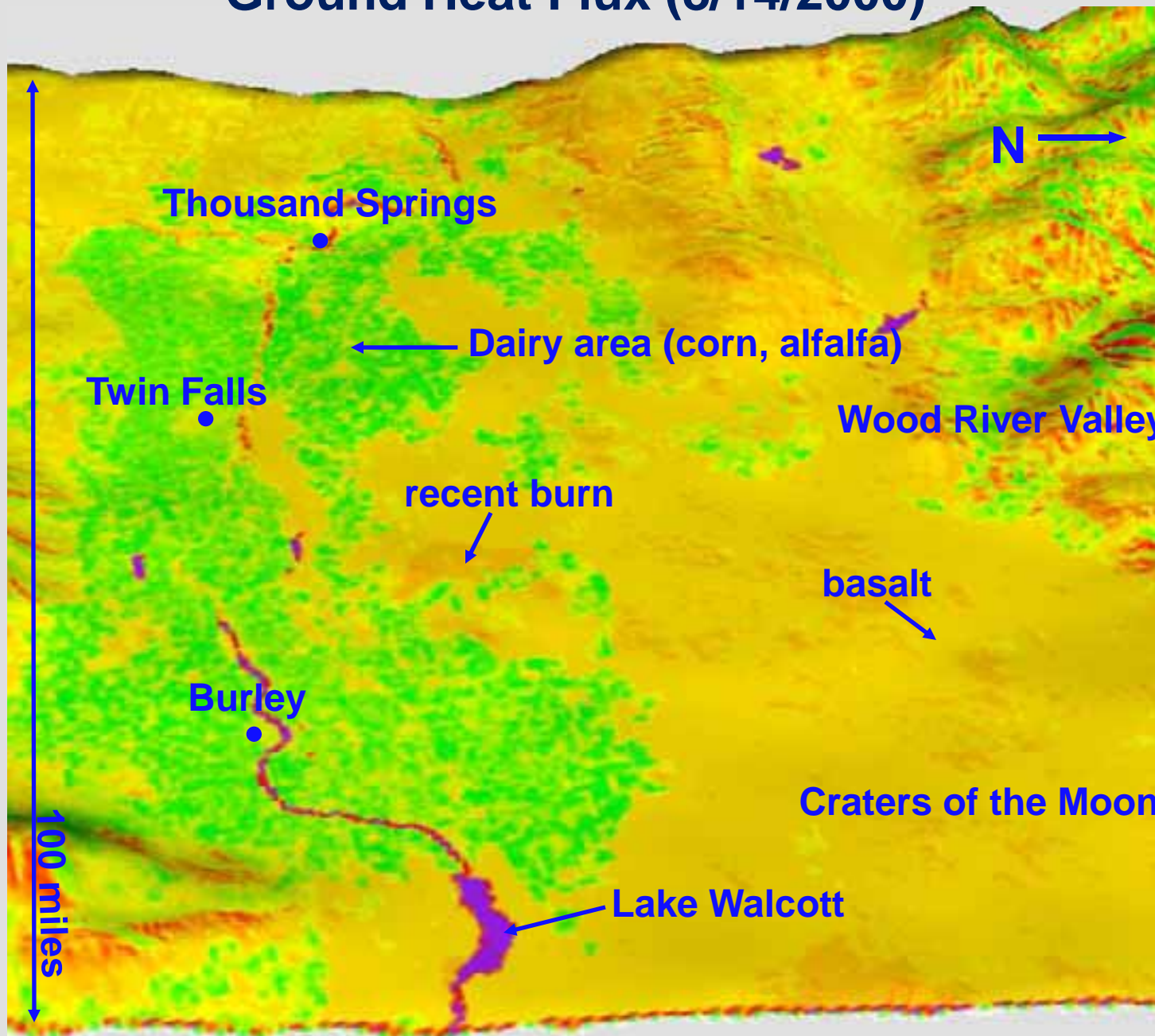


Net Radiation  
( $W/m^2$ )

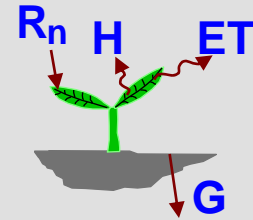
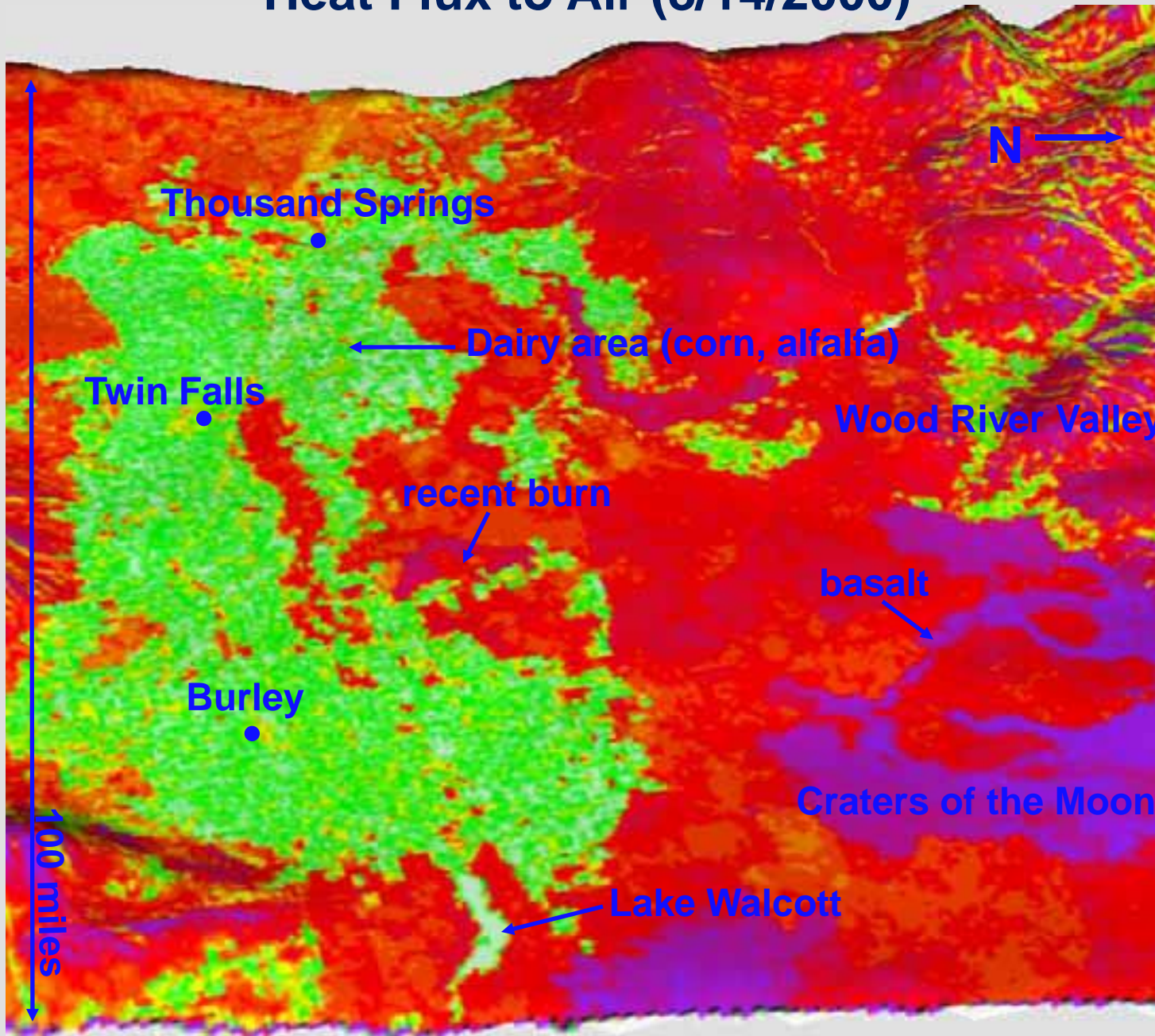




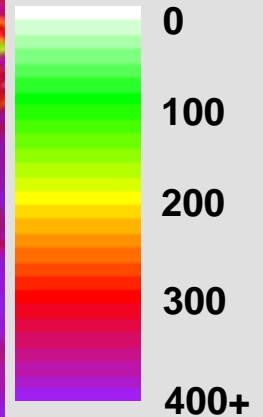
# Ground Heat Flux (8/14/2000)



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

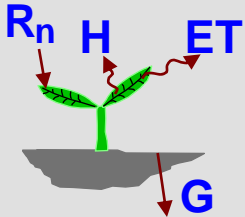
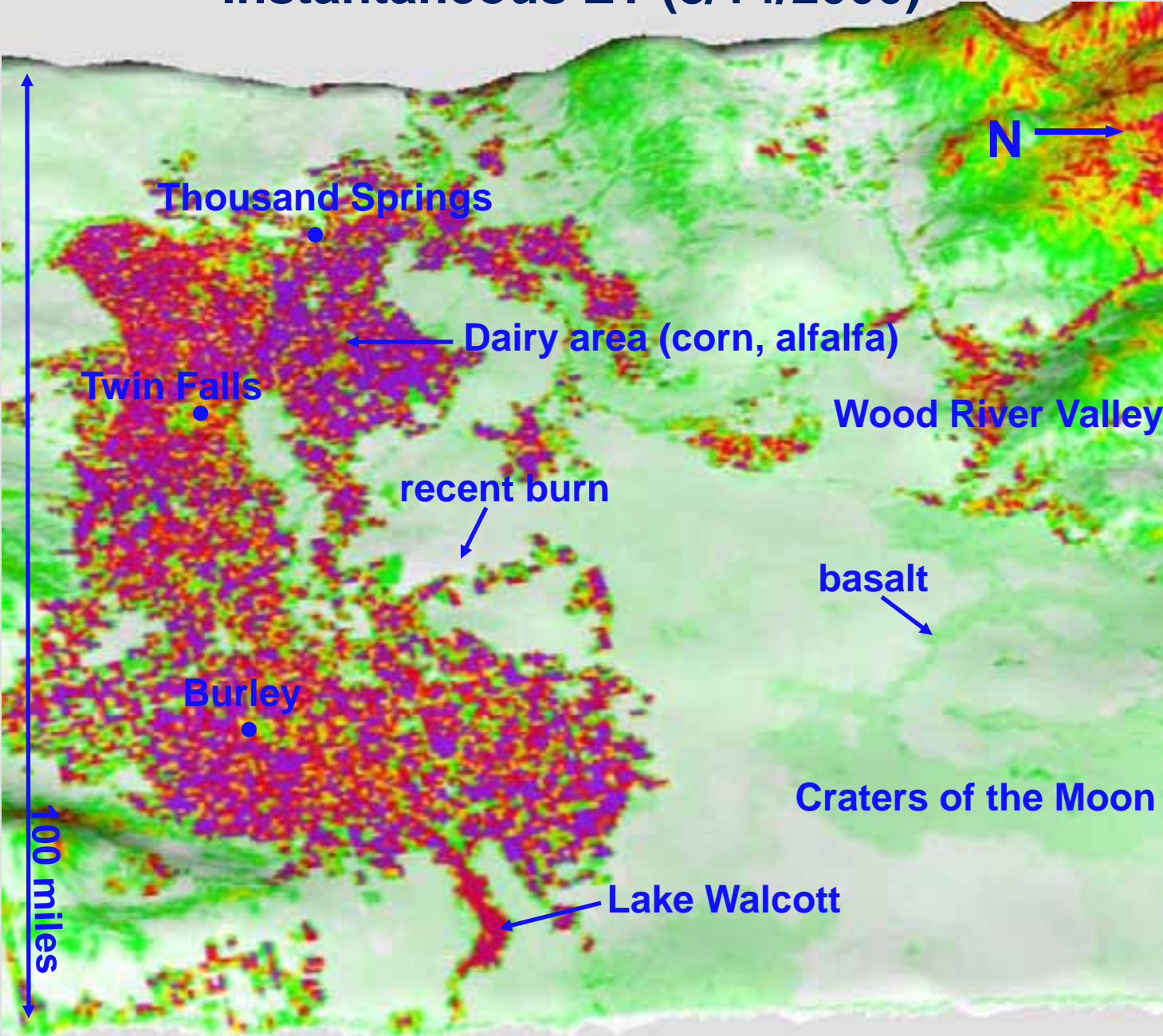


Sensible Heat  
( $W/m^2$ )

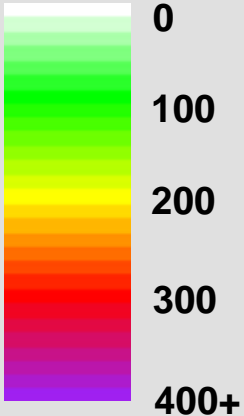




# Instantaneous ET (8/14/2000)

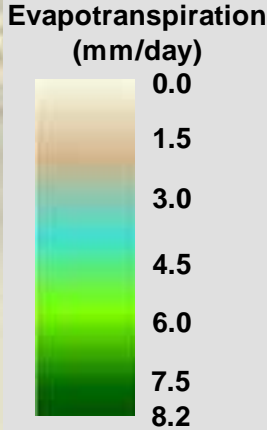
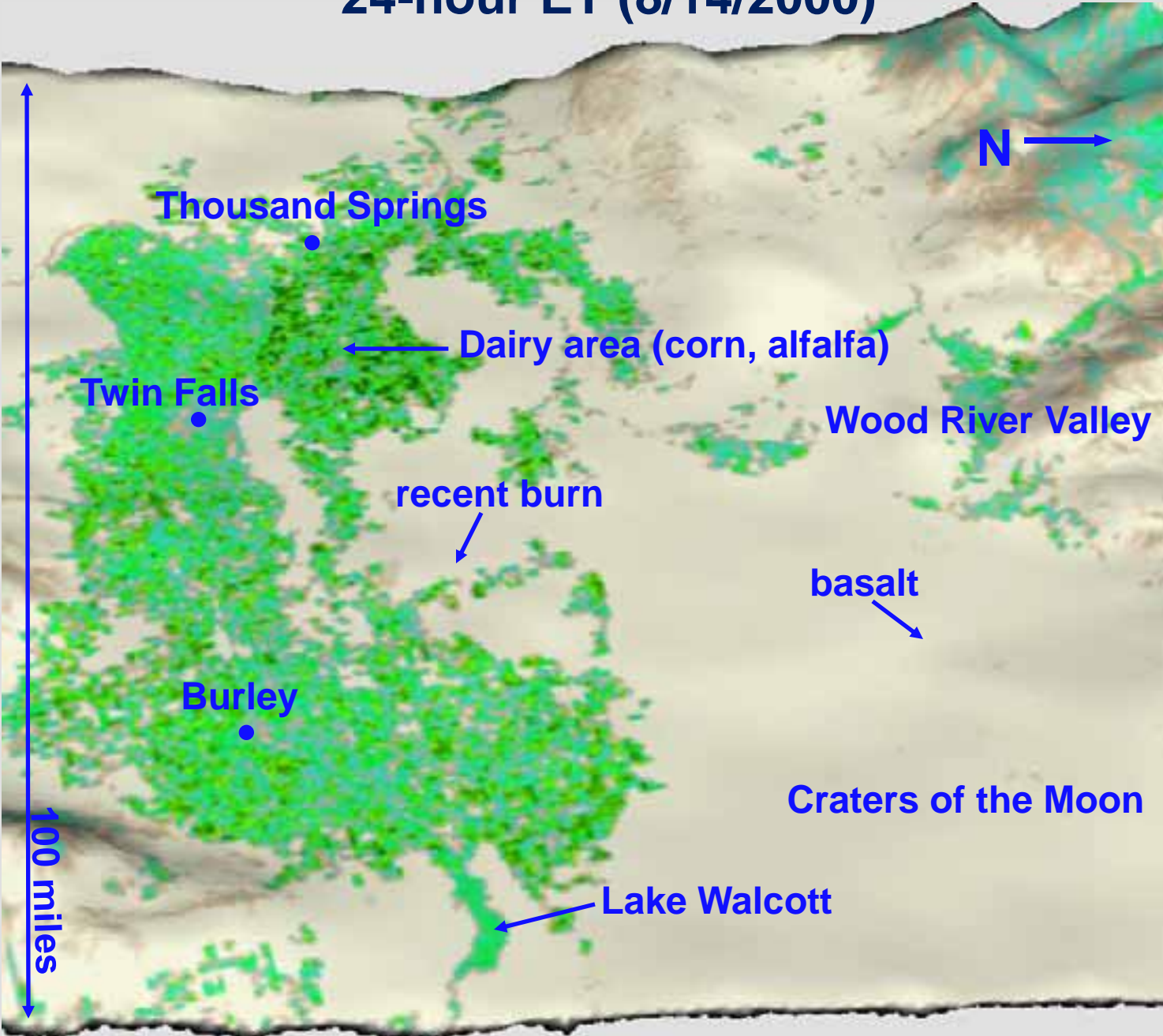


Latent Heat  
( $W/m^2$ )





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



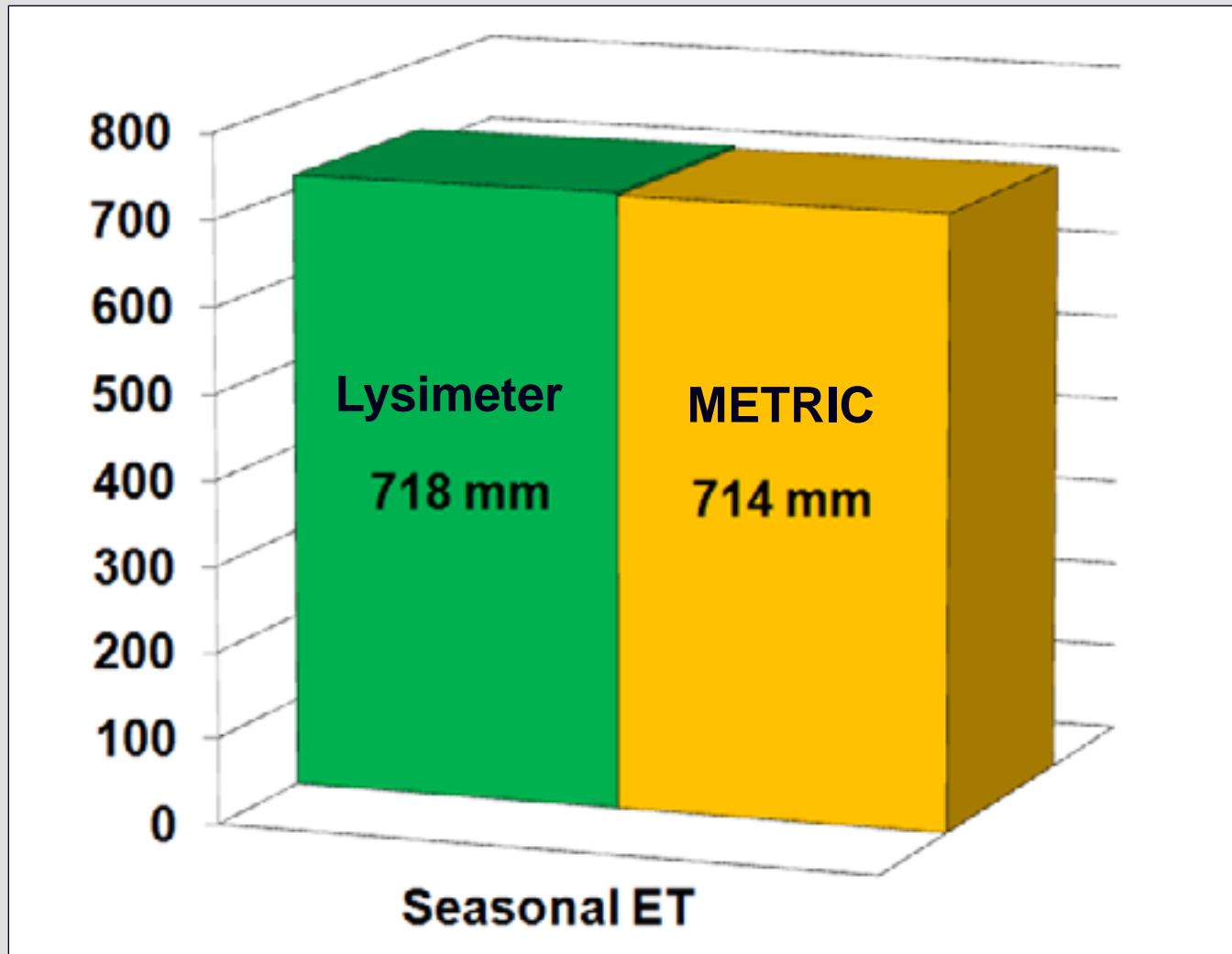
# Comparison with Lysimeter Measurements



1968-1991

Lysimeter at Kimberly (Wright)





Seasonal ET for sugar beets at the Kimberly Research Station, April to September, 1989.

# Water Rights Litigation

## Water Right

- Authorization to use water
- Includes priority date and rate of flow/volume

## Call

- When a senior water right holder experiences a water shortage they may place a call

## Curtailment Order

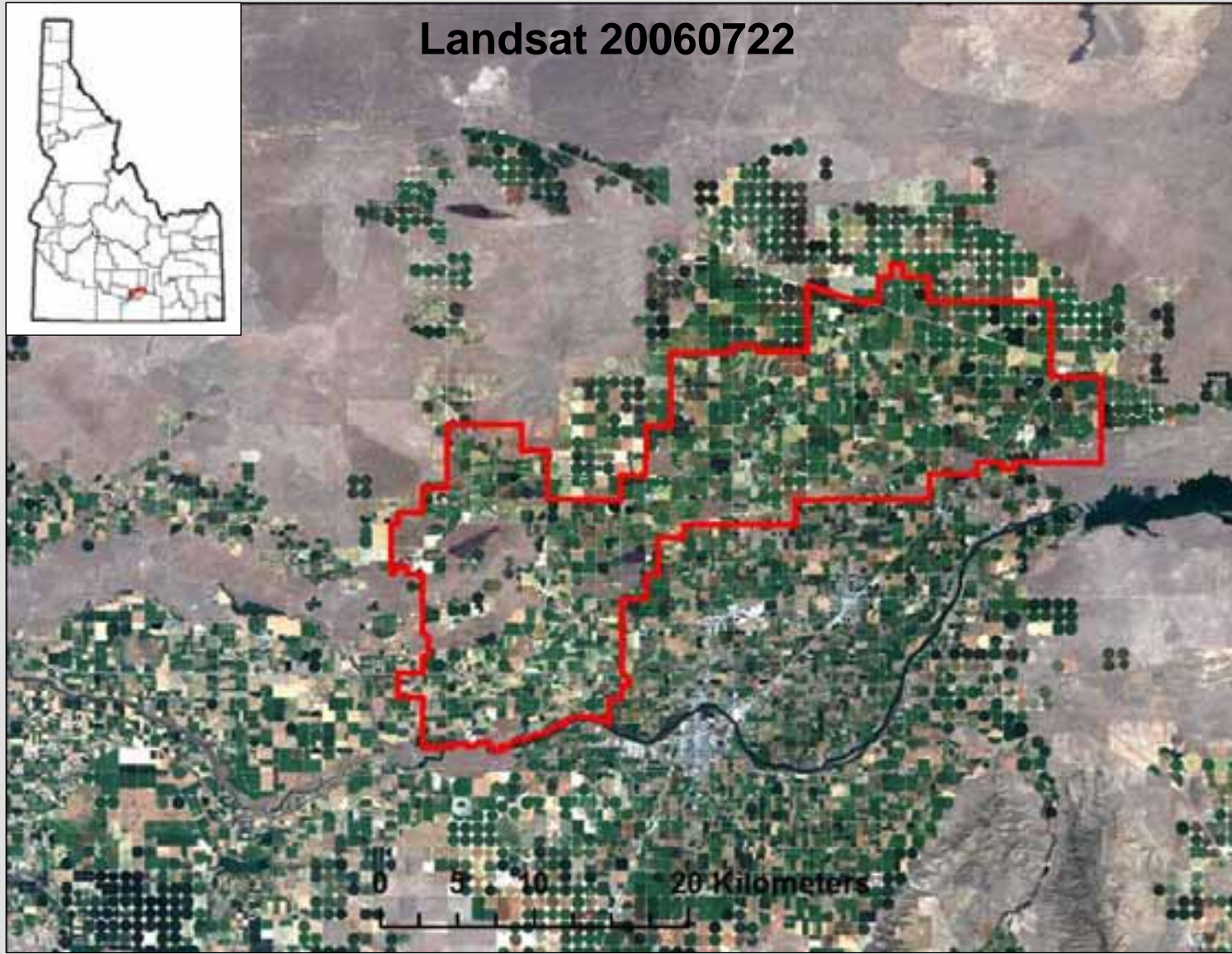
- Defines how the state directs junior water right holders to stop diverting water in response to a call

## Mitigation Plan

- Junior users response to a curtailment order



# A&B Irrigation District



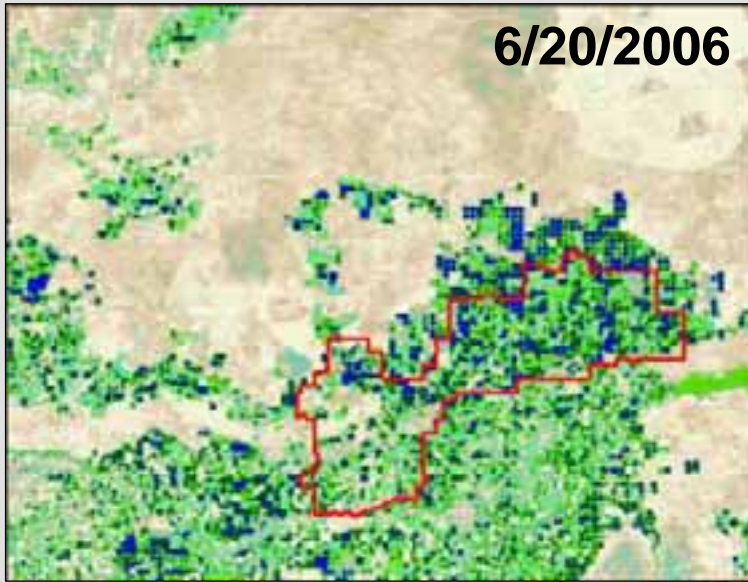
# A&B Irrigation District Water Call

A&B claimed that certain fields were short of water in 2006 due to diversions from junior ground water users

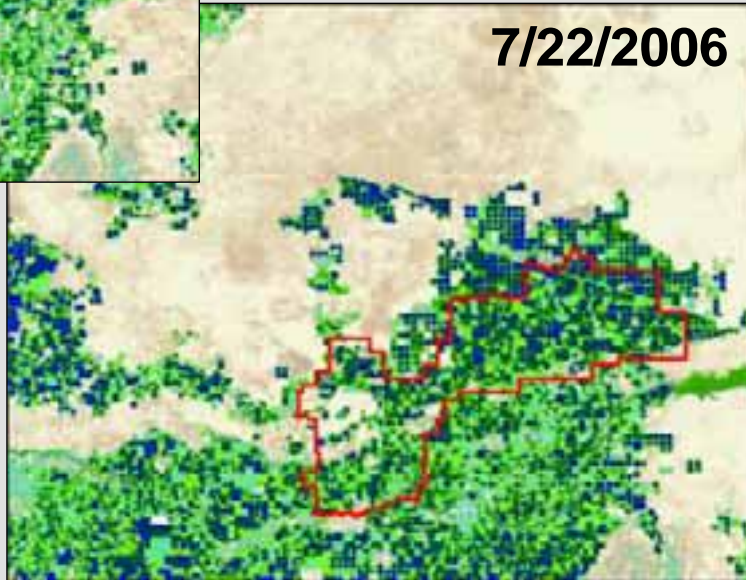
METRIC ET showed that the fields had ET rates as high as surrounding fields that were not identified as short of water

# Daily ET images

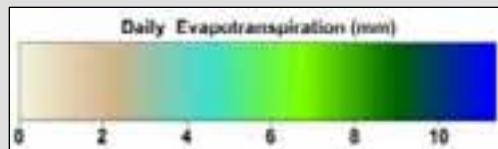
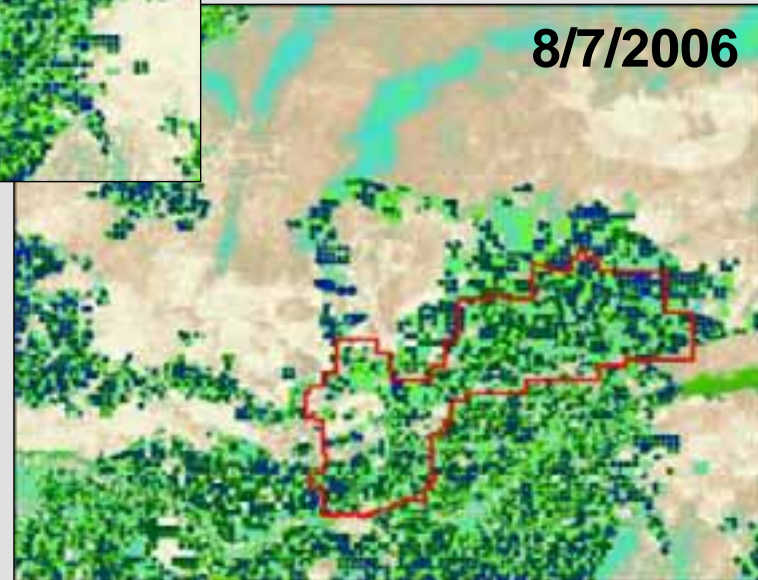
6/20/2006



7/22/2006

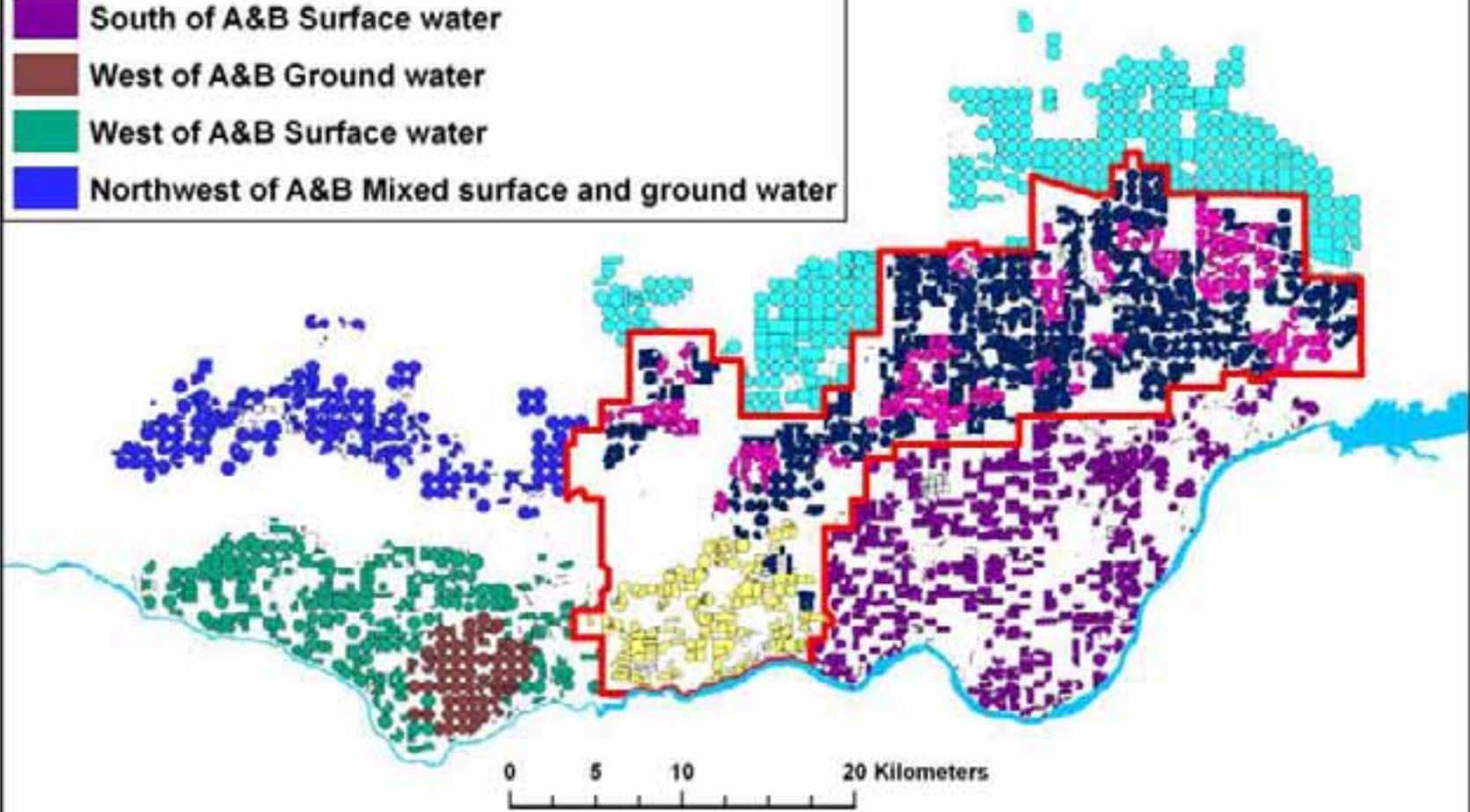
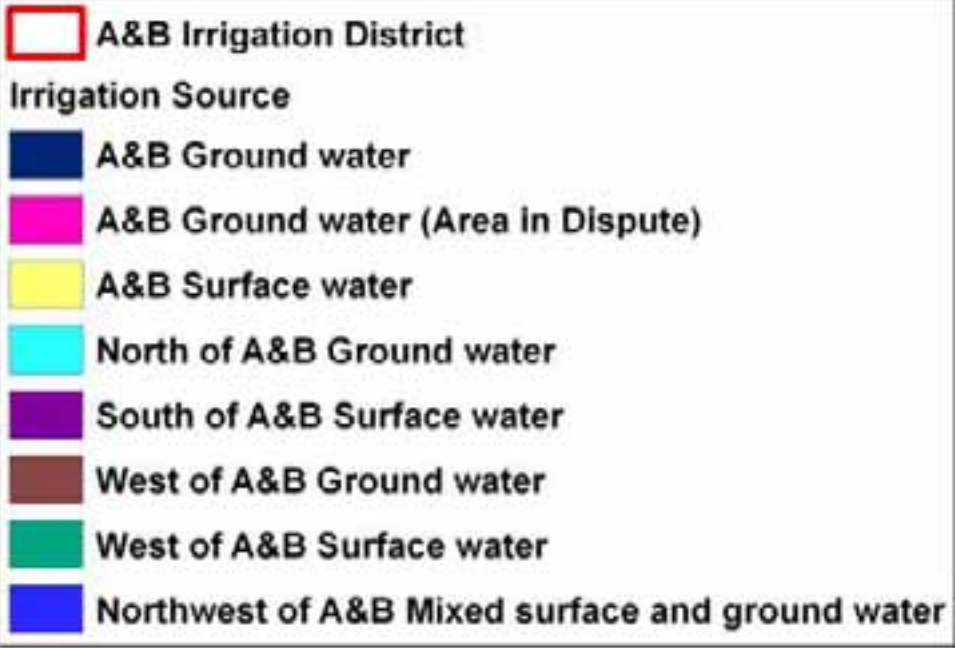


8/7/2006



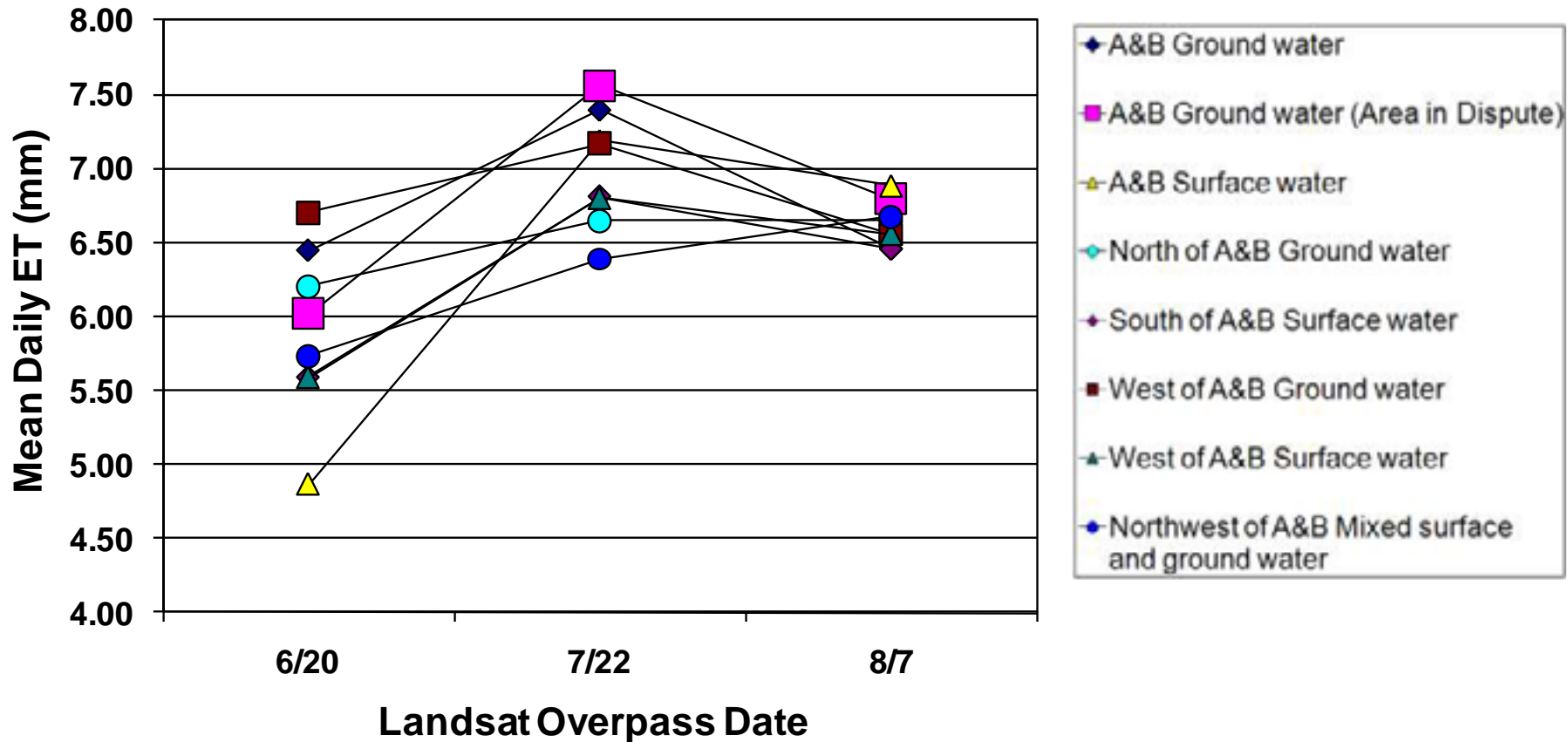


# A&B Irrigation District and adjacent land

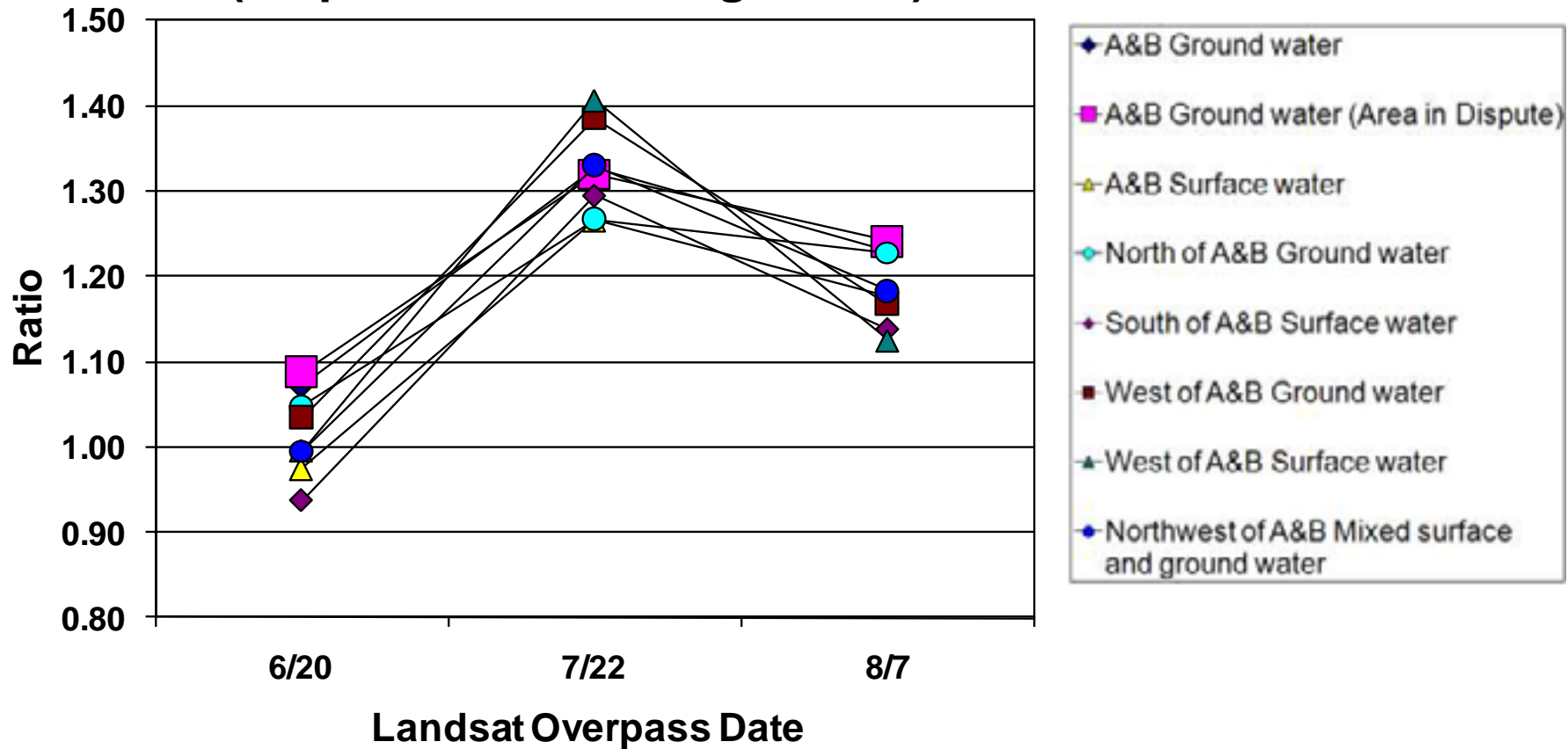




# Year 2006: Mean Daily Evapotranspiration (ET)



## Year 2006: Ratio of ETrF and NDVI (ET per amount of vegetation)



# **A&B Irrigation District Water Call**

## **Summary**

**Director** issued order denying the call

**Hearing Officer** agreed with the Director's decision

**District Court** affirmed the Director's decision

### **Idaho Supreme Court**

- Argued on February 28, 2012
- Waiting for decision

# Other states using 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

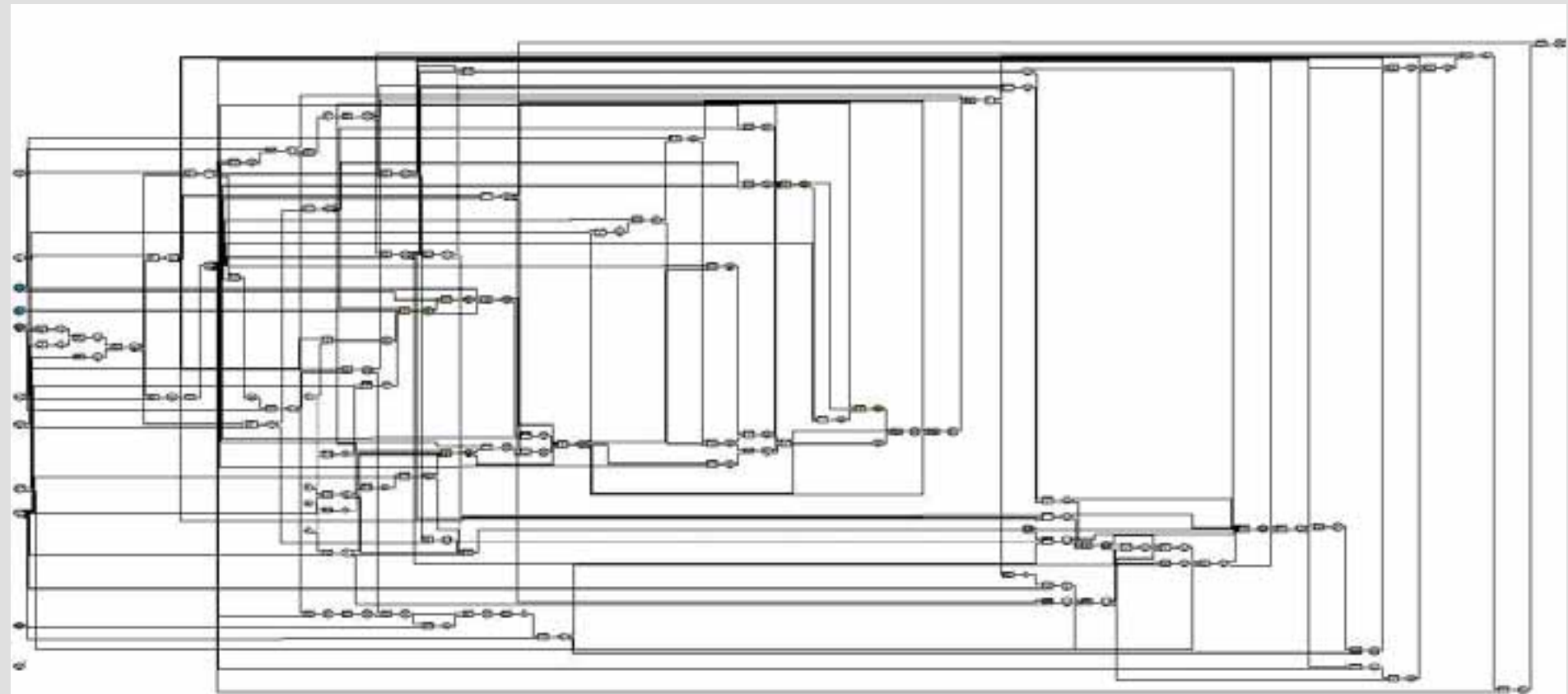
Middle Rio Grande: water consumption by agriculture and riparian systems

## Montana

Flathead Indian Reservation and ground water areas east of Helena: for improved irrigation water management and management of total depletion

# Sharpen Thermal Infrared Landsat 5

ArcInfo ModelBuilder



# Sharpen Thermal Infrared Landsat 5

ET using 120 m  
thermal pixels



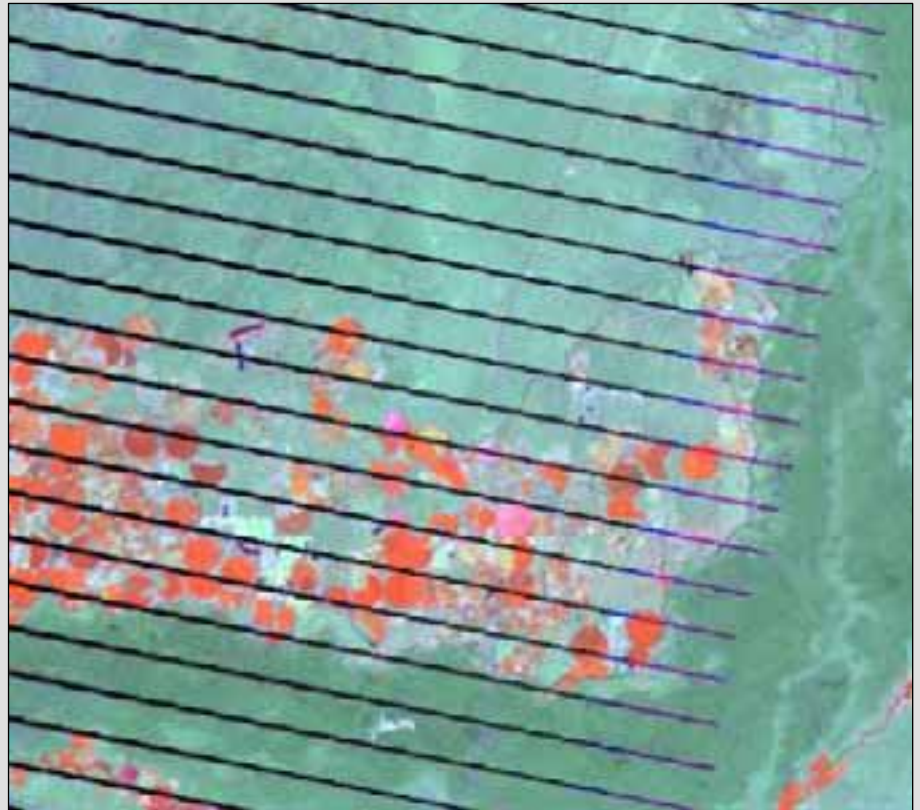
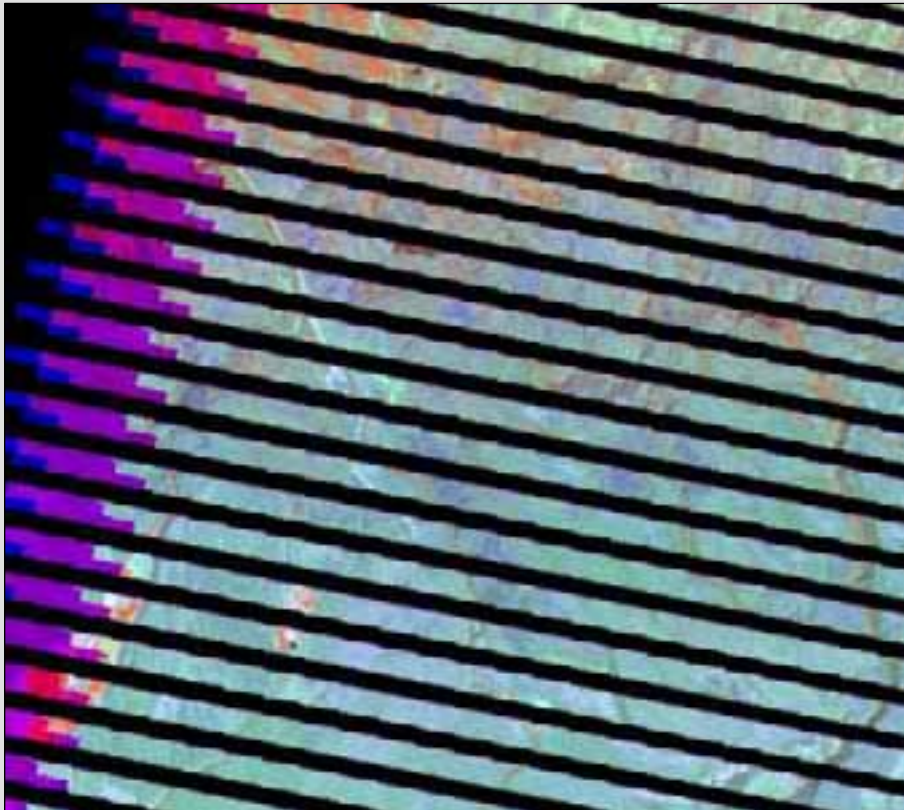
ET using 'Sharpened'  
thermal pixels





# Gaps in Landsat 7

Scan line corrector failed May 31, 2003



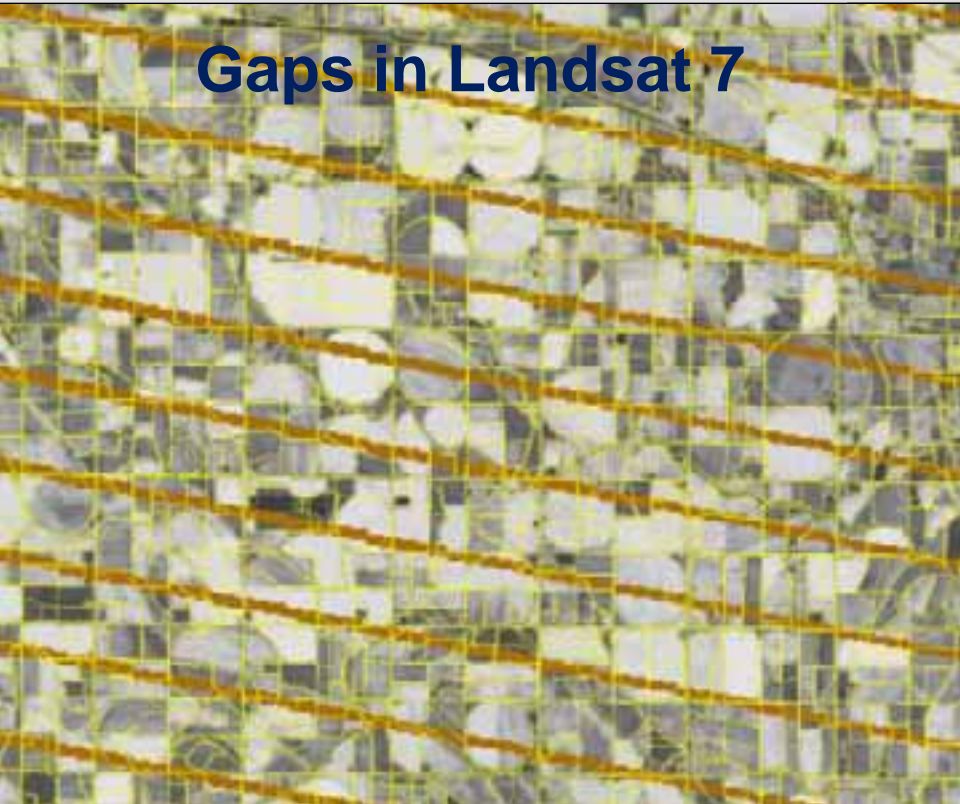
# Gaps filled with ArcInfo Tools

**Set Null:** change gaps to nodata

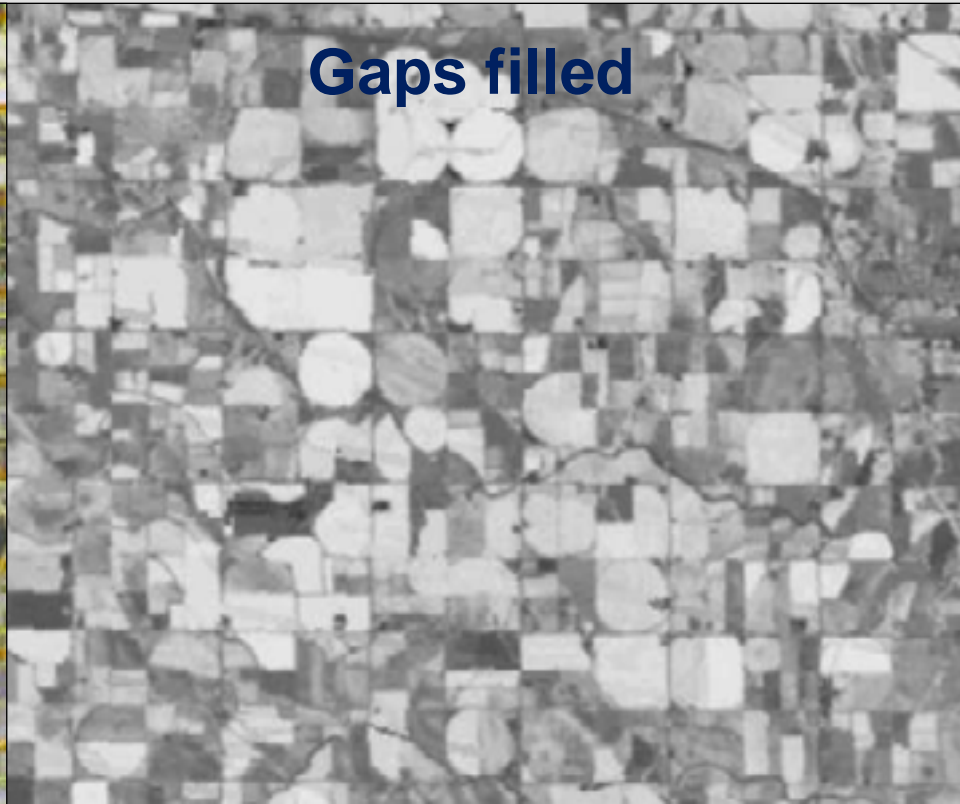
**Zonal Statistics:** compute mean of polygons

**Is Null & Con:** replace gaps with mean value

**Gaps in Landsat 7**



**Gaps filled**





# Concern about Landsat's future

**Landsat 5** is 28 years old

Imaging halted November 2011

**Landsat 7** is 13 years old

Scan line corrector failed March 2003

**Landsat 8** scheduled to launch January 2013

**Landsat 9** funding is uncertain

# The Landsat Archive

- USGS EROS Data Center, Sioux Falls, SD
- ~ 3 million scenes
- July 1972 to present (thermal since 1984)
- Free
- <http://earthexplorer.usgs.gov/>

# 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)

[www.westernstatesetworkshop.com](http://www.westernstatesetworkshop.com)

0 25 50 100 Kilometers