Treasure Valley METRIC Application

Status and Review

University of Idaho

Wenguang Zhao, Clarence Robison and Rick Allen

March 7, 2019

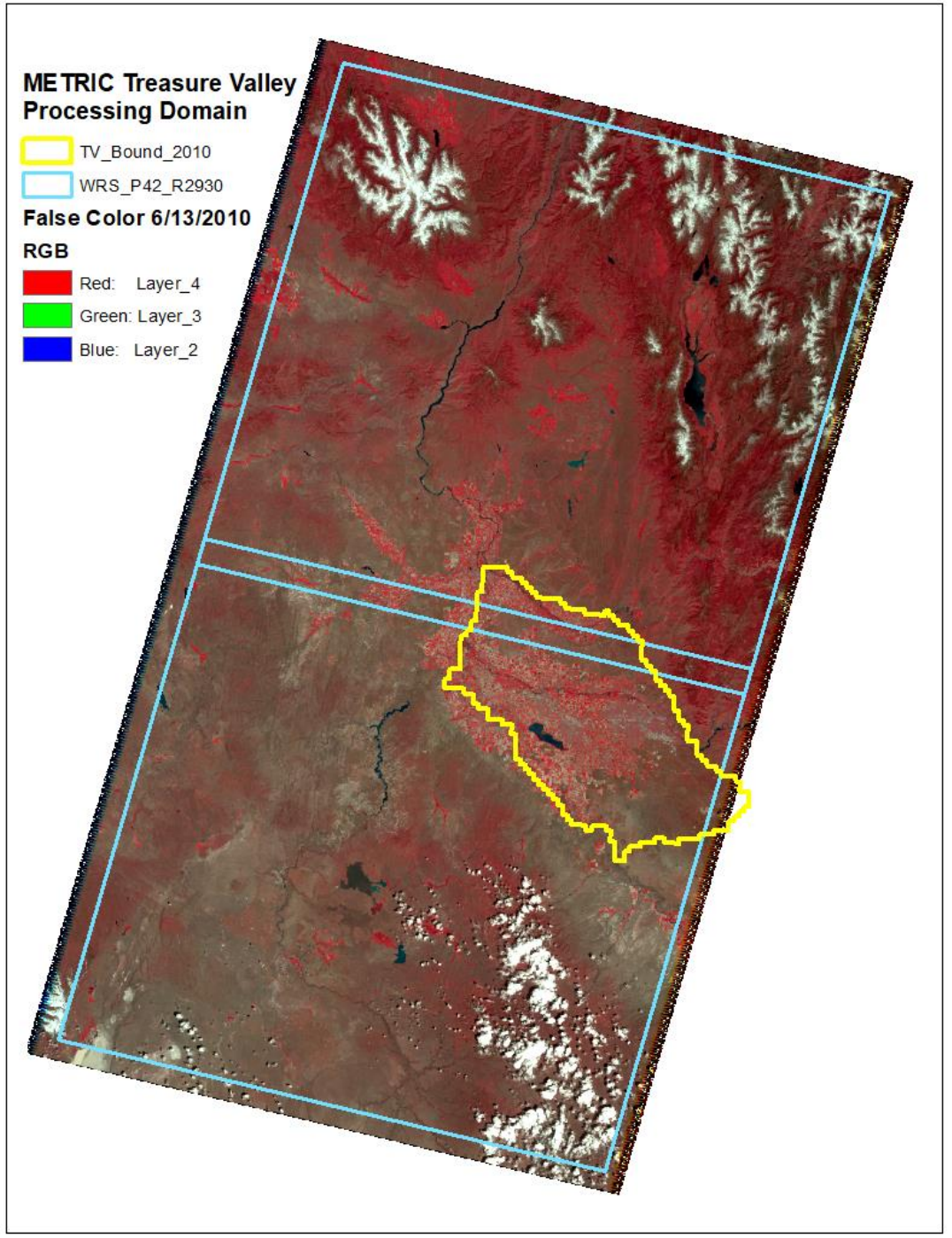
University of Idaho

Assistance by Qiuyan Huang and Ricardo Trezza

Quantifying Evapotranspiration for Treasure Valley

- METRIC Processing for years: 1987, 1994, 1997, 2000, 2004, 2007, 2010, 2015
- ET_{Idaho} based estimation for intervening years adjusted by METRIC processed years and spatial (county) crop distributions.

METRIC processing of Landsat Path 42, Rows 29 and 30



Operational ET “mapping” using energy balance

Mapping EvapoTranspiration with high Resolution and Internalized Calibration (METRIC)

University of Idaho, *Kimberly*

– development began in 2000

– rooted in SEBAL[2000]

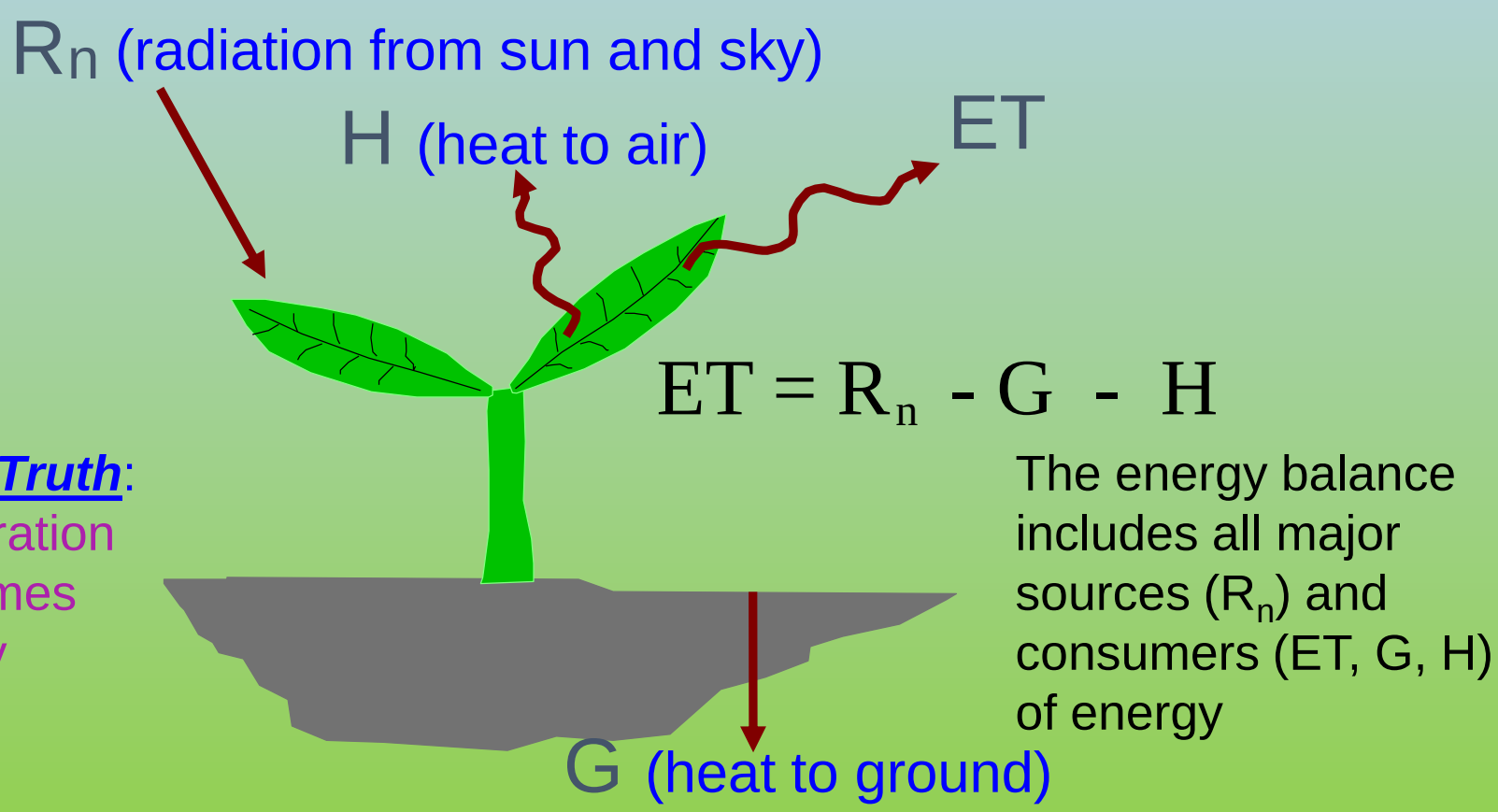
METRIC uses thermal and reflected data

It can be used with Landsat, MODIS, VIIRS, Aster

Energy balance gives us "actual" ET

Surface Energy Balance:

ET is calculated as a "residual" of the energy balance



$$ET = R_n - G - H$$

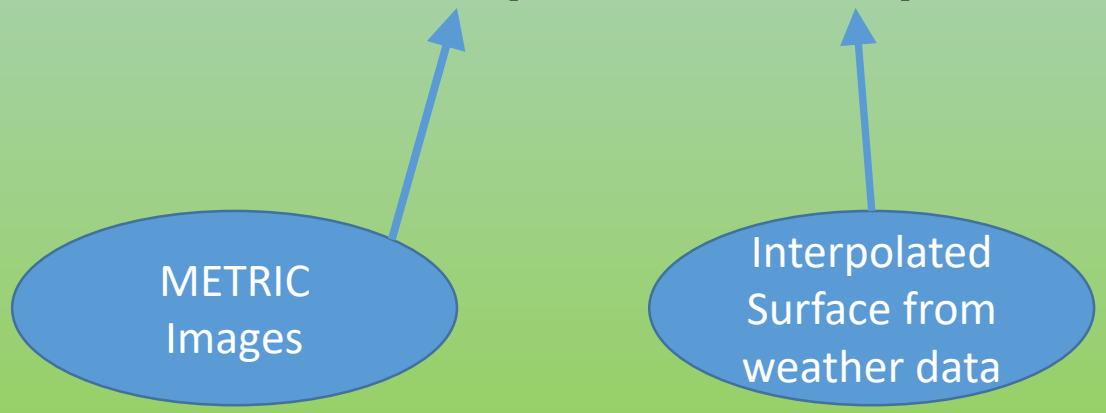
Basic Truth:
Evaporation consumes Energy

The energy balance includes all major sources (R_n) and consumers (ET, G, H) of energy

METRIC uses a two step process:

- Production of fraction of reference ET (ET_rF) from energy balance
- Time integration between Landsat dates to produce daily and monthly ET:

$$ET = ET_rF * ET_r$$



Accuracy of ET by Satellite Energy Balance

What can we expect?

- **METRIC** is an "**engineer's tool**"
- Focus is on a '**small'** region of interest **(100 miles x 100 miles)** (i.e, not the world, not 17 western states all at once)

- **METRIC combines** the strengths of energy balance from satellite and accuracy of ground-based reference ET calculation:
  - **satellite-based energy balance** provides the spatial information and distribution for a large area (and does most of the "**heavy lifting**")
  - **reference ET calculation** "**anchors**" the energy balance surface and provides "reality" to the product.

Accuracy of ET by Satellite Energy Balance

What can we expect?

- Because **METRIC** uses ET_r to tie to and by which to integrate ET over time, ET from METRIC incorporates any errors and bias of the ET_r calculation

- Extrapolation over an area is similar to K_c ET_r approach
  - Use **ET_r** surface to represent climatic demand
  - **Whereas**: Satellite energy balance incorporates effects of vegetation density, water availability (via T_s) etc. in the calculation of **specific ET by field** (K_c curve usually does not)

- **Accuracy** of ET by **METRIC** is probably
  - +/- 10 to 20% for a specific field on a specific day
  - +/- 10 to 15% for many fields on a specific day
  - +/- 10 to 15% for a specific field over a season
    (if done well)

Current status of the TV images processing

- 1987 – Reprocessing with updated models and revised landuse, will be ready for review within a week.
- 1994 – Reprocessed with updated models, in review.
- 1997 – Images ready for processing.
- 2000 – Complete -- have submitted, minor refinement will be submitted within 1 week.
- 2004 – Images ready for processing.
- 2007 – Completed with updated models -- products submitted to IDWR.
- 2010 – Currently processing with updated models.
- 2015 – Complete -- reprocessed with updated models and landuse. Monthly products under refinement should be completed with a month.

Updated models reflect changes in soil heat flux, aerodynamic roughness, adjustments for afternoon water stress.

TV METRIC processing order

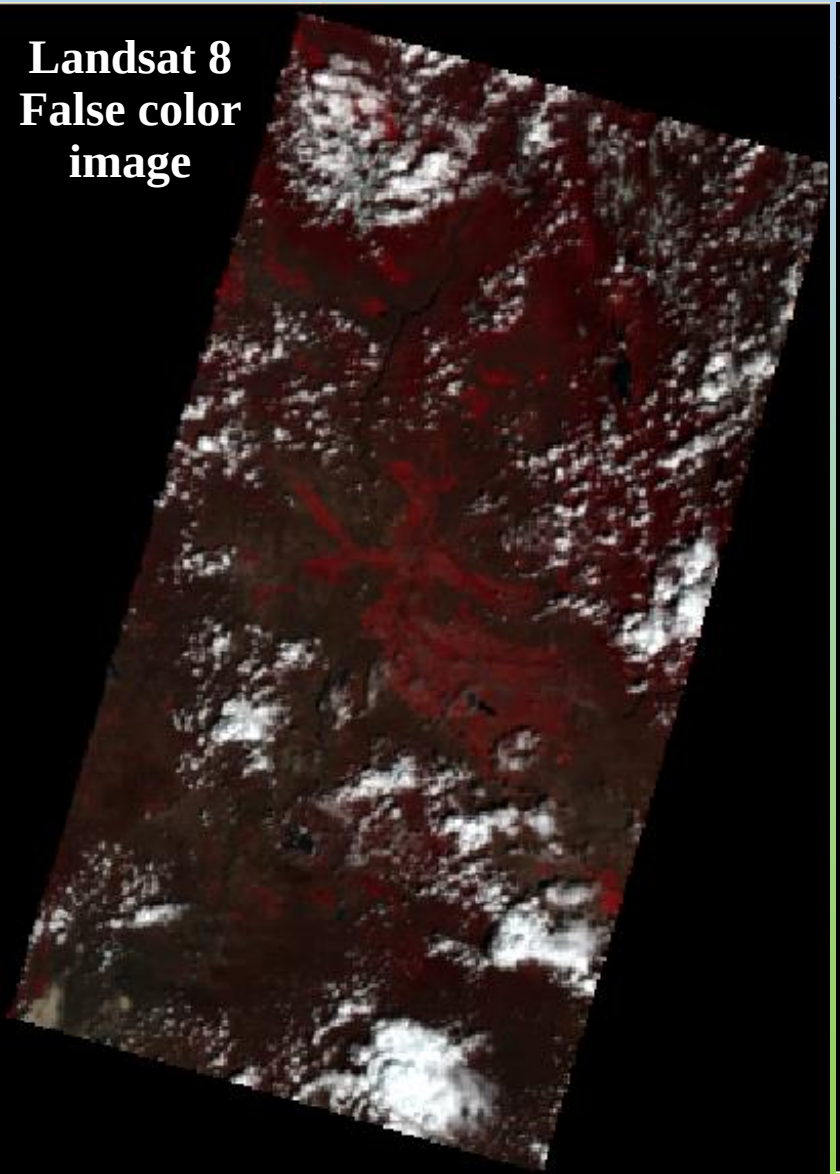
Proposed processing order:

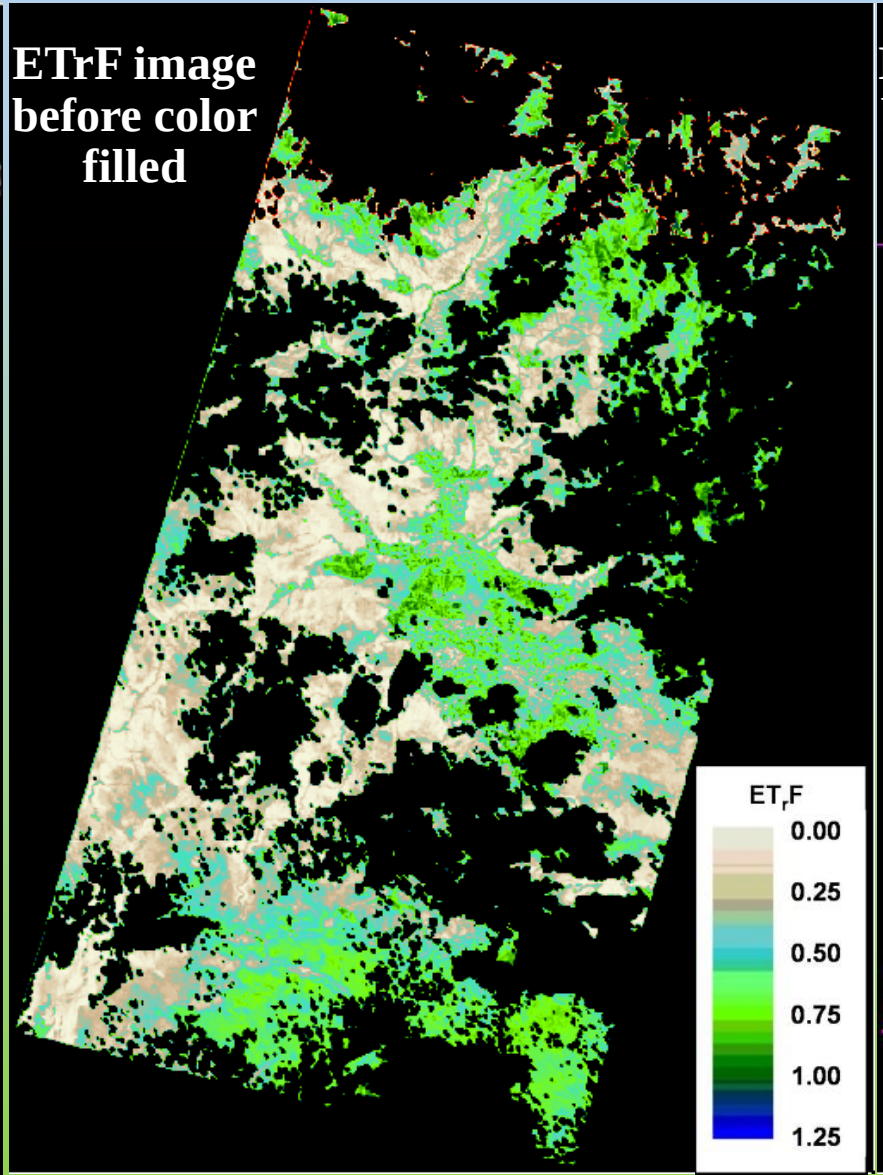
- 1 -- 2015
- 2 -- 1987
- 3 -- 2000
- 4 -- 2007
- 5 -- 1994
- 6 -- 2010
- 7 -- 1997
- 8 -- 2004

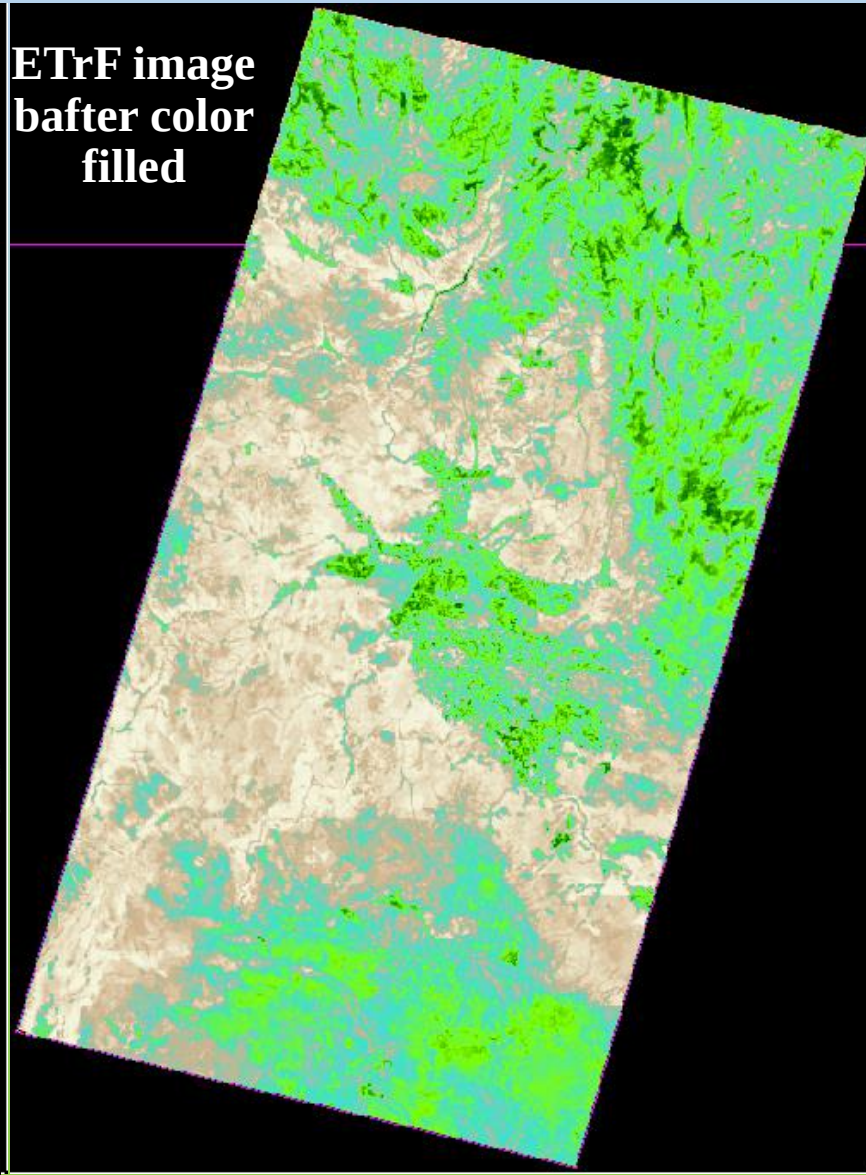
Actual processing order:

- 1 -- 2015
- 2 -- 2007
- 3 -- 2000
- 4 -- 1994
- 5 -- 1987
- 6 -- 2010
- 7 -- 1997
- 8 -- 2004

Cloud filling has been difficult.
(5/25/2015)





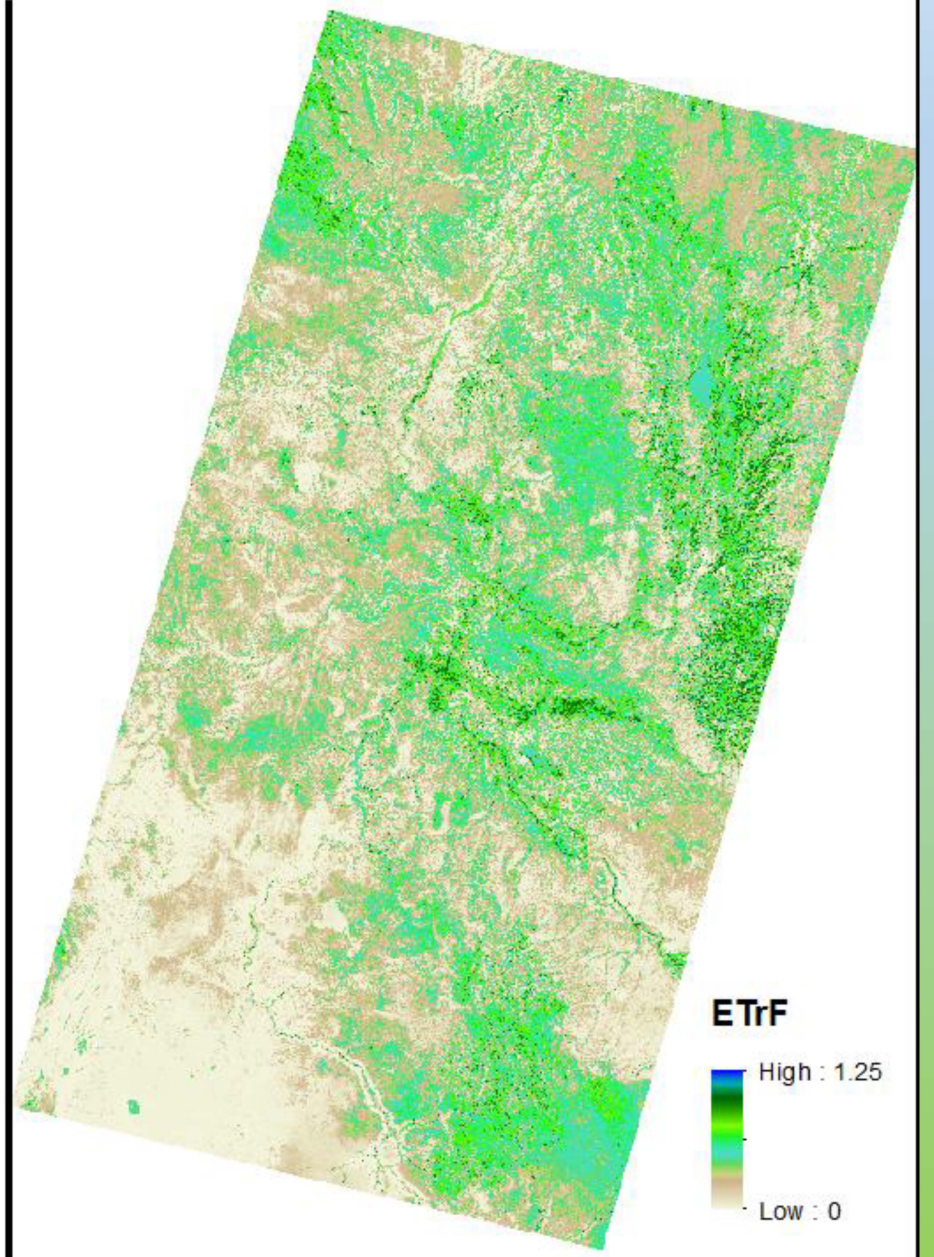


Non METRIC Year ET Estimates

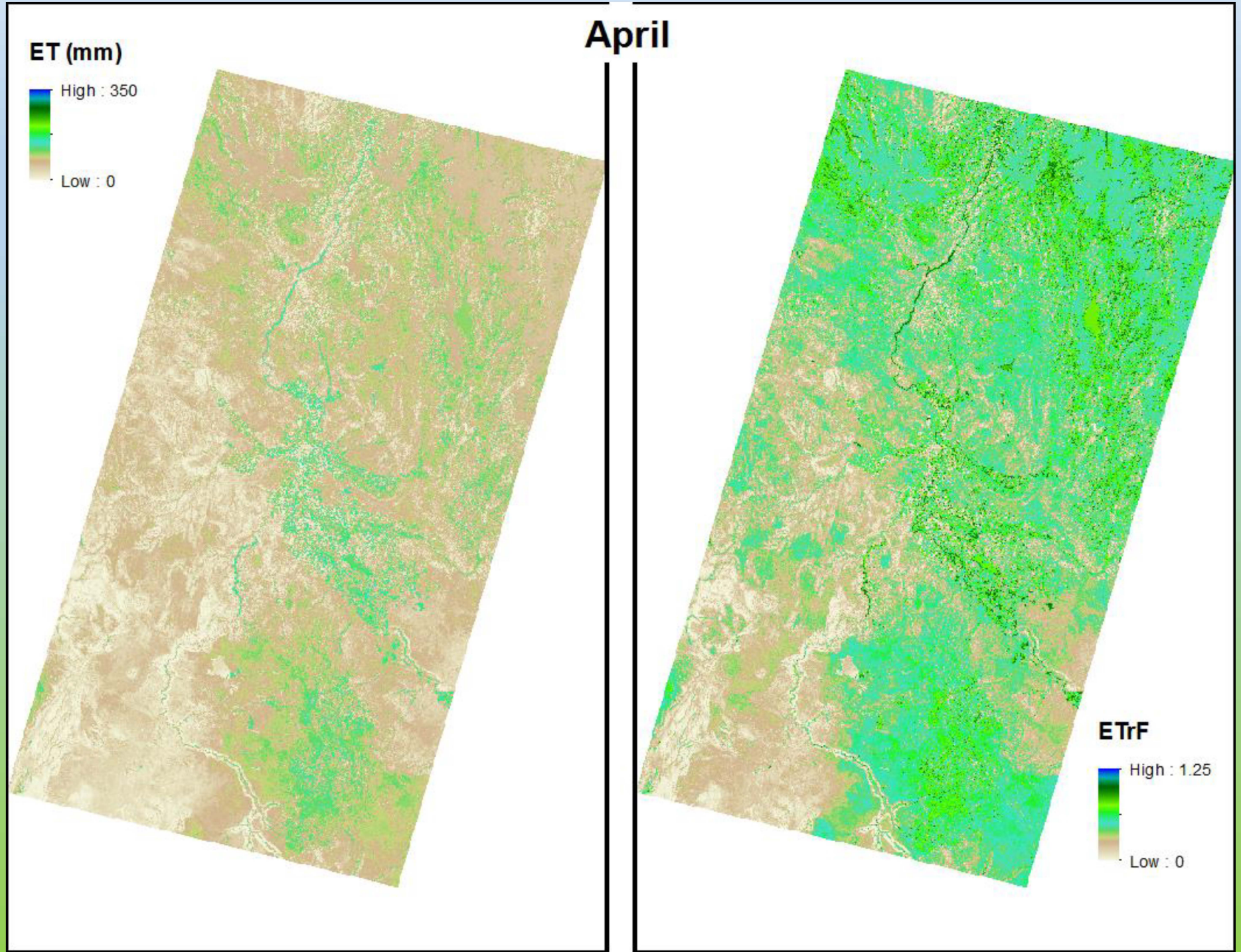
- ET_{Idaho} based estimation for intervening years adjusted by METRIC processed years, spatial crop/vegetation distributions.
- Non METRIC year ET will only be performed for the Treasure Valley aquifer model area.
- METRIC adjustment factors for ET_{Idaho} will require completed monthly METRIC products.
- Factors for ET_{Idaho} monthly data for non METRIC years may need to be interpolated between METRIC years.
- Spatial distribution of crop/vegetation will be categorized by USDA county data and Crop-Scape information. Irrigation entity and aquifer model grid cells may also be used to distribute crop/vegetation patterns.
- This component is waiting for more METRIC years to be completed.

METRIC ET Products
(using year 2015 as an example)

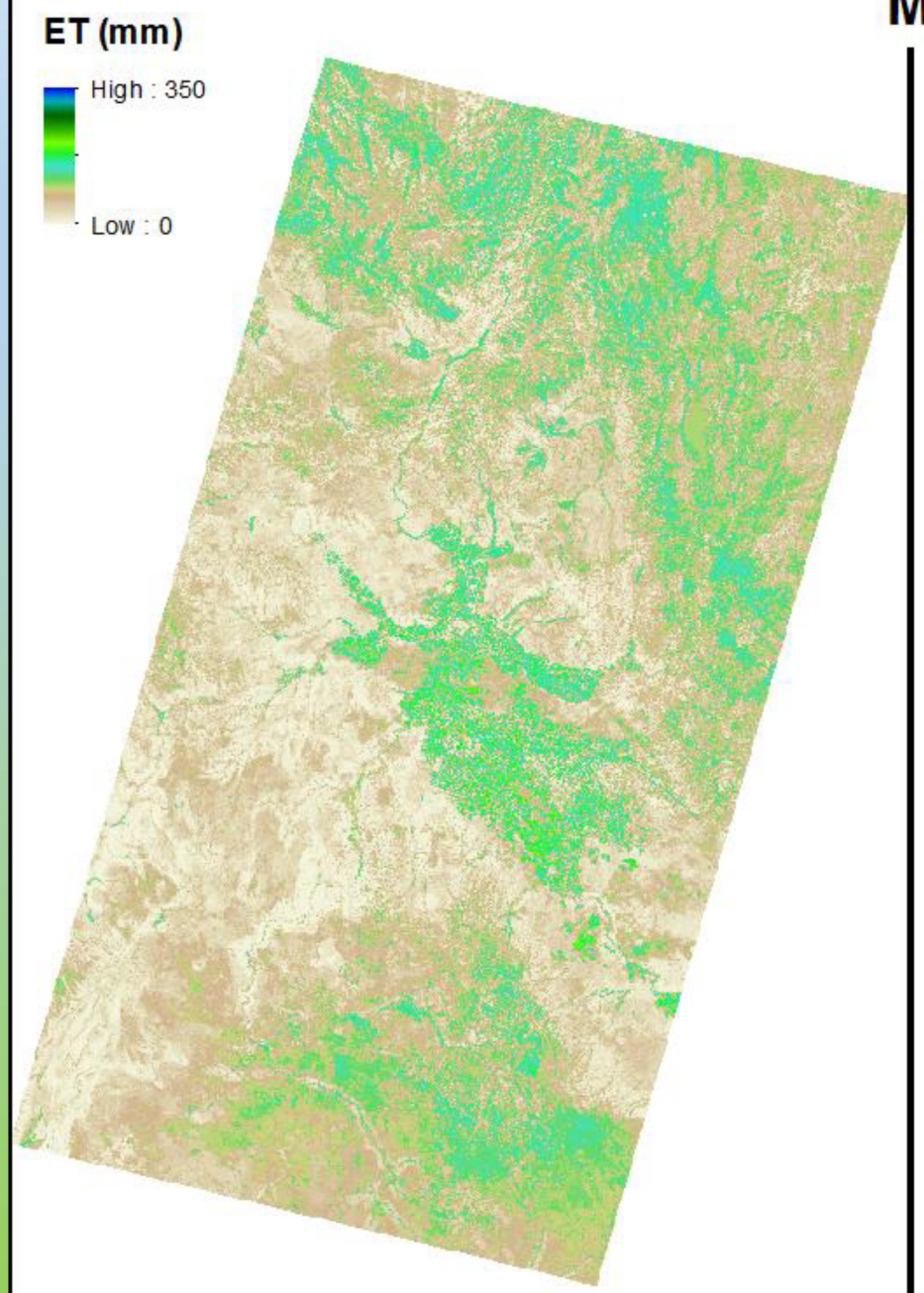
March

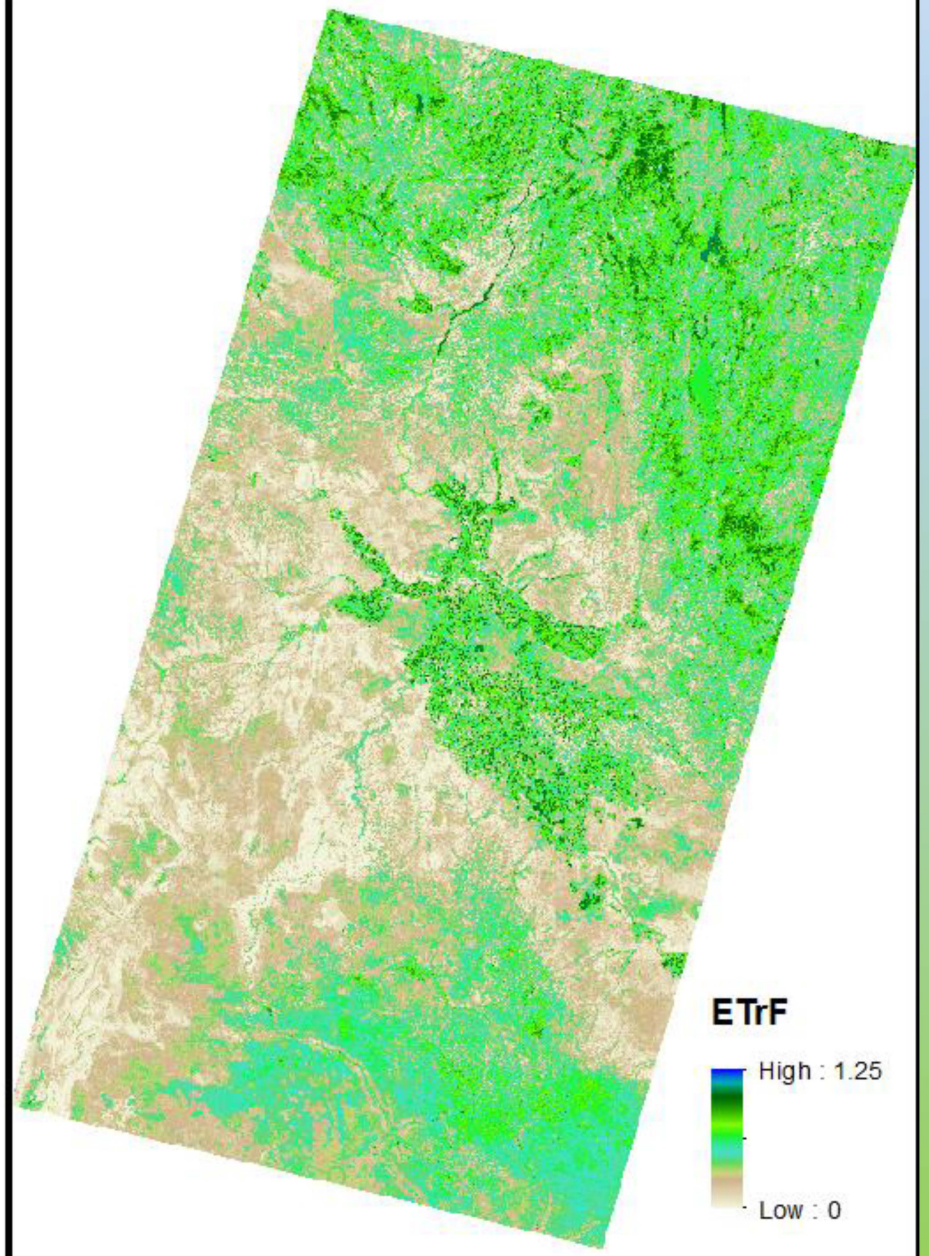


April

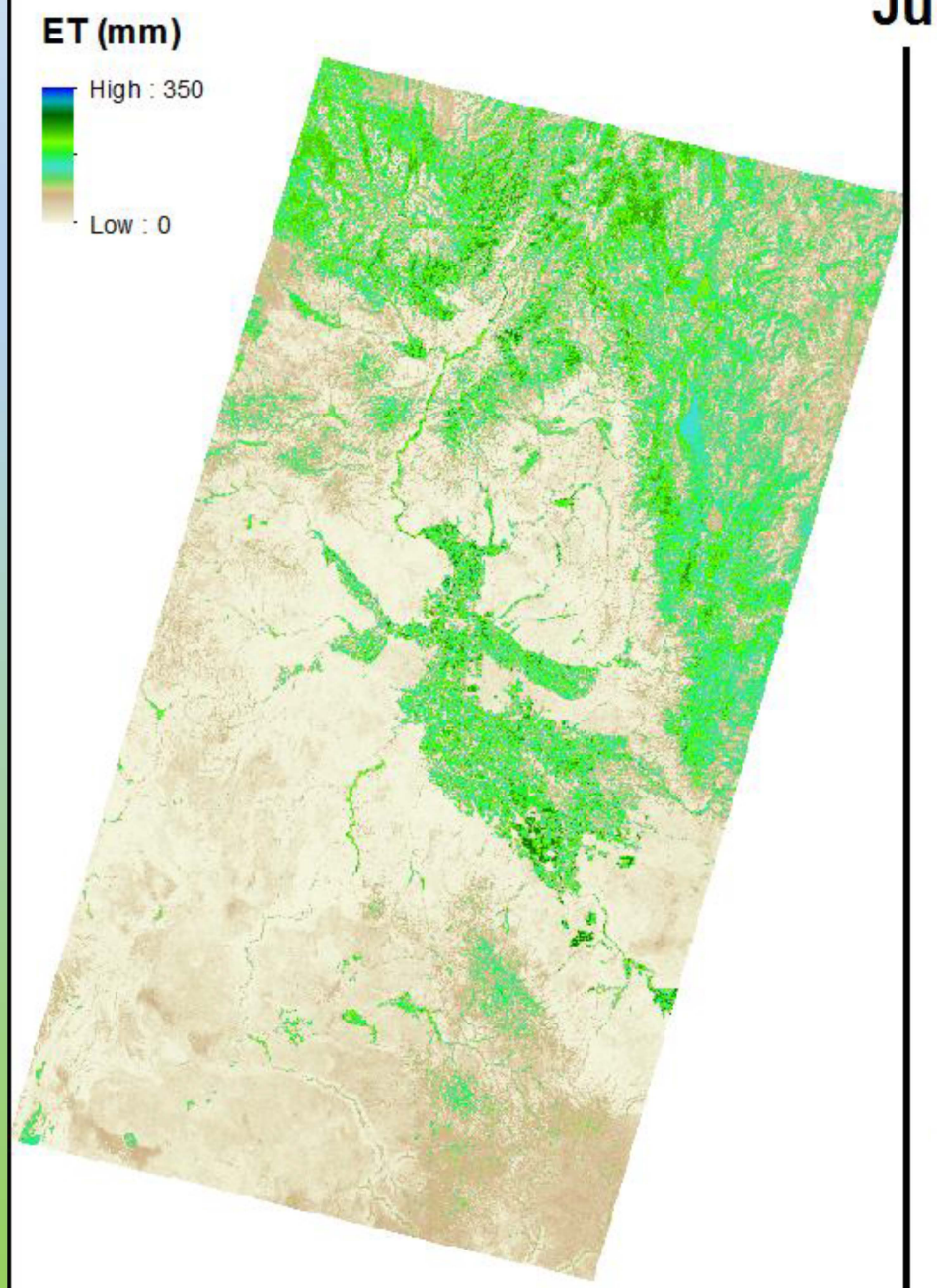


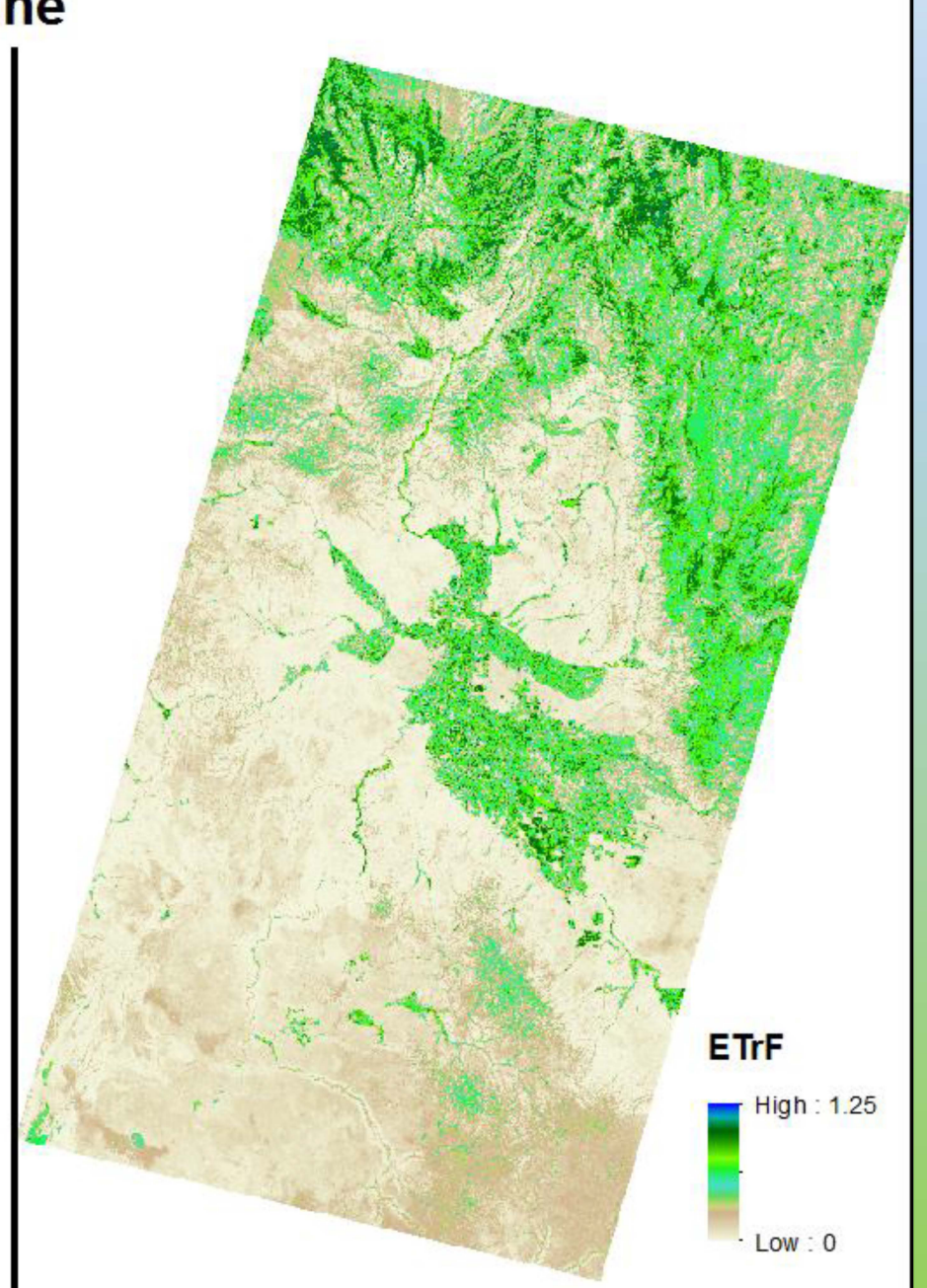
May



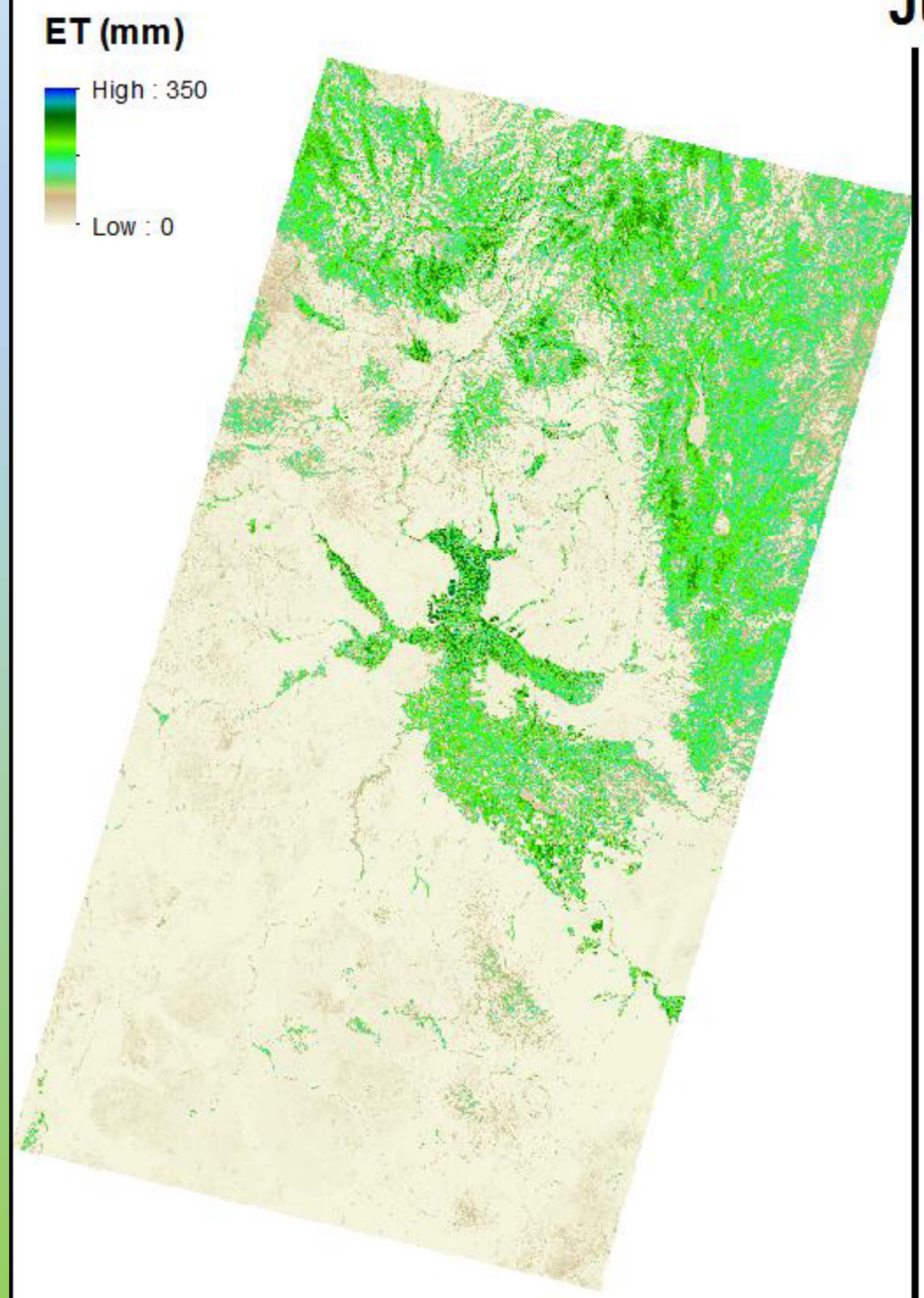


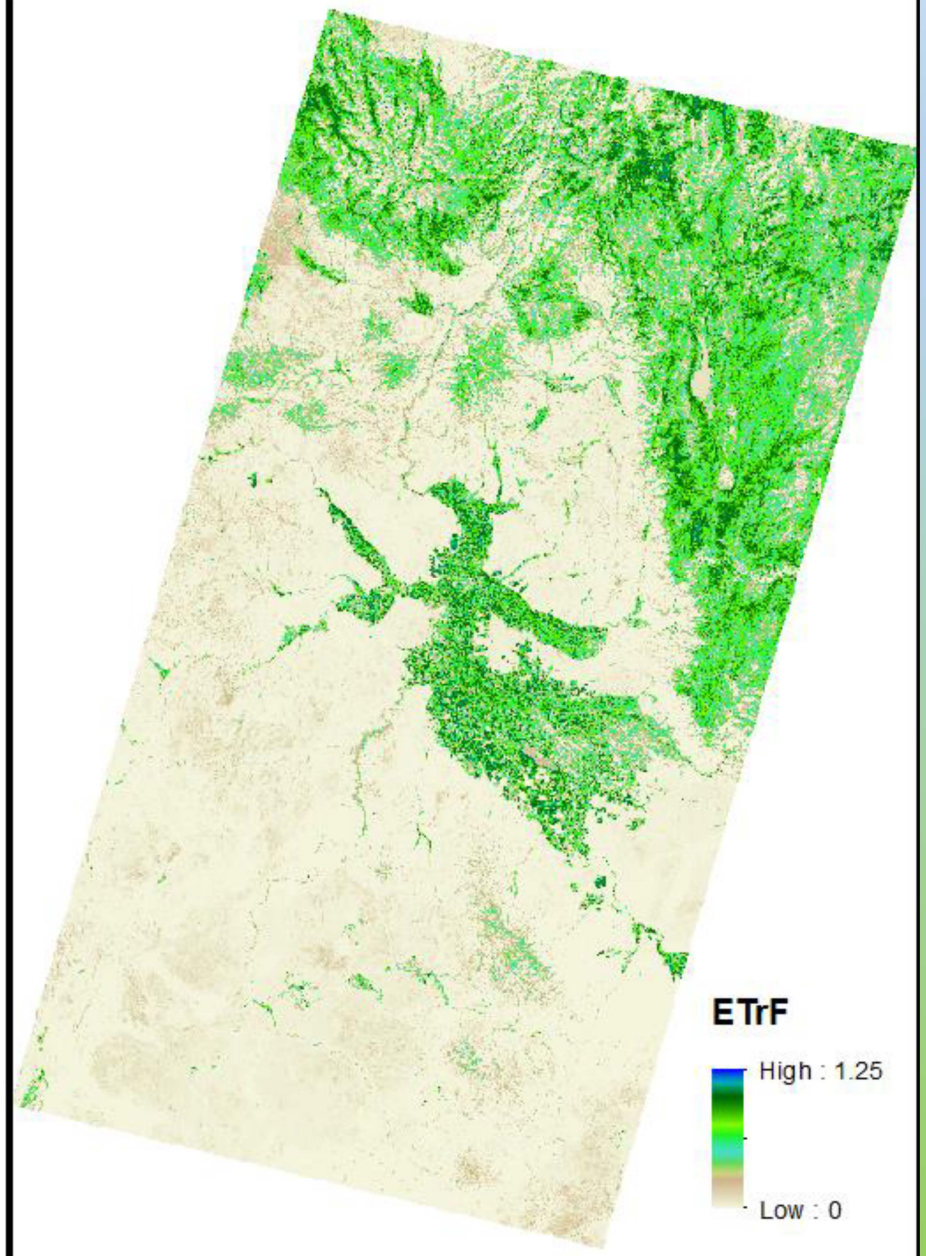
June



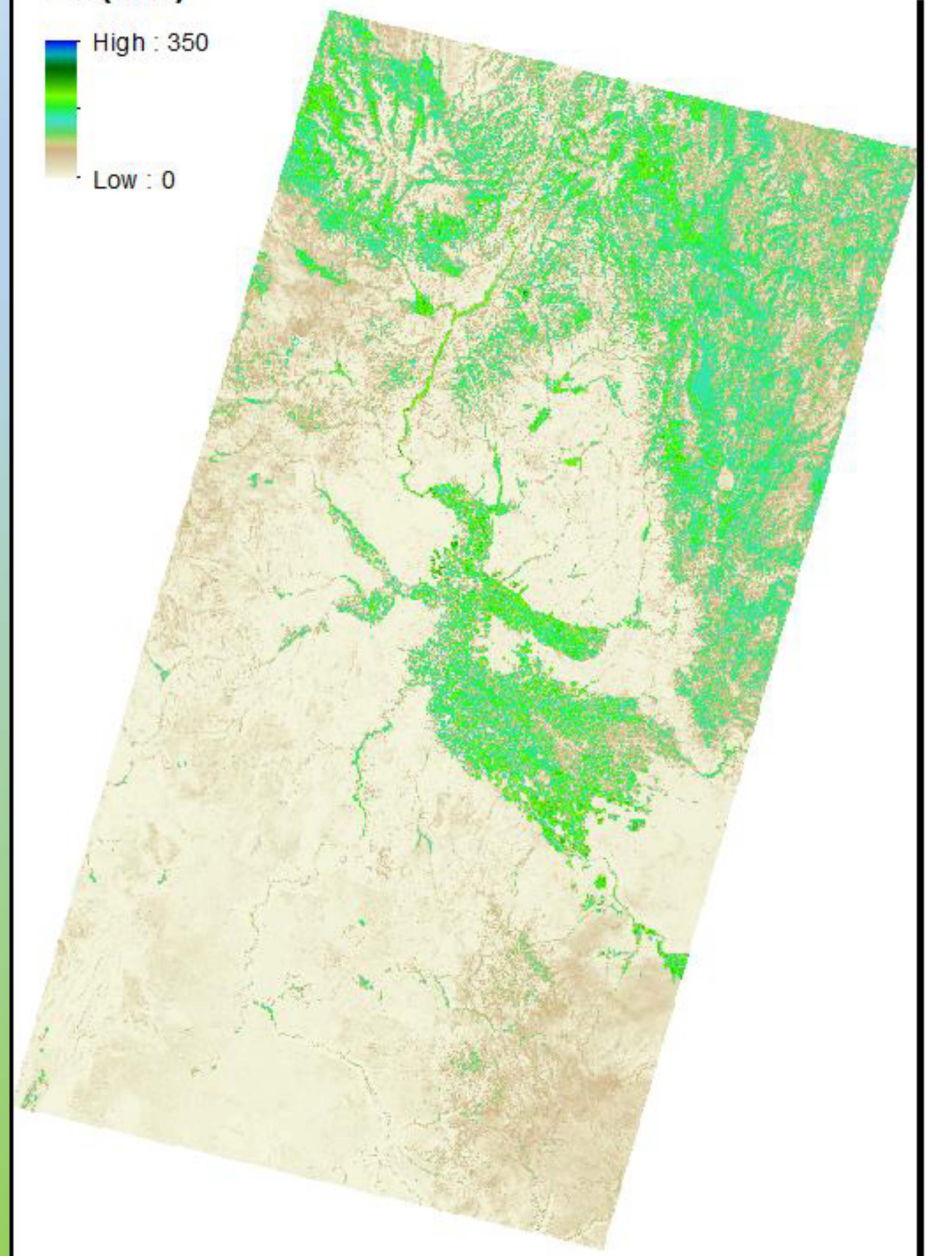


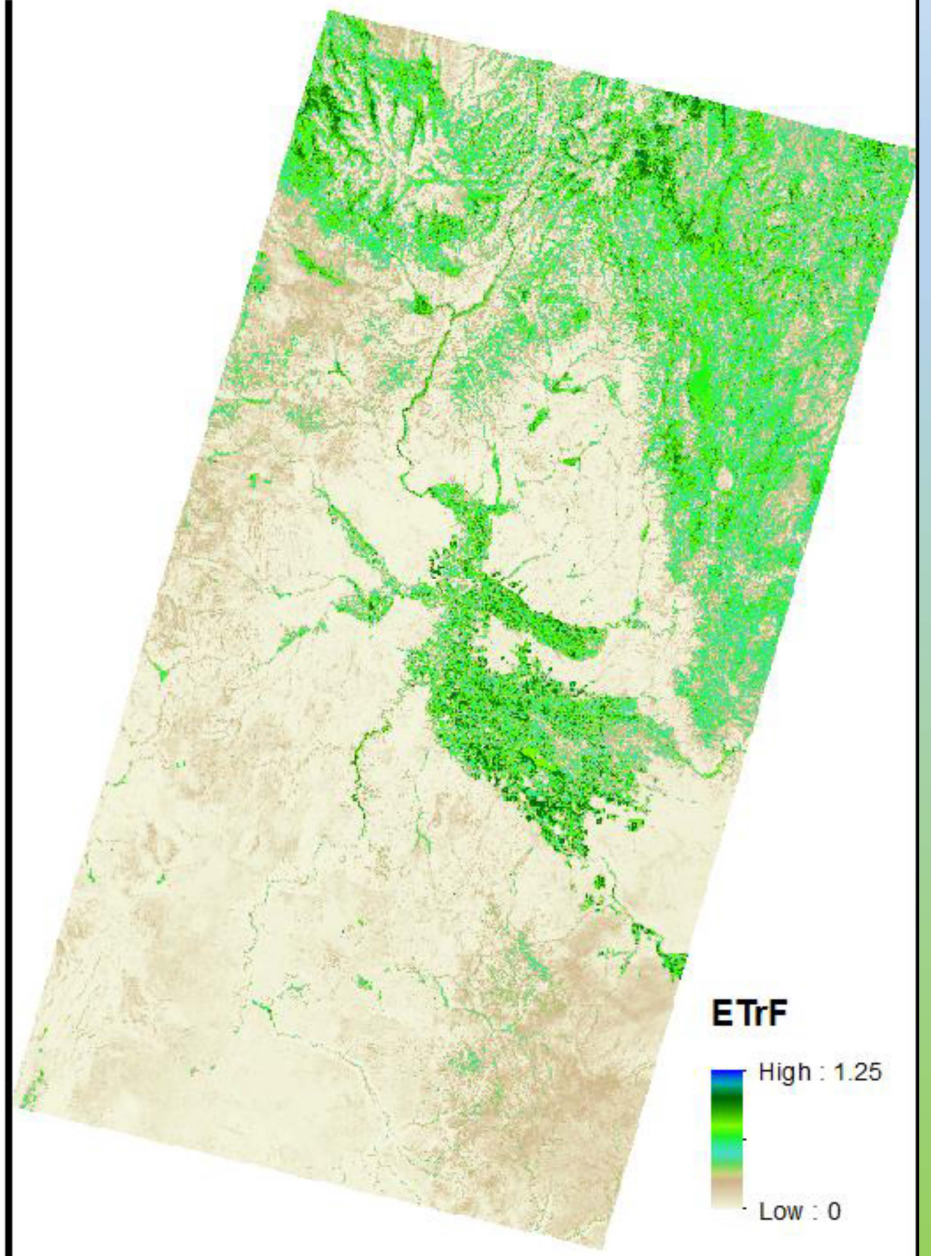
July



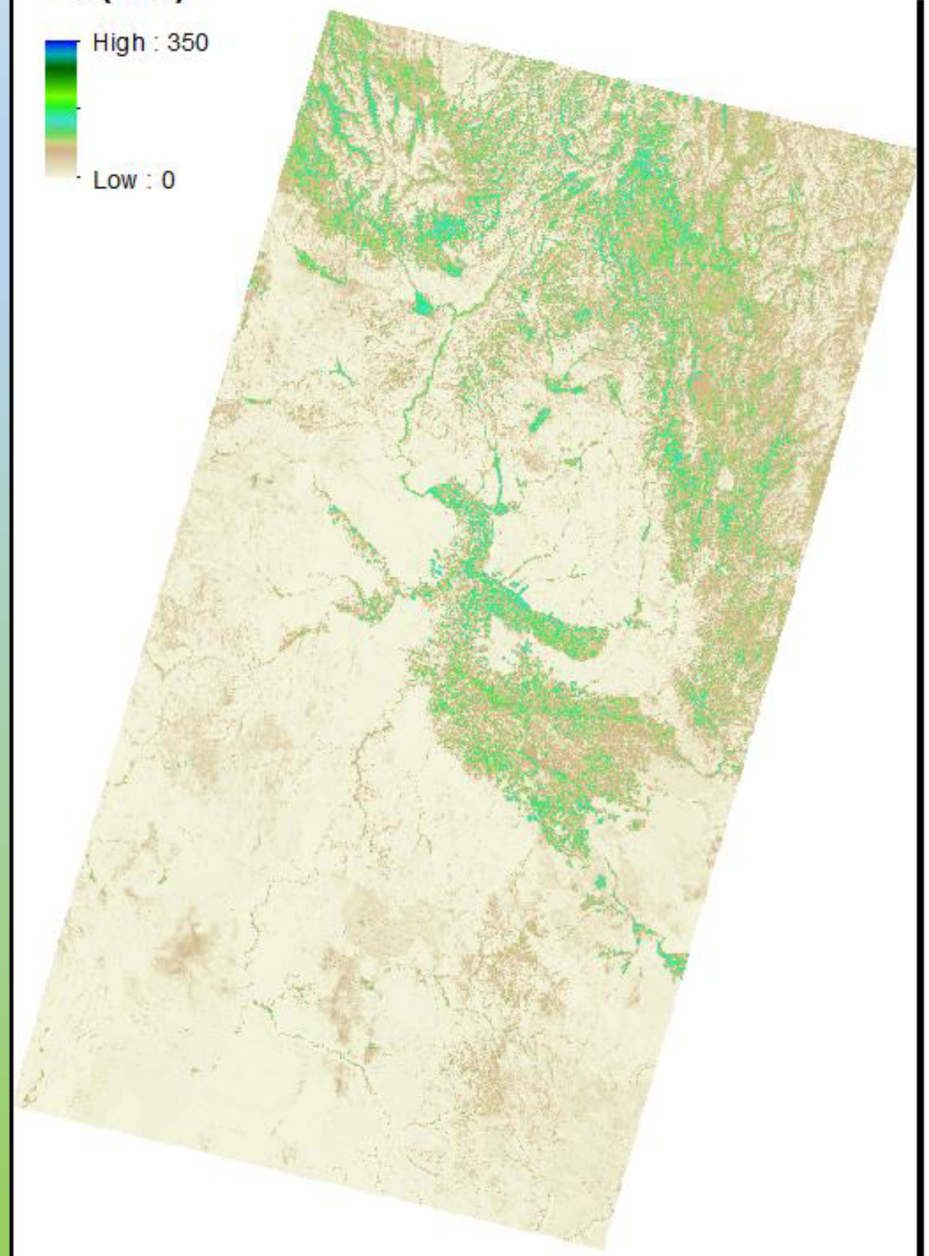


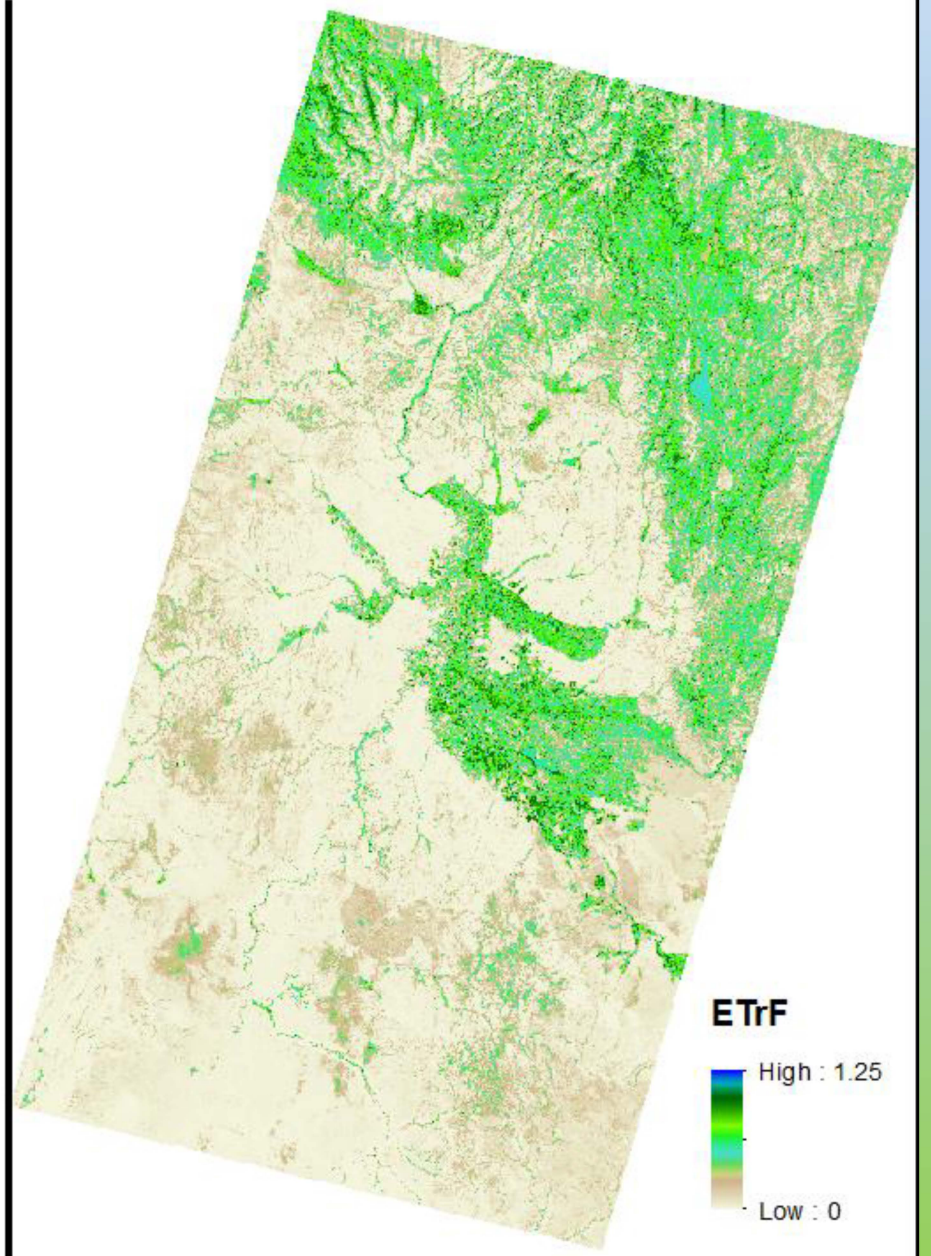
August



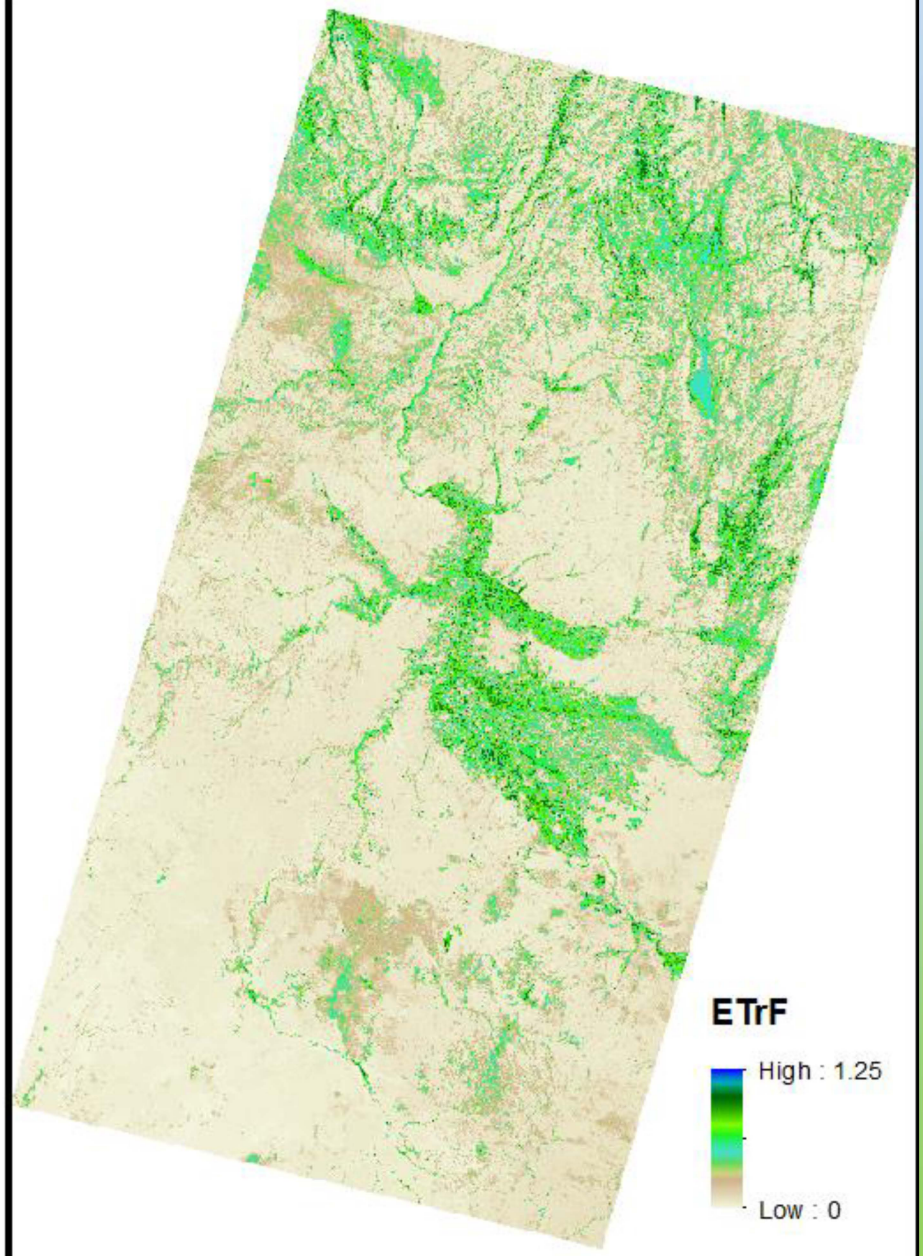


September

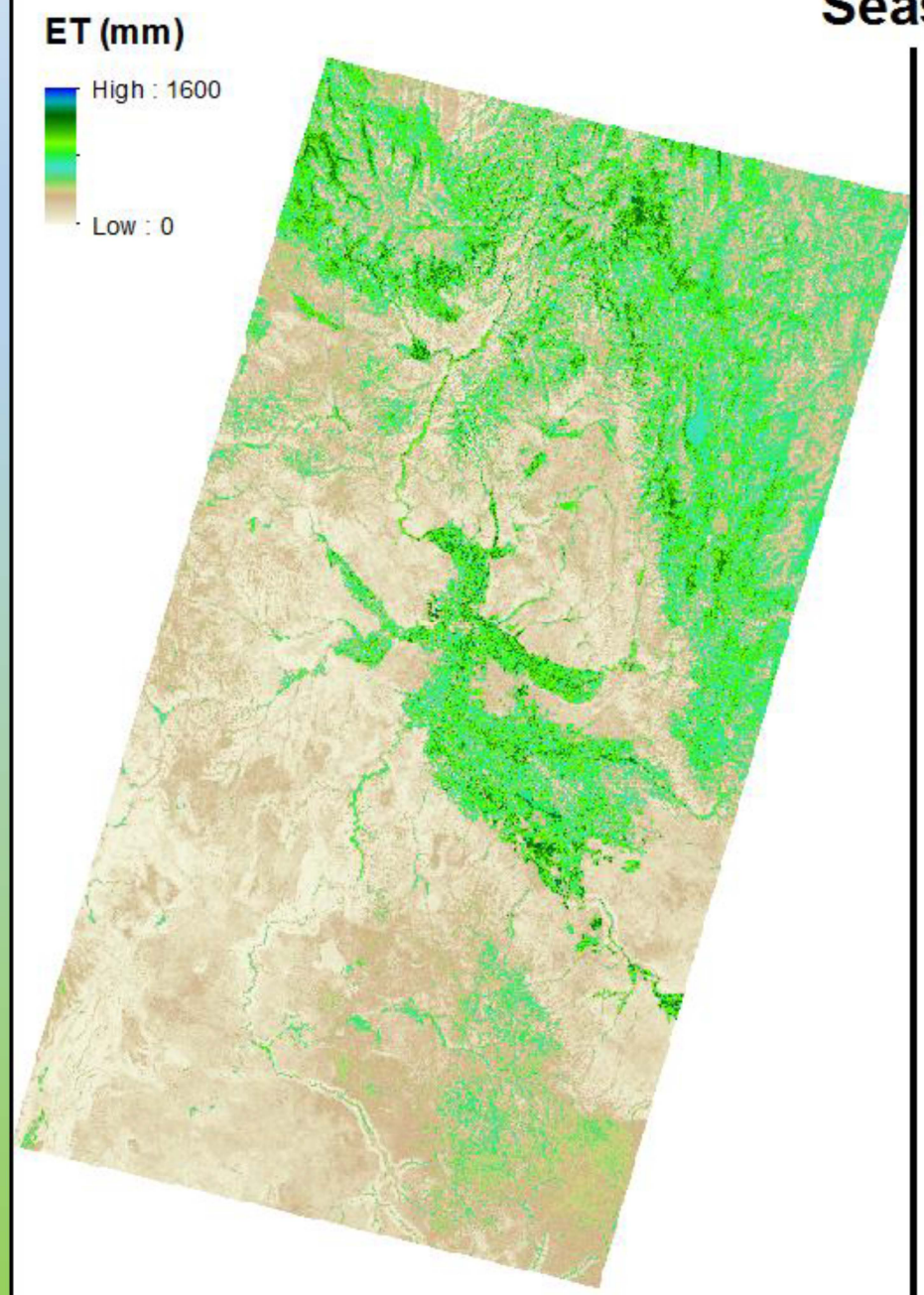


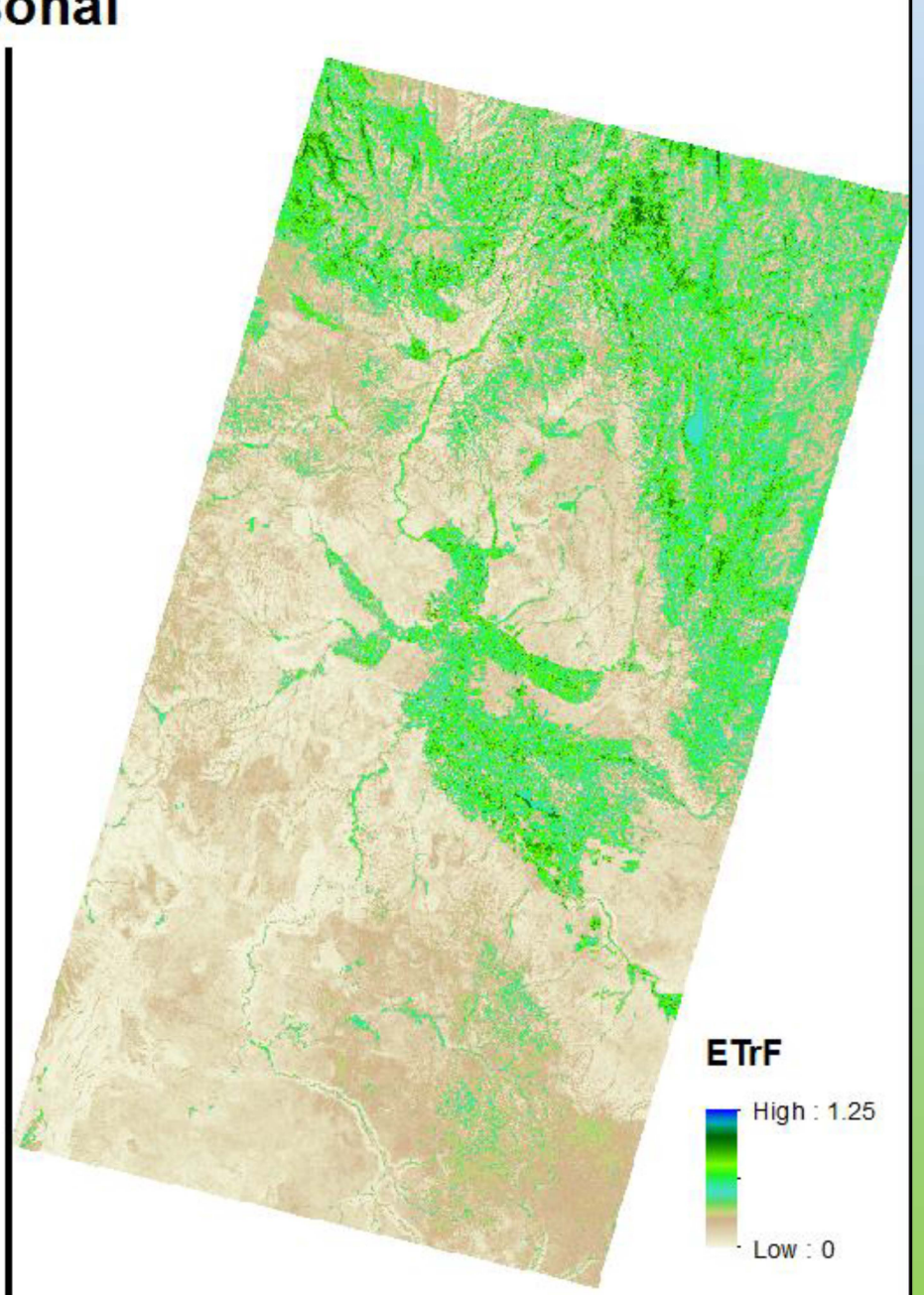


October



Seasonal





Daily Reference ET Surfaces

- Derived from weather data using the ASCE Penman-Monteith alfalfa reference method
- Primarily AgriMet stations are used with supplement from NWS Coop stations
- Stringent QA/QC is applied to the weather data
- Stations are screened to eliminate those impacted by substantial local aridity

Challenge: Consistency in station network among years for consistency in assessing changes in ET

- To assess change in ET between years, the ET*r* station network should use a consistent set of stations to generate ET*r* surfaces.
- Basic Approach in METRIC:

$$ET = ET_r F * ET_r$$

METRIC Interpolated images

Interpolated Surface from weather data

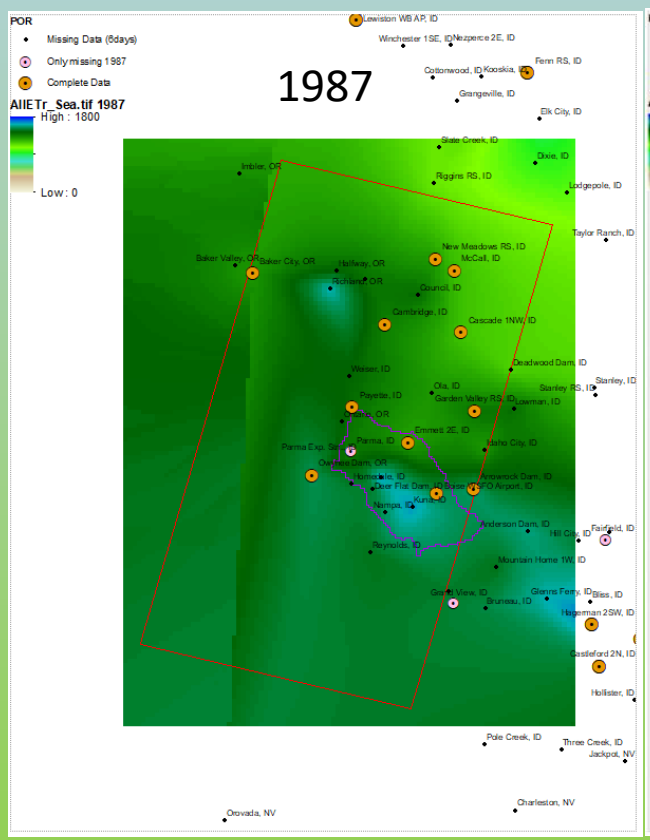
Daily Reference ET_r Surfaces

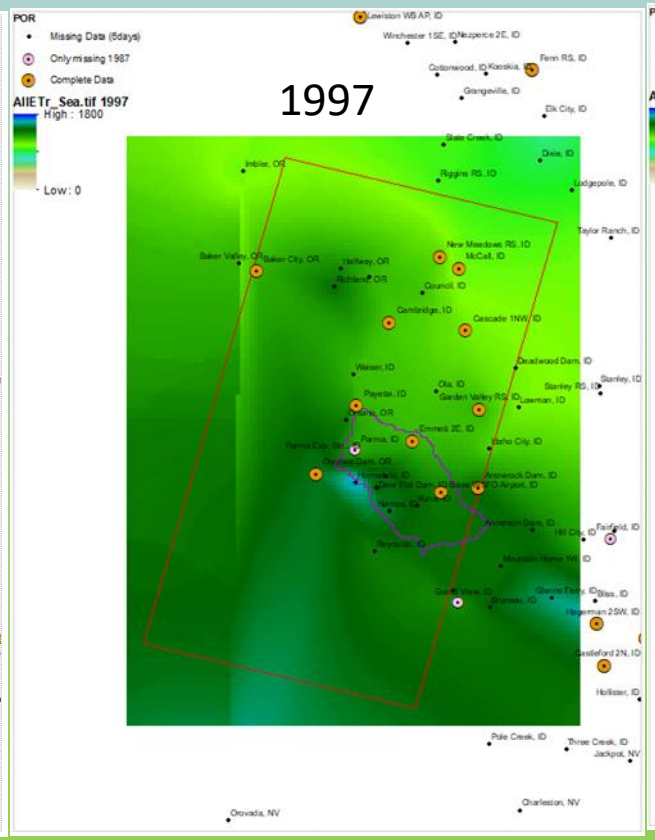
- Because ET_{Idaho} will be used in the non-METRIC years, only ET_{Idaho} stations were evaluated.
- 197 stations had periods of daily data for the METRIC processing years (1987, 1994, 1997, 2000, 2004, 2007, 2010, 2015) between March and October.
- Of those 197 stations, only 45 had at least 240 days of data in the March through October. No AgriMet stations qualified.
- When discounting 1987 and 1994, the station count increased to 78 with 6 AgriMet stations qualifying.
- Review of the various possible networks by looking at seasonal (March through October) reference ET.

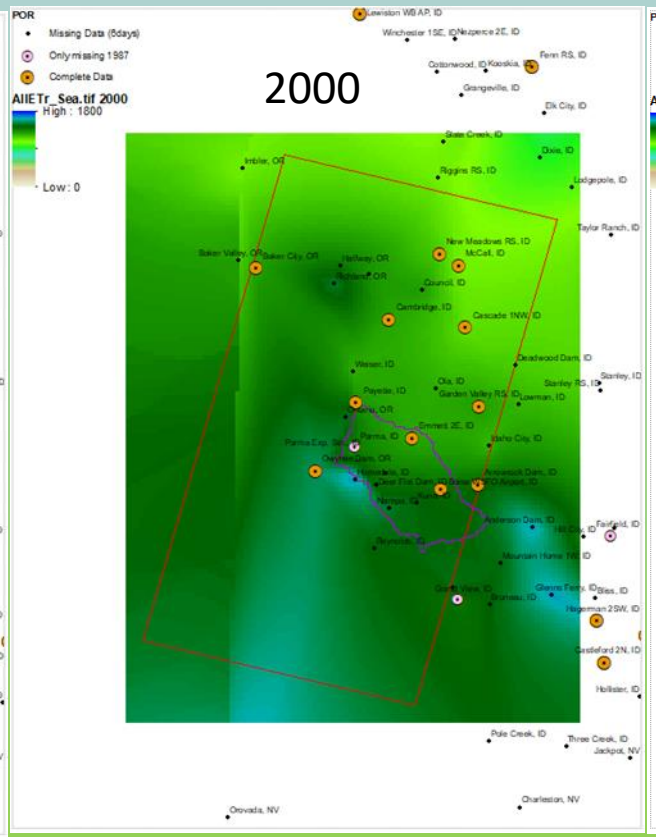
Results from filtered ET_r station network that used the same stations over time

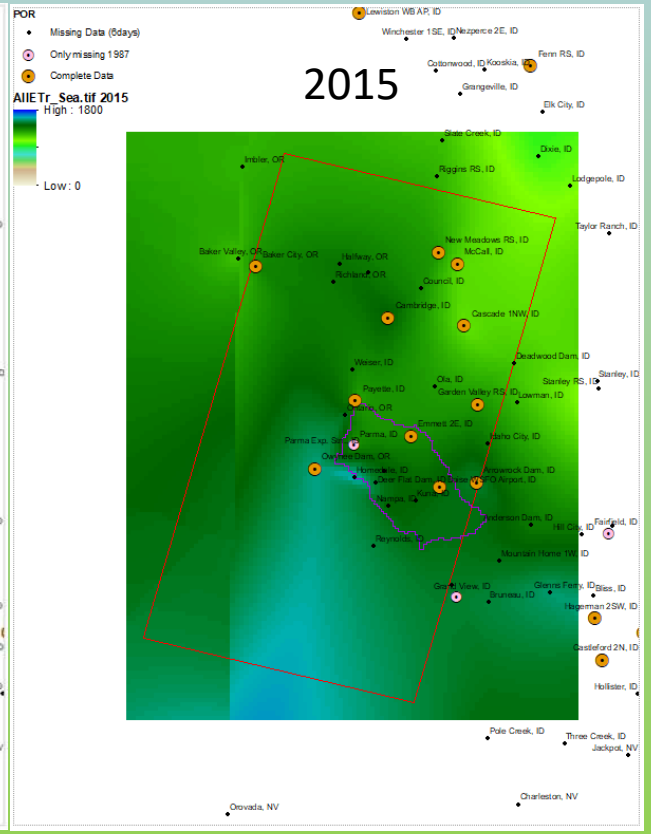
- A few recent stations were dropped for consistency
- Others were dropped to reduce local extremes (by aridity?)

Growing Season(March through October) reference ET



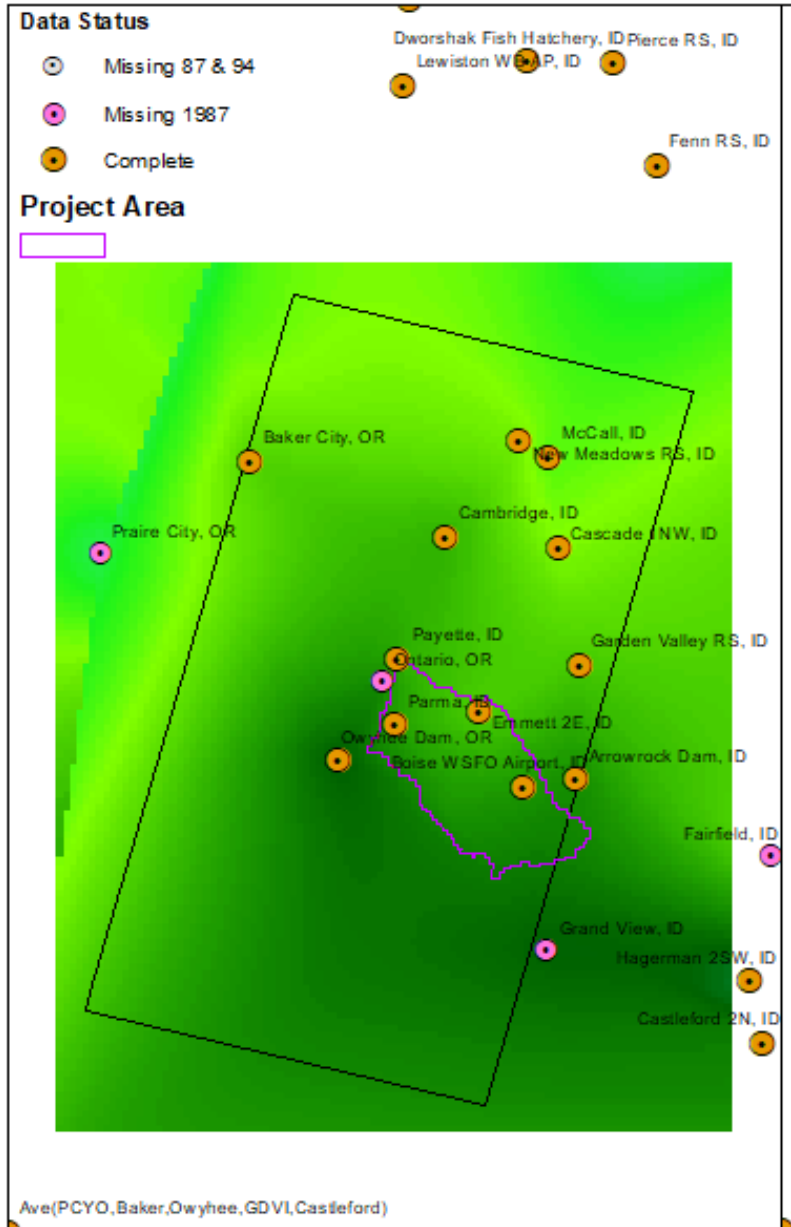




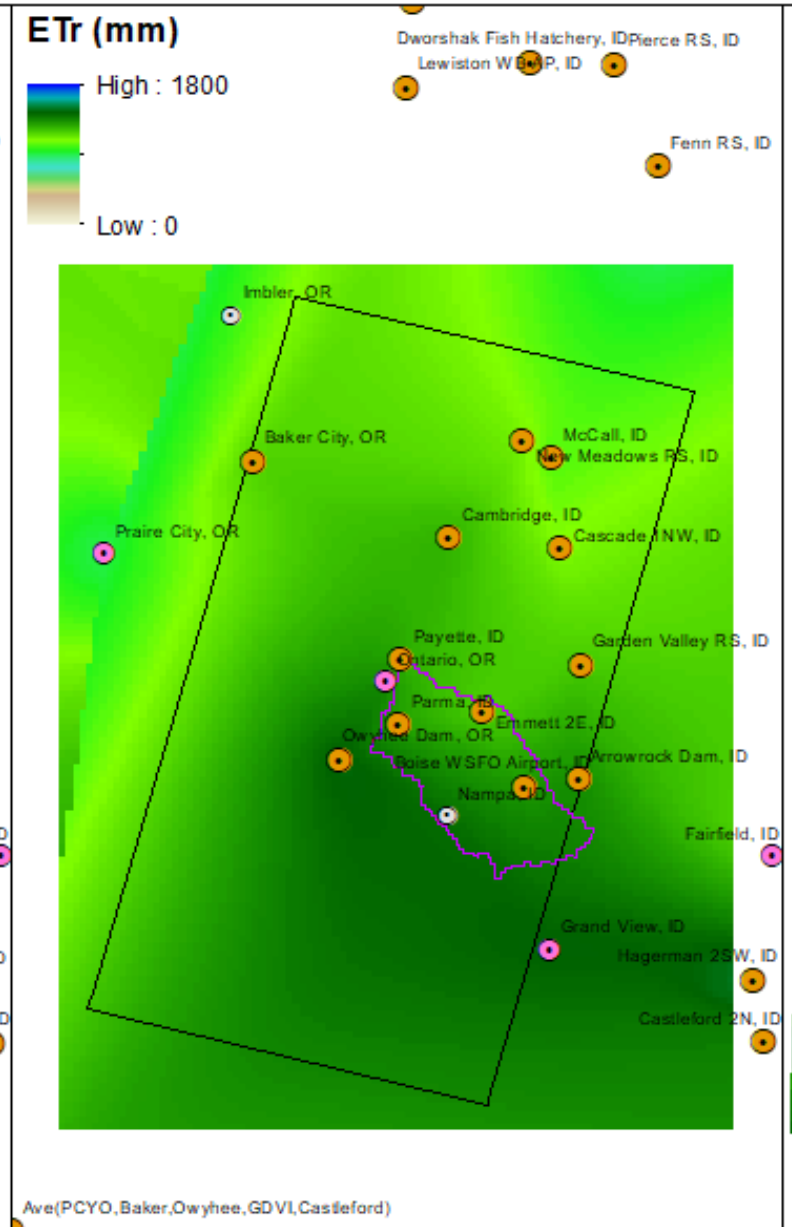


After review of ET_r surfaces, the two networks were reevaluated with the following modifications:

- The Homedale (NOAA Coop) station was discarded.
- The Parma AgriMet record was extended back to 1986. The station data did not have dew point temperature in the record until the summer of 1989.
- The Prairie City, OR, AgriMet daily ET_r was brought in.
- A combination of stations were used to create a “mirror” station in the southwest corner for interpolation purposes.
- Review included looking at GridMET seasonal ET_r surfaces for comparison of trends.



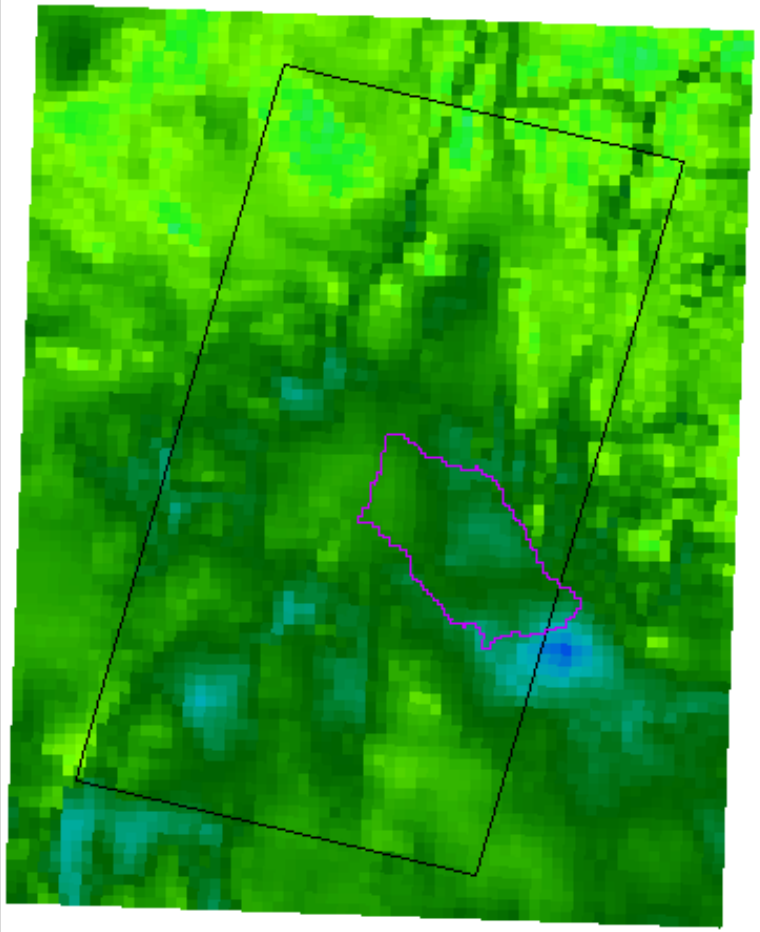
Based on stations having complete data 1994 thru 2015



2010 Mar-Oct ETr (mm)

Based on stations having complete data 1997 thru 2015

Impact of consistency range and Comparison with GridMET



GridMET (EarthEngine)

Treasure Valley Seasonal ET_r Surfaces Final Station Network

Name	Station Characteristics				Seasonal ETr (mm), March through October								
	Network	Latitude Degrees	Longitude Degrees	Elevation meters	1987	1994	1997	2000	2004	2007	2010	2015	Ave
Arrowrock Dam, ID	COOP	-115.916	43.600	968	1569	1546	1428	1430	1417	1488	1345	1509	1467
Baker City, OR	NWS	-117.809	44.843	1024	1321	1314	1256	1297	1245	1319	1181	1362	1287
Boise WSFO Airport, ID	NWS	-116.217	43.567	858	1535	1538	1369	1415	1385	1477	1319	1448	1436
Cambridge, ID	COOP	-116.683	45.567	808	1367	1309	1201	1281	1296	1372	1259	1449	1317
Cascade 1NW, ID	COOP	-116.050	44.533	1492	1214	1175	1115	1147	1093	1182	1086	1137	1143
Castleford 2N, ID	COOP	-114.867	42.550	1166	1488	1473	1442	1493	1435	1497	1371	1469	1458
Emmett 2E, ID	COOP	-116.467	43.867	728	1295	1286	1242	1263	1242	1298	1187	1346	1270
Garden Valley RS, ID	COOP	-115.917	44.067	945	1402	1353	1256	1305	1252	1351	1206	1311	1304
Grandview, ID	AgriMET	-116.056	42.912	768		1541	1341	1394	1438	1551	1449	1508	1460
Hagerman 2SW, ID	COOP	-114.933	42.800	883	1766	1825	1664	1625	1617	1702	1539	1603	1668
Imbler, OR	AgriMET	-117.967	45.433	838			1057	1118	1046	1256	1014	1261	1125
McCall, ID	COOP	-116.117	44.900	1530	1229	1221	1047	1104	1074	1133	1021	1166	1124
Nampa, ID	AgriMET	-116.637	43.442	824			1495	1498	1405	1542	1333	1440	1452
New Meadows RS, ID	COOP	-116.283	44.967	1177	1309	1298	1169	1202	1168	1258	1110	1315	1229
Ontario, OR	AgriMET	-117.015	43.978	689		1524	1386	1486	1402	1560	1352	1491	1457
Owyhee Dam, OR	COOP	-117.247	43.650	732	1545	1522	1488	1556	1494	1594	1457	1588	1530
Parma, ID	AgriMET	-116.933	43.800	703	1442	1196	1263	1379	1242	1380	1291	1329	1315
Payette, ID	COOP	-116.933	44.067	655	1407	1363	1248	1321	1290	1301	1259	1297	1311
Prairie City, OR	AgriMET	-118.628	44.441	1145		1114	1015	1012	939	978	908	1116	1012
Mirrored SW Station	--	-118.927	41.680		1656	1629	1498	1525	1516	1615	1481	1566	1561

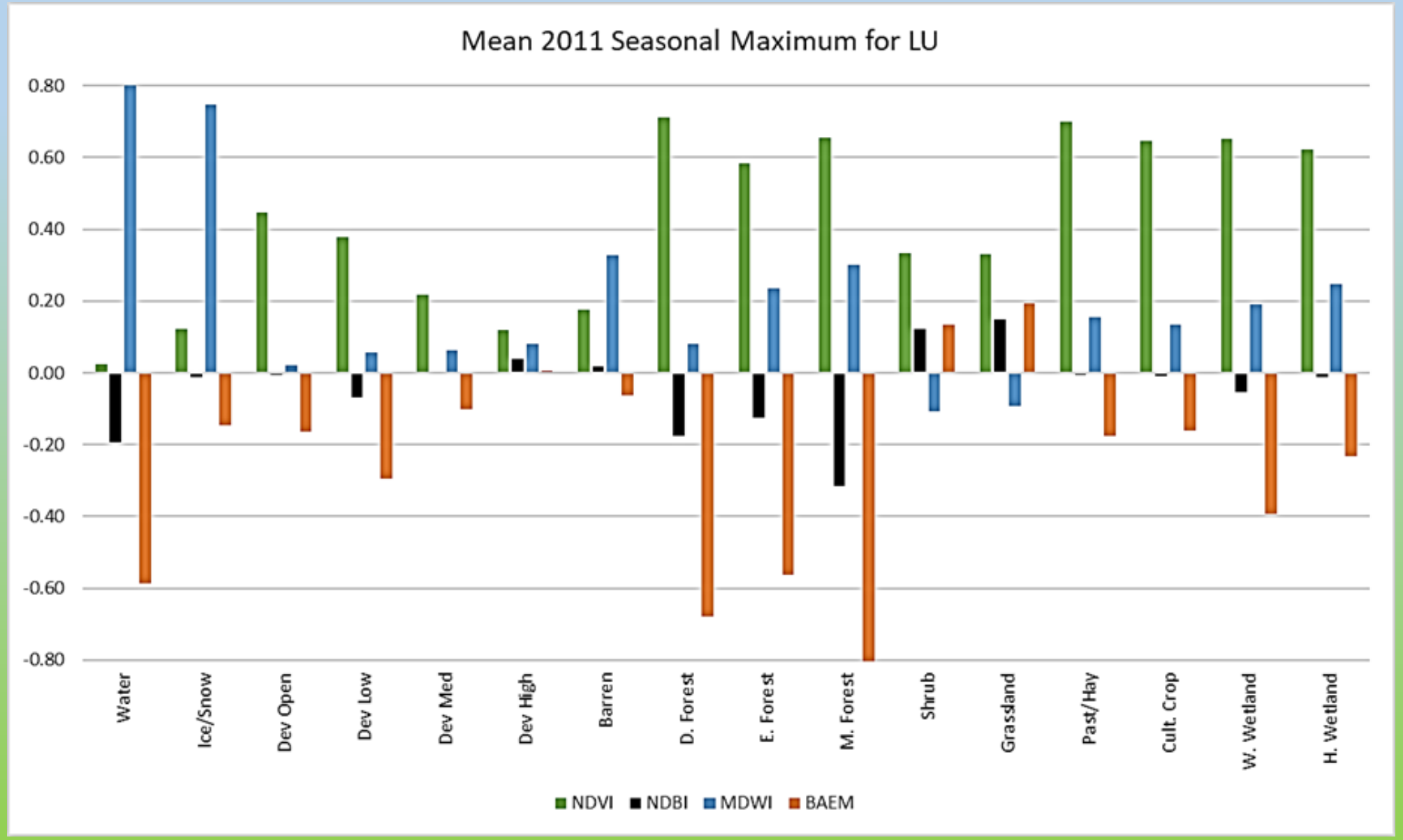
Land Use Modifications for 2015 and 1987.

- Purpose: Adjust the 2011 and 1992 NLCD land use maps to better reflect land use conditions (ag. vs. city) for 2015 and 1987.
- Determination of LU was based on mid-June through mid-July maximum spectral indices, including NDVI, using averages for irrigation polygons.
- Control based on irrigation status coverage supplied by IDWR.
- For 2015, the base land use was the NLCD 2011 dataset
- Focus was limited to the Treasure Valley Aquifer area.
- 2015 was the test year where the 2015 NAIP could be examined.
- For 1987, the base land use was the 1992 NLCD supplemented with NLCD.
- Modification rule set was based on 2011 indices and land use.

Evaluation of vegetation and other indices to identify residential/city etc. based on the average seasonal maximum index during 2011

- NDVI = Normalized difference **vegetation index**
- NDBI = Normalized difference **built-up index**
- MDWI = Modified normalized difference **water index**
- BAEM = **Built-up area** extraction method

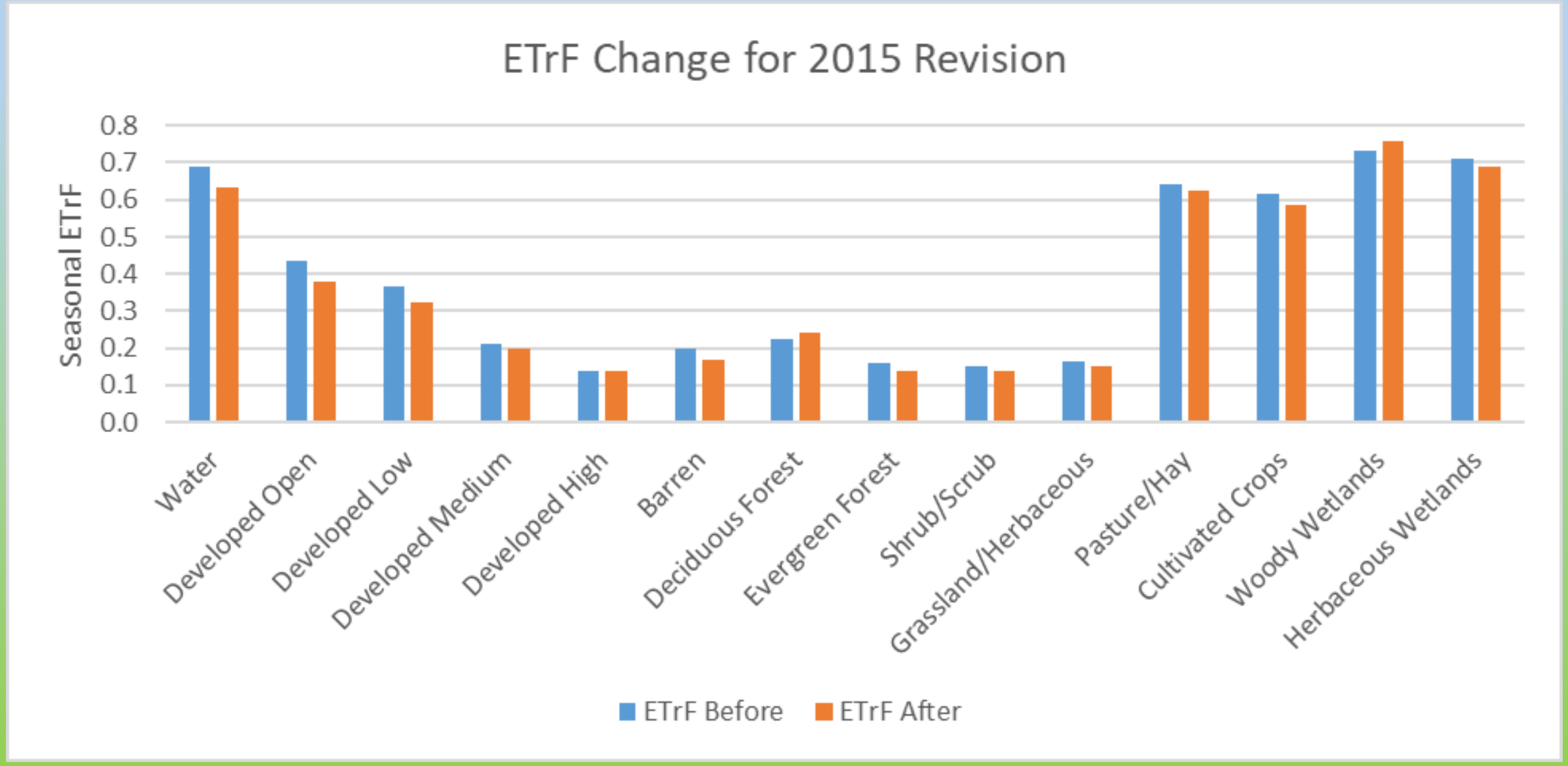
Non-NDVI results were inconclusive



Some of the general rules for separating agriculture from residential/city:

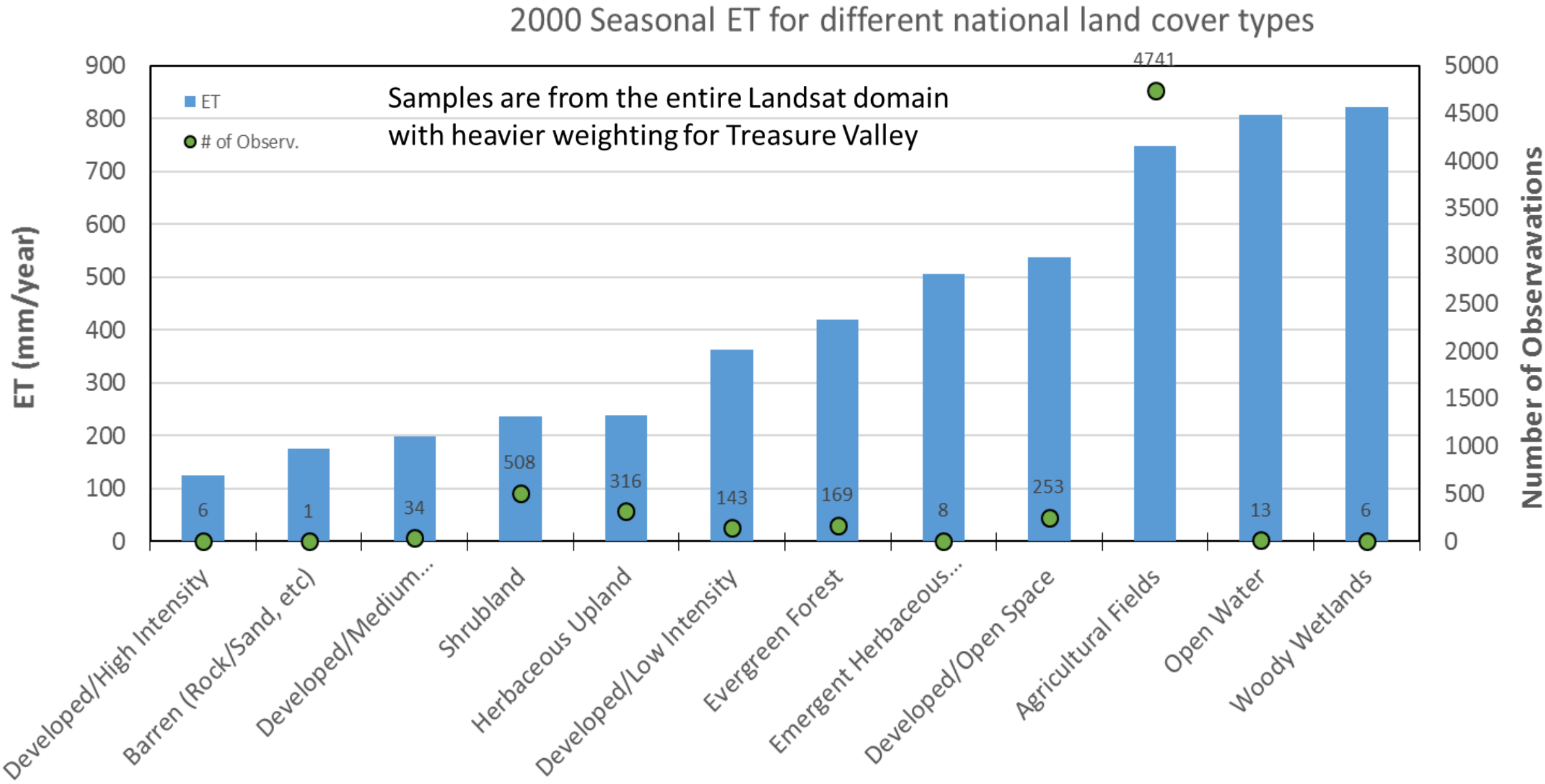
- If the polygon was classified as irrigated, it was assigned agricultural land use.
- If the polygon was classified as semi-irrigated, preference went to development.
  - Except for very high NDVI with agricultural pixels present in 2011.
  - If “native” land use was the majority in 2011, a “native” land use was assigned.
- If the polygon was classified as non-irrigated, preference was to “native” land use.
  - If “developed” land use was the majority for 2011, developed use was assigned.

Area-wide ET_rF before and after Land Use Revision - 2015

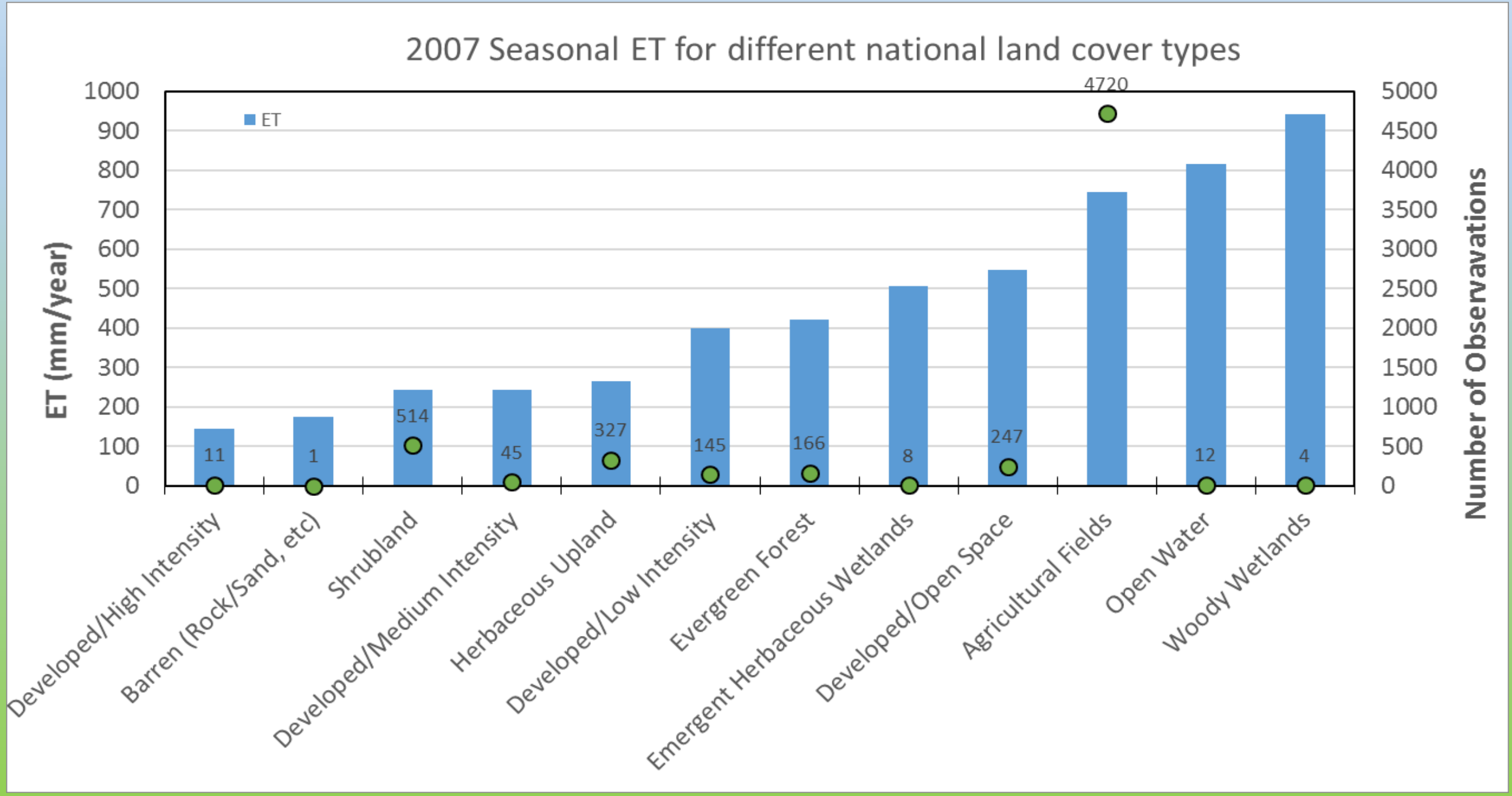


Water Consumption Patterns by Land Use Type

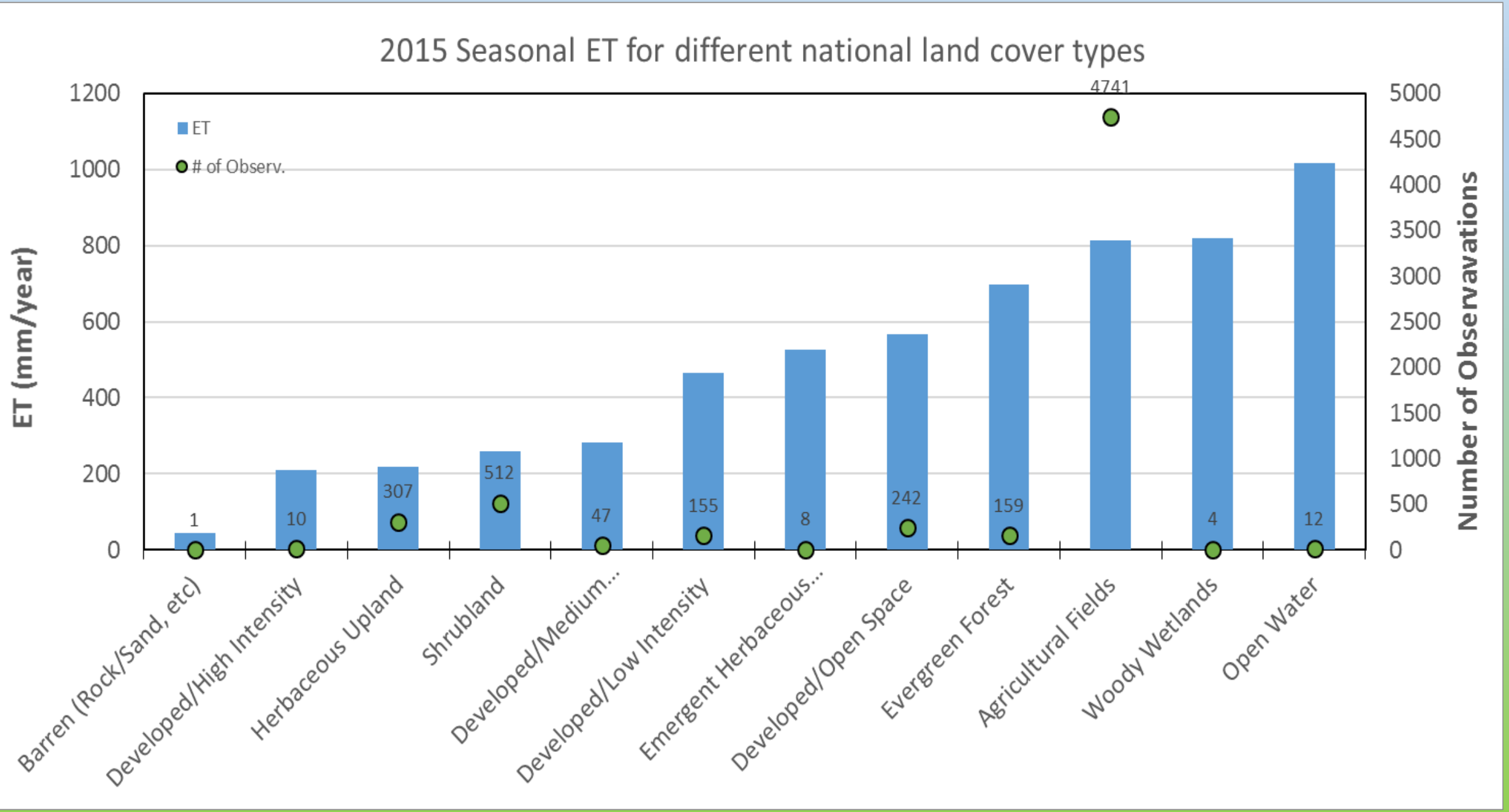
2000 Treasure Valley – March-October



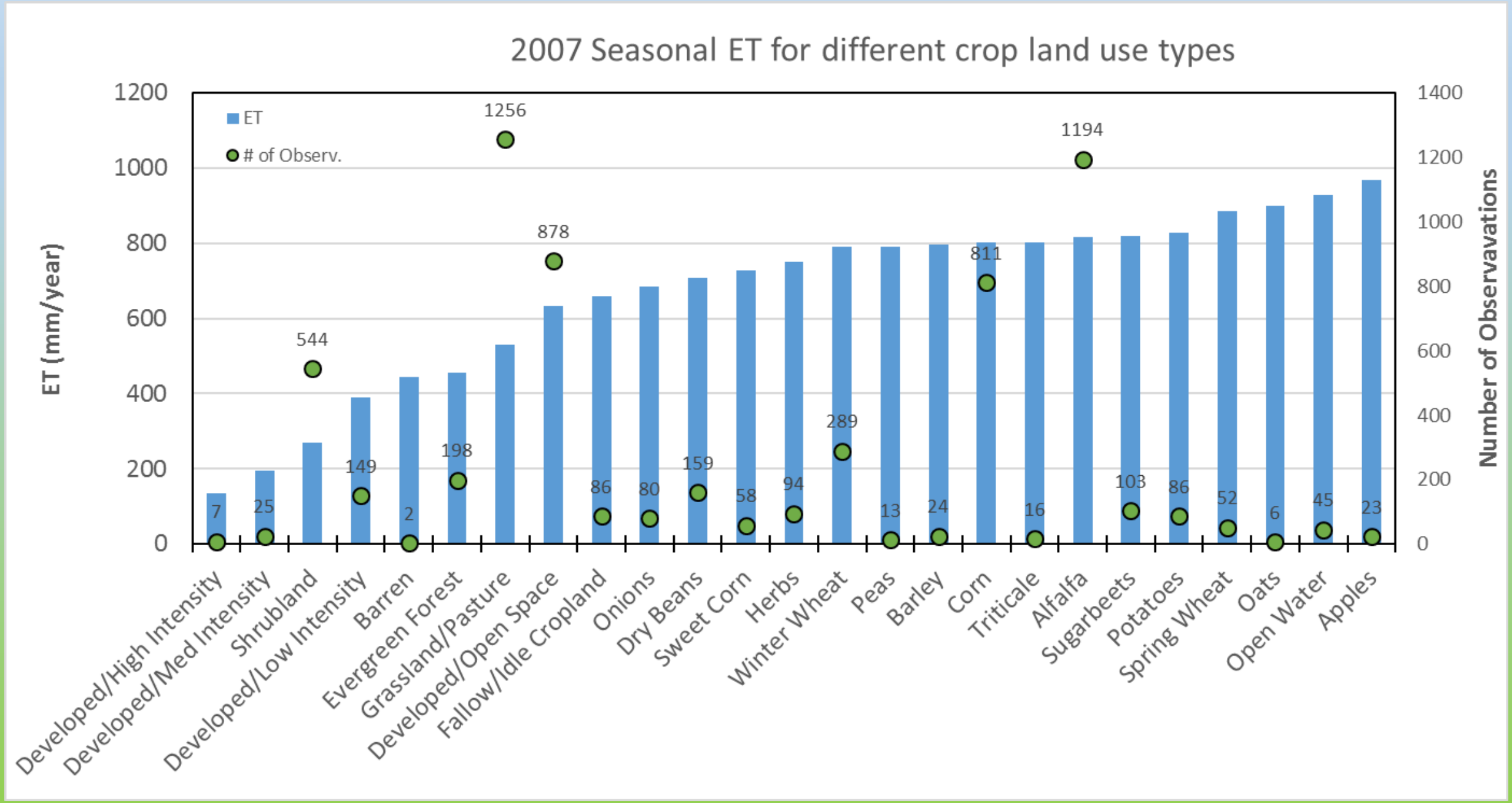
2007 Treasure Valley – March-October



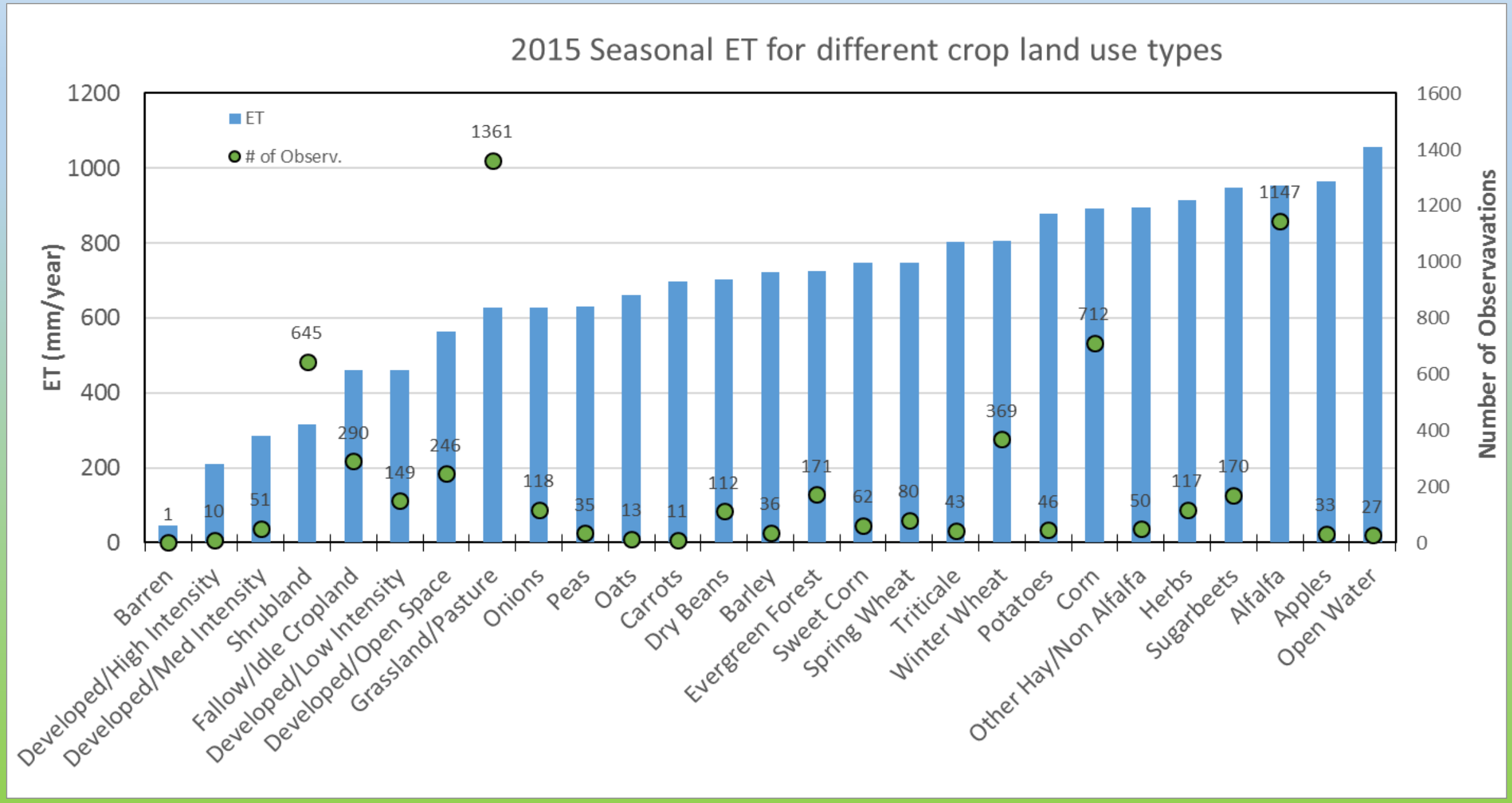
2015 Treasure Valley – March-October



2007 Treasure Valley – March-October

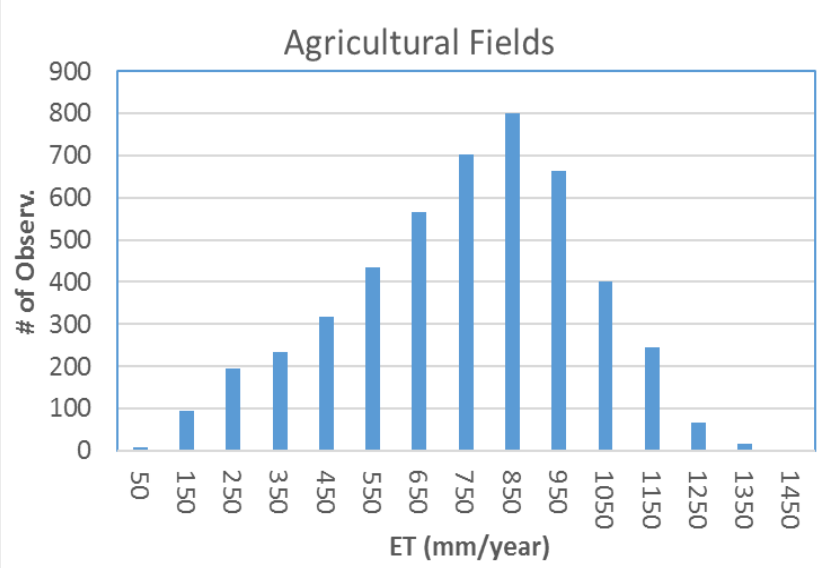


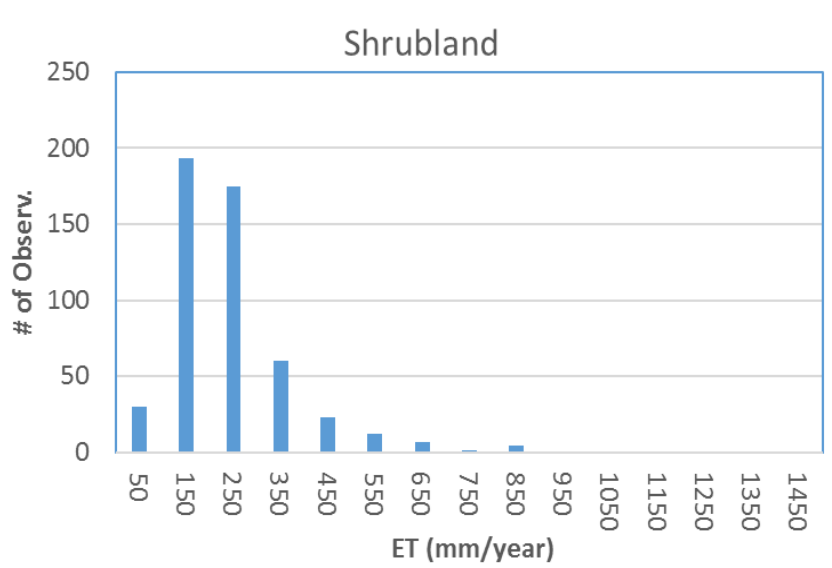
2015 Treasure Valley – March-October

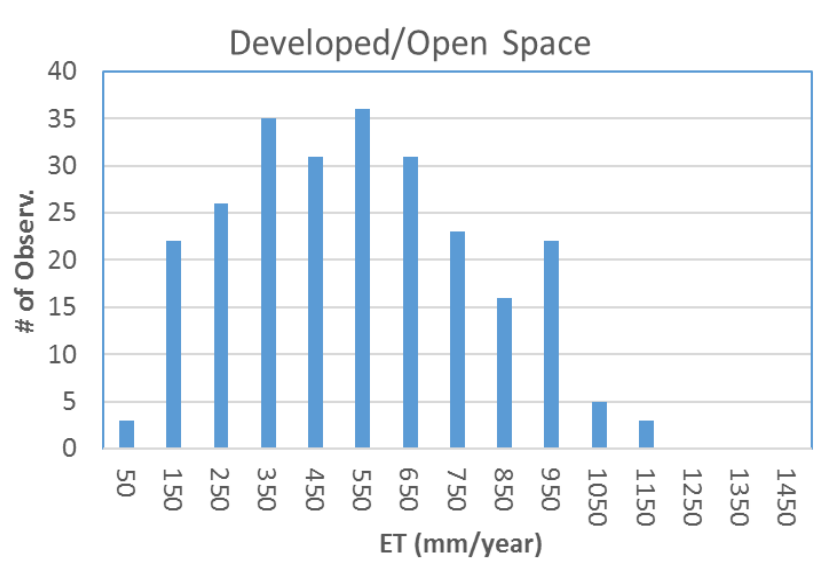


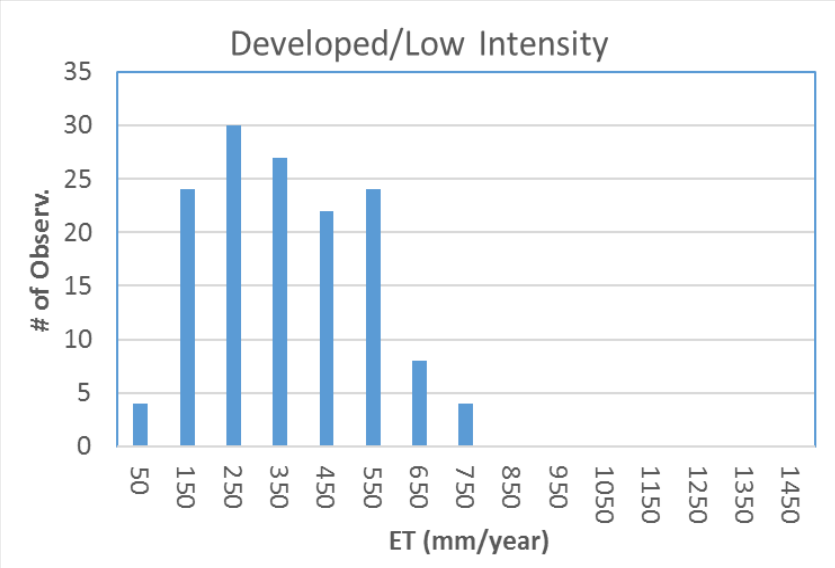
2000 Treasure Valley – March-October

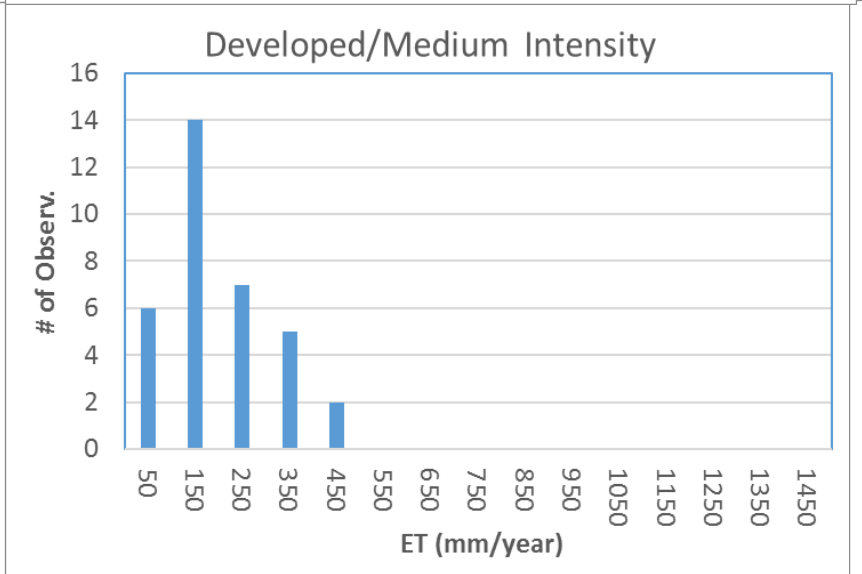
Distribution of Growing Season ET by Field, year 2000

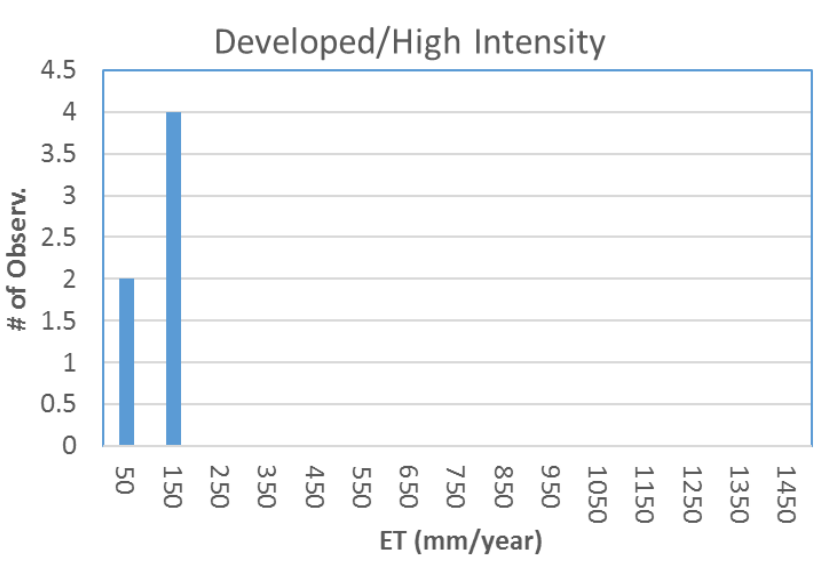






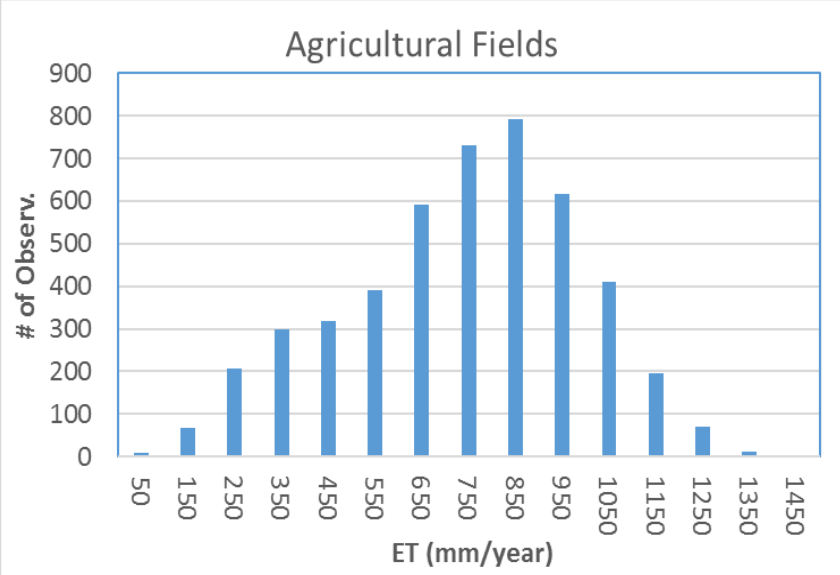


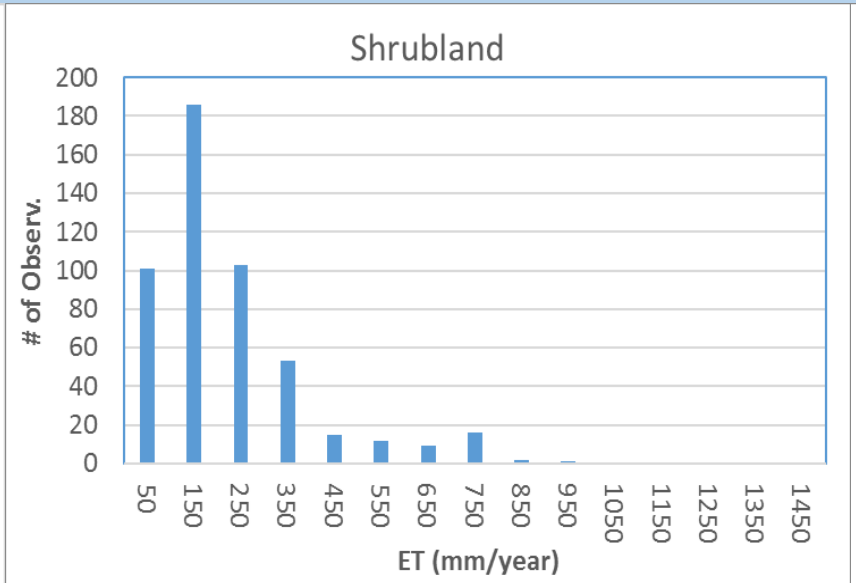


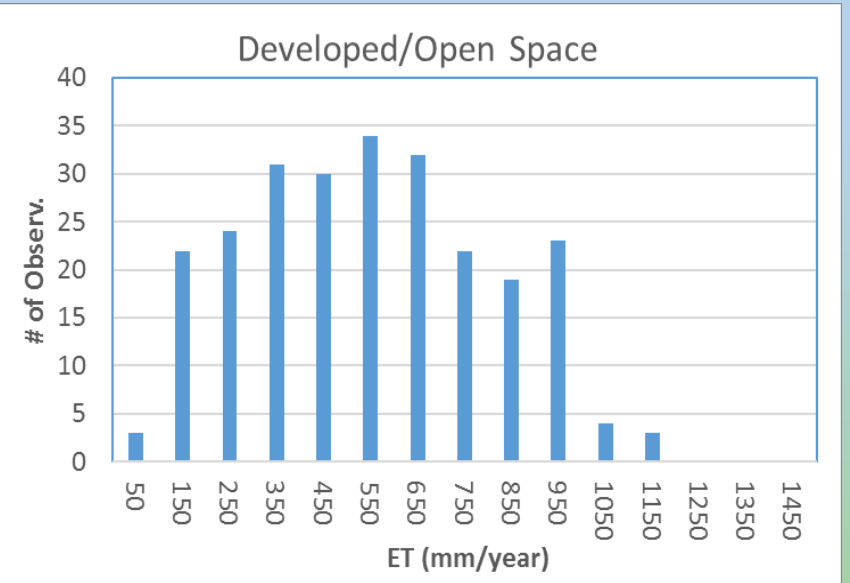


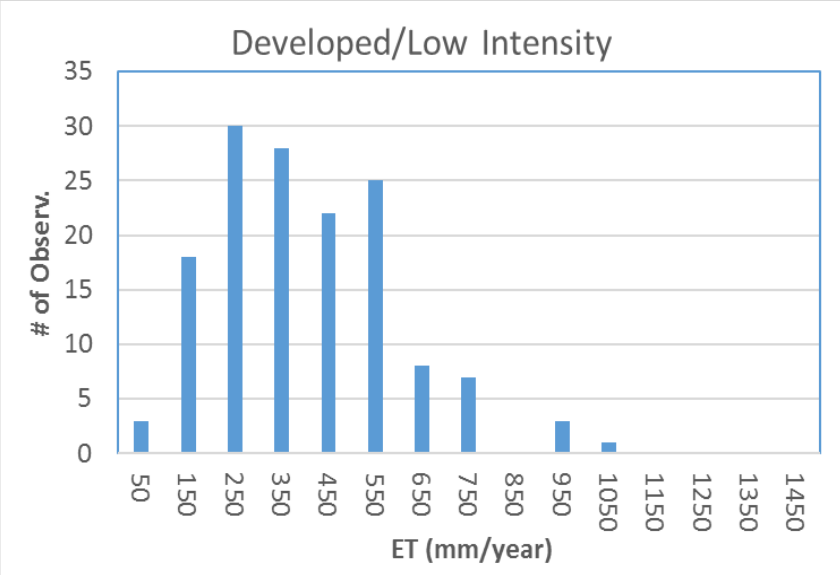
2007 Treasure Valley – March-October

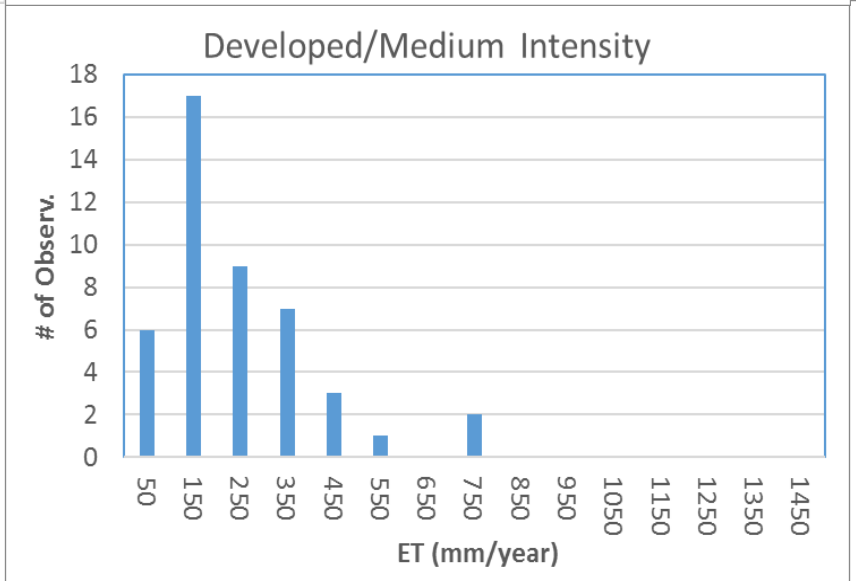
Distribution of Growing Season ET by Field, year 2007

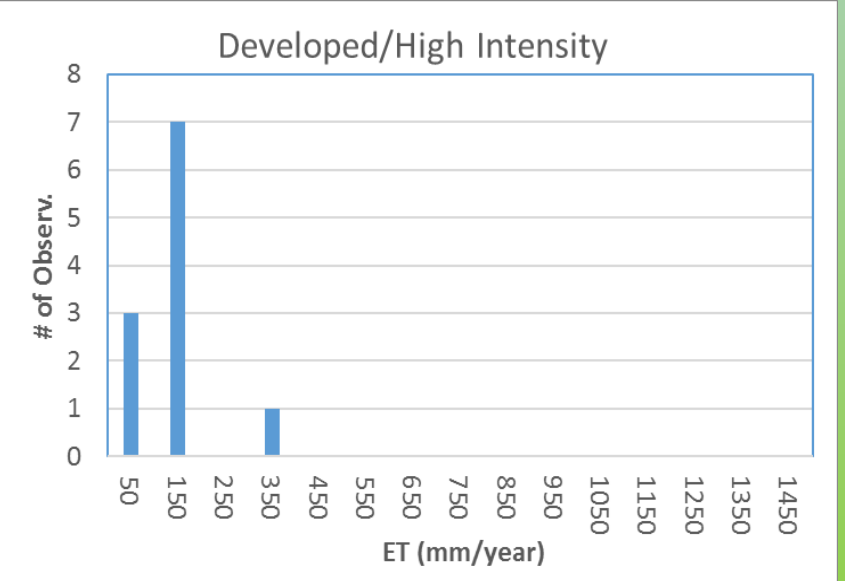






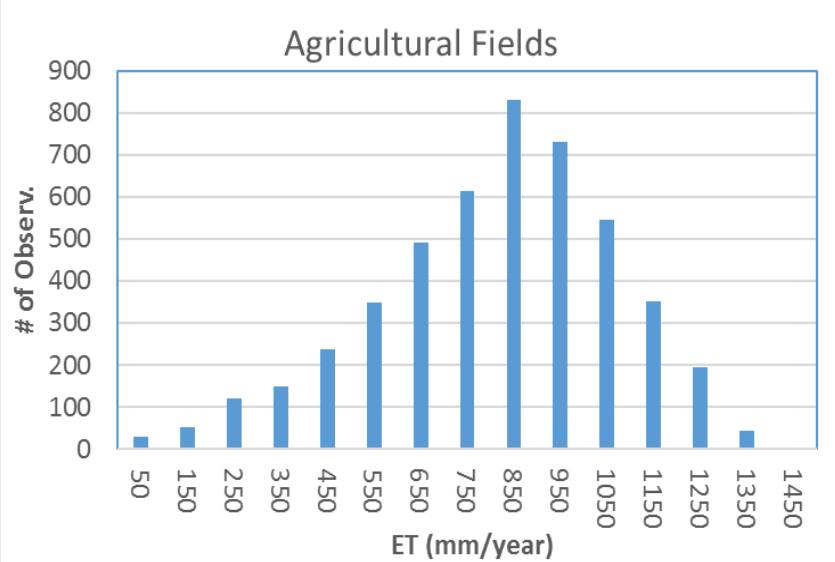


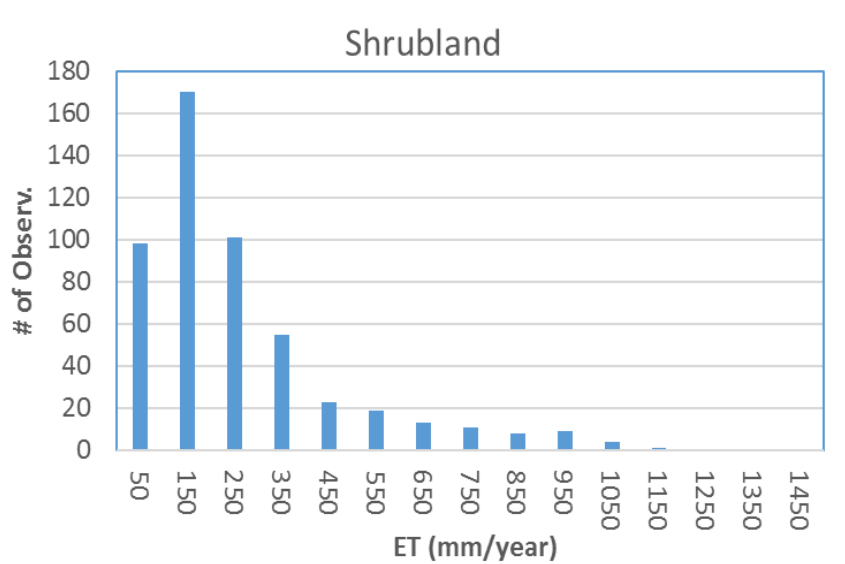


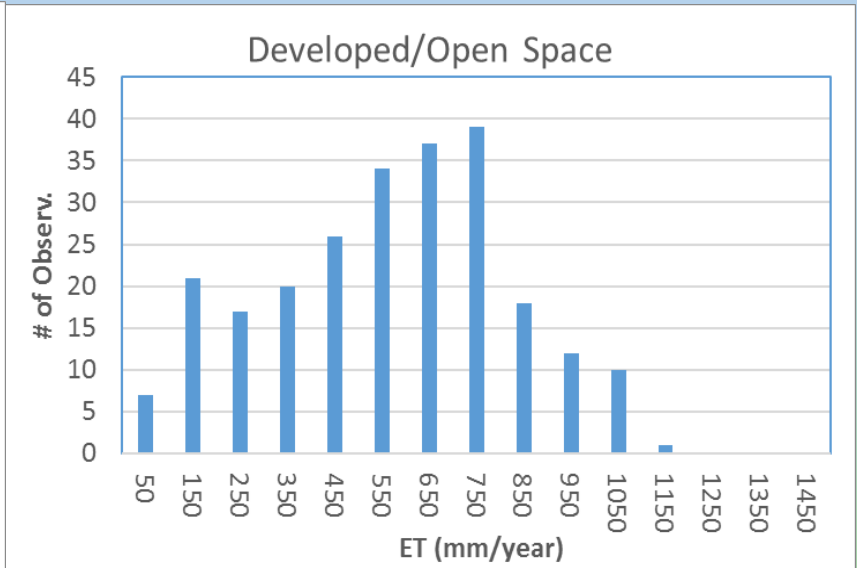


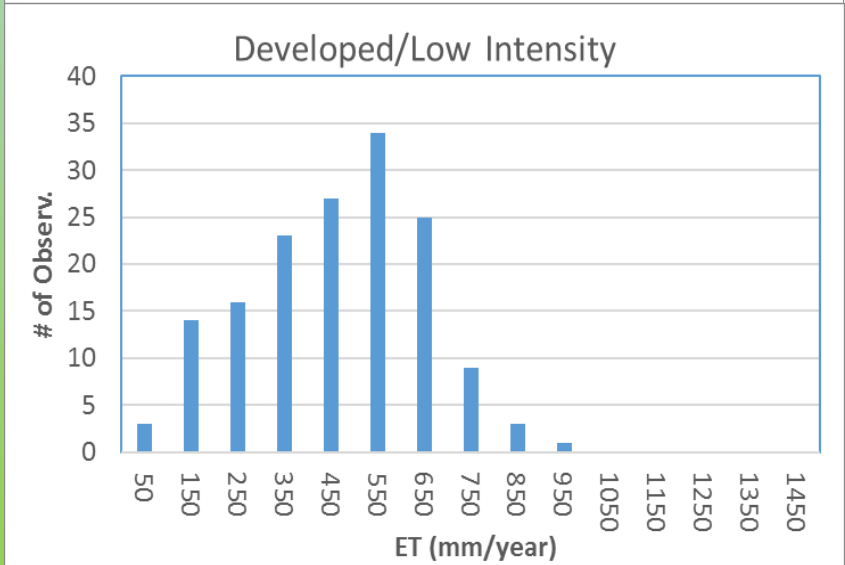
2015 Treasure Valley – March-October

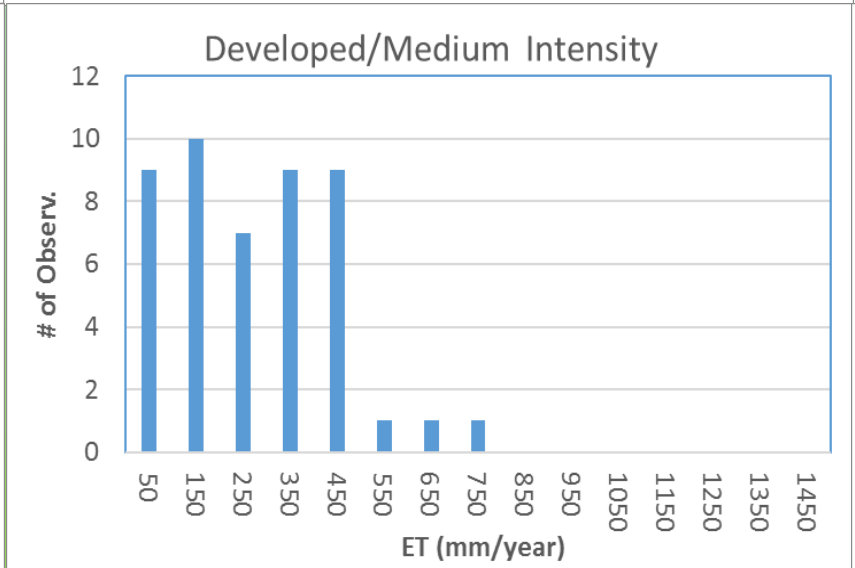
Distribution of Growing Season ET by Field, year 2015

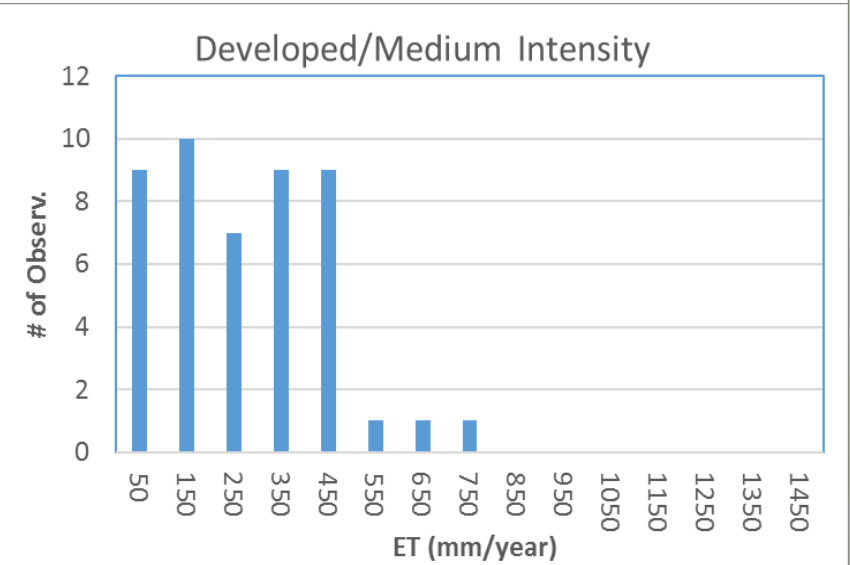








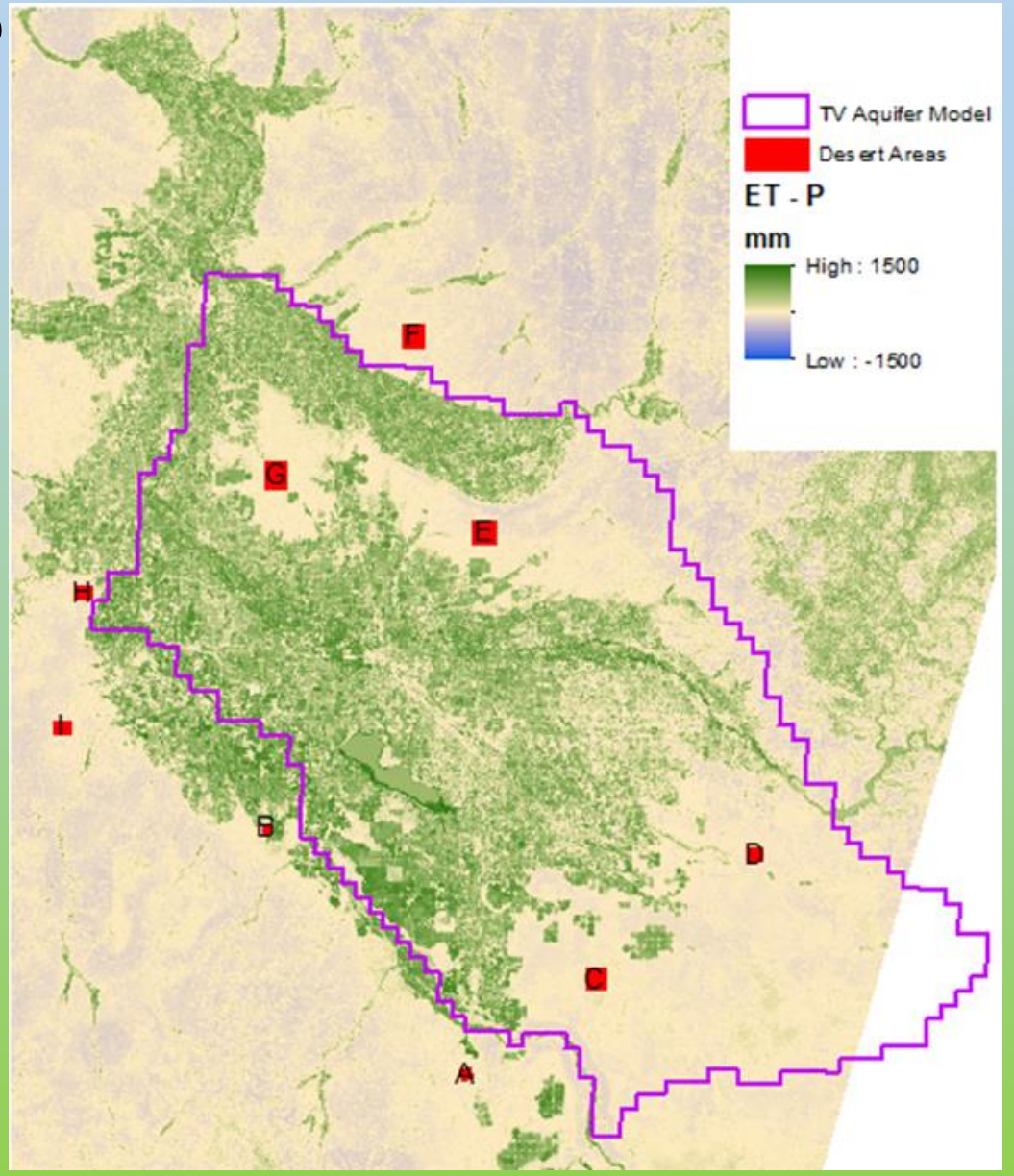




Comparison of ET to Precipitation

For areas of native vegetation, the ET should be close to Precipitation

- Spatially distributed precipitation obtained from GridMET.
- Monthly ET comparisons to monthly precipitation.
- Seasonal ET comparisons to January through October precipitation.
- Evaluation of several areas within or close to the Treasure Valley aquifer study area:
  - North of Murphy
  - Southwest of Marsing
  - North of Swan Falls
  - West of I-84 Rest Area
  - Between Middleton and Emmett
  - East of New Plymouth
  - Northwest of Sand Hollow
  - Southwest of Adrian, OR
  - West of Homedale

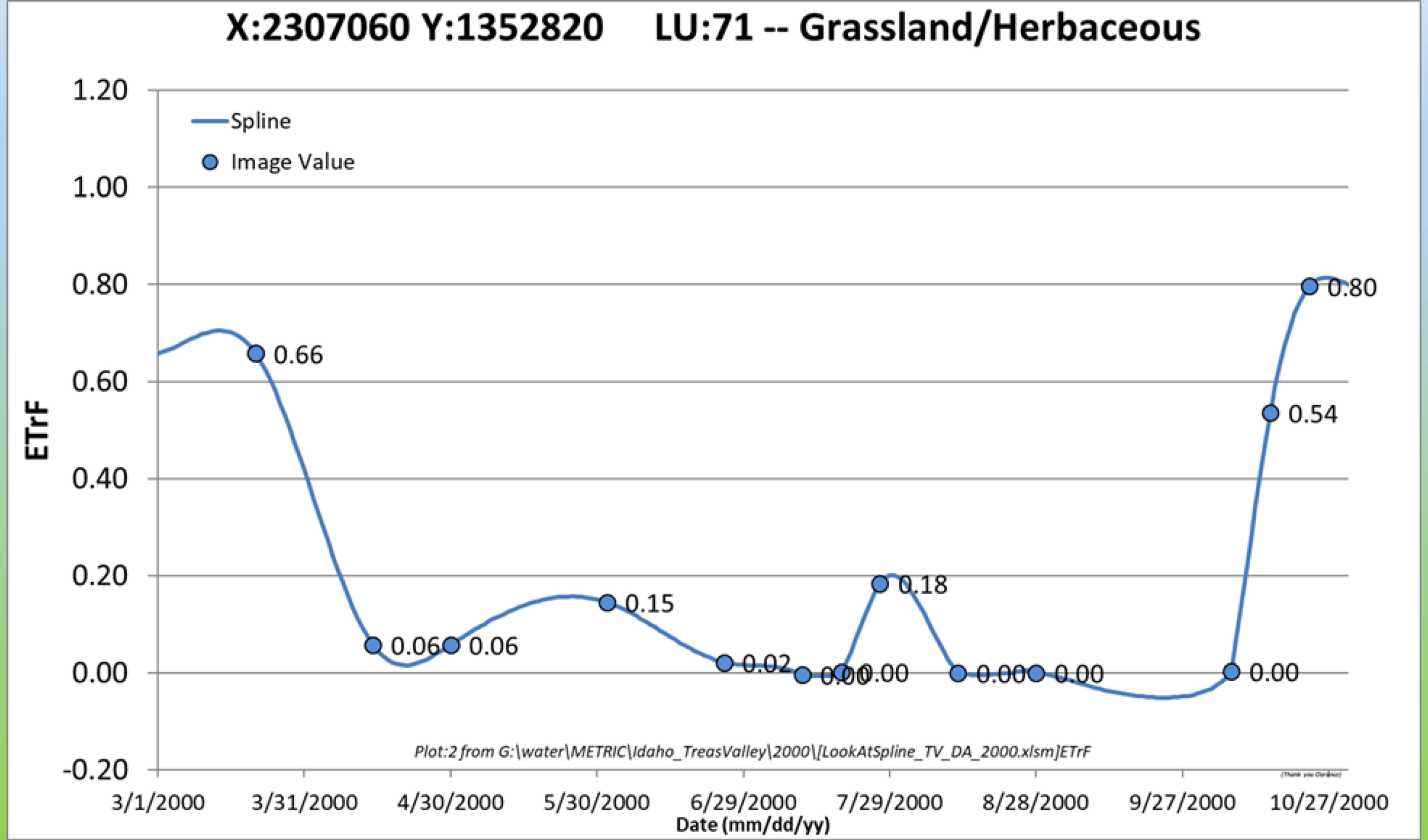


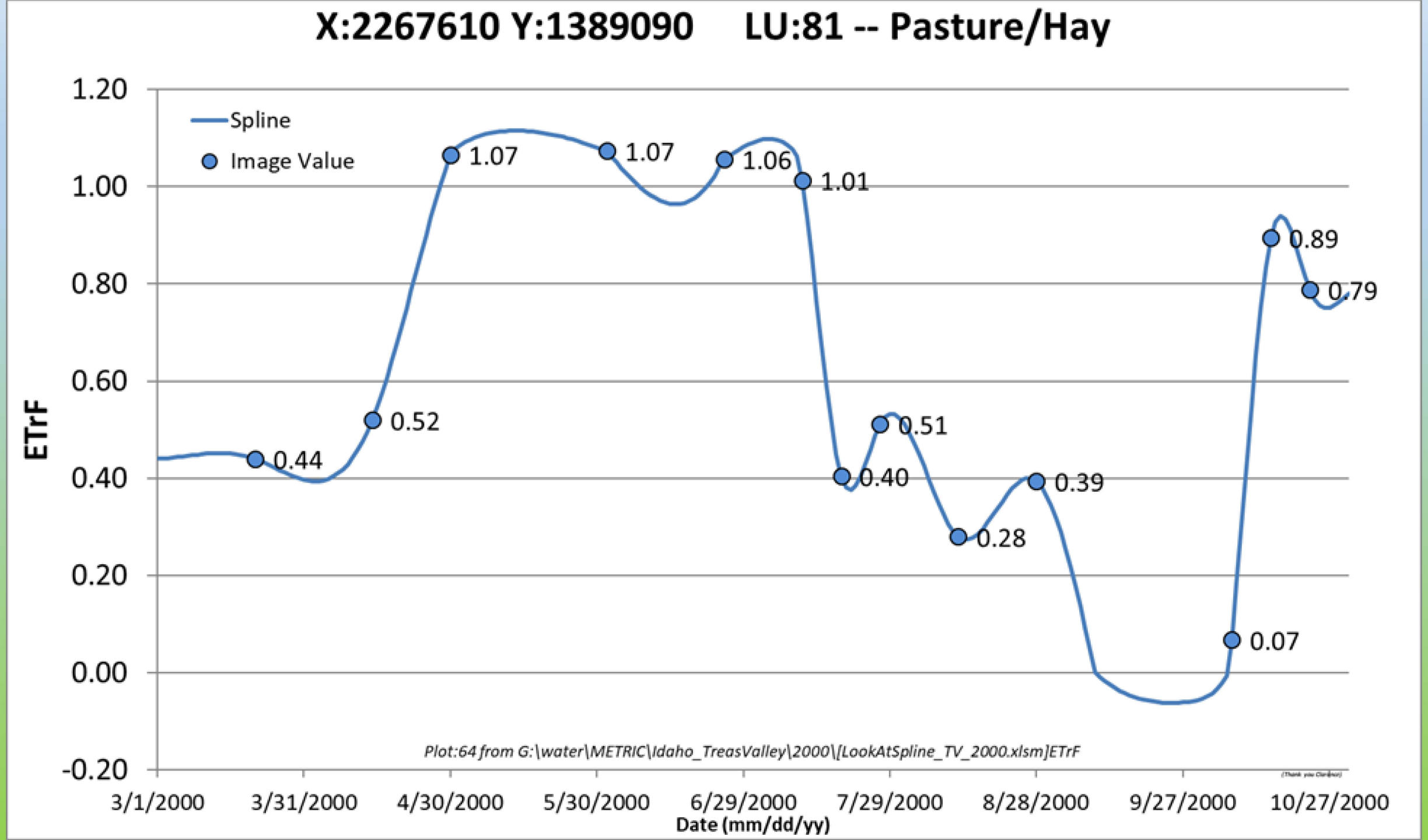
2007 Adjustments were needed	Area (ac)	ETrF Growing Season	ET Growing Season	P (Mar-Oct)	ET - P (Mar-Oct)	P (Jan-Oct)	ET - P (Mar-Oct)-(Jan-Oct)
Treasure Valley Aquifer Model Domain	--	0.41	591	117	474	148	442
A: North of Murphy	262	0.16	251	98	152	129	124
B: Southwest of Marsing	199	0.15	240	114	126	140	99
C: North of Swan Falls	1366	0.21	315	104	211	135	180
D: West of I-84 MP 62 rest area	475	0.21	320	138	182	182	138
E: Between Middleton and Emmett	1544	0.18	249	134	115	173	76
F: East of New Plymouth	1544	0.21	279	127	152	173	105
G: Northwest of Sand Hollow	1620	0.19	257	115	143	139	118
H: Southwest of Adrian, OR	645	0.12	184	107	77	132	52
I: West of Homedale	636	0.17	260	108	154	134	127

After Adjustment	Area (ac)	ETrF Growing Season	ET Growing Season	P (Mar-Oct)	ET - P (Mar-Oct)	P (Jan-Oct)	ET - P (Mar-Oct)-(Jan-Oct)
Treasure Valley Aquifer Model Domain	--	0.33	480	117	363	148	332
A: North of Murphy	262	0.09	139	98	41	129	13
B: Southwest of Marsing	199	0.09	133	114	19	140	-7
C: North of Swan Falls	1366	0.13	194	104	89	135	59
D: West of I-84 MP 62 rest area	475	0.14	202	138	64	182	20
E: Between Middleton and Emmett	1544	0.11	145	134	11	173	-28
F: East of New Plymouth	1544	0.13	171	127	44	173	-2
G: Northwest of Sand Hollow	1620	0.11	149	115	34	139	10
H: Southwest of Adrian, OR	645	0.06	87	107	-20	132	-44
I: West of Homedale	636	0.10	152	108	46	134	18

Daily Spline Interpolation Issues.

- The spline interpolation procedure captures vegetation growth provided that there are sufficient images throughout the season.
- Seasons with a large time period between images can be an issue.
  - Or if images are closely spaced in time and have large differences in ET_rF.
- Looking at ways to incorporated linear interpolation based monthly product with splined based monthly products.


X:2307060 Y:1352820 LU:71 -- Grassland/Herbaceous
Spline
Image Value
ETrF
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
0.66
0.06
0.06
0.15
0.02
0.00
0.00
0.18
0.00
0.00
0.00
0.80
0.54
0.00
Plot:2 from G:\water\METRIC\Idaho_TreasValley\2000\[LookAtSpline_TV_DA_2000.xlsm]ETrF
3/1/2000
3/31/2000
4/30/2000
5/30/2000
6/29/2000
7/29/2000
8/28/2000
9/27/2000
10/27/2000
Date (mm/dd/yy)


X:2267610 Y:1389090 LU:81 -- Pasture/Hay
Spline
Image Value
1.20
1.00
0.80
0.60
0.40
0.20
0.00
-0.20
ETrF
1.07
1.07
1.06
1.01
0.89
0.79
0.52
0.44
0.51
0.40
0.39
0.28
0.07
Plot:64 from G:\water\METRIC\Idaho_TreasValley\2000\[LookAtSpline_TV_2000.xlsm]ETrF
3/1/2000
3/31/2000
4/30/2000
5/30/2000
6/29/2000
7/29/2000
8/28/2000
9/27/2000
10/27/2000
Date (mm/dd/yy)

Thank you!
Questions?