

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

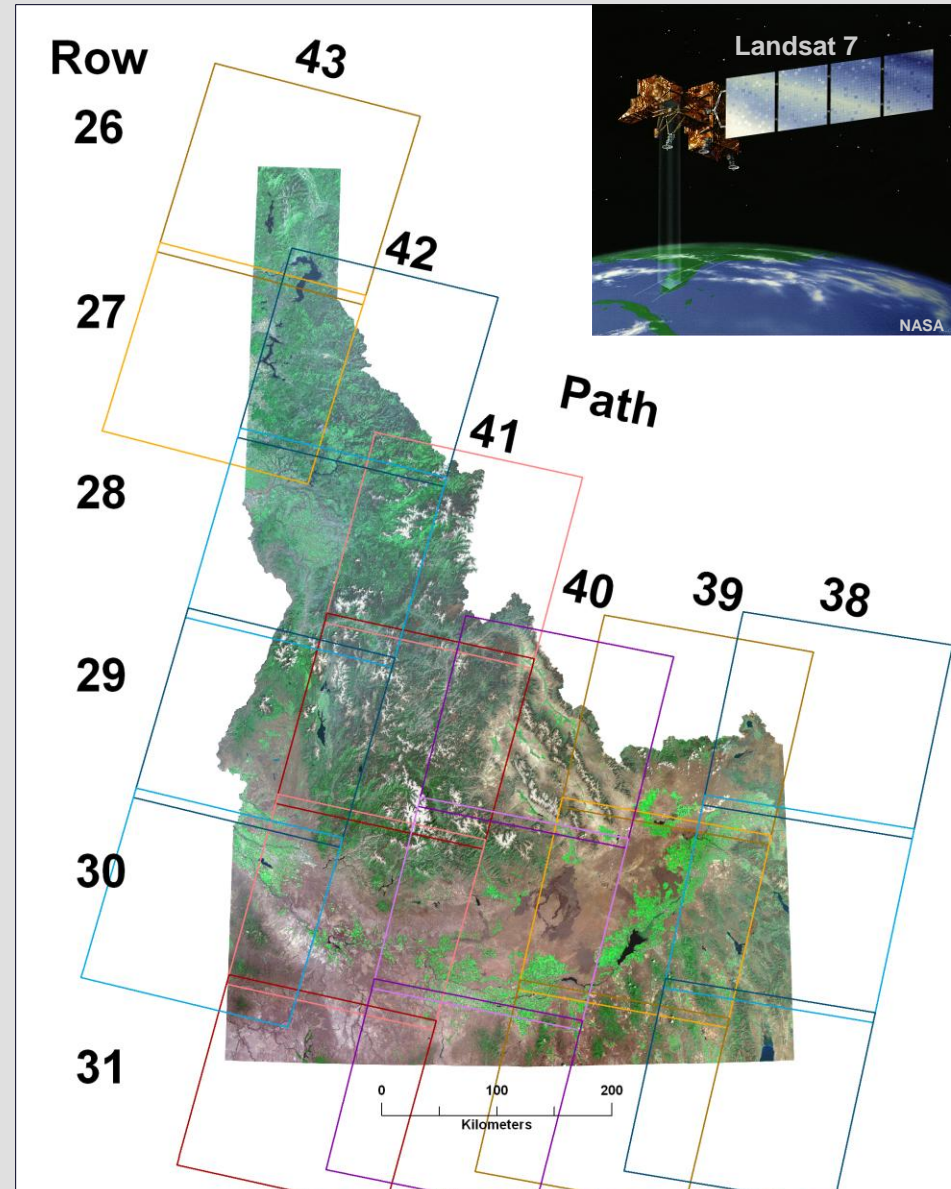
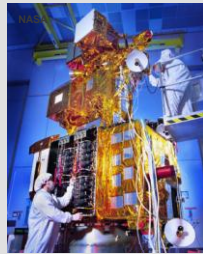
Satellite-based ET

Actual ET from Landsat using METRIC

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

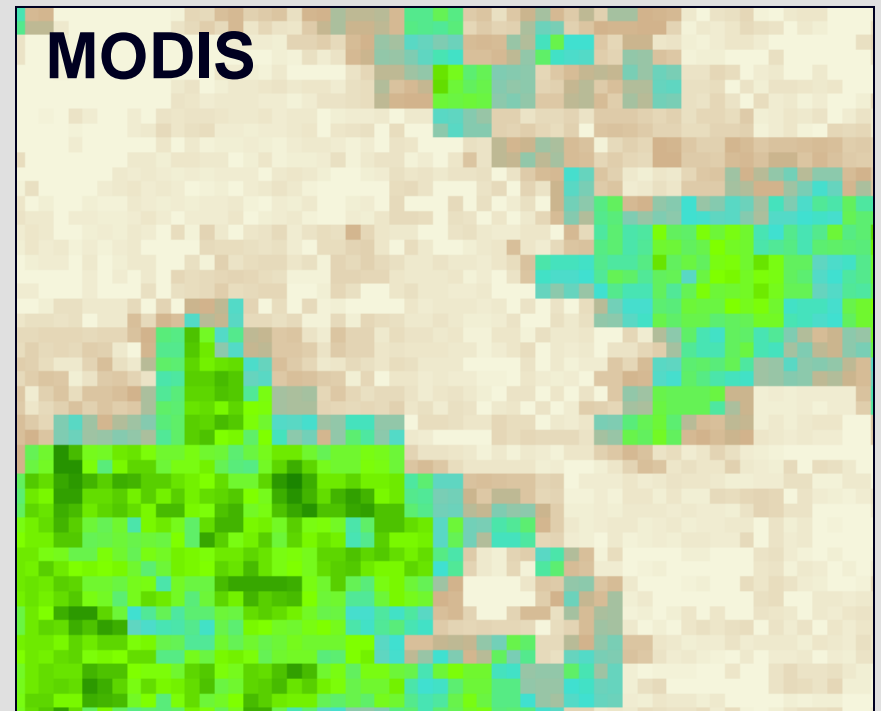
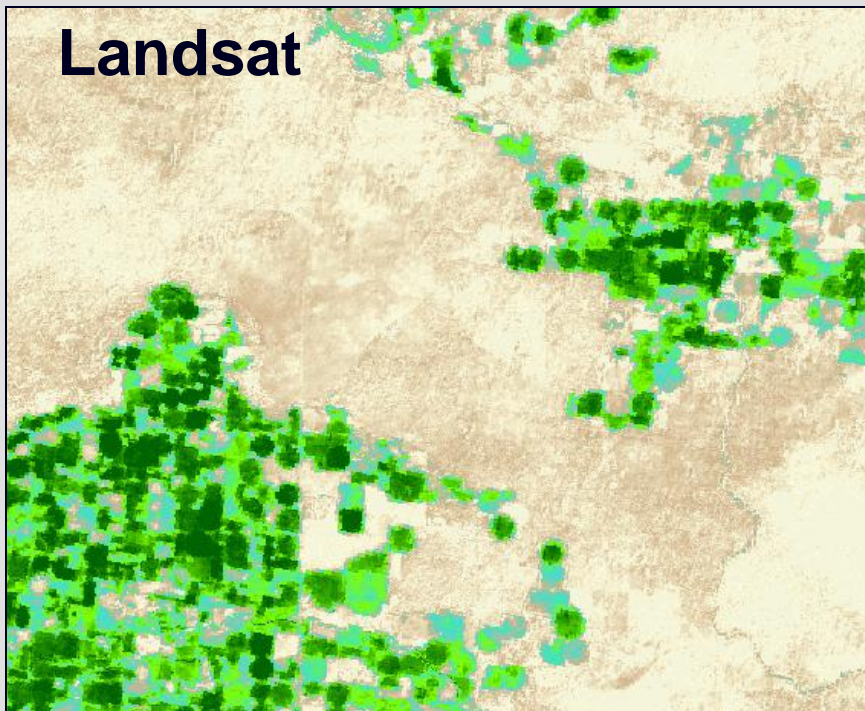
Landsat

- 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 February 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



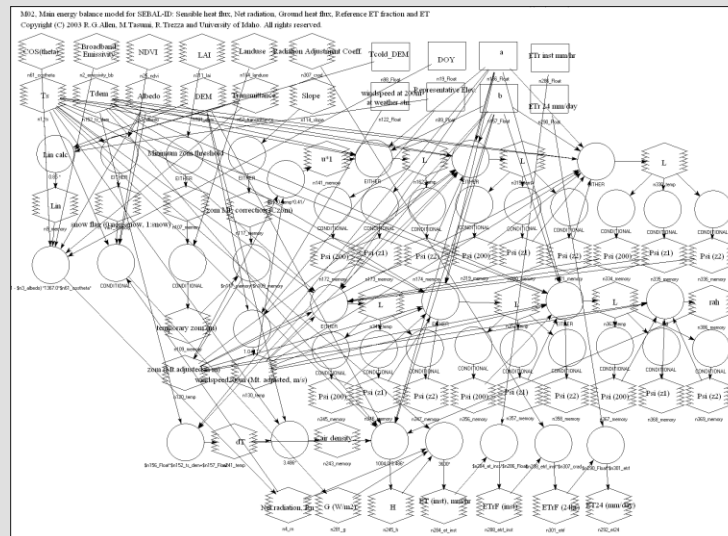
Landsat Thermal Band

- 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

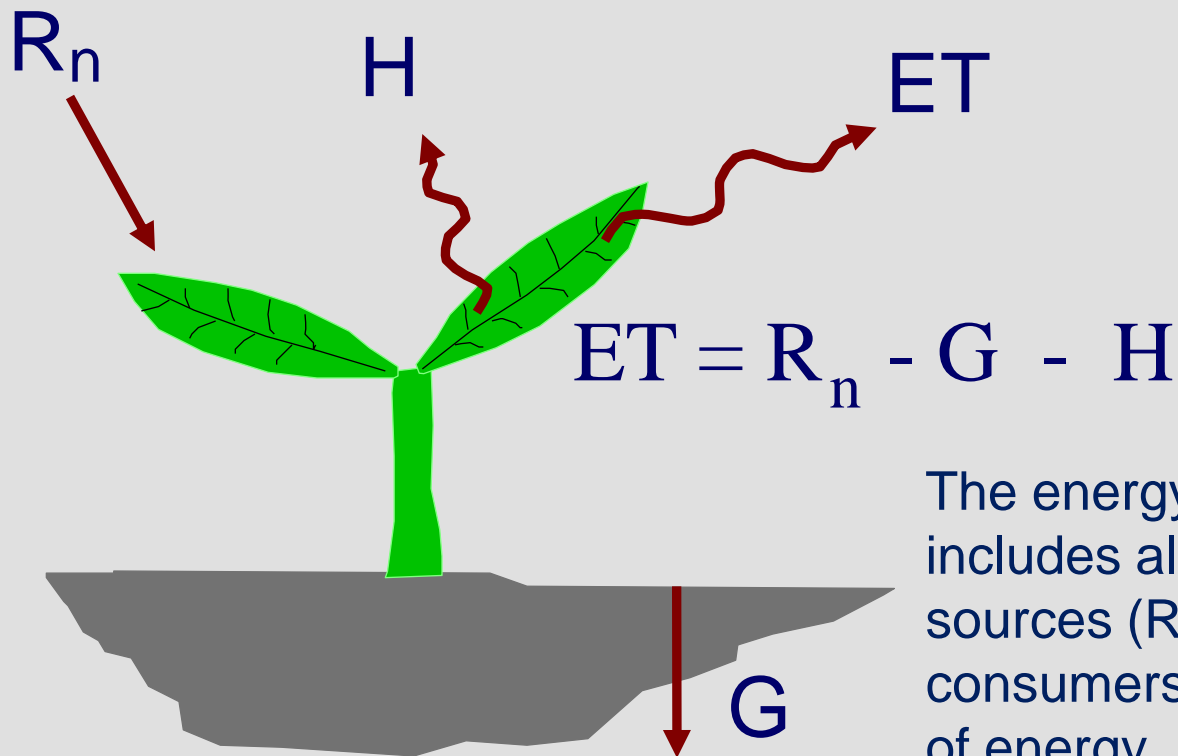
Mapping EvapoTranspiration at high Resolution with Internalized Calibration

- 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

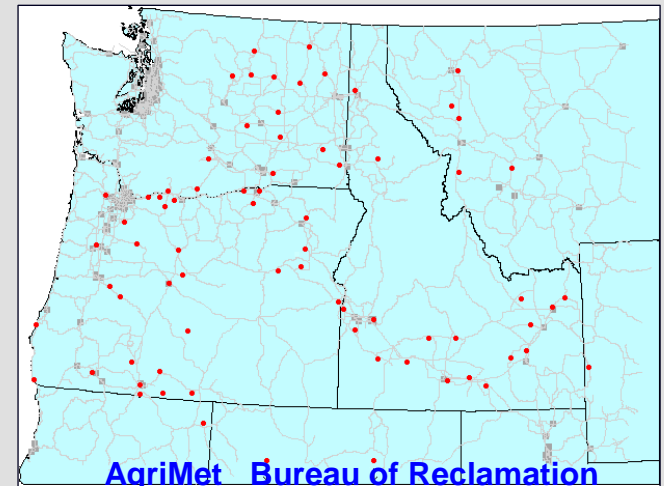
In METRIC, Weather Data are used for:

Wind speed for sensible heat flux calculation

Reference ET for calibrating the Energy Balance

Reference ET to extrapolate ET

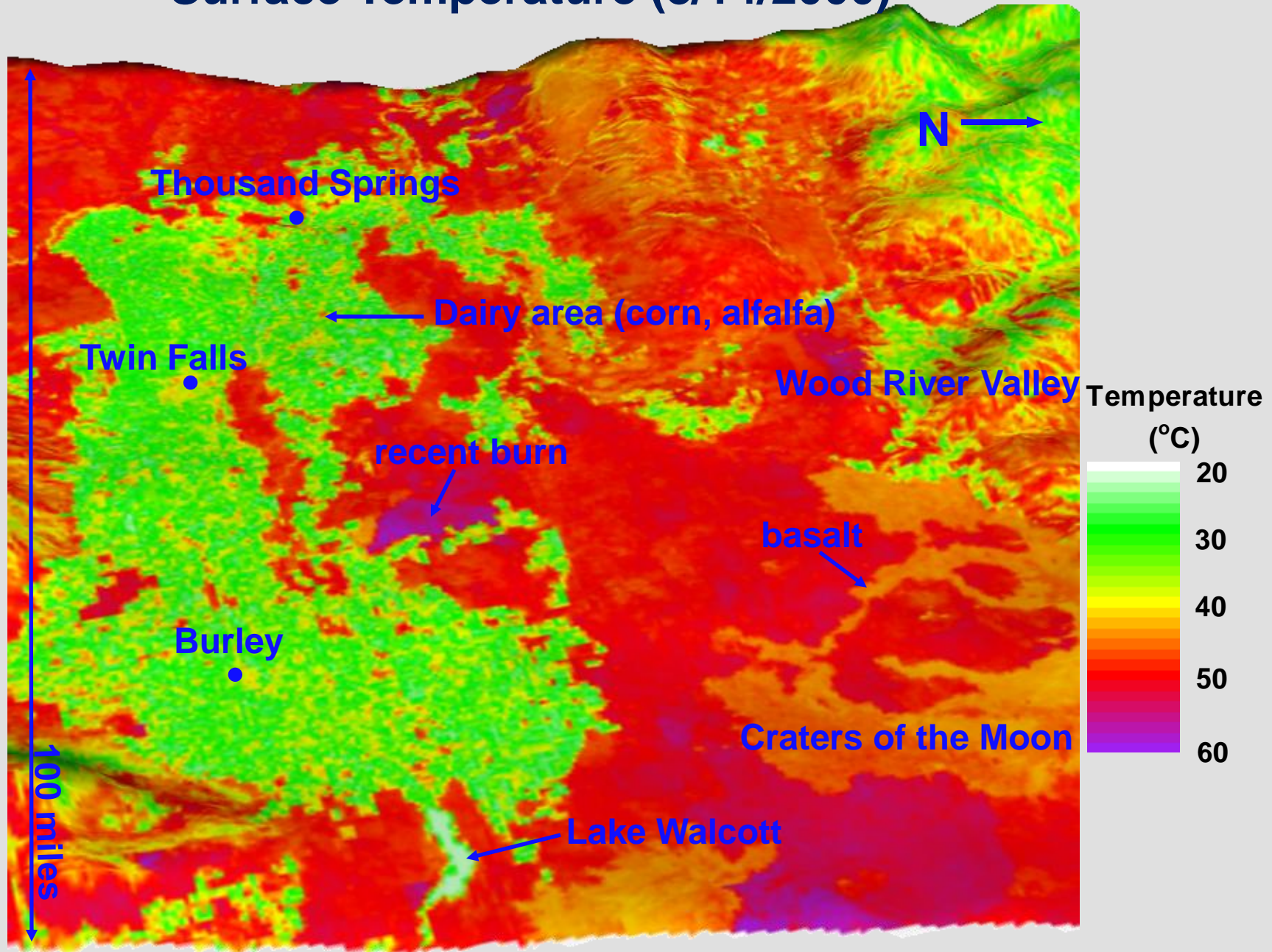
- 24-hour period
- Days between images



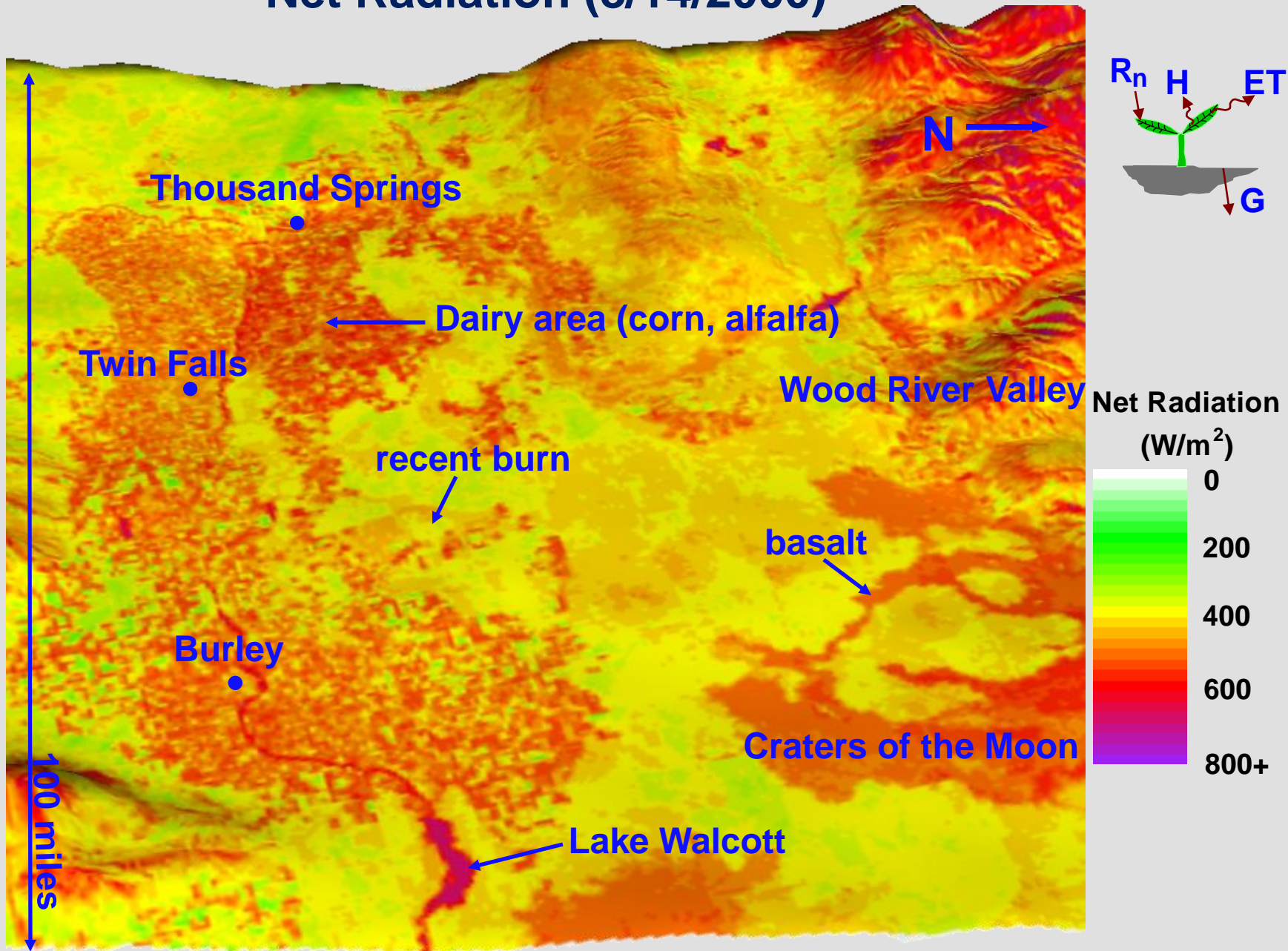
Landsat, south-central Idaho (8/14/2000)



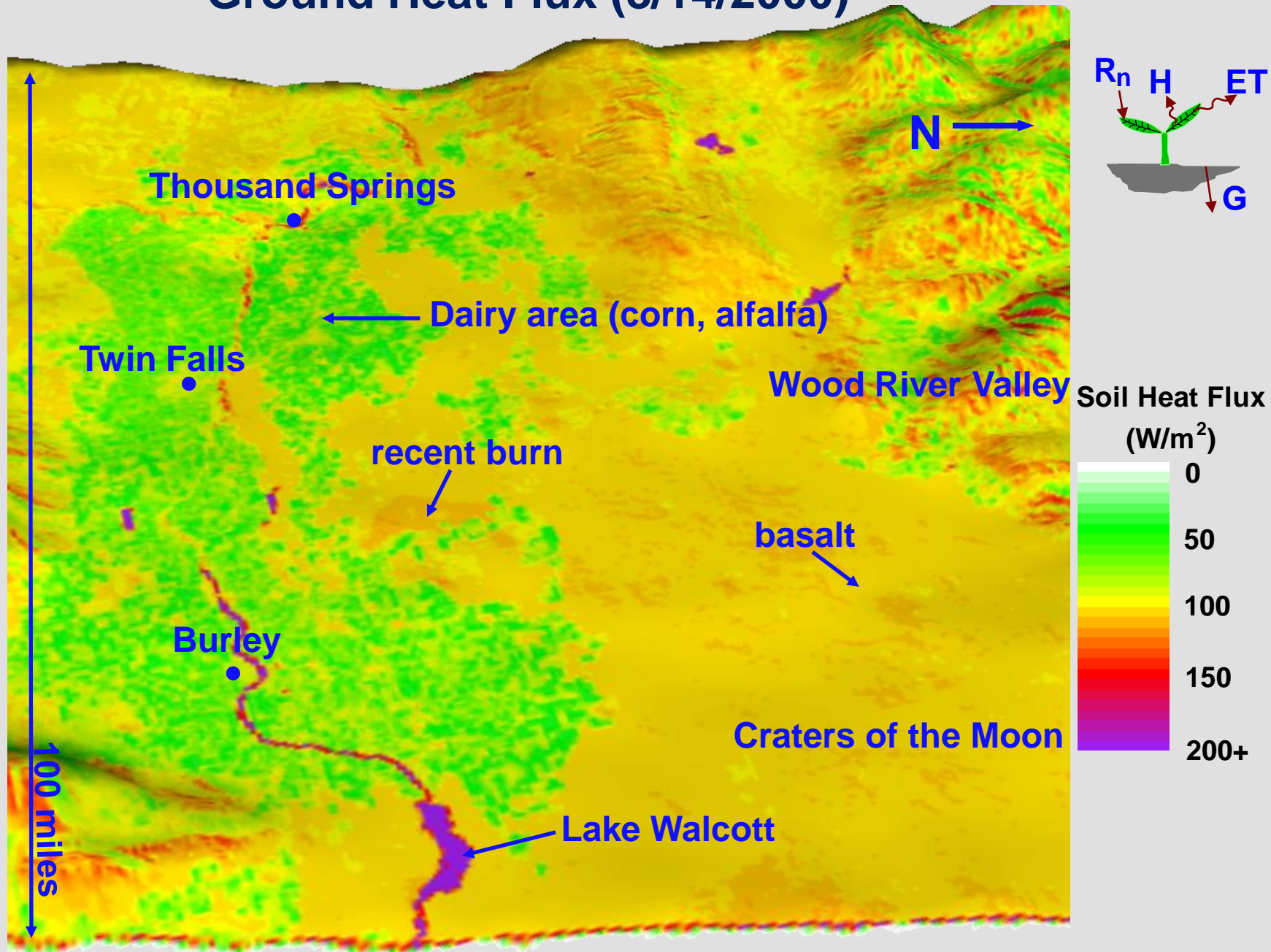
Surface Temperature (8/14/2000)



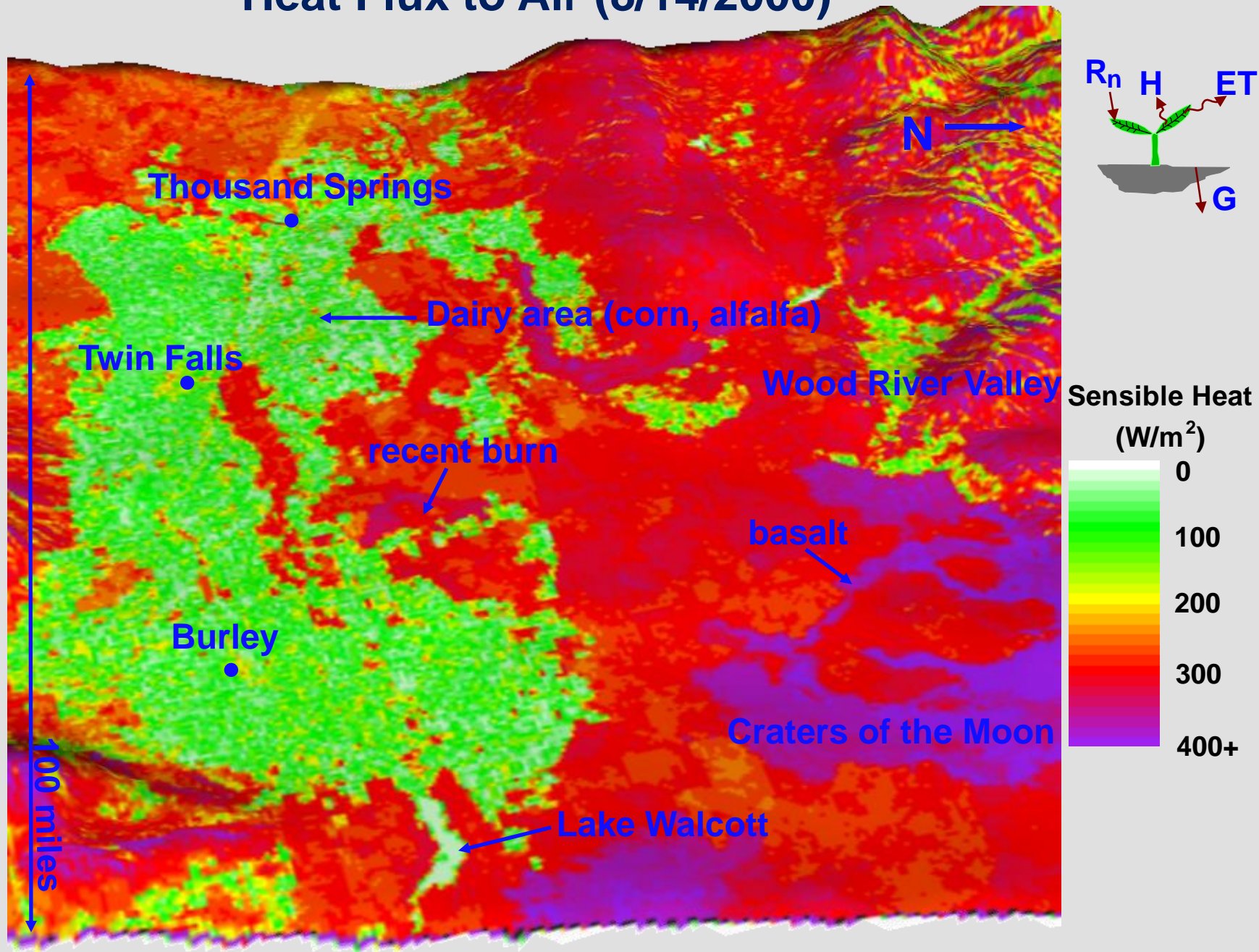
Net Radiation (8/14/2000)



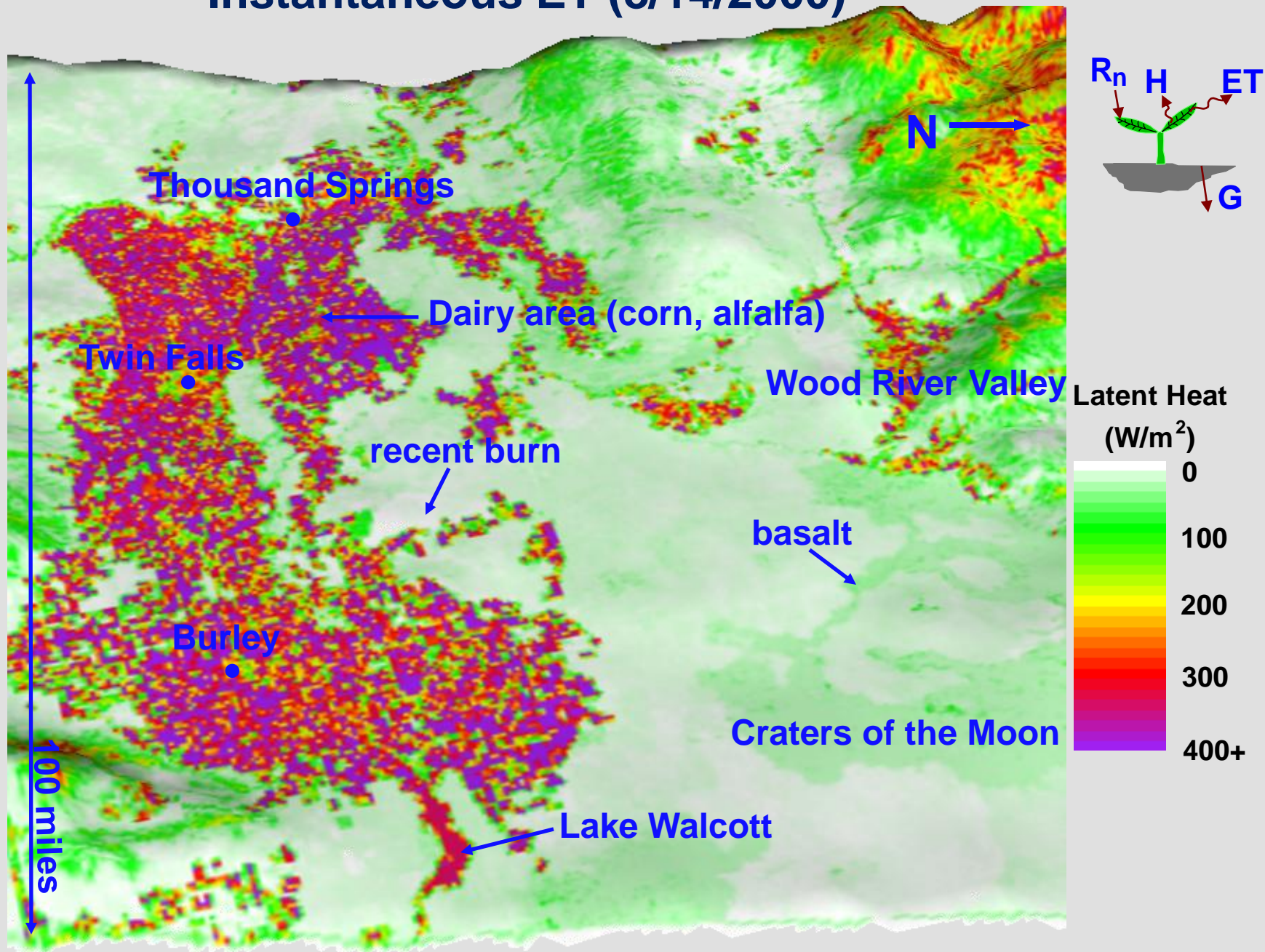
Ground Heat Flux (8/14/2000)



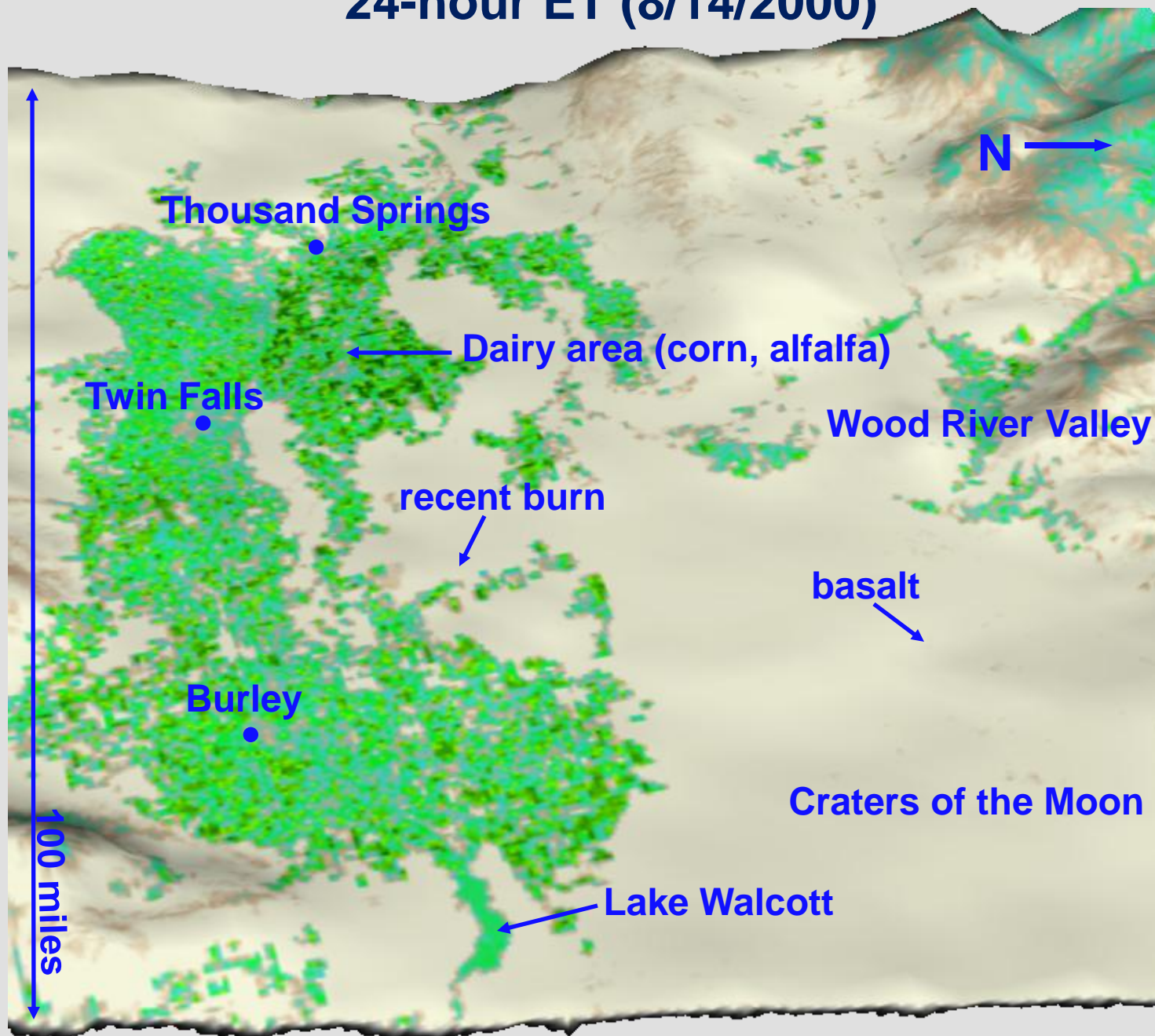
Heat Flux to Air (8/14/2000)



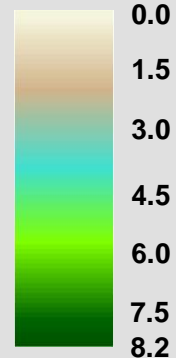
Instantaneous ET (8/14/2000)



24-hour ET (8/14/2000)



Evapotranspiration
(mm/day)



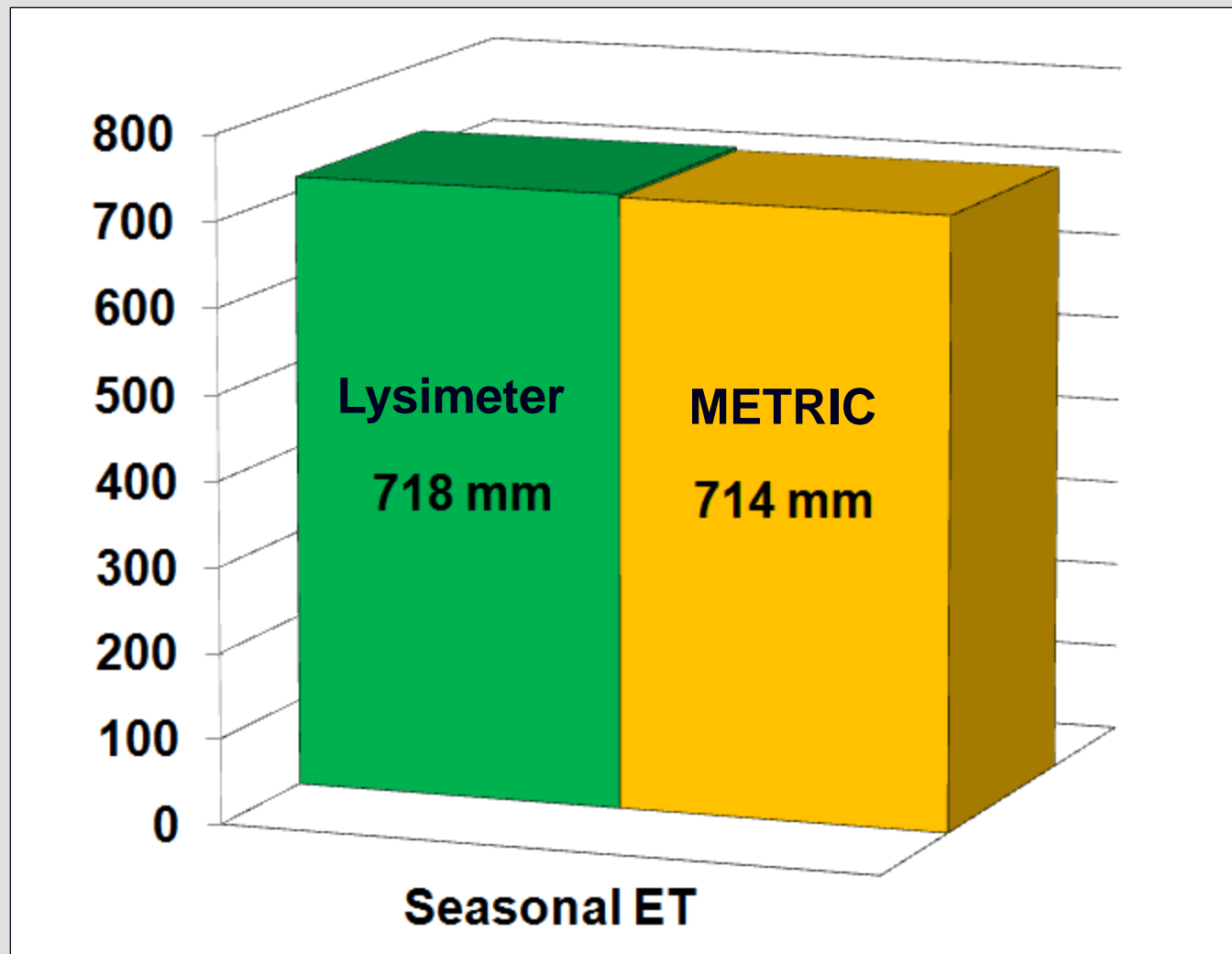
Comparison with Lysimeter Measurements



1968-1991



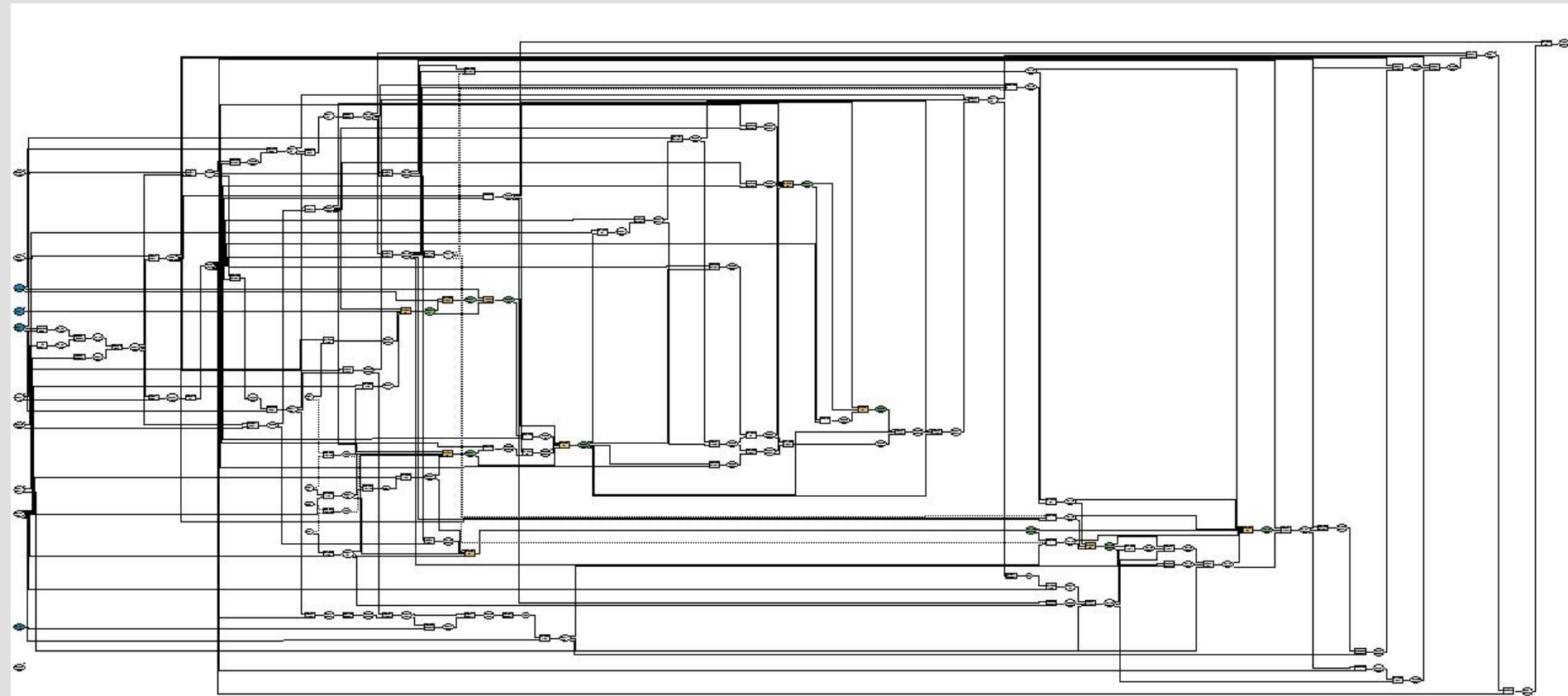
Lysimeter at Kimberly (Wright)



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

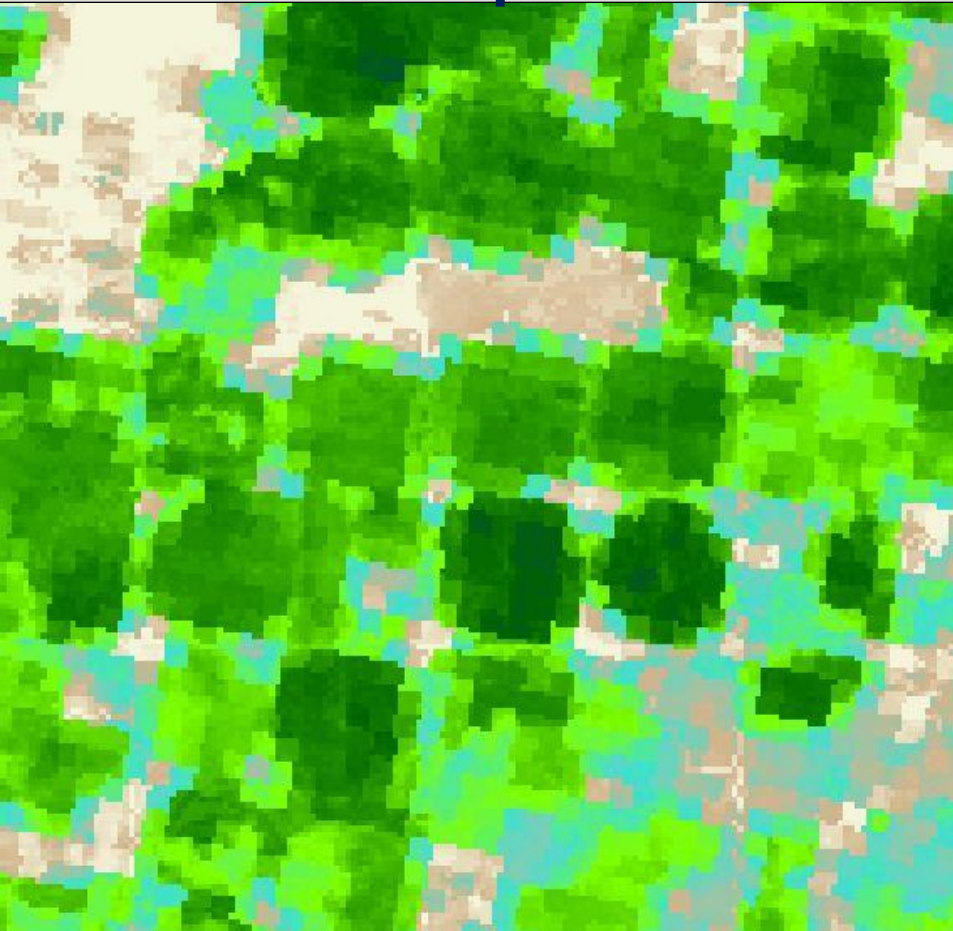
Sharpen Thermal Infrared Landsat 5

ArcInfo ModelBuilder

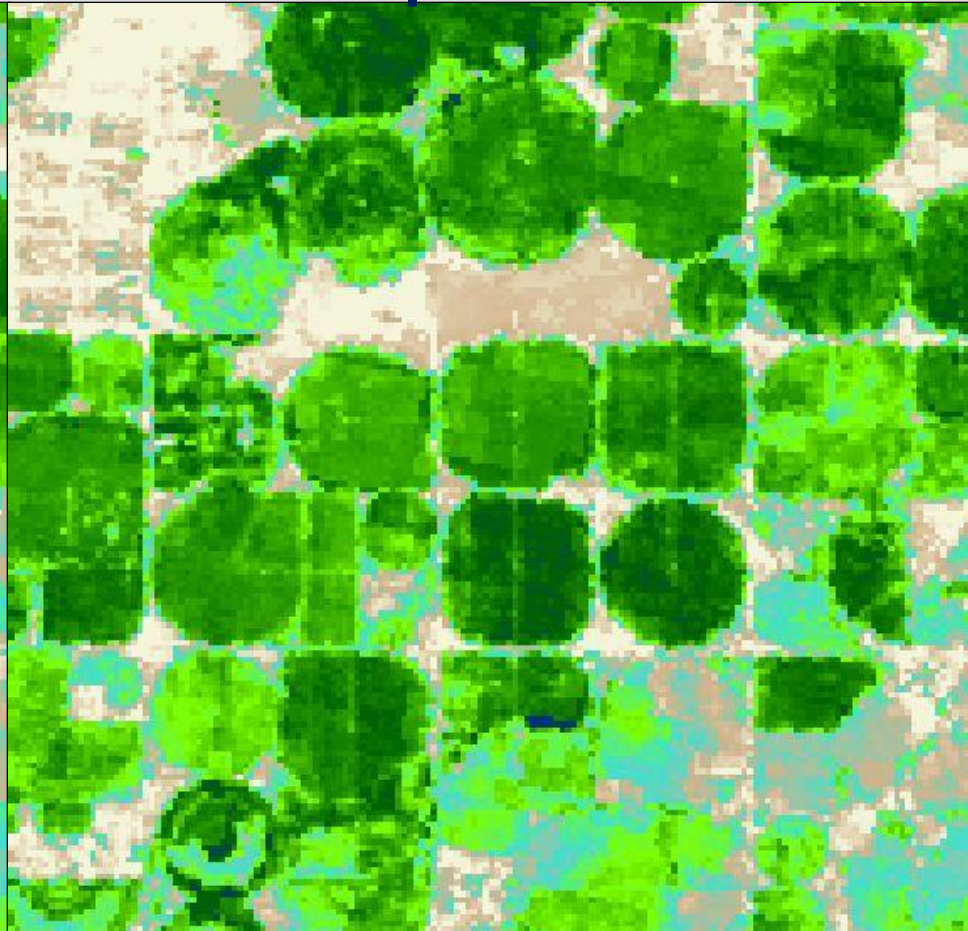


Sharpen Thermal Infrared Landsat 5

ET using 120 m
thermal pixels

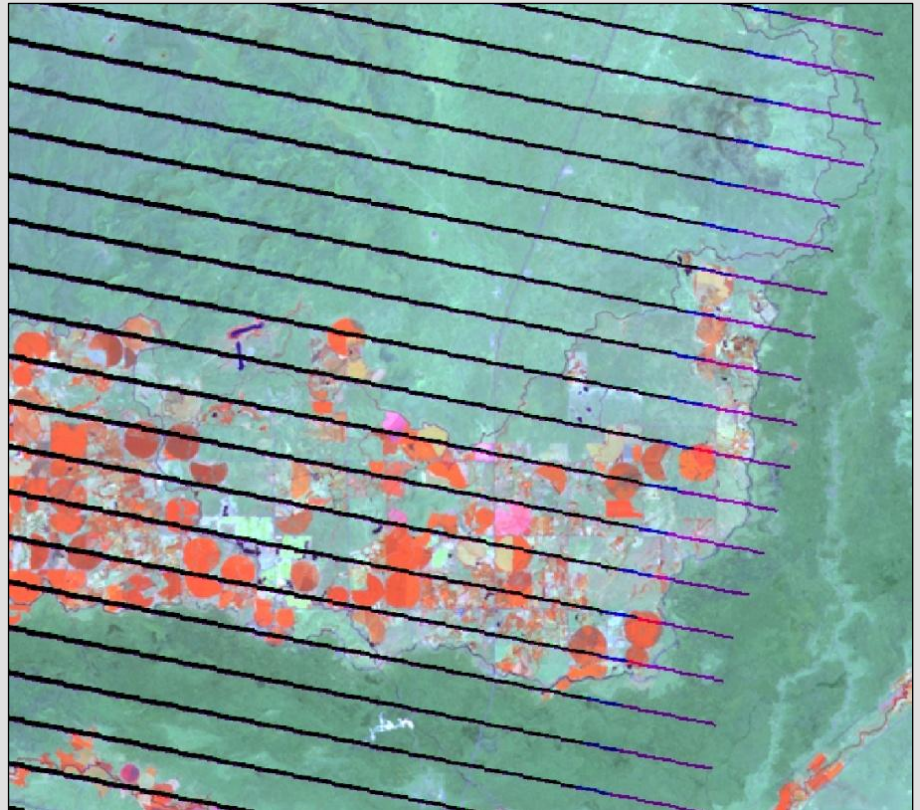
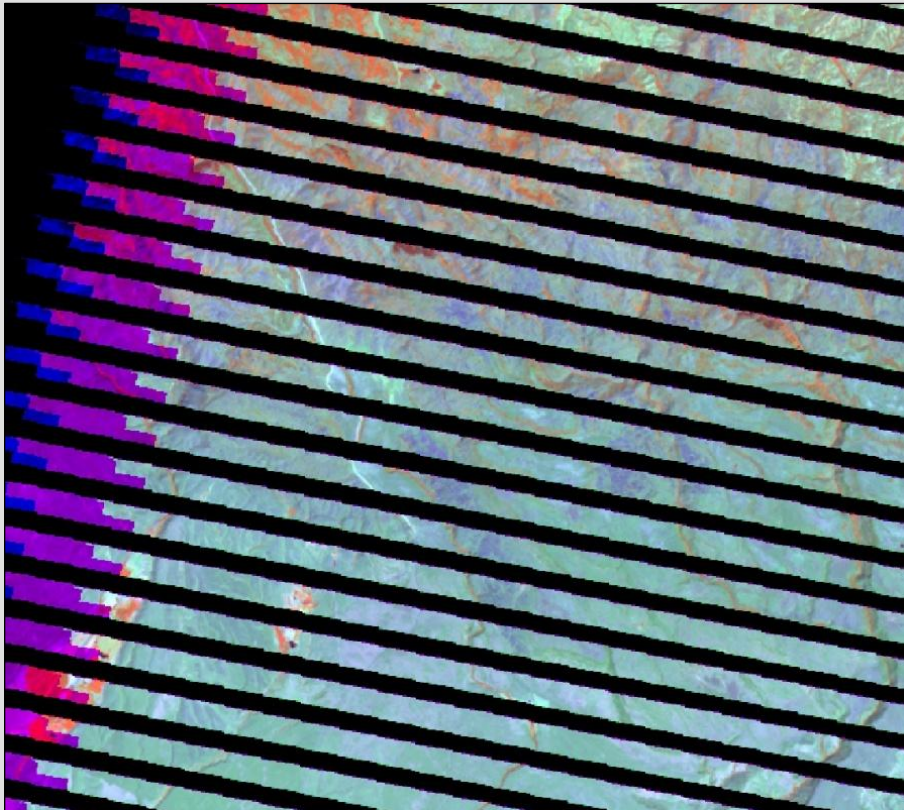


ET using 'Sharpened'
thermal pixels



Gaps in Landsat 7

Scan line corrector failed May 31, 2003

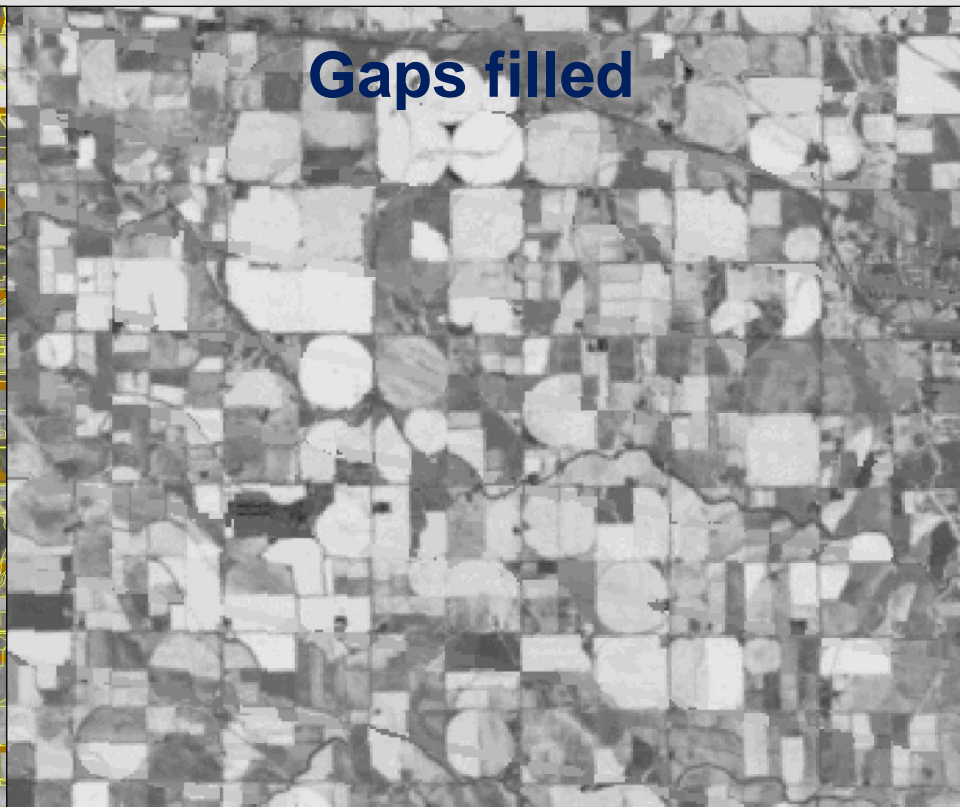
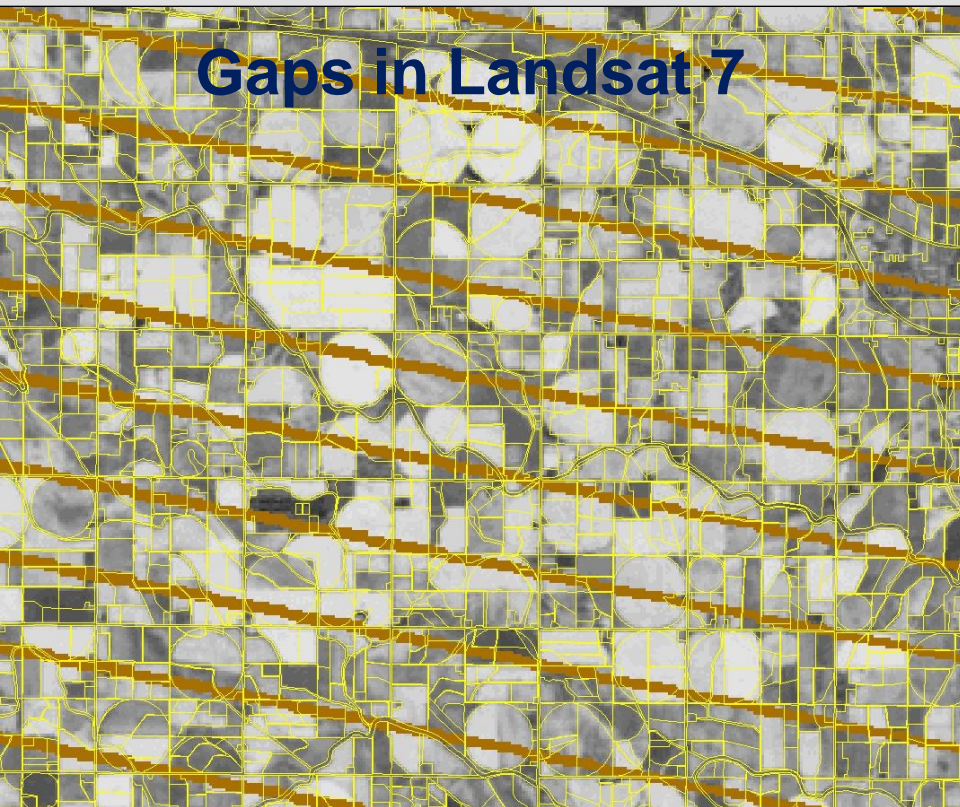


Gaps filled with ArcInfo Tools

Set Null: change gaps to nodata

Zonal Statistics: compute mean of polygons

Is Null & Con: replace gaps with mean value



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

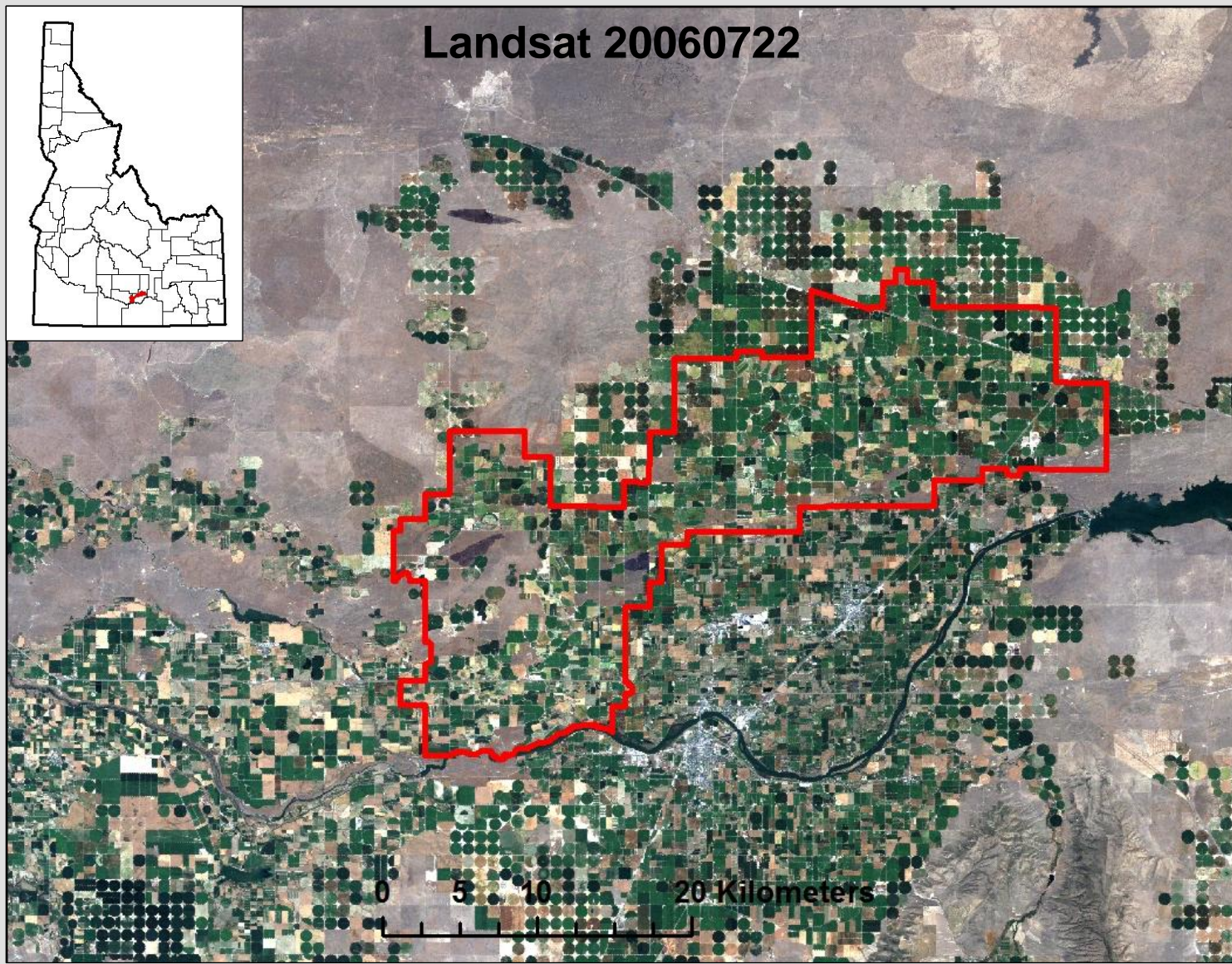
Curtailment Order

- 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



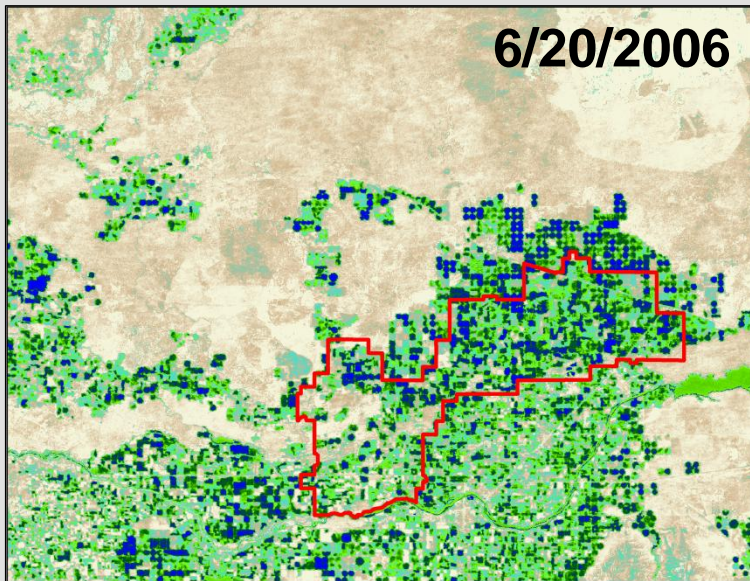
A&B Irrigation District Water Call

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

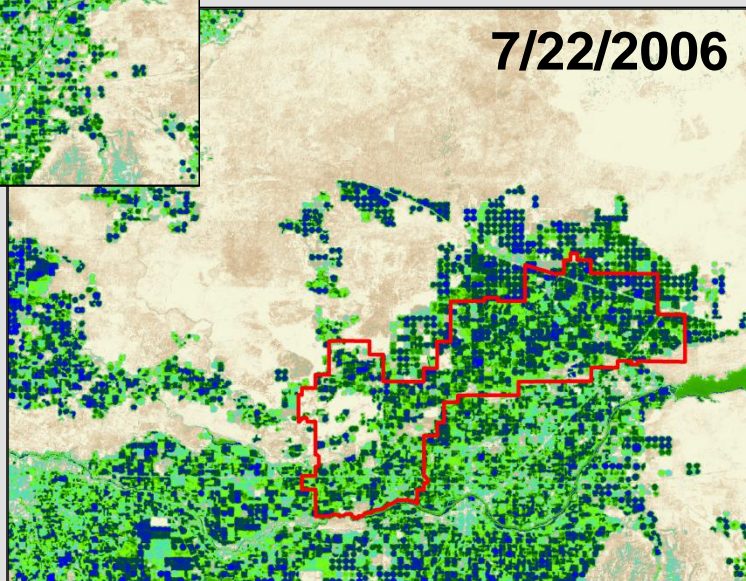
METRIC ET showed that the fields had ET rates as high as surrounding fields that were not identified as short of water

Daily ET images

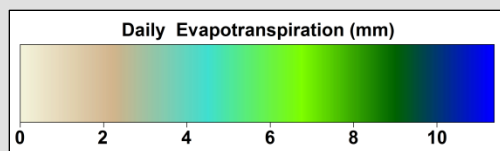
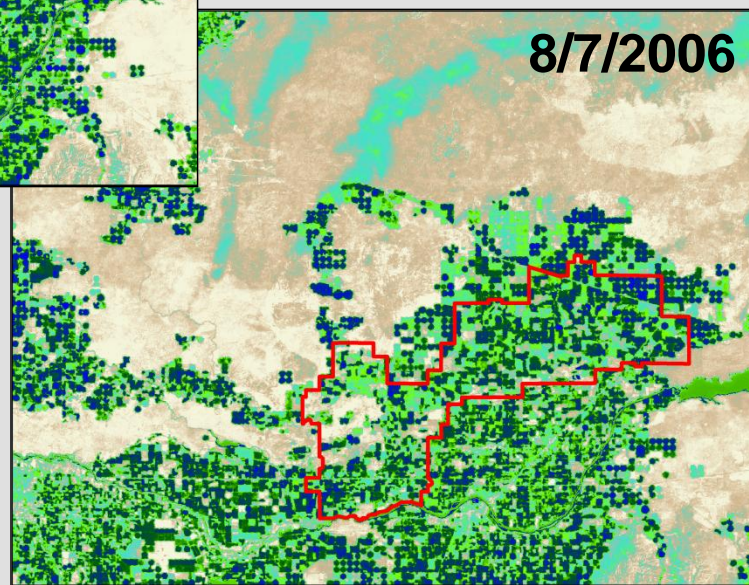
6/20/2006



7/22/2006



8/7/2006



 A&B Irrigation District

Irrigation Source

 A&B Ground water

 A&B Ground water (Area in Dispute)

 A&B Surface water

 North of A&B Ground water

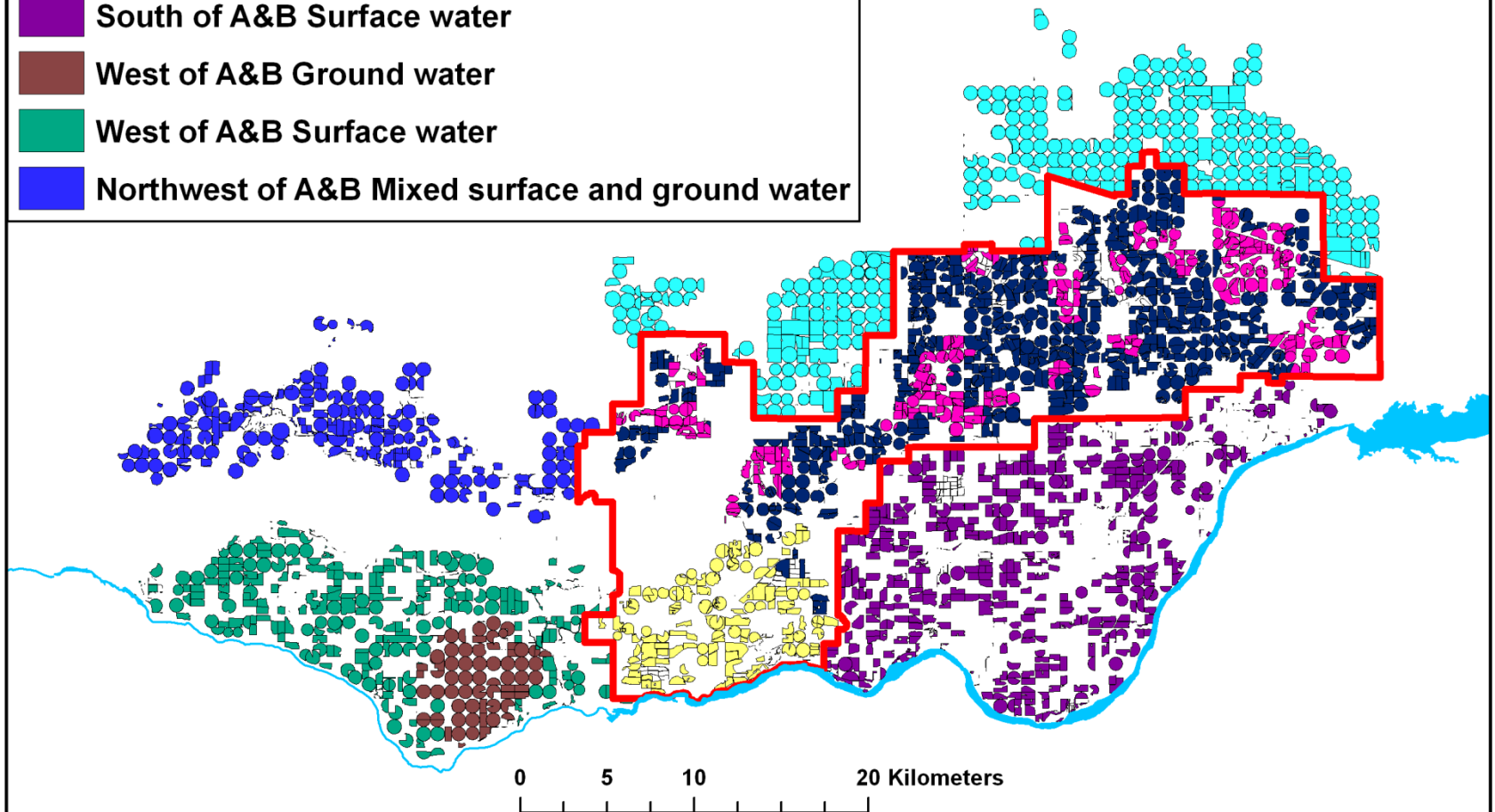
 South of A&B Surface water

 West of A&B Ground water

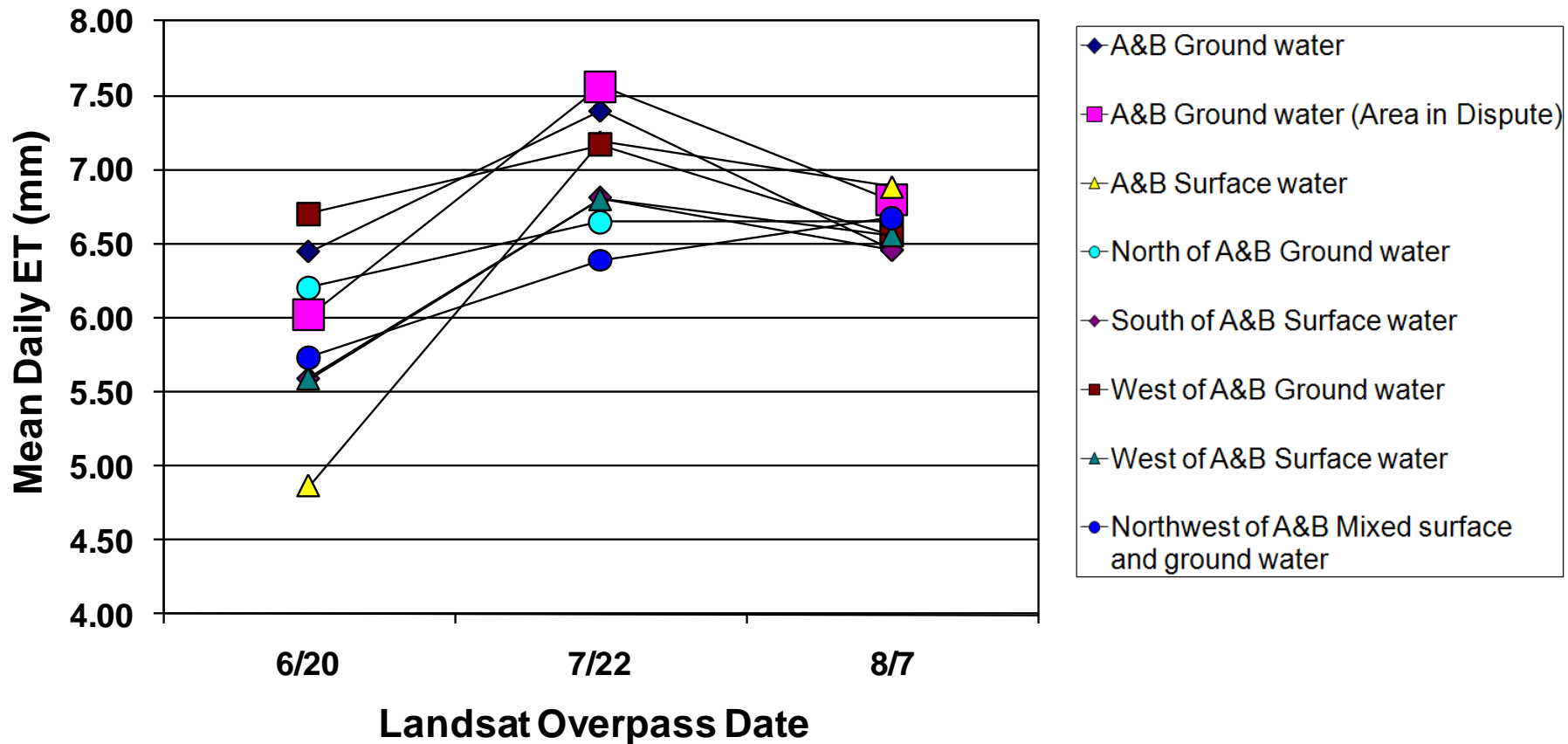
 West of A&B Surface water

 Northwest of A&B Mixed surface and ground water

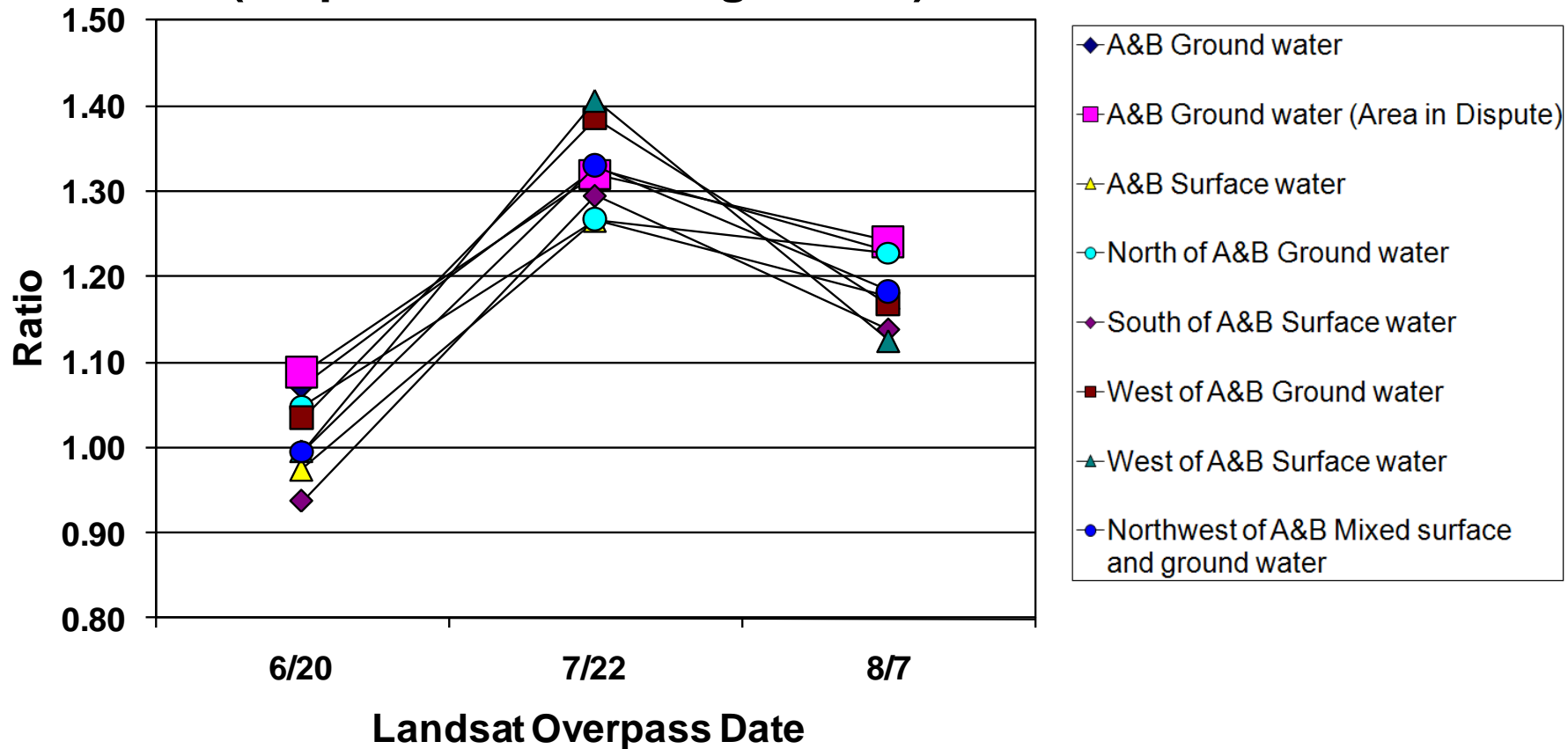
A&B Irrigation District and adjacent land



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

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 February 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

www.kimberly.uidaho.edu/water/metric

www.idwr.idaho.gov/geographicinfo/landsat/LandsatConcerns.htm

www.westernstatesetworkshop.com

0 25 50 100 Kilometers