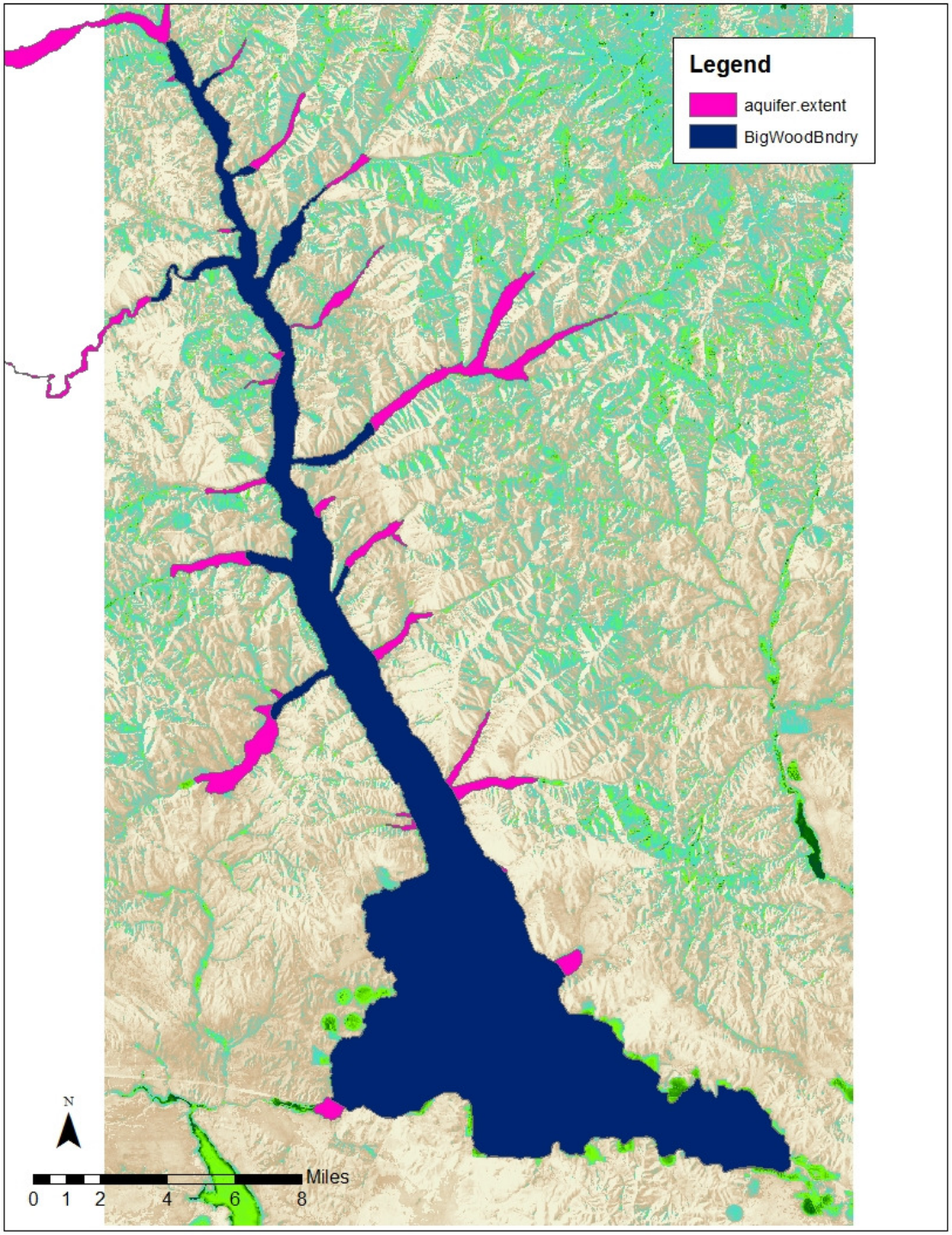
DRAFT Wood River Groundwater Model Development: Update on Evapotranspiration, Precipitation and Recharge

Presented by Mike McVay, P.E., P.G.
Wood River MTAC April 3, 2014

The volumes presented are calculated using the blue “BigWoodBndry” area. This area is slightly smaller than the active model area, but the difference is negligible.



General Techniques for ET Estimation

Two general techniques have been used to estimate ET:

1. Remote Sensing – Data collected by satellites is used in conjunction with weather-station data to estimate Growing-Season ET based on energy balance principles.

2. Traditional Calculation – Land-use data is used in conjunction with weather-station data to estimate Winter-Season ET using the ASCE standardized Penman-Monteith regression equation.

Winter ET Estimation

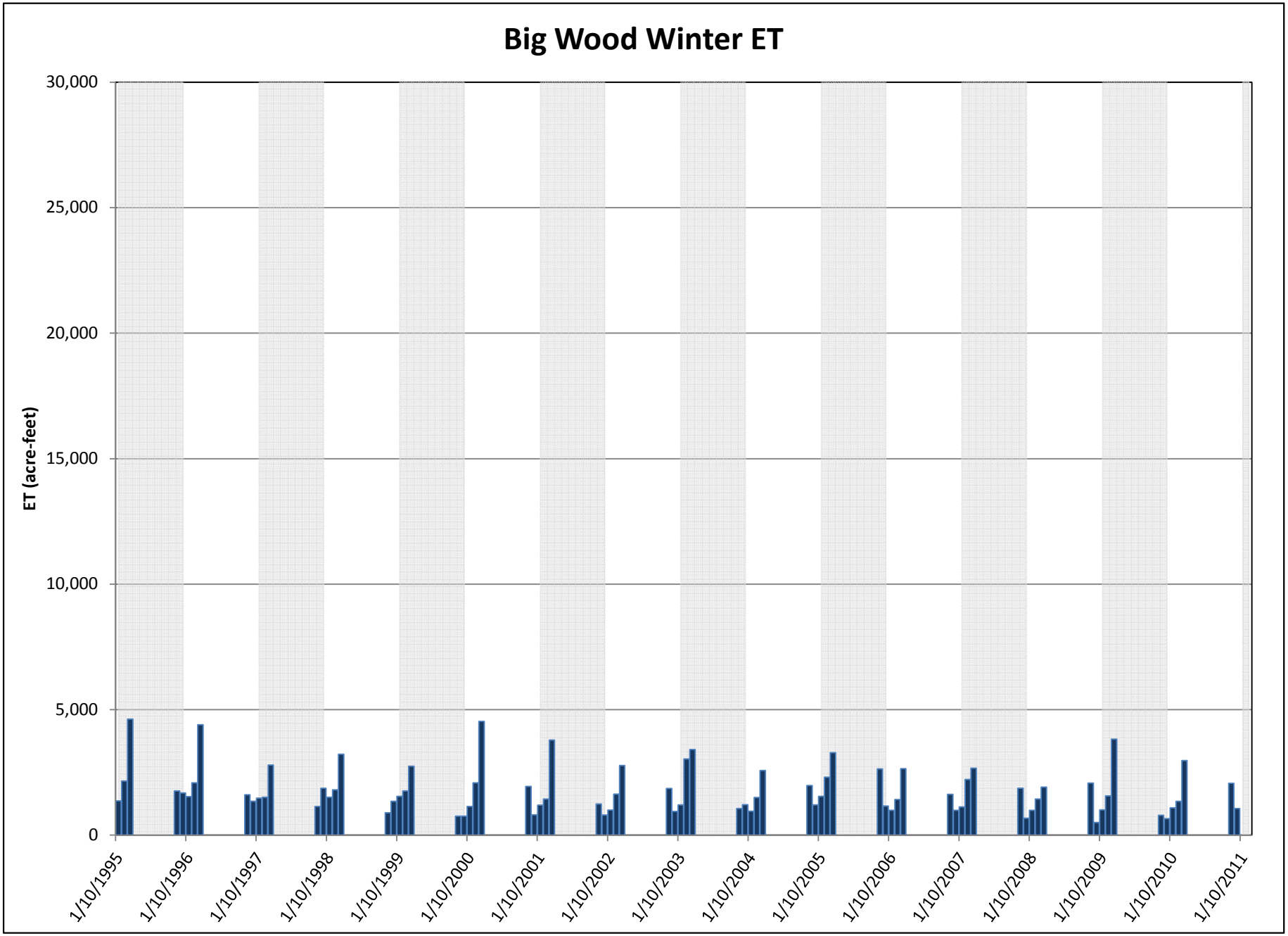
Winter ET estimates are calculated using the ASCE standardized Penman-Monteith regression equation (tabulated in ETIdaho). The issues that make this method less appealing for growing-season months are not applicable to Winter ET.

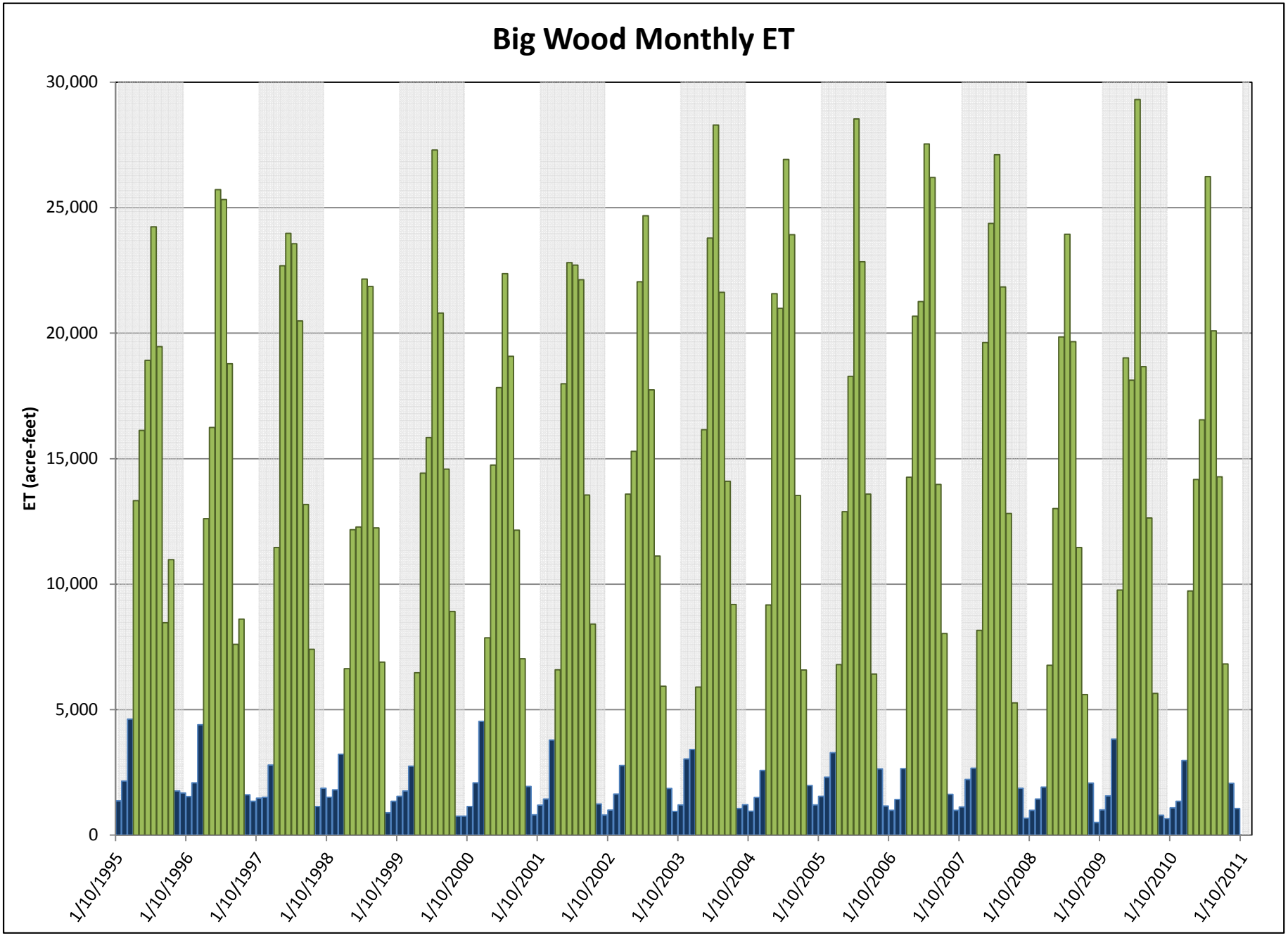
1. Winter ET a function of cover, not crop.
2. Irrigation practices and vegetative health irrelevant for winter ET.

Year	1995	1996	1997	1998	1999	2000	2001	2002
Land Cover	2001 nlcd	2001 nlcd	2001 nlcd	2001 nlcd	2001 nlcd	2001 nlcd	2001 nlcd	2001 nlcd

Year	2003	2004	2005	2006	2007	2008	2009	2010
Land Cover	2005 cdl	2005 cdl	2005 cdl	2006 nlcd	2007 cdl	2008 cdl	2009 cdl	2010 cdl

nlcd – National Land Cover Database, Multi-Resolution Land Consortium
cdl – Cropland Data Layer, National Agricultural Statistics Service

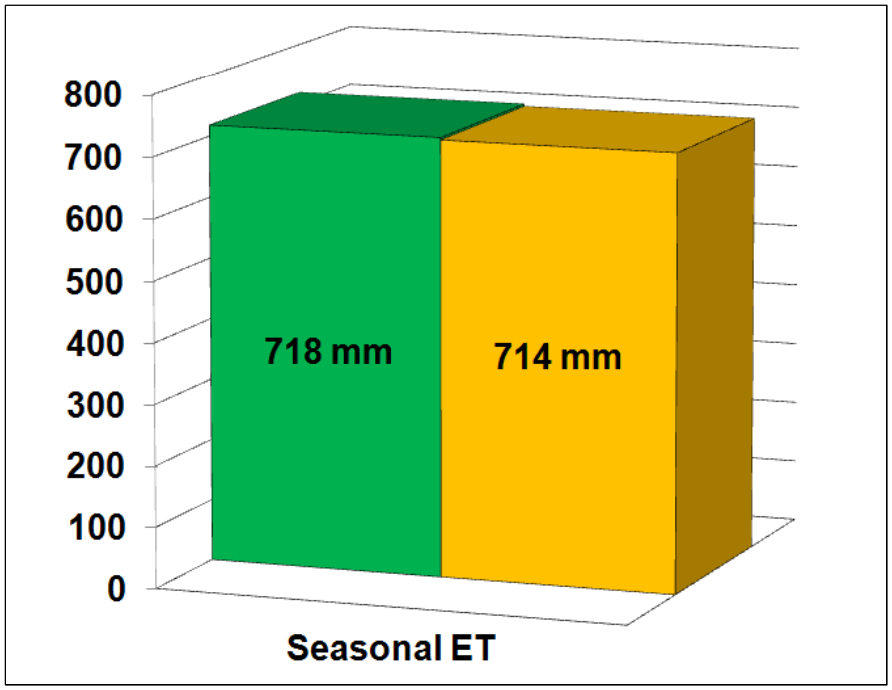

Big Wood Winter ET
ET (acre-feet)
30,000
25,000
20,000
15,000
10,000
5,000
0
1/10/1995
1/10/1996
1/10/1997
1/10/1998
1/10/1999
1/10/2000
1/10/2001
1/10/2002
1/10/2003
1/10/2004
1/10/2005
1/10/2006
1/10/2007
1/10/2008
1/10/2009
1/10/2010
1/10/2011


Big Wood Monthly ET
ET (acre-feet)
30,000
25,000
20,000
15,000
10,000
5,000
0
1/10/1995
1/10/1996
1/10/1997
1/10/1998
1/10/1999
1/10/2000
1/10/2001
1/10/2002
1/10/2003
1/10/2004
1/10/2005
1/10/2006
1/10/2007
1/10/2008
1/10/2009
1/10/2010
1/10/2011

Growing-Season ET Estimation

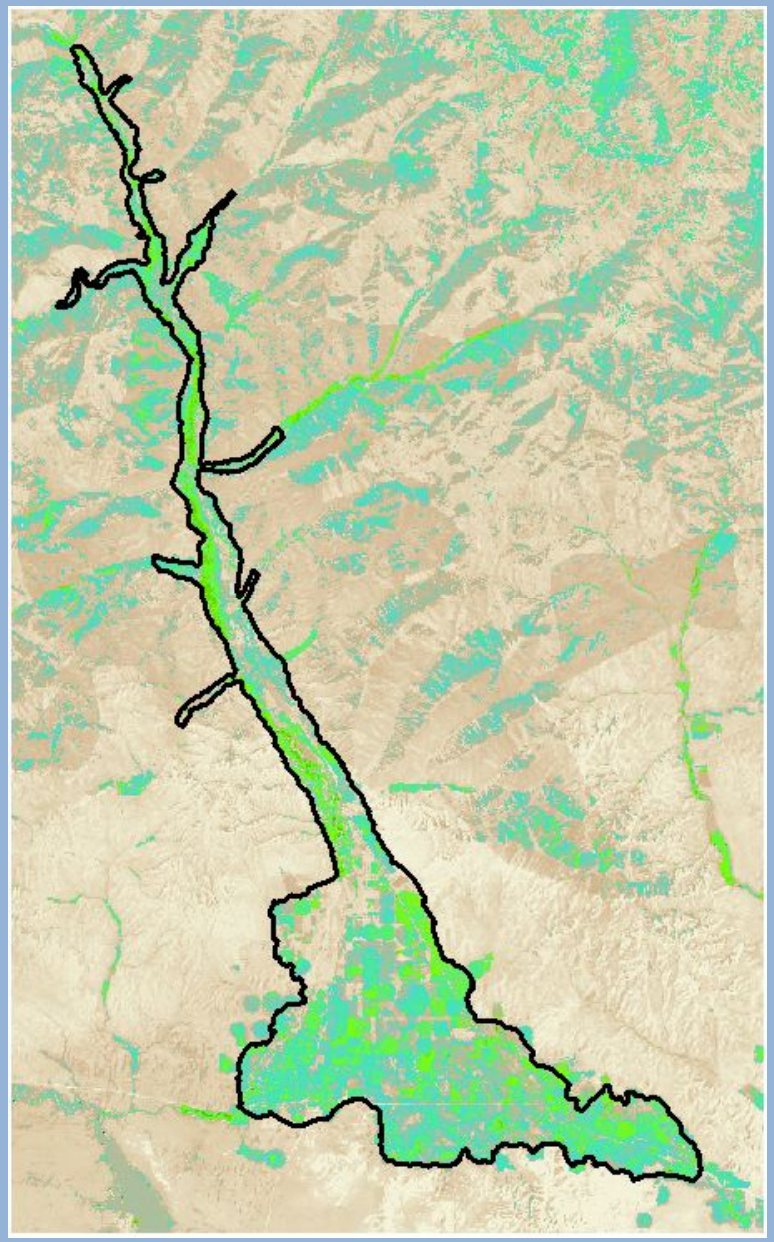
Growing-season ET estimates are based on remotely-sensed data.

METRIC is our best estimate of ET, and all growing-season ET estimates are related to METRIC.



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

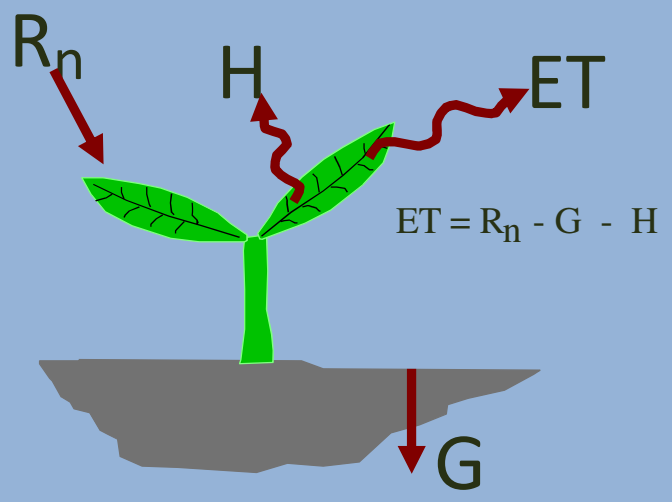
METRIC_ET Estimation



METRIC ET is derived from remote sensing (satellite) data.

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



$$ET = R_n - G - H$$

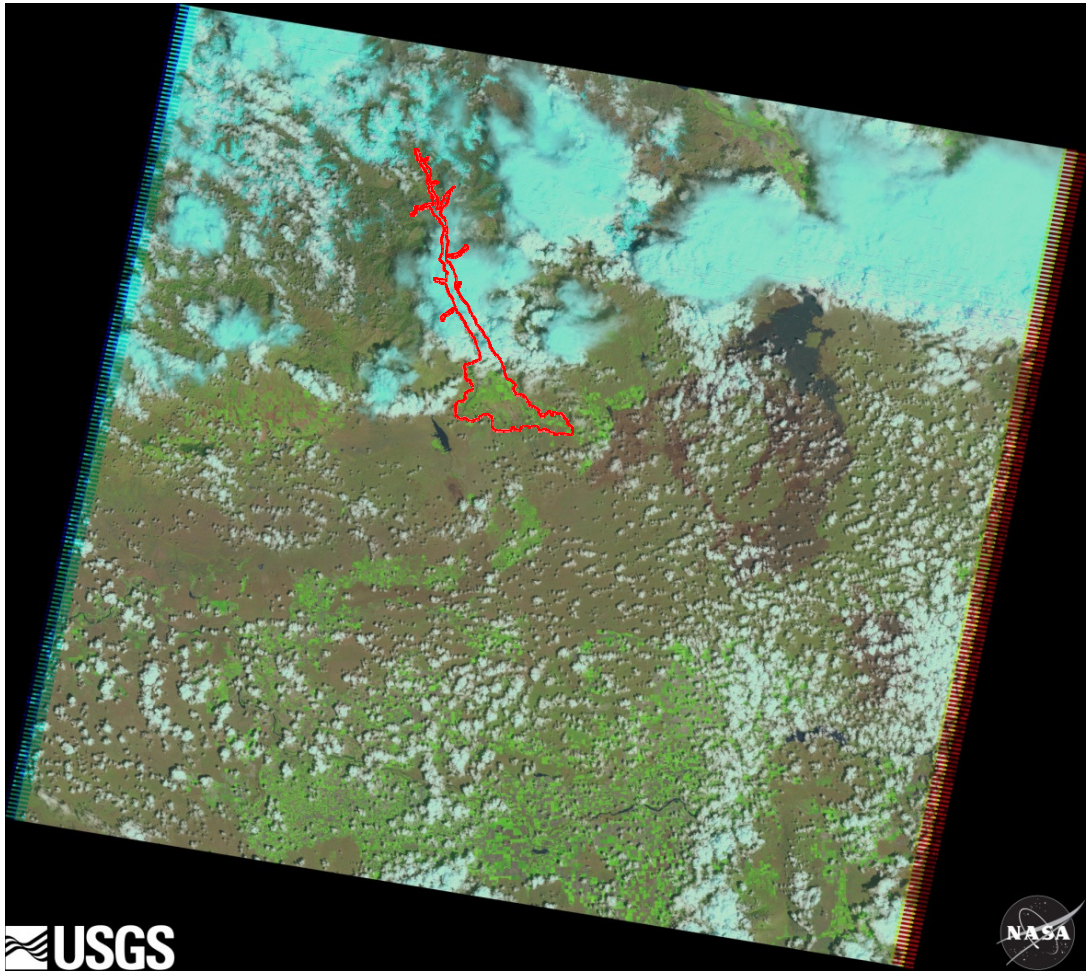
08/2009

Month	ET Estimation Method	Month	ET Estimation Method	Month	ET Estimation Method	Month	ET Estimation Method
Apr-95		Apr-99		Apr-03		Apr-07	
May-95		May-99		May-03		May-07	
Jun-95		Jun-99		Jun-03		Jun-07	
Jul-95		Jul-99		Jul-03		Jul-07	
Aug-95		Aug-99		Aug-03		Aug-07	
Sep-95		Sep-99		Sep-03		Sep-07	
Oct-95		Oct-99		Oct-03		Oct-07	
Apr-96	METRIC	Apr-00	METRIC	Apr-04		Apr-08	METRIC
May-96	METRIC	May-00	METRIC	May-04		May-08	METRIC
Jun-96	METRIC	Jun-00	METRIC	Jun-04		Jun-08	METRIC
Jul-96	METRIC	Jul-00	METRIC	Jul-04		Jul-08	METRIC
Aug-96	METRIC	Aug-00	METRIC	Aug-04		Aug-08	METRIC
Sep-96	METRIC	Sep-00	METRIC	Sep-04		Sep-08	METRIC
Oct-96	METRIC	Oct-00	METRIC	Oct-04		Oct-08	METRIC
Apr-97		Apr-01		Apr-05		Apr-09	METRIC
May-97		May-01		May-05		May-09	METRIC
Jun-97		Jun-01		Jun-05		Jun-09	METRIC
Jul-97		Jul-01		Jul-05		Jul-09	METRIC
Aug-97		Aug-01		Aug-05		Aug-09	METRIC
Sep-97		Sep-01		Sep-05		Sep-09	METRIC
Oct-97		Oct-01		Oct-05		Oct-09	
Apr-98		Apr-02		Apr-06	METRIC	Apr-10	
May-98		May-02		May-06	METRIC	May-10	
Jun-98		Jun-02		Jun-06	METRIC	Jun-10	
Jul-98		Jul-02		Jul-06	METRIC	Jul-10	
Aug-98		Aug-02		Aug-06	METRIC	Aug-10	
Sep-98		Sep-02		Sep-06	METRIC	Sep-10	
Oct-98		Oct-02		Oct-06	METRIC	Oct-10	

METRIC is our best estimate of ET; however, it is not available for all months. Time and expense preclude METRIC_ET for some of the months, while clouds and smoke prevent the possibility of METRIC_ET for other months.

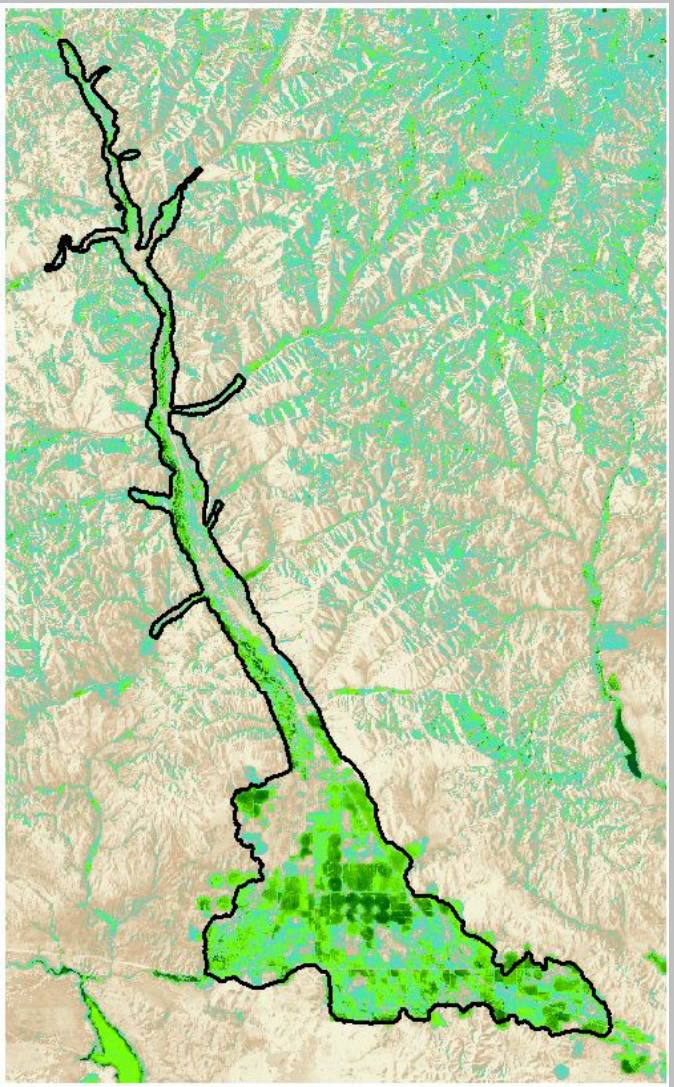
METRIC Limitation

Cloudy images can complicate or even prevent the use of METRIC.



Images with only partial cloud coverage can still be used.

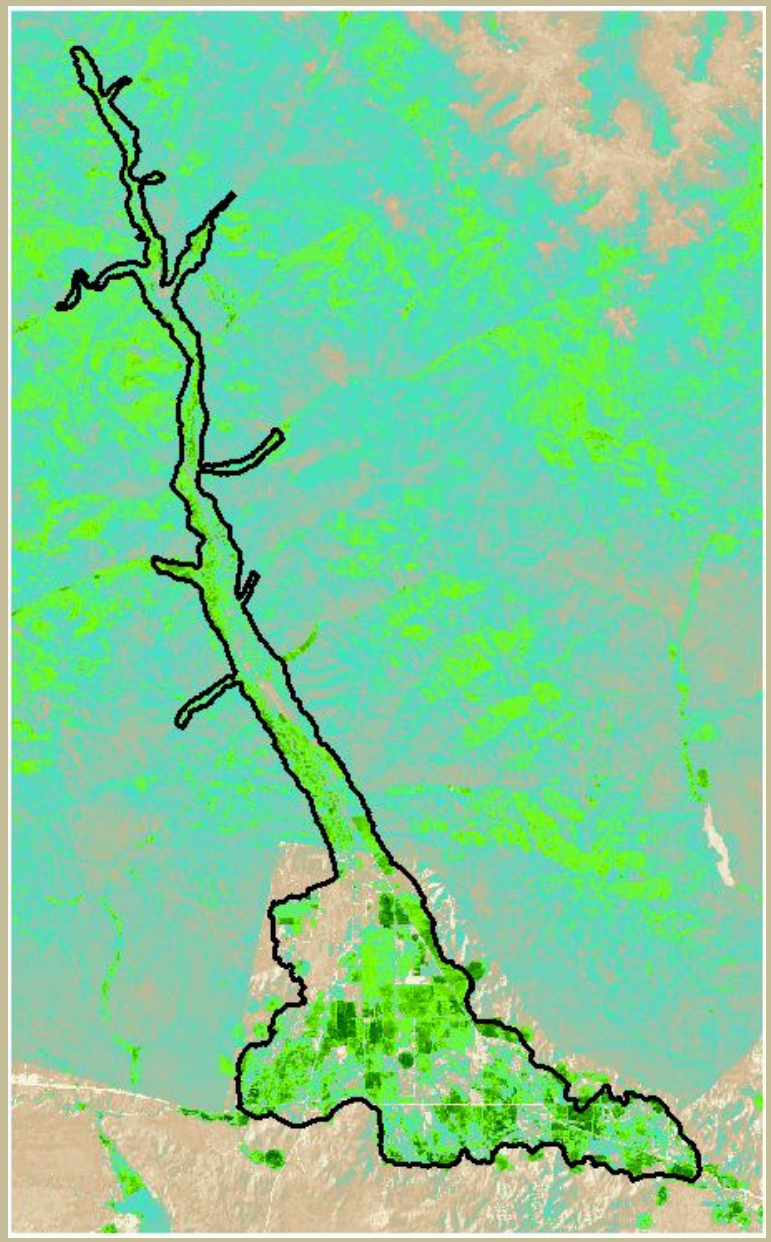
Requires the use of a cloud-mask.



Cloud-free METRIC 07/2008.

Cloud-masked METRIC 04/1996.
April accounts for 10% of 1996 ET.
Masked area (northern portion) accounts for 2% of 1996 ET.

ET Estimation: Growing Season 2002



07/2002

METRIC_ET is available for May – Oct, but only for the Bellevue triangle area. Use a correlation between METRIC and NDVI to estimate northern area ET.

1. Calculate NDVI_ET for the entire model area.
2. Compare NDVI_ET and METRIC_ET in Bellevue triangle.
3. Adjust NDVI_ET to match METRIC_ET in triangle.
4. Use adjusted NDVI_ET in northern area and METRIC_ET in triangle.

Month	ET Estimation Method	Month	ET Estimation Method	Month	ET Estimation Method	Month	ET Estimation Method
Apr-95		Apr-99		Apr-03		Apr-07	
May-95		May-99		May-03		May-07	
Jun-95		Jun-99		Jun-03		Jun-07	
Jul-95		Jul-99		Jul-03		Jul-07	
Aug-95		Aug-99		Aug-03		Aug-07	
Sep-95		Sep-99		Sep-03		Sep-07	
Oct-95		Oct-99		Oct-03		Oct-07	
Apr-96	METRIC	Apr-00	METRIC	Apr-04		Apr-08	METRIC
May-96	METRIC	May-00	METRIC	May-04		May-08	METRIC
Jun-96	METRIC	Jun-00	METRIC	Jun-04		Jun-08	METRIC
Jul-96	METRIC	Jul-00	METRIC	Jul-04		Jul-08	METRIC
Aug-96	METRIC	Aug-00	METRIC	Aug-04		Aug-08	METRIC
Sep-96	METRIC	Sep-00	METRIC	Sep-04		Sep-08	METRIC
Oct-96	METRIC	Oct-00	METRIC	Oct-04		Oct-08	METRIC
Apr-97		Apr-01		Apr-05		Apr-09	METRIC
May-97		May-01		May-05		May-09	METRIC
Jun-97		Jun-01		Jun-05		Jun-09	METRIC
Jul-97		Jul-01		Jul-05		Jul-09	METRIC
Aug-97		Aug-01		Aug-05		Aug-09	METRIC
Sep-97		Sep-01		Sep-05		Sep-09	METRIC
Oct-97		Oct-01		Oct-05		Oct-09	
Apr-98		Apr-02		Apr-06	METRIC	Apr-10	
May-98		May-02	Correlated Upper Valley	May-06	METRIC	May-10	
Jun-98		Jun-02	Correlated Upper Valley	Jun-06	METRIC	Jun-10	
Jul-98		Jul-02	Correlated Upper Valley	Jul-06	METRIC	Jul-10	
Aug-98		Aug-02	Correlated Upper Valley	Aug-06	METRIC	Aug-10	
Sep-98		Sep-02	Correlated Upper Valley	Sep-06	METRIC	Sep-10	
Oct-98		Oct-02	Correlated Upper Valley	Oct-06	METRIC	Oct-10	

METRIC_ET is available for part of the model area during May – Oct 2002. Use correlated data for a complete data set.

NDVI_ET Estimation

NDVI_ET uses a regression equation to relate NDVI values and the ET fraction from METRIC (ETrF).

ETrF = 0.15 + 1.06 NDVI

The ETrF is then combined with weather data (as is done in METRIC) to produce ET. Reference ET (ETr) is the max ET from a perfect alfalfa crop.

ET = ETrF x ETr

NDVI_ET estimates are approximately 9% higher on average than METRIC_ET for areas and times when both values are available.
All NDVI_ET estimates have been reduced by 9%.

07/2010

Month	ET Estimation Method	Month	ET Estimation Method	Month	ET Estimation Method	Month	ET Estimation Method
Apr-95		Apr-99		Apr-03		Apr-07	NDVI
May-95		May-99		May-03		May-07	NDVI
Jun-95		Jun-99		Jun-03	NDVI	Jun-07	NDVI
Jul-95	NDVI	Jul-99		Jul-03	NDVI	Jul-07	NDVI
Aug-95		Aug-99	NDVI	Aug-03	NDVI	Aug-07	NDVI
Sep-95		Sep-99	NDVI	Sep-03	NDVI	Sep-07	NDVI
Oct-95		Oct-99	NDVI	Oct-03		Oct-07	NDVI
Apr-96	METRIC	Apr-00	METRIC	Apr-04	NDVI	Apr-08	METRIC
May-96	METRIC	May-00	METRIC	May-04		May-08	METRIC
Jun-96	METRIC	Jun-00	METRIC	Jun-04		Jun-08	METRIC
Jul-96	METRIC	Jul-00	METRIC	Jul-04	NDVI	Jul-08	METRIC
Aug-96	METRIC	Aug-00	METRIC	Aug-04		Aug-08	METRIC
Sep-96	METRIC	Sep-00	METRIC	Sep-04		Sep-08	METRIC
Oct-96	METRIC	Oct-00	METRIC	Oct-04	NDVI	Oct-08	METRIC
Apr-97		Apr-01		Apr-05	NDVI	Apr-09	METRIC
May-97		May-01		May-05	NDVI	May-09	METRIC
Jun-97		Jun-01	NDVI	Jun-05	NDVI	Jun-09	METRIC
Jul-97		Jul-01	NDVI	Jul-05	NDVI	Jul-09	METRIC
Aug-97		Aug-01	NDVI	Aug-05	NDVI	Aug-09	METRIC
Sep-97	NDVI	Sep-01	NDVI	Sep-05	NDVI	Sep-09	METRIC
Oct-97	NDVI	Oct-01	NDVI	Oct-05	NDVI	Oct-09	
Apr-98		Apr-02		Apr-06	METRIC	Apr-10	
May-98		May-02	Correlated Upper Valley	May-06	METRIC	May-10	
Jun-98		Jun-02	Correlated Upper Valley	Jun-06	METRIC	Jun-10	
Jul-98		Jul-02	Correlated Upper Valley	Jul-06	METRIC	Jul-10	
Aug-98	NDVI	Aug-02	Correlated Upper Valley	Aug-06	METRIC	Aug-10	
Sep-98	NDVI	Sep-02	Correlated Upper Valley	Sep-06	METRIC	Sep-10	
Oct-98	NDVI	Oct-02	Correlated Upper Valley	Oct-06	METRIC	Oct-10	

For months with cloud-free images and no METRIC, use NDVI to estimate ET.

ET Estimation by Interpolation

METRIC_ET = ET Fraction x Reference ET	→	**METRIC_ET** = ETrF x ETr
NDVI_ET = Crop Coefficient x Reference ET	→	**NDVI_ET** = Kc x Etr

Example:
Need: ET June 2004
Have: NDVI July 2004
Have: Reference ET (ETr) for June 2004 from weather station
Have: METRIC June and July 2006
Have: NDVI June and July 2006

1. Divide July 2004 Crop Coef. by July 2006 Crop Coef. to get ratio of July Kc's.

   $Kc_{Jul2004} / Kc_{Jul2006} = ratio_{Jul}$

2. Multiply June 2006 ET Fraction by the ratio of July Kc. To get interpolated ETrF.

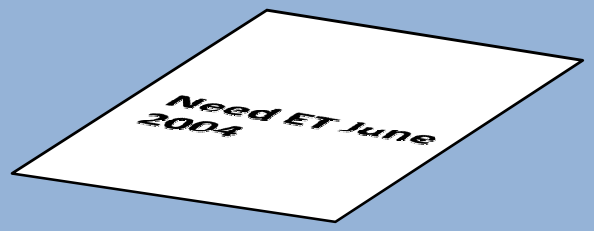
   $ETrF_{Jun2006} \times ratio_{Jul} = ETrF_{Jun2004_INT}$

3. Multiply Interpolated ETrF by June 2004 Reference ET from weather stations to get interpolated June 2004 ET.

   $ETrF_{Jun_INT} \times ETr_{Jun2004} = INT_ET_{Jun2004}$

ET Estimation by Interpolation

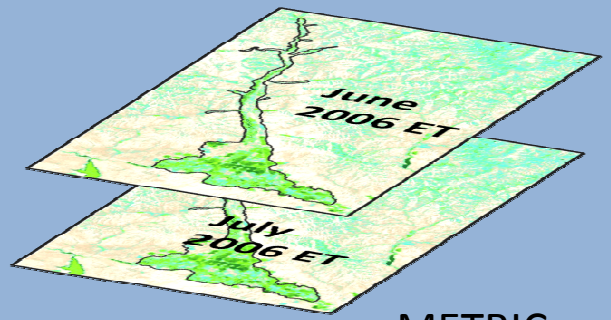
2004



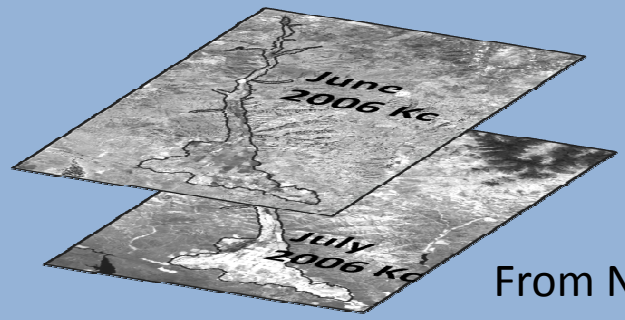
From NDVI

From Weather Station

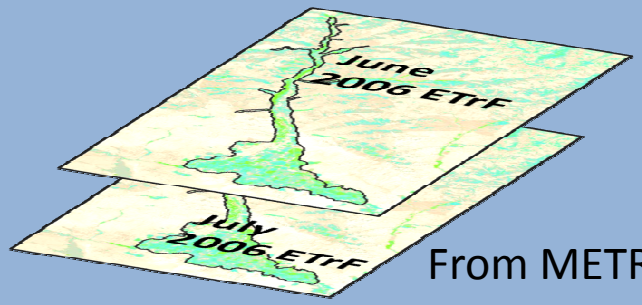
2006



METRIC

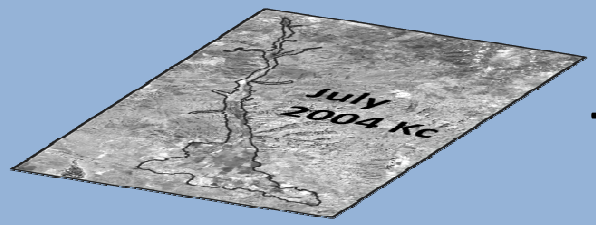


From NDVI



From METRIC

ET Estimation by Interpolation



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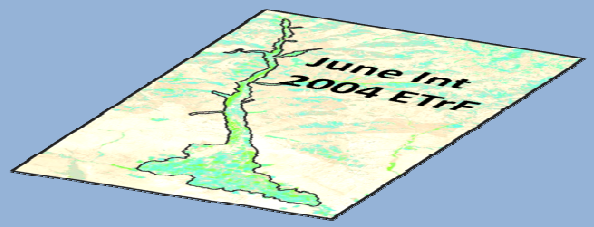
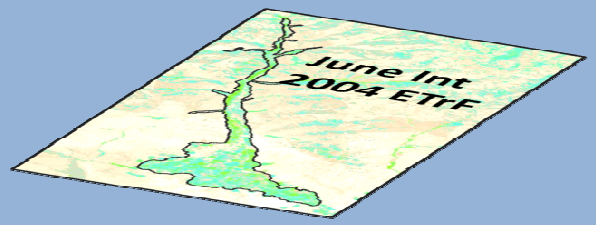
= $ratio_{Jul}$

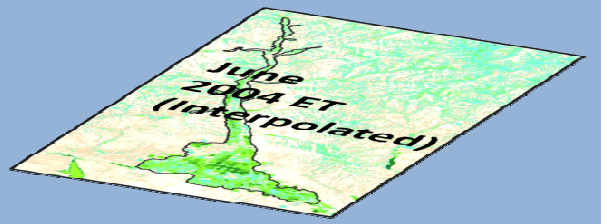
x $ratio_{Jul}$ =





x

=



Month	ET Estimation Method	Month	ET Estimation Method	Month	ET Estimation Method	Month	ET Estimation Method
Apr-95	Interpolated	Apr-99	Interpolated	Apr-03	Interpolated	Apr-07	NDVI
May-95	Interpolated	May-99	Interpolated	May-03	Interpolated	May-07	NDVI
Jun-95	Interpolated	Jun-99	Interpolated	Jun-03	NDVI	Jun-07	NDVI
Jul-95	NDVI	Jul-99	Interpolated	Jul-03	NDVI	Jul-07	NDVI
Aug-95	Interpolated	Aug-99	NDVI	Aug-03	NDVI	Aug-07	NDVI
Sep-95	Interpolated	Sep-99	NDVI	Sep-03	NDVI	Sep-07	NDVI
Oct-95	Interpolated	Oct-99	NDVI	Oct-03	Interpolated	Oct-07	NDVI
Apr-96	METRIC	Apr-00	METRIC	Apr-04	NDVI	Apr-08	METRIC
May-96	METRIC	May-00	METRIC	May-04		May-08	METRIC
Jun-96	METRIC	Jun-00	METRIC	Jun-04		Jun-08	METRIC
Jul-96	METRIC	Jul-00	METRIC	Jul-04	NDVI	Jul-08	METRIC
Aug-96	METRIC	Aug-00	METRIC	Aug-04	Interpolated	Aug-08	METRIC
Sep-96	METRIC	Sep-00	METRIC	Sep-04	Interpolated	Sep-08	METRIC
Oct-96	METRIC	Oct-00	METRIC	Oct-04	NDVI	Oct-08	METRIC
Apr-97		Apr-01		Apr-05	NDVI	Apr-09	METRIC
May-97		May-01		May-05	NDVI	May-09	METRIC
Jun-97		Jun-01	NDVI	Jun-05	NDVI	Jun-09	METRIC
Jul-97		Jul-01	NDVI	Jul-05	NDVI	Jul-09	METRIC
Aug-97		Aug-01	NDVI	Aug-05	NDVI	Aug-09	METRIC
Sep-97	NDVI	Sep-01	NDVI	Sep-05	NDVI	Sep-09	METRIC
Oct-97	NDVI	Oct-01	NDVI	Oct-05	NDVI	Oct-09	Interpolated
Apr-98		Apr-02	Interpolated	Apr-06	METRIC	Apr-10	Interpolated
May-98		May-02	Correlated Upper Valley	May-06	METRIC	May-10	Interpolated
Jun-98		Jun-02	Correlated Upper Valley	Jun-06	METRIC	Jun-10	Interpolated
Jul-98		Jul-02	Correlated Upper Valley	Jul-06	METRIC	Jul-10	Interpolated
Aug-98	NDVI	Aug-02	Correlated Upper Valley	Aug-06	METRIC	Aug-10	Interpolated
Sep-98	NDVI	Sep-02	Correlated Upper Valley	Sep-06	METRIC	Sep-10	Interpolated
Oct-98	NDVI	Oct-02	Correlated Upper Valley	Oct-06	METRIC	Oct-10	Interpolated

For months without satellite data, interpolate from months with known ET values.

Adjusted Interpolation

07/1997

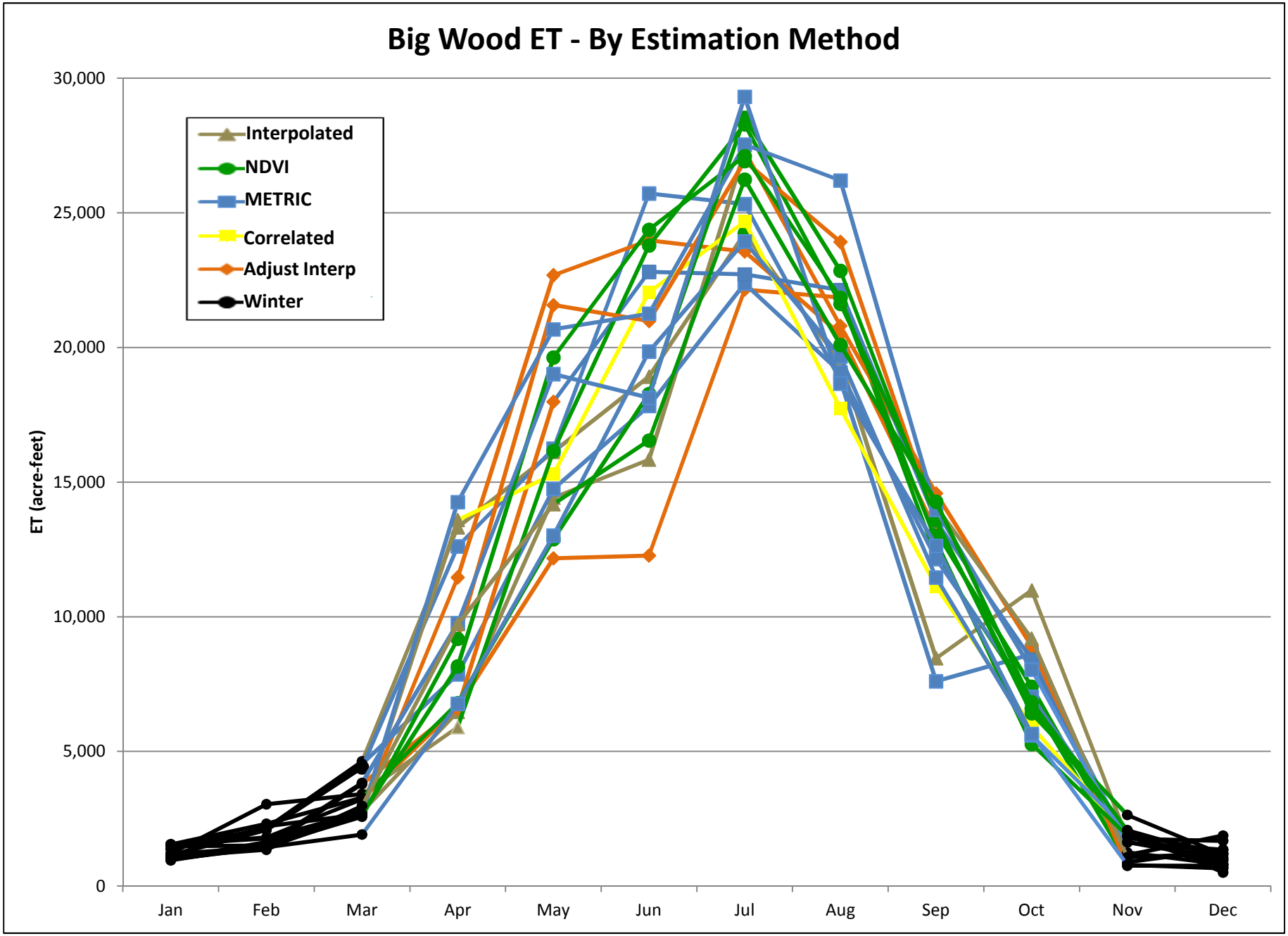
Interpolation works well for most months and most of the land uses. Changes in crop vigor are well represented by the ratio of Kc values for fully vegetated areas. However, sometimes the technique is confounded by drastic changes in land use.

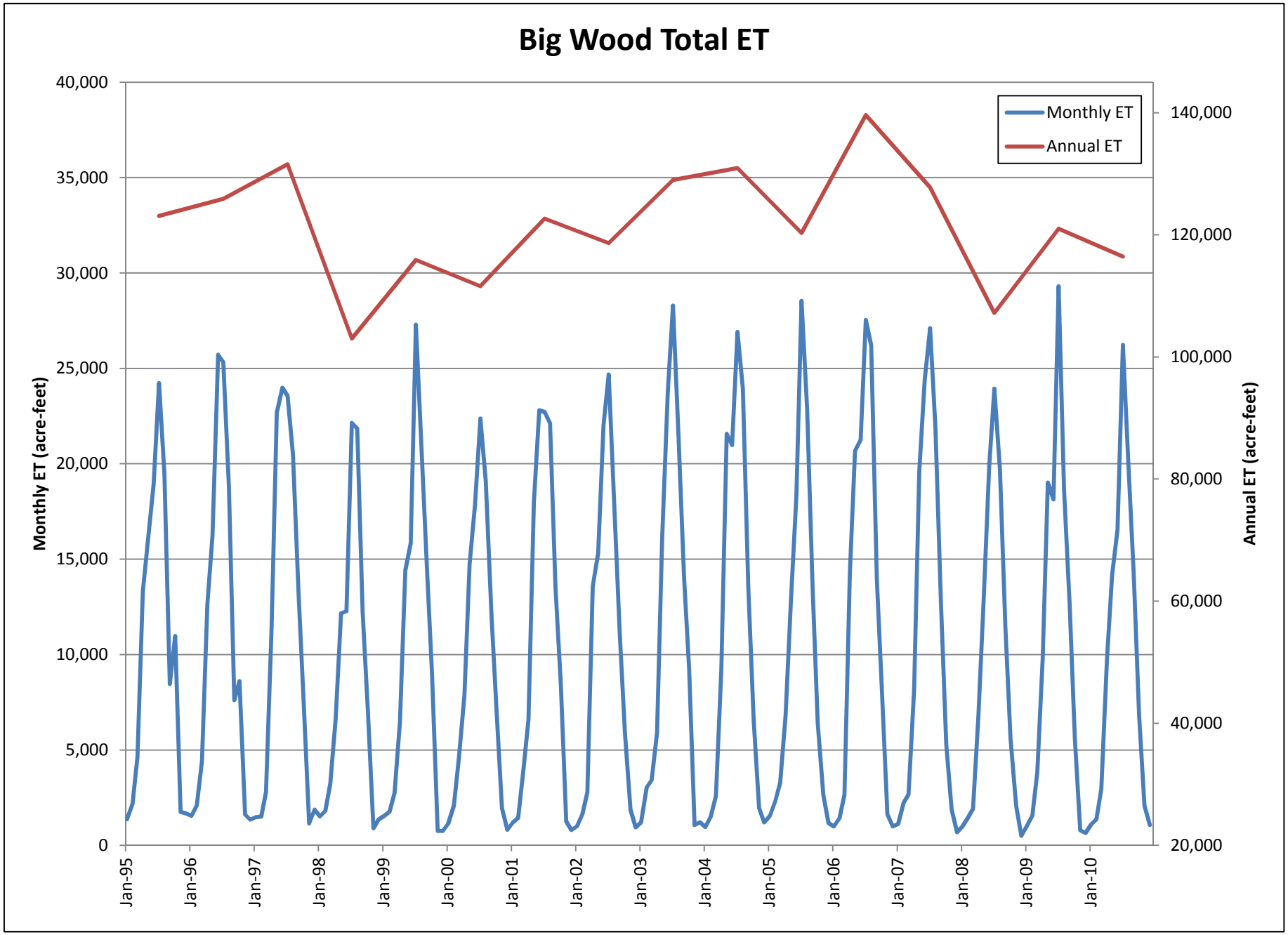
Example:
If the METRIC source year has fields that were cut (alfalfa) or fallow (insufficient water supply) when the satellite passed, the interpolated values will be much too high.

Adjusted excessive ET on cultivated crops by limiting to maximum alfalfa ET.

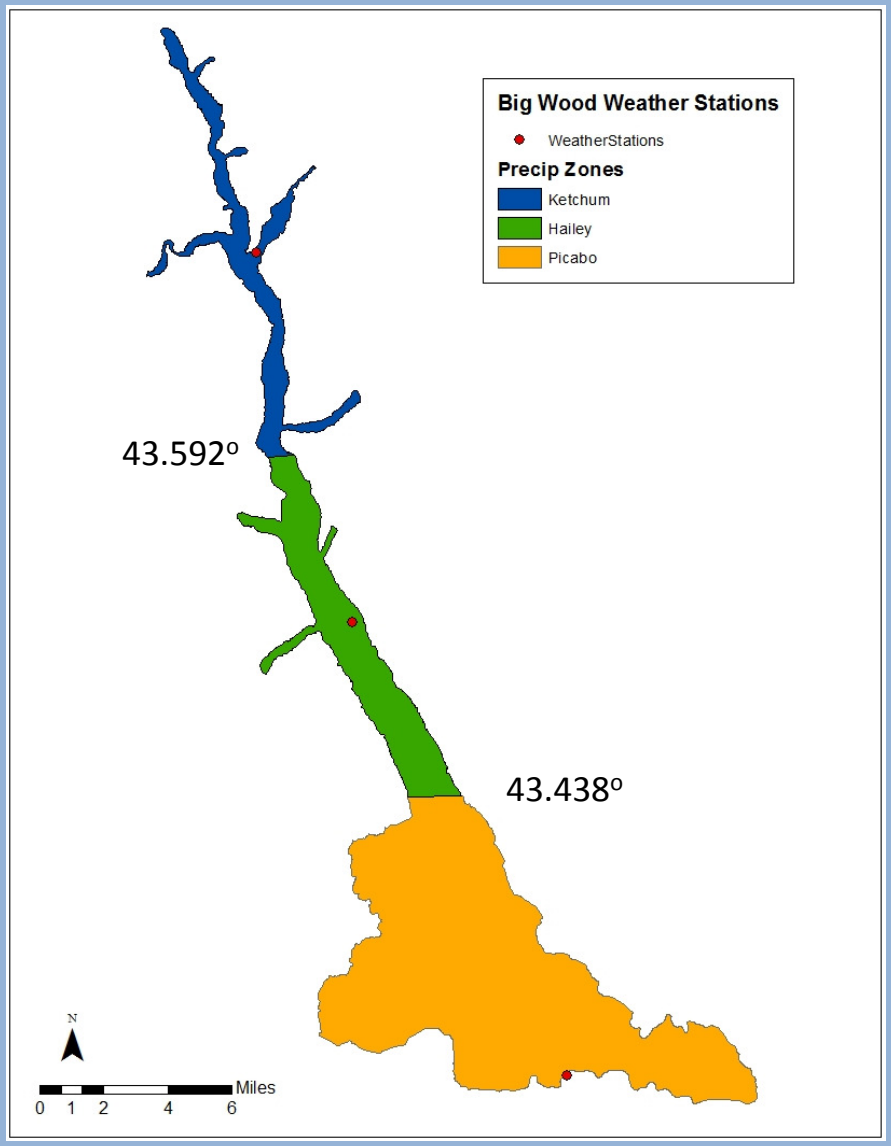
Month	ET Estimation Method	Month	ET Estimation Method	Month	ET Estimation Method	Month	ET Estimation Method
Apr-95	Interpolated	Apr-99	Interpolated	Apr-03	Interpolated	Apr-07	NDVI
May-95	Interpolated	May-99	Interpolated	May-03	Interpolated	May-07	NDVI
Jun-95	Interpolated	Jun-99	Interpolated	Jun-03	NDVI	Jun-07	NDVI
Jul-95	NDVI	Jul-99	Interpolated	Jul-03	NDVI	Jul-07	NDVI
Aug-95	Interpolated	Aug-99	NDVI	Aug-03	NDVI	Aug-07	NDVI
Sep-95	Interpolated	Sep-99	NDVI	Sep-03	NDVI	Sep-07	NDVI
Oct-95	Interpolated	Oct-99	NDVI	Oct-03	Interpolated	Oct-07	NDVI
Apr-96	METRIC	Apr-00	METRIC	Apr-04	NDVI	Apr-08	METRIC
May-96	METRIC	May-00	METRIC	May-04	Adjusted Interpolation	May-08	METRIC
Jun-96	METRIC	Jun-00	METRIC	Jun-04	Adjusted Interpolation	Jun-08	METRIC
Jul-96	METRIC	Jul-00	METRIC	Jul-04	NDVI	Jul-08	METRIC
Aug-96	METRIC	Aug-00	METRIC	Aug-04	Interpolated	Aug-08	METRIC
Sep-96	METRIC	Sep-00	METRIC	Sep-04	Interpolated	Sep-08	METRIC
Oct-96	METRIC	Oct-00	METRIC	Oct-04	NDVI	Oct-08	METRIC
Apr-97	Adjusted Interpolation	Apr-01	Adjusted Interpolation	Apr-05	NDVI	Apr-09	METRIC
May-97	Adjusted Interpolation	May-01	Adjusted Interpolation	May-05	NDVI	May-09	METRIC
Jun-97	Adjusted Interpolation	Jun-01	NDVI	Jun-05	NDVI	Jun-09	METRIC
Jul-97	Adjusted Interpolation	Jul-01	NDVI	Jul-05	NDVI	Jul-09	METRIC
Aug-97	Adjusted Interpolation	Aug-01	NDVI	Aug-05	NDVI	Aug-09	METRIC
Sep-97	NDVI	Sep-01	NDVI	Sep-05	NDVI	Sep-09	METRIC
Oct-97	NDVI	Oct-01	NDVI	Oct-05	NDVI	Oct-09	Interpolated
Apr-98	Adjusted Interpolation	Apr-02	Interpolated	Apr-06	METRIC	Apr-10	Interpolated
May-98	Adjusted Interpolation	May-02	Correlated Upper Valley	May-06	METRIC	May-10	Interpolated
Jun-98	Adjusted Interpolation	Jun-02	Correlated Upper Valley	Jun-06	METRIC	Jun-10	Interpolated
Jul-98	Adjusted Interpolation	Jul-02	Correlated Upper Valley	Jul-06	METRIC	Jul-10	Interpolated
Aug-98	NDVI	Aug-02	Correlated Upper Valley	Aug-06	METRIC	Aug-10	Interpolated
Sep-98	NDVI	Sep-02	Correlated Upper Valley	Sep-06	METRIC	Sep-10	Interpolated
Oct-98	NDVI	Oct-02	Correlated Upper Valley	Oct-06	METRIC	Oct-10	Interpolated

All growing-season ET is derived from remote sensing (satellite) data. Different methods have been employed to obtain satellite-based ET estimates for every month.


Big Wood ET - By Estimation Method
ET (acre-feet)
30,000
25,000
20,000
15,000
10,000
5,000
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Interpolated
NDVI
METRIC
Correlated
Adjust Interp
Winter


Big Wood Total ET
Monthly ET
Annual ET
Monthly ET (acre-feet)
Annual ET (acre-feet)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
140,000
120,000
100,000
80,000
60,000
40,000
20,000
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Jan-07
Jan-08
Jan-09
Jan-10

Precipitation



We have precipitation data for the Picabo and Ketchum weather stations for the entire model period. Data are available at the Hailey weather station for 2005-2010; the remaining months use a correlation with Picabo to fill in the Hailey data set.

Precipitation from the weather stations are applied uniformly to the corresponding precipitation zone.

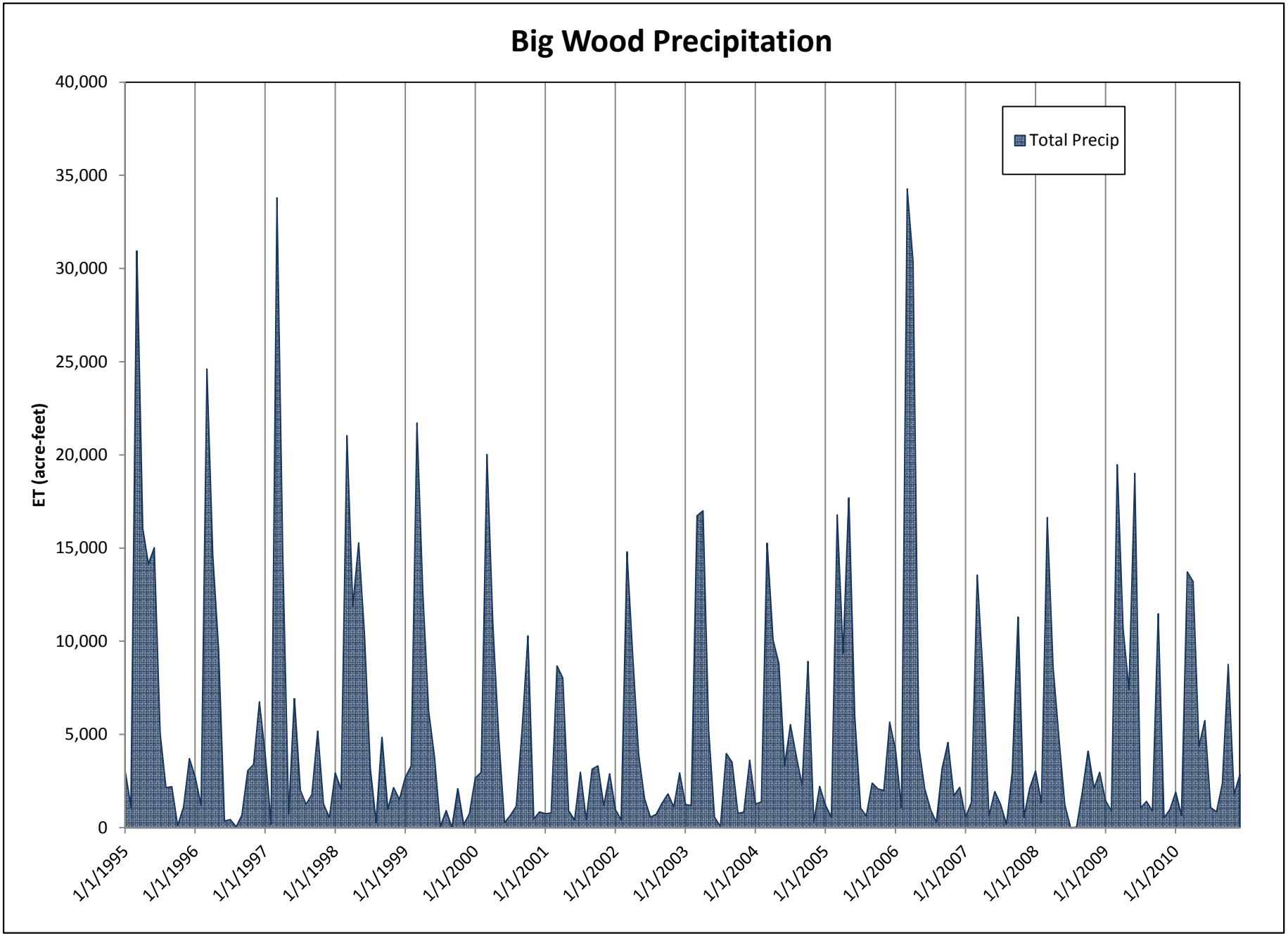
Precipitation Zone boundaries have been drawn at 43.592° and 43.438° latitude.

Winter Precipitation

Winter Precipitation has been "delayed" to simulate freeze/melt.

	Nov	Dec	Jan	Feb	Mar	Apr
Ketchum	0.25 Nov	0.25 Dec	0.25 Jan	0.25 Feb	0.25 Mar	0.75Nov + 0.75Dec + 0.75Jan + 0.75Feb + 0.75Mar + 1.0Apr
Hailey	0.25 Nov	0.25 Dec	0.25 Jan	0.25 Feb	0.25Nov + 0.25Dec + 0.25Jan + 0.25Feb + 0.5Mar	0.5Nov + 0.5Dec + 0.5Jan + 0.5Feb + 0.5Mar +1.0Apr
Picabo	0.25 Nov	0.25 Dec	0.25 Jan	0.25 Feb	0.75Nov + 0.75Dec + 0.75Jan + 0.75Feb + 1.0Mar	1.0Apr

Picabo melt occurs in March.
Hailey melt begins in March and ends in April.
Ketchum melt occurs in April.


Big Wood Precipitation
Total Precip
ET (acre-feet)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001
1/1/2002
1/1/2003
1/1/2004
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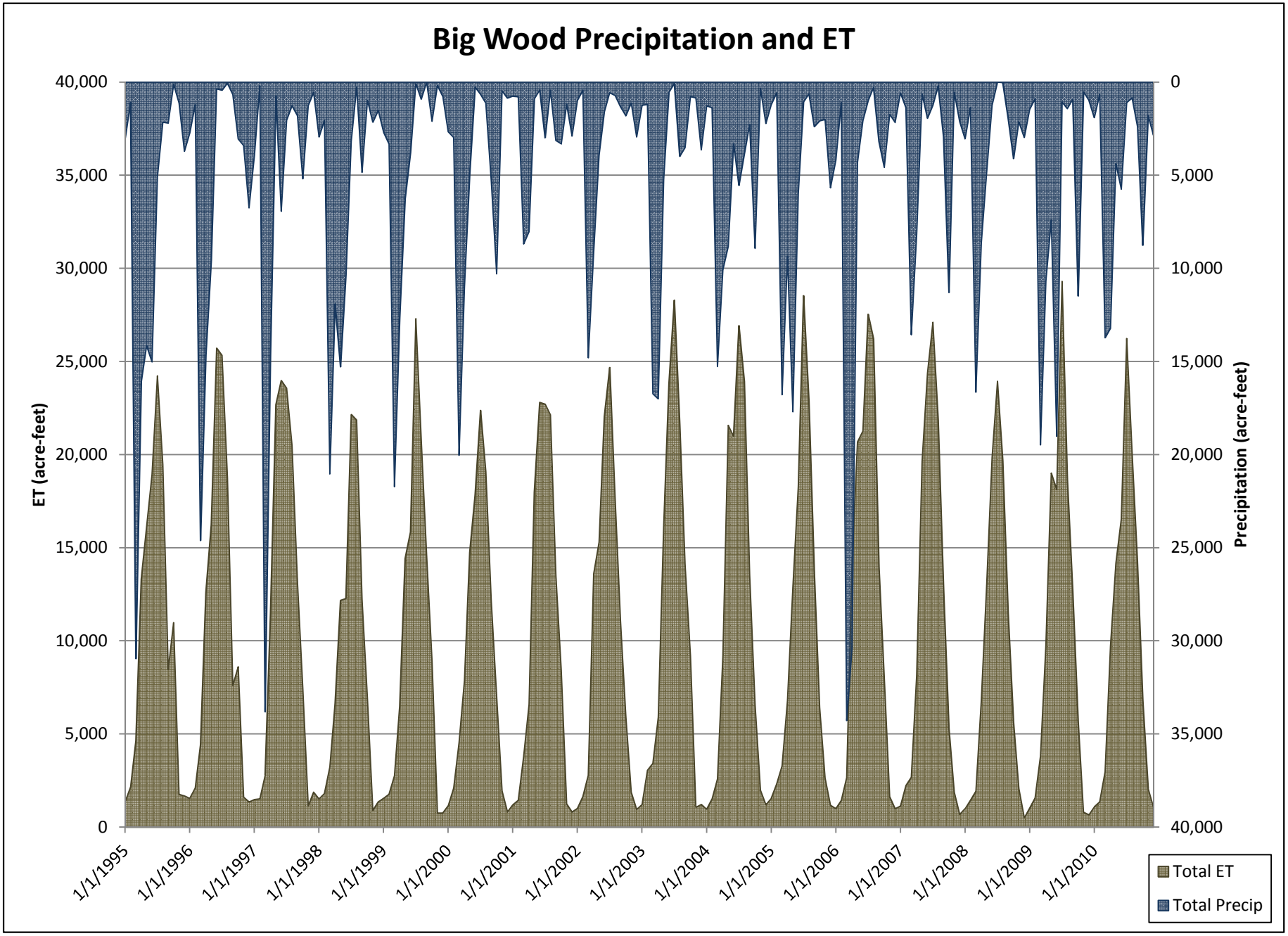
1/1/2007
1/1/2008
1/1/2009
1/1/2010


Big Wood Precipitation and ET
ET (acre-feet)
Precipitation (acre-feet)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
1/1/1995
1/1/1996
1/1/1997
1/1/1998
1/1/1999
1/1/2000
1/1/2001
1/1/2002
1/1/2003
1/1/2004
1/1/2005
1/1/2006
1/1/2007
1/1/2008
1/1/2009
1/1/2010
Total ET
Total Precip

Recharge on Non-Irrigated Land (Growing Season) and All Land-Use Types (Winter Season)

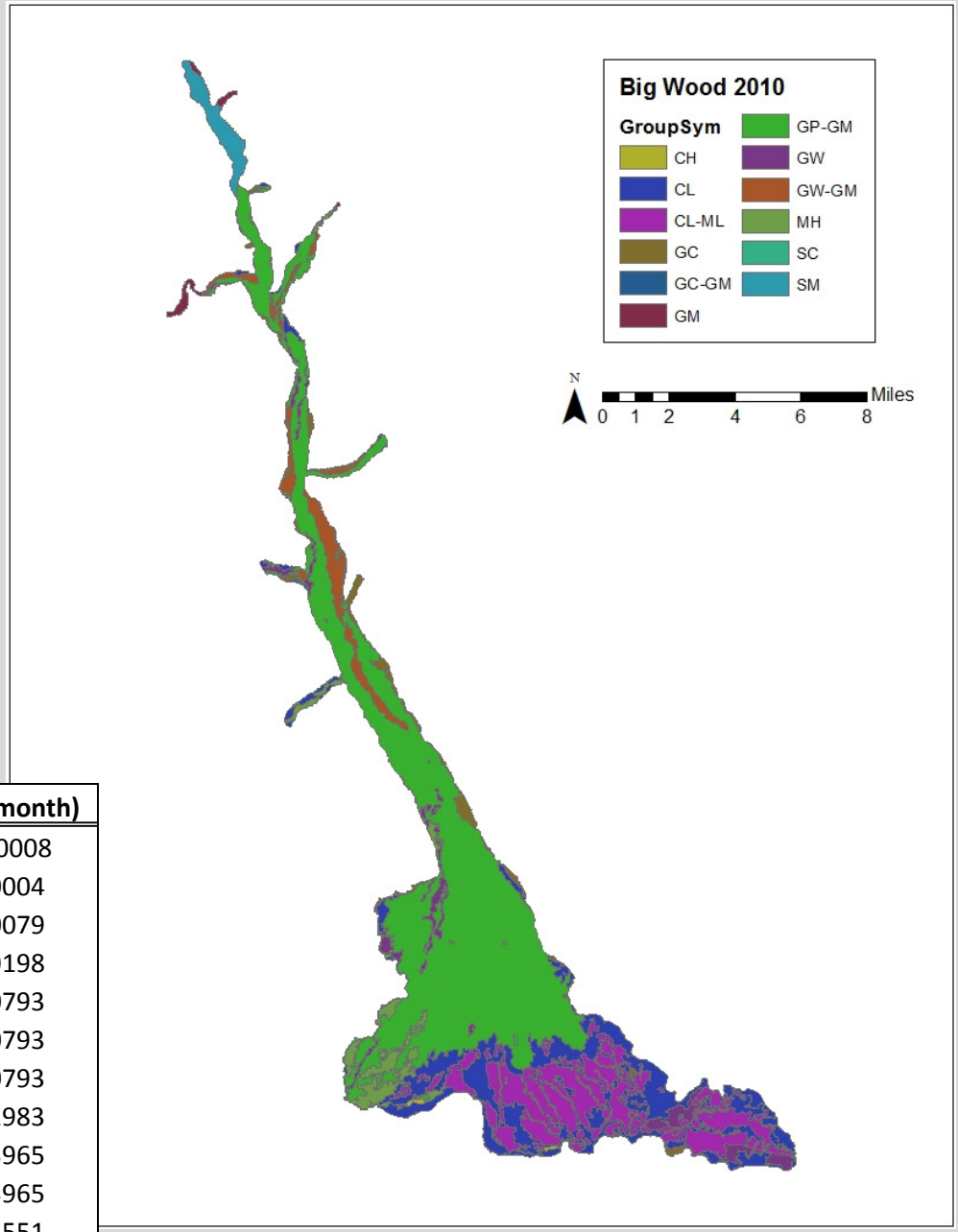
Recharge is calculated as Precipitation minus ET, and is limited by the infiltration capacity of the valley soils.

1. Recharge on All land-use types during winter months.
2. Recharge on Non-Irrigate land during growing-season months.
    a. Recharge on Irrigated and Semi-Irrigated land calculated in a separate process - based on irrigation source.

Preliminary Infiltration Rates

USCS Soil Class	Symbol	Range in K (in/hr)
High Plasticity Clay	CH	1.3x10-7 to 1.3x10-5
Low Plasticity Clay	CL	1.3x10-5 to 1.3x10-3
Clayey Gravel	GC	1.3x10-4 to 1.3x10-2
Silty Gravel	GM	1.3 x 10-4 to 13.5
Poorly Graded Gravel	GP	6.8 to 137
Well Graded Gravel	GW	1.3 to 137
High Plasticity Silt	MH	1.3x10-6 to 1.3x10-5
Low Plasticity Silt	ML	1.3x10-5 to 0.07
Low Plasticity Organic Silt	OL	1.3x10-5 to 1.3x10-2
Clayey Sand	SC	1.3x10-5 to 0.7
Silty Sand	SM	1.3x10-4 to 0.7
Poorly Graded Sand	SP	0.07 to 0.7
Well Graded Sand	SW	0.7 to 68

Big Wood USCS oil Class	Symbol	K (in/hr)	K (ft/month)
High Plasticity Clay	CH	1.30E-06	0.00008
High Plasticity Silt	MH	6.50E-06	0.0004
Low Plasticity Clay	CL	1.30E-04	0.0079
Clay and Silt	CL-ML	3.25E-04	0.0198
Clayey Sand	SC	1.30E-03	0.0793
Clayey Gravel	GC	1.30E-03	0.0793
Clayey and Silty Gravel	GC-GM	1.30E-03	0.0793
Silty Sand	SM	3.25E-03	0.1983
Silty Gravel	GM	6.50E-03	0.3965
Well Graded Gravel and Silty Gravel	GW-GM	6.50E-03	0.3965
Poorly Graded Gravel and Silty Gravel	GP-GM	9.10E-03	0.5551
Well Graded Gravel	GW	1.3	79.300



Discussion.