

Satellite-based Evapotranspiration Mapping in Idaho

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in partnership with
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Upper Colorado River Commission Meeting, June 10, 2010



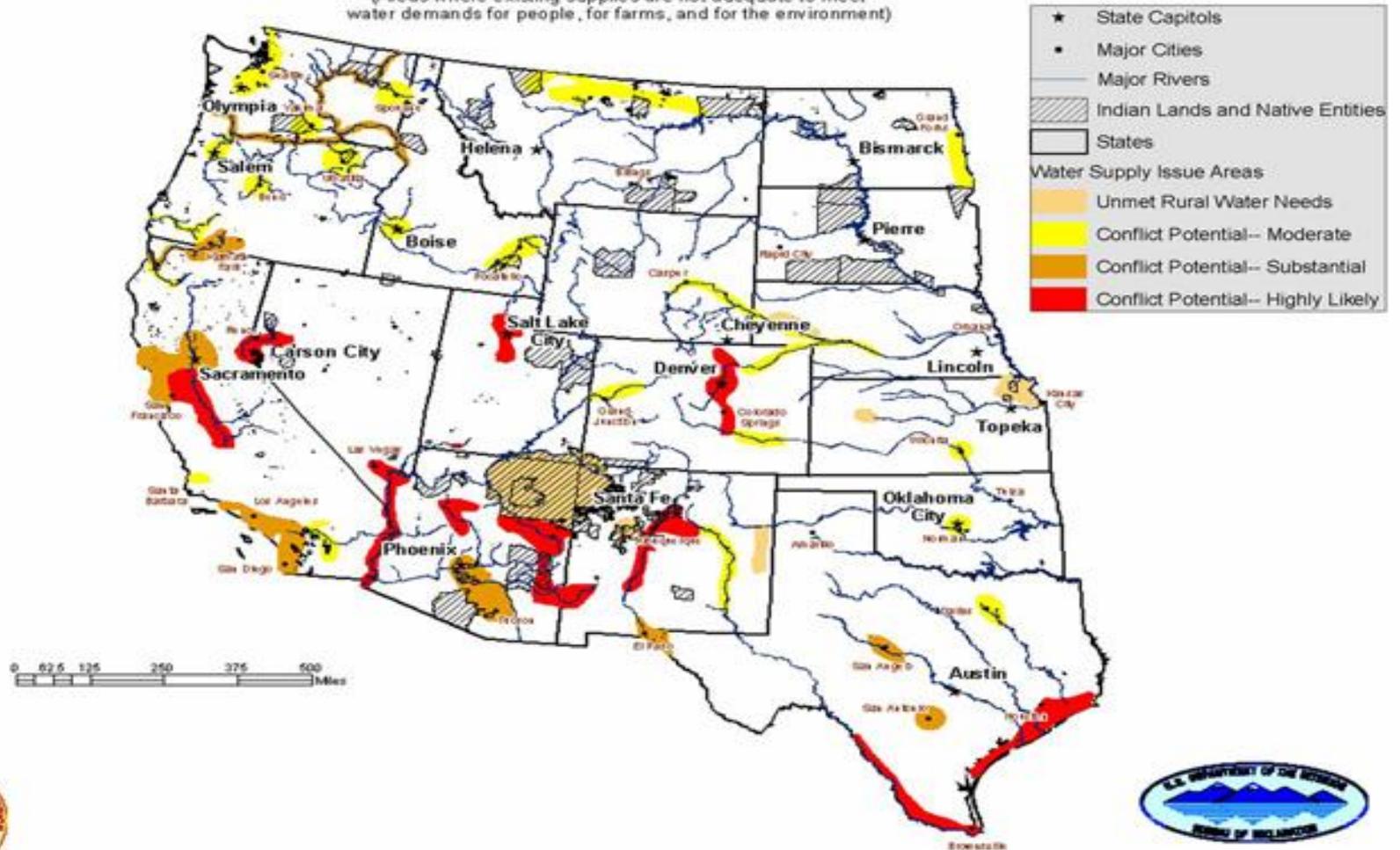
Why is Evapotranspiration (ET) important

- ET is the amount of 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 models

Potential Water Conflicts

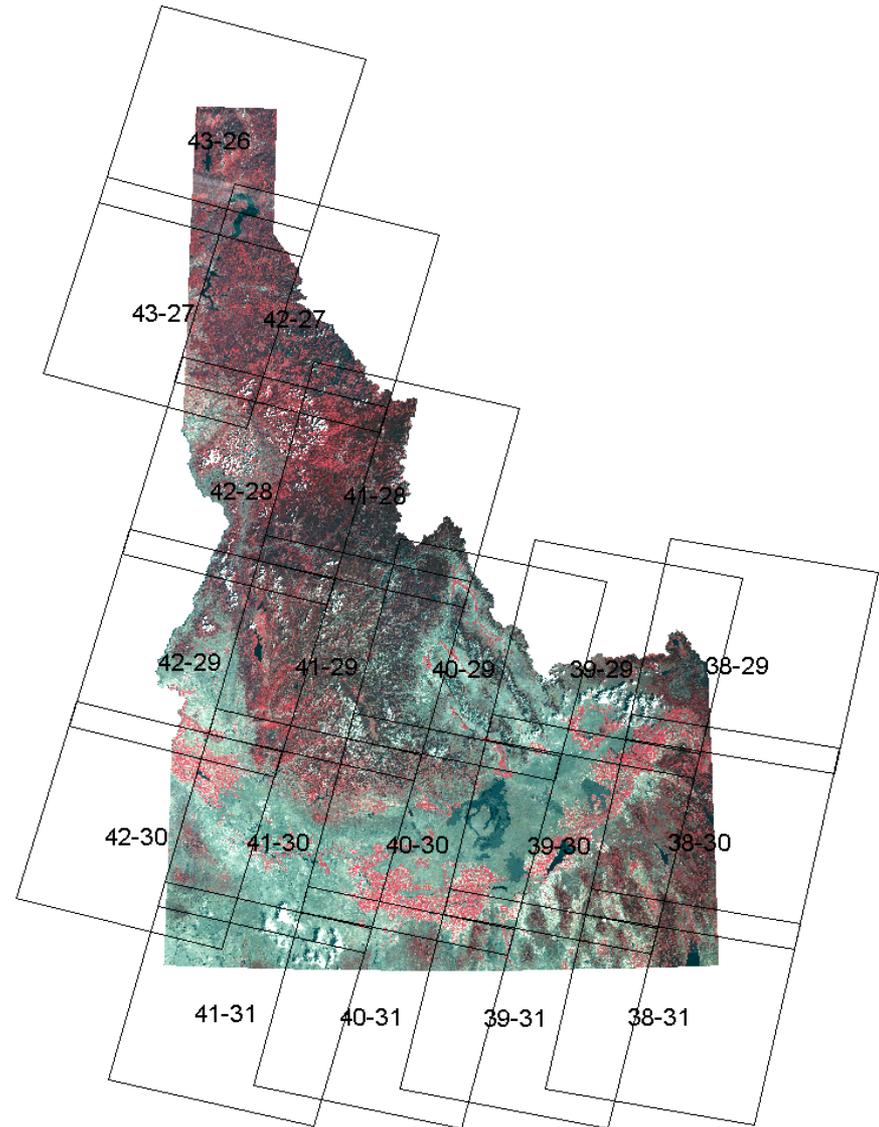
Potential Water Supply Crises by 2025

(Areas where existing supplies are not adequate to meet water demands for people, for farms, and for the environment)



Landsat

- USGS/NASA mission
- L5 launched 1984
- L7 launched 1999
(damaged May, 2003)
- 16 day cycle
- 100 by 100 miles
- Landsat data is free
- Landsat 8 will launch in
December 2012

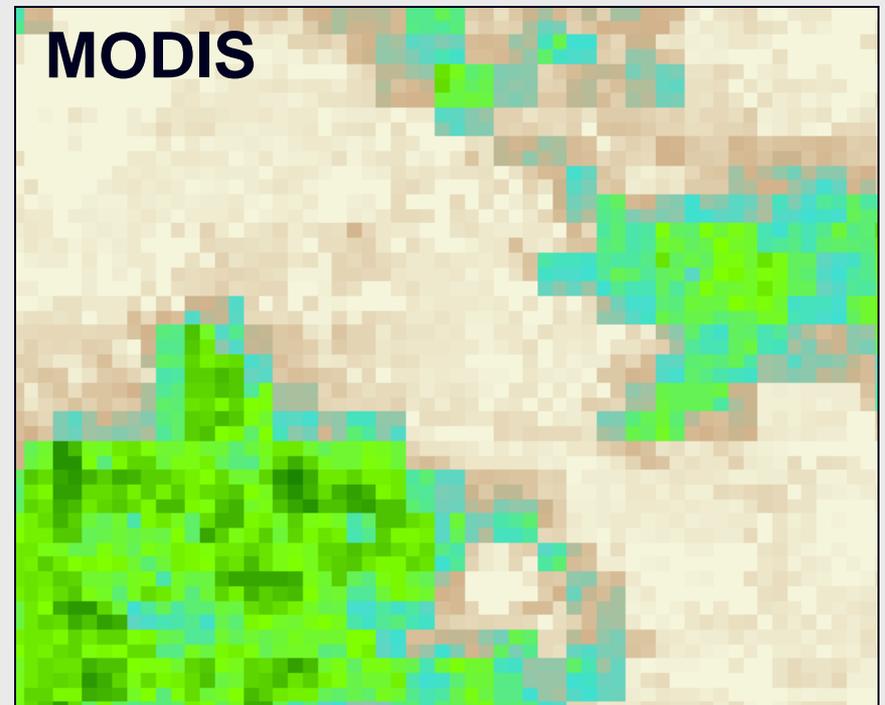
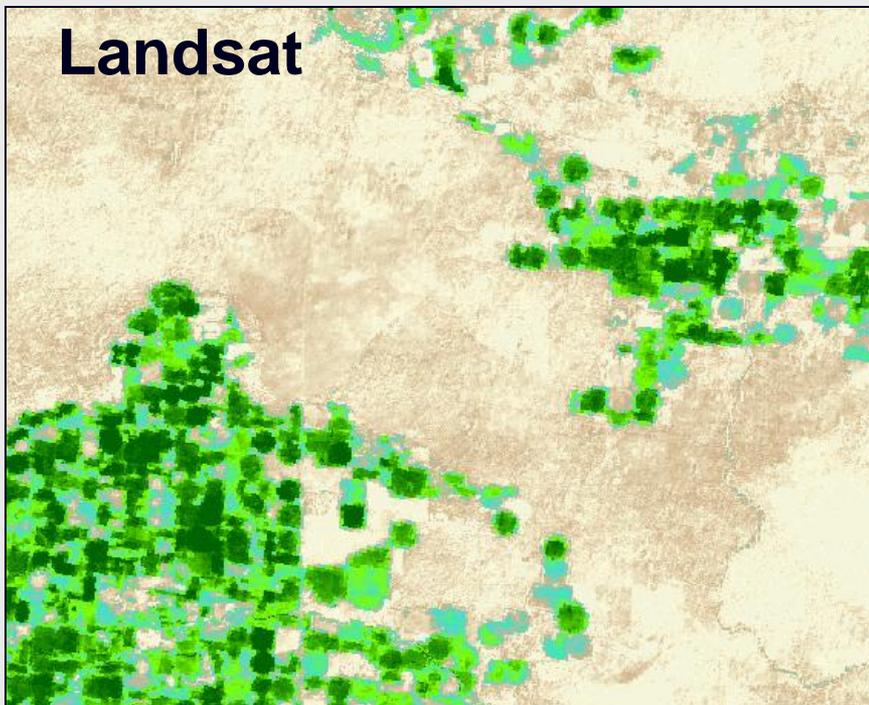


Landsat 7



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



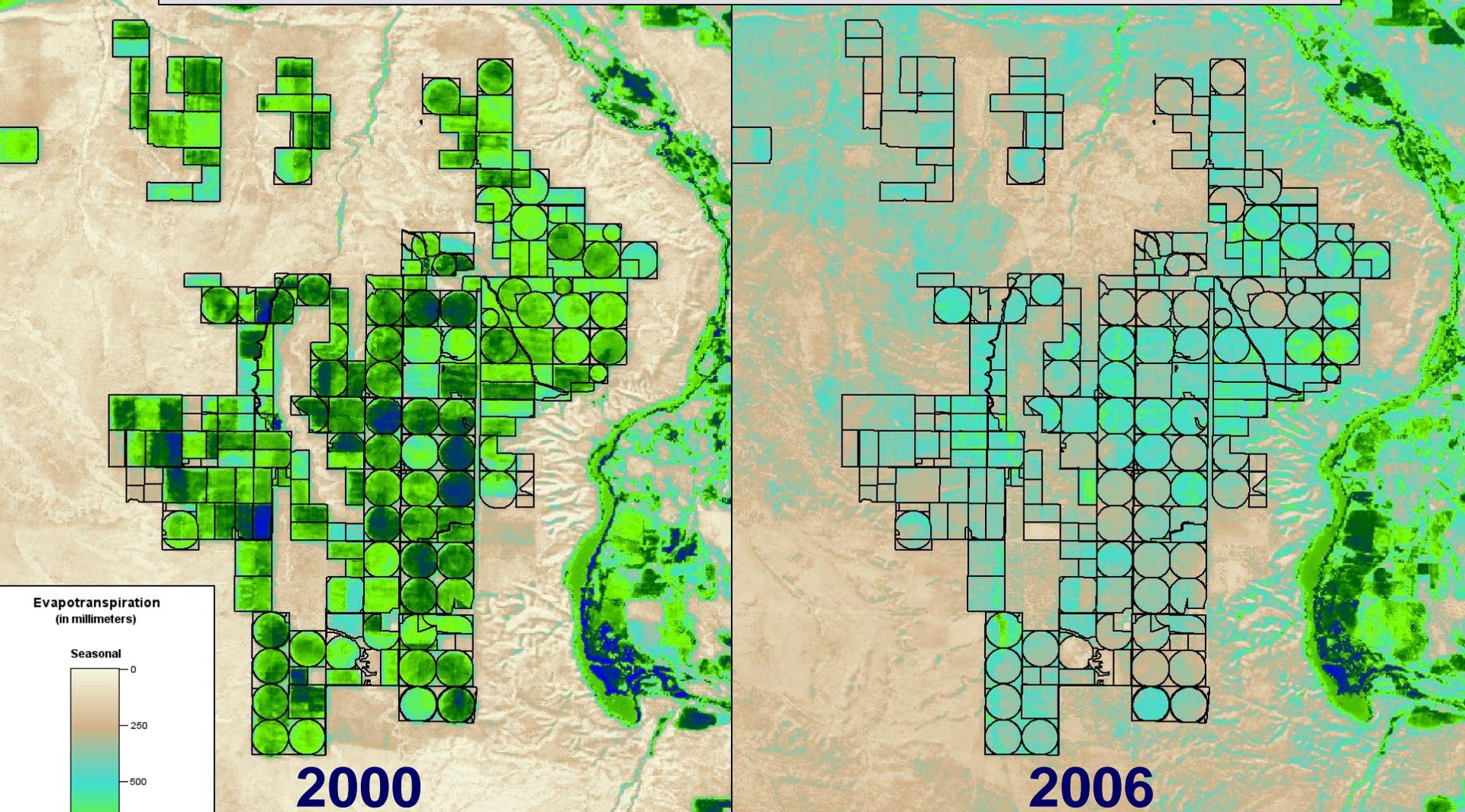
In the past

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

In the present

- 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 Thermal Band

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



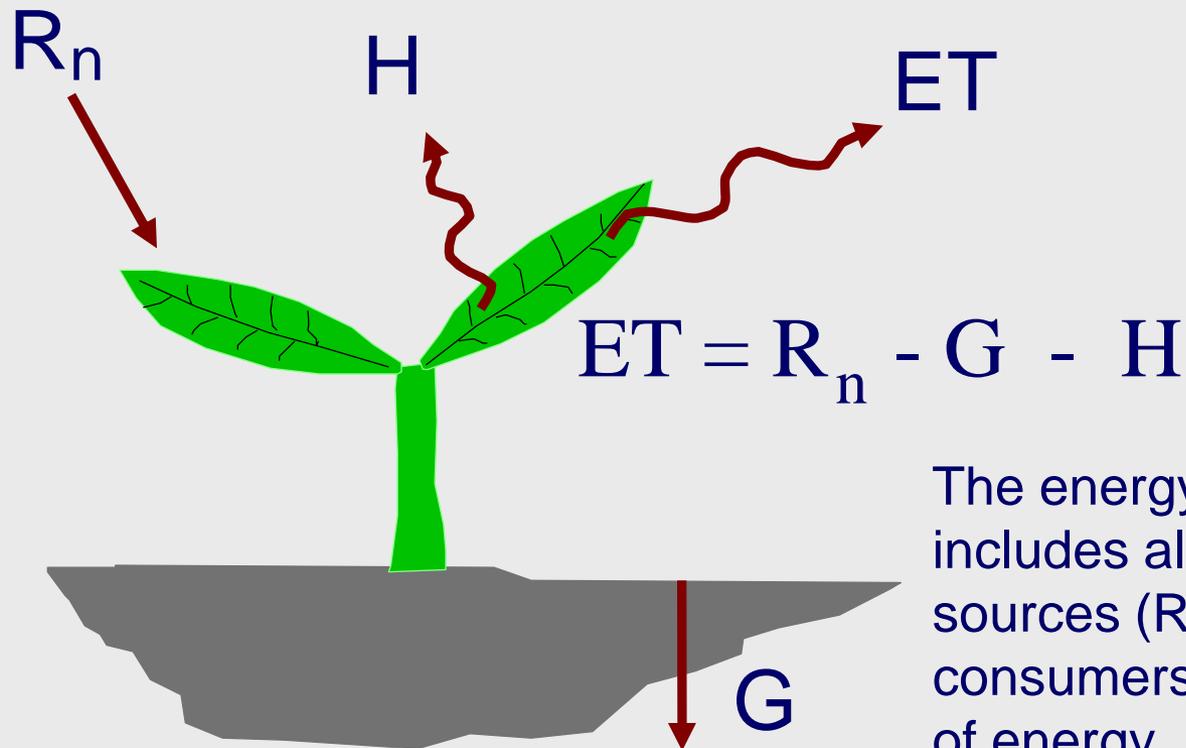
METRIC

Mapping EvapoTranspiration at high Resolution with Internalized Calibration

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

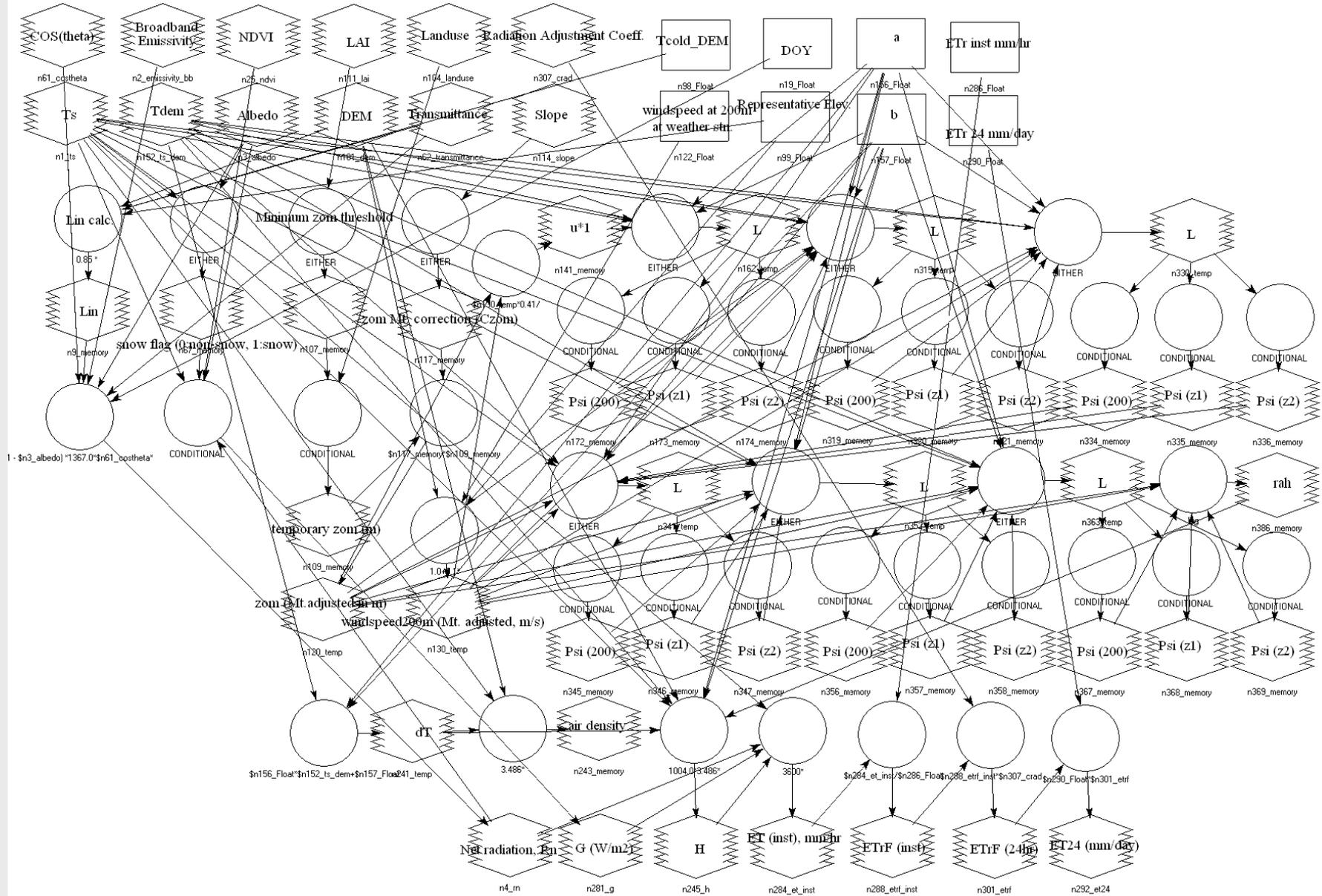


- *(these effects can cause the ratio ET / amount of vegetation to vary widely, thus the need to compute ET as a residual of the energy balance)*

METRICtm-ERDAS submodel for sensible heat and ETrF

M02, Main energy balance model for SEBAL-ID: Sensible heat flux, Net radiation, Ground heat flux, Reference ET fraction and ET

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Weather Data

In METRIC, Weather Data are used for:

Wind speed for sensible heat flux calculation

Reference ET for calibrating the Energy Balance

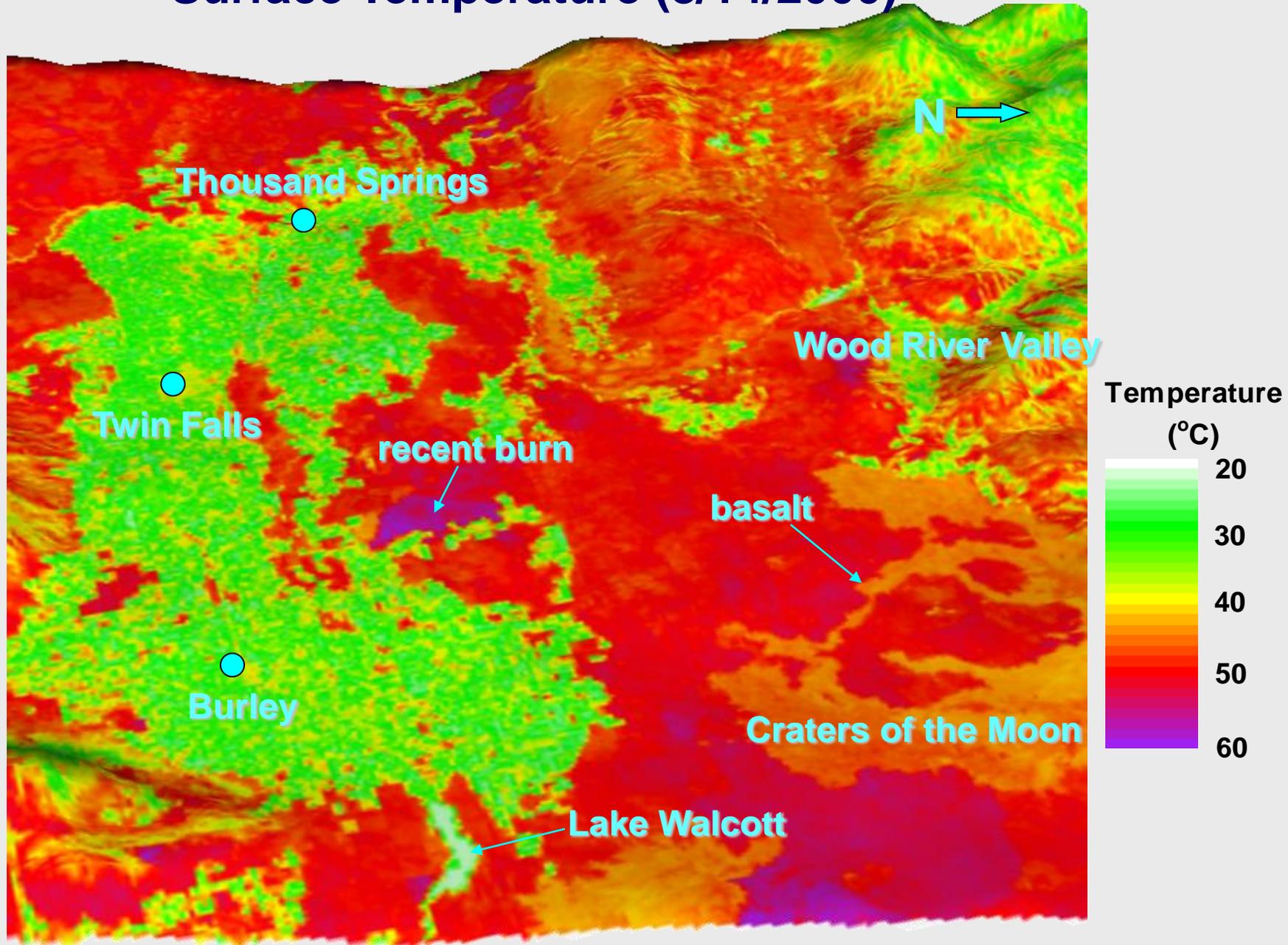
Reference ET to extrapolate ET over:

- 24-hour period
- Days between images

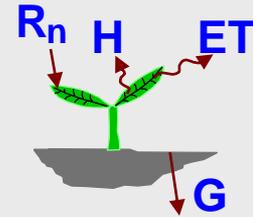
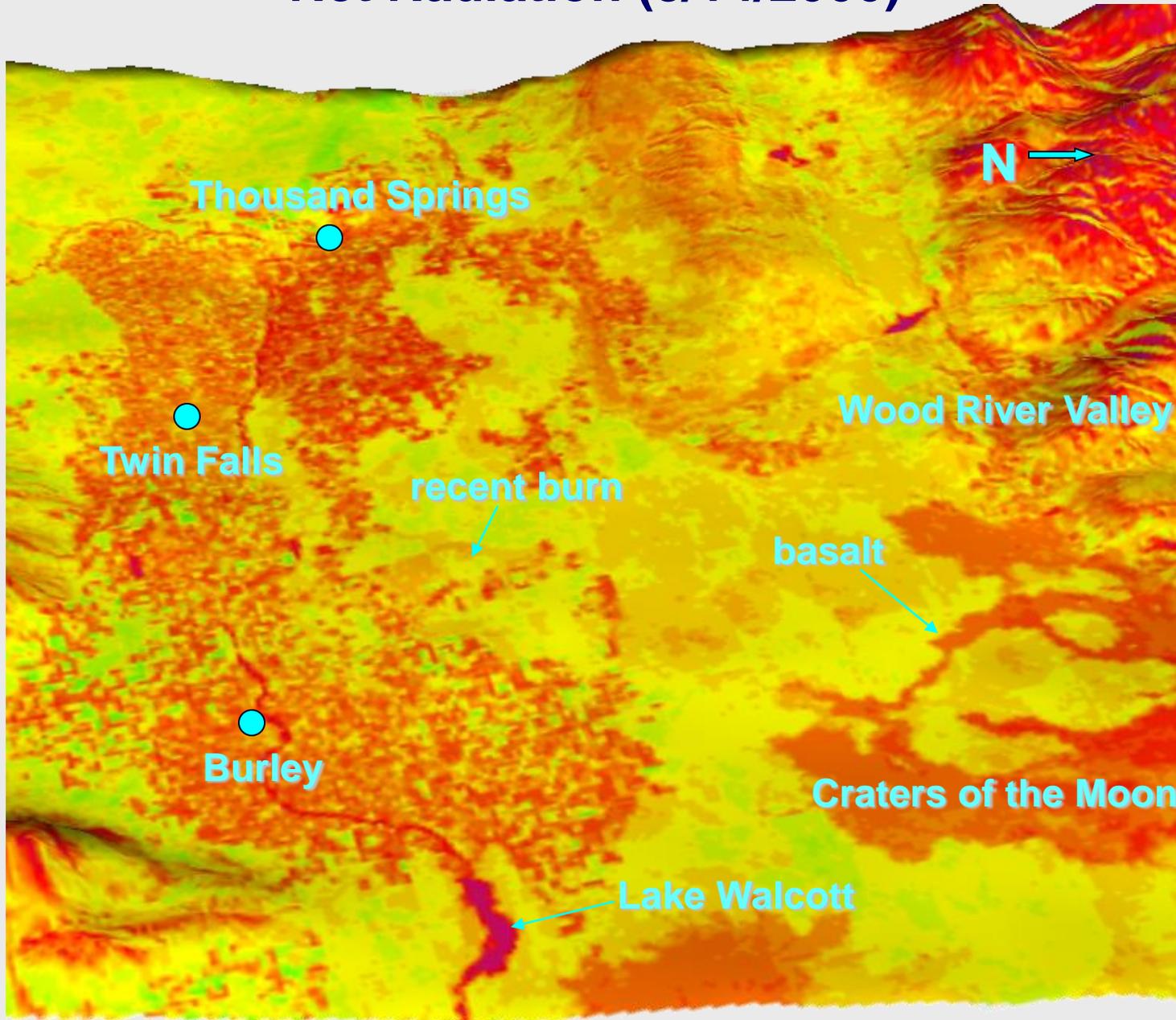
Landsat, south-central Idaho (8/14/2000)



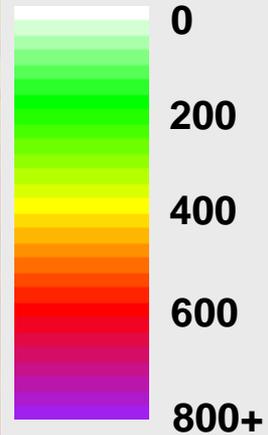
Surface Temperature (8/14/2000)



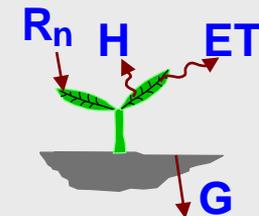
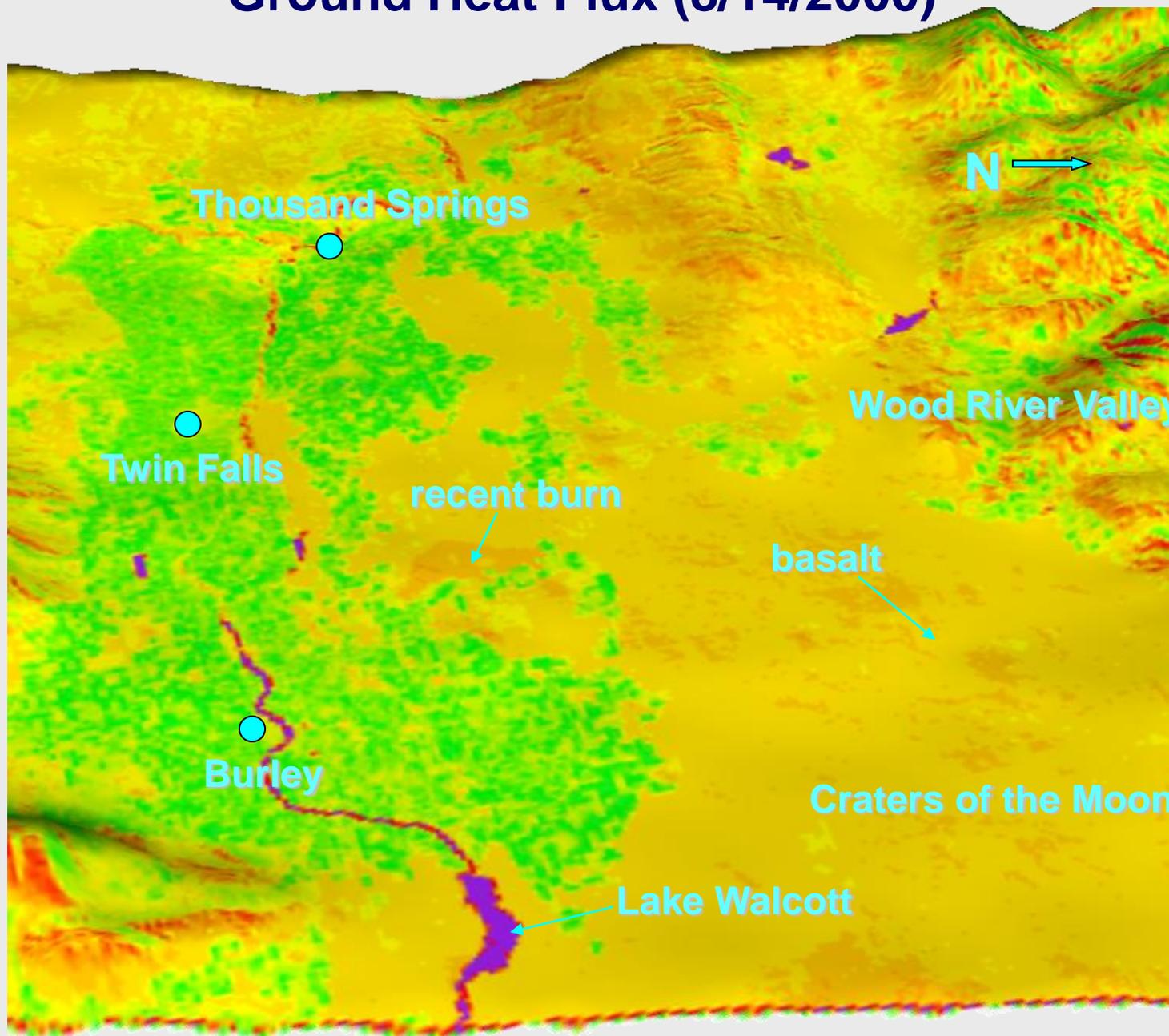
Net Radiation (8/14/2000)



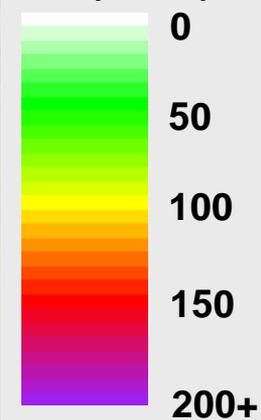
Net Radiation
(W/m^2)



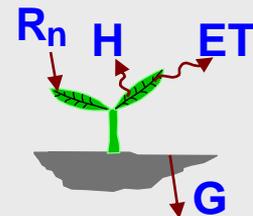
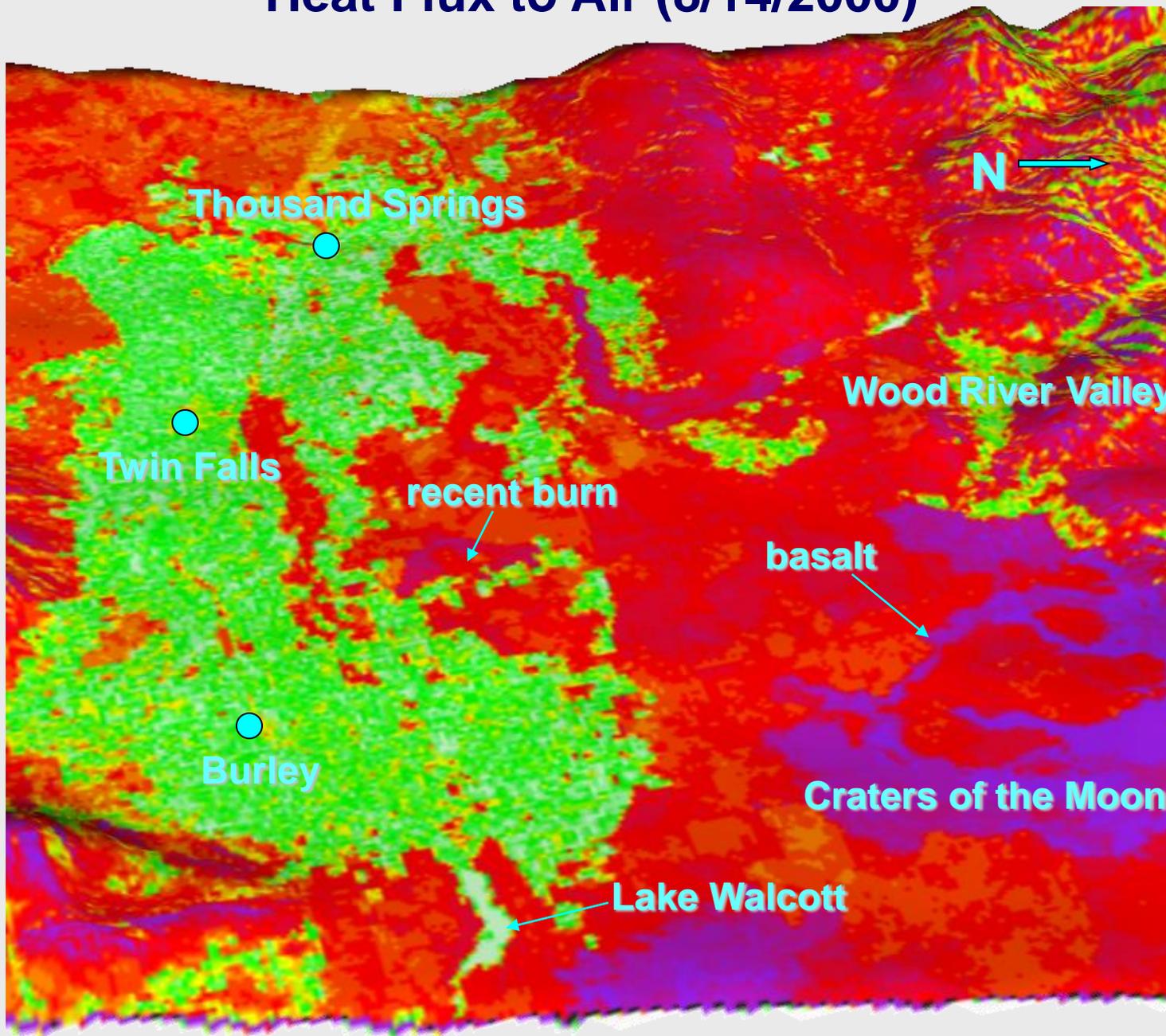
Ground Heat Flux (8/14/2000)



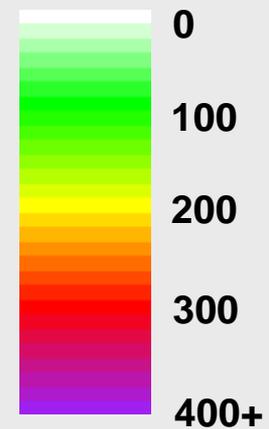
Soil Heat Flux
(W/m^2)



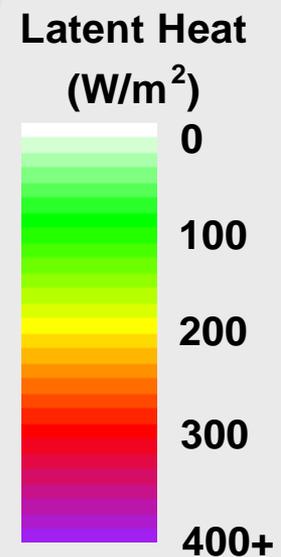
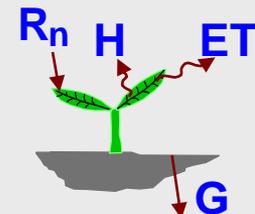
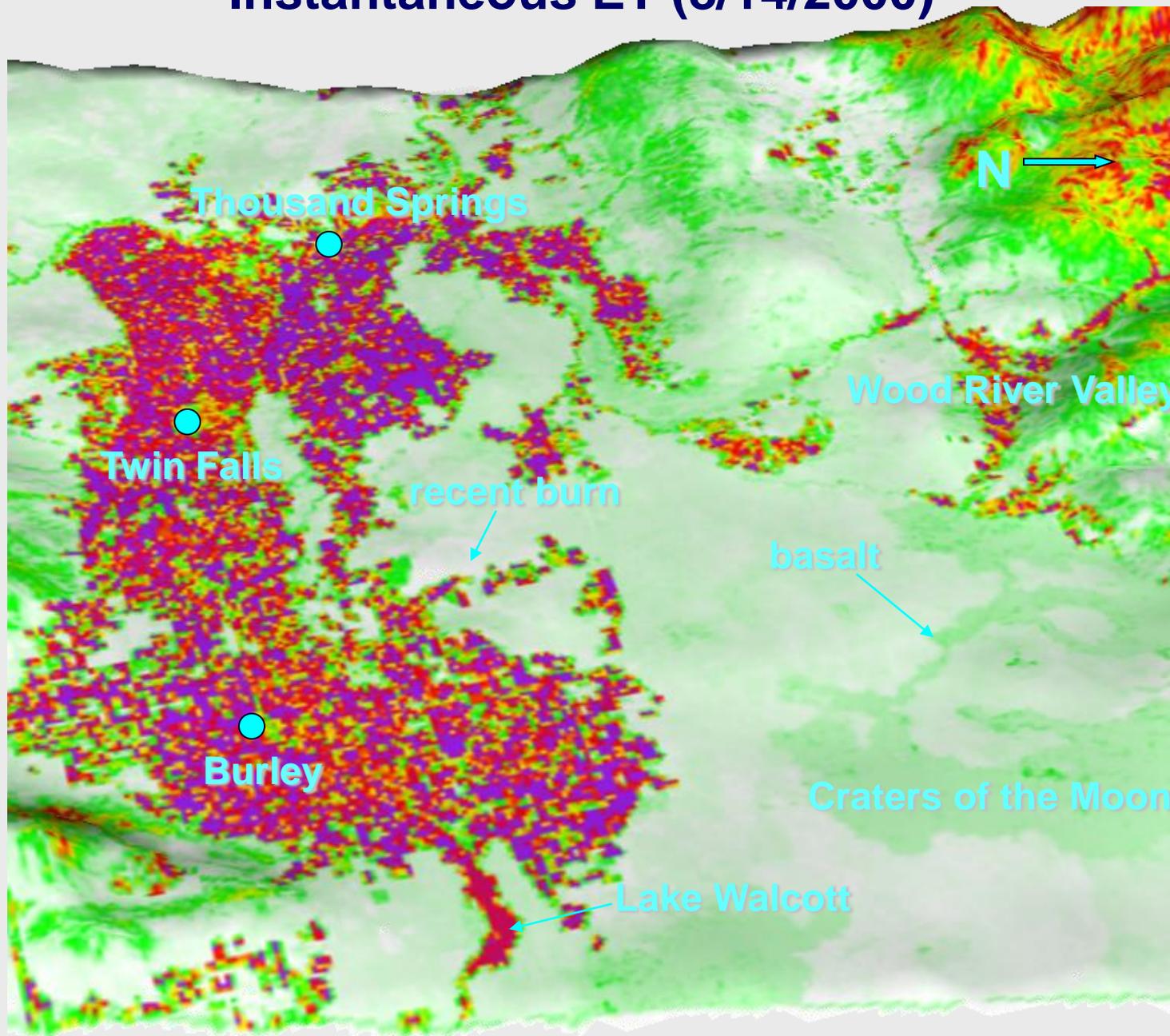
Heat Flux to Air (8/14/2000)



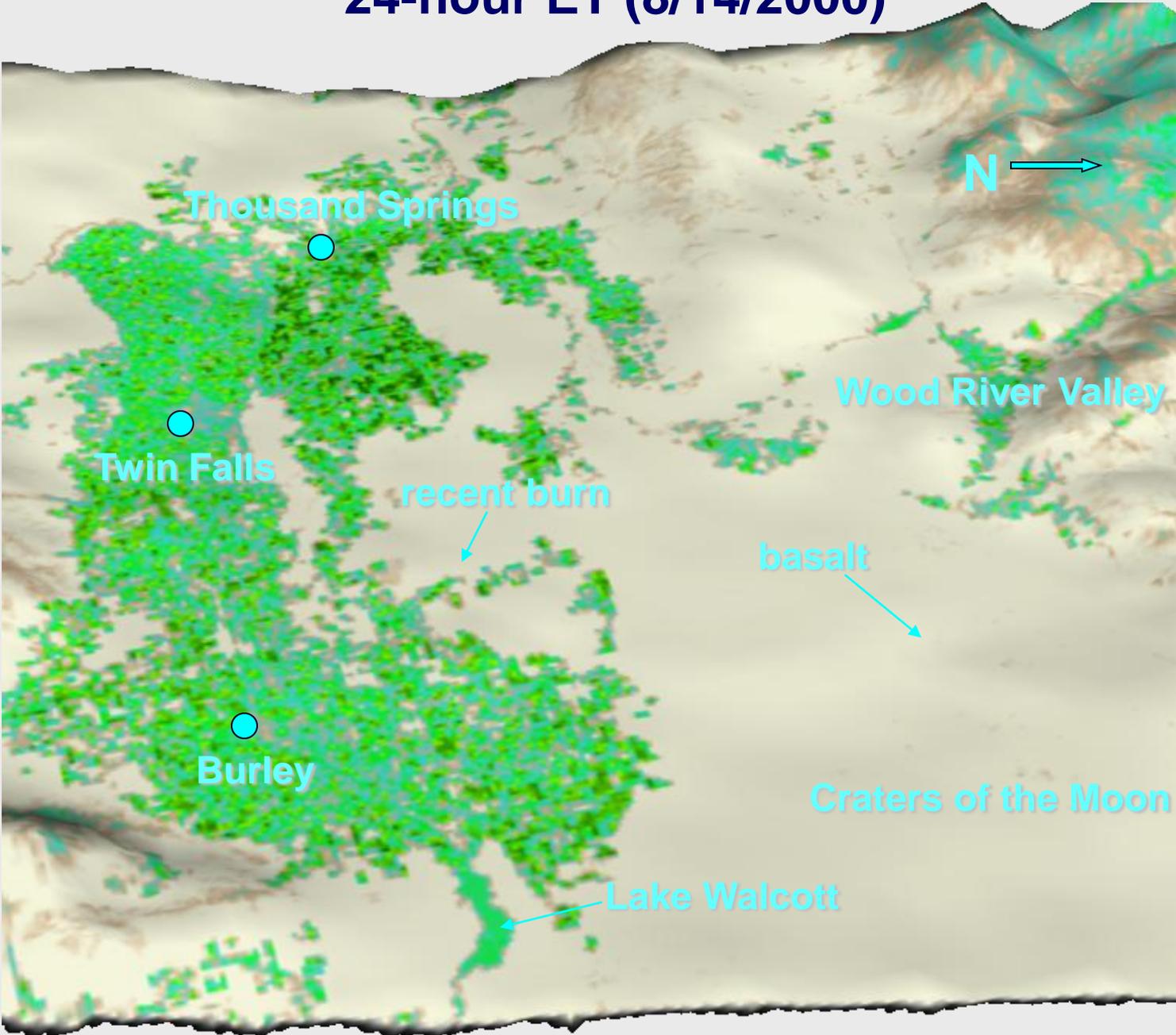
Sensible Heat
(W/m^2)



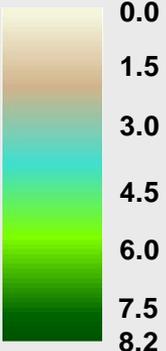
Instantaneous ET (8/14/2000)



24-hour ET (8/14/2000)



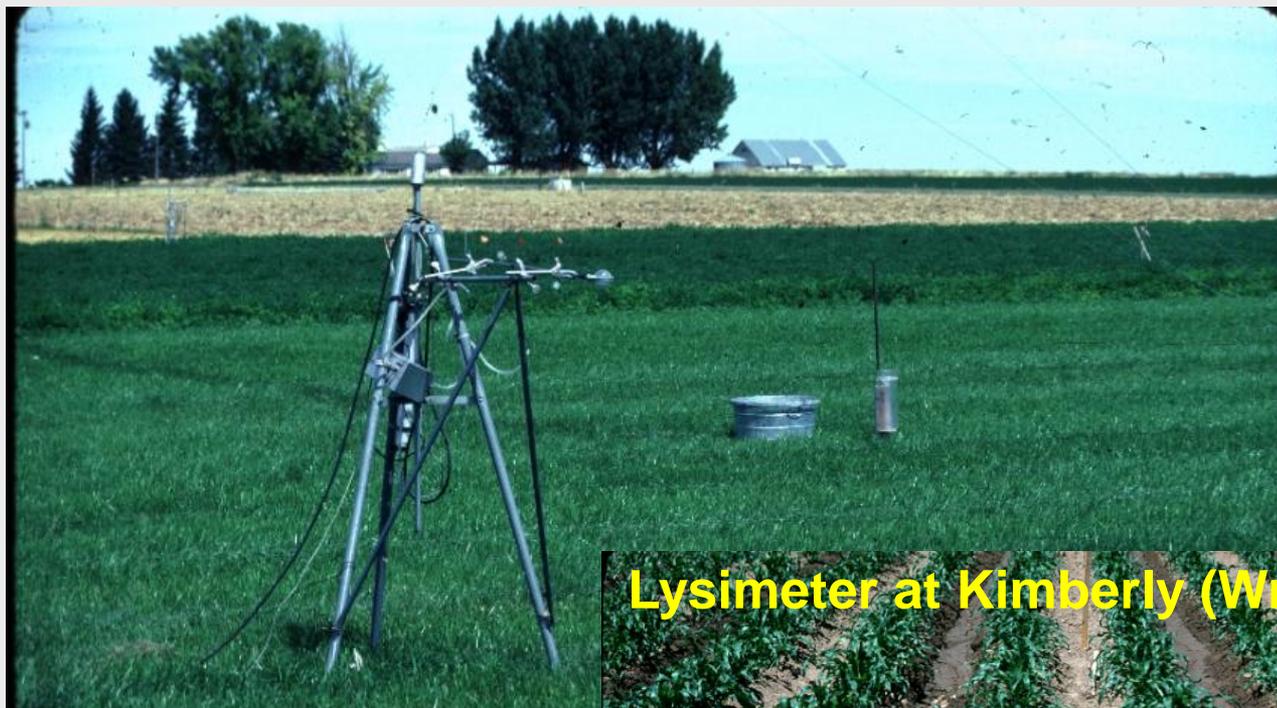
Evapotranspiration
(mm/day)



ETr Fraction



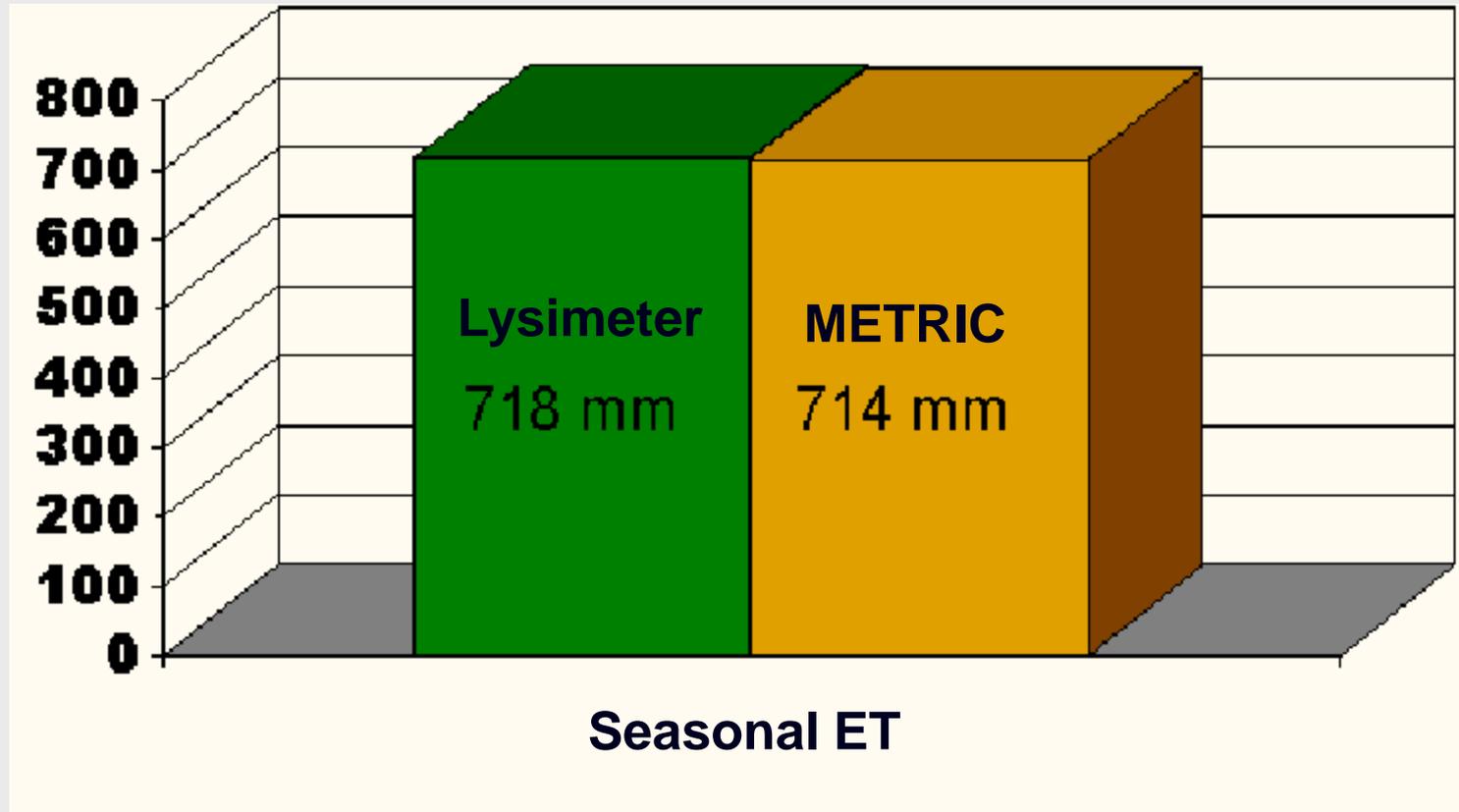
Comparison with Lysimeter Measurements



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.

Other states using or gearing up to use METRIC

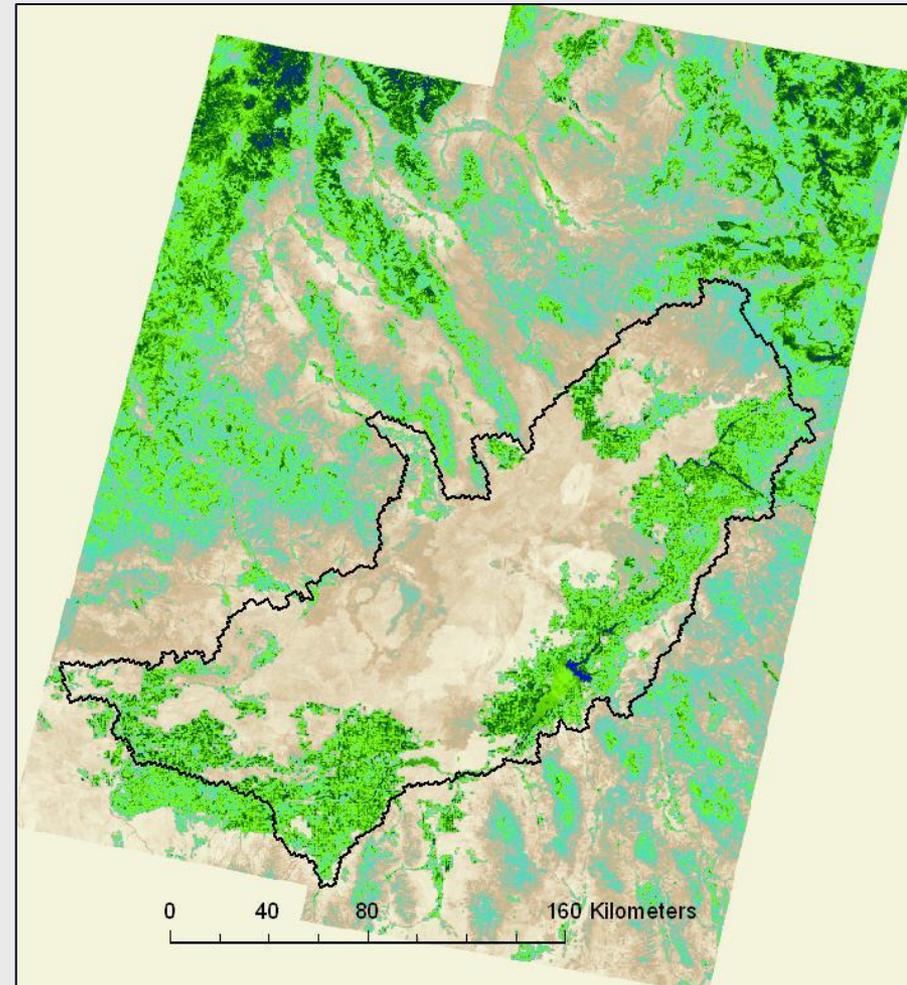
- Nevada
 - Ag. water is being transferred to Reno and Las Vegas – what is impact on environment?
- Nebraska
 - Over pumping of the Ogallala Aquifer (high plains aquifer)
- Colorado
 - Kansas vs. Colorado over Arkansas River
 - Nebraska vs. Colorado over S. Platte River
- Wyoming
 - Nebraska vs. Wyoming over N. Platte River
- Oregon
 - Klamath Basin water shortages

More states using or gearing up to use METRIC

- California
 - Imperial Irrigation District: for total water consumption by irrigated agriculture
- New Mexico
 - Middle Rio Grande: for 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

Cost of METRIC

- About one year to develop monthly ET for 100,000 square kilometers
- Area covered by 4 Landsat images, need one image per month, at least 28 total images
- Cloudy areas require extra effort
- Other costs if you do it yourself
 - training
 - image processing and GIS software
 - disks for processing and storage



An alternative approach

Satellite NDVI

- NDVI (Normalized Difference Vegetation Index)
 - $(IR - Red) / (IR + Red)$
- Based on relationship between METRIC ET and NDVI
- Advantage
 - Quicker and lower cost (about 25% of the cost)
 - Can use other satellite data like SPOT or AWiFS
- Disadvantage
 - May not see ET reductions caused by stress (water shortage)
 - Not as accurate

Innovations in American Government Award

- Idaho's Mapping ET program was one of 6 winners out of nearly 1,000 applicants in 2009
- \$40,000 grant to support replication
 - Short presentations
 - ½-day presentations with more details
 - 4-day hands-on training workshops
 - The 1st will be in Boise the week of August 16th
 - Send me an email if you are interested in the workshop

Bill.Kramber@idwr.idaho.gov

Applications in Idaho

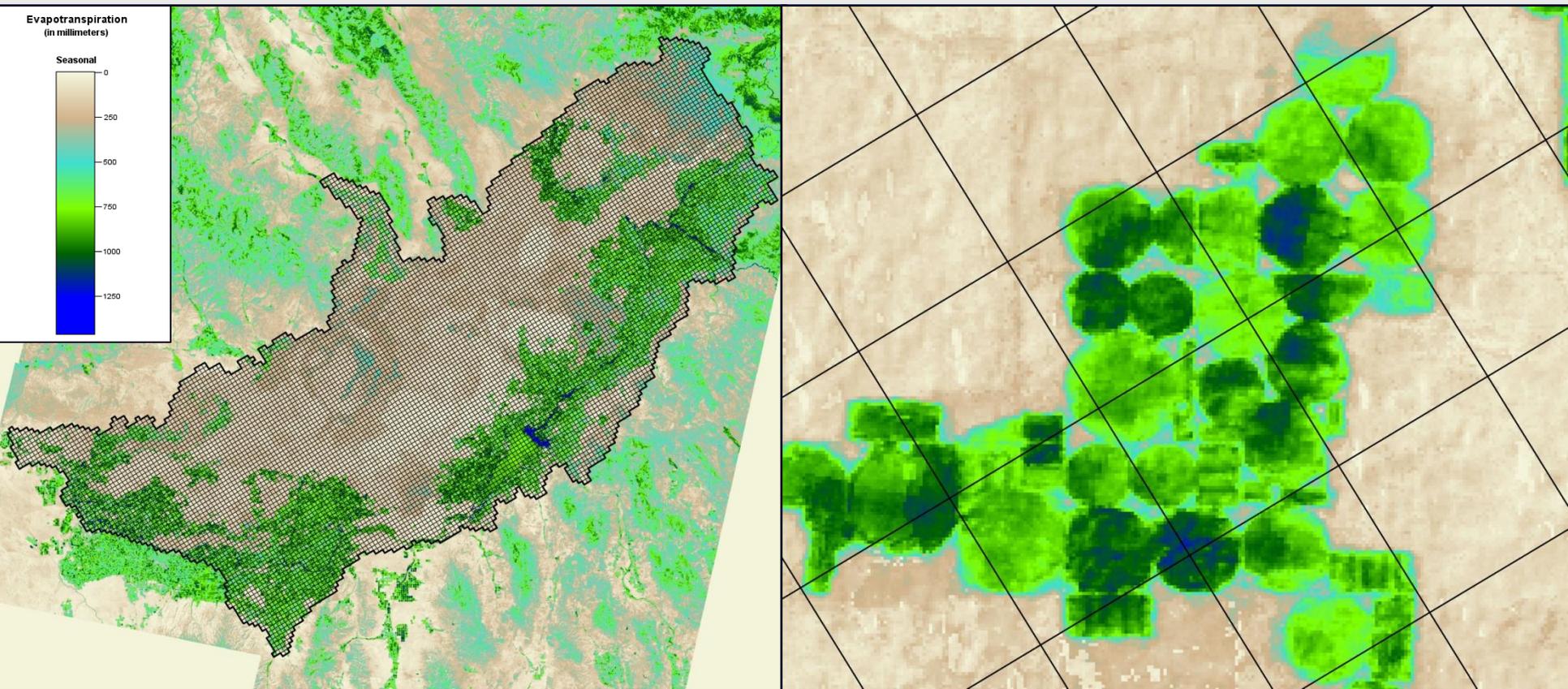
- Hydrologic modeling
- Water planning
- Water administration



Hydrologic Modeling

Eastern Snake Plain Aquifer Model

- Year 2000, 2002, and 2006 data completed
- Developing ET data from 1986 to present



Water Planning

ET by Land Use

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

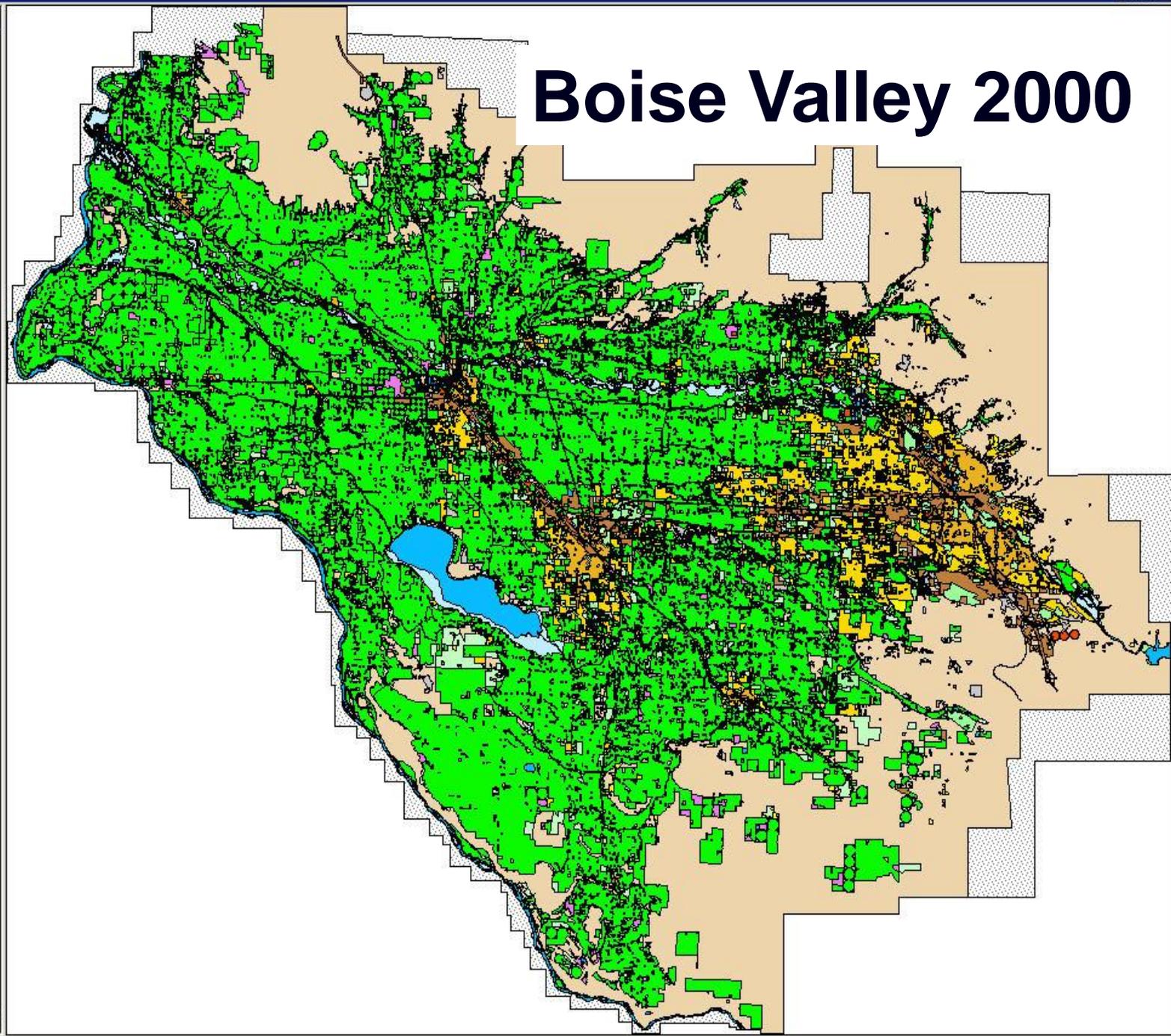
- Tv3994ird.shp
 - Irrigated 1994 and Irrigated
 - Irrigated 1994, Not Irrigated
 - Not Irrigated 1994, Irrigated

- Tv_94imagery.sid

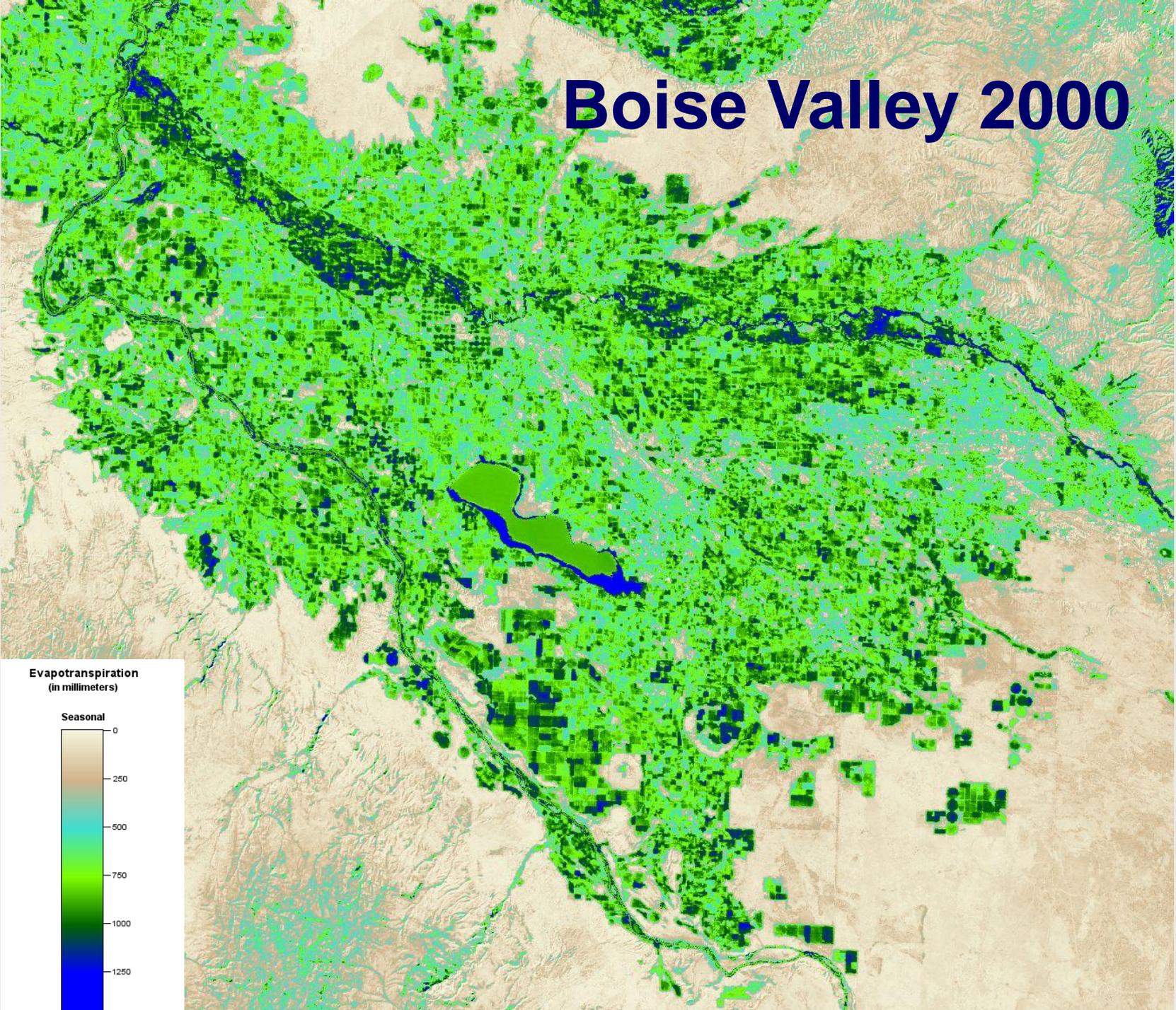
- Tv2000.sid

- Tv_00landcov.shp
 - (12) Residential - Old Urban
 - (13) Residential - New Sub
 - (11,14) Residential - Farms
 - (15,18) Commercial/Industrial
 - (4,7) Water or Canals
 - (5) Wetland & Riparian
 - (16,17) Public or Recreation
 - (21,22) Agricultural Irrigated
 - (23,24,27,28) Agricultural
 - (25,26) Feedlot or Dairy
 - (3) Rangeland
 - (6) Barren Land
 - (19,8,1,82) Sewage Treatment
 - (99) Unclassified

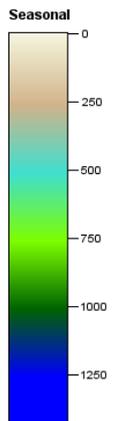
Boise Valley 2000



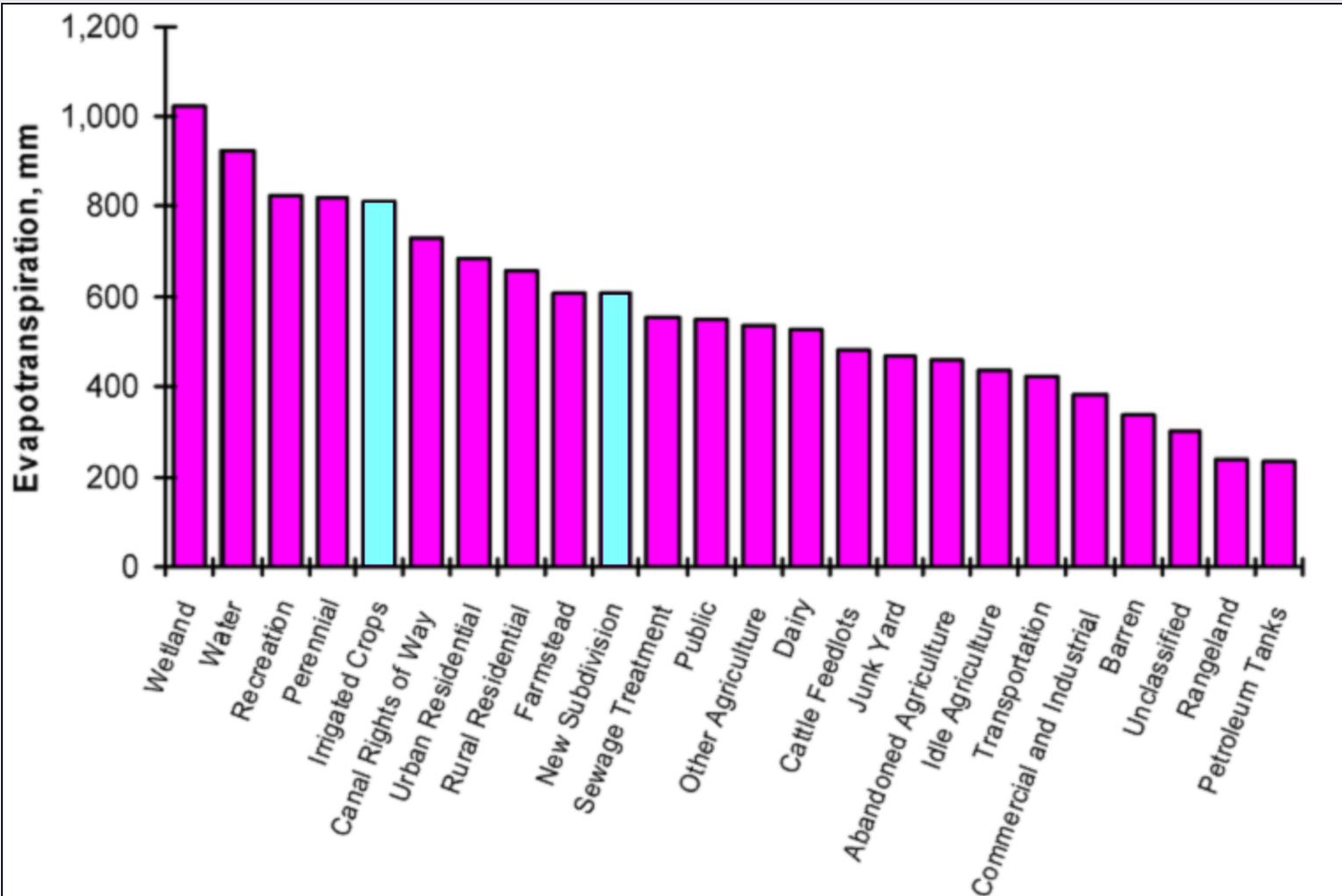
Boise Valley 2000



Evapotranspiration
(in millimeters)



ET by land use

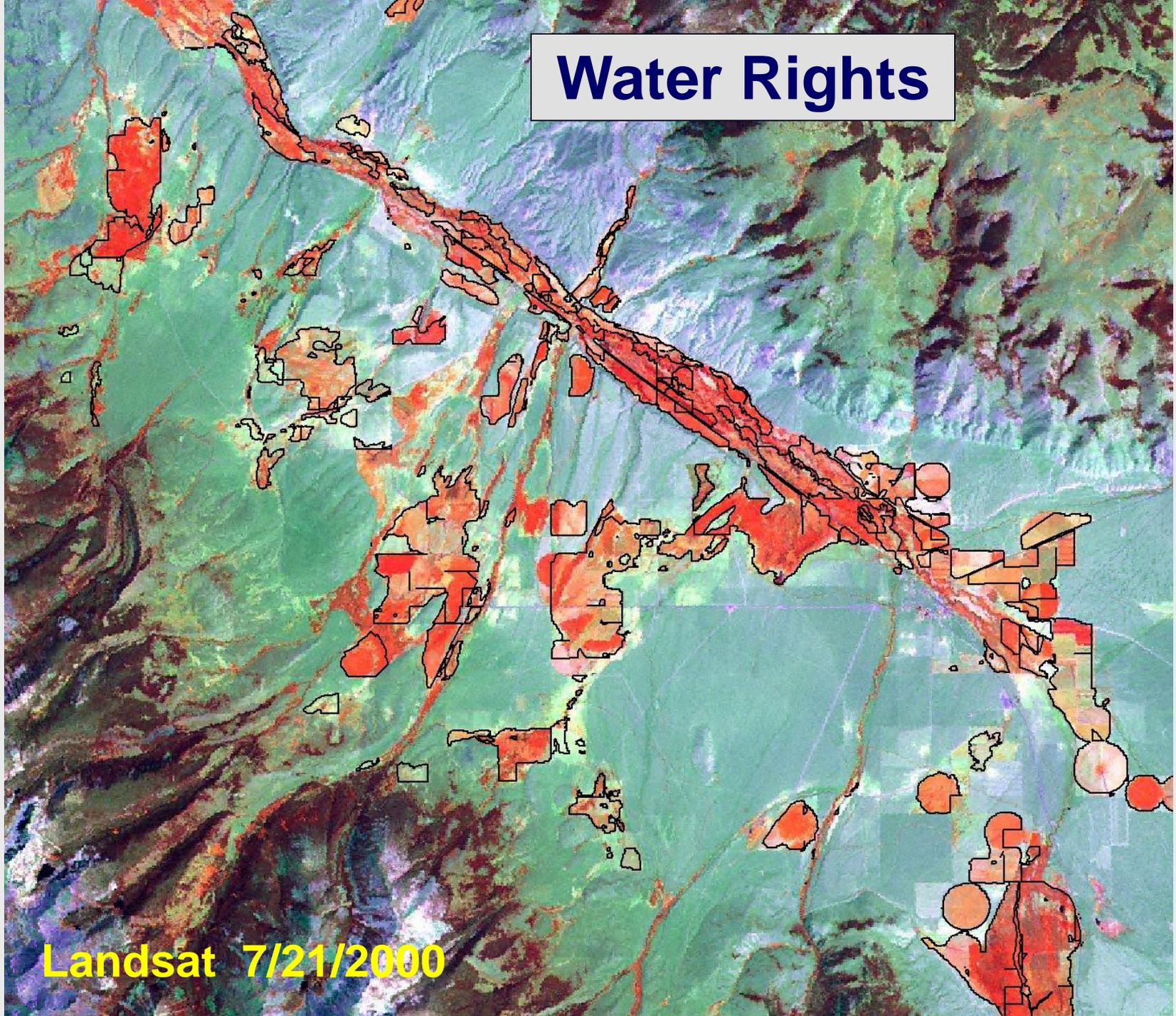


Water Planning

Endangered Species

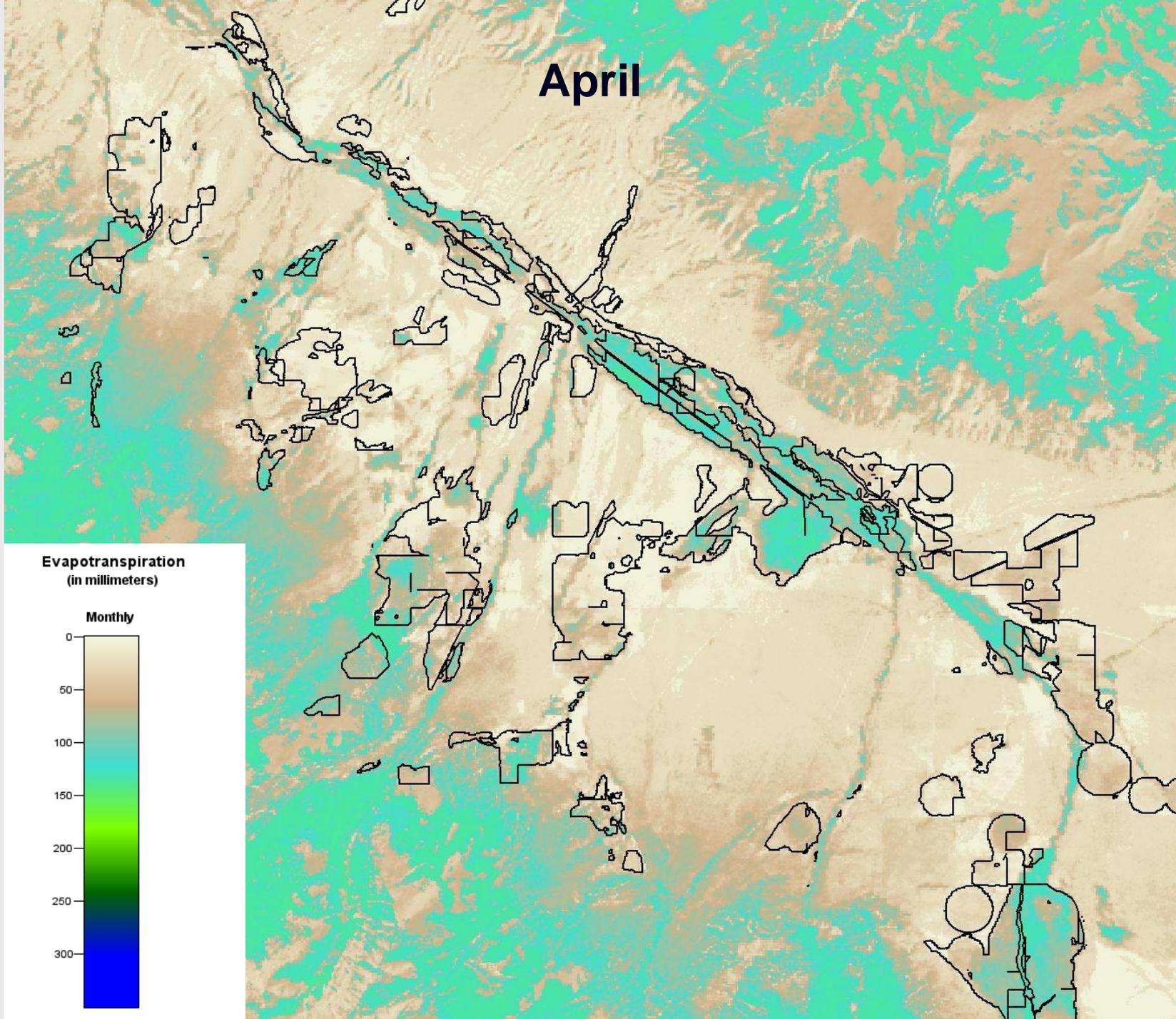
- Landsat-based ET estimates volume of water used for irrigation of specific water rights

Water Rights

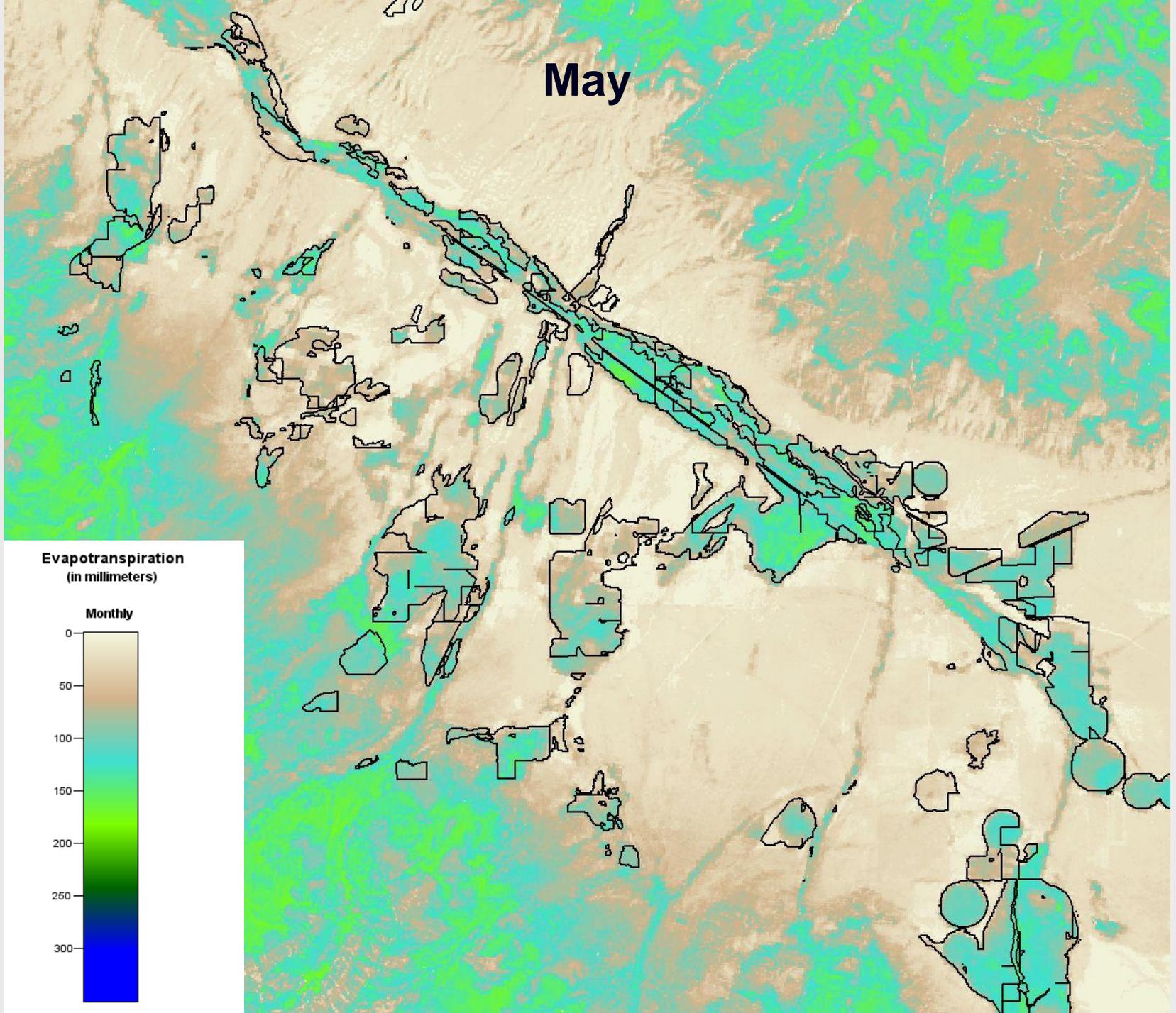


Landsat 7/21/2000

April

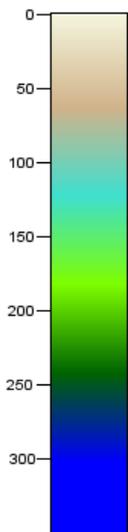


May

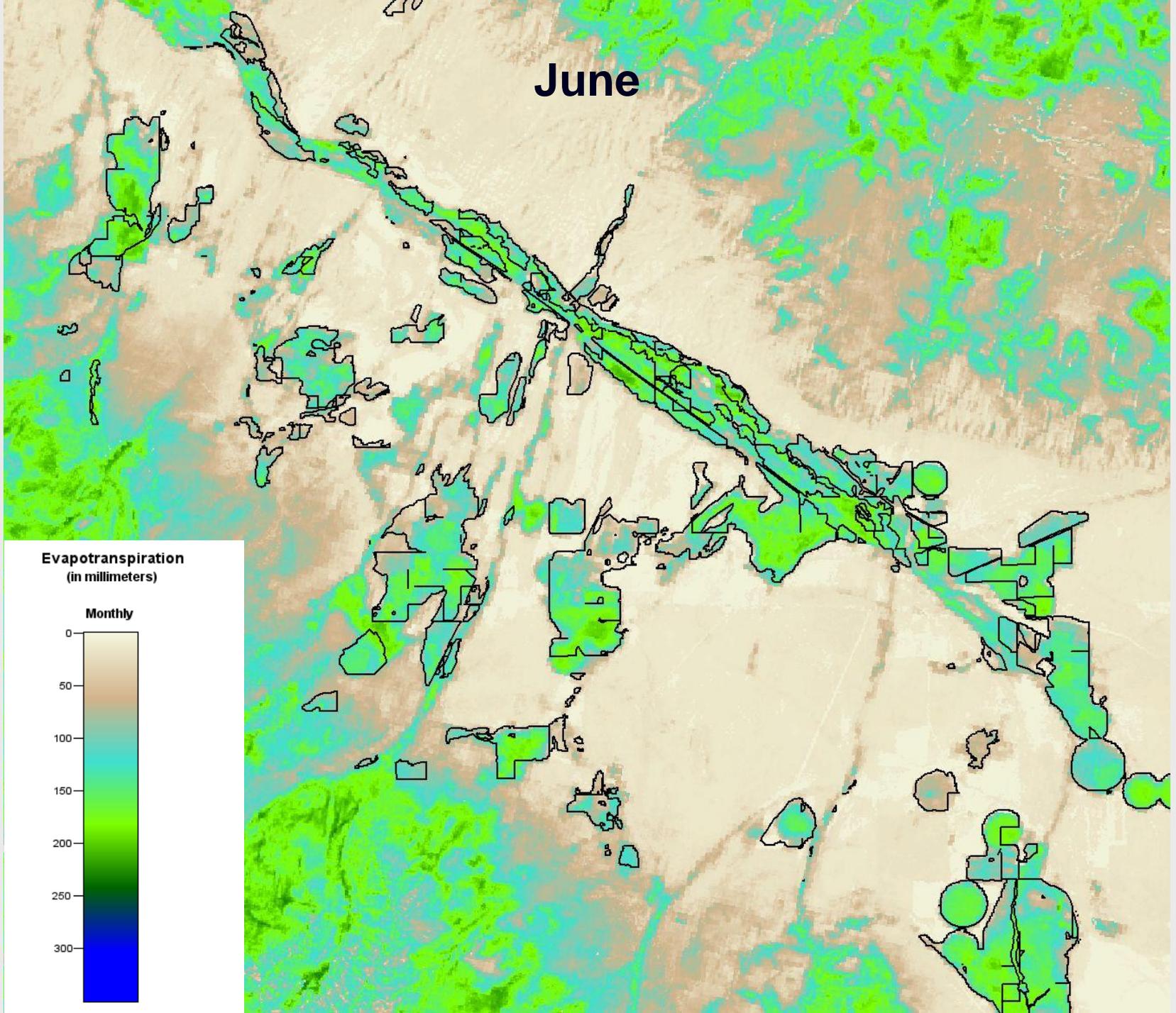
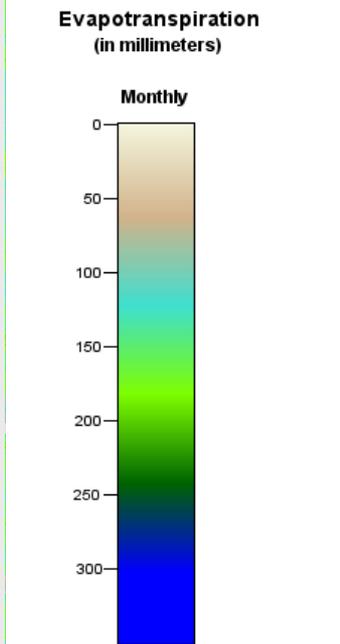


Evapotranspiration
(in millimeters)

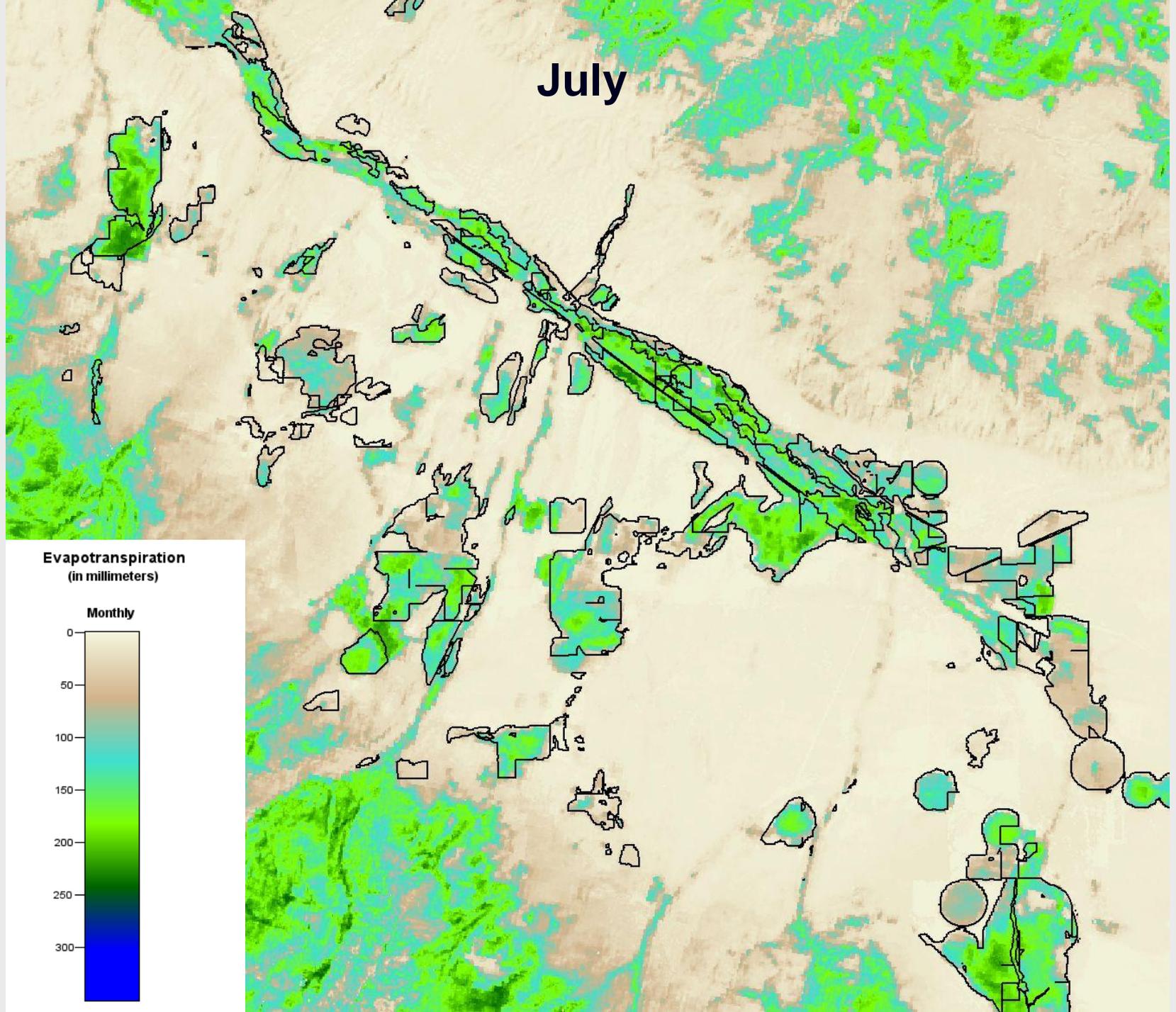
Monthly



June

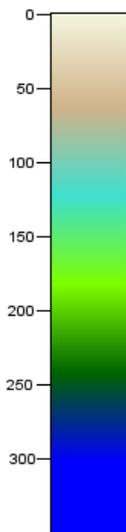


July

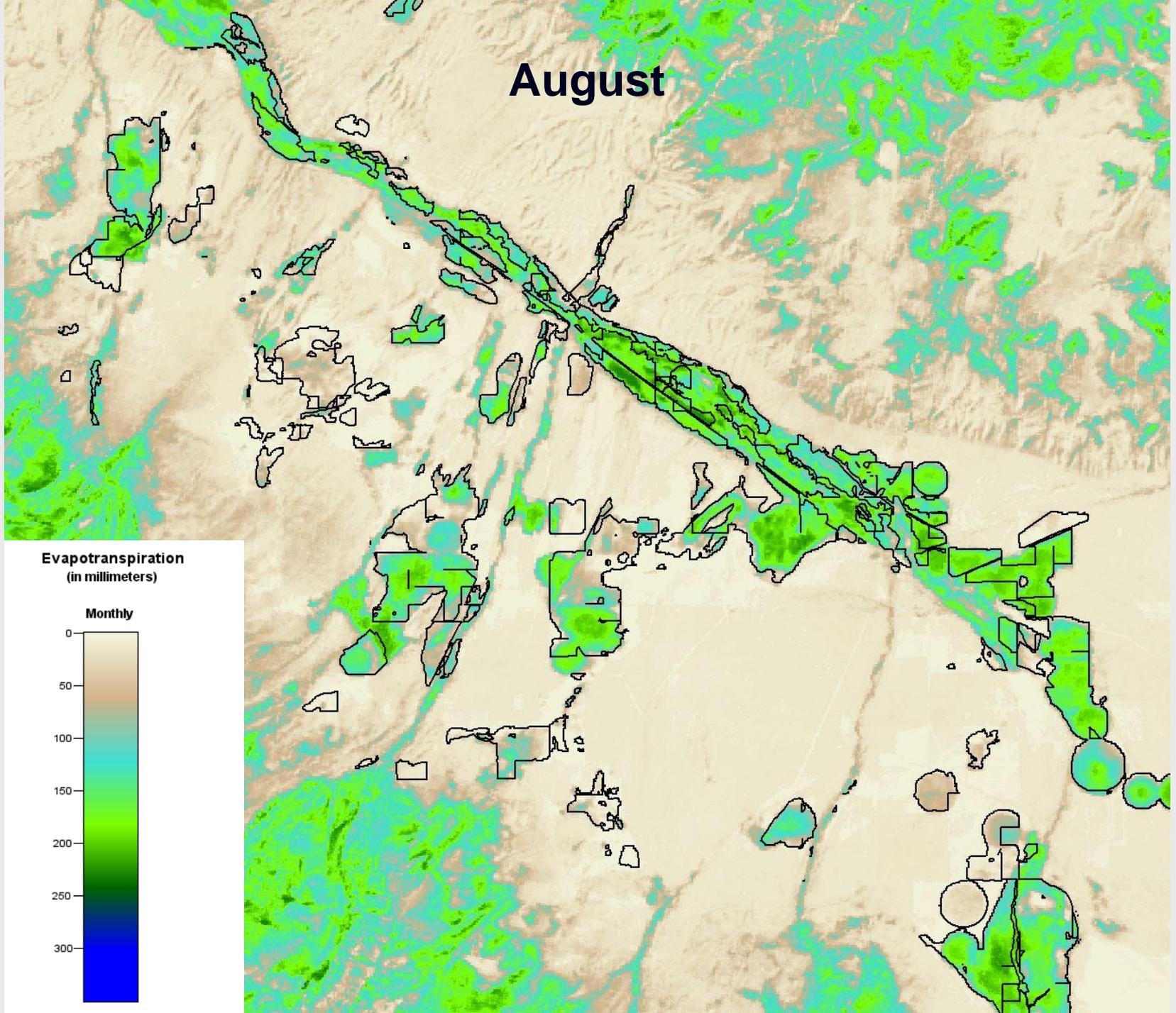


Evapotranspiration
(in millimeters)

Monthly

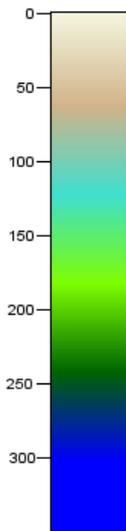


August

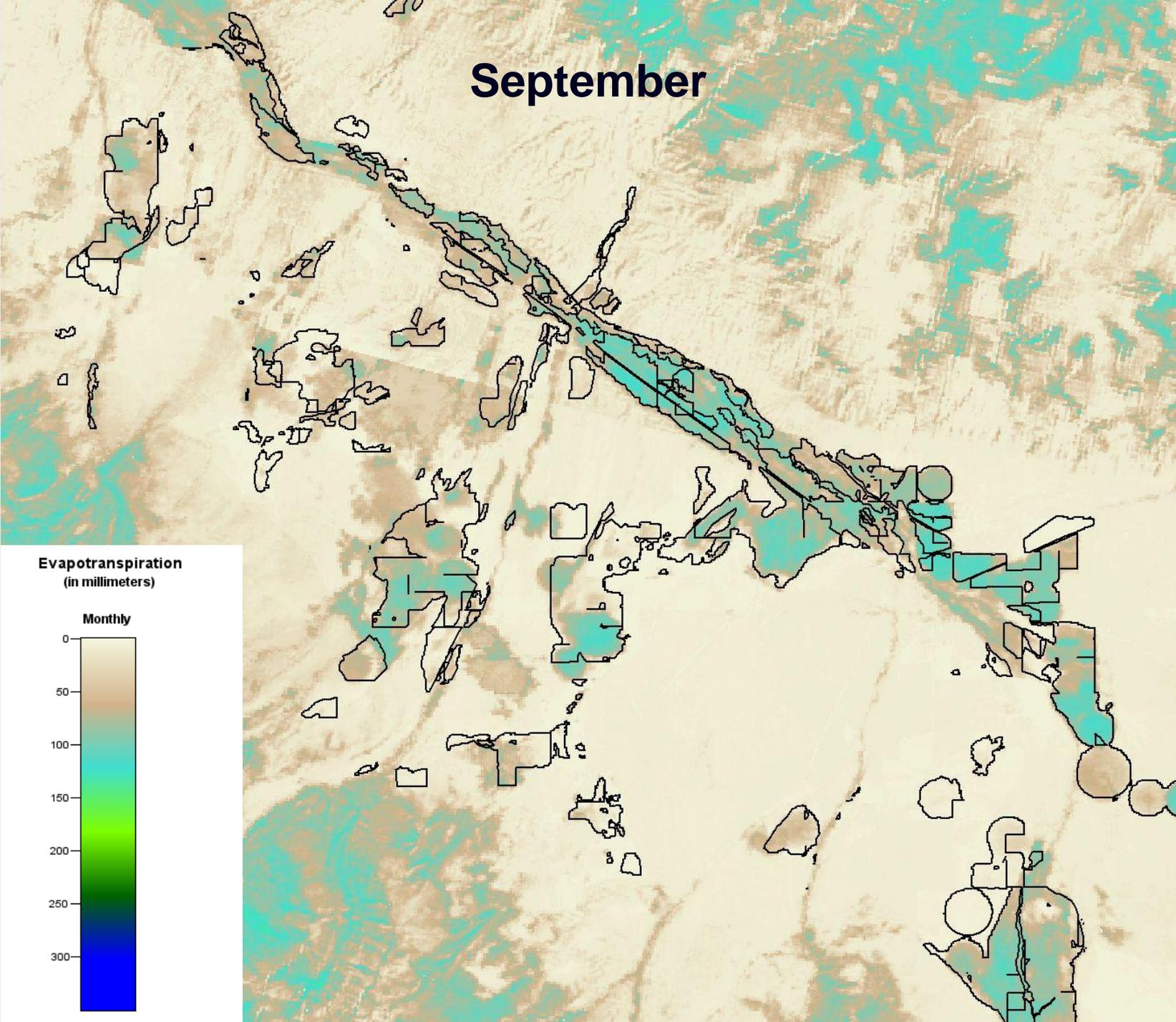


Evapotranspiration
(in millimeters)

Monthly

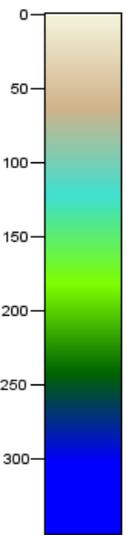


September

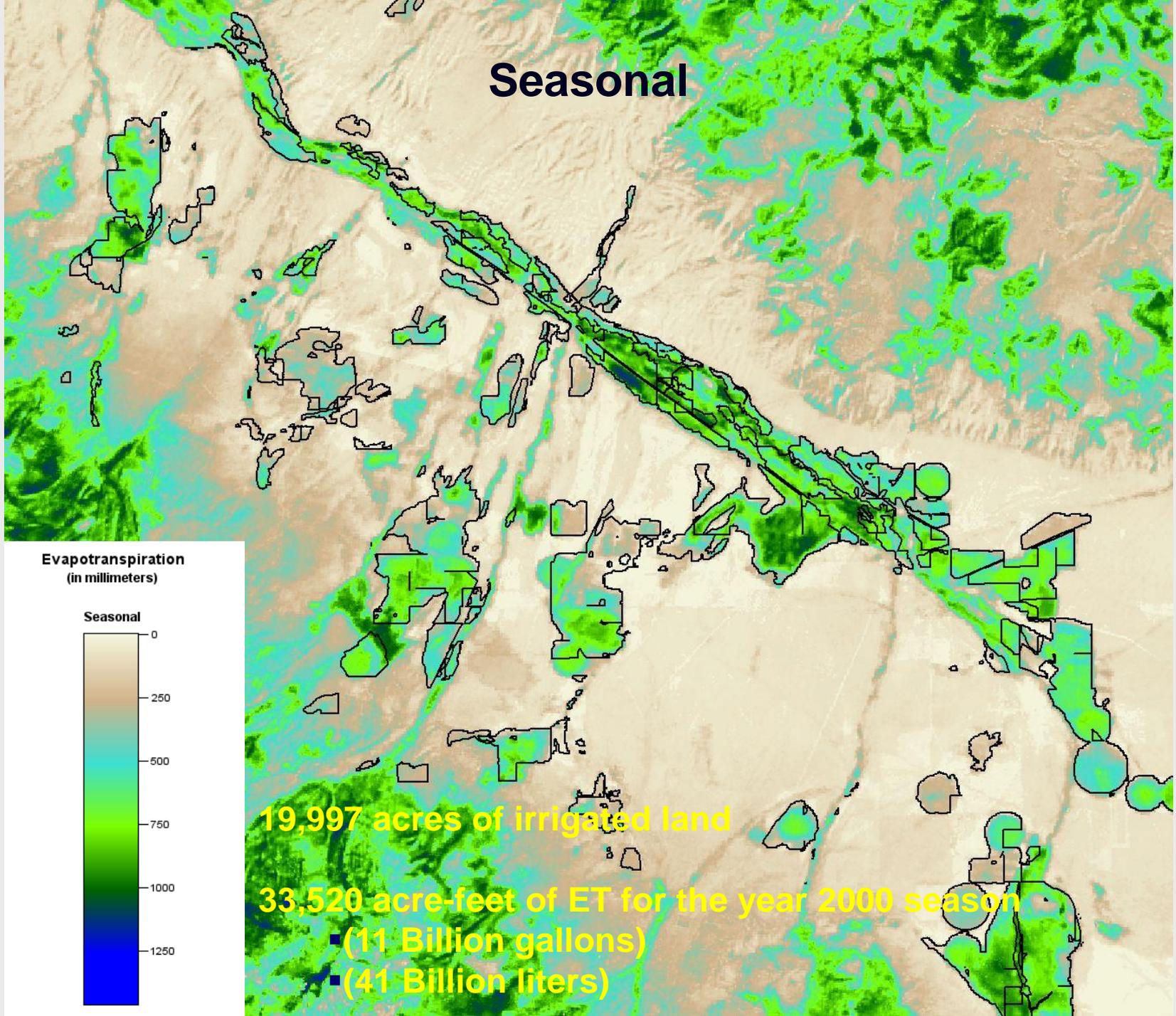


Evapotranspiration
(in millimeters)

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

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

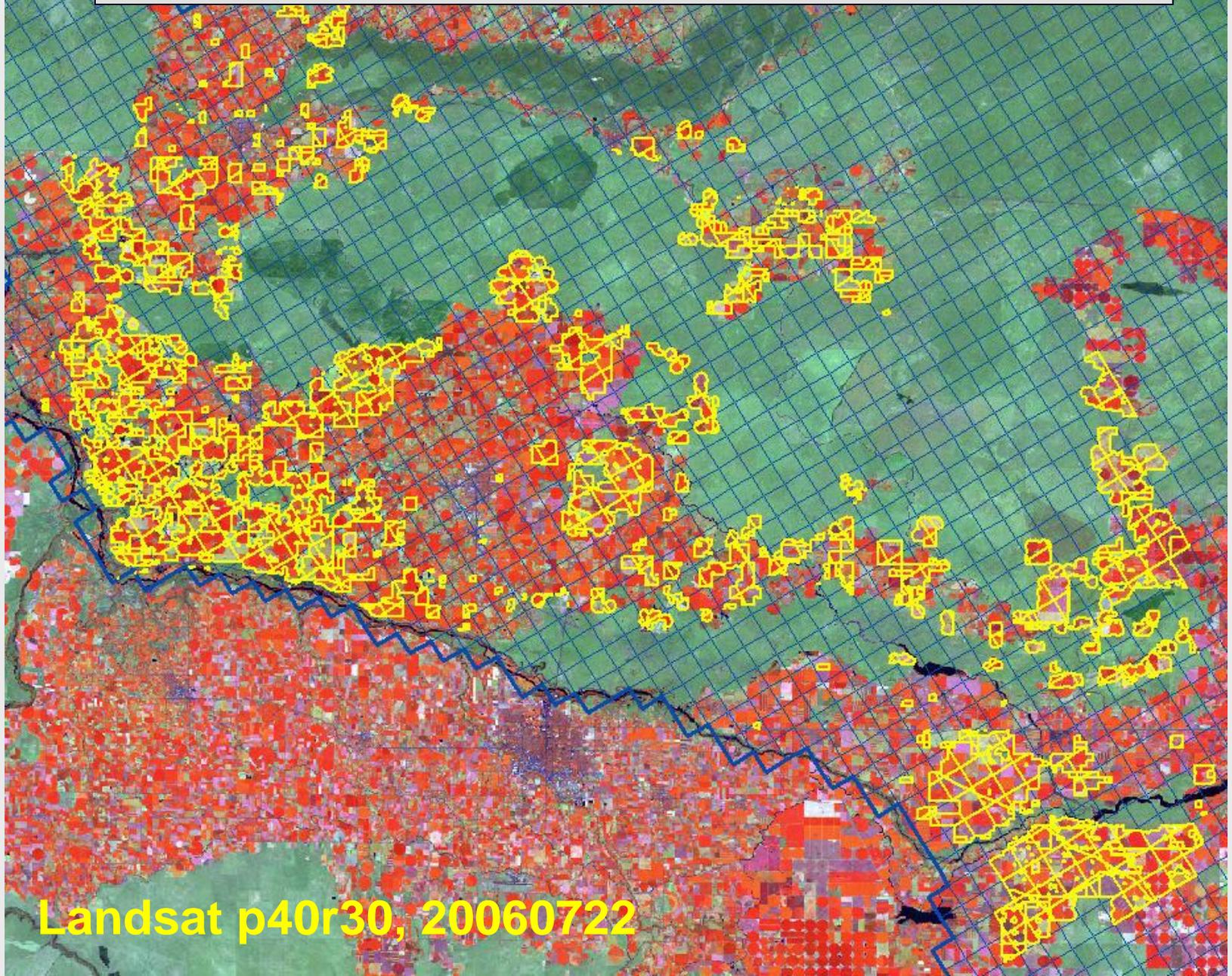
Times-News writer

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.

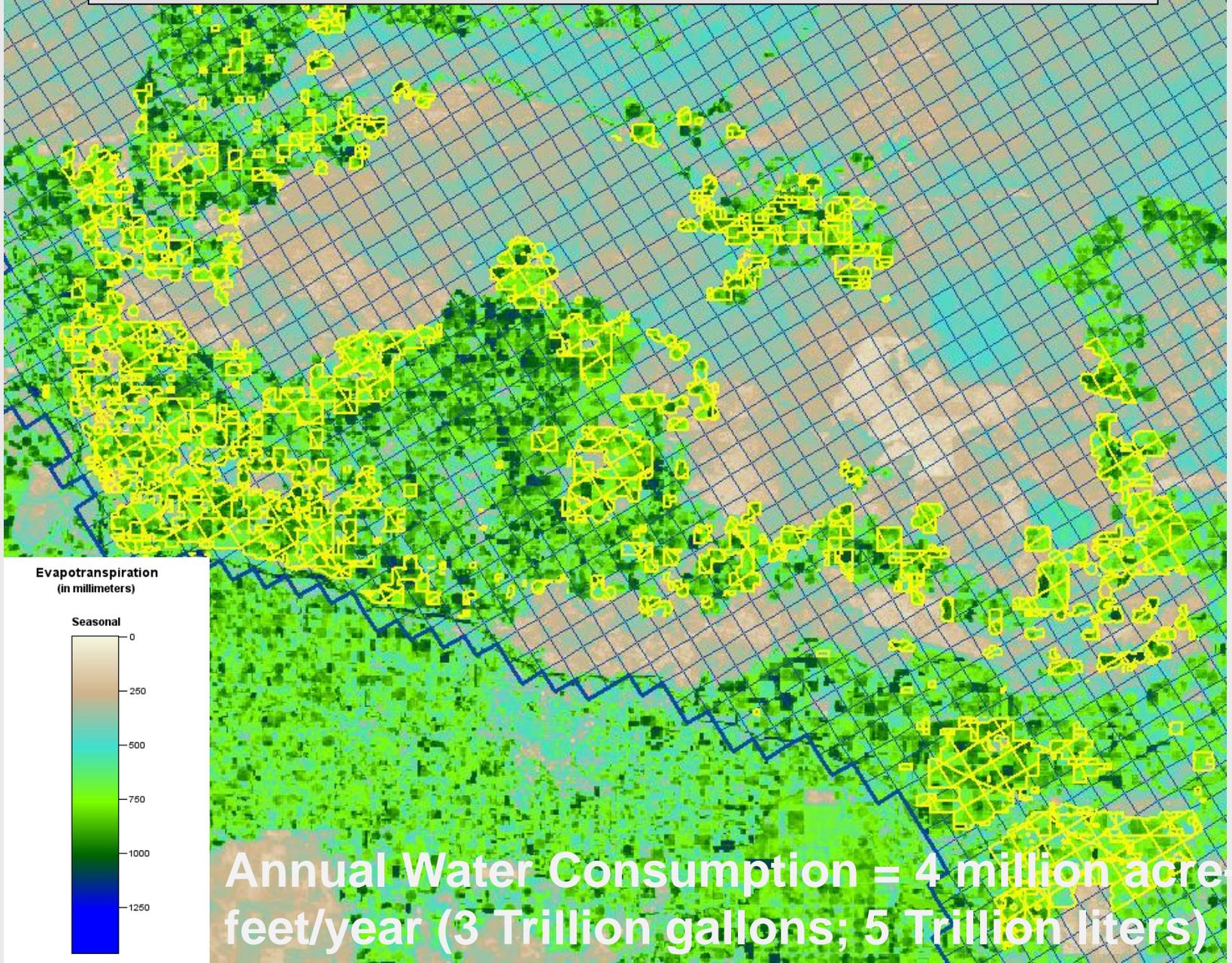


GW Model Cells and Water Rights



Landsat p40r30, 20060722

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

Irrigation Source

 A&B Irrigation District, ground water

 A&B Irrigation District, ground water, Item-G-land

 A&B Irrigation District, surface water

 North of A&B Irrigation District, ground water

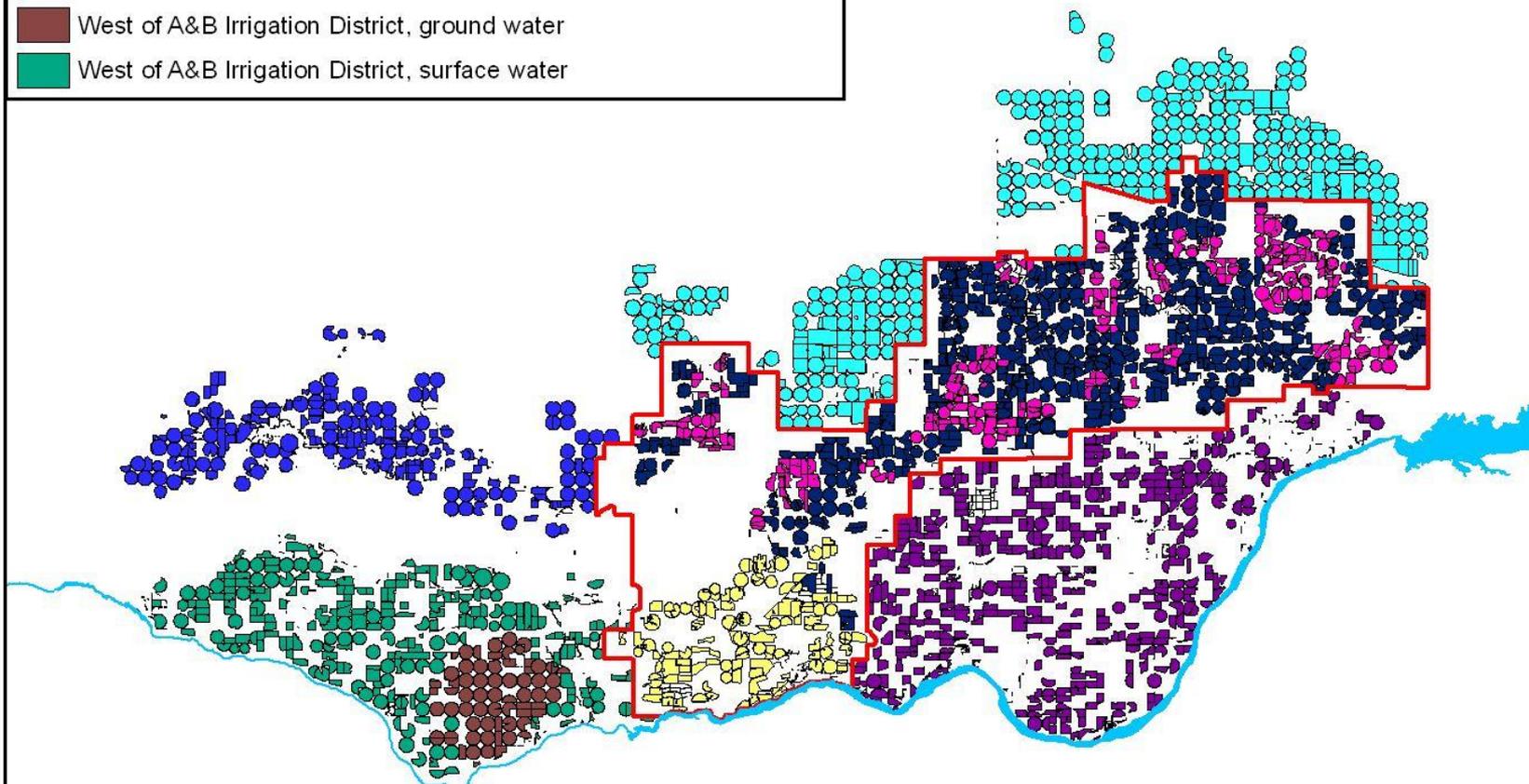
 Northwest of A&B Irrigation District, mixed surface and ground water

 South of A&B Irrigation District, surface water

 West of A&B Irrigation District, ground water

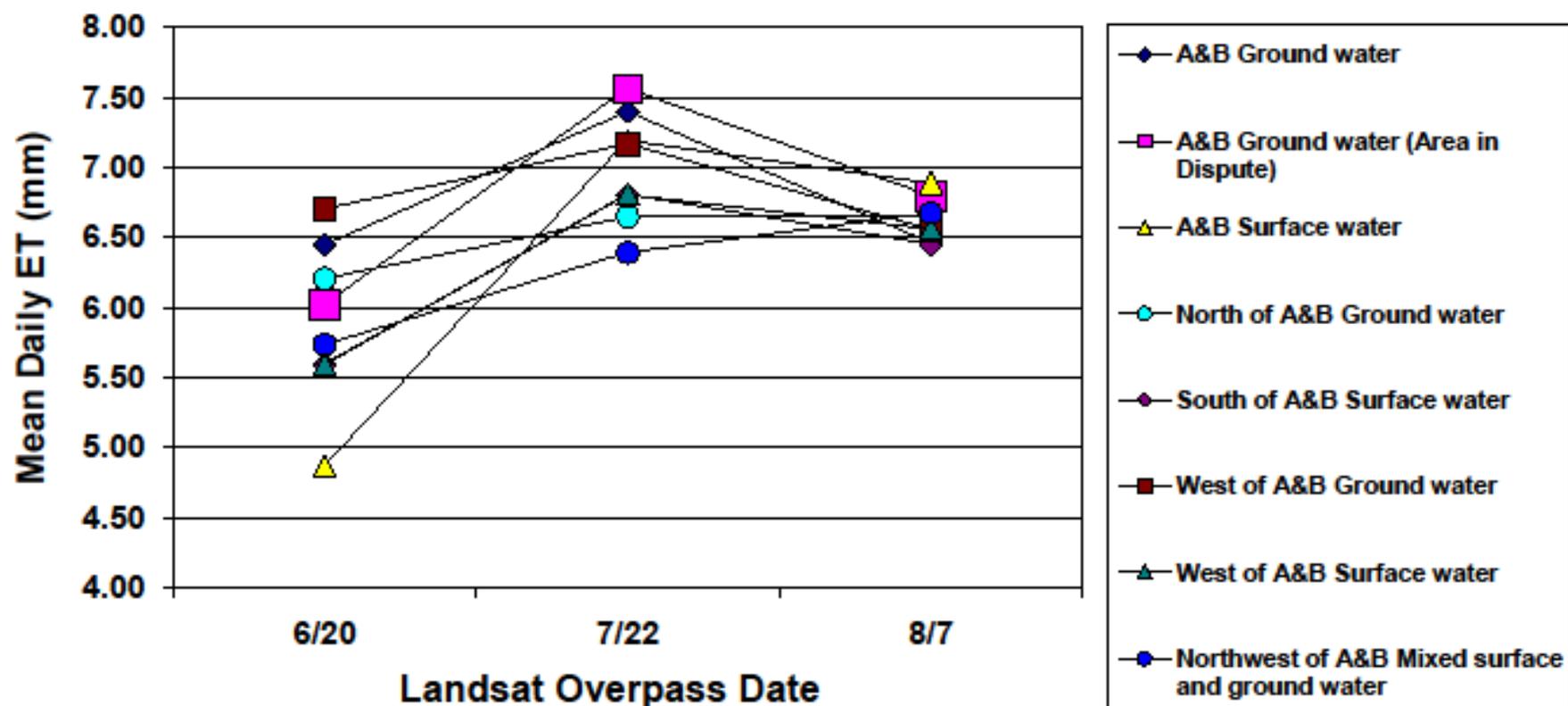
 West of A&B Irrigation District, surface water

A&B Irrigation District and adjacent land



0 5 10 20 Kilometers

Year 2006: Mean Daily Evapotranspiration (ET)



Acknowledgements

Dr. Allan Wylie, IDWR
NASA
USGS

More Information

www.idwr.idaho.gov/GeographicInfo/METRIC/et.htm

www.kimberly.uidaho.edu/water/metric

Snake River Plain

