

How to Generate Standard CAO Effectiveness Indicators

This document provides instructions for how to use datasets from WDFW (High Resolution Change Detection [HRCDC], tree canopy cover, and visible surface water) to report on a standard set of performance indicators regarding the effectiveness of local Critical Area Ordinances (CAOs) for jurisdictions in the Puget Sound basin.

The proposed indicators provide quantitative details regarding:

- the proportion of tree cover within critical areas as of 2017 and the anticipated amount of critical area tree loss in the next decade based on prior trends.
- the quantity and rate of critical area change (total change and canopy cover change).
- the relative rates of change in critical areas compared to non-critical areas.

Together, these indicators can provide a comparison through time (back to 2006) and across jurisdictions of the relative effectiveness of jurisdictions' critical area protections. A highly effective (strong) CAO would shift development out of critical areas – even when the community is experiencing a high growth rate. A less effective (permissive) CAO would allow changes in critical areas during times of low or high community growth. Considering the community growth rate and the overall amount of tree cover in critical areas provides context to the indicator and can be useful when deciding what actions to take to improve the protections a CAO provides.

The accompanying Excel spreadsheet allows users to input statistics created by following the instructions below to generate the indicators for their jurisdiction. There is one spreadsheet for urban areas (incorporated cities as well as unincorporated areas within Urban Growth Areas [UGAs]), and one spreadsheet for rural areas (unincorporated places outside of UGAs).

These instructions are written for users of ArcGIS 10.6; users of different versions of ArcGIS may experience slight differences. For questions, contact Keith Folkerts at keith.folkerts@dfw.wa.gov.

Part 1: Prepare Base Map

In this phase we create a GIS map that shows a best approximation of terrestrial lands where the county or city regulates land use and is responsible for protecting critical areas. See Table 1 for a list of recommended data sources (if better local data is not available).

In steps 1-3 we map the areas where the CAO is not the (primary) regulatory authority to protect critical areas. These areas will not factor into the CAO effectiveness calculations.

1. **“Out of Study Area”: Water.** Create a best estimate map layer of the jurisdiction's surface water (lakes and large rivers but *not* wetlands—just places that trees can't grow and/or development cannot occur).
2. **“Out of Study Area”: Non-GMA.** Create a best estimate map layer of lands within the jurisdiction where local land use regulations (GMA/SMA) are *not* the primary land use laws. These will include areas under the jurisdiction of the **federal** or **tribal** governments

and (primarily for counties) designated **forestry** areas (Assessor code = 88 or 95) where the Forest Practices Act is the predominant land use law.

3. **“Out of Study Area”: Cities** Counties should identify incorporated areas (and UGAs if the Critical Areas within that UGA are regulated by a city).

In steps 4-8 we identify the Critical Areas that the CAO is designed to protect.

4. **Critical Areas: Wetlands:** Create a best estimate map layer of the jurisdiction’s wetlands and their buffers. Wetland buffers may need to be estimated as regional data sources do not include buffer widths.
5. **Critical Areas: Streams:** Create a best estimate map layer of the jurisdiction’s streams and lakes and their CAO-defined buffers.
6. **Critical Areas: FFAs:** Create a best estimate map layer of the jurisdiction’s Frequently Flooded Areas (FFAs). Include only places where development is essentially precluded without extraordinary measures.
7. **Critical Areas: Geohazards:** Create a best estimate map layer of the jurisdiction’s Geological Hazard Areas and their setbacks (only include areas where development is essentially precluded without extraordinary measures).
8. **Critical Areas: Other:** Create a best estimate map layer of other CAO-defined Critical Areas (only include areas where development is essentially precluded without extraordinary measures).

In steps 9-12 we create the jurisdiction’s base map that we will use in our subsequent analysis.

9. **Combine and Simplify:** Using the Union tool under the Geoprocessing tab, union a polygon of your jurisdiction with the map layers created in steps 1-8, name the resulting file “City_basemap_prelim” (. In the resulting layer file, create field called “Category”. Use the “FID_xxx” columns to select the areas identified in steps 1-3; in the “Category” field, label these areas as “Out of Study Area.” Use the “FID_xxx” columns to select the areas identified in steps 4-8; in the “Category” field, label these areas as “Critical Area.” Select and label the non-critical areas that are not outside of the study area as “Non Critical Areas”. Use the Dissolve tool under the Geoprocessing tab to dissolve on the “Category” field. Name the resulting file “City_basemap”.
10. **Split Urban and Rural:** Counties, create one base map for unincorporated places within UGAs and another base map for places outside of UGAs.
11. **Add Acreages:** Open the “City_basemap” layer and, add a field “BaseMapAcres”, and have GIS populate it by right-clicking on the new field and selecting “Calculate Geometry” and then select “Acres (US) [ac]”.
12. **Input Results:** Open the Excel file “CAO Performance Indicators Report template”, click on the Input Summary Statistics tab. Fill in the name of your jurisdiction, cut and paste the acreages calculated in Step 11 into Boxes 3 and 4.

Table 1: Recommended Sources of GIS data

Data Layer	Step	Recommended Data Sources
UGAs, city boundaries	1	Geo.wa.gov: Ecology UGAs , L&I City Limits .
Non-terrestrial areas	1	WDFW HRCDC Hub: WDFW's Visible Surface Water Geo.wa.gov: Commerce's Puget Sound Mapping Project , NHD Waterbody , NHDArea , DNR Hydrography – Water Bodies
Non-GMA areas	1	Geo.wa.gov: Commerce's Puget Sound Mapping Project , Ecology's tribal lands , DNR's Major Public Lands , WSDOT's Tribal Reservation and Trust Lands
Forestry Lands	1	Geo.wa.gov: Commerce's Puget Sound Mapping Project
Wetlands	2	Ecology: Modeled Wetlands Inventory USFS: National Wetlands Inventory Geo.wa.gov: DNR Forest Practices Wetlands , DNR.wa.gov: Wetlands of High Conservation Value
Streams and lakes	3	Geo.wa.gov: NHD Flowline , NHD Waterbody , NHDArea (double-banked rivers, marine water), WDFW's Statewide Washington Integrated Fish Distribution (SWIFD), DNR Hydrography- Watercourses , DNR Hydrography – Water Bodies , WDFW's Visible Surface Water
Frequently Flooded Areas	4	Geo.wa.gov: Ecology Flood Hazard Map
Geological Hazard Areas	5	DNR Portal: DNR Landslide Compilation , DNR NEHRP Site Class and Liquefaction Susceptibility
Other Critical Areas	6	Fish and Wildlife Habitat Conservation Areas: Consult WDFW's PHS on the Web Critical Aquifer Recharge Areas: Consult Ecology information
High Resolution Change Detection	11	Geo.wa.gov: High Resolution Change Detection
Canopy Cover	27	Geo.wa.gov: Search for "Canopy Cover" in search box; if unavailable fill out a data request form at https://hrcd-wdfw.hub.arcgis.com/ .
HRCDC Indicators Spreadsheet	16, 22-26, 32	Contact WDFW's Keith Folkerts at keith.folkerts@dfw.wa.gov

Part 2: Tree Analysis

In this part we obtain the latest version of WDFW's tree canopy dataset, intersect it with your jurisdiction's base map, and extract desired information.

13. **Download**, extract, and add the latest canopy cover file for your county (e.g., x_County_2017_TreeCanopy).
14. **Clip**. Use the Clip tool under the Geoprocessing tab to clip the tree polygons to the city. Input Feature = "x_County_2017_TreeCanopy" and Clip Feature = "City_basemap" and Save the output file as "City_basemap_trees_temp".
15. **Union**. Use the Union tool under the Geoprocessing tab to combine the newly clipped feature with the base map: Features = "City_basemap_trees_temp" and "City_basemap." Save the file as "City_basemap_trees_temp2"
16. **Attribute a new "Trees" Field**. Open this new file's table, select "Add Field...", name it "Trees", Type = Text, Length = 3, then click OK. Select the records that do not have trees by clicking on the "Select by Attribute" button, in the upper box double-click on "FID_City_basemap_trees_temp2" then type "= -1", then Apply. It should select a handful of records. Right-click on the "Tree" column, click on "Field Calculator...", in the box type "No" (with quotes). Click on the "Switch Selection" button in the table header, right-click on the "Trees" column, choose "Field Calculator...", then enter "Yes" in the box and click OK.
17. **Simplify/dissolve**. Ensure no records are selected, then simplify this feature by opening the Dissolve tool under the Geoprocessing tab. Input Feature = City_basemap_trees_temp2; under Dissolve Field check the boxes next to "Category" and "Trees"; type in the Output Feature Class "City_basemap_trees_tenp2".
18. **Calculate acreage**. Open this new feature's attribute table. Click Add Field, enter "Tree_acres" and Type = Float. Right click on the Tree_acres column and select Calculate Geometry and select Units = Acres (US) [ac].
19. **Record results**. Open the Excel file "CAO Performance Indicators Report template", on the Input Summary Statistics tab, cut and paste the acreages calculated in Step 18 into Boxes 5a and 5b (critical area trees acreage and non-critical area trees acreage).

Part 3: HRCD Analysis

In this phase we obtain the latest version of the HRCD dataset, intersect it with your jurisdiction's base map, and extract desired information.

20. Download and extract the latest HRCD data. Add the HRCD polygons. Open the HRCD polygon layer's "Layer Property" box and click on the "Definition Query" tab. Use the Query Builder to create the following expression: CngAgnNm <> 'Forestry' AND CngAgnNm <> 'Other, Natural' AND CngAgnNm <> 'Stream'. Enter Ok. (This filters out changes for which local governments are not typically primarily responsible.)
21. Under the Selection tab, use the Select by Feature tool to select the HRCD polygons that

intersect the City_basemap. (Do NOT clip the HRCD polygons to the City_basemap.)

22. Use the Export Data feature to save the selected HRCD polygons as "HRCD_06_17_City".
23. Open "HRCD_06_17_City" and add five new fields (type = float):
 - a. "PortionCriticalArea"
 - b. "ChangeAcresCriticalArea"
 - c. "CanopyLossAcresCriticalArea"
 - d. "PortionNonCriticalArea"
 - e. "ChangeAcresNonCriticalArea"
24. Union "City_basemap" with "HRCD_06_17_City"; save the output feature class as "HRCD_Analysis_City"

Next, we calculate the amount of change that happened in Critical Areas and non-Critical Areas, enter results into a spreadsheet to generate key performance indicators.

25. Open the "HRCD_Analysis_City" table
26. Calculate the "PortionCriticalArea" field by
 - a. Selecting HRCD polygons within Critical Areas, excluding those HRCD polygons that are outside the study area. To do this in the Select by Attribute tool enter "Start Year >0 and Category = Critical Area". Verify you have selected only the portions of HRCD polygons that lie within critical areas.
 - b. In the table select the "PortionCriticalArea" field and open the Field Calculator.
 - c. Divide the selected polygons' acreage by the "Acres" by entering "[SHAPE_Area] / 43560 / [Acres]"
27. Calculate the "ChangeAcresCriticalArea" field by
 - a. With the same records selected as in the previous step, selecting "ChangeAcresCriticalArea" field and opening the Field Calculator.
 - b. Multiply each polygon's percent of change times its original size times the portion that is within Critical Areas. Enter "[PercentC] * [Acres] * [PortionCriticalArea]"
28. Calculate the "CanopyLossAcresCriticalArea" field by
 - a. With the same records selected as in the previous two steps, selecting "CanopyLossAcresCriticalArea" field and opening the Field Calculator.
 - b. Multiply each polygon's percent of canopy loss times its original size times the portion that is within Critical Areas. Enter "[TreeDec] * [Acres] * [PortionCriticalArea]"

29. Calculate the "PortionNonCriticalArea" field by
 - a. Selecting HRCD polygons within NonCritical Areas. To do this in the Select by Attribute tool enter "Start Year >0 and Category = Non Critical Area". Click Apply. Verify that the selection is correct. In the table select the "PortionNonCriticalArea" field and open the Field Calculator.
 - b. Divide the selected polygons' acreage by the "Acres" by entering "[SHAPE_Area] / 43560 / [Acres] "
30. Calculate the "ChangeAcresNonCriticalArea" field by
 - a. With the same records selected as in the previous step, selecting "ChangeAcresNonCriticalArea" field and opening the Field Calculator.
 - b. Multiply each polygon's percent of change times its original size times the portion that is within Non-Critical Areas. Enter "[PercentC] * [Acres] * [PortionNonCriticalArea]".
31. Open the Excel file "CAO Performance Indicators Report template" and click on the Input Summary Statistics tab. Get info for Boxes 1 and 2: (HRCD start and end years) from StartYr (smallest) and EndYr (largest).

The summary information for boxes 6-8 of the spreadsheet can be obtained an using Excel pivot tables or by using GIS; we recommend pivot tables as they are faster and less prone to error.

32. In ArcGIS, open the table for the layer "HRCD_Analysis_City". Under Table Options select "Export..." Click on the folder icon and select a location, name the file "HRCD_Analysis_City2017", from the drop down box select save as dBASE Table, and click on Save.
33. Open Excel. Under File, select Open, navigate to the folder where you saved the dBASE table. Next to the File Name box, from the drop down list select dBASE Files (*.dbf). Double click on the file to open it. It will open in Excel. Select Save As and save it under the same name as an Excel file.
34. In the Excel file, open a new tab, under Insert double-click "Pivot table". In the pop up box click on the up arrow next to the Table/Range box, then click on the tab with the data, select all the data and hit Enter, and click OK.
35. In the Pivot Fields box drag the fields as follows:
 - a. Start Year to Columns
 - b. ChangeAcre to Σ Values
 - c. CanopyLoss to Σ Values
 - d. (If a new " Σ Values" appears in the Columns box: move it to the Rows box, bottom position)
 - e. ChangeAc_1 (this is the truncated name for the changes in non critical areas) to Σ Values

- f. For Counties: UGA to Rows (top position)
 - g. Category to Rows (below UGA, above Σ Values)
36. The resulting table should be in the same order as the Excel spreadsheet used to create the CAO Effectiveness report. Copy the values from the pivot table and paste (as Value) into the CAO Effectiveness spreadsheet.

If you wish to accomplish the steps to populate the Excel CAO Effectiveness report spreadsheet by working within ArcGIS, follow these steps:

37. To get info for Box 6 (Acres of Total Change within Critical Areas by each time period):
- a. From StartYr column select 2006 (in Select by Attributes enter "StartYr = 2006")
 - b. Right click on the Column "ChangeAcresCriticalArea" chose Statistics, copy the Sum and paste it in the spreadsheet.
 - c. In the Select by Attributes box, change the start year to 2009, get the Sum statistic for the selected records. Repeat with the Start Yr = 2012, 2014, and 2016.
38. To get info for Box 6 (Acres of Canopy Loss within Critical Areas by each time period) we follow the same process:
- a. From StartYr column select 2006 (in Select by Attributes enter "StartYr = 2006")
 - b. Right click on the Column "CanopyLossAcresCriticalArea" chose Statistics, copy the Sum and paste it in the spreadsheet.
 - c. In the Select by Attributes box, change the start year to 2010, get the Sum statistic for the selected records. Repeat with the Start Yr = 2012, 2014, and 2016.
39. To get info for Box 7 (Acres of Change within **Non** Critical Areas by each time period) we follow the same process:
- a. From StartYr column select 2006 (in Select by Attributes enter "StartYr = 2006")
 - b. Right click on the Column "ChangeAcres**Non**CriticalArea" chose Statistics, copy the Sum and paste it in the spreadsheet.
 - c. In the Select by Attributes box, change the start year to 2010, get the Sum statistic for the selected records. Repeat with the Start Yr = 2012, 2014, and 2016.

Part 4: Interpreting the Results