

Satellite-based Evapotranspiration Mapping in Idaho

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in partnership with
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Association of Western States Engineers, May 11, 2010

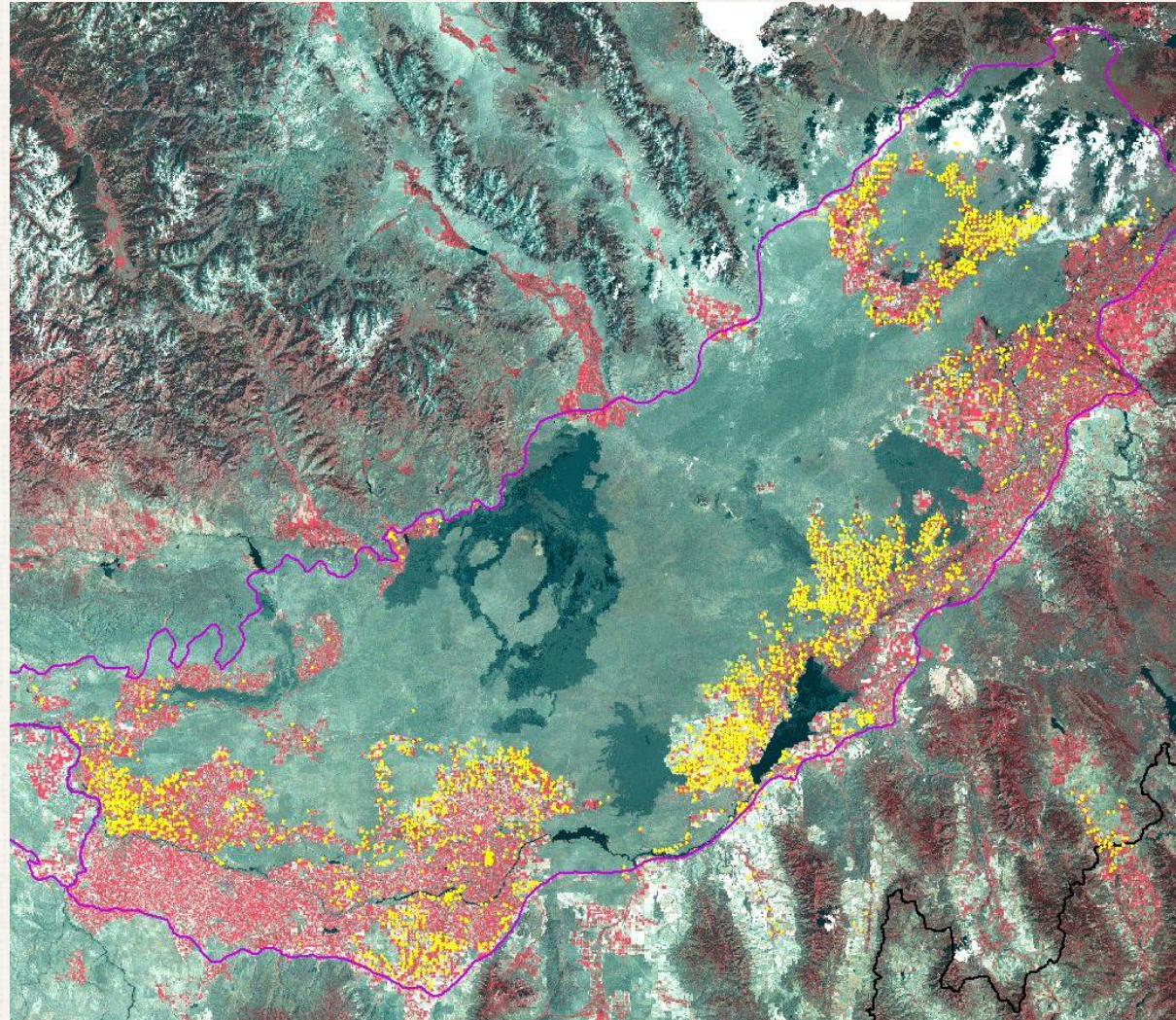


Why is Evapotranspiration (ET) important

- 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

Why Quantify ET

Net Depletion
from ground
water pumping in
Idaho is largely
unmeasured

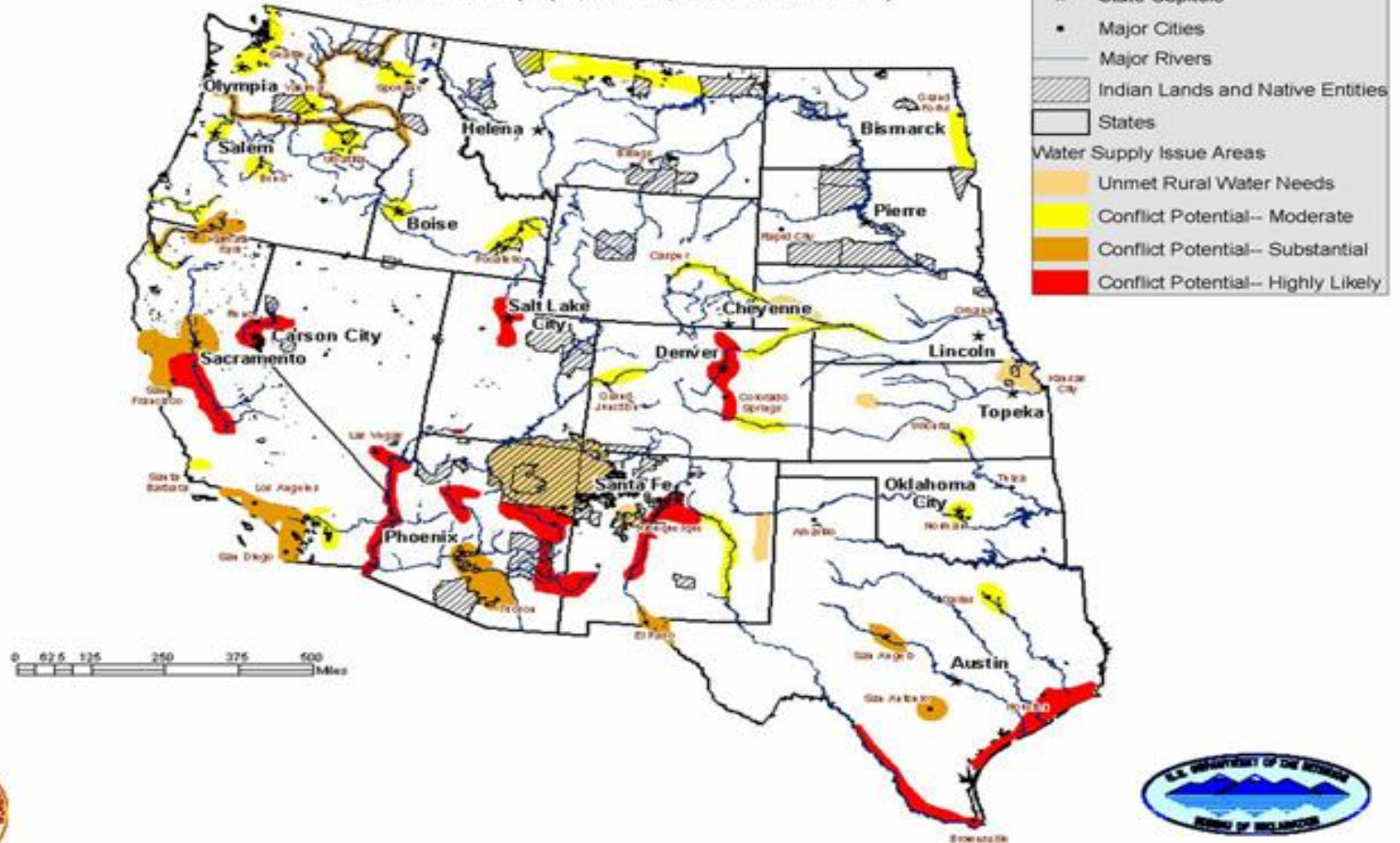


Yellow dots are irrigation wells

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)



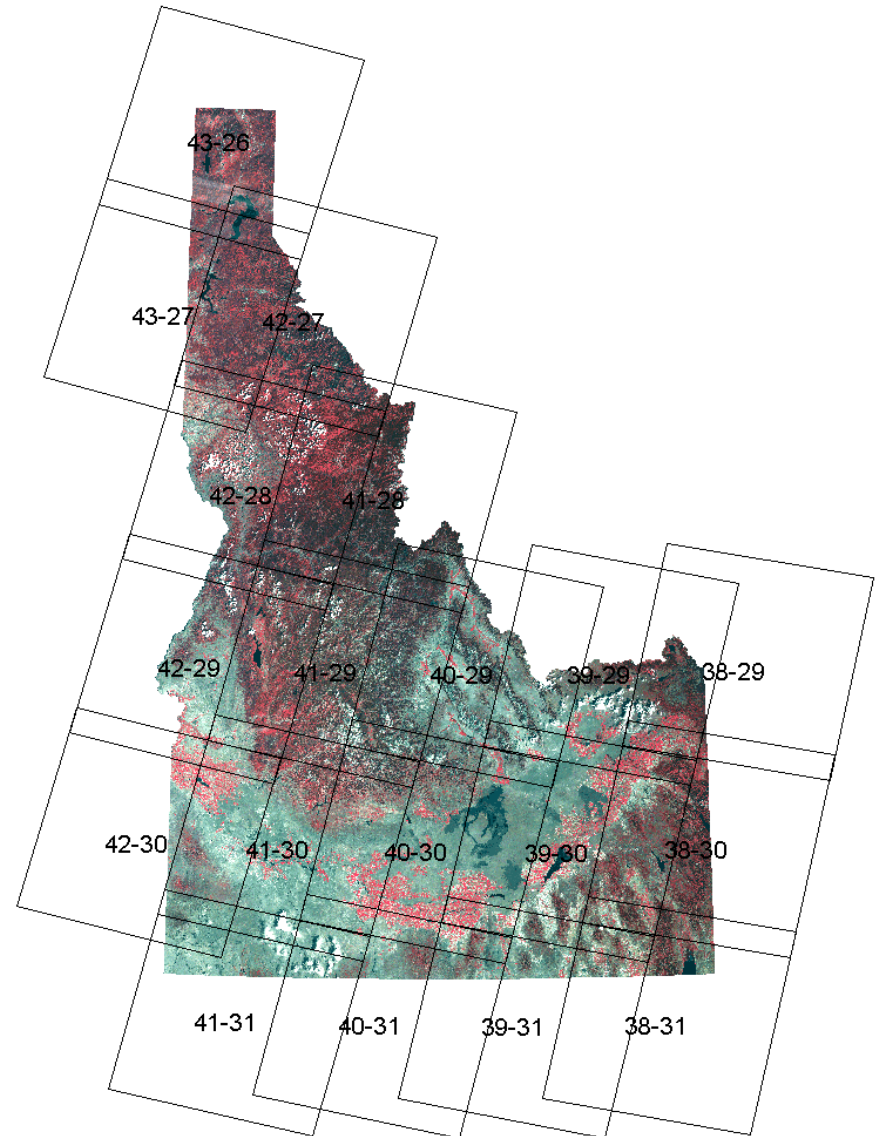
May 2003

Landsat-based ET

Applications in Idaho

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

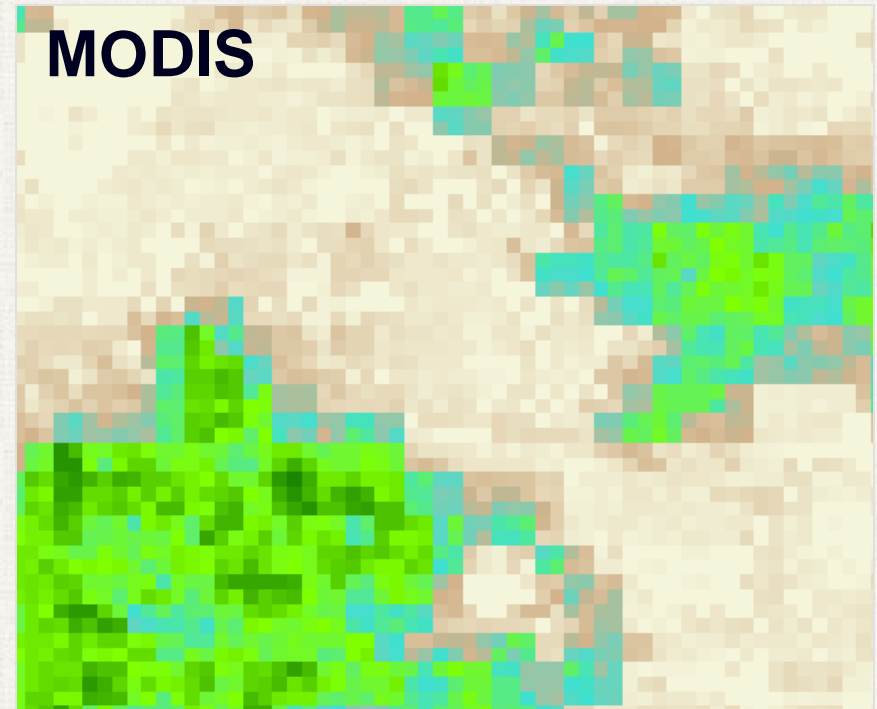
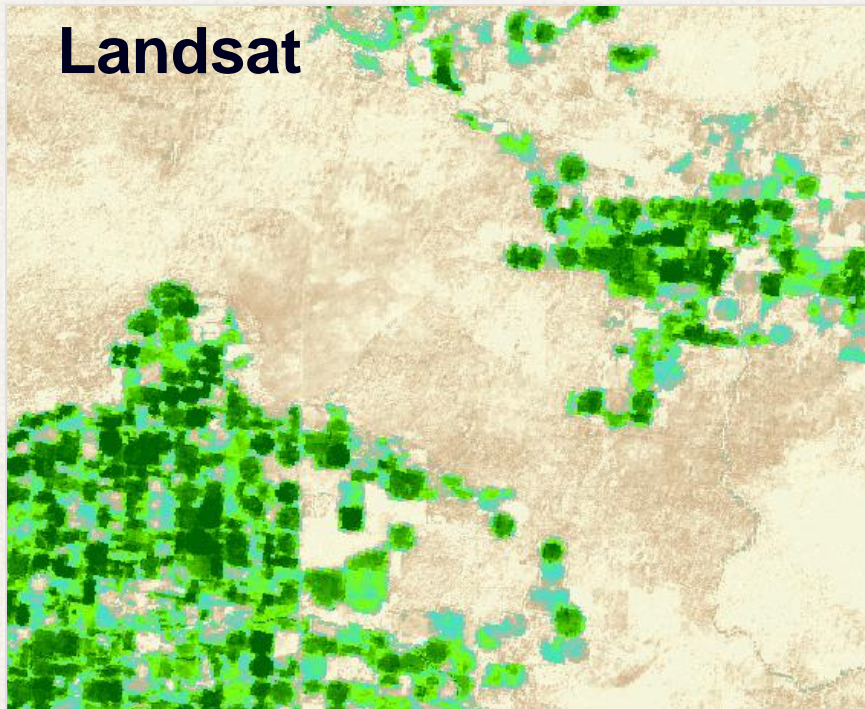


Landsat 7



Why not use other satellites

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



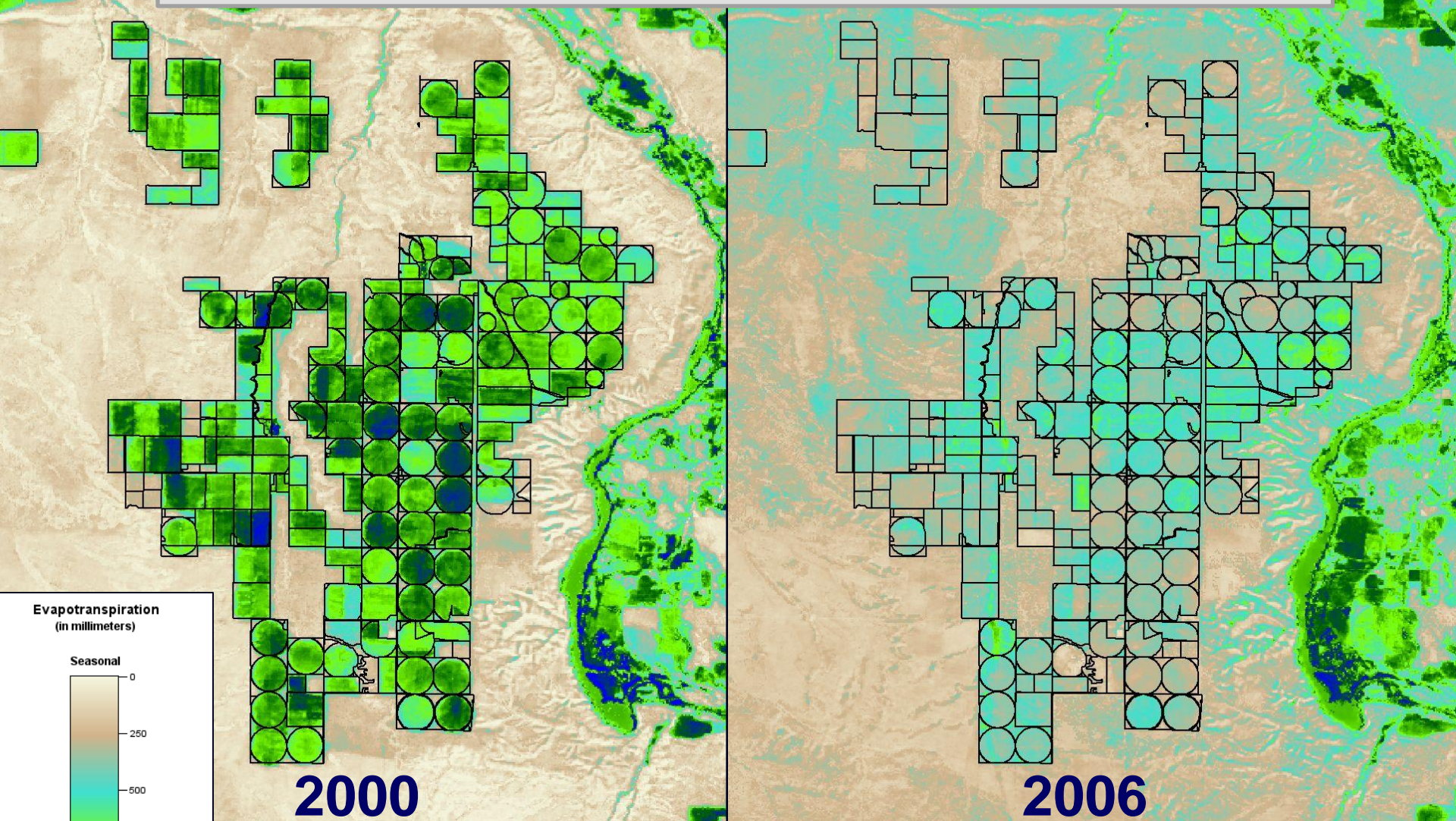
In the past

- 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!



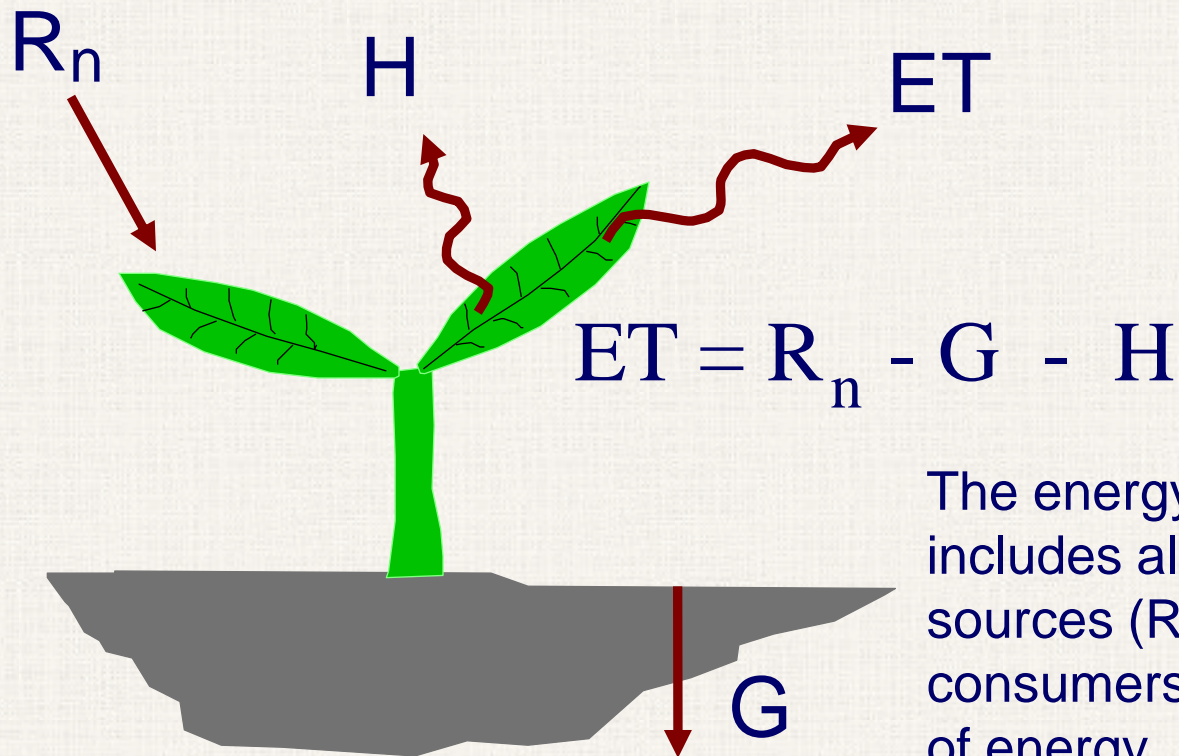
METRIC

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

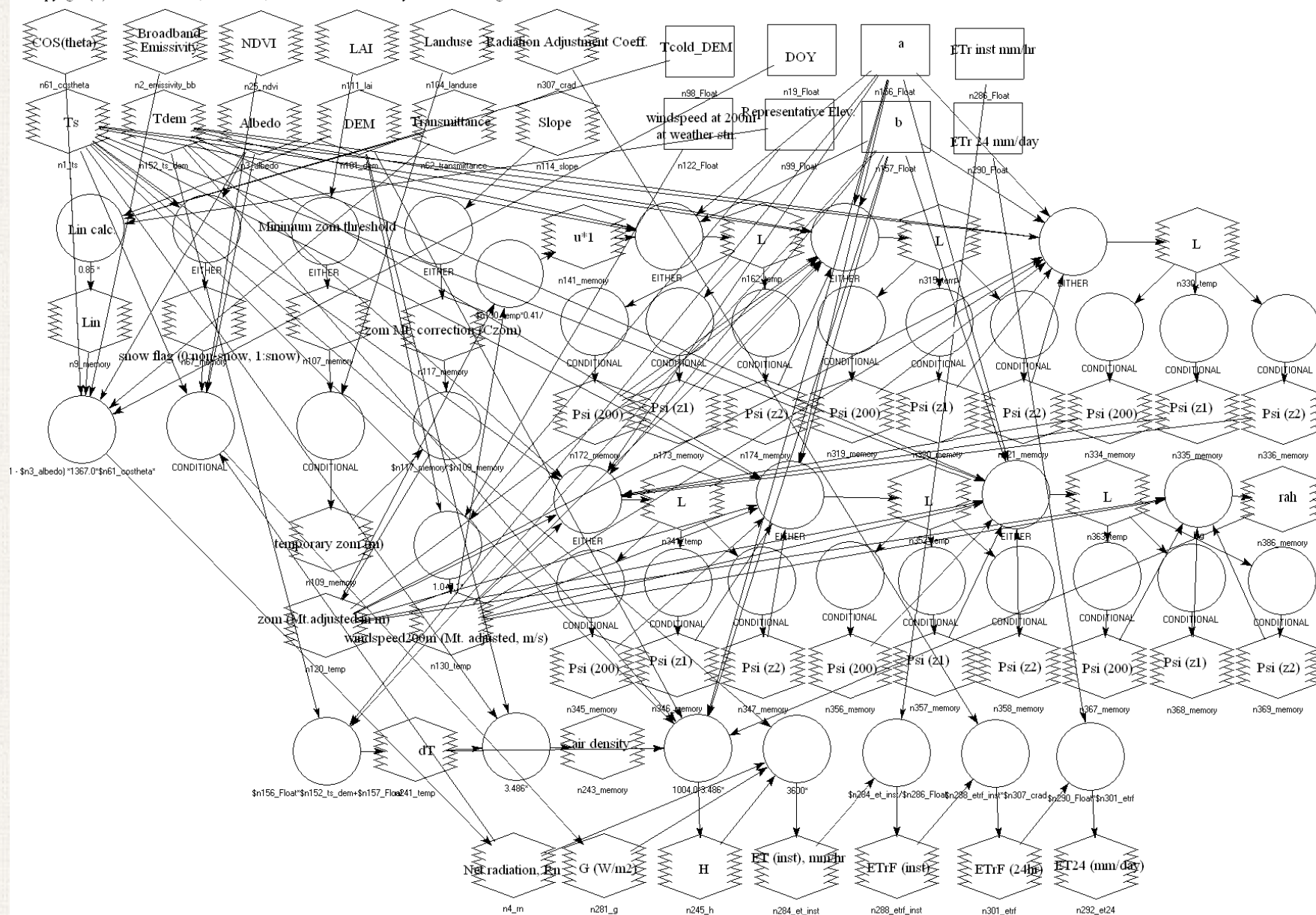


- *(these effects can cause the ratio ET / amount of vegetation to vary widely, thus the need to compute ET as a residual of the energy balance)*

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**

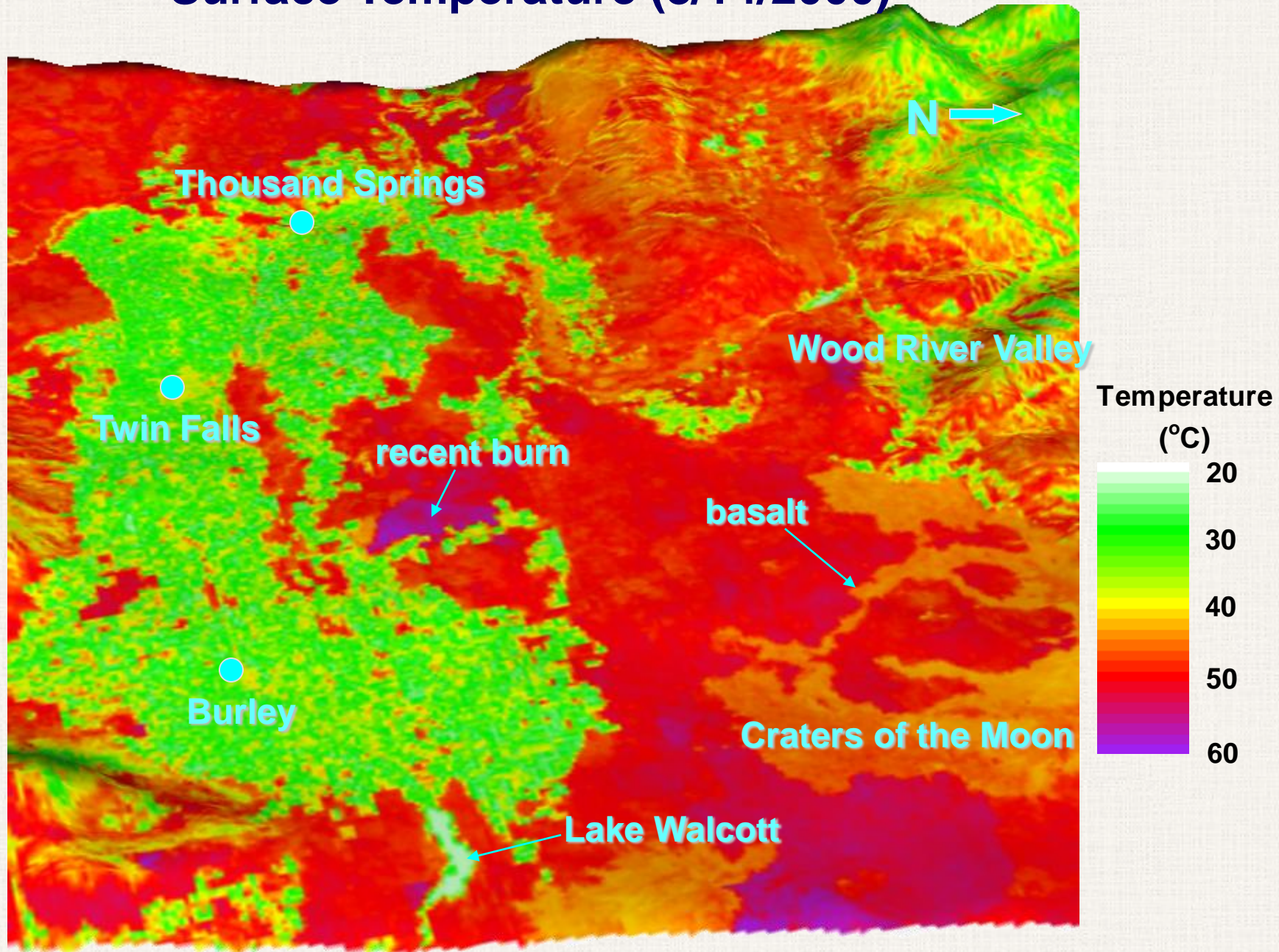
Reference ET to **extrapolate ET** over:

- **24-hour period**
- **Days between images**

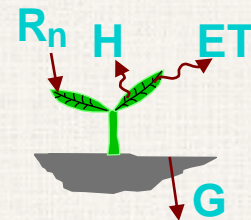
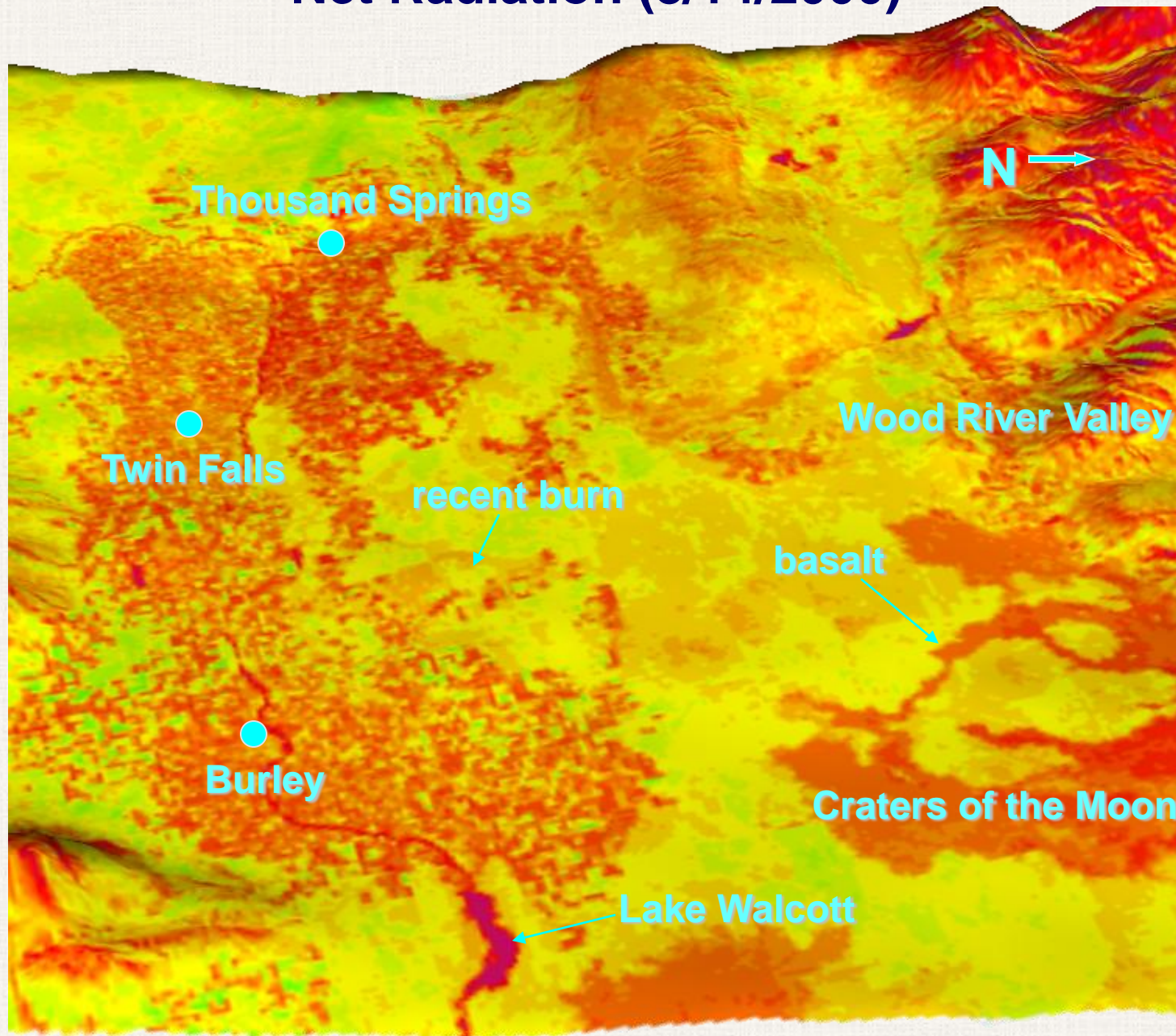
Landsat, south-central Idaho (8/14/2000)



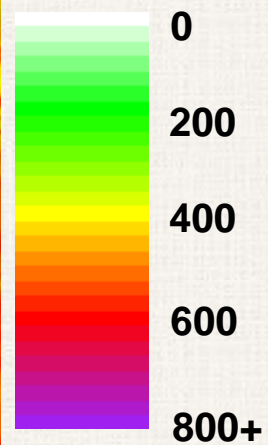
Surface Temperature (8/14/2000)



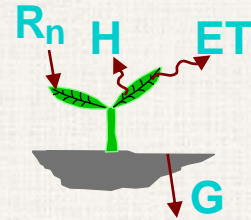
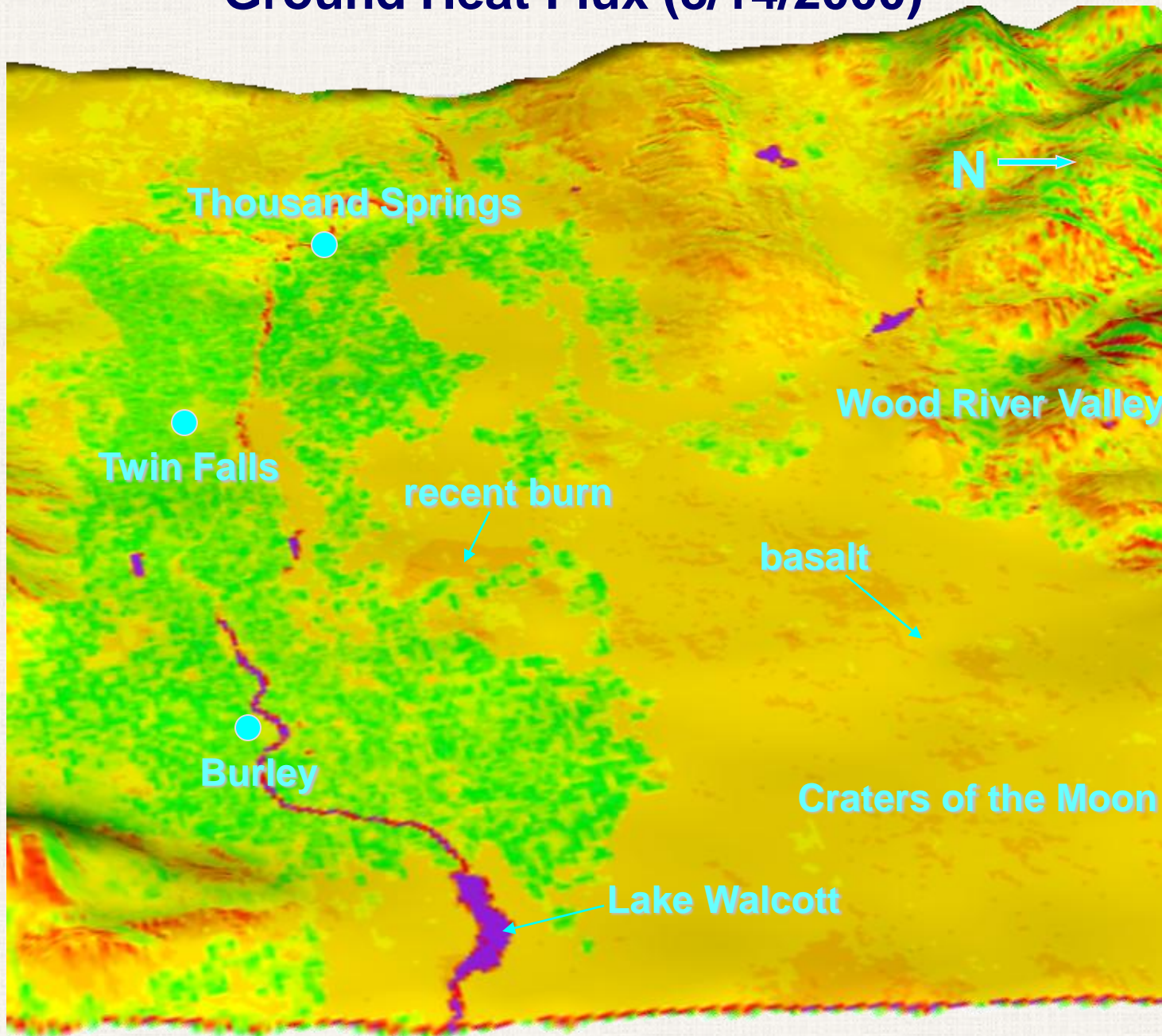
Net Radiation (8/14/2000)



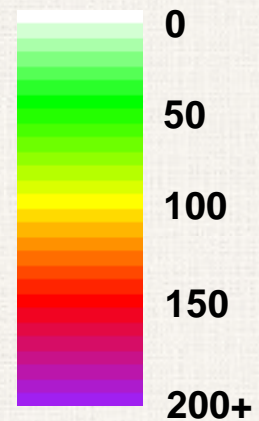
Net Radiation
(W/m^2)



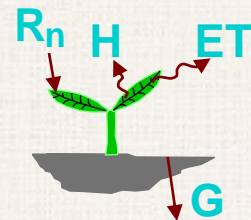
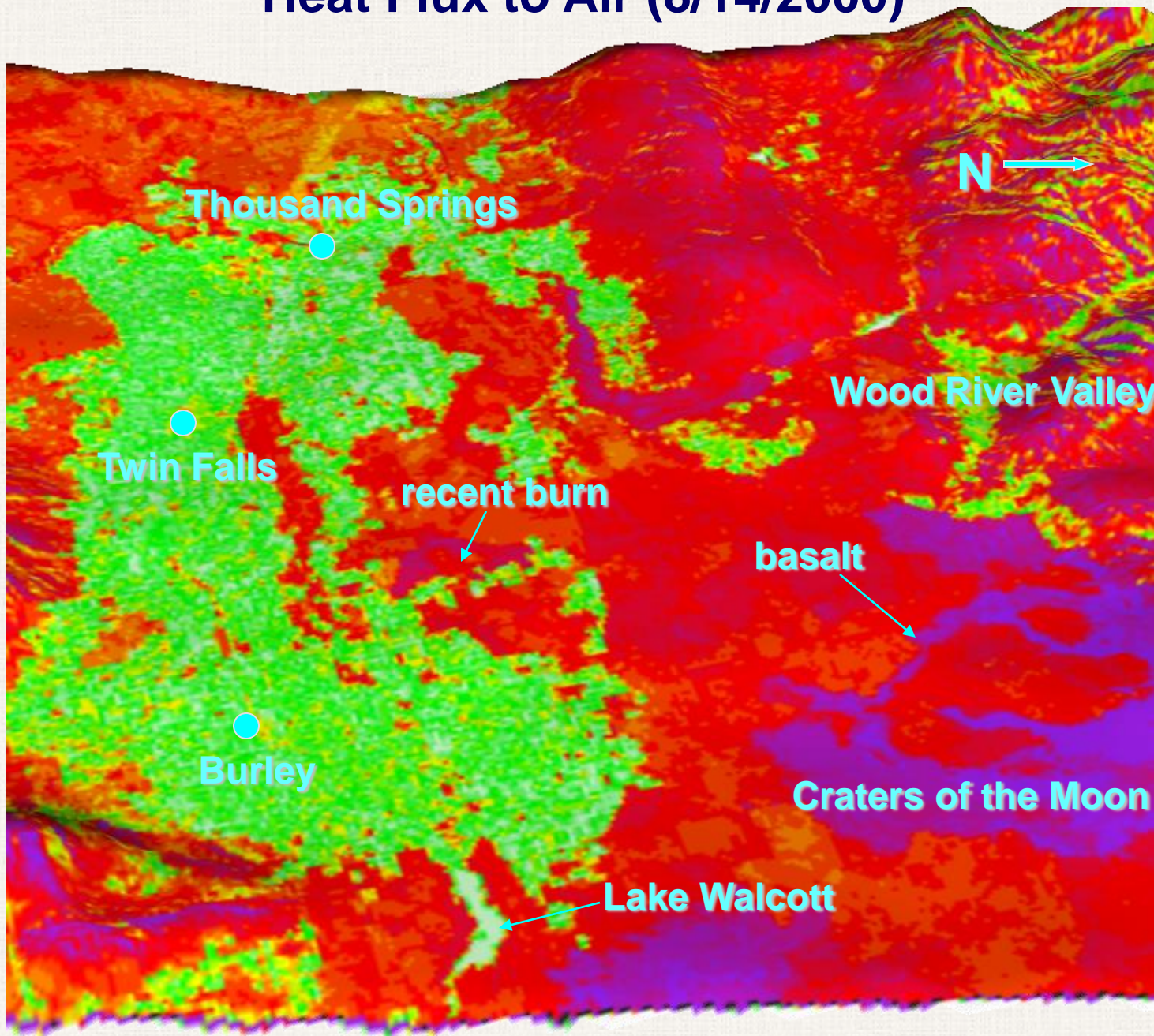
Ground Heat Flux (8/14/2000)



Soil Heat Flux
(W/m^2)



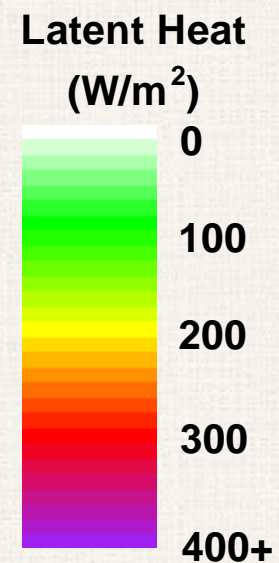
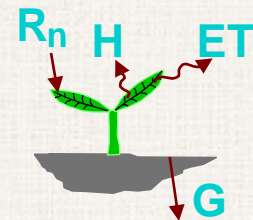
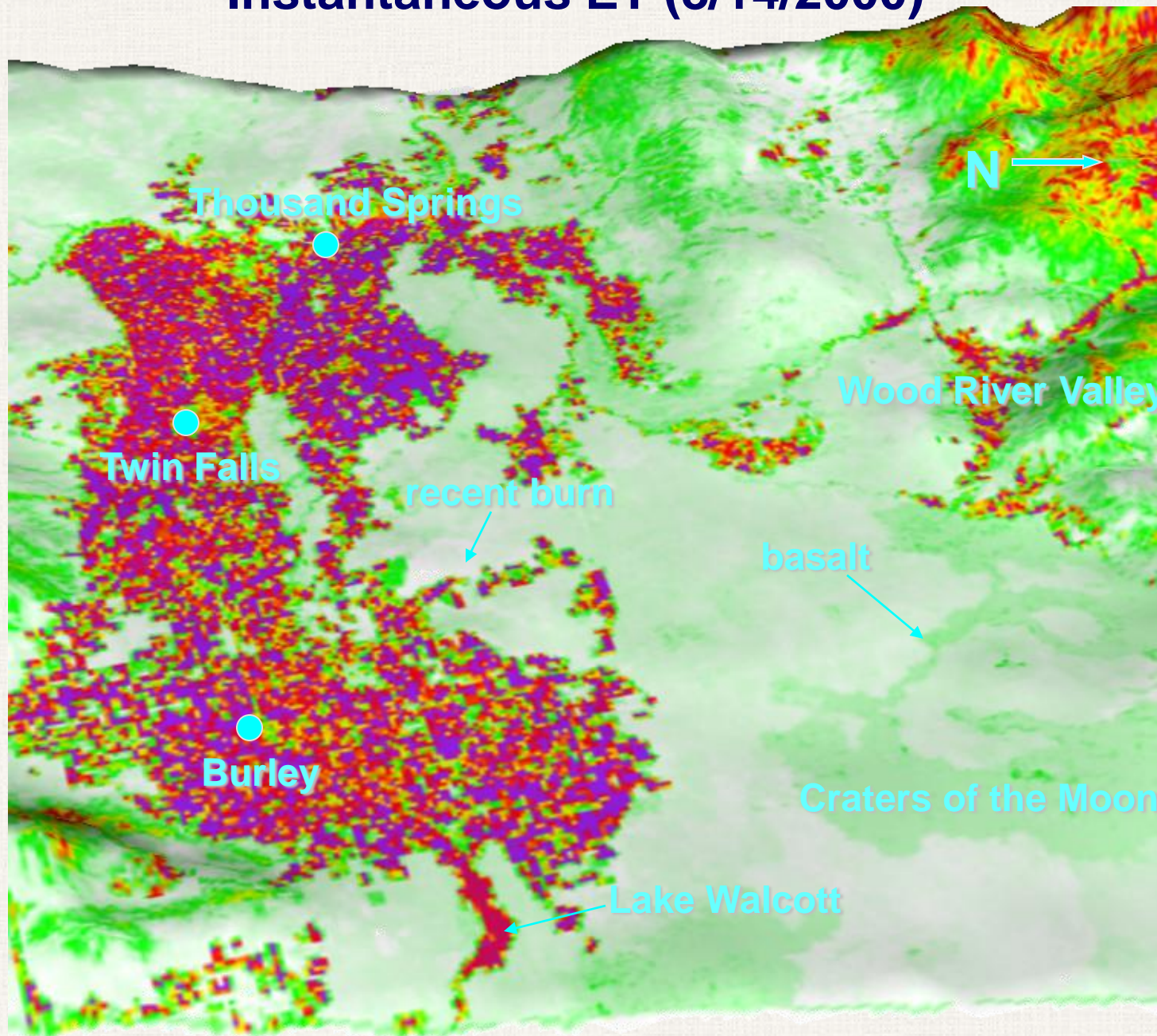
Heat Flux to Air (8/14/2000)



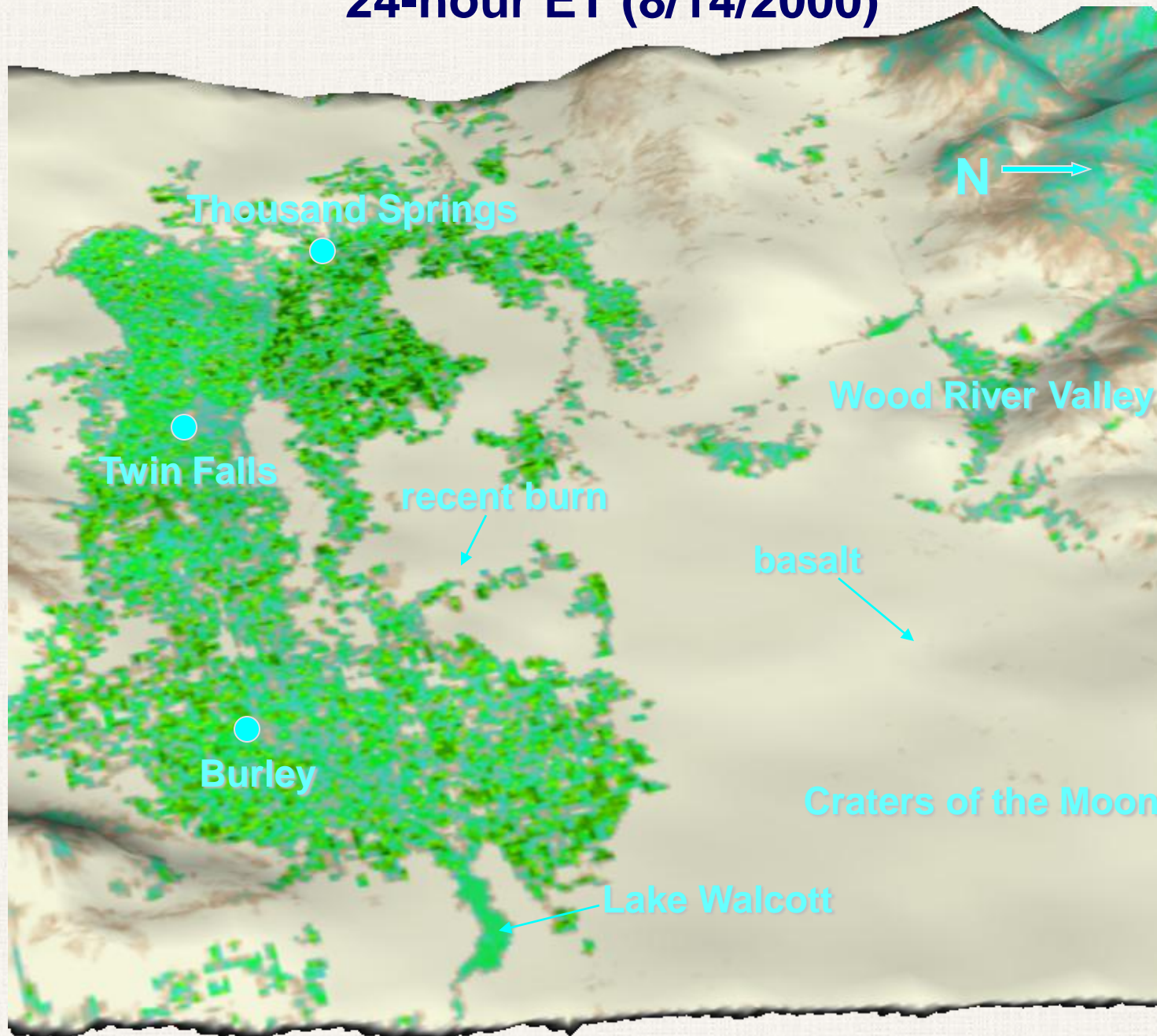
Sensible Heat
(W/m^2)



Instantaneous ET (8/14/2000)



24-hour ET (8/14/2000)



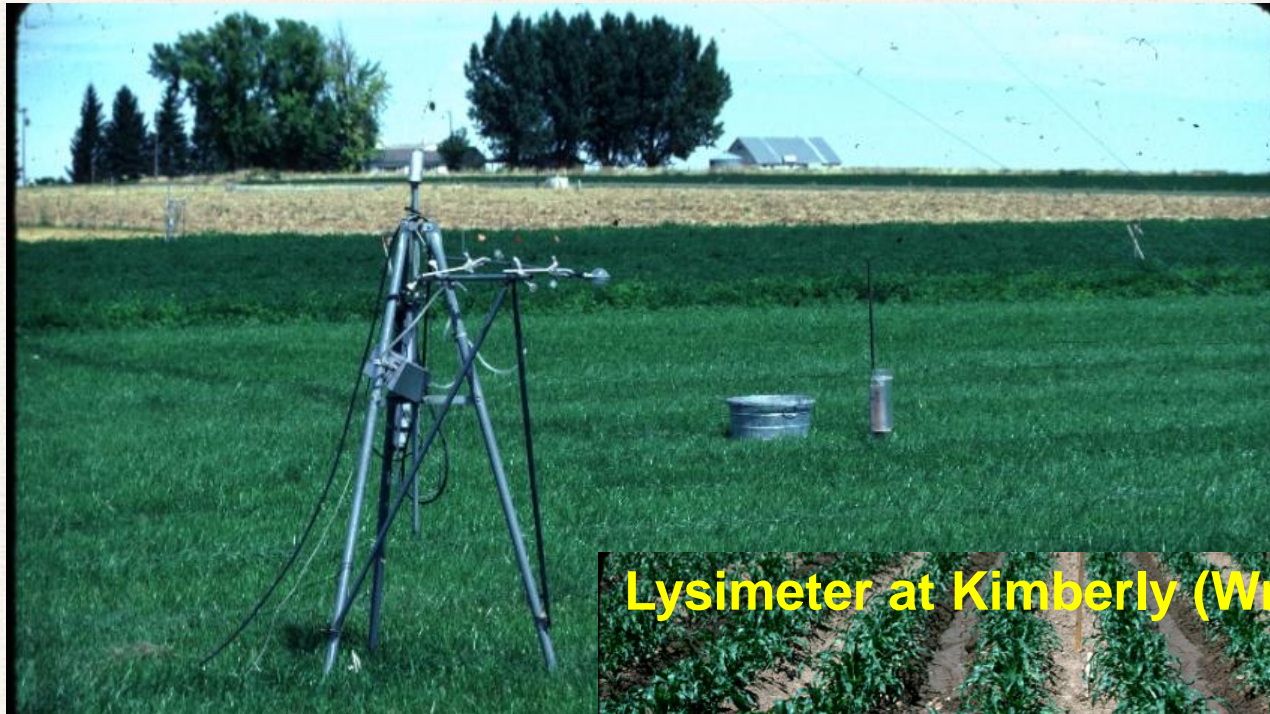
Evapotranspiration
(mm/day)

0.0
1.5
3.0
4.5
6.0
7.5
8.2

ETr Fraction

0.0
0.2
0.4
0.6
0.8
1.0
1.1

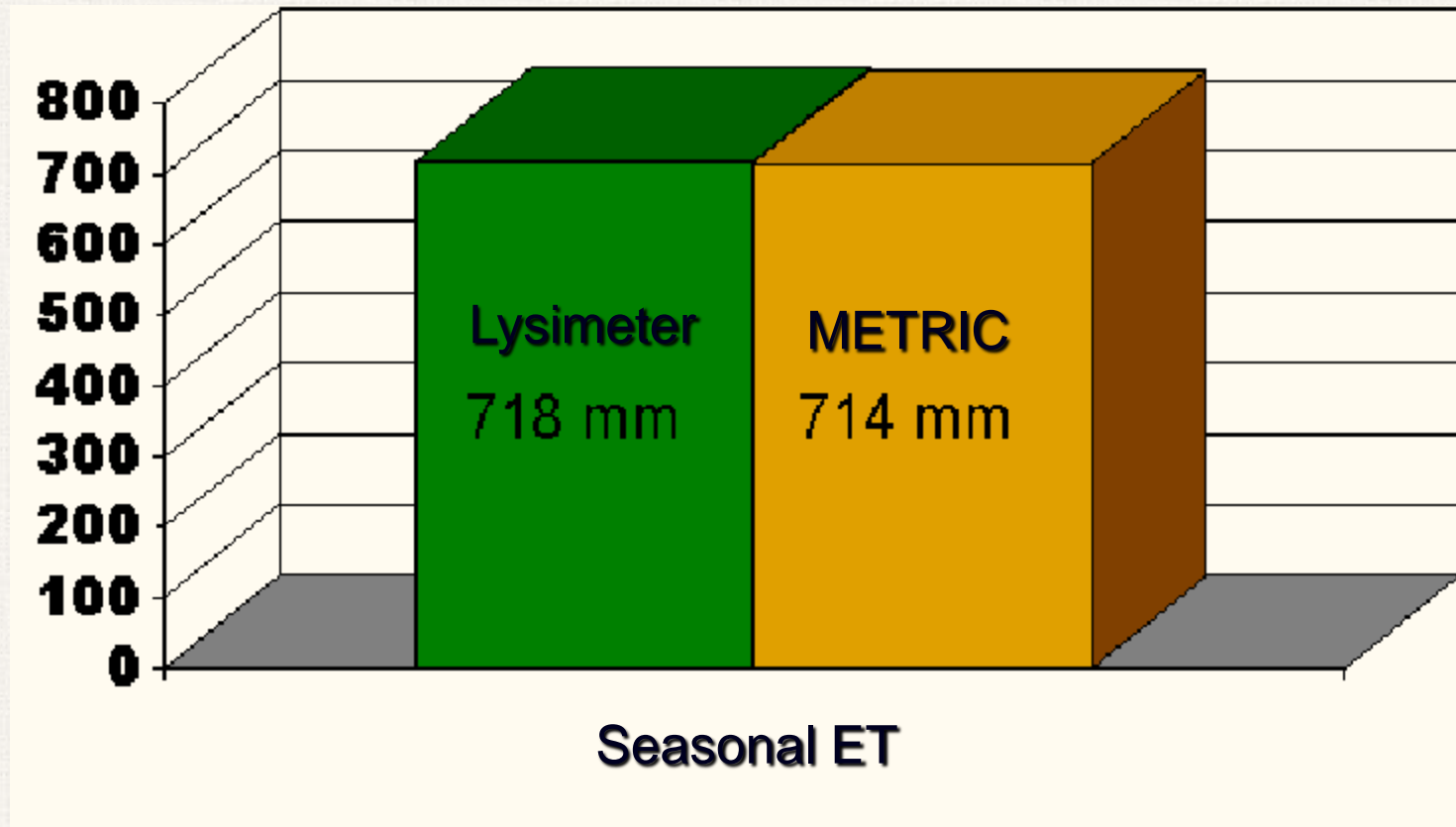
Comparison with Lysimeter Measurements



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

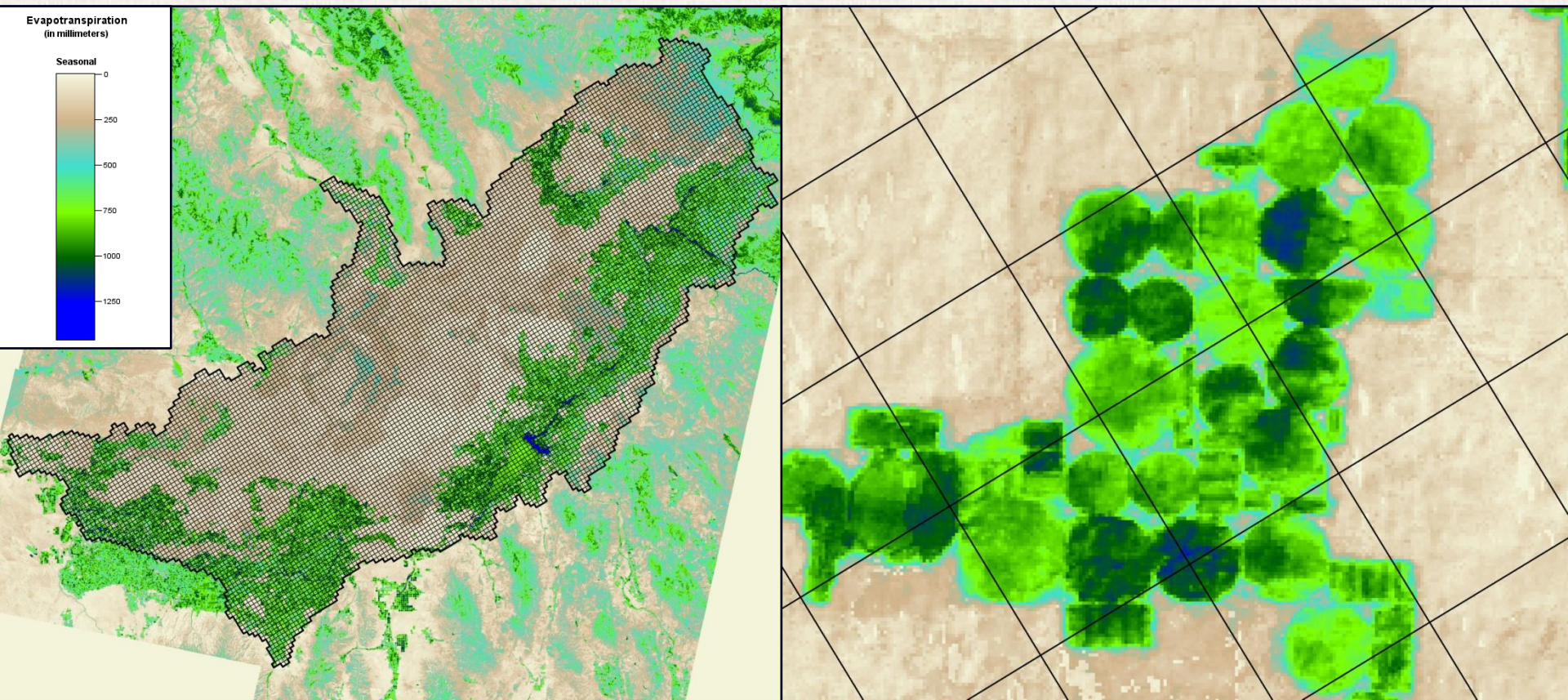
- Hydrologic modeling
- Water planning
- Water administration



Hydrologic Modeling

Eastern Snake Plain Aquifer Model

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



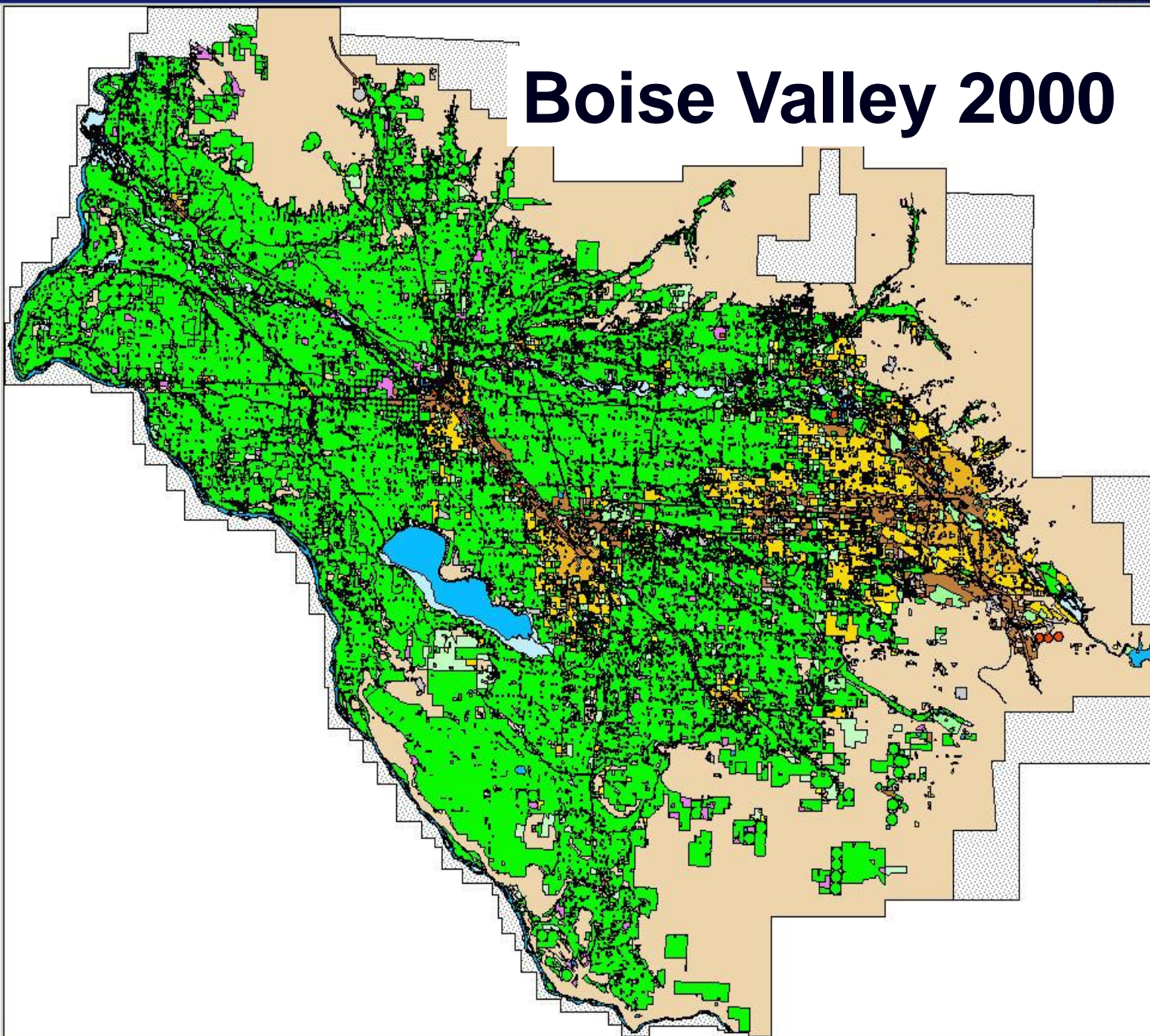
Water Planning

ET by Land Use

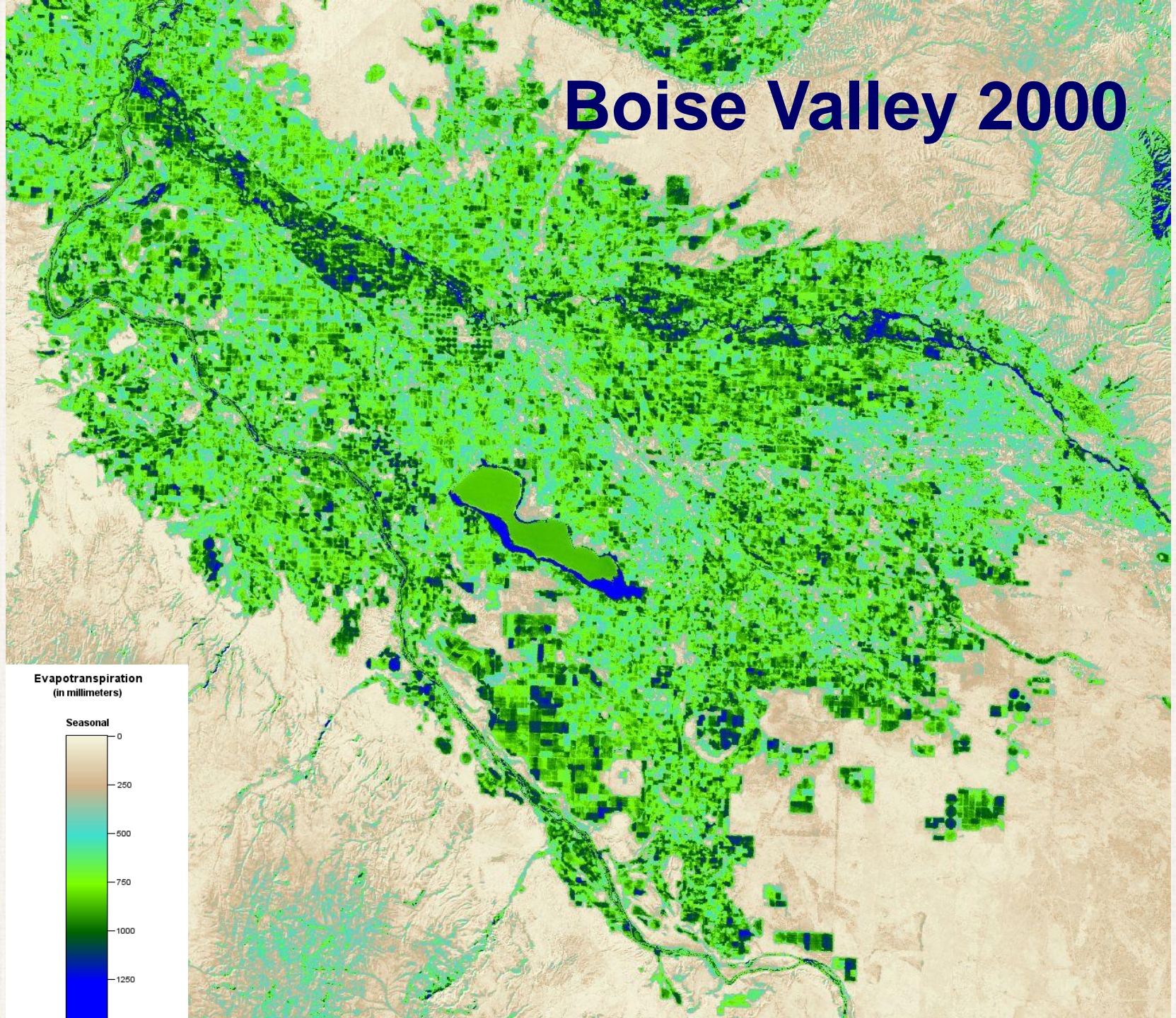
- Used for estimates of future water demand
- Year 2000 land use data overlayed on year 2000 seasonal ET data

Boise Valley 2000

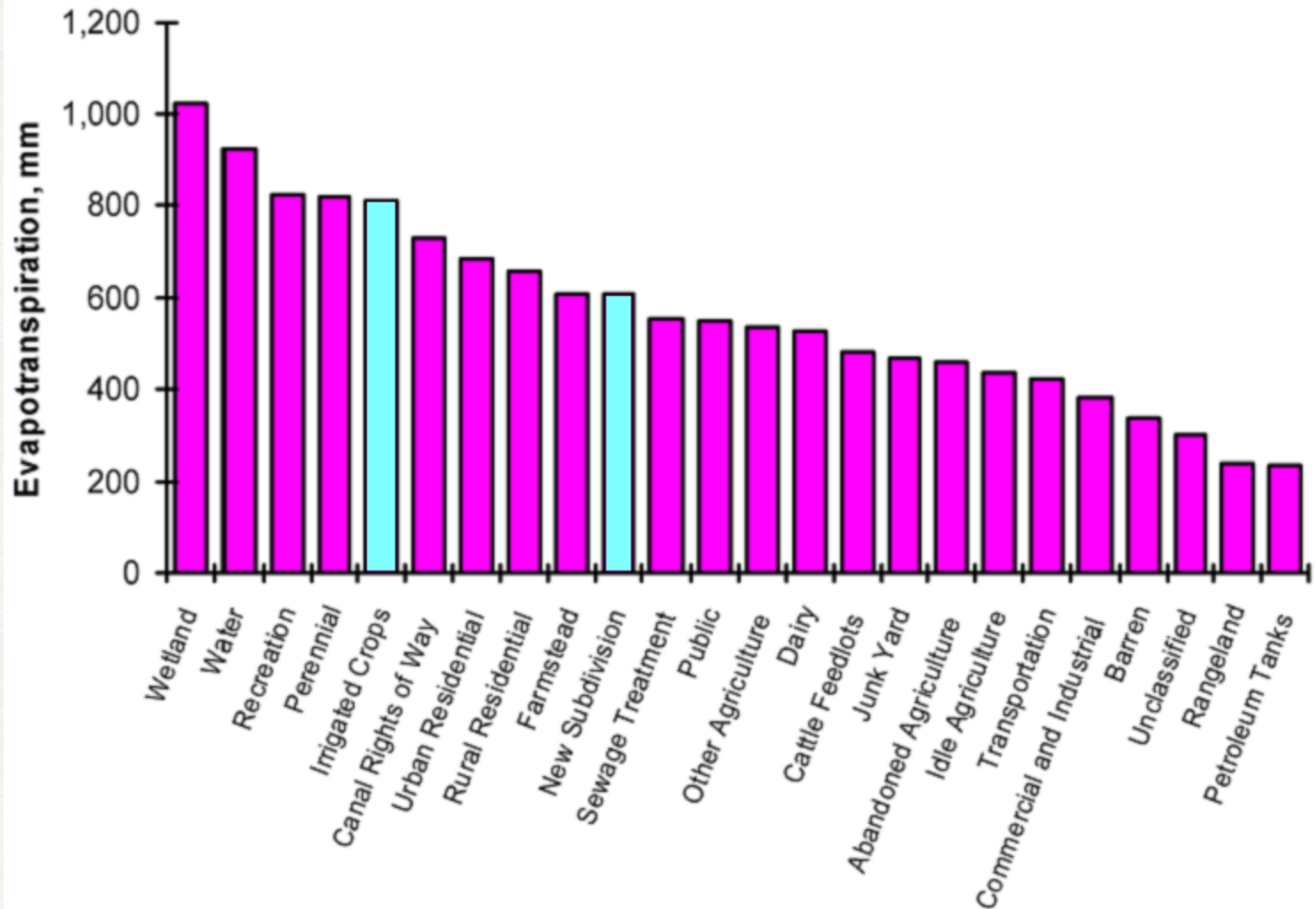
- ☐ Tv3994ird.shp
 - Irrigated 1994 and Irrigated
 - Irrigated 1994, Not Irrigated
 - Not Irrigated 1994, Irrigated
- ☐ Tv_94imagery.sid
- ☐ Tv2000.sid
- ☒ Tv_00landcov.shp
 - (12) Residential - Old Urban
 - (13) Residential - New Sub
 - (11,14) Residential - Farms
 - (15,18) Commercial/Industrial
 - (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
 - (19,81,82) Sewage Treatment
 - (99) Unclassified



Boise Valley 2000



ET by land use

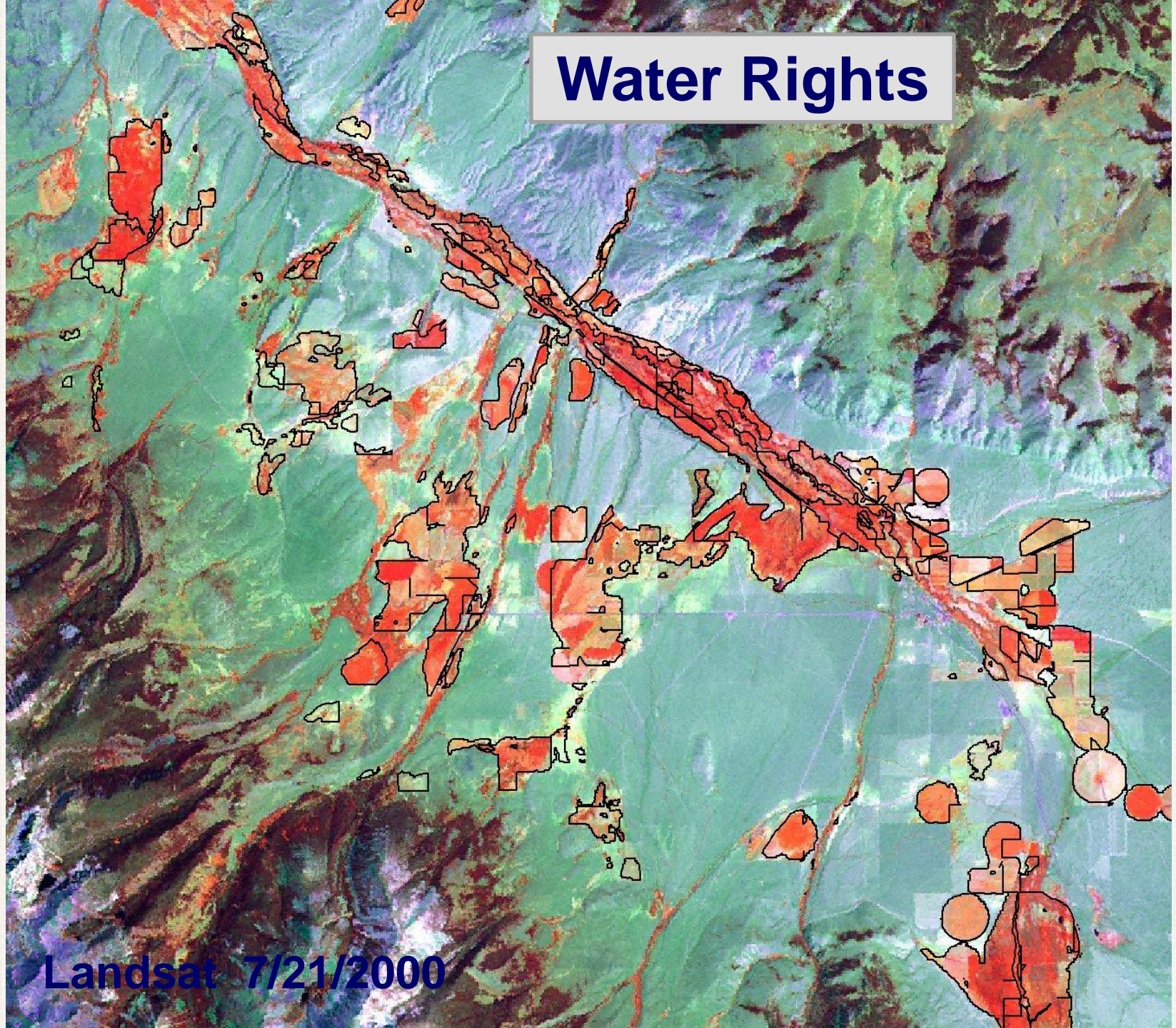


Water Planning

Endangered Species

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

Water Rights

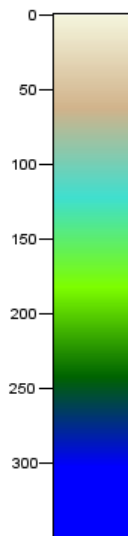


Landsat 7/21/2000

April

Evapotranspiration
(in millimeters)

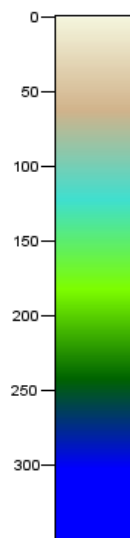
Monthly



May

Evapotranspiration
(in millimeters)

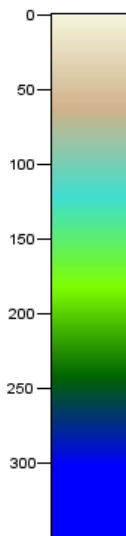
Monthly



June

Evapotranspiration
(in millimeters)

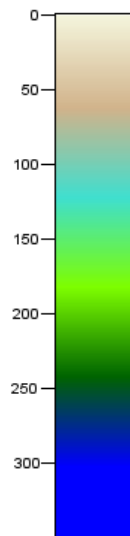
Monthly



July

Evapotranspiration
(in millimeters)

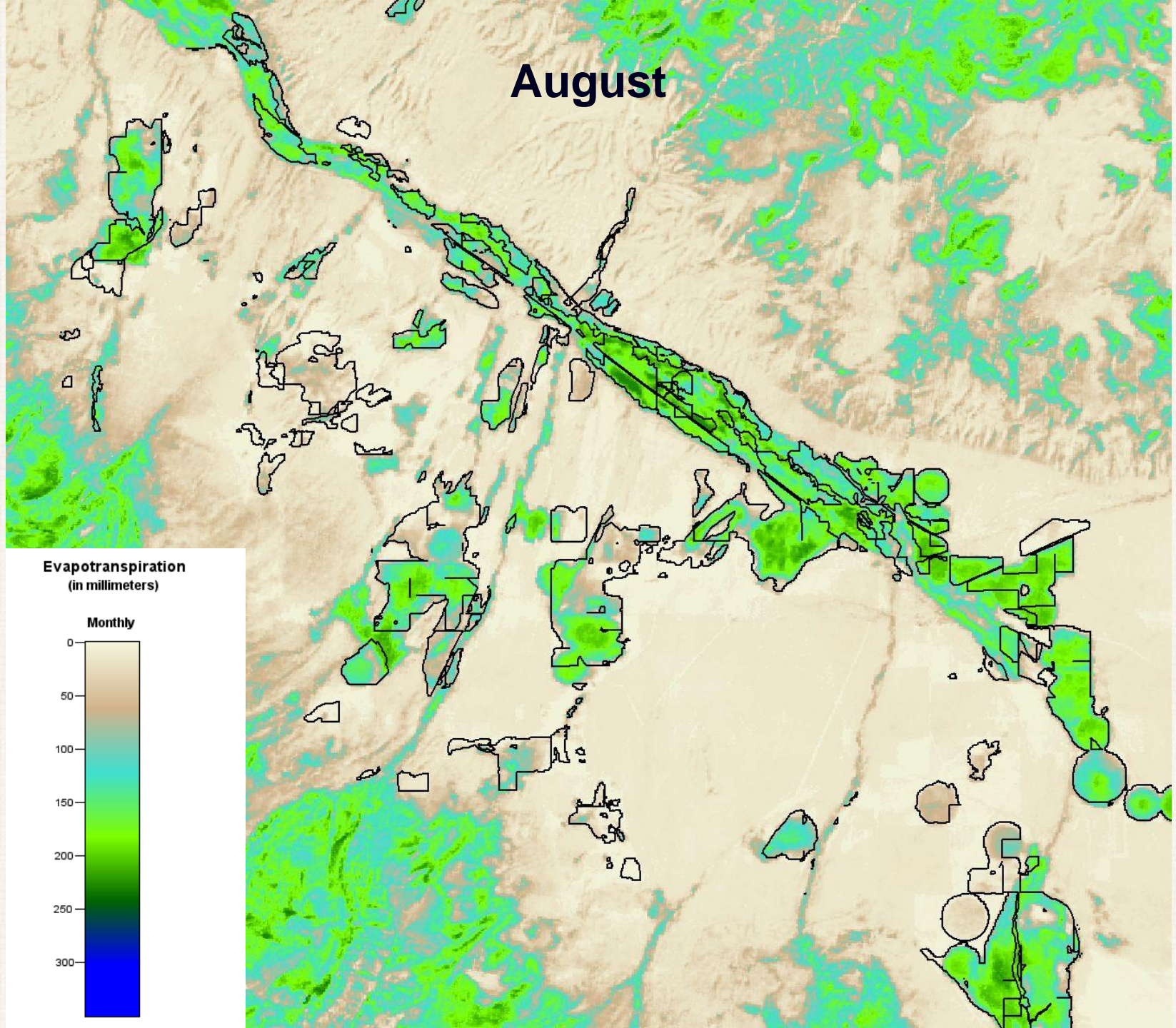
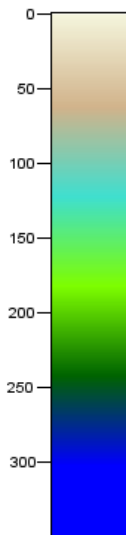
Monthly



August

Evapotranspiration
(in millimeters)

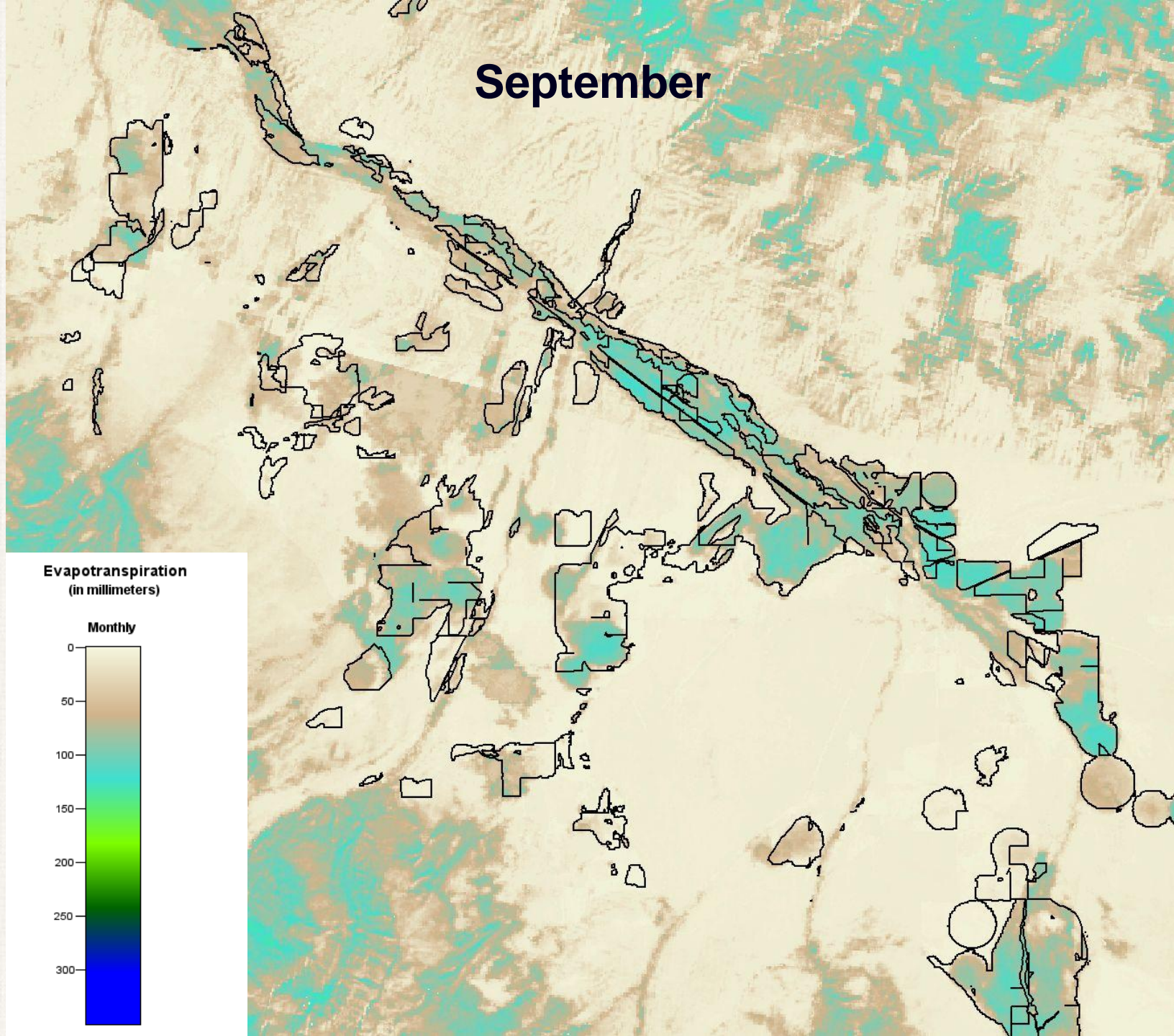
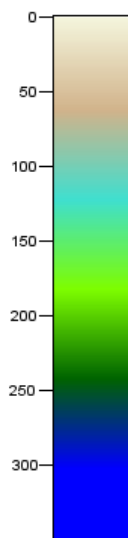
Monthly



September

Evapotranspiration
(in millimeters)

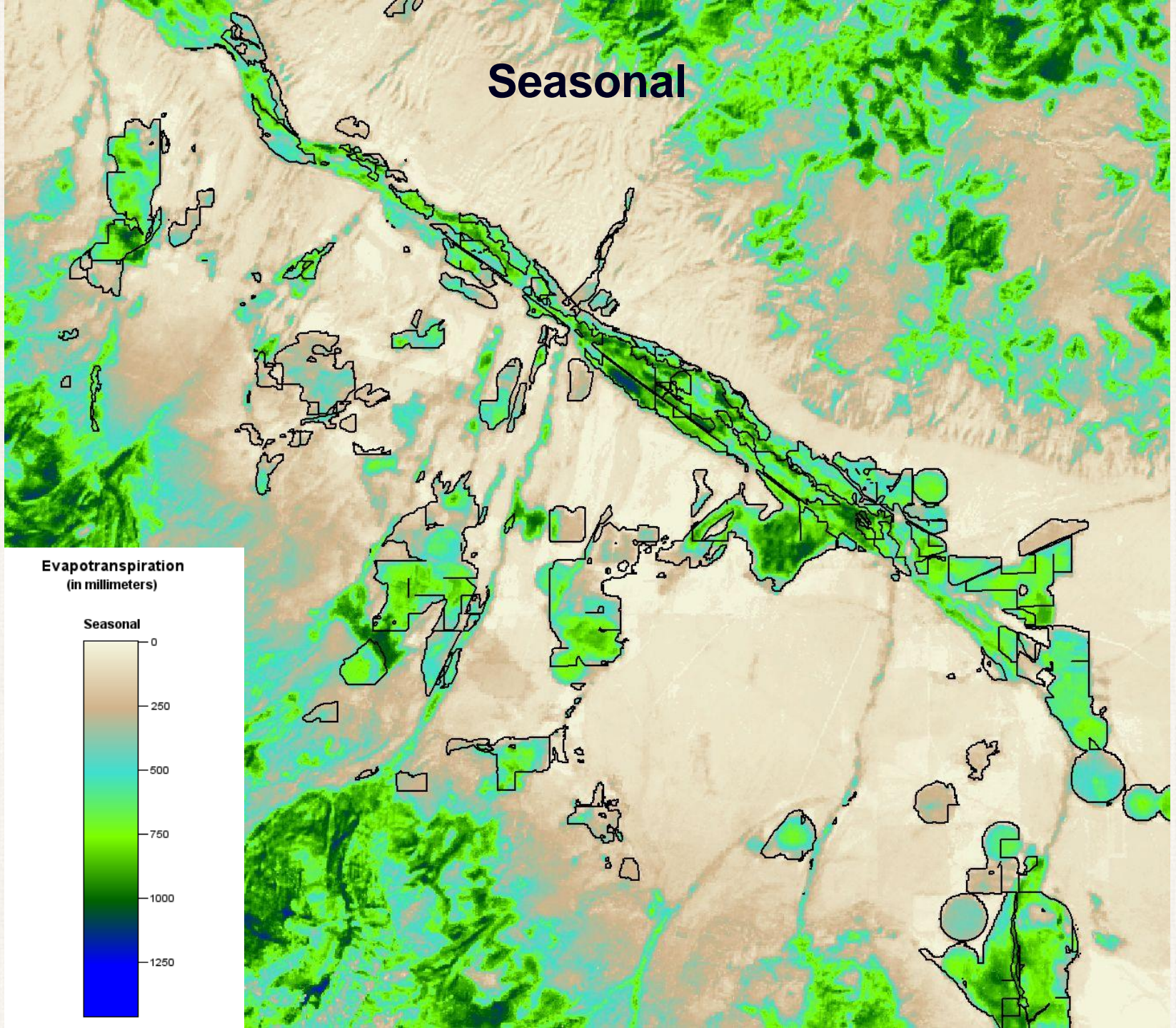
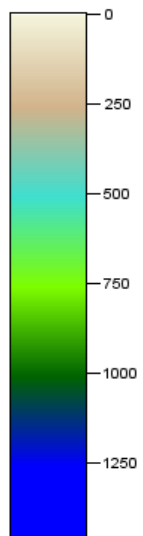
Monthly



Seasonal

Evapotranspiration
(in millimeters)

Seasonal



Water Planning

Endangered Species Summary

- 19,997 acres of irrigated land
- 33,520 acre-feet of ET for the year 2000 season
 - (11 Billion gallons)
 - (41 Billion liters)

Water Administration Litigation

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


 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

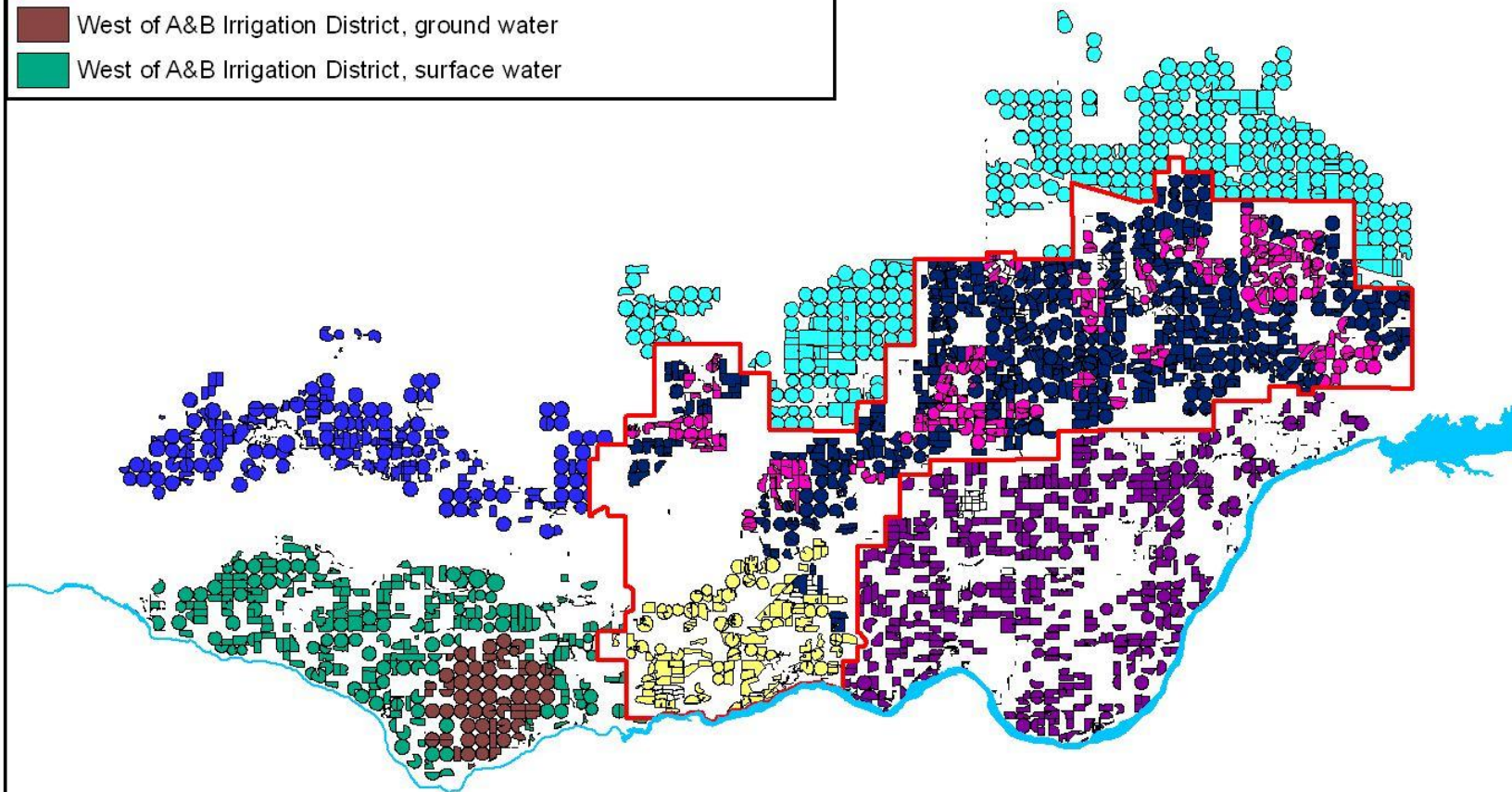
 Northwest of A&B Irrigation District, mixed surface and ground water

 South of A&B Irrigation District, surface water

 West of A&B Irrigation District, ground water

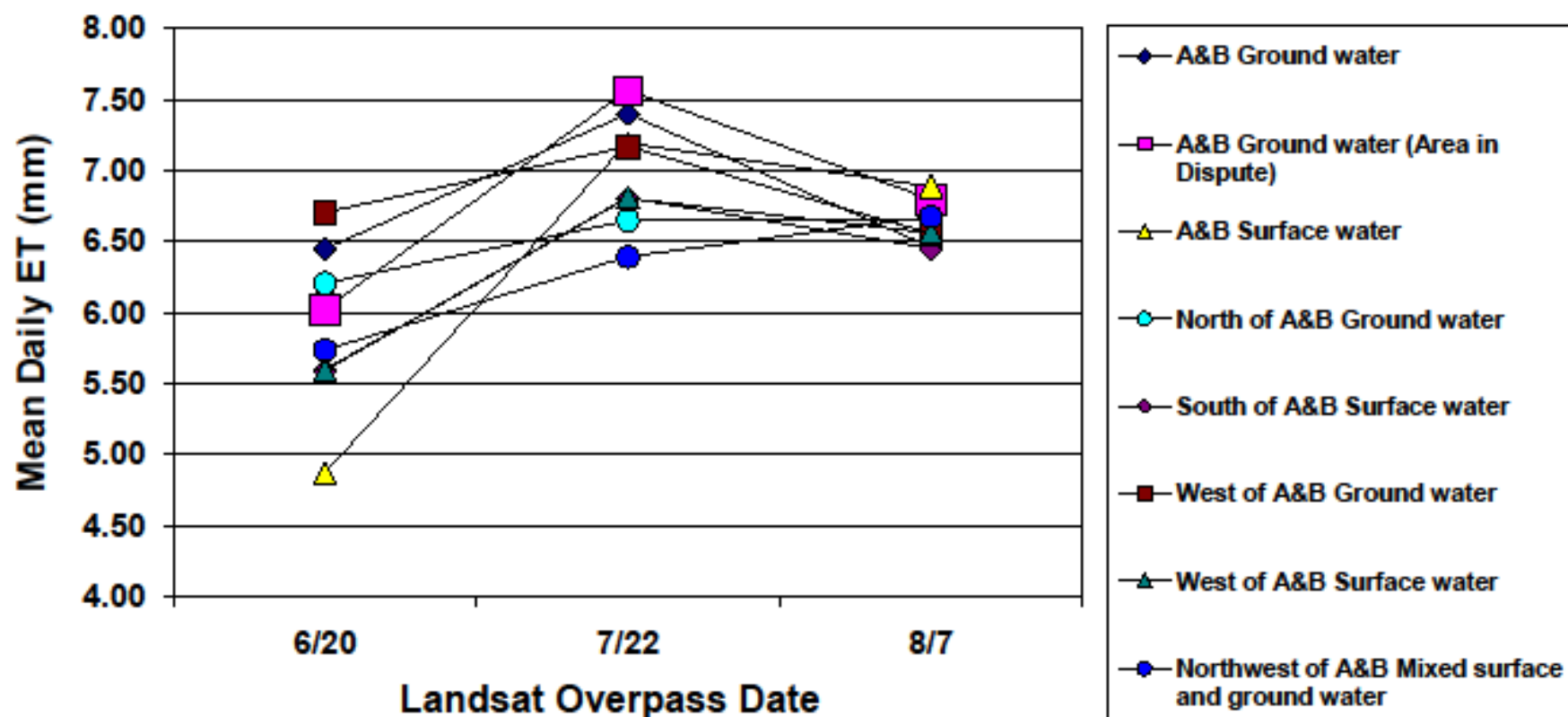
 West of A&B Irrigation District, surface water

A&B Irrigation District and adjacent land



0 5 10 20 Kilometers

Year 2006: Mean Daily Evapotranspiration (ET)



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.



Water watch begins

8/1/2009

Unprecedented well shut-off goes into effect in valley

By Nate Poppino and Jared Hopkins

WENDELL - Employees of Idaho's state water agency quietly fanned out across the Magic Valley Friday morning, to see if nearly 250 water-right holders have complied with an order to stop using some groundwater rights.

It was the first time that the Idaho Department of Water Resources actually enforced widespread well closures to provide water to another entity.

Talks fail to find well shutoff solutions

State continues curtailment enforcement

By Nate Poppino

Times-News writer

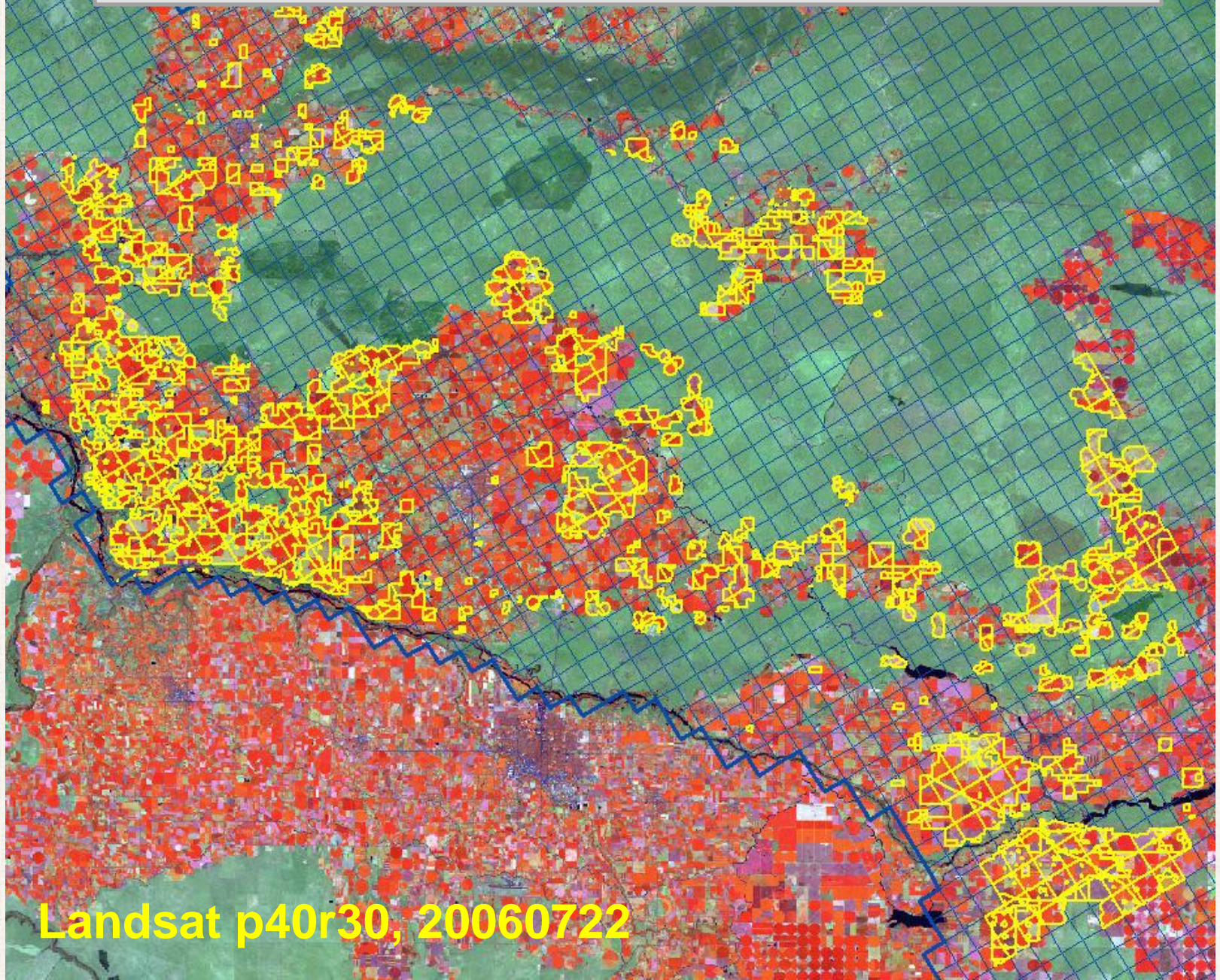
8/11/2009

Officials with two Magic Valley groundwater districts have not been able to reach an arrangement with a Buhl-area fish company, a setback in efforts to lift wide-scale well closures in the region.

Representatives of the North Snake and Magic Valley groundwater districts were attempting to reach an agreement to end curtailment of about 150 water rights affecting businesses, towns and about 4,150 acres of irrigated land. But Lynn Carlquist, chairman of the North Snake Ground Water District, said Monday afternoon that the districts will not be able to agree to requirements Clear Springs Foods listed as necessary for the company to consider a plan submitted last week acceptable.

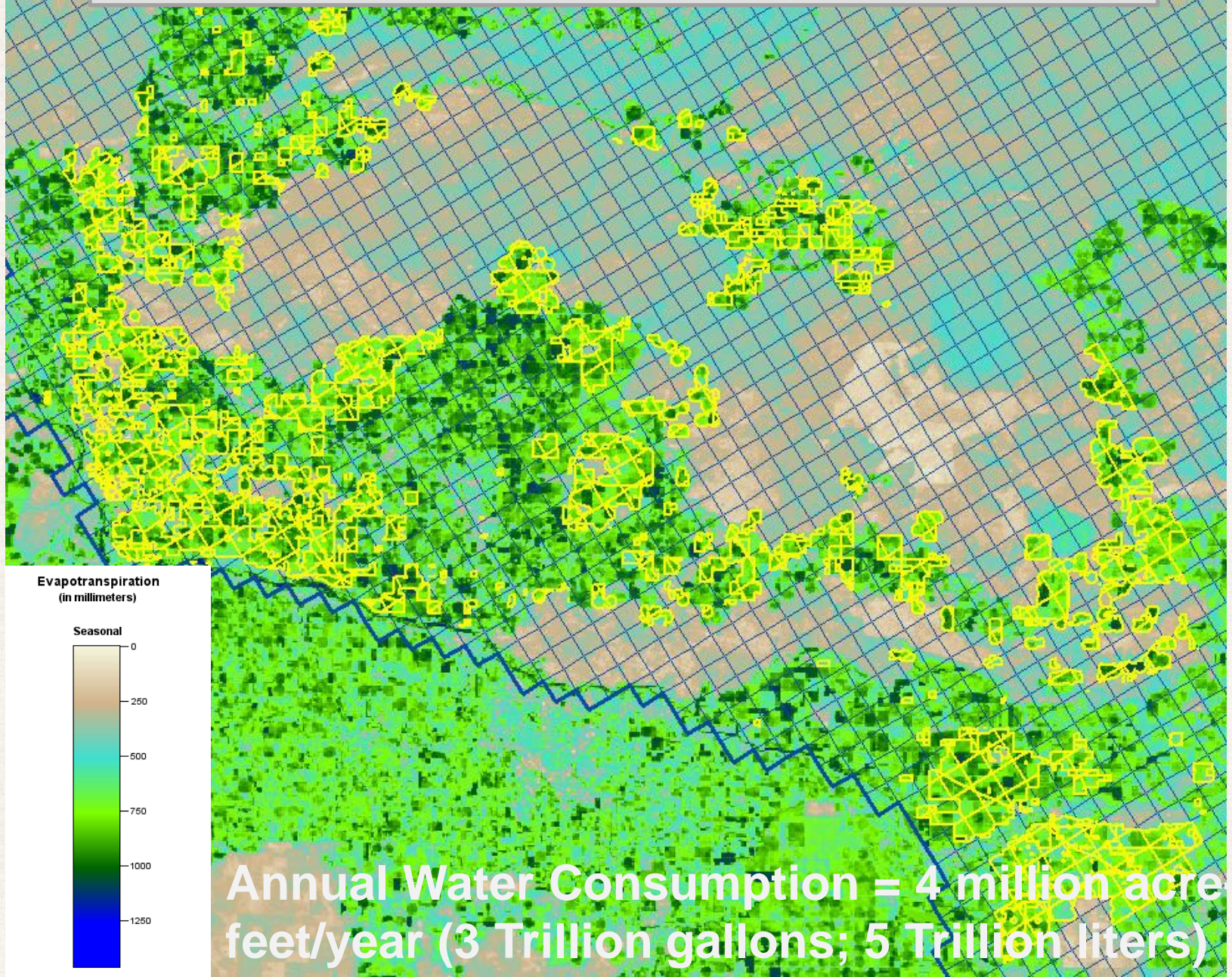
The water rights were ordered shut down on July 31 by Idaho Department of Water Resources Interim Director Gary Spackman after he concluded the districts were not following through on a portion of an agreement aimed at providing more water for the springs Clear Springs relies on. Spackman's predecessor, Dave Tuthill, ruled last year that groundwater pumpers were depriving the company of part of its water.

GW Model Cells and Water Rights

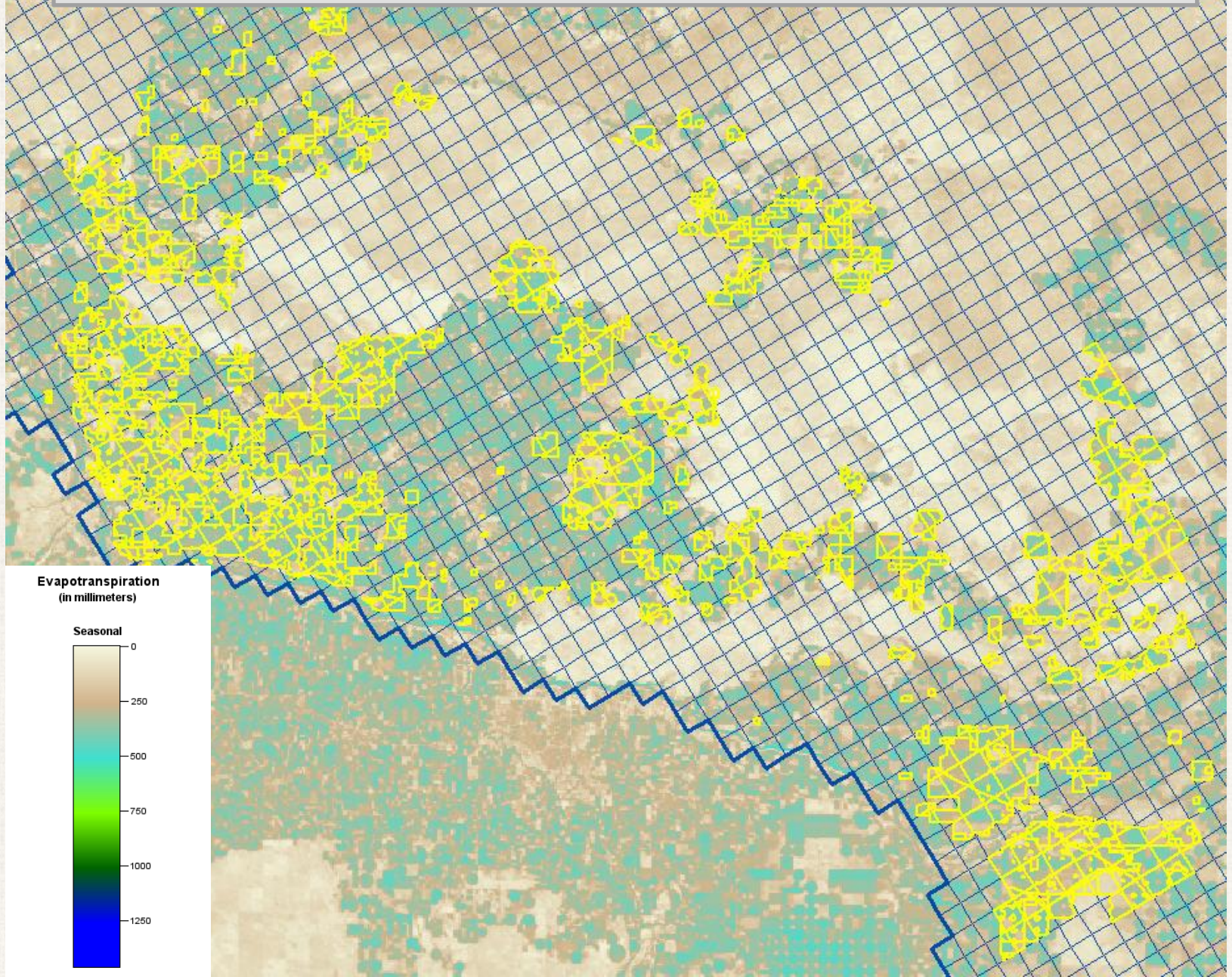


Landsat p40r30, 20060722

METRIC ET 2006 April to October



METRIC ET 2006 August to October



ESPA GW model analysis

Legend

Buhl-Thousand Spgs Trimline

April 12, 1990 priority date

% Junior

0 - 0.1

0.1 - 0.2

0.2 - 0.3

0.3 - 0.4

0.4 - 0.5

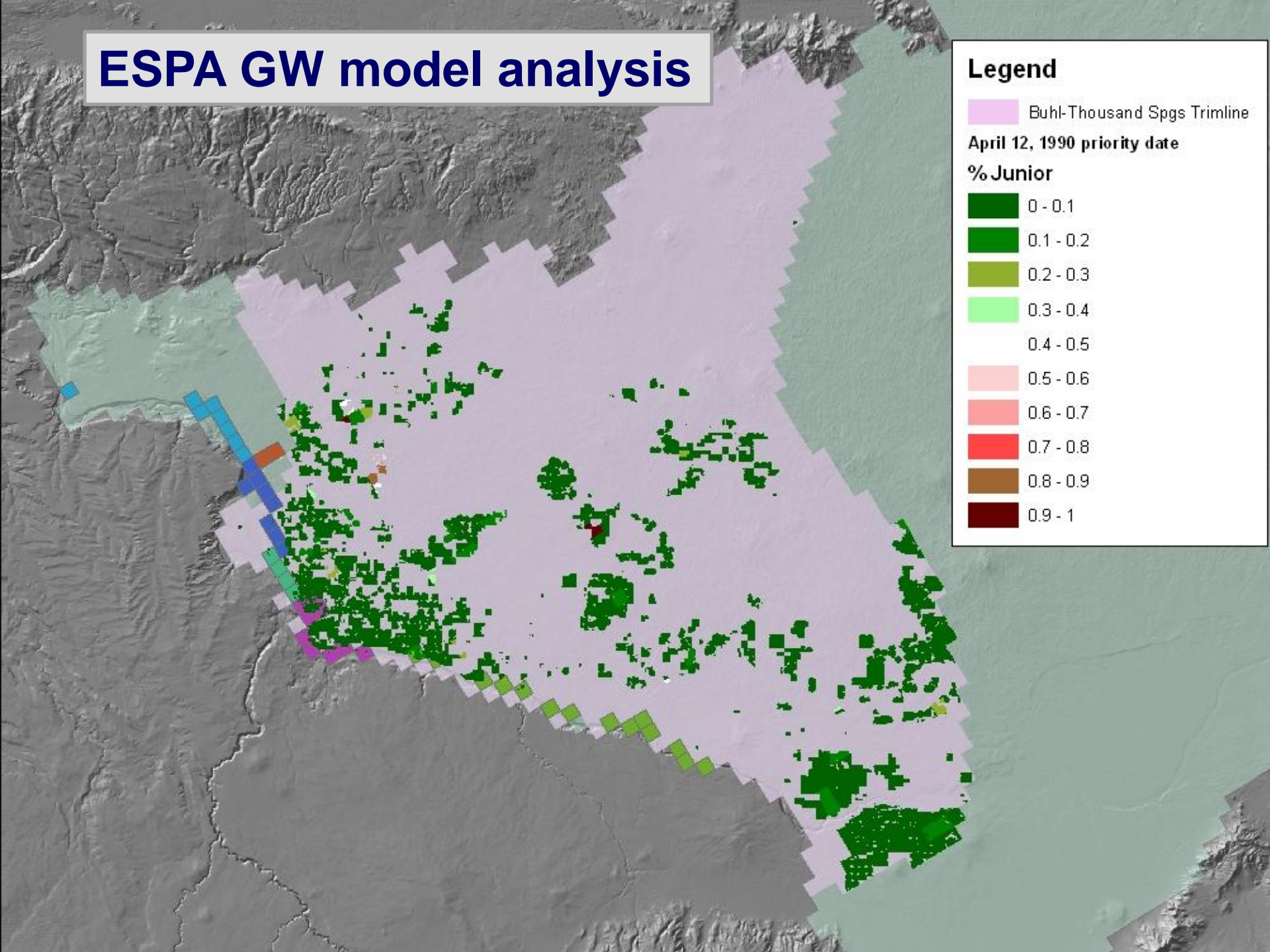
0.5 - 0.6

0.6 - 0.7

0.7 - 0.8

0.8 - 0.9

0.9 - 1



Clear Springs Foods Water Call

Summary

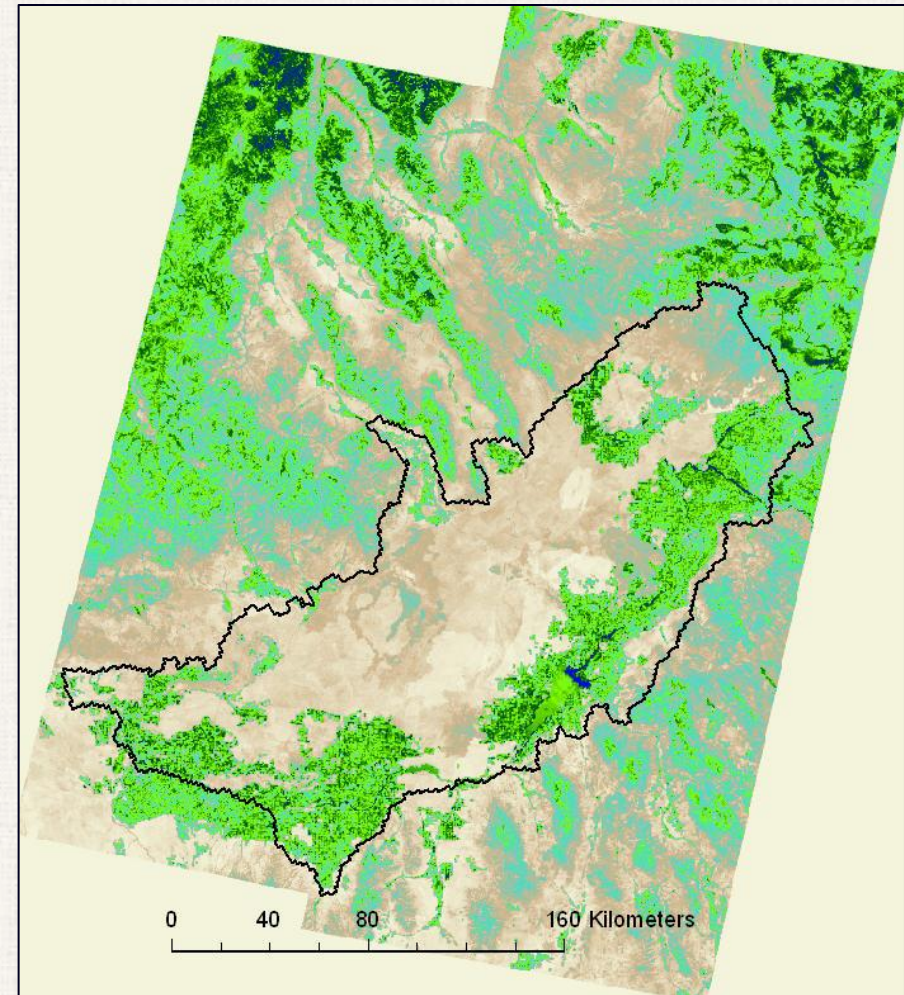
- **ESPA GW model used METRIC ET data**
 - For model calibration
 - To select water rights to curtail
- **No complaints from junior users about GW model or METRIC ET data**

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

Cost of METRIC

- About one year to develop monthly ET for 100,000 square kilometers (4 Landsat 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 IRS
- 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
- Supports 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

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

