Oregon
Statewide Long-Term Water Demand Forecast

Appendix D: Methods for Estimating Crop Consumptive Water Demand by County

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Methods for Computing Crop Consumptive Water Demand by County

The forecast for agricultural water demand presented in Chapter 2 uses the following three variables to compute crop consumptive demand by county:

a) Acreages of irrigated agricultural land use by county,

b) Distributions of crop types by county, and

c) Crop and irrigation water demands (i.e., consumptive demands and net irrigation water requirements), by crop and by demand scenario.

This appendix describes the method used to compute county-wide crop-consumptive demand estimates. The number of irrigated acres and the distribution of crop types form a baseline description of the distribution of irrigated crops across Oregon. These values were held constant for all five of the future agricultural water demand scenarios.

For the current and future agricultural water demand scenarios, agricultural demands were estimated from a combination of information available from the West Wide Climate Risk Assessment (WWCRA) and Oregon State University (Cuenca 1992), giving preference to estimates from WWCRA where overlaps existed. Because the WWCRA only evaluated tributaries of the Klamath and Columbia Rivers, estimates of current agricultural demand for Oregon's coastal drainage basins and areas within the Great Basin were based on the Oregon State University estimates. For the purposes of this forecast, similarities between crops and climatic conditions were used to extrapolate the WWCRA estimated changes in agricultural demands to regions outside of the WWCRA study area. More information on this variable can be found in Appendices C and E. Final calculations of crop consumptive demand by county and administrative basin can be found in Appendix A.

Estimates of Irrigated Land and Crops by County

Estimates of total irrigated land by county were adopted from the 2010 Oregon Water Use Compilation (USGS 2010). This is consistent with the previous Oregon water demand forecast (OWRD 2008). The irrigated crop type distributions reported in the 2012 Census of Agriculture (USDA 2012) were used as the basis for identifying the proportion of irrigated land in each county that was being cultivated for specific crops. Each crop has a different consumptive demand requirement, so establishing a blend of crops was important for simulating current and future water demands.

Determining Irrigated Land Use

Two estimates of agricultural land use were considered for use in this forecast, including:

- USGS Oregon Water Use Compilation (2010)
- U.S. Department of Agriculture (USDA) Census of Agriculture (2012)

Both the USGS Oregon Water Use Compilation and USDA Agricultural Census are compiled on five-year intervals. The Census of Agriculture is conducted every five years by the USDA, National Agricultural Statistics Service, and was most recently completed for 2012. The Census of Agriculture relies on self-reported information across the U.S., and includes information concerning all areas of farming and ranching operations, including production expenses, market value of products, and operator characteristics. The Census of Agriculture for 2008 was evaluated by the USGS, among other sources of information, as input to the 2010 Oregon Water Use Compilation.

Ultimately, estimates of total irrigated land by county were adopted from the 2010 Oregon Water Use Compilation (USGS 2010). This is consistent with the previous Oregon water demand forecast (OWRD 2008).

Determining Crop Types

The USGS Oregon Water Use Compilation ceased reporting acreages of specific crops by county after 2005. As a consequence, this forecast uses other sources to describe the distribution of agricultural land use among various irrigated crops, based on percentages of irrigated acres. Two estimates for the blend of crops by county were evaluated for use in this forecast:

- USDA Census of Agriculture (2012)
- USDA Cropland Data Layer (CDL) (2014)

The USDA Census of Agriculture was selected for describing the distribution of crops within each county. Largely, this selection was made because the full spatial distribution of CDL was beyond the requirements for estimating agricultural land use and because of errors in the CDL that produced poor results for some counties. Additionally, the USDA Census of Agriculture is a reliable source of uniform, comprehensive data making for an equally reliable dataset in each county. Table D.1 identifies the primary irrigated crops for each county. A primary crop is defined as one that occupied at least 2 percent of the irrigated land area at the time of the 2012 census.

Table D.1: Primary Crops by County

County	Primary Crops[1]
Baker	Forage, Wheat, Potatoes
Benton	Forage, Sweet Corn, Mint, Hazelnuts, Grapes
Clackamas	Forage, Hazelnuts, Blackberries, Blueberries, Sweet Corn
Clatsop	Forage
Columbia	Forage
Coos	Forage, Cranberries
Crook	Forage
Curry	Forage, Cranberries
Deschutes	Forage, wheat for grain
Douglas	Forage, Grapes
Gilliam	Forage, Wheat for Grain
Grant	Forage
Harney	Forage
Hood River	Pears, Cherries, Forage, Apples
Jackson	Forage, Pears, Grapes
Jefferson	Forage, Wheat for Grain
Josephine	Forage, Grapes
Klamath	Forage, Barley for grain, Wheat for grain, Potatoes

County	Primary Crops[1]
Lake	Forage
Lane	Forage, Hazelnuts, Mint, Corn for Silage
Lincoln	Forage
Linn	Forage, sweet Corn, Hazelnuts, Peppermint
Malheur	Forage, Corn for Grain, Wheat for Grain, Onions (Dry), Sugarbeets, Corn for Silage, Dry Edible Beans
Marion	Forage, Hazelnuts, Sweet Corn, Snap Beans, Corn for Silage, Hops, Marionberries, Blueberries, Wheat For Grain, Grapes
Morrow	Forage, Potatoes, Wheat for Grain, Corn for Silage, Corn for grain, Onions, Sweet Corn
Multnomah	Forage, Potatoes, Sweet Corn, Raspberries, Sweet Corn, Corn for Silage, Blueberries, Wheat for Grain, Pumpkins, Squash, Cabbage, Snap Beans
Polk	Forage, Grapes, Hazelnuts, Plums and Prunes, Cherries, Apples, Sweet Corn, Corn for Silage, Snap Beans, Sweet Cherries
Sherman	Forage, Wheat
Tillamook	Forage, Corn for Silage
Umatilla	Forage, Wheat for Grain, Corn for Grain, Green Peas, Potatoes, Sweet Corn
Union	Forage, Mint, Wheat for Grain
Wallowa	Forage, Wheat for Grain, Barley for Grain
Wasco	Forage, Sweet Cherries, Wheat for Grain
Washington	Forage, Hazelnuts, Blueberries, Grapes, Sweet Corn, Marionberries, Raspberries, Wheat For Grain, Corn For Silage
Wheeler	Forage
Yamhill	Forage, Hazelnuts, Grapes, Corn for silage, sweet corn, Blueberries

Source: *Census of Agriculture (USDA 2012)*

Notes:

1 – Crops by county identified by the Agricultural Census (USDA 2012). A crop was considered primary if more than 2 percent of irrigated agricultural area in the county was dedicated to it.

Nonetheless, the USDA CDL is the most comprehensive spatial description of agricultural land use in Oregon. The CDL is a raster, geo-referenced, crop-specific land cover data layer created annually for the continental United States using moderate resolution satellite imagery and extensive agricultural ground truth. CDL data demonstrates that agricultural land is broadly distributed across the state and represents a significant portion of land in each of the state's administrative basins (Figure D.1) (USDA 2014). Although CDL datasets are reviewed for accuracy, crops can be misidentified and acreages can be less accurate in comparison to other sources. For example, the extent of land uses that blend with the natural land cover is often mischaracterized in Oregon (e.g., irrigated pasture is delineated as native grassland, while acreages of cranberries are characterized as wetlands). These mischaracterizations cannot be resolved through computational methods, and require considerable human review to rectify. Mischaracterizations within the CDL have important implications for irrigation water requirements that could not be ignored.

Source: USDA NASS 2014. Green areas represent agricultural land.

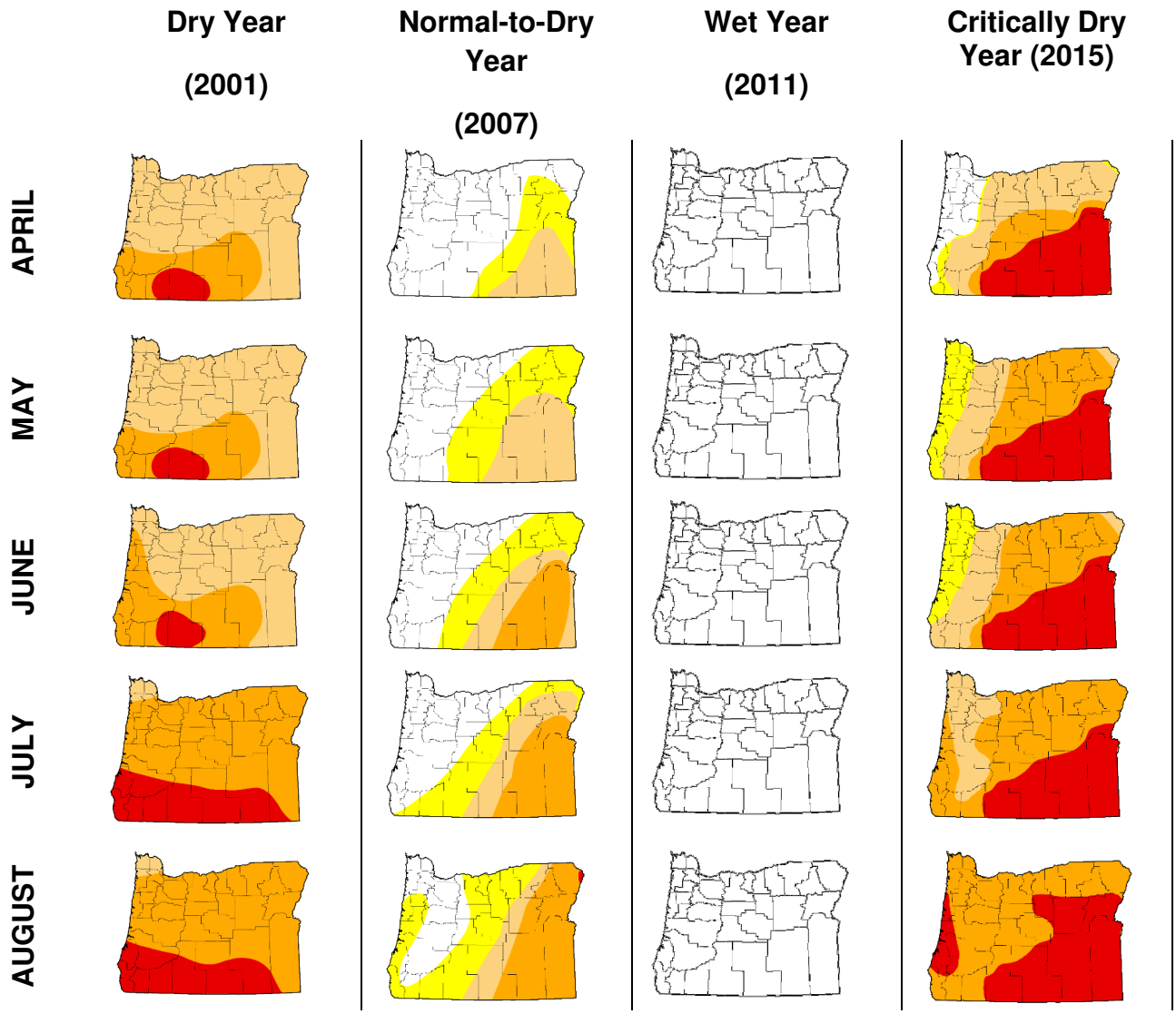
Figure D.1: Oregon's Agricultural Lands, as Detected through Satellite Imagery

The CDL was used for translating county-based agricultural demands into Administrative Basins (Figure D.1). This was accomplished by taking the intersection of agricultural land in each county and determining what fraction fell into each of the overlaying administrative basins. The results of this are included in Appendix A.

Remaining Uncertainties in the Estimate of Future Demand

The previous Oregon Water Demand Forecast (2008) anticipated a long-term growth in agricultural land use. Current estimates of agricultural land use appear to indicate a decline in agricultural land use

between 2005 and 2012. Despite the progressive reductions in the amount of actively farmed land, the previously forecasted increases in agricultural land use may still prove true. Agricultural land use is affected by several factors that vary from year to year, including global demand for crops, the national economy, and water supply availability. Each of these factors impacts the acreage of land and selection of crops across Oregon in a different way. One example of volatility in these factors is the period of national economic downturn in the United States, which occurred during the previous two land use estimates. Another example is depicted in Figure D.2, which shows, for the years with agricultural land use estimates, how Oregon's water supply varied across the state during the growing seasons. The cumulative effect of these factors on long-term agricultural land use was not addressed in this forecast.



Source: United States Drought Monitor (USDA, 2015)
Notes: White indicates normal or wet conditions, darker colors indicate increasing severity of drought.

Figure D.2. Water supply conditions within the past two decades characterizing the range of variability in water supply spatially and across a season.

Estimates of Net Irrigation Water Requirement by County

This report relies on two methods for estimating current and future NIWR across Oregon:

- The Cuenca estimates (Cuenca 1992), and
- The ETDemands model, which provides more modern techniques for calculating evapotranspiration for historical and projected future climates, and was recently applied for the West-Wide Climate Risk Assessments (Reclamation 2015).

WWCRA data were used whenever available; if WWCRA data were not available, the Cuenca estimates were applied. The WWCRA estimates included NIWR for historical climate and the five future climate scenarios used in this forecast. WWCRA estimates of NIWR are available for specific crops at meteorological stations within the Columbia and Klamath river basins. Cuenca estimates of NIWR are available for specific crops in distinct agricultural regions, which are based on areas with generally homogenous climate conditions.

Figure D.3 displays the counties which use WWCRA data for estimating NIWR, and those which relied on Cuenca estimates. Figure D.3 also identifies the location and names of the meteorological stations and Cuenca agricultural regions used in this forecast, and other meteorological stations that were available from WWCRA, but not used in this forecast.

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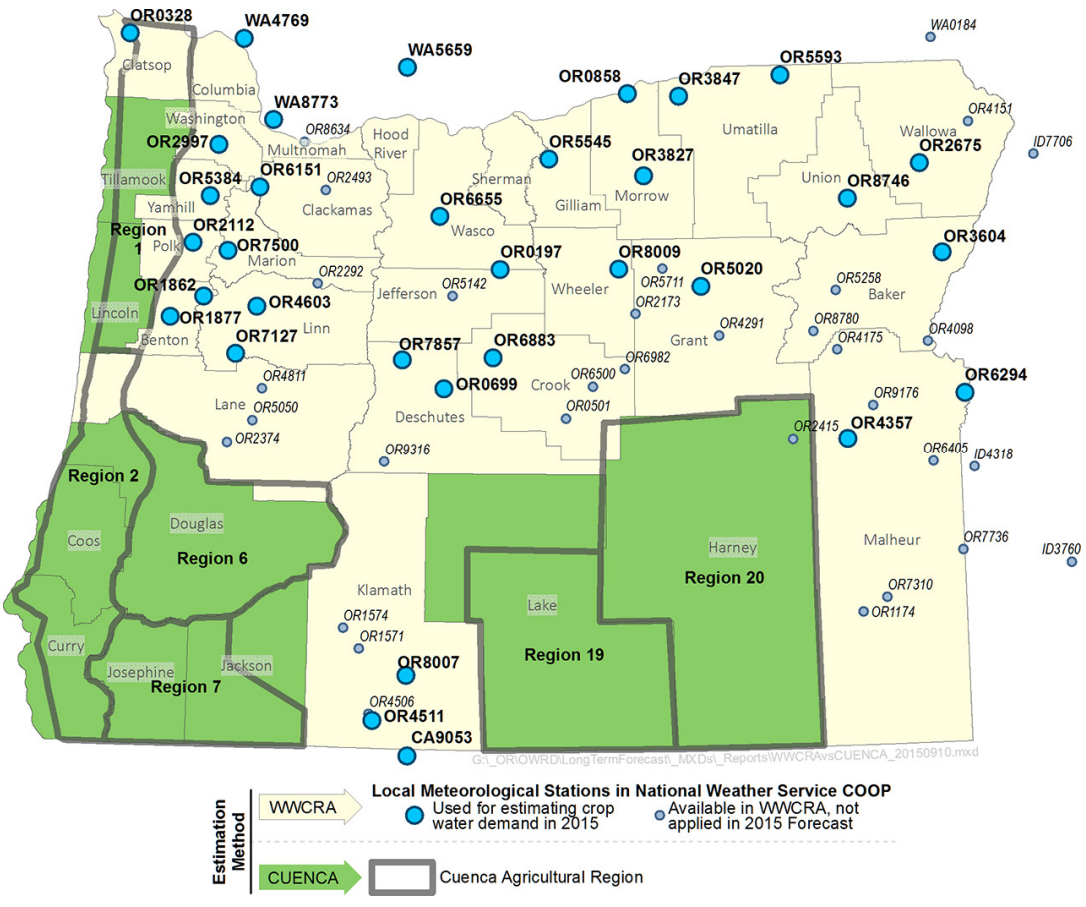

Figure D.3 Sources of Information Used for Current and Future Crop Water Demand Estimates

As noted earlier, acreages of crops were determined for each county based on the 2010 USGS Oregon Water Use Compilation (total acreages) and the 2012 USDA Census of Agriculture (distributions of crop types). In order to estimate volumes of demand by county, depths of crop demands (i.e., NIWR) were assigned to these acreages. Table D.2 identifies the WWCRA meteorological stations or Cuenca Agricultural Regions used to estimate volumes of agricultural demand for each county. For counties and crops assigned to WWCRA stations, data were readily available for future agricultural demands at the meteorological stations identified in Figure D.3. These data are recorded in Appendix G (a database available through OWRD), and encompass three climatic periods, centered on the years 2020, 2050, and 2080. For stations with Cuenca Region assignments, a simplified ratio approach was developed to estimate how climate changes projected for neighboring WWCRA stations with similar climates would affect the estimated agricultural demands. The description of the methods for this are reported in Appendix E, and the results are included in Appendix A.

Table D.2: Sources of Crop Water Demand Estimates, by County

County	Reference Meteorological Station (for WWCRA) or Agricultural Region (from Cuenca)	County	Reference Meteorological Station (for WWCRA) or Agricultural Region (from Cuenca)
Baker	OR8746, OR3604	Lake	Cuenca Agricultural Region 19
Benton	OR1862, OR1877, OR5384, OR 2112, WA8773	Lane	OR7127, OR4603, OR7500
Clackamas	OR6151, WA8773, OR5384	Lincoln	Cuenca Agricultural Region 1
Clatsop	OR0328	Linn	OR4603, OR7500, OR5384
Columbia	WA4769	Malheur	OR6294, OR4357
Coos	Cuenca Agricultural Region 2	Marion	OR7500, OR4603, OR5384, OR2997
Crook	OR6883	Morrow	OR7500, OR0858, OR5593
Curry	Cuenca Agricultural Region 2	Multnomah	WA8773, OR6151
Deschutes	OR0699	Polk	OR2112, OR5384
Douglas	Cuenca Agricultural Region 6	Sherman	OR5545, OR0858
Gilliam	OR0858	Tillamook	Cuenca Agricultural Region 1
Grant	OR5020	Umatilla	OR5593, OR3827, OR0858
Harney	Cuenca Agricultural Region 20	Union	OR8746, OR3604
Hood River	WA5659	Wallowa	OR2675, OR3604
Jackson	Cuenca Agricultural Region 7	Wasco	OR6655, OR0858
Jefferson	OR0197, OR7857	Washington	OR2997, WA8773, OR6151
Josephine	Cuenca Agricultural Region 7	Wheeler	OR8009
Klamath	OR4511, CA9053, OR8007	Yamhill	OR5384, WA8773, OR6151

For all counties, total irrigated acres are computed using the USGS Oregon Water Use Compilation. The distribution of crop types by percent was identified using the USDA Agricultural Census. These two datasets were combined to identify the total acres of irrigated land by crop type within each county, though this final distribution was modified based upon the key crops identified within the next step.

Translation between Crop Categories

Inconsistent crop categories were identified by the USGS Oregon Water Use Compilation, the USDA Agricultural Census, WWCRA, and the Cuenca report. The calculation of agricultural demand by volume required translation between these sources of information. For example, the WWCRA work contains ET for 32 crops in Oregon, though over 93 crops or crop groups were identified for the state of Oregon within the USDA Census of Agriculture.

Assignments of proxies for crops between the various sources of information were conducted for the purpose of calculating NIWR for each county. This was necessary for the following conditions:

- Primary USDA crops not modeled for Oregon, but that were modeled in the WWCRA effort or Cuenca report
- Primary USDA crops that had multiple potential representations in the WWCRA effort or Cuenca report
- Primary USDA crops that were not included in the WWCRA effort or Cuenca report

The largest variability between crop representations depends on whether the plant in question is an annual (requiring consideration of the start of growing season and peak ET) or a perennial (where the major consideration is peak ET). This can be seen in Cuenca's 1999 report, where crops are generally grouped crops by season and region.

With this in mind, the following general strategies were applied to identify appropriate proxy crops:

If the crop, or crop group was modeled in the Cuenca report but not in the region of question, and a crop with similar phenology, ETc, and life cycle type was modeled in the Cuenca report and the WWCRA report but in a different but similar ecoregion, then this crop was substituted;

If the crop was modeled in Cuenca but not in the region of question, but no substitute crop was able to be identified, then other references were sought to identify phenology and life cycle type of the WWCRA modeled crops that may match those identified by Cuenca;

If the crop was not modeled in Cuenca, then other references were sought to identify phenology and life cycle type of the crop and this was either matched to Cuenca information or other references were sought to identify phenology and life cycle type of the crop WWCRA modeled crops; or

If no reliable information could be found for the crop, we assigned it a perennial or annual proxy, or if it represented less than 2 percent of total area within any single county, then the crop was dropped from explicit representation. If dropped from representation, the acreage of land dedicated to that crop was distributed among other crops that were represented, such that the total irrigated acreage in the county remained equal to the acreage estimated in the USGS Oregon Water Use Compilation.

The final step in assigning proxies is to verify that all proxies are represented at all WWCRA weather stations where proxies have been assigned. This was done by identifying the modeled list of crops for each county-assigned station, comparing it to the list of crops for each county, and where appropriate choosing a different proxy based on available crops.

- With respect to the selection of crops where WWCRA information was the basis of calculating ET, the following specific considerations apply. WWCRA information on crop ET is available at National Weather Service COOP stations. In order to choose a primary representative COOP

station, met stations with a 25-mile buffer were mapped with state-wide crop layers. Using ArcGIS, an intersect was run on the buffer and CDL in order to generate a distribution of crops within a 25 mile radius of each station. These distributions were then compared to the distribution of crops by county identified within the USDA Ag Census. Key crops used to identify the viability of specific met station were included if they represented more than 2 percent of irrigated crop grown within county (greater than 2 percent) as identified by the USDA Agricultural Census. When a key crop was not represented at a primary station, alternate stations within the county or similar ecoregion were chosen to represent that crop's ET rate.

- For the counties which were not represented by a WWCRA modeled meteorological station, Cuenca regions were assigned based on geographic coverage. With respect to selection of crops where Cuenca information was the basis of calculating ET, the following specific considerations apply. Only crops identified as representing more than 2 percent of irrigated land or more than 40 acres within a county – as identified using the USDA Agricultural Census – were used in the final calculation of NIWR for these counties. If these crops were not included in Cuenca's 1992 report, then a proxy crop was chosen.

- For counties and crops assigned to WWCRA stations, data were readily available for future agricultural demands. For stations with Cuenca Region assignments, a simplified ratio approach was developed to estimate how climate changes projected for neighboring WWCRA stations with similar climates would affect the estimated agricultural demands. Methods for determining crop water demand are described in Appendix C for WWCRA, and Appendix E for Cuenca.