Landsat-based ET data for water management in Idaho

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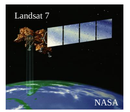

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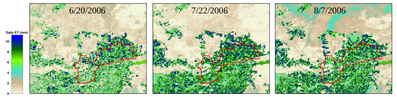
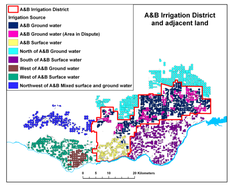
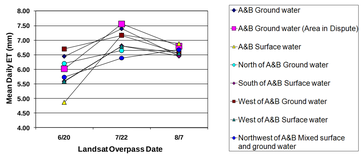
Delivery Call



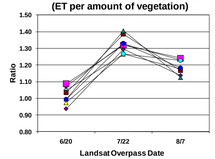
METRIC ET images for three days during summer of 2006.



Year 2006: Mean Daily Evapotranspiration (ET)



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



Idaho water law is based on the prior appropriation doctrine, "first in time is first in right". A water right is the authorization to use water and it includes a priority date. When a senior water right holder experiences a water shortage a delivery call may be placed against junior water right holders. If the state finds the senior holder has experienced a shortage, the state can respond with a curtailment order, which defines how the junior water right holders must respond so that the senior holder can get their water.

The A&B Irrigation District (A&B) filed a delivery call with the Director of IDWR demanding the curtailment of junior water users. Landsat-based ET data were used to compute and map consumptive water use for the A&B and adjacent land for three days in 2006. Analysis showed that the mean ET for the area in dispute was not lower than adjacent areas that were not claimed to be short of water. Further analysis normalized the ET data using NDVI (Normalized Difference Vegetation Index) to adjust for any differences caused by cropping pattern and the results did not vary. The ET analysis was a "legal finding of fact" in the Director's order denying the delivery call and it was referred to in a water rights hearing and subsequent appeals to the District Court and the Idaho Supreme Court where the Director's decision was upheld.

Curtailment Order

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.

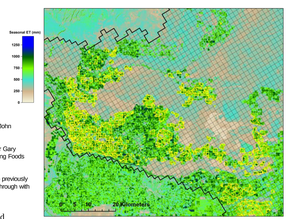
Ground water outflows at Thousand Springs supply water to fish farms that produce 70% of the trout raised in the US. Clear Springs Foods, Inc., is the largest fish farm in the area.

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.

Curtailment on hold for now 8/24/2009
By Nate Poppino
Staff writer
The well closures currently imposed on about 150 water rights in the Magic Valley were lifted today, when 5th District Judge John Melanson conditionally granted a stay sought by two area groundwater districts.

The closures, known as "curtailment," were put in place last month by Idaho Department of Water Resources Interim Director Gary Spackman when he concluded the districts had not followed through with part of an agreement to provide water to Clear Spring Foods in Buhl.

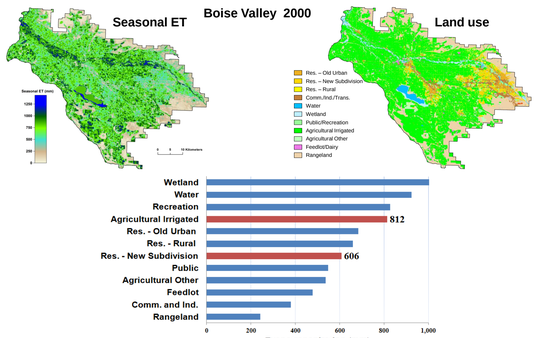
Attorneys for the various parties shared their thoughts on the proposed stay at a hearing Friday in Twin Falls. Melanson, who previously denied a temporary stay of the closures, wrote in today's decision that he would grant the stay as long as the districts follow through with proposed late-season recharge.



Seasonal 2006 METRIC ET with ESPA Model cells. Junior water rights affected by the curtailment order are highlighted in yellow.

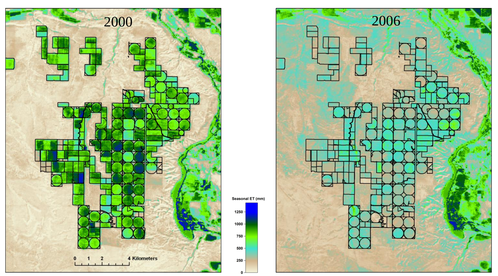
IDWR used METRIC ET data to calibrate the Eastern Snake Plain ground water model and to select the junior water rights to curtail. The initial curtailment order impacted 9,000 acres of land irrigated by ground water. On March 24, 2011, the Idaho Supreme Court ruled in favor of senior water right holder Clear Springs Foods, Inc.

ET by Land Use



Water resources planners needed ET by land use to forecast future water demand in the Boise Valley where new subdivisions were being built on agricultural land. Landsat ET data and land use data developed from aerial photographs were analyzed to develop ET by land use.

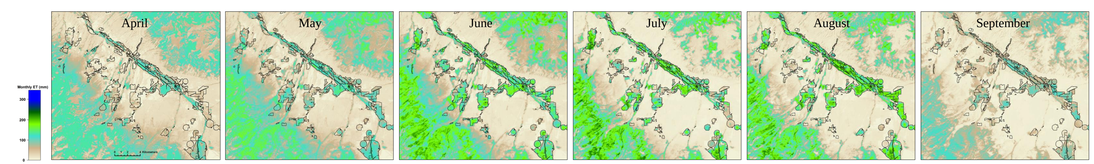
Water Rights Purchase



The Bell Rapids Irrigation Project irrigated 25,000 acres of cropland using high-lift pumps to lift water 200 meters from the Snake River. The state purchased the water rights in 2005 for $24.3 million. The Bureau of Reclamation leases the water from the state to increase flows for salmon recovery.

METRIC ET images for the irrigation seasons of 2000 and 2006 show the large change in consumptive water use (ET) before and after the water rights buyout in 2005.

Endangered Species



Monthly sequence of ET images for the Lemhi Valley within the Upper Salmon River basin in 2000.

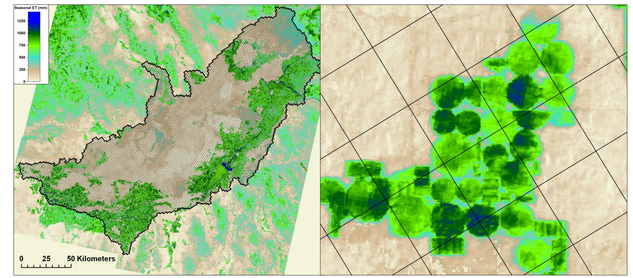
There are times of the year when stream flow is low in some basins and there is not enough water to meet the needs of irrigation and fish. This is especially true during drought years, and in some areas irrigation can divert all the flow in a stream (photo at left).

The State of Idaho developed a conservation plan for the Upper Salmon River Basin that put in place measures that increase stream flow for endangered fish. Data about the consumptive use (ET) of irrigated land was needed for this process. Monthly METRIC ET data were developed for the year 2000. The data showed that irrigation consumed 33,520 acre-feet (11 billion gallons) of water.

The ET data were also used to assess the consumptive use of water rights that may be leased under the Columbia Basin Water Transactions Program to improve stream flows. IDWR identified stream reaches that would benefit from flow enhancement and worked with willing irrigators through leases, agreements not to divert, and other transaction methods. The ET data allowed negotiations with irrigators to be based on the consumptive use of the water rights (table at right) instead of the maximum diversion allowed for the water rights.

Water Right	Acres	Mean ET (mm)	ET acre-feet
74-1008	81	297	81
74-1016	41	506	68
74-1030	24	332	26
74-1036	51	350	59
74-1058	51	629	105
74-1061	14	736	34
74-1083	22	490	36
74-1103	53	599	104
74-1106	198	343	223
74-1114	42	422	59
74-1140	27	960	85

Hydrologic Modeling



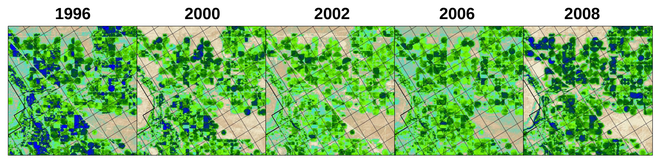
Seasonal 2000 METRIC ET with the ESPA model cells (close up on the right). Each model grid cell is one square mile.

Cell ID	Source	Acres	Mean ET (mm) 2000	2002	2006
SP022011	Surface water	105	574	601	782
SP022013	Surface water	59	593	568	752
SP022111	Mixed	122	741	632	791
SP022112	Mixed	388	727	736	704
SP022113	Mixed	350	619	715	739
SP022114	Mixed	73	646	814	738
SP022163	Mixed	369	785	749	867
SP022164	Ground water	12	755	765	840
SP022165	Ground water	227	942	757	782
SP022170	Mixed	81	529	671	879
SP022171	Surface water	69	508	700	714
SP022172	Surface water	45	560	657	771
SP022196	Surface water	320	460	512	567
SP022197	Mixed	51	309	538	465
SP022197	Surface water	505	413	548	581

Hydrologists used monthly and seasonal METRIC ET to calibrate MODFLOW ground water models of the Eastern Snake Plain Aquifer (ESPA) and the Boise Valley aquifer. This improves the accuracy of estimated distribution and quantities of depletions from the aquifers caused by pumping, as well as improving estimates of incidental recharge to the aquifers stemming from irrigation diversions. These more accurately calibrated ground water models are being used in litigation involving conjunctive use of ground water and surface water resources.

For the ESPA model, METRIC ET data has been processed for years: 1996, 2000, 2002, 2006, and 2008. Monthly and seasonal METRIC ET data are being developed for all years having sufficient cloud-free imagery from the mid 1980s to the present. This will allow analysis of long term trends in ET over the ESPA and the resulting impact on the aquifer.

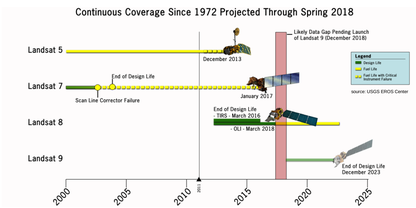
The table shows trends in ET from irrigated land for years 2000, 2002, and 2006 by model cell and source. The sources are surface water, ground water, and mixed (both surface water and ground water).



Trends in ET on the ESPA from 1996 to 2008.

Developing ET Data
The U of I developed METRIC (Mapping EvapoTranspiration at high Resolution with Internalized Calibration) to compute and map ET. METRIC is a satellite-based energy balance model for computing ET as a residual of the energy balance at the earth's surface using the equation ET = Rn - G - H, where Rn is net radiation, G is sensible heat flux conducted into the ground, and H is sensible heat flux convected into the air.

Landsat
IDWR uses Landsat because it is the only operational satellite with a thermal sensor that can map ET at the field level. Landsat has 16-day repetitive coverage and a large archive of images that are free. The Landsat Data Continuity Mission (Landsat 8) will launch in February of 2013 with the Operational Land Imager (OLI) and the Thermal InfraRed Sensor (TIRS). The LDCM is a joint NASA and USGS mission. Funding for Landsat 9 is uncertain.



ET Websites
IDWR. Mapping Evapotranspiration, http://www.idwr.idaho.gov/GeographicInfo/METRIC/et.htm
U of I. Generation of Evapotranspiration Maps using Landsat Satellite Images, http://www.kimberly.uidaho.edu/water/metric/index.html