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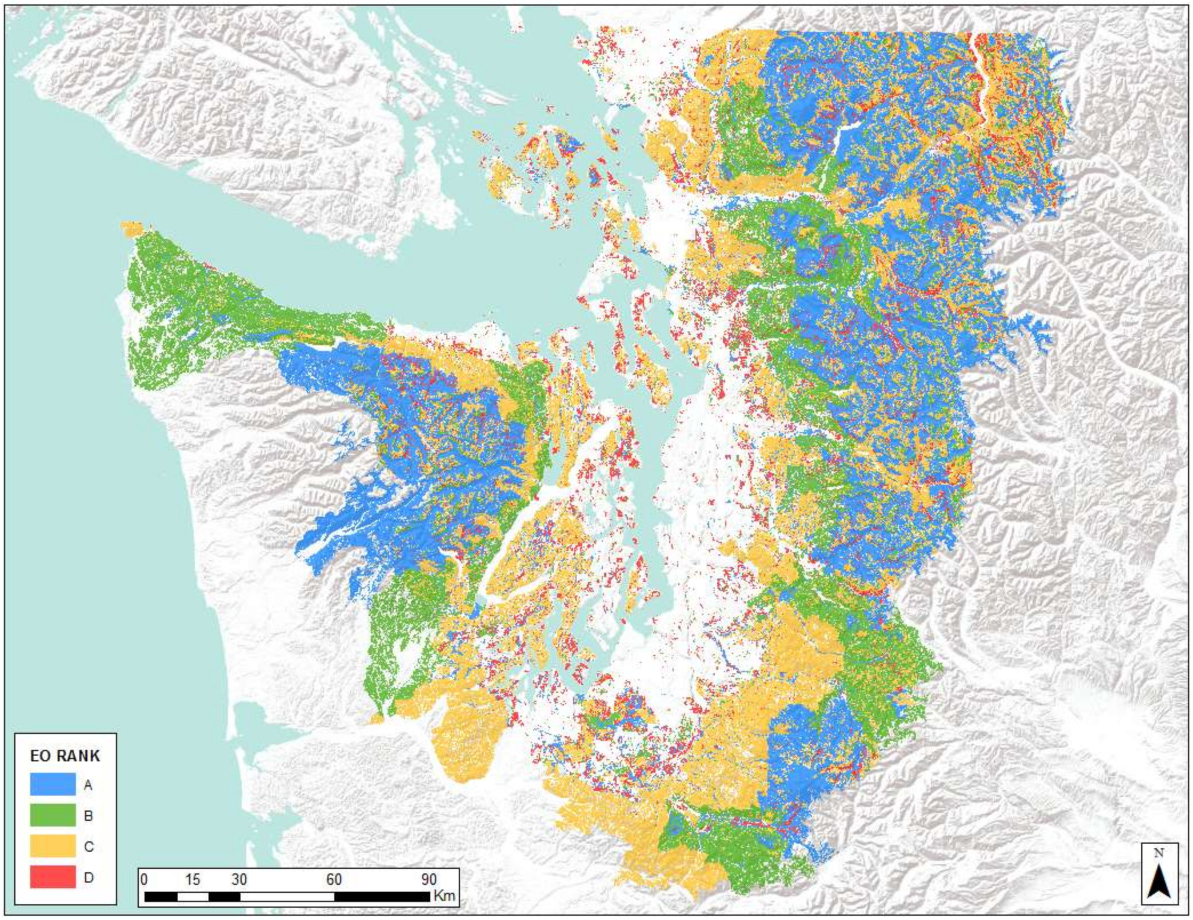

Ecological Integrity Assessments to Inform Prioritization of Protection and Restoration Actions and Monitor Progress in the Puget Sound Region: Final Report

Prepared for

Washington Department of Fish and Wildlife

Prepared by

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ON THE COVER: Level 1 EIA NVC model of the Puget Sound drainage basin

Table of Contents

Tables

Figures

Acknowledgements

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1 Introduction

Local government planners need to know the locations of ecologically important lands when developing land use policy and permitting guidance. Similarly, land managers need to identify portions of the landscape that retain ecological integrity in order to prioritize conservation, restoration, and management actions. Once these areas are identified, both parties need systematic methods for monitoring progress towards their respective goals. For this project, we define ecologically important lands as occurrences of rare or high-quality ecosystems. The Washington Natural Heritage Program (WNHP) maintains a database of the locations of such features and utilizes a rapid assessment approach to measuring their current ecological integrity. Together, these tools can tell decision makers where ecologically important lands are and provide a standardized methodology for prioritizing and monitoring their conservation, restoration, and management.

The first step in identifying these ecologically important lands is to determine the variety, rarity, and imperilment of ecosystems on the landscape. WNHP uses the U.S. National Vegetation Classification (NVC) as the primary ecosystem classification for vegetated wetland and terrestrial ecosystems (USNVC, 2021). This hierarchical vegetation classification system operates at multiple levels of resolution—upper levels describe major structural components (forest, grassland, etc.), while the lowest, finest scale levels are defined by characteristic ranges of plant species composition, habitat conditions, and physiognomy. The rarity and imperilment of these classification units are determined using Conservation Status Ranking, a method used across the NatureServe and the Network of member programs (Master et al., 2012). To aid communication, WNHP then converts each rank to a simpler "State Conservation Status" to guide regulatory decisions, proactive management and conservation, and conservation acquisitions within Washington (WNHP, 2022).

Once ecosystems and their state conservation status are identified, the next step is to assess the condition of specific occurrences that may be in need of restoration or conservation. Ecological Integrity Assessments (EIAs) were developed by the Washington Natural Heritage Program (WNHP) and others to measure the condition of upland and wetland ecosystems using standardized metrics to categorize sites into condition classes (Rocchio & Crawford, 2011; Faber-Langendoen et al., 2016a, 2016b, 2016c; Rocchio et al., 2020b, 2020a). Identifying which areas on the landscape retain ecological integrity is a critical step to prioritizing where conservation and management actions may be most effective. WNHP tracks such areas (along with rare plant occurrences) in a database of "Element Occurrences" (EOs). An EO is simply an ecosystem stand or rare species location with practical biodiversity conservation value—these are areas where land managers can be assured that their investment of time, money, and effort will have conservation impact. Some local jurisdictions already use these EOs in their protection programs.

In addition to being helpful for identifying protection priorities, information collected as part of an EIA can also help identify areas in most need of restoration. Places not meeting desired ecological integrity goals can be highlighted and the underlying EIA metrics can be used to identify specific stressors (e.g., invasive species) and restoration goals. EIAs seek to measure "the degree to which, under current conditions, the structure, composition, processes, and connectivity of an ecosystem corresponds to reference conditions, and are within the bounds of natural or historical disturbance regimes" (Faber-Langendoen et al., 2016d). EIAs may be conducted at three different sampling intensities: Level 1 (entirely remote sensing/GIS-based), Level 2 (rapid, mostly qualitative, field-based), and Level 3 (intensive, quantitative, field-based). This tiered approach is integrated such that Level 1 assessments can be made across all sites in the study area, followed by Level 2 assessments at a subset of locations accessed on the ground, and—in some cases—Level 3 assessments of a smaller subset requiring more precise/detailed information (Faber-Langendoen et al., 2020). Notably, data from Level 2 and 3 EIA may be used to help calibrate and/or assess the sensitivity of remotely sensed Level 1 assessments.

For this project, WNHP aimed to improve the knowledge and data accessibility of the locations of ecologically important lands in the Puget Sound drainage basin, develop and distribute a systematic approach to identify and prioritize areas for restoration and protection, and enable land managers to assess current ecological conditions and monitor restoration progress. To these ends, we began by developing a Level 1 EIA to assess current ecological condition of undeveloped areas in the Puget Sound drainage basin using remote sensing data. Based on local input, we then selected the Puyallup-White Water Resource Inventory Area (WRIA 10) in which to conduct Level 2 EIAs (rapid, field-based assessments). Level 2 field assessments occurred at a subset of locations, helping to refine priority areas for restoration and protection through the identification of new EOs. Level 2 data were also used to refine and adjust rank thresholds in the Level 1 model. Together, these EOs and EIA data support local government planners by highlighting the locations of these ecologically important lands in the Puget Sound drainage basin, while the EIA methodology may continue to be deployed to track changes in integrity over time.

1.1 Project Goals

The project goals were to:

1. Identify Priority Protection Areas. This was accomplished using:

    a. EOs: Both those already known to exist in the Puget Sound drainage basin and new EOs identified during Level 2 EIA surveys.

    b. Ecological Integrity Assessments

        i. Level 1 EIA: A high level model of ecological integrity that can be used to identify areas within the Puget Sound drainage basin of potentially good to excellent integrity.

        ii. Level 2 EIA: On-the-ground assessments of ecological integrity that confirmed areas modeled to have good to excellent integrity (in the Level 1 model). These data were then used to adjust rank thresholds in the Level 1 EIA model.

2. Identify Restoration Priorities

    a. Level 1 EIA: The resulting map can be used to identify areas of potentially fair to poor integrity that may be good candidates for restoration.

b. Level 2 EIA: Confirmed modeled and identified other ecosystems of fair to poor integrity that may be good candidates for restoration.

3. Provide EIA Training: Demonstrated applications and enabled project partners and the local ecological professional community to apply EIA methodologies.

2 Level 1 EIA

The goal of EIA is to measure the current ecological condition of an assessment area (AA) compared to a reference standard for that ecosystem, also known as the "natural range of variability". This assessment is made via a multi-metric index of biotic and abiotic measures of Condition, Size, and Landscape Context (i.e. "primary rank factors"). Each metric is rated by comparing measured values with expected values under relatively unimpaired conditions (i.e. the reference standard), and the ratings are aggregated into a total score. AAs that deviate from the natural range of variability due to human-induced stressors receive lower scores than those that more closely match the reference standard. EIA uses a scorecard to communicate individual metric ratings, as well as an overall index of ecological integrity. All together, the EIA framework provides a standardized language for assessing and communicating ecosystem integrity across all terrestrial ecosystem types—both uplands and wetlands (Faber-Langendoen et al., 2019; Rocchio et al., 2020b).

We implemented two scales of EIA: Level 1, which is a GIS-based approach to assessing ecosystem condition, and Level 2, which is a ground-based, rapid assessment of ecosystem condition.

Level 1 EIAs are based primarily on metrics derived from remote sensing imagery and other GIS datasets. The goal is to develop metrics that assess the landscape context and—to the degree possible—the on-site conditions of an ecosystem. Satellite imagery and aerial photos are the most common sources of information for these assessments. These sources typically do a good job of capturing landscape-level stressors, but actual degradation of ecological integrity must largely be inferred from the scope and severity of those stressors. This often results in a heavy focus on stressor-based metrics in a Level 1 EIA.

For this project, we sought to build and improve upon a previous wetland-specific Level 1 EIA model (Rocchio et al., 2014) to assess the current condition of all undeveloped areas and identify the locations of ecologically important lands in the Puget Sound region. The updated Level 1 EIA model incorporates additional data layers and new metrics not used in the 2014 version. It also expands the scope of the previous Level 1 EIA model to include both upland and wetland ecosystems.

Level 1 EIA results have two primary applications in this project. First, they were used to help prioritize and stratify where to conduct on-site Level 2 EIAs, which were then used to tune the Level 1 EIA. Second, the results of the updated Level 1 EIA provide a landscape summary of ecosystem condition to inform restoration and protection needs across the Puget Sound basin.

Development of the Level 1 EIA consisted of three main steps:

1. Define assessment area polygons (AAs).

2. Compile applicable spatial data sets that span the Puget Sound region and/or Washington State. We targeted data sets providing insight into the landscape context (land cover, land use), condition (vegetation, hydrology, soil), and/or ecological processes of the AAs.

3. Determine what metrics to derive from those data sets for use in estimating the condition of the AAs, calculate EIA scores, and tabulate results.

2.1 Methods

2.1.1 Define Assessment Areas

We used two data sets to define our AAs. First, AAs were created using vegetated palustrine, lacustrine, riverine, and estuarine polygons from the National Wetlands Inventory (NWI) (USFWS, 2018). Data are reported in terms of the Cowardin classification (FGDC, 2013) used in NWI mapping. We initially intended to crosswalk the Cowardin classification to the U.S National Vegetation Classification, but were unable to consistently determine USNVC lower units based on remotely sensed data at the scale of this project. While some NWI polygons could be related to NVC alliances—one of the finer scales of the classification system—others could not be confidently crosswalked to even a single NVC class, the very highest level. As a result, Level 1 EIA results are reported only in terms of Cowardin classification. The Level 2 EIA results are reported using both Cowardin and NVC classifications.

Marine polygons were excluded from NWI AAs because EIA methodology is not well-suited for such systems. The only other filter applied to our NWI AAs was to exclude all polygons < 0.05 ha (the minimum size of an EIA assessment area (Rocchio et al., 2020a)).

Our second set of AAs were derived from the GAP/LANDFIRE NVC Groups raster (LANDFIRE, 2016), aggregated at the macrogroup level—one step up the NVC hierarchy from groups (Figure 1). This AA method was used primarily to capture upland ecosystems, which are mapped much less extensively and precisely than wetlands in WA. It also serves as a coarse, secondary method for wetlands. The NVC Groups raster was parsed into AAs (containing both upland and wetland ecosystems (Table 1)) using the following procedure:

1. Cultural (i.e. non-natural) and ruderal groups were excluded, along with groups mapped by GAP/LANDFIRE but known not to occur in Washington (WNHP, 2022).

2. A patch-finding algorithm was used to aggregate and smooth neighboring pixels representing the same ecosystem. This procedure was originally developed by Washington Department of Natural Resources (DNR) staff for identifying old-growth patches in forest inventory data.

3. Old-growth forest patches defined using Gradient Nearest Neighbor [GNN] data (see Table 2 and Section 3.3.1 below) were subset as separate AAs.

4. AAs were screened for size based on the spatial pattern type of the Group (very-small-patch, small-patch, or linear > 0.05 ha, medium-small-patch > 0.2 ha, large-patch > 0.4 ha, matrix > 2 ha) (Rocchio et al., 2020b). AAs that did not meet the minimum size requirement were dissolved into neighboring AAs.

5. For more detail on this process, see Appendix B.

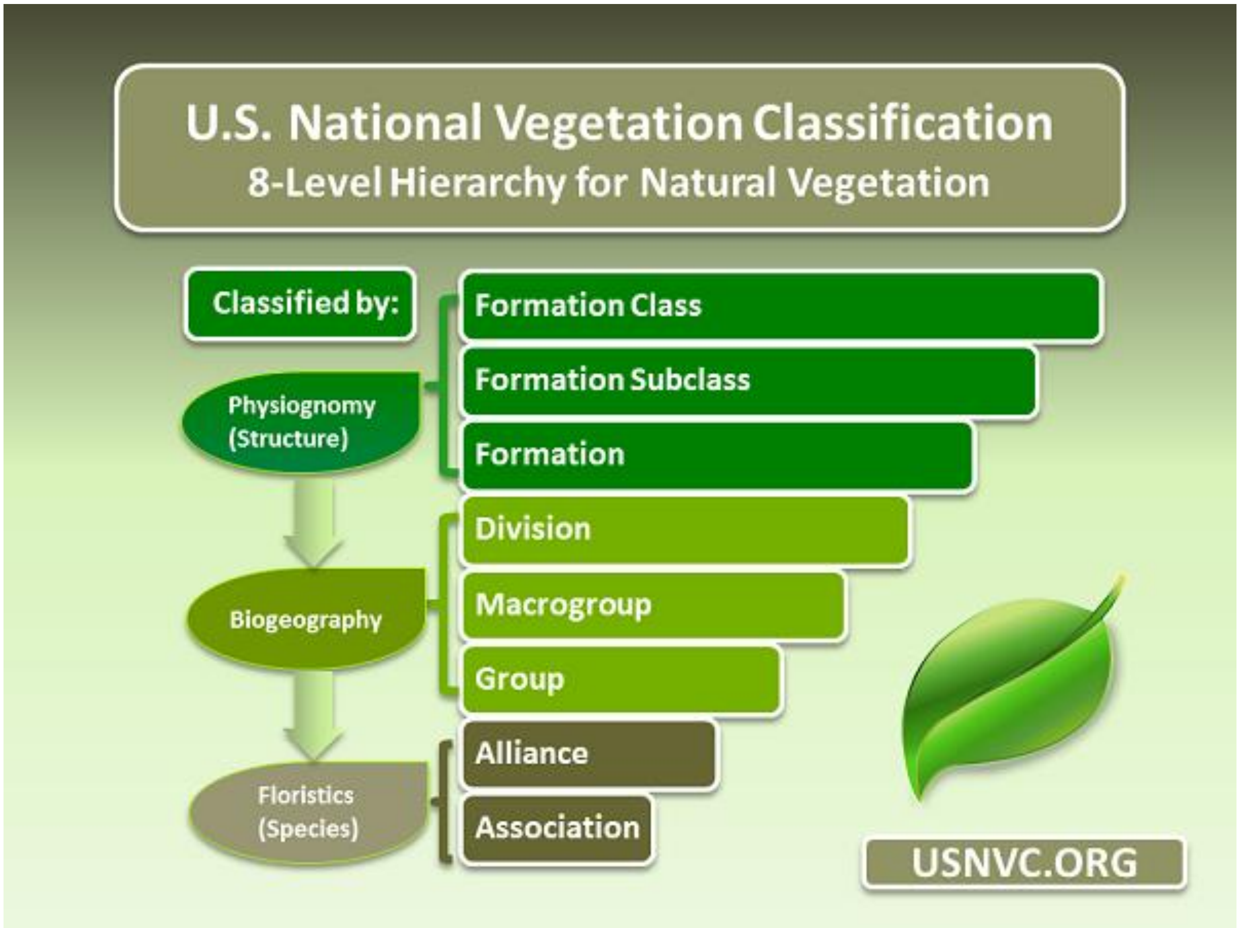

Figure 1. An Illustration of the NVC hierarchy.

Table 1. Macrogroups with assessment areas (AAs) within the Puget Sound drainage basin, based on GAP/LANDFIRE modeling. Some represent mapping errors (e.g. M169).

Macrogroups Assessed
M020 Rocky Mountain Subalpine-High Montane Forest
M024 Vancouverian Coastal Rainforest
M025 Vancouverian Subalpine-High Montane Forest
M035 Vancouverian Flooded & Swamp Forest
M048 Central Rocky Mountain Montane-Foothill Grassland & Shrubland
M050 Southern Vancouverian Lowland Grassland & Shrubland
M059 Pacific Coastal Beach & Dune
M073 Vancouverian Lowland Marsh, Wet Meadow & Shrubland
M081 North American Pacific Coastal Salt Marsh
M101 Vancouverian Alpine Tundra
M168 Rocky Mountain-Vancouverian Subalpine-High Montane Mesic Meadow
M169 Great Basin-Intermountain Tall Sagebrush Steppe & Shrubland
M500 Central Rocky Mountain Mesic Lower Montane Forest
M501 Central Rocky Mountain Dry Lower Montane-Foothill Forest
M886 Southern Vancouverian Dry Foothill Forest & Woodland
M887 Western North American Cliff, Scree & Rock Vegetation
M888 Arid West Interior Freshwater Marsh
M893 Western North American Montane Marsh, Wet Meadow & Shrubland

2.1.2 Compile Data Sets to Assess Ecological Integrity

Level 1 Ecological Integrity Assessment data sets were compiled from a number of state and federal sources (Table 2). Many of the Level 1 EIA metrics (Section 2.1.3) were calculated based on the intersection of an AA (or its buffer) with a composite land use layer. The foundation of this layer is the same NVC Groups raster used to generate the NVC assessment areas. We incorporated additional data sets in order to capture changes in land use/land cover since 2016 (the imagery year used for the groups mapping) and to correct potential errors. These additional data sources included DNR's roads, fire, and forest practices layers, WDFW's High Resolution Change Detection (HRCD) data set, Bonneville Power Administration (BPA) powerline and utility corridor layers, and developed map classes from the Coastal Change Analysis Program (C-CAP). The result was a composite land use layer that provided our best estimate of the full extent of anthropogenic land use in the Puget Sound drainage basin and across Washington State.

Table 2. Layers used for composite land use layer and EIA metric rating. All websites accessed January 2021.

Data Set	Source	Primary EIA Rank Factor	Function
NVC Groups Raster	GAP/LANDFIRE - http://gapanalysis.usgs.gov/gaplandcover/	Landscape Context	Cultural (non-natural) land cover used to calculate stressor-based metrics of landscape context.
Land Use Coefficients	Level 2 EIA (Mack, 2001; Hauer et al., 2002; Comer & Faber-Langendoen, 2013; Rocchio et al., 2020b, 2020a)	Landscape Context	Rates the impact of different land use categories. Used in conjunction with NVC Groups raster to calculate stressor-based metrics of landscape context.
Roads and Highways	WSDOT - https://www.wsdot.wa.gov/mapsdata/geodatacatalog/	Landscape Context	Combined with non-natural land cover classes from NVC Groups raster to produce comprehensive estimate of impervious and semi-pervious land cover
Forest Roads	WA DNR https://data-wadnr.opendata.arcgis.com/datasets/bfdb0455c3b24aa6ae46c9502f814c25_5	Landscape Context	
Access Roads	BPA https://www.bpa.gov/news/pubs/Pages/Maps.aspx	Landscape Context	
Substations	BPA https://www.bpa.gov/news/pubs/Pages/Maps.aspx	Landscape Context	
Transmission Corridors	BPA https://www.bpa.gov/news/pubs/Pages/Maps.aspx	Landscape Context	Used as a modifier to reduce the land use coefficient of any pixels that intersect a transmission corridor.
High Resolution Change Detection (HRCD)	WDFW https://data-wdfw.opendata.arcgis.com/datasets/puget-sound-high-resolution-change-detection-2006-2017	Landscape Context	Land use impacts detected in these data sets since the GAP/LANDFIRE mapping (2016) were incorporated into the composite land use layer.
Coastal Change Analysis Program (C-CAP)	NOAA - https://coast.noaa.gov/digitalcoast/data/ccapregional.html	Landscape Context	
National Wetlands Inventory (NWI)	USFWS - https://www.fws.gov/wetlands/	Landscape Context + Condition	Used for scoring a landscape context hydrology metric as well as a hydrology metric w/i the AA (condition). Also used to score a soil disturbance metric. Only used for wetlands.

Data Set	Source	Primary EIA Rank Factor	Function
National Hydrography Data Set (NHD)	USGS - https://www.usgs.gov/national-hydrography/national-hydrography-dataset	Landscape Context + Condition	Used for scoring a landscape context hydrology metric as well as a hydrology metric w/i the AA (condition). Also used to score a soil disturbance metric. Only used for wetlands.
Gradient Nearest Neighbor (GNN)	LEMMA - https://lemma.forestry.oregonstate.edu/data (Ohmann & Gregory, 2011)	Landscape Context + Condition	Used for scoring a landscape context vegetation structure metric as well as a structure metric w/i the AA (condition). Only used for forested ecosystems.
Forest Resource Inventory System	WA DNR - https://data-wadnr.opendata.arcgis.com/documents/polygon-rs-fris-download/about	Landscape Context + Condition	Used for scoring a landscape context vegetation structure metric as well as a structure metric w/i the AA (condition). Only used for forested ecosystems.
Washington Large Fires 1973-2020	WA DNR - https://data-wadnr.opendata.arcgis.com/documents/wadnr::washington-large-fires-1973-2020-download/about	Condition	Used for scoring a 'recent fire' metric. Only used for shrub-steppe ecosystems.
Washington Forest Practices Permit Data	WA DNR - https://www.dnr.wa.gov/programs-and-services/forest-practices	Landscape Context	Clearcuts and variable retention harvests occurring since the GAP/LANDFIRE mapping (2016) were incorporated into the composite land use layer.

2.1.3 Develop Level 1 EIA Metrics

All EIAs can be divided into three primary rank factors: Landscape Context, Condition, and Size. Level 1 EIAs assess these rank factors primarily using remote sensing data. In this project, metrics were developed within each of the rank factors in order to estimate the deviation from the natural range of variability (i.e. the reference standard) for each assessment area. Mathematical notation and additional information for each metric may be found in Appendix C. Some metrics were applied differently for NWI and NVC assessment areas. Metrics were derived from the data sets listed in Section 2.1.2.

Landscape Context

Landscape context metrics measure the capacity for natural disturbances and other ecological processes to occur on the landscape, the intensity of human land use, and the degree to which the area surrounding the AA buffers it from anthropogenic stressors or introduces additional stressors.

M1. Landscape Connectivity
The percentage of the area within 500m of the AA with natural land cover (%NLC). Natural land cover near the AA was weighted higher than on the edge of the 500m buffer (Figure 2). This metric is the same as in the previous Level 1 EIA model (Rocchio et al., 2014).

Data set(s) used: Composite Land Use Layer

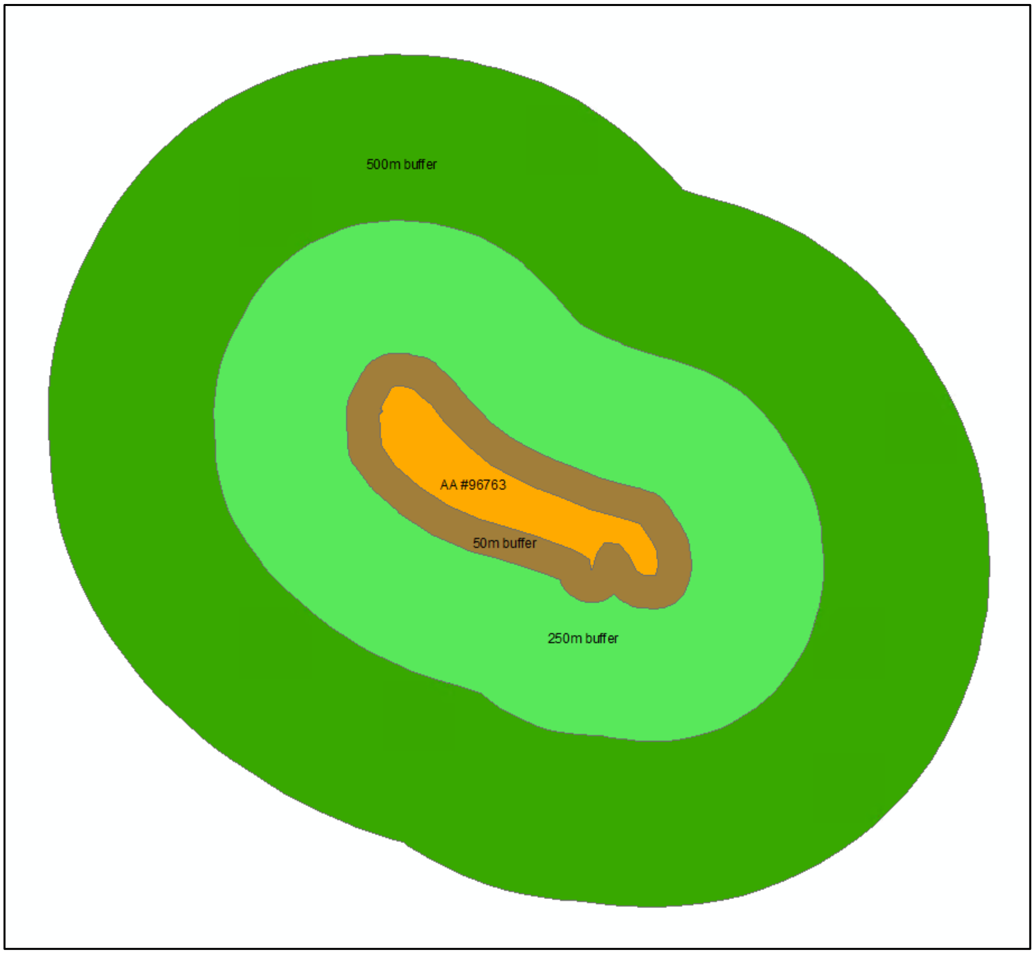

Figure 2. An NWI wetland assessment area surrounded by three buffered rings. Landscape context metrics weighted land cover within inner rings more heavily than outer rings.

M2. Landscape Land Use
The mean land use (LU) coefficient between 50 and 500 m of the AA. Land use coefficients (Appendix C) have been assigned to each land cover class, indicating the intensity of human land use. This metric is the same as in the previous Level 1 EIA model (Rocchio et al., 2014).

Data set(s) used: Composite Land Use Layer

M4. Buffer Land Use
The mean land use (LU) coefficient within 50 m of the AA. Land use coefficients have been assigned to each land cover class, indicating the intensity of human land use. This metric is the same as in the previous Level 1 EIA model (Rocchio et al., 2014).

Data set(s) used: Composite Land Use Layer

M5. Landscape Structure
Proportion of the forested area between 50 and 500 m of the AA that is mature and/or old-growth. This metric was only scored if 25% of the area within 50 to 500 m of the AA was forested. For some ecosystems—those not expected to occur near old-growth, like alpine tundra—this metric was only included in the roll-up if it would increase the overall score.

Data set(s) used: GNN structure map. OGSI200 pixels considered old-growth. OGSI80 pixels considered mature.

M6. Landscape Hydrology
Only applied to wetland ecosystems (NWI and NVC). The AA is marked down if the area between 50 to 500 m of the AA overlaps with an NWI polygon with an "artificially flooded" water regime OR non-natural special modifiers (partly drained/ditched, managed, or diked/impounded) OR overlaps with non-natural NHD feature (Dam/Weir, Gate, Lock Chamber, Reservoir, Canal/Ditch, Flume, Levee).

Data set(s) used: NWI, NHD

M7. Buffer Structure
Proportion of the forested area within 50 m of the AA that is mature and/or old-growth. This metric was only scored if 25% of that area was forested. For some ecosystems—those not expected to occur near old-growth, like alpine tundra—this metric was only included in the roll-up if it would increase the overall score.

Data set(s) used: GNN structure map. OGSI200 pixels considered old-growth. OGSI80 pixels considered mature.

M8. Buffer Hydrology
Only applied to wetland ecosystems (NWI and NVC). The AA is marked down if the area within 50 m of the AA overlaps with an NWI polygon with an "artificially flooded" water regime OR non-natural special modifiers (partly drained/ditched, managed, or diked/impounded) OR overlaps with non-natural NHD feature (Dam/Weir, Gate, Lock Chamber, Reservoir, Canal/Ditch, Flume, Levee).

Data set(s) used: NWI, NHD

Condition
Condition metrics measure the on-site ecological integrity within the assessment area. Level 2 EIAs score up to six vegetation metrics, three hydrology metrics, and a soil metric. Such metrics are difficult to assess via remote sensing data and our level 1 EIA model has only one metric each for vegetation, hydrology, and soils. An additional “recent fire” metric is also scored for shrub-steppe ecosystems (which were only assessed via our exploratory statewide application of the model). These metrics were derived from the data sets listed in Section 2.1.2.

M9. Forest Structure

Proportion of the AA that is mature and/or old-growth. Only scored for forested ecosystems. For naturally early seral forest types (e.g. lodgepole pine forests), or those for which old-growth characteristics are poorly defined (e.g. subalpine larch and whitebark pine woodlands), this metric was only included in the roll-up if it would increase the overall score.

Data set(s) used: GNN structure map. OGSI200 pixels considered old-growth. OGSI80 pixels considered mature.

M10. Hydrology
Only applied to wetland ecosystems (NWI and NVC). For NWI AAs, the score is marked down if the polygon has an "artificially flooded" water regime OR non-natural special modifiers (partly drained/ditched, managed, or diked/impounded) OR overlaps with non-natural NHD feature (Dam/Weir, Gate, Lock Chamber, Reservoir, Canal/Ditch, Flume, Levee). For NVC AAs, the score is marked down if the AA overlaps with an NWI polygon with any of those attributes.

Data set(s) used: NWI, NHD

M11. Soil Disturbance
Only applied to wetland ecosystems (NWI and NVC) due to data limitations in uplands. For NWI AAs, the score is marked down if the polygon has an "artificially flooded" water regime OR non-natural special modifiers (partly drained/ditched, managed, or diked/impounded) OR contains a non-natural NHD feature (Dam/Weir, Gate, Lock Chamber, Reservoir, Canal/Ditch, Flume, Levee). For NVC AAs, the score is marked down if the AA overlaps with an NWI polygon with any of those attributes.

Data set(s) used: NWI, NHD

M12. Recent Fire
Percentage of the AA that does not overlap with a major fire since 2016 in the DNR layer. Only applied to shrub-steppe ecosystems in our exploratory statewide application of the model, specifically Intermountain Mesic Tall Sagebrush Steppe & Shrubland (G302) and Intermountain Mountain Big Sagebrush Steppe & Shrubland (G304). While fire was historically a natural component in these ecosystems at relatively long return intervals (Baker, 2006), modern fires often trigger a cycle of repeated burning, in conjunction with introduced annual grasses, that may extirpate or severely degrade shrub-steppe occurrences. Fires before 2016 (year of the GAP/LANDFIRE imagery) are presumably accounted for in the landcover mapping—LANDFIRE tends to incorrectly map recently burned shrub-steppe as grassland.

Data set(s) used: DNR Washington Large Fires 1973-2020

Size
Small ecosystem occurrences do not necessarily have less ecological integrity than larger ones, but all other things being equal, larger occurrences are more resilient and of greater conservation interest. Size interacts with landscape context such that small occurrences embedded in entirely natural landscapes do not, necessarily have less ecological integrity than a larger example in the same landscape. However, a large occurrence in a fragmented landscape is likely to be more resilient to landscape-level stressors—effectively "buffering itself"—than a small one in a similarly fragmented landscape. Essentially, the size of the occurrence can impact the likelihood

of the plant community persisting on the landscape. Level 2 EIAs use two size metrics: one that evaluates comparative size (relative to other occurrences) and another that evaluates an occurrence's *change* in size (when known). Only the comparative size metric was used in this Level 1 model.

M13. Comparative Size
The size of the AA is evaluated relative to the patch size distribution of that ecosystem type across its range (Rocchio et al., 2020b). The resulting rating may either add or subtract points from the overall score (Table C-6).

<u>Data set(s) used</u>: AA spatial size

Roll-Up
The EIA score is an estimate of the overall ecological integrity of a given AA. EIA scores were calculated by combining the Landscape Context and Condition metrics into an overall numeric value, with varying weights for each of the component metrics. EIA scores were then divided into Excellent (A), Good (B), Fair (C), and Poor (D) bins, known as EIA ranks. EIA ranks aid interpretation and dispel the false sense of precision imbued by an EIA score that goes to multiple decimal places.

The Element Occurrence rank score (EO rank score) is an estimate of the overall conservation significance of an AA and its potential to persist on the landscape—it incorporates size (see Section 2.1.2). Modifier values derived from the Comparative Size metric (M13) were added (or subtracted) from EIA scores to produce EO rank scores. These were also divided into Excellent, Good, Fair, and Poor EO ranks in the same manner as the EIA scores. In typical Natural Heritage methodology, EO ranks are only assigned based on in-person field visits, so these Level 1 results should be treated as *provisional* EO ranks.

The roll-up processes for upland and wetland ecosystems differ slightly, because the ecosystems themselves vary in how they are impacted by the landscape factors captured in the component data sets. For example, the presence of a nearby ditch (mapped in the National Hydrography Data Set) is likely to have more impact on the ecological integrity of a wet meadow than on an upland forest. Metric weightings and the roll-up procedures for the primary rank factors, EIA score, and EO rank score may be found in Appendix C.

3 Level 2 EIA

3.1 Focus Watershed Selection

After completing the first iteration of the Level 1 Ecological Integrity Assessment (EIA), WNHP conducted rapid Level 2 EIAs in a subset of ecosystem types in a single Water Resource Inventory Area (WRIA). These on-the-ground data provided refined information concerning the condition of ecologically important lands and helped calibrate and revise the Level 1 model.

3.1.1 WRIA Selection

Initial Filter
There are 19 WRIAs in the Puget Sound drainage basin. We narrowed these down to 5 potential watersheds (Table 3) based on the following criteria:

- Very small watersheds, or those with very little elevational gradient were excluded (e.g. Chambers-Clover, #12)

- Watersheds with little land use diversity or with a very high percentage of protected land were excluded (e.g. Upper Skagit, #4, and Skokomish - Dosewallips, #16).

- Watersheds that contain large areas that are difficult to access due to drinking water considerations (e.g. Cedar - Sammamish, #8) or military reservations were not preferred.

- Watersheds like the San Juan Islands WRIA (#2) that involved extra travel time /considerations/expense without an outweighing benefit were excluded.

Table 3. Subset of Puget Sound Water Resource Inventory Areas (WRIA) considered for Level 2 EIA Sampling.

WRIA #	WRIA Name
7	Snohomish
10	White-Puyallup
11	Nisqually
17	Quilcene-Snow
18	Dungeness/Elwha

The five remaining WRIAs are listed in Table 3 and included Snohomish (#7), White-Puyallup (#10), Nisqually (#11), Quilcene-Snow (#17), and Dungeness/Elwha (#18). Nisqually (#11) was found to be similar to the White-Puyallup (#10) drainage in terms of size, proportions of different elevation zones, land use diversity (though Nisqually is somewhat less developed overall), etc. The White-Puyallup has updated NWI mapping however, and a large portion of the lower Nisqually is within Joint Base Lewis-McChord, so Nisqually was dropped from consideration.

The Quilcene-Snow (#17) WRIA was also dropped, as sub-watersheds within that WRIA were found to be disproportionately small, lowland drainages with less land use diversity than the other remaining options.

Of the remaining three WRIAs, Dungeness/Elwha (#18) appeared to have somewhat less land use diversity and a more uneven distribution of land use intensity than the Snohomish (#7) and White-Puyallup (#10). The latter two WRIAs were also found to be larger and have additional benefits/synergy such as pre-identified collaborative opportunities (the ongoing Department of Natural Resources Salmon Action Plan in the Snohomish (WADNR, 2020) or the previously mentioned updated NWI-mapping (White-Puyallup). The Snohomish and White-Puyallup were retained as the two finalists.

3.1.2 Watershed Technical Advisory Group Meetings

After selecting the two final WRIAs, we reached out to committee chairs for the respective watershed restoration and enhancement boards organized by the Department of Ecology. These chairs then directed us to their respective Technical Advisory Groups, which are led by local entities, to gauge local interest in this project and help develop research questions. WNHP coordinated web meetings with the TAGs, presenting the conceptual background, data sets, and metrics used in the Level 1 EIA. We solicited input on knowledge gaps regarding ecologically important lands in each watershed, known stressors of concern, potential overlap/synergy with ongoing restoration and conservation projects in the watershed, as well as additional data sets that could be incorporated into the Level 1 model. We also received input on sub-WRIA geographic areas of interest and specific ecosystem types that would benefit from Level 2 (on-the-ground) sampling.

The Snohomish TAG (WRIA 7) was receptive and had the following comments/contributions:

- They are in the process of updating their habitat restoration/protection targets for salmon recovery. To that end, they were primarily interested in overall impervious surface number, overall forest cover, and overall riparian forest cover within 150 ft. of major rivers.

- The primary ecosystem focus of the TAG is wetlands (and riparian areas, specifically). They are targeting floodplains and wetlands for long-term protection.

- Some of the TAG members have been using Coastal Change Analysis Program (C-CAP) and High Resolution Change Detection (HRCD) land cover data (which we are also using in our model) to calculate riparian cover and other data products. They are also working on new methods for assessing floodplain connectivity.

- The committee suggested working with Tim Beechie (NOAA) who is working on a salmon lifecycle model with data needs concerning current riparian conditions (mainly tree height and buffer width along streams), as well as historical conditions.

- Sediment accretion (particularly fine sediment) was of particular interest.

The White-Puyallup TAG (WRIA 10) was enthusiastic about the project and had the following comments/contributions:

- TAG members pointed us towards a previous analysis conducted by WDFW, University of Washington, and Pierce County, which resulted in the creation of the Pierce County Biodiversity Network (focused on terrestrial animal species) (Brooks et al., 2004). These were noted as areas of interest.

- Riparian forests and woodlands came up repeatedly as ecosystems of interest. Additionally, it was noted that floodplain marshes, wet meadows, and wet prairies have experienced significant degradation and reduction in area due to timber harvest and agriculture. As a consequence, TAG members were concerned about impacts to water storage/recharge.

- Estuarine areas were also identified as data gaps.

- The "upper watersheds" of the WRIA (essentially above the dams) were geographic areas of particular interest.

- TAG members are working on a riparian decision support tool and thought that our project would be very complimentary to their efforts. They have made concerted efforts in the past five years to do more comprehensive watershed wide planning efforts, rather than working more opportunistically.

- They noted that DNR and NPS lands in the watershed are data “black holes” for them and hoped that our involvement in the area might assist with that.

- TAG members noted that our data products could be useful for identifying areas of conservation and restoration interest.

- They have been working on a number of GIS projects, so the TAG chair offered up comprehensive roads layers, infrared imagery, and other data layers if they would be helpful. They also pointed us towards Pierce County’s Wetland Inventory data set, which has wetlands that have not been mapped by the National Wetland Inventory (NWI).

3.1.3 Final WRIA Selection

Using the initial draft of the Level 1 EIA results and our composite land use data set, we confirmed that both WRIA 7 and 10 had 1) sufficient distribution of ecosystem occurrences across a human disturbance gradient (as determined by the Level 1 EIA rank spectrum (A - D)) for our NWI wetland assessment areas (Figure 3, Figure 4) and 2) sufficient distribution of land area across a human land use intensity gradient (based on coefficients assigned in our composite land use layer) (Figure 5). This analysis ensured that we would have enough assessment areas across these gradients with which to test and calibrate the Level 1 model.

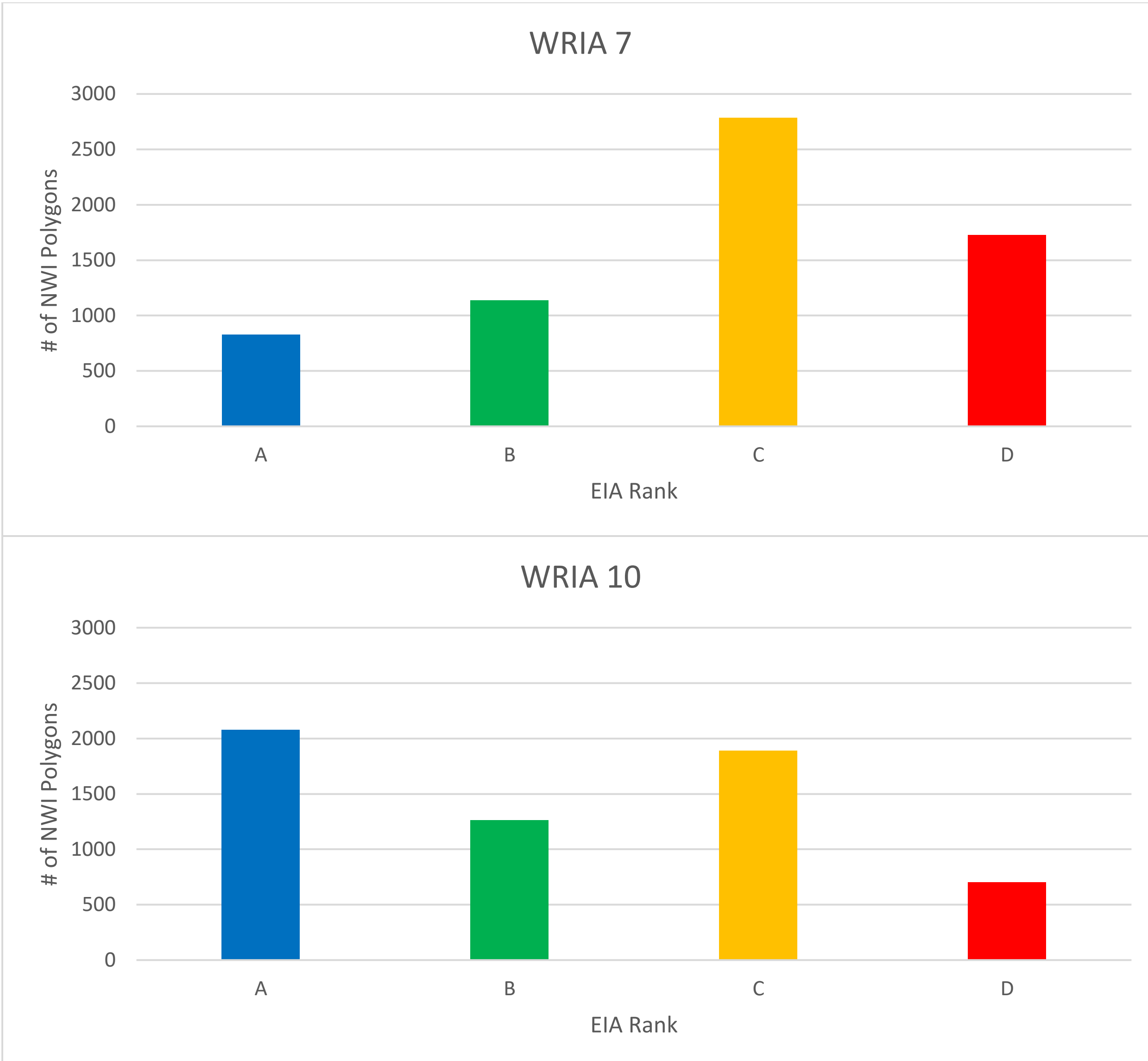

Figure 3. Number of National Wetland Inventory AAs by initial Level 1 EIA rank (Water Resource Inventory Areas 7 and 10).

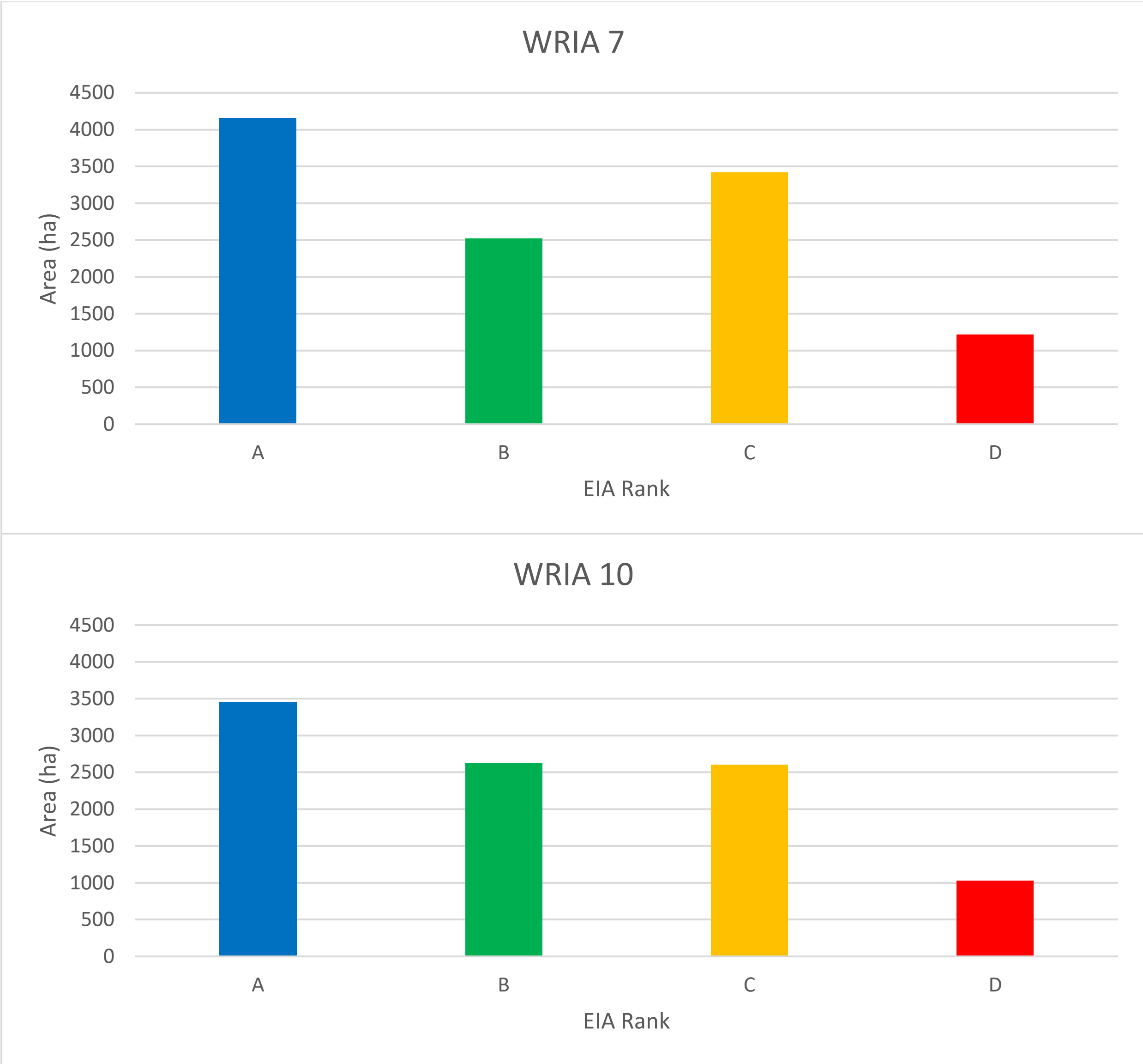

Figure 4. Area of National Wetland Inventory AAs by initial Level 1 EIA rank (Water Resource Inventory Areas 7 and 10).

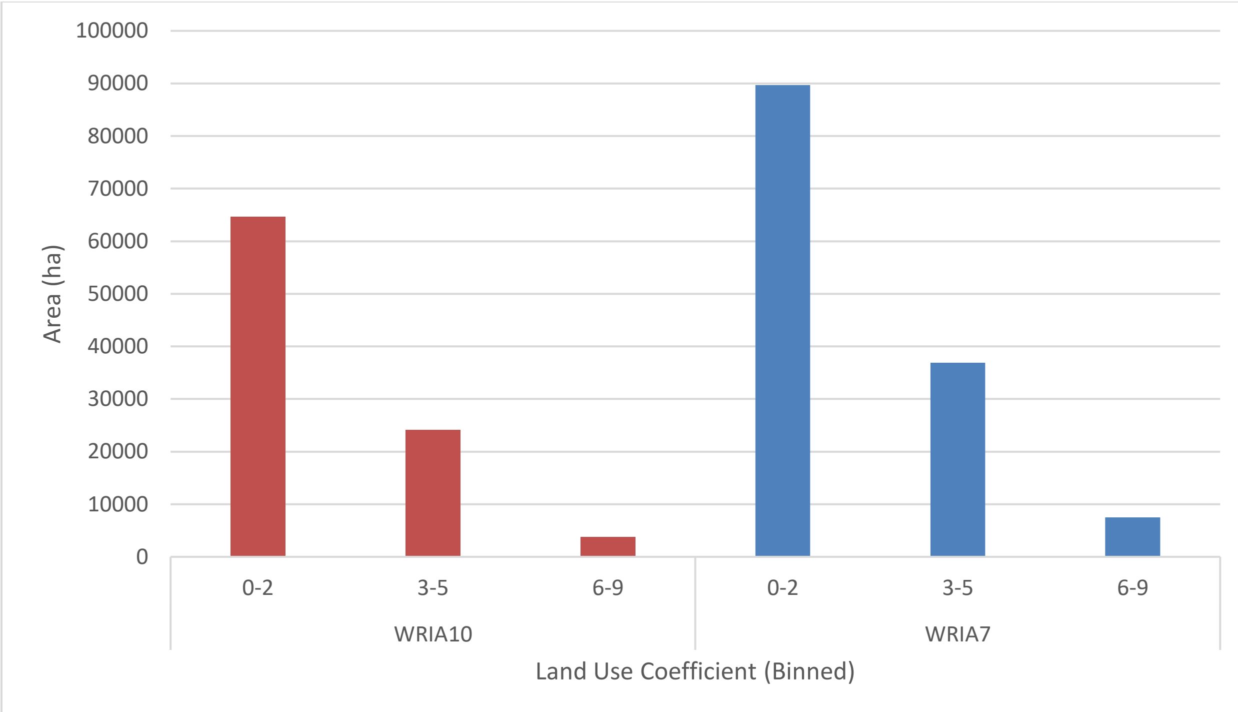

Figure 5**.** Area (ha) of Land Use coefficients in Water Resource Inventory Areas 7 and 10 (0 = intense development, 10 = managed for natural vegetation). Areas mapped as natural vegetation, i.e., areas with a coefficient of 10 (WRIA 10 = 179,913 ha; WRIA 7 = 360,526 ha) are excluded from this graphic for legibility.

Both TAGs welcomed additional research and surveys in their respective watersheds. Members of the WRIA 10 TAG quickly identified potential applications for our work that would help address critical information needs. As such, we decided WRIA 10 would be an excellent pilot area in which to conduct this initial effort and provide a demonstration of its utility. Additionally, field survey logistics were deemed easier in this watershed (our offices are located in Olympia) which became important when the COVID-19 pandemic complicated field travel.

3.2 Ecosystem Targets for Level 2 EIA Sampling

Because we used different mapping systems (and slightly different metrics) for upland and wetland ecosystems in the Level 1 EIA, we decided to target one wetland and one upland ecosystem type for Level 2 sampling.

3.2.1 Upland Ecosystem Targets for Level 2 EIAs

For uplands, we targeted forests classified in the Vancouverian Coastal Rainforest Macrogroup (M024) of the NVC, based on GAP/LANDFIRE mapping. The ecological integrity of this upland forested ecosystem has known impacts on the ecological integrity of the targeted wetland/riparian systems of interest to the local stakeholders. For example, riparian areas within older, less-impacted forest landscapes may experience higher summer stream flows than those in more heavily logged landscapes, impacting salmon habitat. Logged watersheds are also characterized by greater sedimentation, nutrient fluxes, “flashier” hydrology, etc. (Keppeler & Ziemer, 1990;

Surfleet & Skaugset, 2013; Segura et al., 2020). Finally, these forests cover a large proportion of the watershed, providing abundant sample locations.

3.2.2 Wetland Ecosystem Targets for Level 2 EIAs

Based on feedback from the WRIA 10 Technical Advisory Group, we targeted riparian forests and woodlands for our Level 2 wetland EIAs. These wetlands correspond to Palustrine Forested wetlands (PFO) in the Cowardin classification used in NWI mapping, and Vancouverian Flooded & Swamp Forest (M035) in the NVC. Riparian forests and woodlands were targeted because of their well-documented direct and indirect impacts on salmon habitat (Cederholm et al., 1997; May et al., 1997; Beechie et al., 2003; Burnett et al., 2007). We also thought that a comprehensive assessment of these wetlands would be synergistic with the riparian decision support tool being developed by the WRIA 10 TAG. Note, however, that Palustrine Forested wetlands also include non-riparian ecosystems such as swamps and freshwater tidal systems. To eliminate freshwater tidal stands, we restricted sampling to polygons with the following nontidal water regimes: Temporarily Flooded, Seasonally Saturated, Seasonally Flooded, Continuously Saturated, Seasonally Flooded/Saturated, and Intermittently Flooded. However, the level of specificity available in the NWI data did not allow us to confidently exclude all basin and seepage swamps.

3.3 Identifying Potential Sample Sites

3.3.1 Upland AAs

Level 2 EIAs are usually often conducted using a polygon-based AA approach (as in Section 3.3.2, below). However, Vancouverian Coastal Rainforests are "matrix" ecosystems, meaning they form extensive and contiguous cover across much of the landscape, resulting in potential assessment area polygons of many thousands of hectares. To demonstrate another application of EIA methodology—and as a matter of practicality—WNHP decided to use a point-based approach to assess these upland ecosystems, rather than polygons. This method is outlined briefly in Rocchio et al. (2020b) and a similar approach is demonstrated in Lemly (2012). With this approach, relatively small areas (0.5 to 2 ha) are assessed around predetermined points distributed in a spatially balanced, stratified design across the watershed (Figure 6). First, the NVC-derived assessment areas provided the sample universe for the Level 2 EIA. Second, Level 2 upland AAs were stratified spatially within WRIA 10 *and* across the Level 1 EIA rank spectrum—from 'A' to 'D'—using the Reverse Randomized Quadrant-Recursive Raster procedure (RRQRR) (Theobald et al., 2007) via the ArcGIS tool "Create Spatially Balanced Points". RRQRR is quite similar to Generalized Random Tesselation Stratified (GRTS). The two methods differ primarily in how they handle unequal inclusion probabilities (which were not used in this project) and different sample unit densities in finite designs (Dumelle et al., 2022). The number of targeted samples (80) was based on methods described in Stevens and Olsen (2004)—taking into account budgeted field days (two NVC AAs per day)—and stratified across the Level 1 EIA ranks. The number of samples in each rank was weighted by its relative area (Table 4). The resulting data provides a population estimate of ecological integrity of the ecosystem across the watershed. These points also serve as spot-checks of the Level 1 EIA model and can incidentally identify specific ecosystem occurrences of conservation interest. At the start, we also selected oversample locations to account for access denials and rejected sites. When an AA was dropped, the next one on the list—within the same EIA rank bin—was selected as its replacement. We used broad access criteria (< 5 km from a road) in creation of the stratified samples, but AAs were also subjectively rejected by field staff when they proved inaccessible via reasonable, safe effort. Only 51 upland AAs were assessed due to access issues and time constraints. Note that the initial Level 1 EIA model produced very few B and D-ranked Vancouverian Coastal Rainforest assessment area in WRIA 10. Additional oversample AAs were generated to facilitate sampling of a D-ranked point as all the D-ranked areas in the initially generated assessment areas (target and oversamples) were on parcels that denied access.

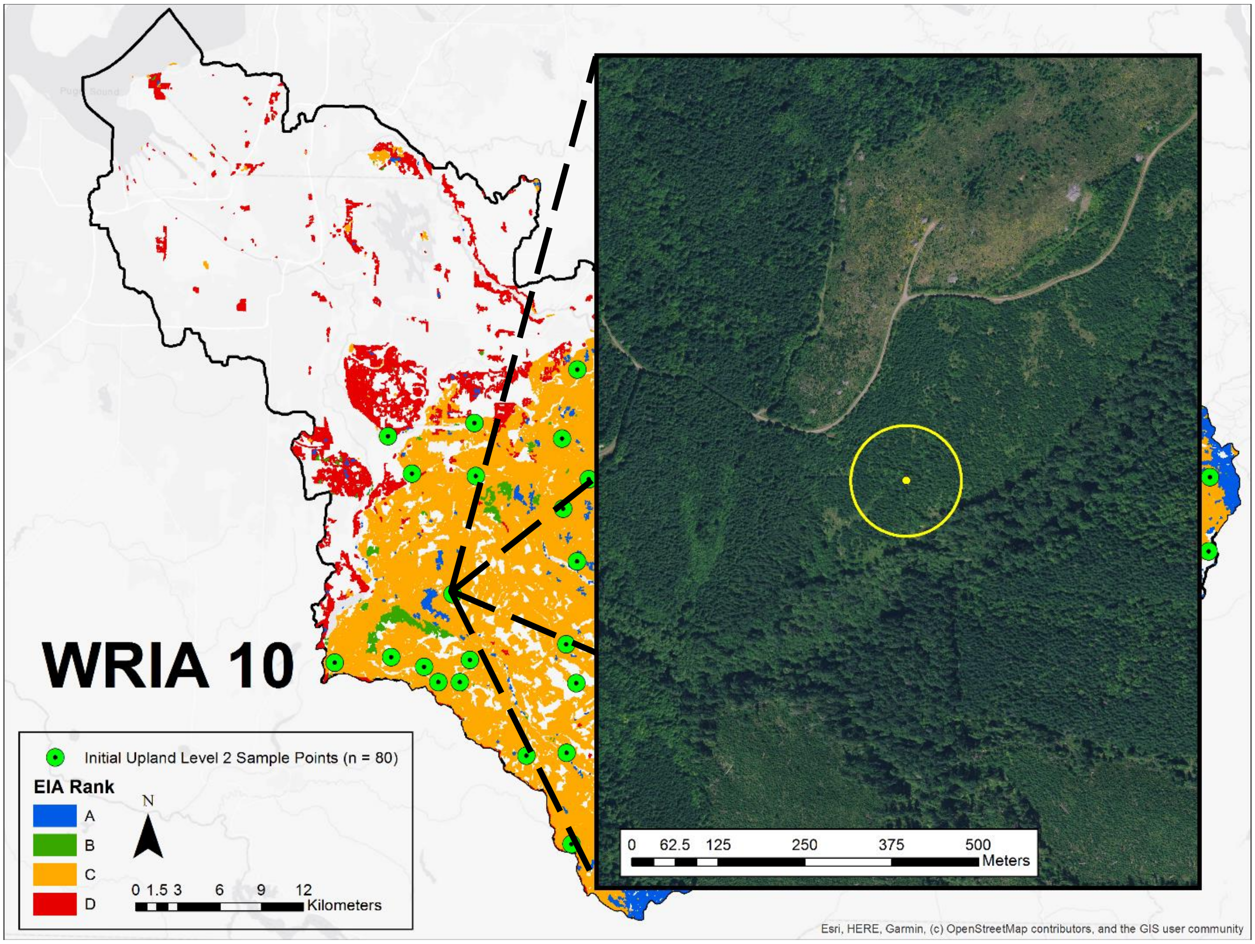

Figure 6. Example of upland AA in Vancouverian Coastal Rainforest.

Table 4. Initial Level 2 upland AAs by EIA rank.

EIA Rank	Area (ha)	Target # of Samples
A	21,581	24
B	8	1
C	48,502	54
D	820	1

3.3.2 Wetland AAs

While we used a polygon-based sampling approach for our wetland ecosystem targets, the stratified sampling process was largely the same as for uplands. We stratified the sample using RRQRR and the number of AAs in each rank was weighted by relative area in the initial Level 1

EIA (Figure 7, Figure A-1, Table 5). Polygons were first converted to points, as suggested in Theobald et al. (2007). The number of targeted samples (80) was based on Stevens and Olsen (2004) and budgeted field days (two NWI AAs per day), with the same oversample process used for wetlands. Of the 80 sites selected for sampling, we ended up sampling only 49 NWI AAs due to access issues and time constraints.

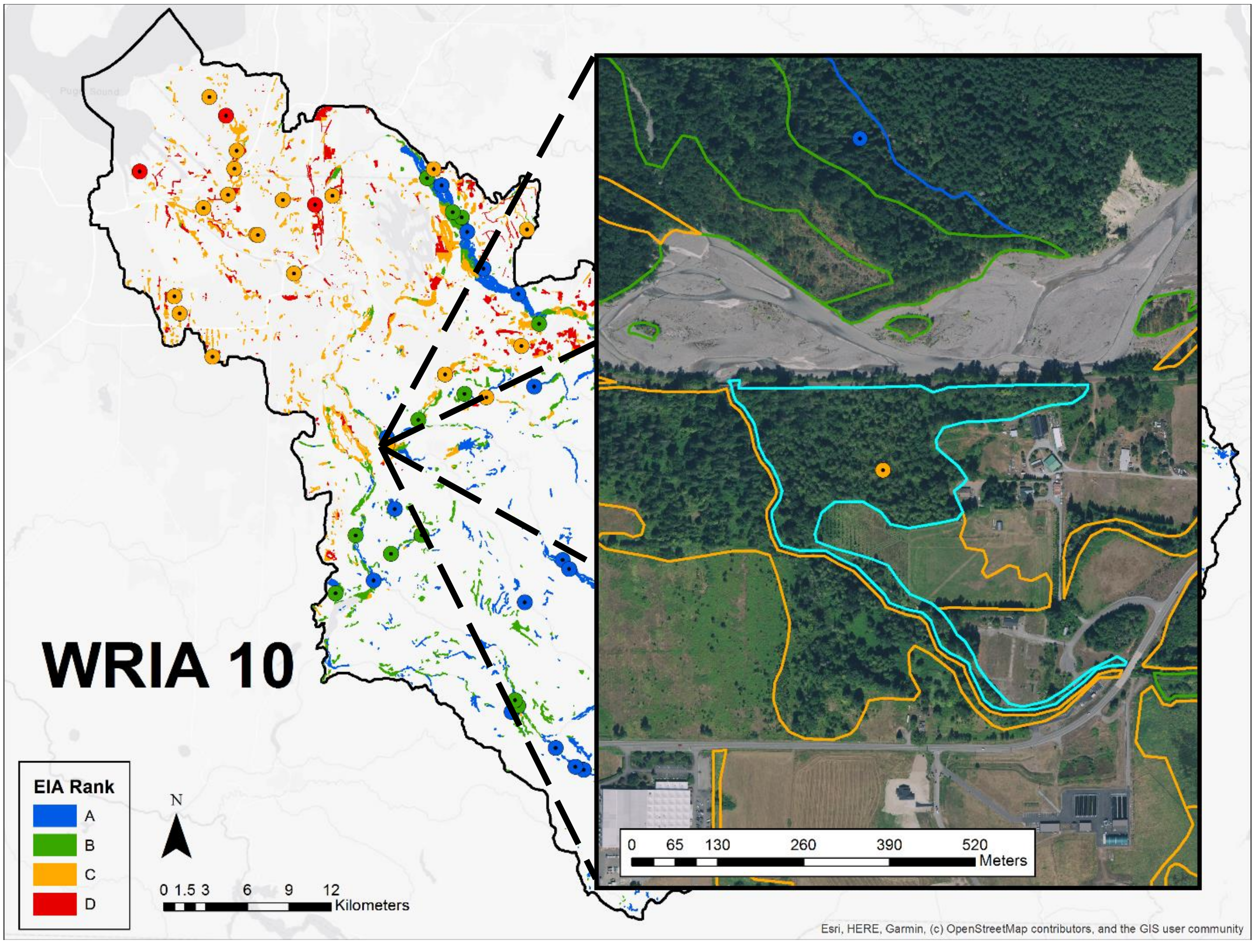

Figure 7. Example of wetland assessment area derived from initial Level 1 Ecological Integrity Assessment of National Wetland Inventory riparian forest polygons.

Table 5. Initial Level 2 targeted wetland AAs by EIA rank.

EIA Rank	Area (ha)	Target # of Samples
A	2,122	33
B	1,236	23
C	1,236	20
D	258	4

3.4 Level 2 EIA Field Methods

3.4.1 Site Selection and Land Owner Contact

Once AAs were identified, we began the process of determining ownership, contacting the owners, and obtaining requisite permits. This process varied by landowner, sometimes taking several months. Access proved difficult for NWI AAs that received C-ranks (i.e. fair ecological integrity) in the Level 1 EIA—they frequently fell within complex matrices of private land ownership. As a result, C-ranked wetlands were under-sampled. We were able to access 51 upland AAs and 49 NWI AAs during the 2021 field season, due to access denials, permitting timelines, and unavoidable terrain issues. This fell short of our planned total of 160 AAs, but we attempted to maintain the same *proportion* of AAs in each rank category (Table 6, Table 7). We were able to sample an adequate number of AAs in each rank category for upland ecosystems, but ended up over-sampling A and B-ranked wetlands. This enabled us to increase our sample size for correlation analyses with the Level 1 EIA (Section 5), but it also meant that we could not use the Level 2 wetland data to produce a separate estimate of overall watershed forested wetland integrity as we could not draw conclusions about the condition of the under sampled C and D-ranked wetlands.

Table 6. Level 2 wetland AAs by EIA rank. A-Rank = excellent ecological integrity; B-Rank = good ecological integrity; C-Rank = fair ecological integrity; and D-Rank = poor ecological integrity.

EIA Rank	Area Assessed by Level 1 EIA (ha)	Initial Target # of AAs	Adjusted Target # of AAs	AAs Sampled
A	2,122	33	20	23
B	1,236	23	14	20
C	1,236	20	13	4
D	258	4	3	2

Table 7. Level 2 upland AAs and samples assessed by EIA rank. A-Rank = excellent ecological integrity; B Rank = good ecological integrity; C-Rank = fair ecological integrity; and D-Rank = poor ecological integrity.

EIA Rank	Area Assessed by Level 1 EIA (ha)	Initial Target # of AAs	Adjusted Target # of AAs	AAs Sampled
A	21,581	24	15	16
B	8	1	1	1
C	48,502	54	33	33
D	820	1	1	1

3.4.2 Field Assessment Methods

Field assessments were primarily performed between June 21st and September 10th, 2021. Field assessors worked together on the first seven AAs to calibrate themselves and ensure consistent evaluations.

Some areas were inaccessible due to hazardous terrain, road washouts, or fire closures. If we could not reach an upland point, but there was an accessible area of the same ecosystem type and Level 1 EIA rank within 500m of the original AA, we simply shifted the point. If the area was completely inaccessible, we selected the next point from the oversample list. NWI AAs could not be shifted because they were assessed using a polygon-based approach. If an NWI AA was rejected, we automatically moved to the next wetland on the oversample list.

3.4.3 Upland Assessment Areas

Upland ecosystems were sampled using a point-based sampling strategy employing 40-meter fixed-radius AAs. At each upland AA point, the following data were collected: slope, aspect, landscape position, GPS coordinates, general site description, and ecological integrity ratings and supporting data using WNHP Ecological Integrity Assessment methodology. Upland EIA protocols are described in Rocchio et al. (2020a). The following EIA metrics were rated at each upland AA point:

- Condition Primary Factor Score (PFS)
  - Vegetation Major Ecological Factor (MEF)
    - VEG1 Native Plant Species Cover
    - VEG2 Invasive Nonnative Plant Species Cover
    - VEG3 Native Plant Species Composition
    - VEG4 Vegetation Structure
    - VEG5 Woody Regeneration
    - VEG6 Coarse Woody Debris and Snags
  - Soil Major Ecological Factor
    - SOI1 Soil Condition

Vegetation community classification was determined using Ramm-Granberg et al. (2021) and Chappell (2006) and then crosswalked to the current version of the NVC (Version 2.03, hierarchy 36). Because the upland areas were surveyed at fixed points within larger expanses of the same ecosystem, we did not score Landscape Context metrics. We collected field notes on the condition of the area within 100 m surrounding the point—and of the general landscape—to aid metric interpretation and to provide insight when identifying potential element occurrences (EOs).

Four relatively high-elevation AAs mapped as M024 actually represented occurrences of Vancouverian Subalpine – High Montane Forest (M025) when surveyed. We still evaluated these four AAs to help calibrate the Level 1 EIA, but they were not used to assess overall condition of M024 in the WRIA 10 watershed.

3.4.4 NWI Wetland Assessment Areas

Ecological integrity was assessed within the boundary of targeted NWI polygons. Occasionally NWI AAs contained upland areas due to mapping errors (or inclusions). In these cases, we assessed only the wetland area within the AA polygon and made note of any upland areas. If < 75% of the AA was wetland, we modified the AA boundary. The following data were collected within each NWI wetland assessment area: slope, aspect, landscape position, GPS coordinates, general site description, and ecological integrity data (using WNHP EIA methodology). Protocols for applying the EIA are described in Rocchio et al. (2020b). Because we used polygon-based AAs for wetlands, we scored Landscape Context EIA metrics in addition to Condition metrics. The EIA metrics scored at each wetland polygon included:

- Landscape Context Primary Factor Score (PFS)
  - Landscape Major Ecological Factor
    - LAN1 Contiguous Natural Land Cover

        - LAN2 Land Use Index
    - Buffer Major Ecological Factor
        - BUF1 Perimeter with Natural Buffer
        - BUF2 Width of Natural Buffer
        - BUF3 Condition of Natural Buffer
- Condition Primary Factor Score (PFS)
    - Vegetation Major Ecological Factor
        - VEG1 Native Plant Species Cover
        - VEG2 Invasive Nonnative Plant Species Cover
        - VEG3 Native Plant Species Composition
        - VEG4 Vegetation Structure
        - VEG5 Woody Regeneration
        - VEG6 Coarse Woody Debris and Snags
    - Hydrology Major Ecological Factor
        - HYD1 Water Source
        - HYD2 Hydroperiod
        - HYD3 Hydrological Connectivity
    - Soil Major Ecological Factor
        - SOI1 Soil Condition

Wetland plant communities were identified primarily using Ramm-Granberg et al. (2021) and Rocchio et al. (2021). HGM (Brinson, 1993) and Cowardin classifications were determined using the keys in Rocchio et al. (2020a).

4 Data Analysis Methods

4.1 Level 2 EIA Analysis

4.1.1 Agreement between Initial Level 1 EIA and Level 2 EIA Methods

We conducted a preliminary analysis of the relationship between Level 1 and Level 2 EIA using standard accuracy assessment statistics: overall accuracy, kappa statistic, producer's accuracy, and user's accuracy. Overall accuracy describes the proportion of Level 2 EIA ranks that match those assigned via the Level 1 EIA. Kappa statistic is similar, but adjusts the overall accuracy to account for the number of AAs expected to be correct due to random chance. A kappa value less than 20% indicates that the compared sets of data show slight agreement, 21 to 60% shows fair to moderate agreement, and > 60% shows substantial to near perfect agreement (Landis & Koch, 1977). The higher the kappa statistic, the more the Level 1 and Level 2 metrics agree.

Producer's and user's accuracy are less intuitive for many practitioners. These statistics are calculated for each individual map class (EIA ranks of A, B, C, or D in this project). Producer's accuracy is a measure of omission errors—these are "false negatives", or errors that occur when something is erroneously excluded (Lavrakas, 2012). In the context of this project, if a surveyor conducts an on-the-ground Level 2 EIA that results in an "A" rank, the producer's accuracy equals the probability that the Level 1 EIA will also have ranked that site as an "A".

$$\text{Producer's Accuracy} = 100\% - \text{Omission Error}$$

User's accuracy, on the other hand, is a measure of commission errors—these are "false positives", or errors that occur when something is erroneously included (Lavrakas, 2012). User's accuracy is essentially a measure of the map's reliability. Consider a land manager interested in finding C-ranked wetlands where they might want to do restoration work. If the land manager uses our Level 1 EIA map to navigate to a C-ranked wetland, the user's accuracy equals the probability that a Level 2 EIA of that site will also result in a "C".

User's Accuracy = 100% - Commission Error

To clarify the distinction with a further example: Consider a theoretical Level 1 EIA that predicts that the entirety of WRIA 10 has "A" ecological integrity. In this case, the producer's accuracy for the A-ranked category would, by definition, be 100%. In other words, anytime a site was ranked as an "A" via a Level 2 EIA, it would always receive that rank in the Level 1 EIA, as well. On the other hand, the user's accuracy for the A-ranked category would be *terrible*, because the map would be wrong the vast majority of the time that it was used to navigate to an A-ranked site (the user would frequently end up in B, C, or D-ranked sites instead).

Both accuracy measures are important for evaluating the Level 1 EIA model and map. Since a primary objective of this project was to use the Level 1 EIA to help identify ecologically important lands for conservation and restoration, the producer's accuracy for the A and B ranks can tell you how likely it is that one of these high integrity sites will slip the cracks and *not* be identified by the model. Conversely, the user's accuracy for A and B ranks tells you how likely it is that using the Level 1 map to navigate to a purportedly high integrity site will actually take you to a *low* integrity site.

For additional information about these statistics, see Lea and Curtis (2010) for a comprehensive overview.

4.1.2 Level 1 EIA Correlation and Adjustment Methods

Correlation between Level 1 EIA scores and Level 2 EIA scores were assessed using scatter plots and correlation coefficients (Rocchio, 2007; Lemly & Rocchio, 2009). Correlations were considered strongly correlated if $R^2 \geq |0.5|$. We looked at overall correlation between EIA scores, Primary Factor Scores (PFS), Major Ecological Factors (MEF), and individual Level 1 EIA metrics to determine if any metrics/factors, metric weightings, or ranking bins required adjustment. We used a simple iterative process of adjusting these elements and then recalculating correlations. We then re-ran the final model to produce the updated Level 1 EIA results presented below.

5 Results

As noted previously, Level 1 EIA results were used to stratify the Level 2 EIA sampling. The results of the Level 2 EIA sampling were then used to more precisely assess the condition of certain ecosystems in WRIA 10. These data were also compared to the initial Level 1 EIA results to determine agreement. Based on the agreement between the two data sets, we then calibrated the initial Level 1 EIA to produce the updated Level 1 EIA model.

5.1 Condition of Upland Forests and Forested Wetlands in WRIA10

5.1.1 Upland Condition in WRIA 10

As noted previously, Landscape Context metrics were not scored as part of the point-based Level 2 EIA sampling procedure used for upland AAs, so Condition rank is reported in the summaries below. In other contexts, Condition ranks would be integrated with a Landscape Context rank to produce an overall EIA rank (Rocchio 2020a). Condition ranks have been summarized by both NVC macrogroup and group, potentially demonstrating differences in ecological integrity *within* macrogroups.

Overall, upland AAs showed a range of fair to excellent condition across areas sampled in the Level 2 EIA. Stressors negatively impacting ecological integrity, such as land conversion, nonnative species cover, roads, and fragmentation, were much more prevalent at lower elevations. Note that some of the higher elevation upland sites we surveyed fell outside of the Vancouverian Coastal Rainforest Macrogroup (M024) and were classified on-site as Vancouverian Subalpine-High Montane Forest Macrogroup (M025) (Table 8, Figure 8).

Table 8. Summary of Level 2 Upland Condition rank by NVC group and macrogroup. A-Rank = Excellent ecological integrity; B-Rank = good ecological integrity; C-Rank = fair ecological integrity; and D-Rank = poor ecological integrity.

	Level 2 Condition Rank			
NVC Classification	**A**	**B**	**C**	**Total**
M024 Vancouverian Lowland & Montane Forest	21	14	12	47
G237 North Pacific Red Alder - Bigleaf Maple - Douglas-fir Forest Group			1	1
G240 North Pacific Maritime Douglas-fir - Western Hemlock Forest Group	6	5	10	21
G241 North Pacific Maritime Silver Fir - Western Hemlock Forest Group	14	8	1	23
G750 North Pacific Maritime Western Hemlock - Sitka Spruce Rainforest Group	1	1		2
M025 Vancouverian Subalpine Forest	4			4
G245 North Pacific Mountain Hemlock - Silver Fir Forest & Tree Island Group	4			4
Total	25	14	12	51

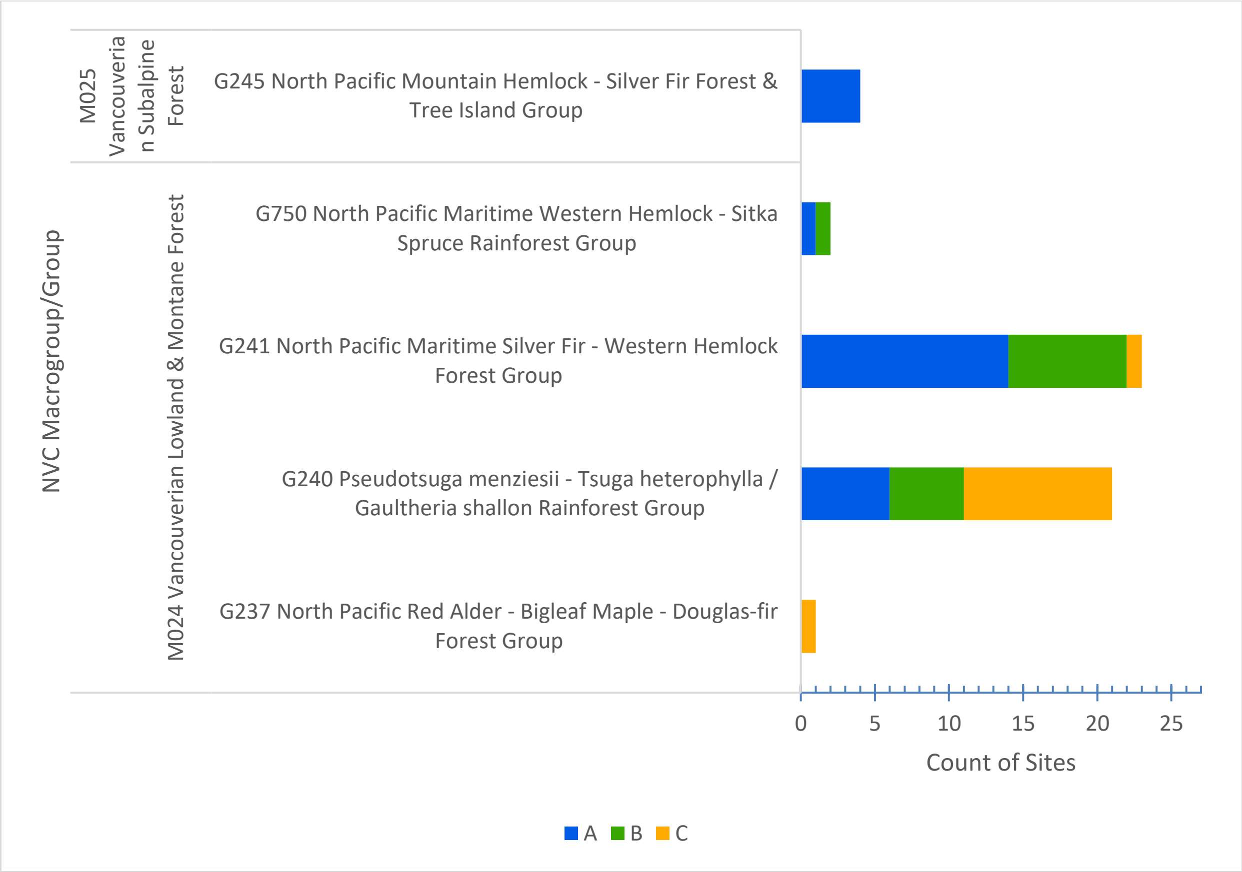

Figure 8. Level 2 upland Condition ranks at all AAs evaluated in WRIA 10. A-Rank = excellent ecological integrity; B-Rank = good ecological integrity; C-Rank = fair ecological integrity.

Within the Vancouverian Coastal Rainforest Macrogroup (M024), 45% of the observed AAs had A Condition ranks, 30% were B-ranked, and 25% were C-ranked. Therefore, only 25% of the AAs evaluated fell outside of the natural range of variability (A and B-ranks). Primary stressors observed in upland areas included roads and recreational impacts, which impacted Soil and Edge metric scores, and nonnative and invasive species, which impacted Native Plant Species Cover and Invasive Nonnative Plant Species Cover metrics.

Elevation

Overall, upland AAs sampled at higher elevations had higher Level 2 EIA Condition scores than those at lower elevations both across the Vancouverian Coastal Rainforest Macrogroup (Figure 9) and within individual groups (G241: Figure 10, G240: Figure 11). The correlation between elevation and condition score was weaker in G240 North Pacific Maritime Silver Fir – Western Hemlock Forest Group, but there was also less variability in management types (NPS vs. USFS or private timber) across its range within WRIA 10. The higher elevation areas of WRIA 10 are largely within Mt. Rainer National Park and USFS-managed lands including wilderness areas. These areas are less developed and logging impacts are often less recent, or entirely absent. Invasive species are also generally less problematic at higher elevations.

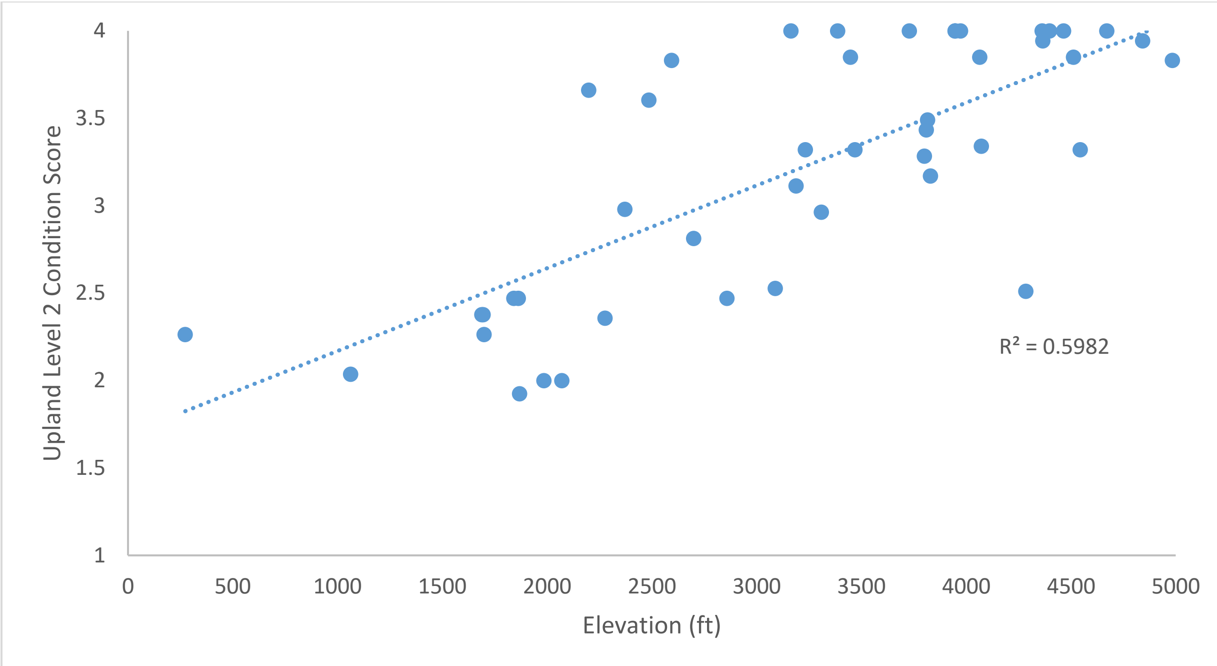

Figure 9. Upland Level 2 EIA AA condition score vs elevation of AA within Vancouverian Coastal Rainforest Macrogroup (M024).

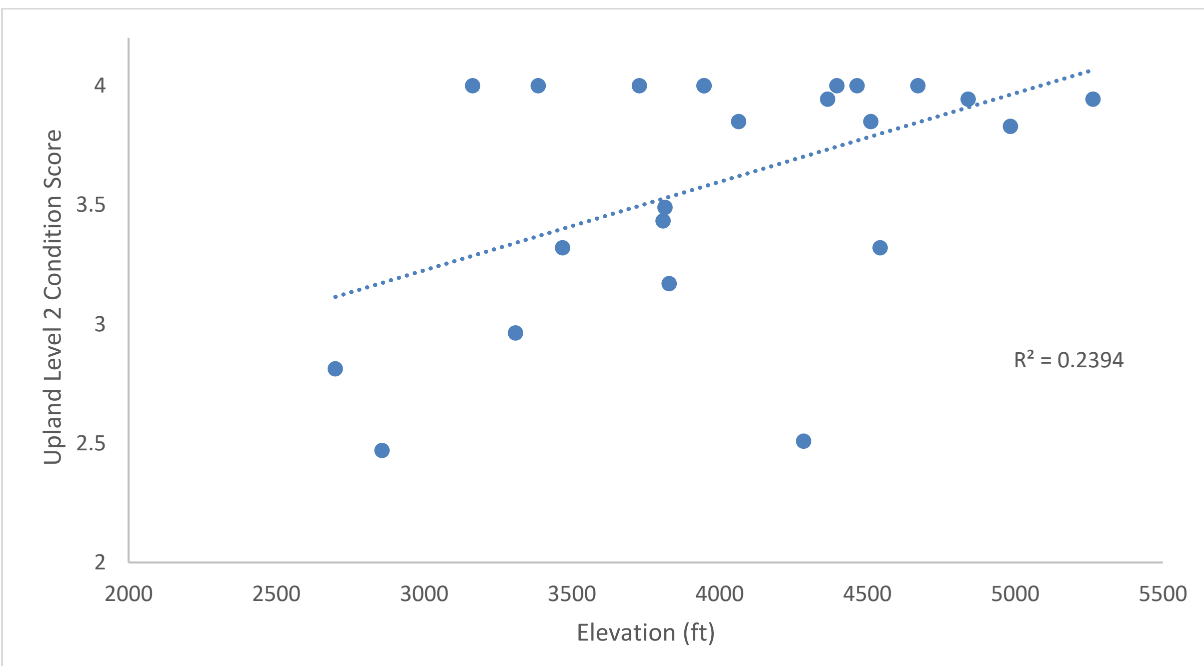

Figure 10. Correlation between Level 2 EIA AA Condition score and elevation (ft) in G241: North-Central Pacific Maritime Silver Fir - Western Hemlock Rainforest (n=24).

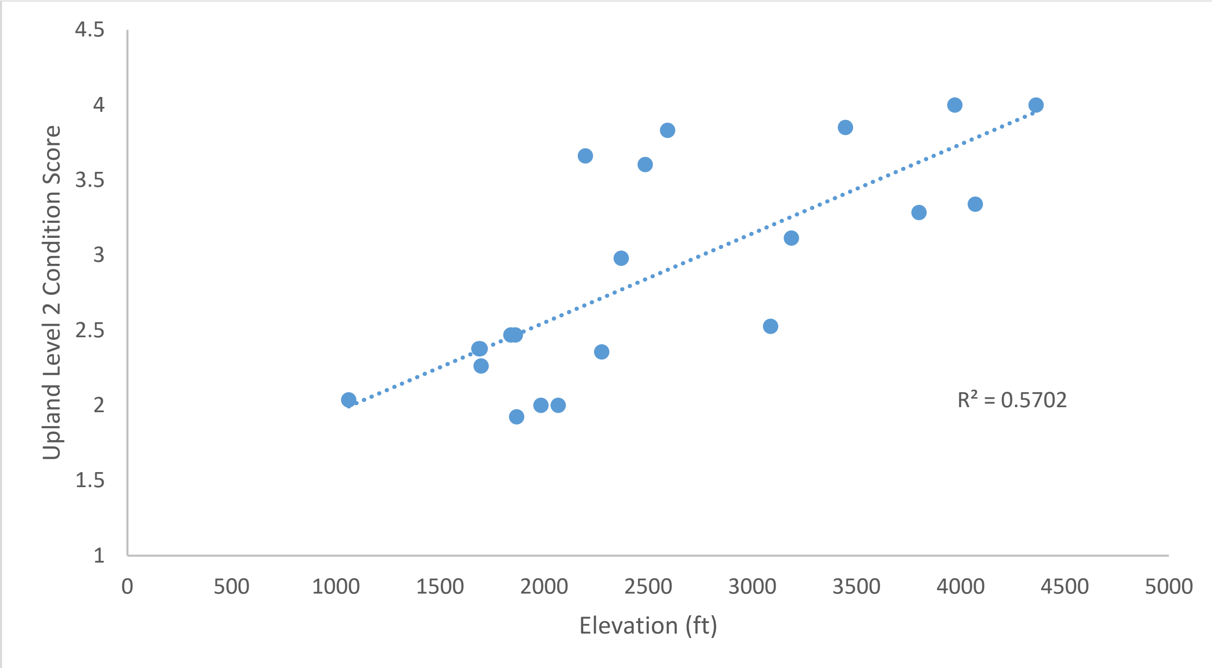

Figure 11. Correlation between Level 2 EIA AA Condition score and elevation (ft), in G240: North Pacific Maritime Douglas-fir - Western Hemlock Rainforest (n=22).

5.1.2 Wetland Condition in WRIA 10

Because both Condition and Landscape Context metrics were scored for wetland (polygon-based) AAs, we use EIA ranks in the data summaries below. Remember that EIA ranks integrate both on-site Condition and Landscape Context.

The Level 2 EIA ranks in WRIA 10 ranged from excellent to poor across all of the AAs (Table 9, Figure 12). When conducting Level 2 sampling, we ended up oversampling relatively accessible Level 1 A and B-ranked AAs in order to increase data points for correlation analyses with the Level 1 EIA—many C/D assessment areas were not accessible. However, this impacted our ability to use the Level 2 data to estimate overall ecological integrity of target wetlands across the watershed because the distribution of sampled AAs was skewed towards higher integrity locations than the spatially balanced study design initially prescribed. This is important to remember when interpreting the results below.

Note that one AA we surveyed was a Vancouverian Wet Shrubland (G322) rather than a forest, as the tree cover had recently burned away. This AA was not used to assess ecological integrity in M035 Vancouverian Flooded & Swamp Forest.

Table 9. Summary of Wetland Level 2 EIA ranks by NVC Group and Macrogroup. A-Rank = Excellent ecological integrity; B-Rank = good ecological integrity; C-Rank = fair ecological integrity; and D-Rank = poor ecological integrity.

	Level 2 EIA Rank				
NVC Classification	A	B	C	D	Total
M073 Vancouverian Lowland Wet Shrubland, Wet Meadow & Marsh Macrogroup	1				1
G322 Vancouverian Wet Shrubland Group	1				1
M035 Vancouverian Flooded & Swamp Forest	17	23	5	3	48
G507 North Pacific Montane Riparian Woodland	5	1			6
G851 North-Central Pacific Lowland Riparian Forest Group	8	7	5	2	22
G853 North-Central Pacific Maritime Swamp Forest Group	4	15		1	20
Total	18	23	5	3	49

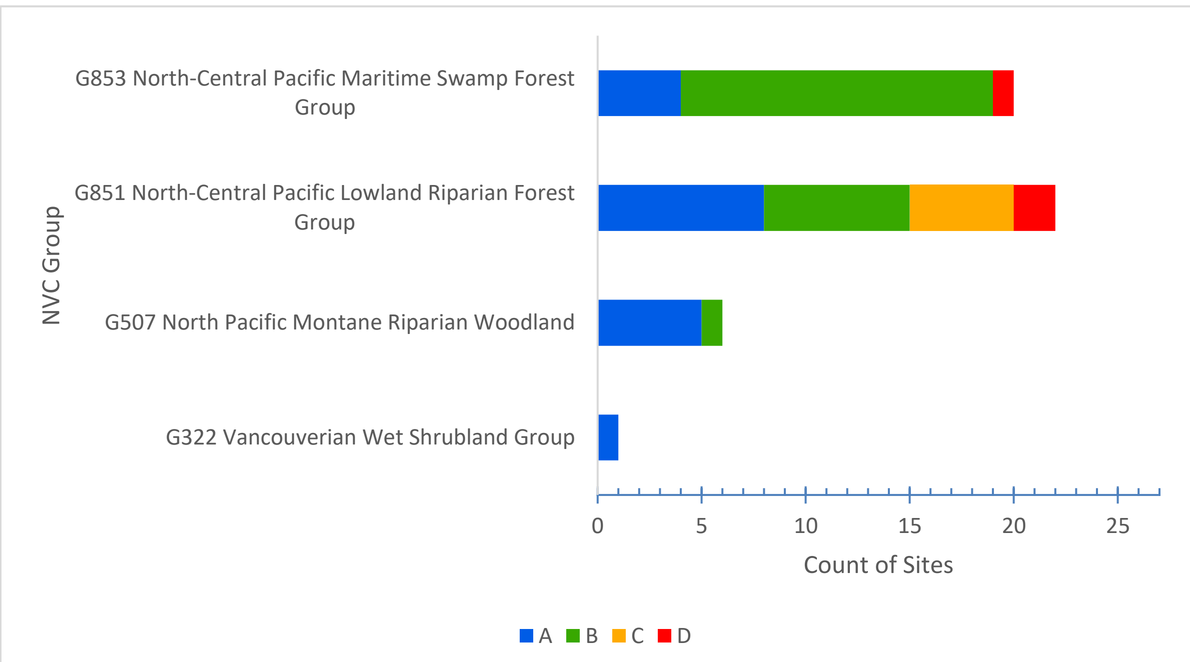

Figure 12. Level 2 wetland EIA ranks at all AAs in WRIA 10. A-Rank = excellent ecological integrity; B-Rank = good ecological integrity; C-Rank = fair ecological integrity; and D-Rank = poor ecological integrity.

Within the Vancouverian Flooded & Swamp Forest Macrogroup (M035), 35% of the observed AAs were EIA A-ranked, 48% were B-ranked, 10% were C-ranked, and 6% were D-ranked. Therefore, 16% of the sites we evaluated in M035 fell outside of the natural range of variability. Primary stressors observed in wetland areas included roads, channelization along roads, recreational impacts, and nonnative and invasive species. In general, wetlands are often more susceptible to nonnative invasive plant introductions than uplands due to more frequent natural disturbance regimes (Magee et al., 2010). Many nonnative species are well adapted to take advantage of disturbed soil commonly seen in wetlands, particularly riparian wetlands (i.e., bank collapse, wind throw, newly exposed soils, etc.). This provides an opportunity for nonnative plants (that may be established along roadsides) to infiltrate the wetland areas we assessed and impact the Native Plant Species Cover and Invasive Nonnative Plant Species Cover metrics. Forested upland plant communities have a lower frequency of this kind of natural soil disturbance, so nonnative species expansion from roadsides is less common or less rapid in otherwise intact upland ecosystems.

Elevation

Overall, wetland AAs sampled at higher elevations had higher Level 2 EIA scores than those at lower elevations (Figure 13), although this is a weaker correlation than was observed for upland AAs (Figure 9).

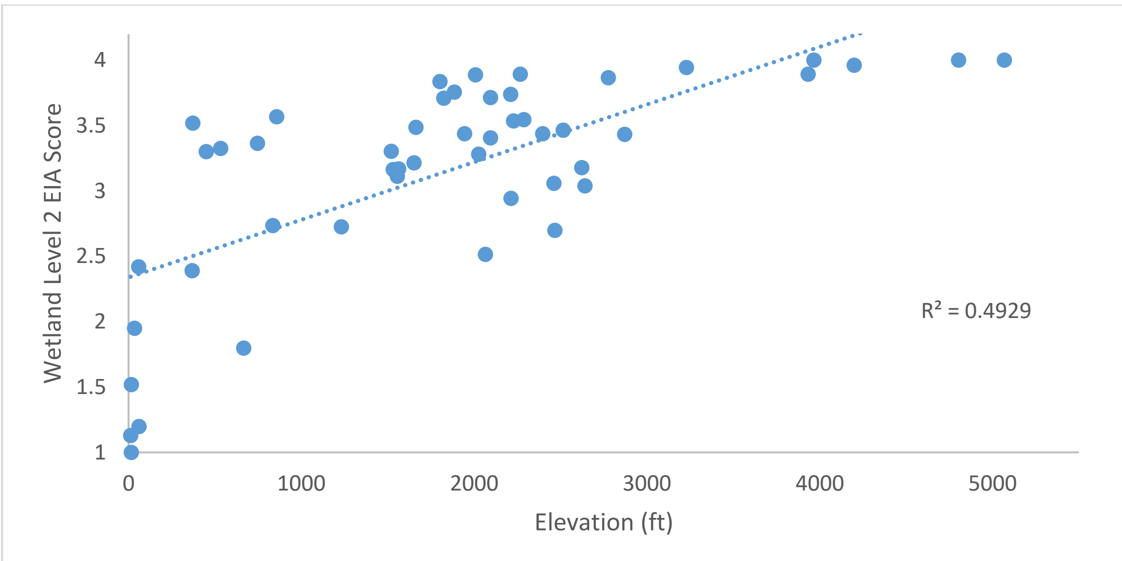

Figure 13. Correlation between Wetland Level 2 EIA score and elevation of AAs within M035 Vancouverian Flooded & Swamp Forest (n=49).

As with the upland communities, these data suggest the groups associated with higher elevations (G507) have more intact ecological integrity than those associated with lower elevations (G851, G853). As with the upland AAs, the high elevation areas sampled in WRIA 10 frequently fell within Mt. Rainer National Park, or wilderness areas of Mt. Baker-Snoqualmie National Forest, which have more restrictions on the types of development or natural resource extraction allowed, resulting in fewer impacts to these wetlands.

Within the North Pacific Montane Riparian Woodland Group (G507), there was a fair correlation between elevation and ecological integrity, but there were only six AAs in this group ranging between 372 ft and 5068 ft (Figure 14).

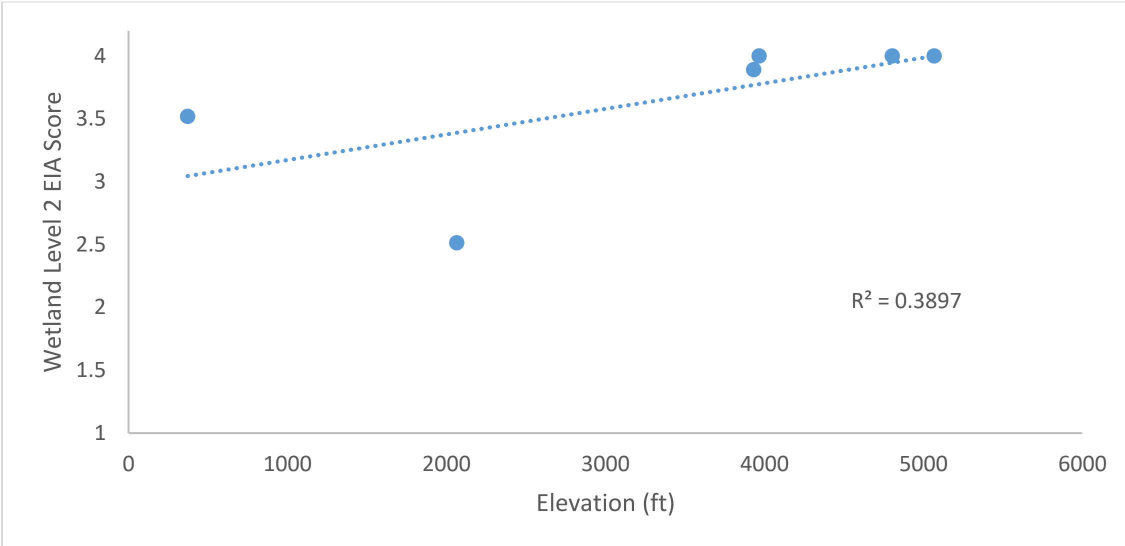

Figure 14. Correlation between wetland Level 2 EIA score and elevation (ft) in G507 (n=6).

Within G851 North-Central Pacific Lowland Riparian Forest Group, there is a strong correlation between elevation and ecological integrity (Figure 15). Many of the sampled lower elevation AAs within this group were directly along roadways and had been converted to ruderal vegetation types. These areas had very little native vegetation, soils and hydrology had been significantly altered, and there was a large amount of development within the buffer and surrounding landscapes. At higher elevations, AAs sampled in this group had fewer stressors impacting their ecological integrity due to being in less developed areas (NPS or USFS land).

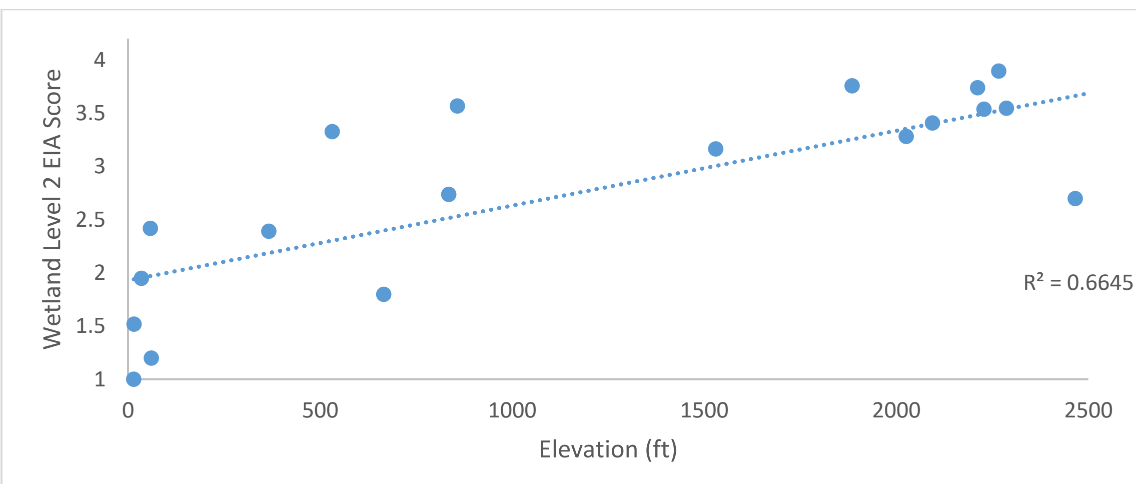

Figure 15. Correlation between wetland Level 2 EIA score and elevation (ft) in G851 (n=22).

Similarly, the AA with the least ecological integrity within G853 North-Central Pacific Maritime Swamp Forest Group was an area surrounded by significant development and had largely been converted to a ruderal type. Overall, this group shows a weak correlation between ecological integrity and elevation (Figure 16). These sites had varying levels of impacts from logging and development that are less easily predicted by land ownership or elevation.

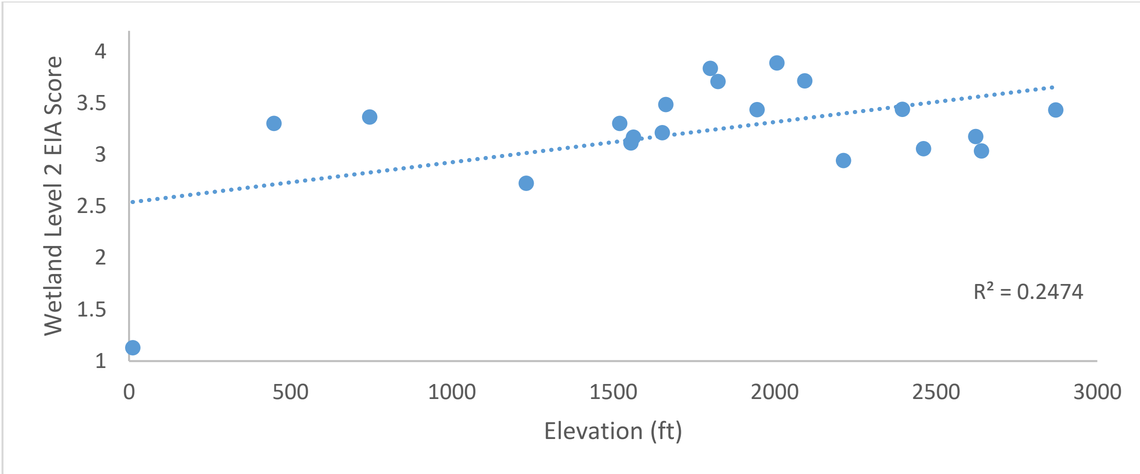

Figure 16. Correlation between Level 2 EIA score and elevation (ft) in G853 (n=20).

5.2 Agreement between Initial Level 1 EIA and Level 2 EIA

Comparisons of Level 2 and initial Level 1 EIA data show that, as expected, the first iteration of the Level 1 EIA required some fine-tuning to improve accuracy. The data collected in the Level 2 EIA assessment were was used to help calibrate the Level 1 EIA ranking bins and increase agreement.

5.2.1 Level 2 NVC Upland AAs

As a reminder, Level 2 EIA ranks are calculated by integrating Landscape Context and Condition scores which are then rolled-up into a rank of A, B, C, or D. Since we did not score Landscape Context metrics during point-based upland EIA sampling, we only used Level 2 Condition scores to calibrate Level 1 EIA ranks for NVC AAs (Table 10). Upland Condition scores were calculated based on vegetation composition, structure, native plant cover, invasive plant cover, coarse woody debris, woody regeneration, and soil disturbance metrics scores. Meanwhile, Level 1 EIA ranks rely heavily on remotely sensed proxy measures of on-site condition and are generally less successful at predicting on-site biological characteristics such as the cover of nonnative plants. Some upland AAs in areas of poor landscape context (e.g. timberlands, parks embedded in urban areas) that had Level 1 EIA ranks of C or D (fair to poor ecological integrity) received A or B Level 2 Condition Ranks (excellent to good ecological integrity). This was due, in part, to low cover of nonnative and/or invasive species, despite their proximity to developed areas/roads.

Table 10. Comparison of upland initial Level 1 EIA ranks vs Level 2 Condition rank. A-Rank = excellent ecological integrity; B-Rank = good ecological integrity; C-Rank = fair ecological integrity; and D-Rank = poor ecological integrity.

		Level 1 EIA Ranks				
Level 2 Condition Score		**A**	**B**	**C**	**D**	**Total**
	A	15	1	9		25
	B	1		13		14
	C			11	1	12
	D					0
	Total	16	1	33	1	51

Level 1 EIA rank matched the Level 2 Condition rank with an overall accuracy of 51% and a kappa statistic of 29% showing fair agreement between the EIAs (Table 11). This kappa statistic shows that while there is a fair correlation between the initial Level 1 EIA ranks and the Level 2 Condition rank, some of that correlation may be due to chance. The initial Level 1 EIA was better at predicting ecological integrity where more sampling occurred, i.e., A and C-ranked areas. B and D-ranked areas did not cover a large portion of the WRIA in the first iteration of the Level 1 EIA and therefore had very small sample sizes. Based on the authors' previous experience in WRIA 10, B and possibly D-ranked areas seemed to be under-mapped in the initial Level 1 EIA. This is supported by the wide range in Level 2 Condition scores/ranks from upland areas that the Level 1 EIA predicted to be "C's". These Level 2 data were used for adjusting the rank bin cutoffs for the Level 1 EIA.

Table 11. Accuracy assessments comparing upland Level 1 EIA ranks and Level 2 Condition ranks.

Overall Accuracy:	51%			
Kappa:	29%			
	A	**B**	**C**	**D**
Producer Accuracy:	94%	0%	33%	0%
User Accuracy:	60%	0%	92%	0%
N	16	1	33	1

5.2.2 Level 2 NWI Wetland AAs

NWI wetland assessment areas were evaluated with a polygon approach, so Landscape Context metrics were scored in addition to Condition metrics in Level 2 assessments. Polygon-based assessment areas have discrete boundaries beyond which are different natural ecosystems or non-natural landcover that influence the ecosystem within the AA. Landscape Context metrics evaluate the continuity, condition, and land use of the landscape surrounding the assessment area. These metrics capture landscape fragmentation, development, and condition of the natural buffer surrounding a wetland. With both Landscape Context and Condition scores available, we can compare the Level 2 EIA rank to the initial Level 1 EIA rank, or look at the Landscape Context and Condition ranks individually relative to the initial Level 1 EIA rank.

Table 12. Comparison of NWI Wetland Level 1 EIA ranks vs observed Level 2 EIA ranks. A-Rank = excellent ecological integrity; B-Rank = good ecological integrity; C-Rank = fair ecological integrity; and D-Rank = poor ecological integrity.

		Level 1 EIA Ranks				
Level 2 EIA Ranks		**A**	**B**	**C**	**D**	**Total**
	A	13	5			18
	B	8	14			22
	C	2	1	3		6
	D			1	2	3
	Total	23	20	4	2	49

The initial Level 1 EIA rank correctly predicted the Level 2 EIA rank with an overall accuracy of 65% and a kappa statistic of 45%, indicating moderate agreement between the two assessments (Table 13). The Level 1 EIA had the highest accuracy when predicting areas with low integrity. The kappa statistic shows that while there is a strong correlation between initial Level 1 EIA ranks and Level 2 EIA ranks, some of this correlation is due to random chance. We found that some of the areas with initial Level 1 EIA A-ranks had high cover of nonnative plants, potentially due to extensive social trails that were not included in the Level 1 EIA. This contributed to significant disagreement with Level 2 EIA results for polygons that received A or B ranks in the Level 1 EIA.

Table 13. Accuracy assessments comparing NWI wetland Level 1 EIA ranks and Level 2 EIA ranks.

Overall Accuracy:	65%			
Kappa:	45%			
	A	**B**	**C**	**D**
Producer Accuracy:	57%	70%	75%	100%
User Accuracy:	72%	64%	50%	67%
N	23	20	4	2

Landscape Context ranks had the strongest correlation with an overall accuracy of 59% and a kappa statistic of 36%, showing fair agreement (Table 14). This makes sense, as the landscape context metrics in a Level 2 EIA use many of the same land cover data sets that are employed in a Level 1 EIA. Some of the deviation from the initial Level 1 EIA is potentially due to roads, development, or land use within the AA or in the surrounding landscape that was not apparent from the GIS data sets that fed into the initial Level 1 EIA but were apparent on site. For instance, a large portion of land along the White River near Lake Tapps had Level 1 EIA ranks of A, but when we visited the site, we observed a large network of OHV recreation trails that degraded ecological integrity both within and adjacent to the AA. These trails were not part of the known trail or roads networks that fed into the Level 1 EIA and their exclusion likely lead to artificially high Level 1 EIA ranks in this area.

Table 14. Accuracy assessments comparing NWI wetland Level 1 EIA ranks and Level 2 Landscape Context ranks.

Overall Accuracy:	59%			
Kappa:	36%			
	A	**B**	**C**	**D**
Producer Accuracy:	**52%**	70%	25%	100%
User Accuracy:	75%	58%	33%	33%
N	23	20	4	2

The overall accuracy between Level 1 EIA ranks and Level 2 Condition ranks was 55% and the kappa statistic was 27%, showing fair agreement between the Level 1 and Level 2 EIA (Table 15). As these scores are based on metrics that are difficult to ascertain from landscape level data sets (e.g., vegetation composition, soil disturbance, etc.), the Level 1 EIA would be expected to have less success at predicting on-site condition. The initial Level 1 EIA was more likely to overstate the ecological integrity of a site rather than vice versa. The Level 1 EIA rank bins were adjusted using these Level 2 data to reduce such overestimation.

Table 15. Accuracy assessments comparing NWI wetland Level 1 EIA ranks and Level 2 Condition ranks.

Overall Accuracy:	55%			
Kappa:	27%			
	A	**B**	**C**	**D**
Producer Accuracy:	61%	45%	50%	100%
User Accuracy:	58%	50%	50%	67%
N	23	20	4	2

5.3 Level 1 EIA Correlation

To better understand how the Level 1 and Level 2 EIA data interact, we assessed the correlation between EIA scores, Condition score, Vegetation and Soil MEF, and individual metrics.

5.3.1 NVC Level 1 and Level 2 Upland EIA Correlation

Because the Level 2 EIA sampling methodology was point-based for upland AAs, we did not assess landscape level impacts for the entirety of upland ecosystem occurrence—our goal was to make a "population-level" assessment across the watershed. For this reason, we primarily used the Level 2 Condition score in place of the Level 2 EIA score when calculating upland correlations.

The Level 1 NVC EIA model and the Level 2 Condition score showed fair correlation (Figure 17, R^2=0.4034, $p < 0.001$). Because we did not assess landscape metrics in the Level 2 EIA for upland AAs, we were unable to roll up the Level 2 into an EIA score. Were we able to assess all of the upland ecosystem AAs at the landscape level (which can be on the order of thousands of hectares), the correlation between the Level 1 model and the Level 2 EIA score may have been stronger.

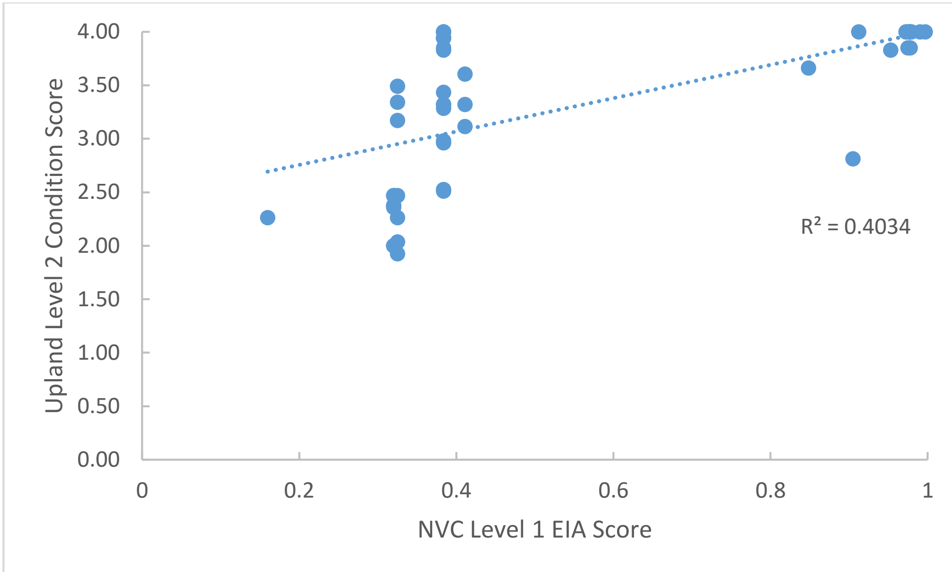

Figure 17. Correlation between NVC Level 1 EIA score and upland Level 2 Condition score (p <0.001).

The Level 1 Landscape score and the Level 2 Condition score showed a slightly stronger correlation (Figure 18, R^2=0.5138, p <0.001).

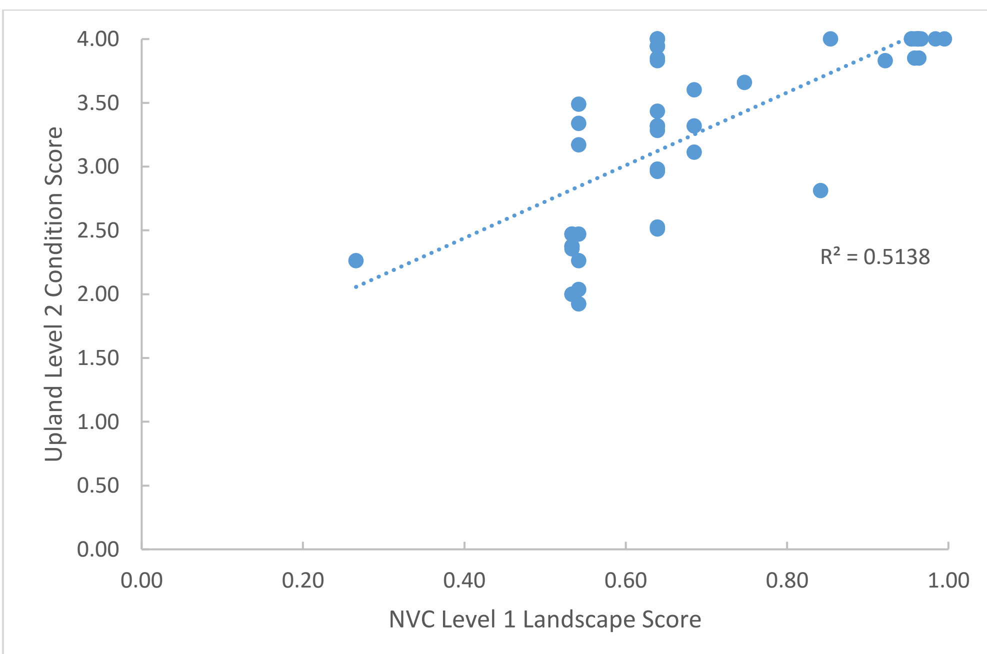

Figure 18. Correlation between NVC Level 1 Landscape score and upland Level 2 Condition score (p <0.001).

Because we had fewer condition metrics for upland ecosystems, the roll-up of Level 1 NVC Condition scores produced results that were nearly binary (e.g., scores were either 1.0 or an exceedingly small decimal). For that reason, calculating correlation coefficients did not make sense. However, individual metrics related to condition are compared with the Level 2 Condition score below.

Individual Level 1 Metrics:
Several individual metrics that are included in the NVC Level 1 EIA are not assessed here as we only surveyed upland AAs generated from this model during the Level 2 EIA. M6, M8, M10, M11 are only assessed for wetland ecosystems. M12 is only assessed for shrub-steppe ecosystems, which were not sampled during this project. No individual metrics in the NVC Level 1 EIA correlated as strongly with Level 2 scores as those in the NWI Level 1 EIA (discussed below, in Section 5.3.2). The remaining Level 1 Condition metrics (M5, M7, M9) showed the strongest correlation with Level 2 Condition scores. Scatterplots for all metrics can be found in Appendix E.

Table 16. Correlation between NWI Level 1 EIA metrics and NWI Level 2 EIA scores ($p < 0.001$ for all scores).

		Level 1 EIA Metrics					
Level 2 EIA Scores		**M1 Landscape Connectivity**	**M2 Landscape Land Use**	**M4 Buffer Land Use**	**M5 Landscape Structure**	**M7 Buffer Structure**	**M9 Forest Structure**
	Condition score	0.27	0.42	0.13	0.47	0.51	0.32
	Vegetation MEF	0.10	0.11	0.16	0.16	0.17	0.12
	Soil MEF	<0.01	<0.01	0.02	<0.01	<0.01	<0.01

Because no individual metrics showed particular influence or correlation with the Level 2 EIA results, we chose not to adjust any of the weighting within the model. Instead, we simply calibrated the ranking bins for the Level 1 EIA (i.e., the cutoffs between ranks) to improve correlation with the Level 2 results, then produced an adjusted Level 1 EIA model. Ideally, we would have samples from many different ecosystem types (i.e. marshes, grasslands, etc.), but due to the scope of this project, we were limited to only a few ecosystems (Section 3.2). Additional recommendations for future work including assessment of more ecosystems are outlined in Section 7.2.

5.3.2 NWI Wetland Level 1 and Level 2 EIA Correlation

NWI wetland Level 2 and Level 1 EIA scores showed good correlation ($R^2 = 0.6935$, $p < 0.001$) indicating that the Level 1 EIA model was successful in predicting Level 2 EIA scores in the majority of cases (Figure 19).

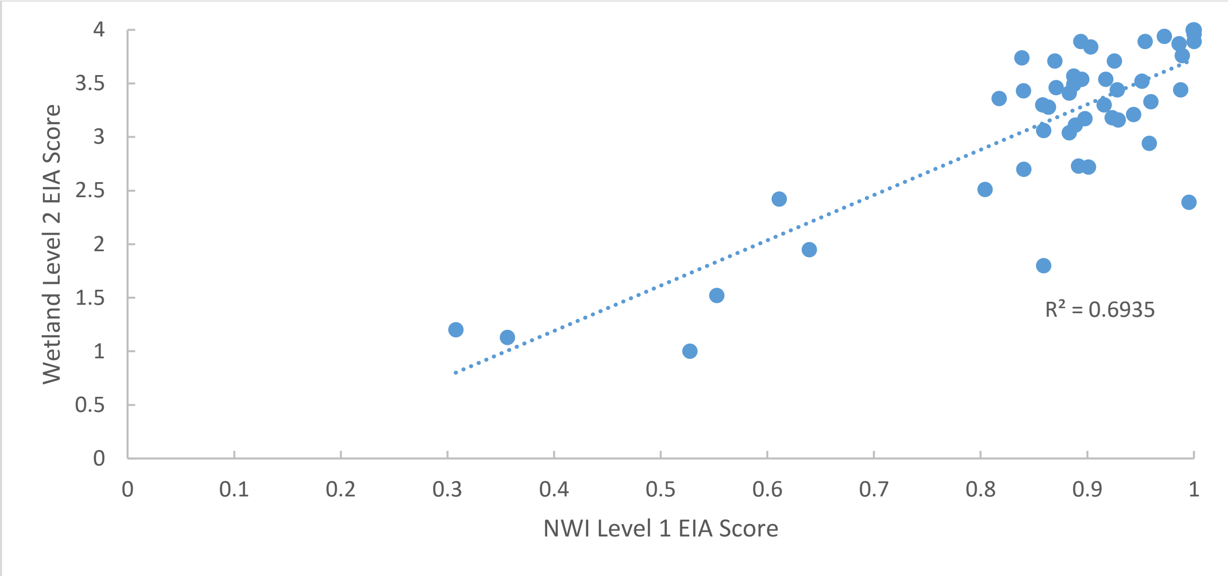

Figure 19. Correlation between NWI Level 1 and wetland Level 2 EIA scores ($p < 0.001$).

The Level 1 Landscape Primary Factor Score (PFS), a component of the overall Level 1 EIA score, also strongly correlated with the Level 2 EIA score (Figure 20, R^2=0.6971, $p < 0.001$).

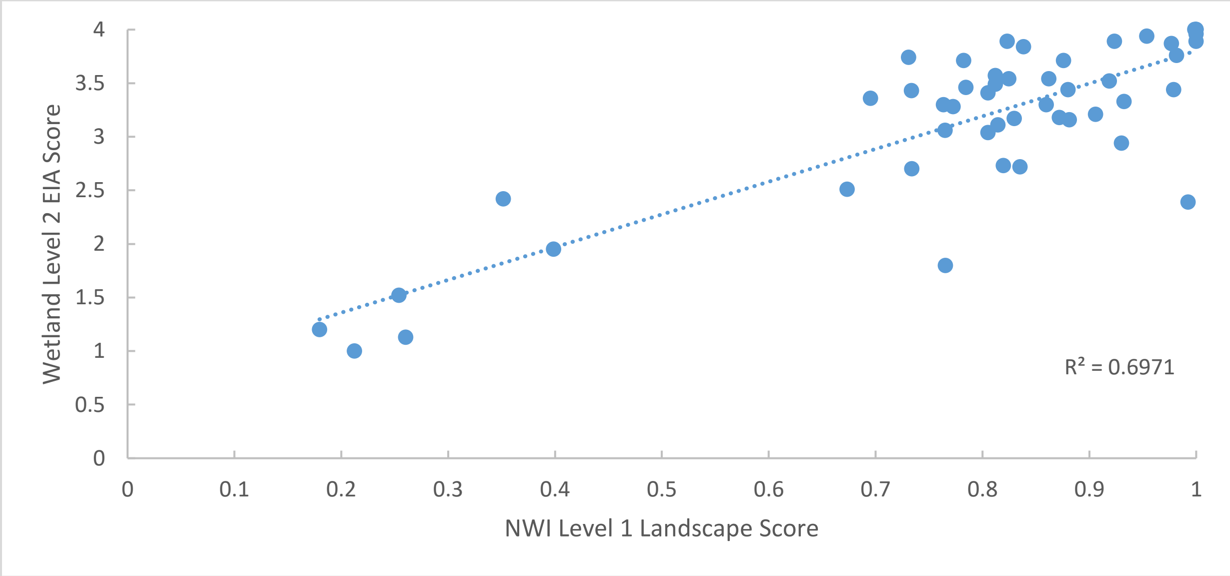

Figure 20. Correlation between NWI Level 1 Landscape score and wetland Level 2 EIA Score ($p < 0.001$).

Individual Level 1 Metrics:
Correlations with some of the metrics described in Section 2.1.3 are unable to be assessed with these Level 2 EIA plots. Level 1 metrics M6, M8, and M10 assessed whether the AA, inner buffer, or broader landscape overlapped with artificially flooded NWI polygons, NWI polygons with non-natural special modifiers (drained, diked, etc.), or non-natural NHD features (weirs, canals, etc.). None of the Level 2 plots in the random sample had those characteristics. Similarly, M11 (which penalizes AAs with certain special soil modifiers) also did not apply to any Level 2 plots. M12 was developed as part of a pilot run of a statewide version of the Level 1 model—it only applies

to shrub-steppe ecosystems, which do not occur within the Puget Sound drainage basin. M6 and M13 were scored on a binary scale (1 or 0) and so it did not make sense to calculate correlation coefficients with continuous Level 2 EIA scores. They were still included in the calculations for overall Level 1 scores (primary factor scores and EIA scores).

Metrics related to landscape impacts (M1, M2) showed the strongest correlations to Level 2 scores of all the metrics assessed (Figure 21, Figure 22). Metrics related to on-site condition (M5, M7, and M9) had weaker correlations with Level 2 EIA scores (Table 17). Scatter plots for all metrics can be found in Appendix E.

Table 17. Correlation between NWI Level 1 EIA metrics and NWI Level 2 EIA scores ($p < 0.001$ for all scores).

		Level 1 EIA Metrics					
Level 2 EIA Scores		M1 Landscape Connectivity	M2 Landscape Land Use	M4 Buffer Land Use	M5 Landscape Structure	M7 Buffer Structure	M9 Forest Structure
	Landscape Score	0.77	0.80	0.64	0.23	0.20	0.14
	Condition score	0.63	0.68	0.55	0.13	0.09	0.12
	Vegetation MEF	0.45	0.54	0.36	0.16	0.12	0.17
	Hydrology MEF	0.66	0.63	0.63	0.05	0.01	0.04
	Soil MEF	0.46	0.31	0.40	0.09	0.02	0.04
	EIA Score	0.63	0.68	0.55	0.13	0.09	0.12

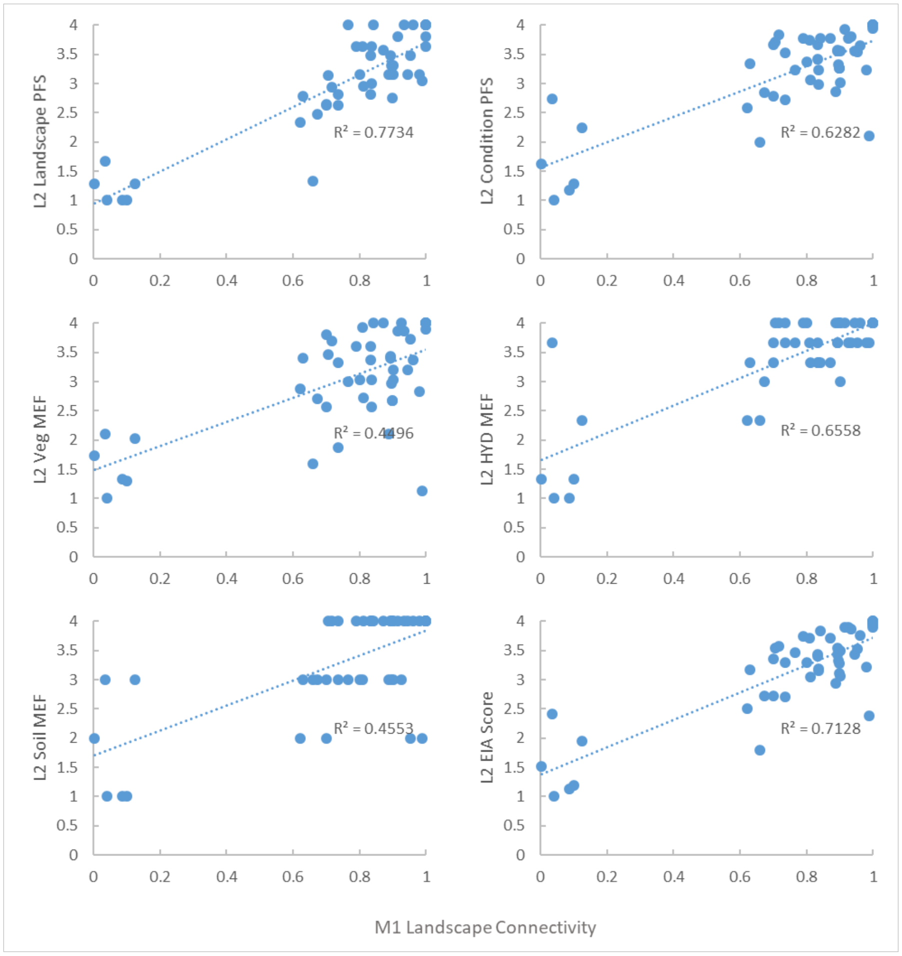

Figure 21. NWI Level 1 M1 Landscape Connectivity metric correlation with wetland Level 2 scores ($p < 0.001$ for all).

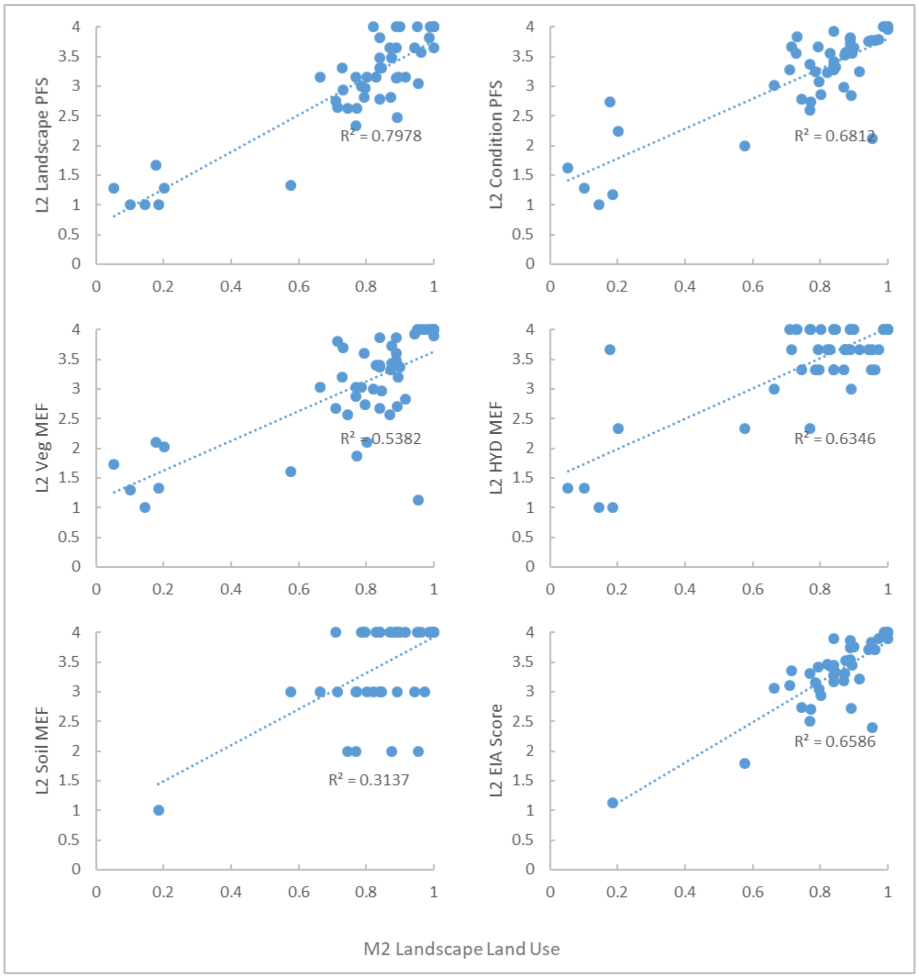

Figure 22. NWI Level 1 M2 Landscape Land Use metric correlation with wetland Level 2 scores ($p < 0.001$ for all).

Correlations between Level 1 and Level 2 NWI EIA scores were relatively strong, as were correlations between individual Level 1 and Level 2 metrics. We decided that adjusting metric weights or other roll-up protocols was not necessary and simply adjusted the Level 1 ranking bins (i.e., the cutoffs between ranks) to slightly improve the correlation with Level 2 EIA results (Section 5.3.4). No individual metrics were altered in the updated Level 1 EIA. In the future, we hope to collect additional Level 2 EIA plot data to independently test the calibration of the Level 1 model for both NWI and NVC AAs. We may also incorporate additional datasets (such as remotely sensed estimates of annual grass cover) into our metrics to improve results.

5.3.3 Calibrating Ranking Bins for NVC Level 1 EIA Model

In Natural Heritage methodology, different rank factors (Landscape Context, Condition, and Size) have varying impacts on overall ecological integrity depending on the spatial pattern type of the ecosystem (Matrix, Large, Small, Linear) (NatureServe, 2002). Matrix ecosystems cover very large areas and have significant connectivity with other communities, so size and landscape context are considered more important than condition. Condition can be quite variable in matrix ecosystems and, regardless, often difficult to assess over such large areas. Comparatively, small-patch and linear wetlands represented by the NWI wetland assessment areas have less variation in size, more specialized species, and a greater proportion of edge, making them more sensitive to factors affecting landscape context. Most of the NVC upland assessment areas represented large-patch or matrix upland ecosystems, for which size is a primary or secondary rank factor. We determined that the EO rank, which incorporates the size metrics from EIA methodology (Rocchio et al., 2020b) better represented ecological condition in these matrix and large-patch upland ecosystems in the Level 1 EIA model than EIA rank (which does not incorporate size metrics). While a large occurrence of an ecosystem does not necessarily have greater ecological integrity (EIA rank) than a smaller occurrence, it is more likely to persist on the landscape, provides more suitable habitat for non-edge species and is a generally superior target for conservation (EO rank).

Based on the Level 2 EIA data, we calibrated the ranking bins of the Level 1 EIA to better correlate with the Level 2 EIA data. We adjusted the range of all rank bins (Table 18) creating a stronger correlation between the two data sets and to produce a more accurate map (Table 19).

Table 18. Initial NVC Level 1 EIA model ranking bins vs. adjusted NVC Level 1 EIA model ranking bins.

Rank	Old Bins			New Bins		
	Upper limit	Lower limit	Range	Upper limit	Lower limit	Range
A	1	0.85	0.15	1.48	0.91	0.57
B	0.84	0.7	0.15	0.9	0.83	0.07
C	0.69	0.3	0.40	0.83	0.35	0.48
D	0.29		0.30	0.35	-0.34	0.69

Table 19. Comparison of upland adjusted NVC Level 1 EIA ranks vs. upland Level 2 Condition score. A-Rank = excellent ecological integrity; B-Rank = good ecological integrity; C-Rank = fair ecological integrity; and D-Rank = poor ecological integrity.

		Level 1 EIA Ranks				
Level 2 Condition Score		A	B	C	D	Total
	A	13	8	4		25
	B	2	8	4		14
	C			11	1	12
	D				0	0
	Total	15	16	19	1	51

Adjusted Level 1 EIA ranks matched the Level 2 Condition Ranks with an overall accuracy of 51% and a kappa statistic of 29% showing improved agreement between the Level 1 EIA and the Level 2 Condition scores (Table 20). This kappa statistic shows that while there is a fair correlation between the adjusted Level 1 EIA rank and the Level 2 Condition Rank, some of that correlation may be due to chance. The initial Level 1 EIA was better at predicting ecological integrity where more sampling occurred, i.e., A and C-ranked areas. B and D-ranked areas did not cover a large portion of the WRIA in the first iteration of the Level 1 EIA and therefore had very small sample sizes. As stated above, B and possibly D-ranked areas seemed to be under mapped in the initial Level 1 EIA. This is supported by the wide range in Level 2 Condition scores/ranks from upland areas that the Level 1 EIA predicted to be "C's". These bin adjustments slightly reduced both the producer and user accuracies of the areas modeled as A-ranked, but greatly improved the accuracies of the B and C-ranked bins.

Table 20. Accuracy assessment statistics comparing NVC Level 1 EIA ranks and upland Level 2 Condition ranks.

Overall Accuracy:	51%			
Kappa:	29%			
	A	**B**	**C**	**D**
Producer Accuracy:	87%	50%	58%	0%
User Accuracy:	52%	57%	92%	0%
N	15	16	19	1

5.3.4 Calibrating Ranking Bins for NWI Wetlands

As with the upland Level 1 EIA model, we used the Level 2 data to adjust the EIA rank bins and improve the accuracy of the NWI wetland model. Wetlands assessed via the NWI AAs tend to be smaller, more discrete patches on the landscape than upland ecosystems and their ecological integrity is less influenced by the size of the AA. For this reason, we chose to continue to use the EIA rank (which does not incorporate Size) for NWI AAs in this model.

As the Level 1 and Level 2 EIA scores were already better correlated than with the NVC Upland model, the wetland model ranking bins needed less adjustment , we adjusted the range of only the B, C, and D-rank bins (Table 21, Table 22) to better correlate with Level 2 EIA ranks determined by our fieldwork in WRIA 10.

Table 21. Initial NWI Level 1 EIA Model ranking bins vs. Adjusted NWI Level 1 EIA Model ranking bins.

Rank	**Old Bins**			**New Bins**		
	Upper limit	Lower limit	Range	Upper limit	Lower limit	Range
A	1	0.9	0.1	1	0.9	0.1
B	0.89	0.75	0.14	0.89	0.65	0.24
C	0.74	0.5	0.24	0.64	0.55	0.09
D	0.49	0	0.49	0.54	0	0.54

Table 22. Comparison of wetland Adjusted NWI Level 1 EIA ranks vs. observed wetland Level 2 EIA ranks. A-Rank = excellent ecological integrity; B-Rank = good ecological integrity; C-Rank = fair ecological integrity; and D-Rank = poor ecological integrity.

		Level 1 EIA Ranks				
Level 2 EIA Ranks		**A**	**B**	**C**	**D**	**Total**
	A	13	5			18
	B	9	14			23
	C	1	1	3		5
	D				3	3
	Total	23	20	3	3	49

The adjusted Level 1 EIA rank correctly predicted the Level 2 EIA rank with an overall accuracy of 67% and a kappa statistic of 48%, indicating a slightly improved agreement between the two assessments (Table 23). The kappa statistic shows that while there is a strong correlation between adjusted Level 1 EIA ranks and Level 2 EIA ranks, some of this correlation is due to random chance. While this adjustment in the ranking bins is minor, it does result in a Level 1 EIA model that correlates better with the Level 2 EIA. Adjusting these bins slightly improved the producer and user accuracies, particularly for the low ranking bins (C and D). This improves upon the initial Level 1 EIA model's tendency to overstate ecological integrity within the Puget Sound drainage basin, but the adjusted model still skews in favor of overstating ecological integrity to some degree.

Table 23. Accuracy assessment statistics comparing NWI Level 1 EIA ranks and wetland Level 2 EIA ranks.

Overall Accuracy:	67%			
Kappa:	48%			
	A	**B**	**C**	**D**
Producer Accuracy:	57%	70%	100%	100%
User Accuracy:	72%	61%	60%	100%
N	23	20	3	3

5.4 Updated Level 1 EIA Results

5.4.1 Puget Sound Drainage Basin NVC Natural Vegetation

According to our Level 1 model, 56% of the naturally vegetated area mapped by the GAP/LANDFIRE NVC Groups raster in the Puget Sound drainage basin is within the natural range of variability (A and B-ranked), while 44% is outside the natural range of variability (Table 24). This includes both upland and wetland ecosystems, but developed and ruderal upland areas were not assessed. As a reminder, we determined that the EO rank, which incorporates the size metrics from EIA methodology (Rocchio et al., 2020b) better represented ecological condition in these matrix and large-patch upland ecosystems in the Level 1 EIA model than EIA rank (which does not incorporate size metrics). While a large occurrence of an ecosystem does not necessarily have greater ecological integrity (EIA rank) than a smaller occurrence, it is more likely to persist on the landscape, provides more suitable habitat for non-edge species and is a generally superior target for conservation (EO rank).

Table 24. Total area of NVC raster-mapped natural vegetation within the Puget Sound drainage basin by Level 1 EO rank.

	Level 1 EO Rank				
	A	**B**	**C**	**D**	**Total**
Total Hectares	849,123	500,762	899,067	248,748	2,497,699
Percent of Area	34%	20%	36%	10%	

Comparison Across NVC Macrogroups

According to GAP/LANDFIRE modeling, Vancouverian Coastal Rainforest (M024) covers the majority of the Puget Sound drainage basin (70%) and approximately 54% of that received a Level 1 EO rank within the natural range of variability (Table 25, Figure 23). Note that the GAP/LANDFIRE NVC Groups raster that the assessment areas were derived from has some known errors. M094 Cool Interior Chaparral and M169 Great Basin-Intermountain Tall Sagebrush

Steppe & Shrubland are ecosystems that only occur east of the Cascade Crest in Washington. Likely, these AAs are incorrectly mapped examples of M050 Southern Vancouverian Lowland Grassland & Shrubland, or other west-side shrubland types. Similarly, M501 Central Rocky Mountain Dry Lower Montane-Foothill Forest are eastside plant communities. In this model, the areas mapped as M501 are likely M500 Central Rocky Mountain Mesic Lower Montane Forest and even these areas are likely small examples of this eastern Washington ecosystem, occurring west of the Cascade Crest only in small rainshadow areas. Recent revisions to the NVC have split a few broad-ranging associations within M888 Arid West Interior Freshwater Marsh, which formerly spanned low elevation ecoregions both east and west of the Cascades. These communities are typically dominated by *Typha latifolia*, *Schoenoplectus* spp., or other common species that often form monocultural stands. Because these communities are nearly identical floristically—whether they occur in the Puget Trough or the Columbia Basin—revisions have produced separate associations based largely on geography (e.g. *Typha latifolia* Pacific Coast Marsh and *Typha latifolia* Arid Marsh). Stands mapped as M888 Arid West Interior Freshwater Marsh likely represent associations that were split up in this fashion and likely represent M073 Vancouverian Lowland Marsh, Wet Meadow & Shrubland under the new system.

Table 25. Total area (hectares) of NVC raster-mapped natural vegetation within the Puget Sound drainage basin by NVC Macrogroup and Level 1 EO rank. * = Likely misclassified by GAP/LANDFIRE.** = Classification has changed since GAP/LANDFIRE mapping.

	Level 1 EO Rank				
Macrogroup	**A**	**B**	**C**	**D**	**Total**
M020 Rocky Mountain Subalpine-High Montane Forest	100	3,084	24,982	636	28,801
M024 Vancouverian Coastal Rainforest	536,915	398,165	625,069	176,743	1,736,892
M025 Vancouverian Subalpine-High Montane Forest	17,359	28,095	134,114	2,971	182,540
M035 Vancouverian Flooded & Swamp Forest	109,184	29,646	3,487	4,884	147,201
M048 Central Rocky Mountain Montane-Foothill Grassland & Shrubland	164	2,858	6,640	34	9,696
M050 Southern Vancouverian Lowland Grassland & Shrubland	205	2,327	2,138	172	4,843
M059 Pacific Coastal Beach & Dune	248	977	2,296	473	3,994
M073 Vancouverian Lowland Marsh, Wet Meadow & Shrubland	9,771	8,908	1,812	2,976	23,466
M081 North American Pacific Coastal Salt Marsh	849	943	804	2,026	4,622
***M094 Cool Interior Chaparral**	992	2,049	7,681	806	11,529
M101 Vancouverian Alpine Tundra	130,808	8	408	1	131,224

	Level 1 EO Rank				
Macrogroup	**A**	**B**	**C**	**D**	**Total**
M168 Rocky Mountain-Vancouverian Subalpine-High Montane Mesic Meadow	616	3,095	6,185	91	9,987
***M169 Great Basin-Intermountain Tall Sagebrush Steppe & Shrubland**	45	0	61	0	106
M500 Central Rocky Mountain Mesic Lower Montane Forest	2,442	1,885	18,355	22,082	44,764
***M501 Central Rocky Mountain Dry Lower Montane-Foothill Forest**	0	0	0	120	120
M886 Southern Vancouverian Dry Foothill Forest & Woodland	218	377	40,236	33,512	74,343
M887 Western North American Cliff, Scree & Rock Vegetation	19,446	14,047	13,741	954	48,189
****M888 Arid West Interior Freshwater Marsh (=M073 Vancouverian Lowland Marsh, Wet Meadow & Shrubland)**	78	74	6	13	171
M893 Western North American Montane Marsh, Wet Meadow & Shrubland	2,762	1,417	158	205	4,542
Barren	16,921	2,808	10,893	48	30,670
Total	849,123	500,762	899,067	248,748	2,497,699

Figure 23. Proportion of each NVC raster-mapped macrogroup within the Puget Sound drainage basin by Level 1 EO rank. A=excellent ecological integrity; B=good ecological integrity; C=fair ecological integrity; and D=poor ecological integrity.

Comparison Across Elevation Gradient

The Level 1 EIA model tends to ascribe higher ecological integrity to areas at higher elevations, where there is steeper topography and less development. The largest proportion of natural vegetation in the Puget Sound drainage basin (36%) occurs between 2000 and 4000 ft (Table 26). Approximately 70% of the NVC raster-mapped natural vegetation within this elevation band have Level 1 EO ranks within the natural range of variability (A and B-ranked). Meanwhile, only 26% of the natural vegetation below 500 ft is within the natural range of variability.

Table 26. Total area (hectares) of NVC raster-mapped natural vegetation within the Puget Sound drainage basin by elevation and NVC Level 1 EO rank.

	Level 1 EO Rank				
Elevation	**A**	**B**	**C**	**D**	**Total**
0-500	64,979	32,574	160,829	111,714	370,096
500-2000	54,637	248,687	294,927	54,255	652,506
2000-4000	475,844	157,187	224,368	46,913	904,312
4000-6000	123,224	37,733	118,907	14,280	294,144
6000+	66,332	1,208	6,182	132	73,853
No Data	64,107	23,371	93,854	21,454	202,787
Total	849,123	500,762	899,067	248,748	2,497,699

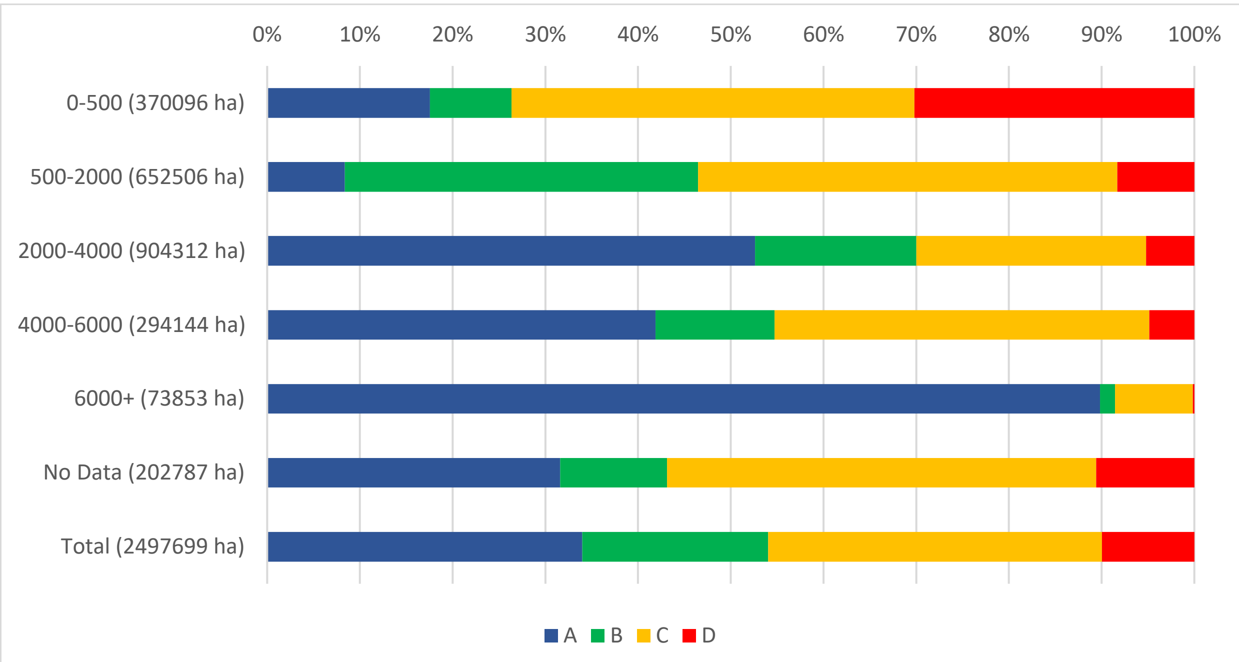

Figure 24. Proportion of NVC raster-mapped natural vegetation within the Puget Sound drainage basin by elevation (ft) and NVC Level 1 EO rank. A=excellent ecological integrity; B=good ecological integrity; C=fair ecological integrity; and D=poor ecological integrity.

Comparison Across Watershed Resource Inventory Areas (WRIAs)

As with the NWI wetland AAs, higher elevation natural vegetation mapped by the NVC Groups raster is predicted to have higher ecological integrity in the Level 1 EIA (see Upper Skagit and Skokomish-Dosewallips, Table 27, Figure 25).

Table 27. Total area (hectares) of NVC raster-mapped natural vegetation within the Puget Sound drainage basin by watershed/WRIA and NVC Level 1 EO rank.

	Level 1 EO Rank				
WRIA	**A**	**B**	**C**	**D**	**Total**
Cedar-Sammamish	6,483	21,686	14,616	5,460	48,245
Chambers-Clover	1,525	392	1,479	2,866	6,263
Deschutes	4,262	1,000	18,815	6,193	30,269
Duwamish-Green	4,286	25,613	41,433	5,092	76,424
Elwha-Dungeness	77,269	7,355	49,286	14,193	148,102
Island	494	712	9,191	8,663	19,060
Kennedy-Goldsborough	6,992	2,124	40,216	9,346	58,678
Kitsap	8,618	22,82	48,245	22,277	81,423
Lower Skagit / Samish	8,329	15,634	42,292	10,272	76,527
Lyre-Hoko	11,460	66,992	6,572	678	85,702
Nisqually	27,229	50,255	45,619	18,664	14,1768
Nooksack	80,884	38,422	80,614	18,717	21,8636
Puyallup-White	61,853	25,193	90,703	10,164	18,7913
Quilcene-Snow	11,926	21,473	35,579	8,367	77,345
San Juan	3,229	624	13,807	6,208	23,868
Skokomish-Dosewallips	64,822	31,016	39,576	5,271	140,685
Snohomish	133,372	74,477	120,273	32,018	360,140
Stillaguamish	56,093	48,626	22,796	15,526	143,041
Upper Skagit	279,963	66,877	177,874	48,771	573,484
Total	849,090	500,750	898,987	248,744	2,497,571

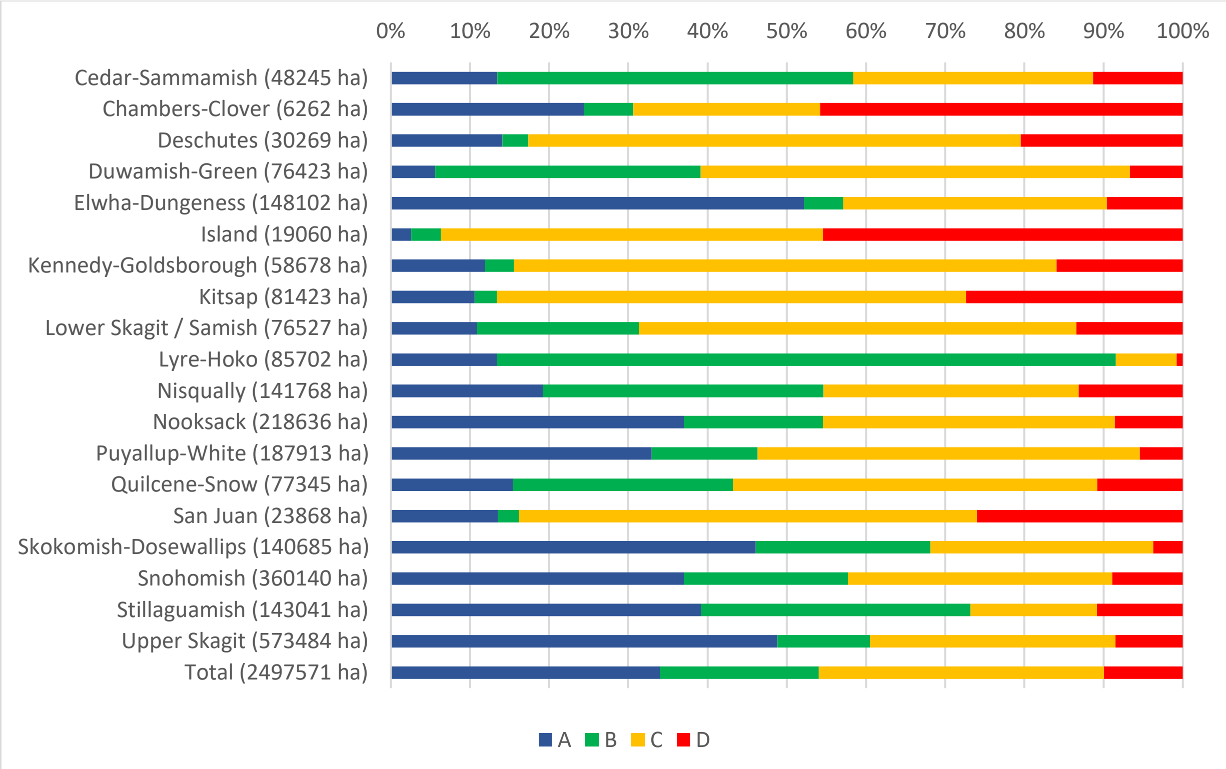

Figure 25. Proportion of NVC raster-mapped natural vegetation within the Puget Sound drainage basin by watershed/WRIA and Level 1 EO rank. A=excellent ecological integrity; B=good ecological integrity; C=fair ecological integrity; and D=poor ecological integrity.

Comparison Across Counties

Only 6% of the NVC Groups raster-mapped natural vegetation in Island County is predicted to be within the natural range of variability (A or B-ranked) in our Level 1 model (Figure 26). On the other end of the extreme, nearly 70% of natural vegetation in the Puget Sound-draining portion of Clallam County is within that range. The portion of Lewis County in the drainage basin is even higher (77%). Several other counties listed in Table 28 either only partially fall within the Puget Sound drainage basin. In other cases, very large upland AAs spill over into counties adjacent to the Puget Sound drainage basin (Grays Harbor, Okanogan).

Table 28. Total area (hectares) of NVC raster-mapped natural vegetation within the Puget Sound drainage basin by county and NVC Level 1 EO rank.

	Level 1 EO Rank				
County	**A**	**B**	**C**	**D**	**Total**
Clallam County	62,425	81,806	51,198	12,508	207,937
Grays Harbor County	165	0.26	70	14	249
Island County	494	712	9,191	8,663	19,060
Jefferson County	70,981	21,355	57,358	12,251	161,946
King County	90,394	91,418	140,175	29,001	350,988
Kitsap County	4,925	1,587	22,222	14,649	43,382
Lewis County	7,519	32,628	10,130	2,186	52,464
Mason County	40,856	26,177	72,715	13,720	153,468
Okanogan County	60	4	4	0.01	68
Pierce County	79,057	35,266	120,143	28,491	262,957
San Juan County	3,229	624	13,807	6,208	23,868
Skagit County	131,910	76,307	119,683	27,186	355,086
Snohomish County	175,818	84,417	94,183	38,911	393,329
Thurston County	7,914	4,020	26,963	11,331	50,228
Whatcom County	173,343	44,430	161,145	43,626	422,544
Total	849,090	500,750	898,987	248,744	2,497,571

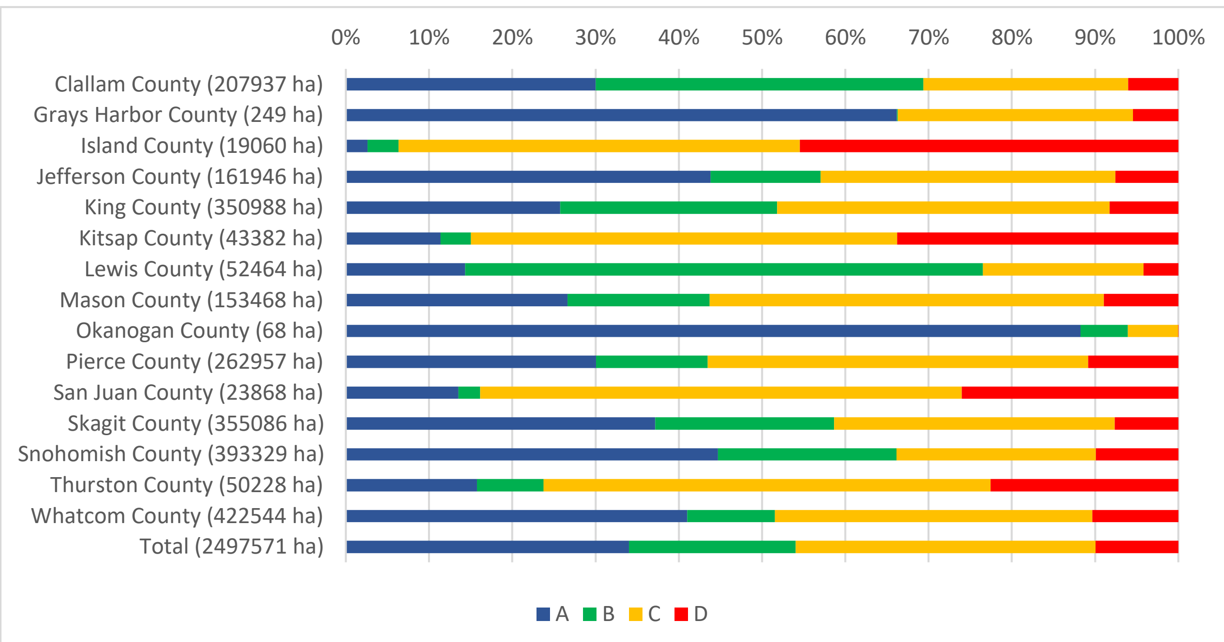

Figure 26. Proportion of NVC raster-mapped natural vegetation within the Puget Sound drainage basin by county and Level 1 EO rank. A=excellent ecological integrity; B=good ecological integrity; C=fair ecological integrity; and D=poor ecological integrity.

5.4.2 Puget Sound Drainage Basin NWI Wetlands

According to our Level 1 model, 75% of NWI-mapped wetland area within the Puget Sound drainage basin is within the natural range of variability (A and B-ranked), while 25% falls outside the natural range of variability (Table 29).

Table 29. Total area of NWI-mapped wetlands within the Puget Sound drainage basin by NWI Level 1 EIA rank.

	Level 1 EIA Rank				
	A	B	C	D	Total
Total Hectares	21,473	29,112	6,052	11,141	67,778
Percent of Area	32%	43%	9%	16%	

Comparison across Cowardin Wetland Types

Riverine wetlands had lower Level 1 EIA ranks than the other wetland classes, but these wetlands represent less than 1% of the total wetland area within the Puget Sound drainage basin. The majority (92%) of NWI wetlands within the Puget Sound drainage basin are mapped as Palustrine (nontidal wetlands dominated by trees, shrubs, persistent emergent plants, emergent mosses, or lichens), and had Level 1 EIA ranks within the natural range of variability 74% of the time (Table 30, Figure 27).

Table 30. Total area (hectares) of NWI-mapped wetlands within the Puget Sound drainage basin by Cowardin Type and Level 1 EIA rank.

	Level 1 EIA Rank				
Cowardin Type	A	B	C	D	Total
Estuarine	1,806	1,692	179	547	4,225
Aquatic Bed		130			130
Emergent	1,806	1,555	179	547	4,088
Unconsolidated Shore		6			6
Lacustrine	264	538	111	47	959
Aquatic Bed	246	537	111	47	940
Emergent	3.14	0.31			3.44
Unconsolidated Bottom	14.7	0.64			15.35
Palustrine	19,403	26,880	5,762	10,540	62,585
Aquatic Bed	537	524	56	48	1,165
Emergent	3,134	8,015	32,88	7,489	21,926
Forested	7,905	9,941	1,615	2,055	21,516
Scrub-Shrub	7,745	8,334	789	931	17,798
Unconsolidated Bottom	67	55	9	9	140
Unconsolidated Shore	16	11	4	8	40
Riverine		2	0.77	7	10
Aquatic Bed		2		5	7
Emergent				1.78	1.78
Unconsolidated Bottom			0.77		0.77
Total	21,473	29,112	6,052	11,141	67,778

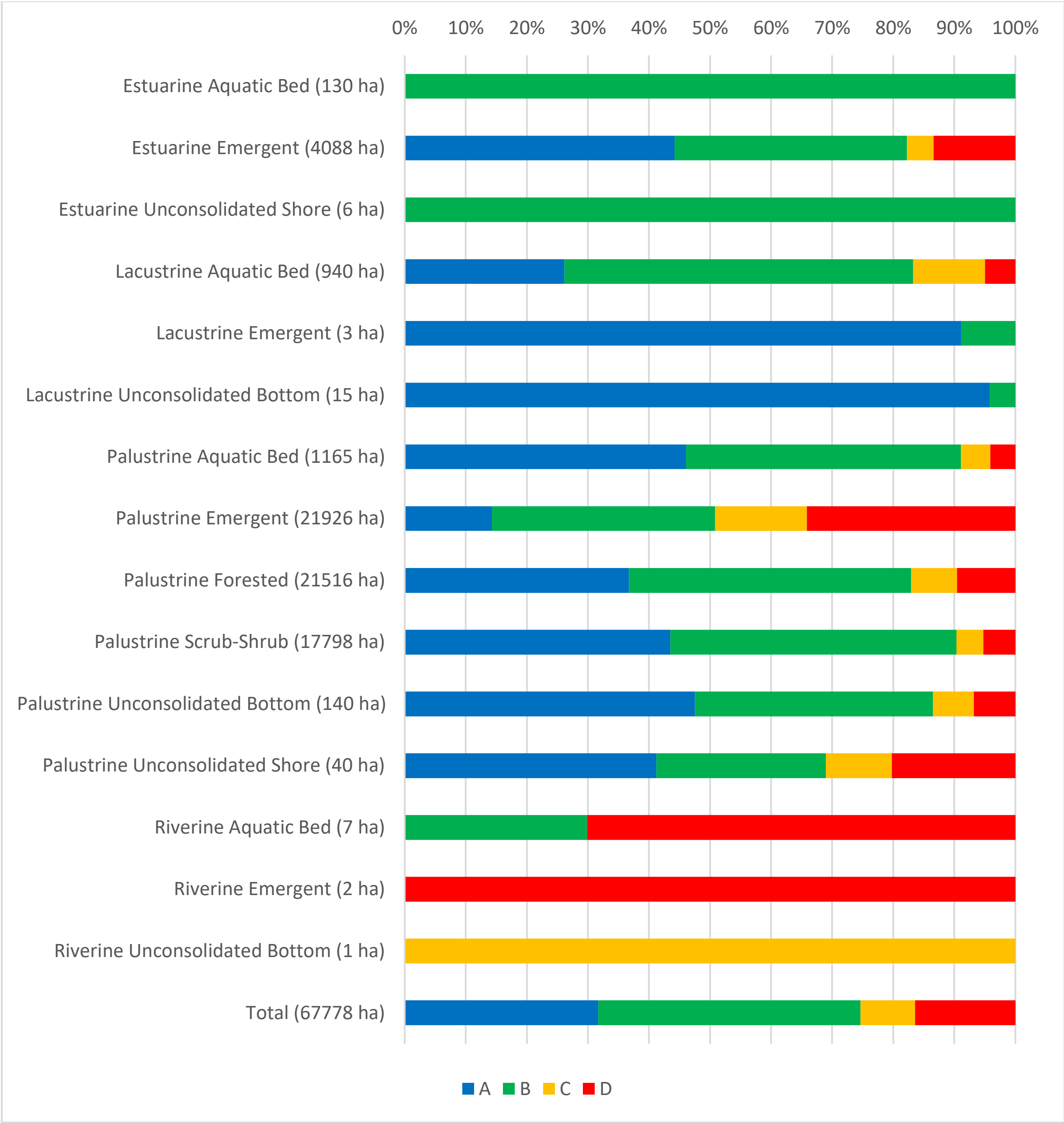

Figure 27. Proportion of each NWI-mapped Cowardin Class within the Puget Sound drainage basin by NWI Level 1 EIA rank. A=excellent ecological integrity; B=good ecological integrity; C=fair ecological integrity; and D=poor ecological integrity.

Comparison Across Elevation Gradients

The Level 1 EIA model tends to ascribe higher ecological integrity to areas at higher elevations (Table 24; Figure 20). The majority of NWI Wetland AAs in the Puget Sound drainage basin are between 0 and 500 ft in elevation (98%). Within this elevation band, 70% of NWI wetlands are modeled as within the natural range of variability (Table 31, Figure 28).

Table 31. Total area (hectares) of NWI-mapped wetlands within the Puget Sound drainage basin by elevation and NWI Level 1 EIA rank.

	Level 1 EIA Rank				
Elevation (ft)	**A**	**B**	**C**	**D**	**Total**
0-500	21,110	28,769	6,040	11,141	67,060
500-1000	87	147			233
1000-1500	137	114	8		258
1500-2000	93	42			135
2000-2500	7	34	4		46
2500-3000	5	4			9
3000-3500	8				8
3500-4000	7	1			8
No Elevation Data	19	1			20
Total	21,473	29,112	6,052	11,141	67,778

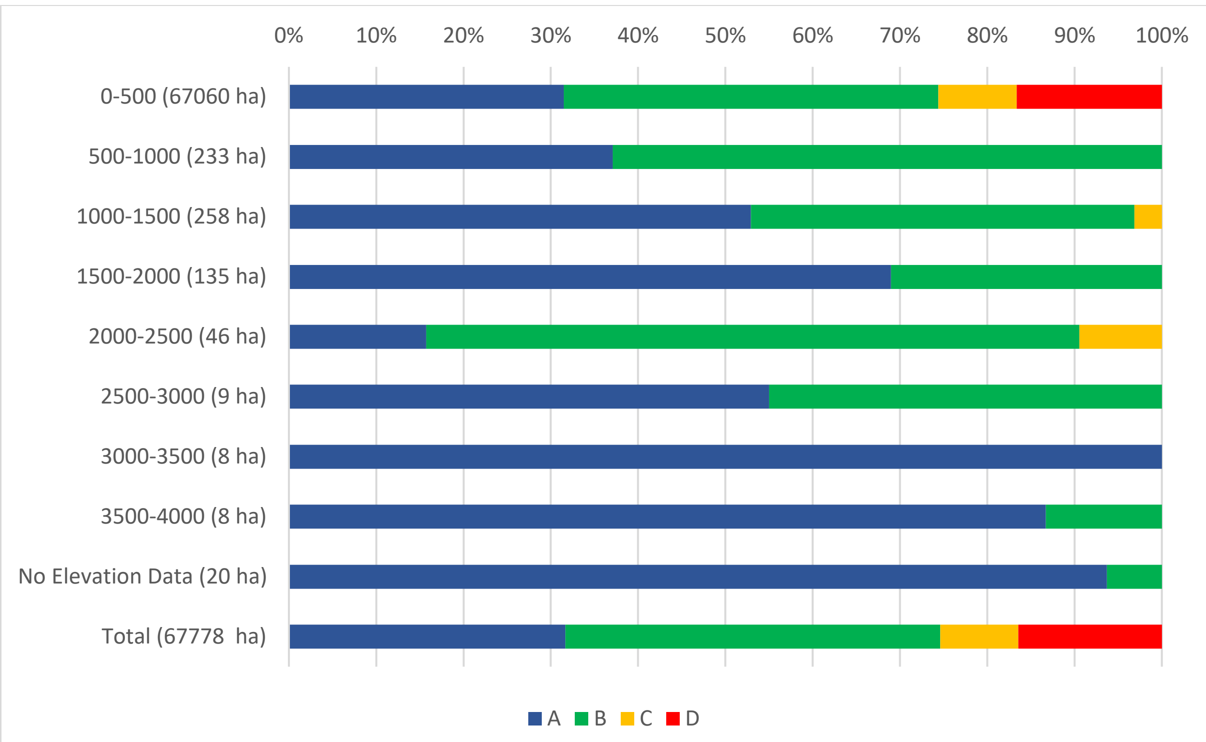

Figure 28. Proportion of NWI-mapped wetland area within the Puget Sound drainage basin by elevation (ft) and NWI Level 1 EIA rank. A=excellent ecological integrity; B=good ecological integrity; C=fair ecological integrity; and D=poor ecological integrity.

Comparison Across Watershed Resource Inventory Areas (WRIAs)

Higher elevation, low-development WRIAs such as Upper Skagit and Skokomish-Dosewallips received relatively high Level 1 EIA ranks, within the natural range of variability (e.g., A or B ranks, Table 32, Figure 29). The Duwamish-Green WRIA, which has a wide elevation range but also has a high level of development, has a lower proportion of area modeled within the natural range of variability than, for instance, the Kennedy-Goldsborough WRIA, which is low elevation but has substantially less development.

Table 32. Total area (hectares) of NWI-mapped wetlands within the Puget Sound drainage basin by watershed/WRIA and NWI Level 1 EIA rank.

	Level 1 EIA Rank				
WRIA	**A**	**B**	**C**	**D**	**Total**
Cedar-Sammamish	300	1108	392	383	2,182
Chambers-Clover	291	229	55	10	586
Deschutes	362	1,637	67	187	2,252
Duwamish-Green	296	1,159	252	750	2,457
Elwha-Dungeness	446	381	65	128	1,020
Island	168	492	397	670	1,727
Kennedy-Goldsborough	1,630	1,347	25	3	3,004
Kitsap	1,243	1,983	321	240	3,787
Lower Skagit / Samish	1,768	2,150	586	1,076	5,580
Lyre-Hoko	360	230	40		630
Nisqually	2,274	4,281	460	824	7,838
Nooksack	1,686	2,732	991	3,916	9,325
Puyallup-White	3,429	3,235	495	627	7,786
Quilcene-Snow	514	794	643	401	2,352
San Juan	202	374	282	59	917
Skokomish-Dosewallips	1,029	1,142	0.32	15	2,186
Snohomish	2,843	4,059	763	1,715	9,380
Stillaguamish	874	1,317	185	130	2,505
Upper Skagit	1,758	462	34	8	2,262
Total	21,473	29,112	6,052	11,141	67,778

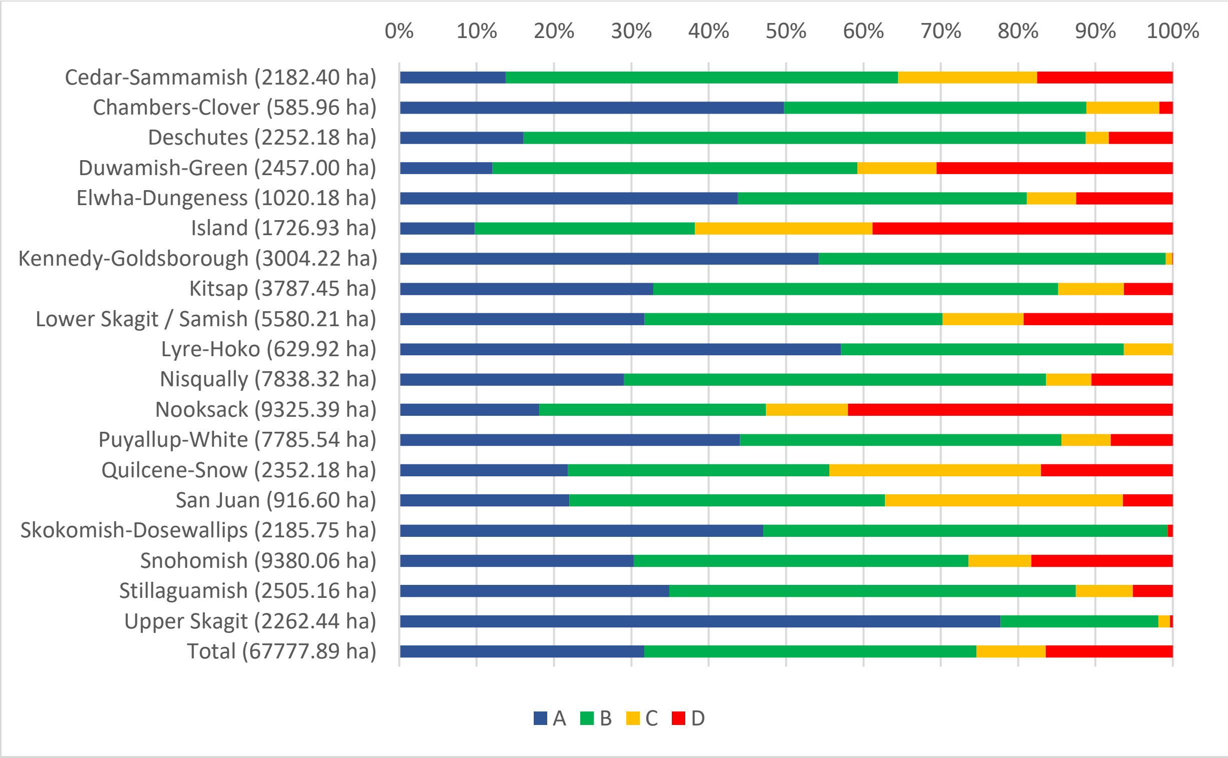

Figure 29. Proportion of NWI-mapped wetland area within the Puget Sound drainage basin by watershed/WRIA and NWI Level 1 EIA rank. A=excellent ecological integrity; B=good ecological integrity; C=fair ecological integrity; and D=poor ecological integrity.

Comparison Across Counties

Mason County has a large proportion of wetlands in working timberland settings, rather than urban/suburban development, resulting in a high proportion of Level 1 EIA ranks within the natural range of variability. Island County and Whatcom County show the lowest percentage of area with Level 1 EIA ranks within the natural range of variability (38% and 49% respectively) (Table 33, Figure 30). In both of these counties, the NWI polygons with low Level 1 EIA ranks are adjacent to areas of urban/suburban development. Lewis County is an outlier, as only a small portion of the county extends into the Puget Sound drainage basin. That small area is at relatively high elevation, with little development. If the portion outside of the Puget Sound drainage basin is factored in, only 36% of Lewis County is within the natural range of variability.

Table 33. Total area (hectares) of NWI-mapped wetlands within the Puget Sound drainage basin by county and NWI Level 1 EIA rank.

	Level 1 EIA Rank				
County	**A**	**B**	**C**	**D**	**Total**
Clallam County	663	655	115	138	1,571
Island County	168	492	397	670	1,727
Jefferson County	766	856	633	405	2660
King County	2,604	4,378	831	1,400	9,,214
Kitsap County	680	1,300	251	208	2438
Lewis County	344	323	12		679
Mason County	2,890	2,731	56	16	5,692
Pierce County	4,507	5,656	794	894	11,851
San Juan County	202	374	282	59	917
Skagit County	2,793	2,579	555	775	6,701
Snohomish County	2,879	4,039	881	2,008	9,808
Thurston County	961	2,922	204	567	4,654
Whatcom County	2016	2,807	1,042	4,001	9,867
Total	21,473	29,112	6,052	11,141	67,778

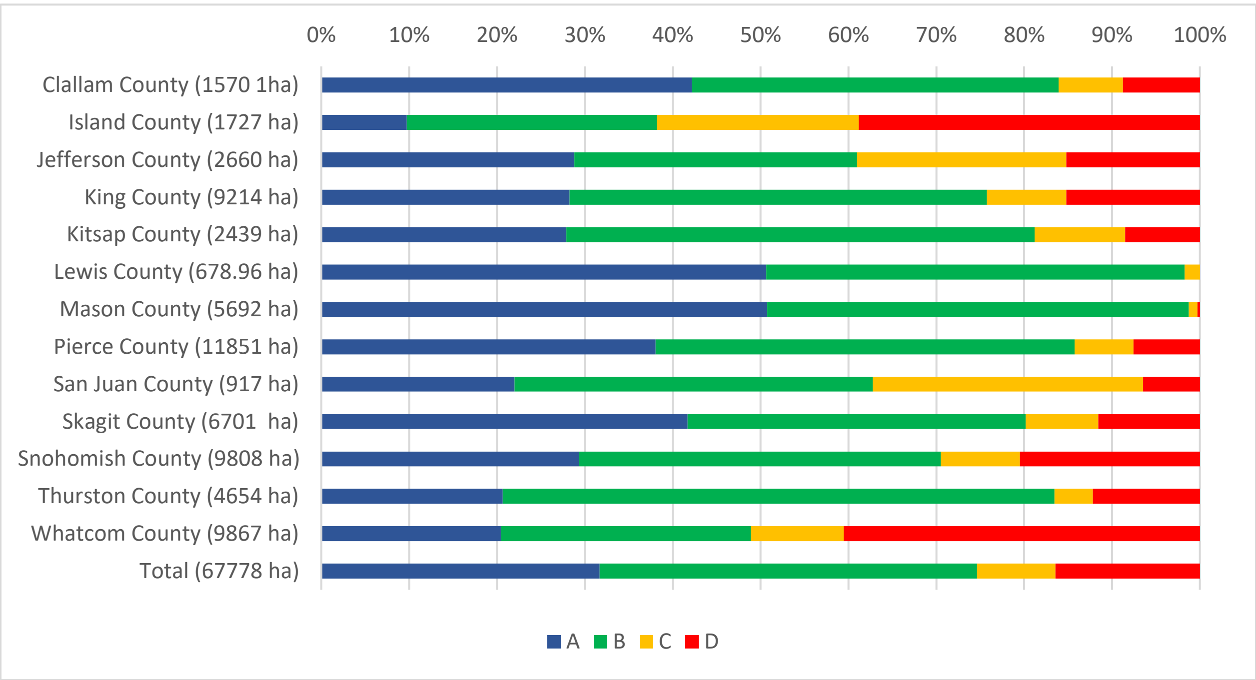

Figure 30. Proportion of NWI-mapped wetland area within the Puget Sound drainage basin by county and NWI Level 1 EIA rank. A=excellent ecological integrity; B=good ecological integrity; C=fair ecological integrity; and D=poor ecological integrity.

5.5 Element Occurrences (EOs)

As noted in Section 3.4.3, an element occurrence (EO) is simply an ecosystem stand or cluster of stands that has practical conservation value. Element occurrences (EOs) are a core component of natural heritage methodology (https://www.dnr.wa.gov/NHPmethods), helping to guide conservation action on the ground, as well as informing our understanding of an ecosystem's degree of imperilment more broadly. EO ranks derived from Level 2 EIA sampling are used in conjunction with conservation status ranks (rarity and/or degree of imperilment) to determine which ecosystem stands should be mapped as EOs (NatureServe, 2002). Six EOs were identified while conducting Level 2 EIA surveys in WRIA 10.

5.5.1 Upland EOs

Two upland sites surveyed during the Level 2 EIA were of sufficient size and ecological integrity to qualify as EOs. Due to the nature of our upland field surveys (i.e., point-sampling), we were not able to determine the exact boundaries of these occurrences, therefore the extent of these EOs are estimated based on the GAP/LANDFIRE and NPS vegetation models (Nielsen et al., 2021). These EOs will be added to our database (Figure 31).

CEGL005518 Tsuga heterophylla - Abies amabilis - (Pseudotsuga menziesii) / Vaccinium alaskaense Forest G4/S4, EO Rank A-

This forest community is located on an old river terrace along the west fork of the White River in Mt. Rainier National Park. Large old-growth *Pseudotsuga menziesii* were present but the canopy was dominated by mature *Tsuga heterophylla*. *Abies amabilis* is the dominant regenerating tree. The understory is dominated by *Vaccinium ovalifolium*, *Rubus pedatus*, *Rubus lasiococcus*, and *Orthilia secunda*. This stand showed little anthropogenic impact with only sparse non-native species restricted to the river edge. Canopy gaps, epicormic branching, and other old-growth indicators were present.

CEGL005567 Tsuga heterophylla - Abies amabilis - Pseudotsuga menziesii / Gaultheria shallon Forest GNR/S4, EO Rank A-

This upland forest community is located in the valley along Huckleberry Creek on the northern border of Mt. Rainier National Park. *Tsuga heterophylla* is dominant in the canopy, with *Pseudotsuga menziesii* and *Abies amabilis* also common. *Taxus brevifolia* creates a prominent tall shrub layer in the understory and the low shrub layer is codominated by *Gaultheria shallon* and *Mahonia nervosa*. Stand structure is in the late vertical diversification stage, with a large range of age classes, canopy gaps beginning to develop, and CWD accumulating. The largest trees showed epicormic branching. Light recreation along Huckleberry Creek Trail is the only sign of anthropogenic disturbance. No non-native species were observed in the assessed area.

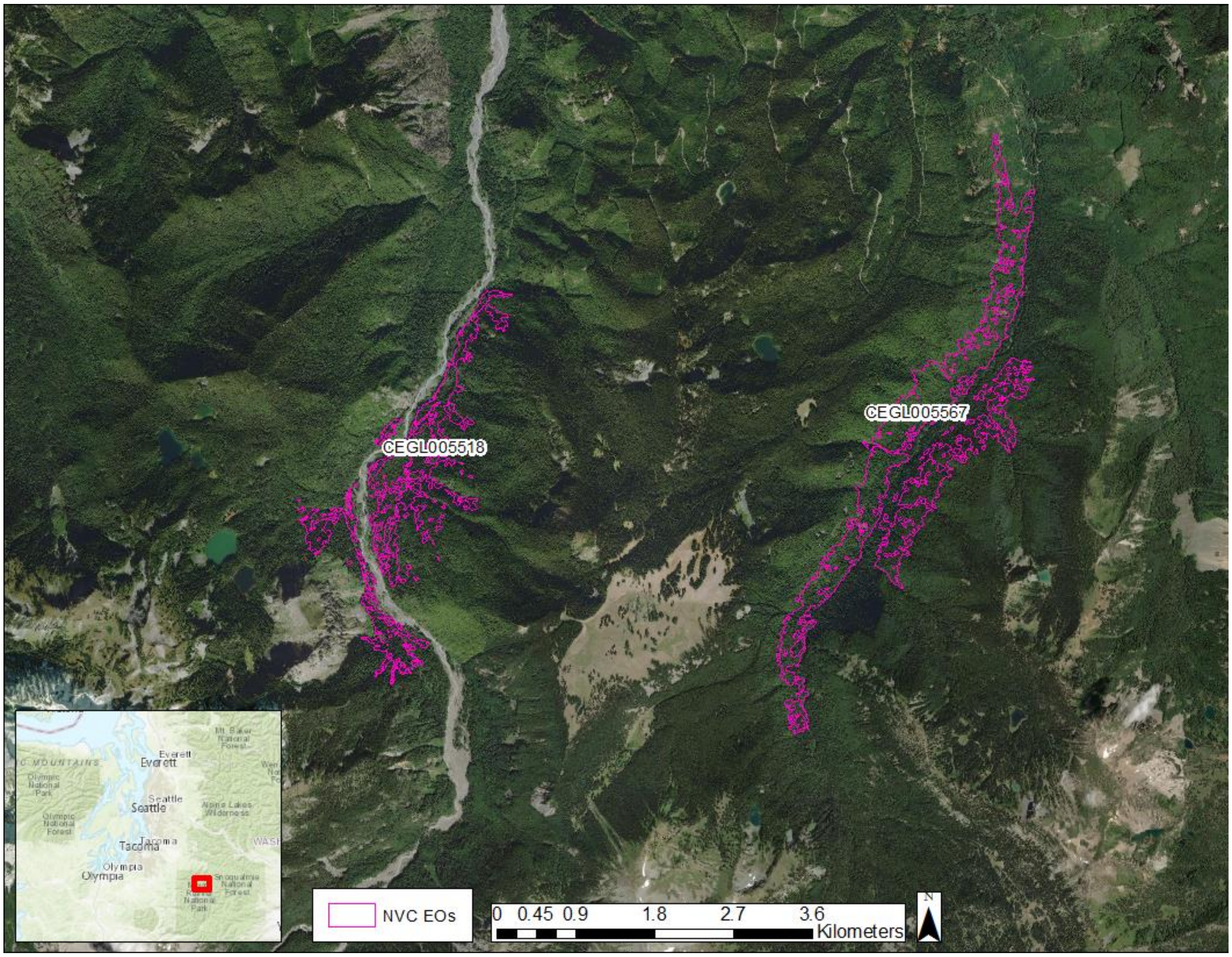

Figure 31. Upland NVC EOs

5.5.2 Wetland EOs

Four wetlands surveyed during the Level 2 EIA were of sufficient size and ecological integrity to qualify as EOs within WRIA 10. In some cases, EO boundaries extend beyond the surveyed NWI polygon to include neighboring polygons of the same Cowardin class (and estimated to be of similar ecological integrity). These EOs will be added to our database (Figure 32).

CEGL003398 Alnus rubra / Elymus glaucus Riparian Forest G4/S3S, EO Rank A-

This isolated riparian forest on an alluvial bar along the west fork of the White River on USFS property is a fairly young stand of *Alnus rubra* with a few emergent *Populus trichocarpa* (= *balsamifera*). *Elymus glaucus* and *Montia parvifolia* are the dominant herbaceous species in areas that are not bare alluvium. The area has been historically logged but there is no recent anthropogenic disturbance. Invasive species are less than 1% cover throughout the site. No hydrologic degradation was observed.

CEGL000497 Tsuga heterophylla - Pseudotsuga menziesii - (Thuja plicata) / Oplopanax horridus / Polystichum munitum Swamp Forest G4/S4, EO Rank B+

This is a large wetland complex along the Carbon River in Mt. Rainier National Park. The EO is an old-growth swamp forest with a canopy dominated by *Tsuga heterophylla*, with *Thuja plicata* and *Pseudotsuga menziesii* also common. The understory consists primarily of *Oplopanax horridus*, *Rubus spectabilis*, a diverse herbaceous layer, and significant bryophyte cover. This wetland complex has a well-used trail through the center, but anthropogenic disturbance off trail is minimal. Structurally this forest has a wide range of tree sizes, abundant regeneration, and numerous size classes of coarse woody debris and snags.

CEGL003418 Populus trichocarpa (= balsamifera)- Picea sitchensis - (Acer macrophyllum) / Oxalis oregana Riparian Forest G2G3/S2, EO Rank A-
This unique, sandy-soiled riparian forest typically has only previously been reported from the Olympic peninsula, but had been expected to occur in other locations (Ramm-Granberg et al., 2021). This occurrence on USFS property is characterized by an emergent canopy of large, old *Populus trichocarpa* (= *balsamifera*) with a dense secondary canopy of *Picea sitchensis.* The White River has migrated away from the southern end of the wetland and that area has a much denser canopy, with little understory vegetation. The elevation drops towards the northern end of the wetland, where the hydrology remains influenced by the river. That portion has a higher prevalence of *Acer macrophyllum* and *Oxalis* sp. Little anthropogenic disturbance was observed in the site as a back channel separates the wetland from the popular hiking trail on the west side of the river.

CEGL000501 Tsuga mertensiana - Abies amabilis / Caltha leptosepala ssp. howellii Swamp Forest G3/S3, EO Rank B+
This is a small occurrence of swamp forest near Deadwood Lake in Mt. Rainier National Park. Hummock tree islands of *Tsuga mertensiana*, *Abies amabilis*, and *Callitropsis nootkatensis* occur over a diverse shrub and herbaceous layer. Many small channels meander through this wetland situated in a montane basin. Excellent structure was observed in this area with a wide range of tree ages and sizes. No signs of anthropogenic alterations were observed on site.

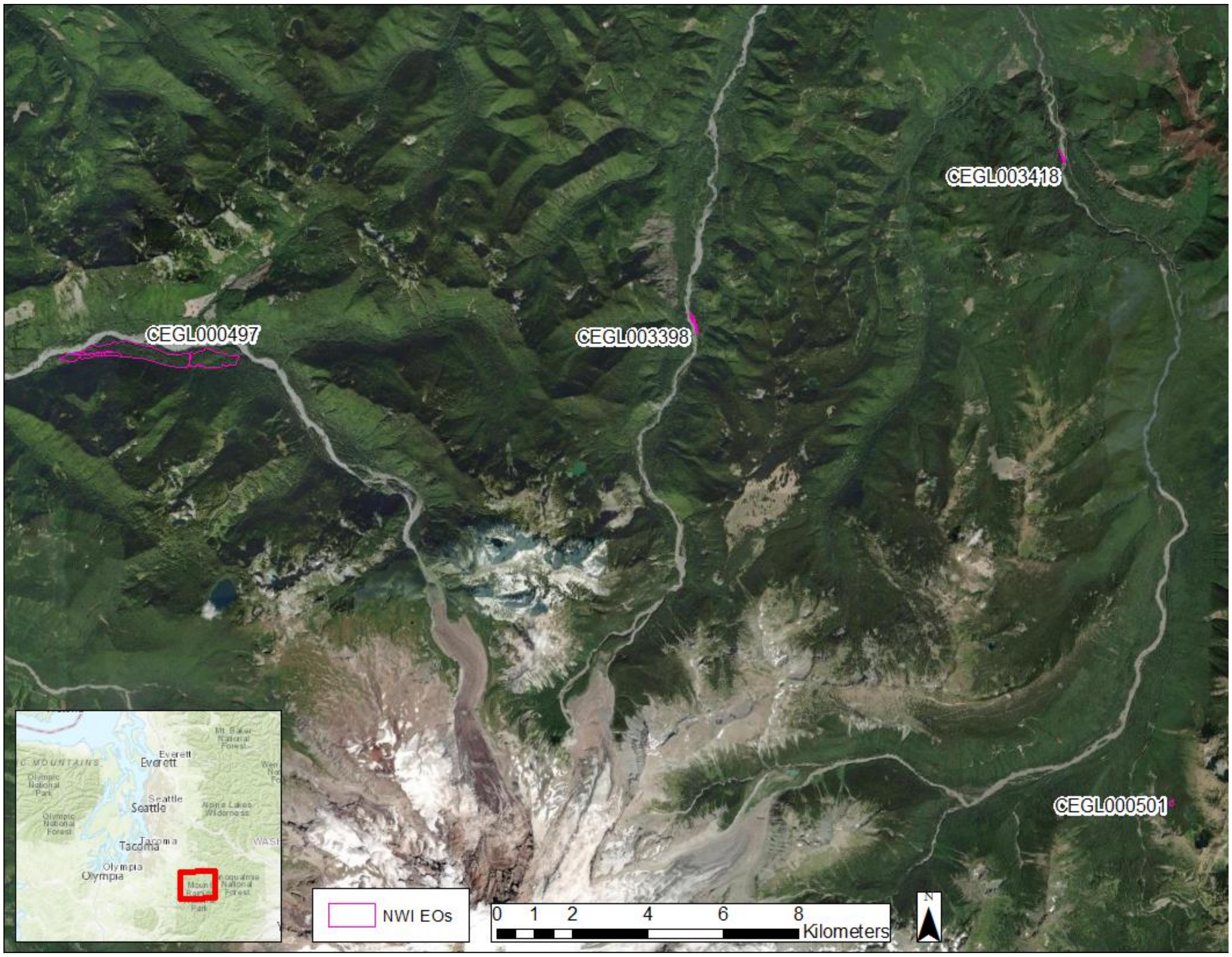

Figure 32. Wetland NWI EOs

6 Areas for Restoration and Conservation

The EIA data compiled in this project may be used for guiding restoration and conservation work in several different ways, depending on organizational goals. Organizations seeking to acquire land to improve habitat corridors may find the ecological integrity of a parcel to be secondary to its location between protected lands. However, if the goal is to protect intact rare and/or imperiled ecosystems, one may focus more on ecological integrity and size than location, as larger, higher-integrity occurrences will have a greater likelihood of persisting in the long-term. High integrity sites also require less restoration and may need less management to maintain ecological integrity.

Level 1 EIA data are most appropriate for landscape level assessments, such as highlighting watersheds or management districts with high or low predicted integrity. Level 1 EIA may also be used as an initial site-scale screening tool, guiding managers to degraded sites in otherwise intact landscapes (high restoration potential) or pointing out intact sites in otherwise degraded landscapes (conservation targets, if sufficient monitoring and management of stressors is available). However, ground-truthing via Level 2 EIA is imperative to confirm the ecological integrity of any specific location.

Level 2 EIA results may be used in a variety of ways to support restoration and conservation actions. Level 2 data may be used for site scale monitoring to track changes in ecological integrity at a site over time. Individual metrics from initial Level 2 surveys at a site may be used to indicate which components of ecological integrity need improvement. Reference conditions for a restoration site may be developed from areas of high ecological integrity determined in Level 2 EIA surveys.

Below, we discuss imperiled ecosystems within the Puget Sound drainage basin that may be conservation or restoration targets wherever they are found. We then highlight specific sites that could benefit from conservation or restoration action. These sites were identified using our existing database of rare and/or high-quality ecosystem occurrences along with the Level 1 and Level 2 EIA data compiled as part of this project.

6.1 Puget Sound Drainage Basin Ecosystems in Need of Restoration and Conservation

There are several upland NVC macrogroups occurring within the Puget Sound drainage basin that are in need of conservation and/or restoration action (Table 34). These are by no means the only areas in need, but rather examples that could be targeted based on the results of this project. Some of our recommendations in this report are based on ecosystem state conservation statuses and priorities outlined in the 2022 Natural Heritage Plan (WNHP, 2022). These syntheses are useful for focusing regulatory and conservation activities towards the most imperiled ecosystems in the state. The discussion below is not comprehensive, but serves as a broad survey of the range of systems at risk around the Puget Sound. Note that discussion of wetland ecosystems refers to areas mapped by the NVC Groups raster—not NWI—because we could not confidently crosswalk NWI Cowardin attributes to consistent levels of the NVC.

Table 34. Summary of imperiled ecosystems of the Puget Sound drainage basin in need of restoration and/or conservation. Precise locations of element occurrences for each of these groups is available in the accompanying geodatabase. Natural range of variability = A/B EIA rank.

Macrogroup/Group	State Conservation Status	EOs	Proportion Outside Natural Range of Variability in Level 1 EIA
M886 Southern Vancouverian Dry Foothill Forest & Woodland			**99%**
G206 Cascadian Oregon White Oak - Conifer Forest & Woodland	Endangered	8	
G800 Southern Vancouverian Dry Douglas-fir - Madrone Woodland	Threatened	8	
M059 Pacific Coastal Beach & Dune			**69%**
G498 North Pacific Maritime Dune & Coastal Beach	Threatened	6	
M050 Southern Vancouverian Lowland Grassland & Shrubland			**48%**
G488 Southern Vancouverian Shrub & Herbaceous Bald, Bluff & Prairie	Threatened	12	
M024 Vancouverian Coastal Rainforest			**46%**
G205 Vancouverian Dry Coastal Beach Pine Forest & Woodland	Threatened	2	
G240 North Pacific Maritime Douglas-fir - Western Hemlock Rainforest	Threatened	13	
G751 North-Central Pacific Western Hemlock - Sitka Spruce Rainforest	Threatened	0	
M035 Vancouverian Flooded & Swamp Forest			**6%**
G851 North-Central Pacific Lowland Riparian Forest	Sensitive	1	
G853 North-Central Pacific Maritime Swamp Forest	Sensitive	1	
M073 Vancouverian Lowland Marsh, Wet Meadow & Shrubland			**20%**
G517 Vancouverian Freshwater Wet Meadow & Marsh	Sensitive	4	
G525 Temperate Pacific Freshwater Wet Mudflat	Sensitive	0	

6.1.1 M886 Southern Vancouverian Dry Foothill Forest & Woodland

M886 Southern Vancouverian Dry Foothill Forest & Woodland comprises 74,343 hectares of the Puget Sound drainage basin according to GAP/LANDFIRE modeling—approximately 3% of the area assessed in the Level 1 EIA. Nearly all (99%; Table 25) of the area covered by this macrogroup has Level 1 EIA ranks outside the natural range of variability (C or D-ranked). Included in this macrogroup is G206 Cascadian Oregon White Oak - Conifer Forest & Woodland, a state endangered ecosystem and previously identified as a priority for conservation (WNHP, 2022). Due to scarcity on the landscape and the frequently poor ecological integrity of these plant communities, any highly ranked communities found would be valuable conservation targets. Areas of lesser quality would be good potential candidates for restoration.

6.1.2 M059 Pacific Coastal Beach & Dune

This macrogroup comprises 3,994 hectares (less than 1%) of the Puget Sound drainage basin and over 69% of this macrogroup is outside the natural range of variability according to Level 1 EIA Ranks (Table 30). Within this macrogroup is the state threatened ecosystem G498 North Pacific Maritime Dune & Coastal Beach. Due to scarcity on the landscape, the potentially poor ecological integrity of these plant communities, the inherent vulnerability of coastal plant communities to the impacts of climate change, any highly ranked communities found would be valuable conservation targets. Any areas of lesser quality would be good potential candidates for restoration.

6.1.3 M050 Southern Vancouverian Lowland Grassland & Shrubland

Southern Vancouverian Lowland Grassland & Shrublands cover 4,843 hectares (less than 1%) of the Puget Sound drainage basin according to the GAP/LANDFIRE model. 48% of this macrogroup is modeled as outside the natural range of variability (Table 30). Within this macrogroup is G488 Southern Vancouverian Shrub & Herbaceous Bald, Bluff & Prairie, a state threatened ecosystem (WNHP, 2022). These are small grassland communities that occur in the lowlands to mid-montane elevations of western Washington associated with terrain with shallow soils, abiotic factors that exclude trees and large shrubs, and/or regular fire return intervals. Major threats to this ecosystem include fire suppression that leads to encroachment by woody vegetation and non-native species (Rocchio & Crawford, 2015).

6.1.4 M024 Vancouverian Coastal Rainforest

Vancouverian Coastal Rainforests cover 1,736,892 hectares (69%) of the Puget drainage basin according to the GAP/LANDFIRE model. 46% of this macrogroup is modeled as outside the natural range of variability (Table 30). While this macrogroup is abundant on its own, it includes G205 Vancouverian Dry Coastal Beach Pine Forest & Woodlands, a state threatened ecosystem that occurs on old stabilized dunes covered in forests or woodlands (Natureserve & WNHP, 2015). This ecosystem is threatened by development, logging, changes to disturbance regimes, and invasive species (Rocchio & Crawford, 2015).

6.1.5 M035 Vancouverian Flooded & Swamp Forest

Vancouverian Flooded & Swamp Forests cover 147,200 hectares (6%) of the Puget Sound drainage basin according to the GAP/LANDFIRE model. This macrogroup contains North-Central Pacific Lowland Riparian Forests (G851), a state sensitive, palustrine forested wetland ecosystem that occurs throughout western Washington riparian areas (Ramm-Granberg et al., 2021). While only 6% of this macrogroup is modeled as outside the natural range of variability (Table 30), these ecosystems are particularly threatened by logging and development. Historical and contemporary land use practices, both in and adjacent to riparian ecosystems, fragment and alter these communities, leading to decreased ecological integrity (Rocchio & Crawford, 2015).

6.1.6 M073 Vancouverian Lowland Marsh, Wet Meadow & Shrubland

Vancouverian Lowland Marsh, Wet Meadow & Shrubland covers 23,466 hectares (1%) of the Puget Sound drainage basin according to the GAP/LANDFIRE model. 20% of this macrogroup is modeled as outside the natural range of variation (Table 30) Two palustrine emergent wetland Groups within this macrogroup are state sensitive ecosystems. Temperate Pacific Freshwater Wet Mudflat (G525) is a state sensitive ecosystem that consists of freshwater mudflats, primarily in seasonally or tidally flooded shallow lakebeds and on floodplains (Natureserve & WNHP, 2015). The primary threat to this ecosystem is alterations to hydrology that change the amount and pattern of herbaceous wetland habitat (Rocchio & Crawford, 2015). Vancouverian Freshwater Wet Meadow & Marsh (G517) is a state sensitive ecosystem that occurs inland of tidal marshes, common along sloughs and levees (Natureserve & WNHP, 2015). Like mudflats, these meadows and marshes are sensitive to alterations in hydrology. Human land use in contributing watersheds can result in reduction in wetland habitat and reduced connectivity between wetland patches (Rocchio & Crawford, 2015).

6.2 Specific Targets for Restoration and Conservation Action in the Puget Sound Drainage Basin

Specific locations for restoration and conservation action may be derived from several sources: element occurrence (EO) data, Level 2 EIA data, and Level 1 EIA data. These sources are listed in descending order of our confidence in their on-site conservation values.

6.2.1 Conservation and Restoration of EOs

There are 979 ecosystem EOs in the Puget Sound drainage basin, representing practical conservation units of 32 different NVC groups in 19 macrogroups. 822 of these EOs are displayed in Figure 33, while the remainder have been masked for data sensitivity reasons (i.e. private landowners allowed sampling, but requested that these locations not be publicized). By definition, all EOs have significant conservation value, but those representing endangered or threatened ecosystems have the highest priority (WNHP, 2022). These locations are also included in an accompanying geodatabase.

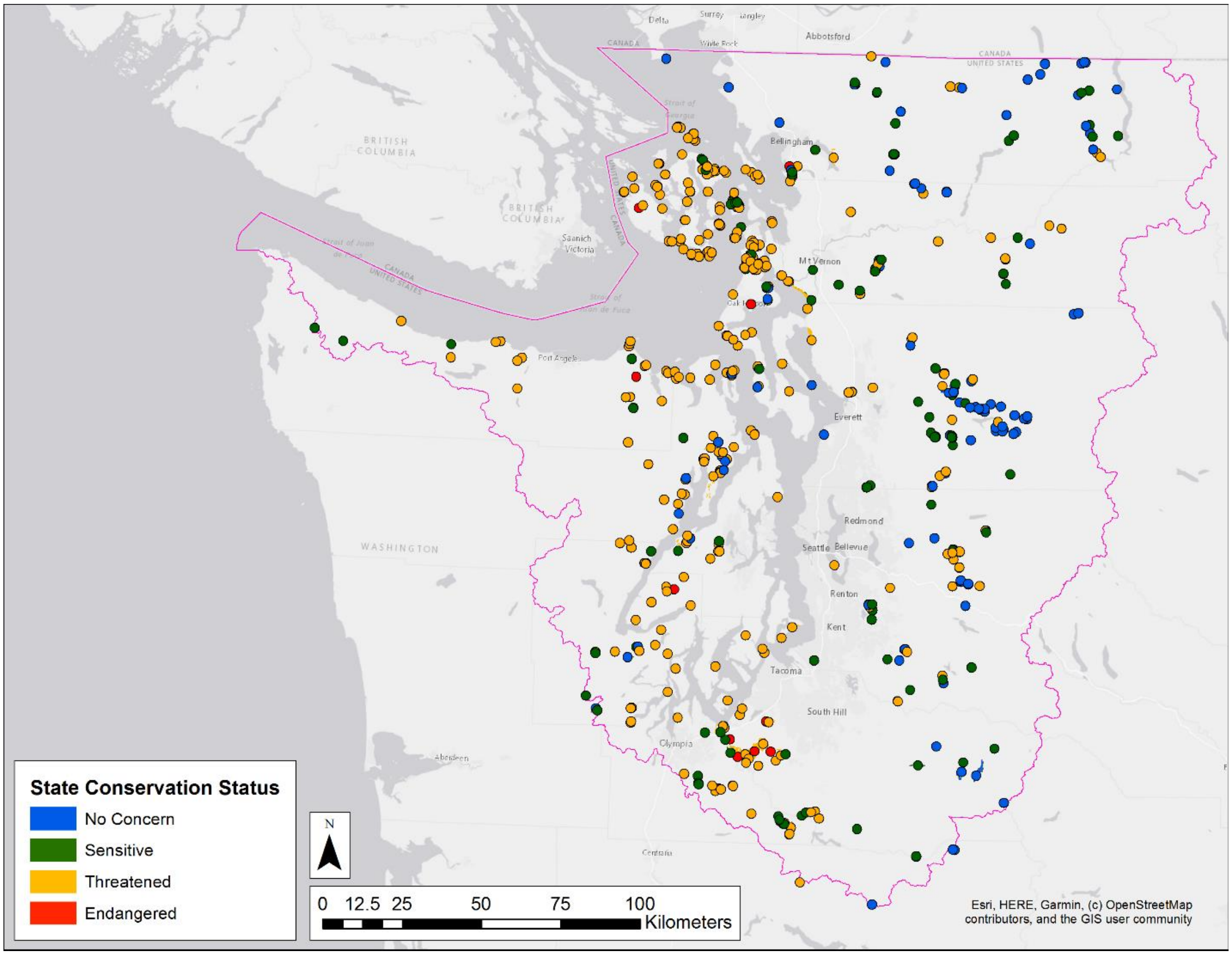

Figure 33. Puget Sound drainage basin EOs (n = 822), converted to points and color-coded by NVC Group State Conservation Status. See accompanying geodatabase for more detail. All EOs have significant conservation value, but those representing endangered ecosystems have the highest priority.

Occurrences of less imperiled ecosystem types (e.g. No Concern or Sensitive) must have high ecological integrity to be considered EOs. However, more imperiled and/or rare ecosystems (Threatened or Endangered) remain valuable conservation targets even when they have relatively poor integrity—they are the best examples remaining on the landscape. C or D-ranked EOs (outside the "natural range of variability") are frequently excellent targets for restoration (Figure 34).

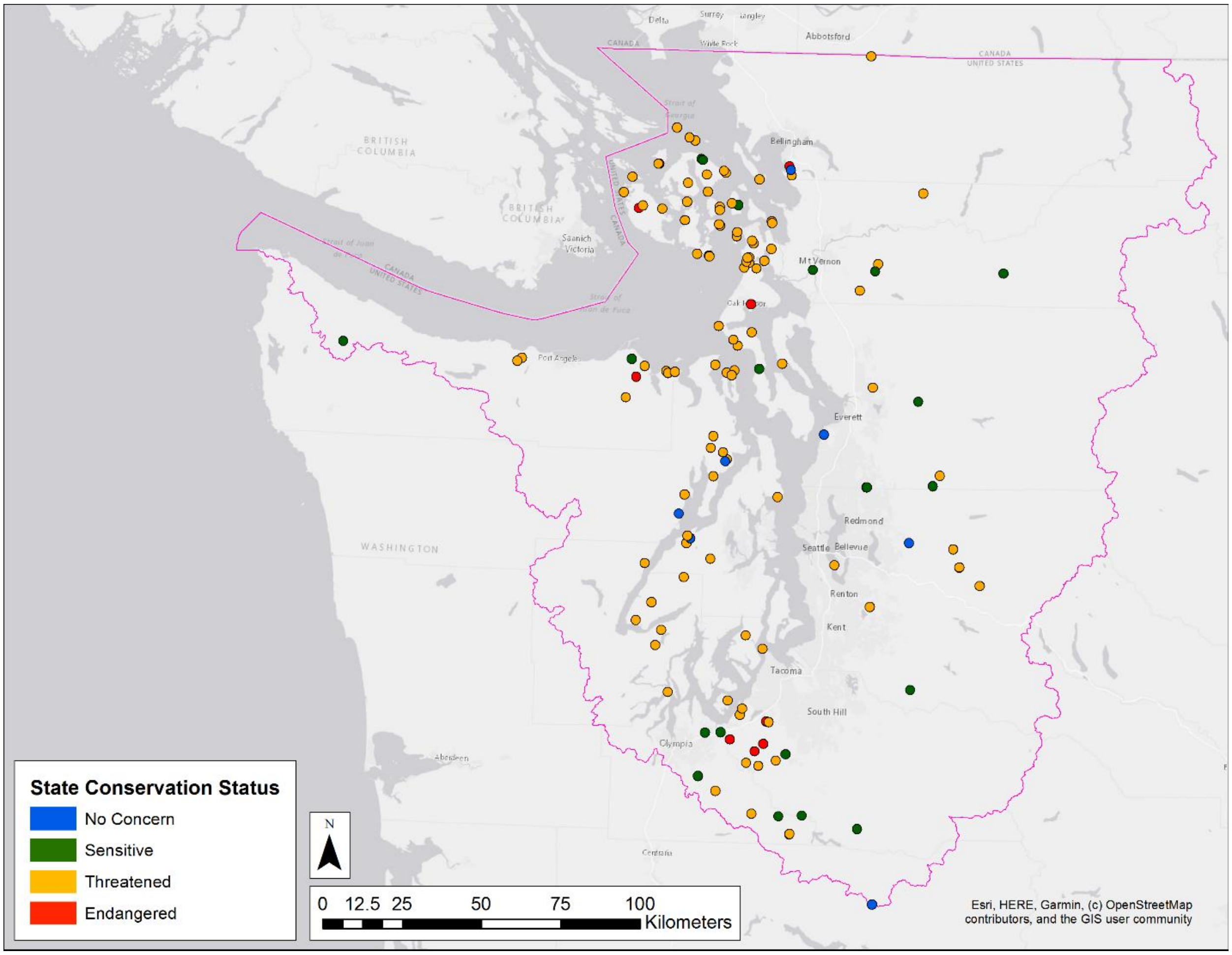

Figure 34. Puget Sound drainage basin EOs with EO ranks of ‘C’ or ‘D’, converted to points and color-coded by NVC Group State Conservation Status. See accompanying geodatabase for more detail. These EOs are in greatest need of restoration. EOs with ‘No Concern’ or ‘Sensitive’ conservation statuses on this map represent particularly rare or imperiled plant associations within otherwise less imperiled/more common NVC groups.

6.2.2 Conservation and Restoration of Level 2 EIA Assessment Areas

51 upland (NVC) and 49 wetland (NWI) AAs in WRIA 10 were visited for Level 2 EIA data collection during this project. Six of these had sufficient ecological integrity to be added to our EO database, but the remainder still have varying degrees of conservation value. 39 upland and 41 wetland sites received ‘A’ or ‘B’ ranks (Figure 35; 12 are not displayed on this map, due to data sensitivity issues on some private timberlands). In other words, these are the locations operating within the “natural range of variability”. While they received positive ecological integrity marks, these stands may have been too small to clear the threshold for EOs. Many represented relatively common and/or secure ecosystems, but could still serve as potential conservation targets, as they require minimal restoration effort. These should be prioritized below EOs.

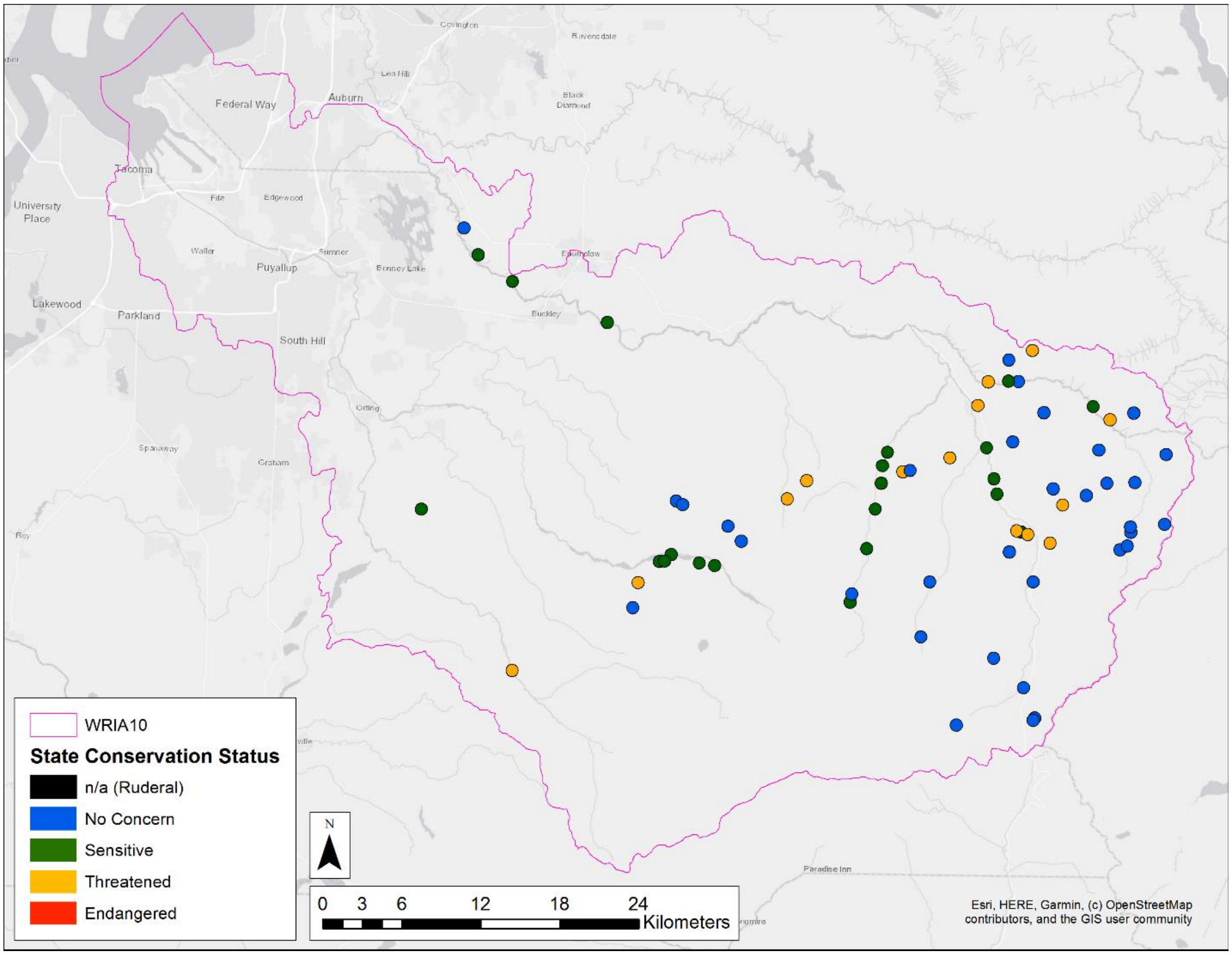

Figure 35. A and B-ranked Level 2 Assessment Areas in WRIA 10 (n = 68), converted to points and color-coded by NVC Group State Conservation Status. For NWI wetlands, these are EIA ranks. For NVC upland AAs, these are Condition Ranks. These sites are considered to be “within the natural range of variability” and may be targets for conservation.

8 upland and 12 wetland sites in WRIA 10 received C or D ranks (Figure 36; 10 are not displayed on this map, due to data sensitivity issues on some private timber lands). These sites were found to be outside the natural range of variability. Some were degraded to such a degree that they represented novel, ruderal communities that are very difficult to restore. The remainder may serve as targets for restoration, though they should be prioritized below C or D-ranked EOs (which represent rarer and/or more imperiled ecosystems).

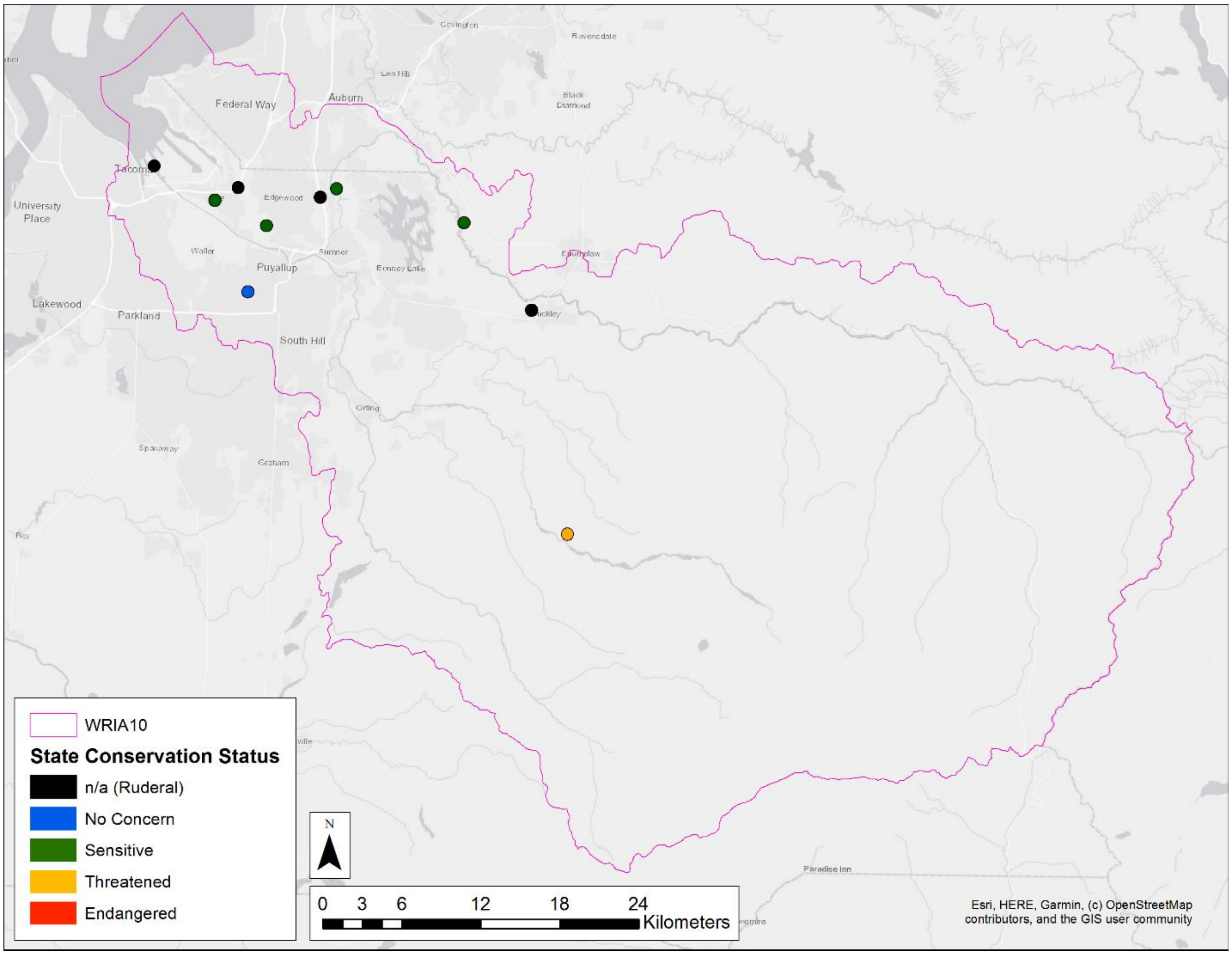

Figure 36. C and D-ranked Level 2 Assessment Areas in WRIA 10 (n = 10), converted to points and color-coded by NVC Group State Conservation Status. For NWI wetlands, these are EIA ranks. For NVC upland AAs, these are Condition Ranks. These sites are considered to be "outside the natural range of variability" and may be targets for restoration.

6.2.3 Conservation and Restoration of Level 1 EIA Assessment Areas

While we have less confidence in the on-the-ground conservation significance of A- or B-ranked Level 1 assessment areas— relative to EOs and Level 2 AAs—they may still be used as an initial screening tool for conservation and restoration. As previously outlined, areas estimated to be within the natural range of variability (A or B ranks) are likely to be good candidates for conservation, while C or D-ranked locations are likely to require signification restoration action (Appendix D). Level 1 EIA AAs should be prioritized below both EOs and Level 2 AAs.

7 Conclusions, Lessons Learned, and Future Directions

7.1 Limitations of the Level 1 Model

Our analyses showed our initial Level 1 EIA model to be correlated with Level 2 EIA data, but with only fair to moderate accuracy. The adjusted Level 1 EIA improves that relationship, but still tends to overestimate ecological integrity.

The Puget Sound drainage basin was the focus of this project, but we also ran provisional analyses for the entire state of Washington. Outside of western Washington, inspection of the Level 1 EIA indicates the model greatly over predicts ecological integrity of grassland ecosystems—many areas we know first-hand to be of poor ecological integrity were given high marks in the Level 1 EIA model. This likely occurs because stressors that impact grasslands (grazing, invasive species) can be difficult to detect through remote sensing. Future iterations of this model at a statewide level will need to include additional data sets to improve predictions in these areas. Options include data sets that measure *Bromus tectorum* (cheatgrass) invasion (Maestas et al., 2020) and identify grazed areas (https://agr.wa.gov/departments/land-and-water/natural-resources/agricultural-land-use).

As outlined above, Size and Landscape Context have been considered the primary and secondary rank factors for matrix communities, as their persistence on the landscape is more closely tied to spatial extent and to landscape level processes than to the condition of any specific small portion of the community (Rocchio et al., 2020b). It is also difficult to assess condition over such large areas, as there are many variations in biotic and abiotic factors that may influence condition at any discrete location within a matrix community. However, when matrix ecosystems become large enough, even Landscape Context becomes less and less important, as the community itself essentially becomes its own context (the outer portions buffer the inner portions from external stressors). When assessing these communities in a Level 1 EIA, it may be more effective to simply focus on identifying large, intact areas of matrix ecosystems—at least for forests where management history data (i.e. past logging) is unavailable—rather than attempting to assess Landscape Context and Condition. Where management history *is* available, more effort to assess Condition may be incorporated. Similarly, while GNN and other data sets that we incorporated into our Level 1 forest structure metrics are valuable resources for identifying old-growth forests at low to middle elevations, they are less useful for distinguishing naturally earlier seral communities that may still have excellent ecological integrity. Outside of small areas that have been intensively mapped, current upland vegetation mapping also remains too coarse and inaccurate to reliably distinguish forest types, such as subalpine communities, that never achieve old-growth structure.

Besides Level 1 EIA, another option to assess condition in large ecosystems is to use a raster/distance based methodology such as the NatureServe Landscape Condition Model (Comer & Hak, 2009). This is another GIS-based algorithm that incorporates GIS land use layers (roads, land cover, water diversions, groundwater wells, dams, mines, etc.) weighted according to their perceived impact on ecological integrity. However, rather than using polygon-based assessment areas, the Landscape Condition Model feeds these remote sensing data into a distance-based decay function. Each pixel (as opposed to polygon AA, as in our methodology) is then assigned a score, which results in a raster map depicting landscape integrity. This type of model provides a condition assessment at a finer scale than a polygon based approach; however, it is more difficult to use a system like this to identify areas of conservation significance. Rasters are generally less intuitive to work with than discrete polygons. Combining these two methodologies may be one way to improve Level 1 EIA results, perhaps by starting with a raster based model and then utilizing a patch-finding algorithm to identify sites/polygons for conservation or restoration. In particular, this may be better for identifying large, intact matrix communities as suggested above.

7.1.1 Assessment Area Issues

Creating AAs from raster data (our NVC AAs) proved very complicated and took weeks to run using GIS servers. On the other hand, AAs generated from NWI polygons were artificially reduced in size according to standard EIA methodology. For instance, in the NWI data set, two palustrine wetlands separated by a river are considered two separate wetlands, while EIA would normally assess the two palustrine types together so long as they were hydrologically connected and not divided by a significant span of non-natural land cover. In future Level 1 EIA efforts, we may explore automated methods of merging NWI wetland polygons of the same Cowardin type that are adjacent to one another.

7.2 Recommendations for Future Work

With additional ground-truthing against independent data sets, we can continue to train this Level 1 EIA model to be a better predictor of ecological integrity. In this project, our Level 2 EIA surveys focused on forested ecosystems, so our Level 1 EIA model is now best trained to predict ecological integrity in those communities. Targeting additional Macrogroups with different physiognomy (i.e. grassland ecosystems) for additional fieldwork could help us identify more ways to improve our predictions of ecological integrity.

8 Deliverables

8.1 Deliverables Accompanying this Report

8.1.1 Level 1 EIA map of the Puget Sound Drainage Basin

The Level 1 EIA map is included in the accompanying geodatabase (see below). In addition, PDF copies are included in this deliverable package and in Appendix D.

8.1.2 GIS Database of Level 1 and Level 2 EIA Results + User Guide

A geodatabase including the updated Level 1 EIA model and the results from the Level 2 EIA is included with this report. The User Guide includes a description of the shapefiles and attributes included in the database and guidance on attributes and symbology.

8.1.3 EIA Training Curriculum

A preliminary curriculum may be found in the workshop memo provided in January 2022. These materials have been developed into training modules hosted by DNR that include video, protocol documents, and background information. This self-guided online training will continue to be developed and enriched moving forward. The training is available at the following links:

https://deptofnaturalresources.box.com/s/asms62r1q2hv8uvn0z6hls9mrvnxhpgf

https://bit.ly/EIA_training

8.1.4 Online Map Viewer

In 2017, the Washington Natural Heritage Program (WNHP) released the Wetlands of High Conservation Value Map Viewer. This publicly available map viewer shows the known locations of wetland and riparian plant communities, and rare plant and nonvascular species tracked by the WNHP, and was developed to increase accessibility to information relevant for the Department of Ecology wetland rating system. A deliverable for this project is an updated version of this map viewer. The new viewer incorporates new tools and additional information, including Ecological Integrity Assessment data and upland ecosystem data. The map will enhance understanding of ecologically important lands, directing protection and restoration efforts to areas in most need of such actions.

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Appendix A: Initial Level 1 EIA Results for the Puget Sound Drainage Basin

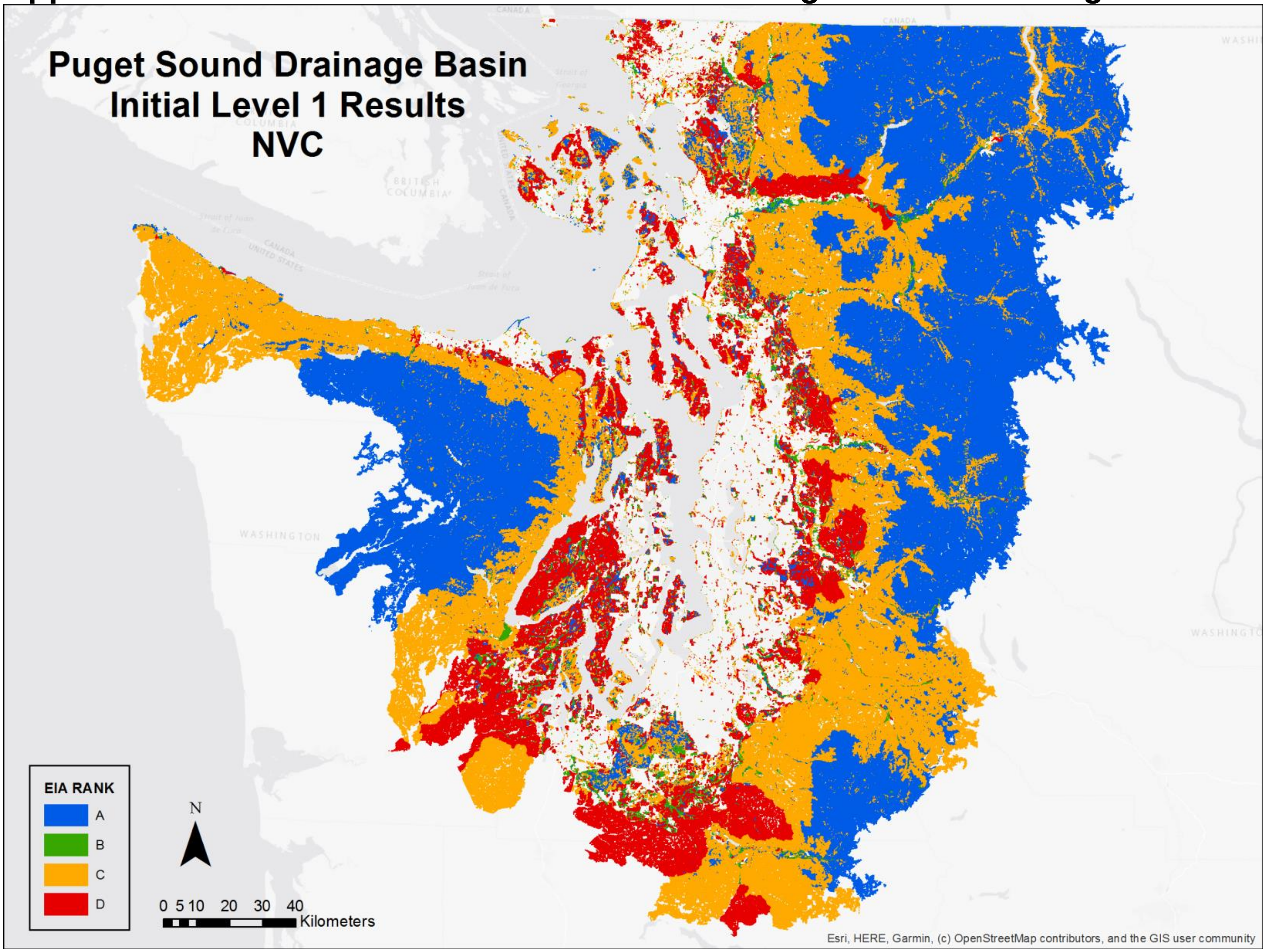

Figure A-1. Initial draft Level 1 Ecological Integrity Assessment of US National Vegetation Classification polygons within the Puget Sound drainage basin. A-Rank = excellent ecological integrity; B-Rank = good ecological integrity; C-Rank = fair ecological integrity; and D-Rank = poor ecological integrity.

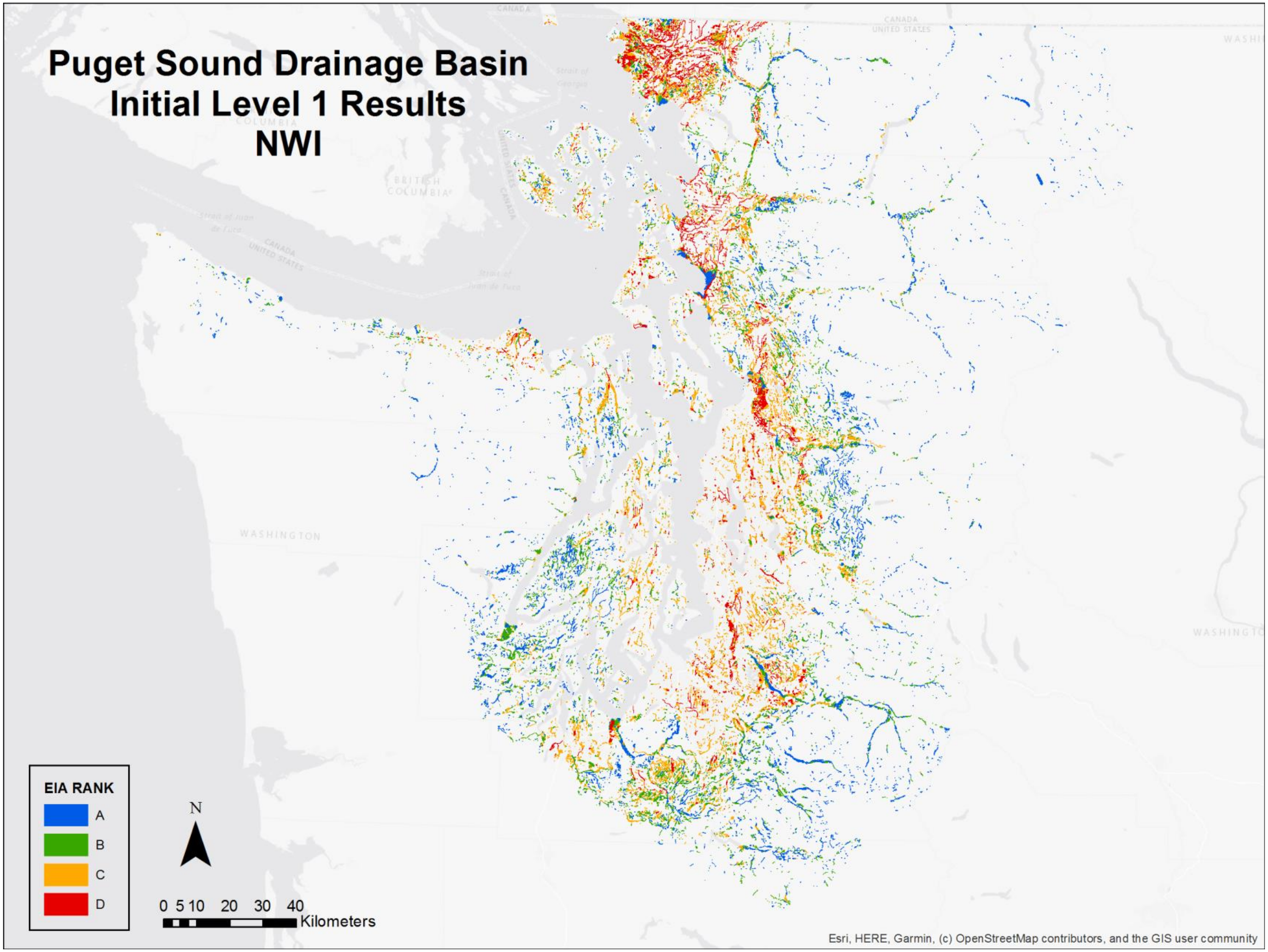

Figure A-2. Initial draft Level 1 Ecological Integrity Assessment of National Wetland Inventory polygons within the Puget Sound drainage basin. A-Rank = excellent ecological integrity; B-Rank = good ecological integrity; C-Rank = fair ecological integrity; and D-Rank = poor ecological integrity.

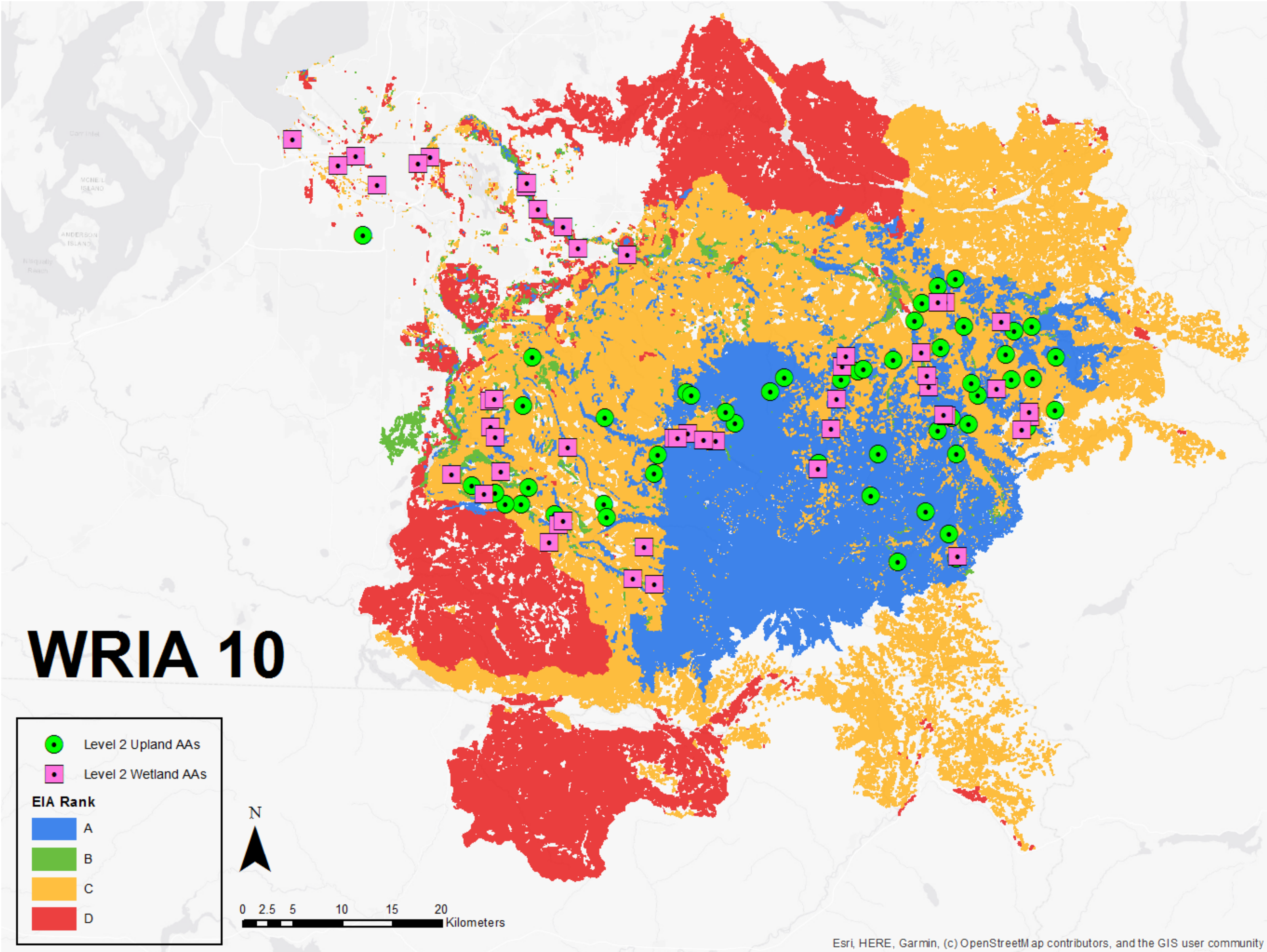

Figure A-3. Level 2 upland and NWI AAs completed June - September of 2021 in WRIA 10. A-Rank = excellent ecological integrity; B-Rank = good ecological integrity; C-Rank = fair ecological integrity; and D-Rank = poor ecological integrity .

Appendix B: Creating Assessment Areas for the Level 1 EIA Model

This appendix outlines the methods extracting assessment areas from the GAP/LANDFIRE NVC Groups raster using ESRI ArcGIS software (ESRI, 2018) and python scripting. This method was adapted from a procedure used by DNR Forest Resources Division's Forest Inventory workgroup for identifying old-growth forest patches.

Patch Delineation

We ran the 'Set Null' tool on the NVC raster to exclude non-target Groups from our analyses. These Groups represented cultural or ruderal vegetation, or Groups erroneously mapped in Washington. We wanted pixels of the same Macrogroup that touched only at the corners to be considered part of the same feature, so we ran 'Region Group' with 8 neighbors instead of 4, a zone connectivity of 'within', and included the 'link' field. The link field ties the zone Group value back to the original raster value. Next, this region-grouped raster was converted to polygons based on the grid code (raster value) without the default ESRI smoothing option enabled. These polygons were then dissolved on the grid code value, with multipart polygons enabled, to blend the vectorized 'adjacent pixels' into the same feature. Then, the raster attribute table was joined back into this feature class by using the 'link' field from the region Group output. Lastly, this joined feature class of region-grouped polygonised pixels was exported to a new feature class to preserve the joined raster attributes.

These polygons were then smoothed to fill holes and narrow the breaks between pixelated patches. Smoothing started by buffering all features by 132 ft (2 chains) and then buffering the resulting features by -132 ft. Figure B- 1 and Figure B-2 present a graphical example of how the method begins to smooth out the sharp corners produced by polygonised pixels. To remove small/narrow features and narrow portions of features, this process was repeated using -25 ft and 25 ft buffers.

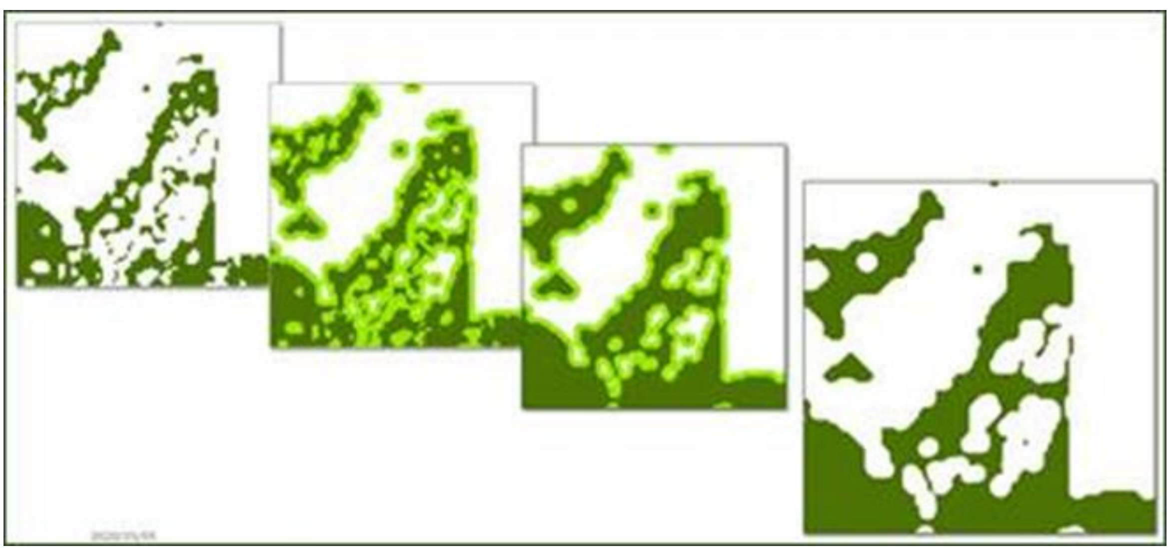

Figure B- 1 Step one of NVC AA polygon smoothing procedure.

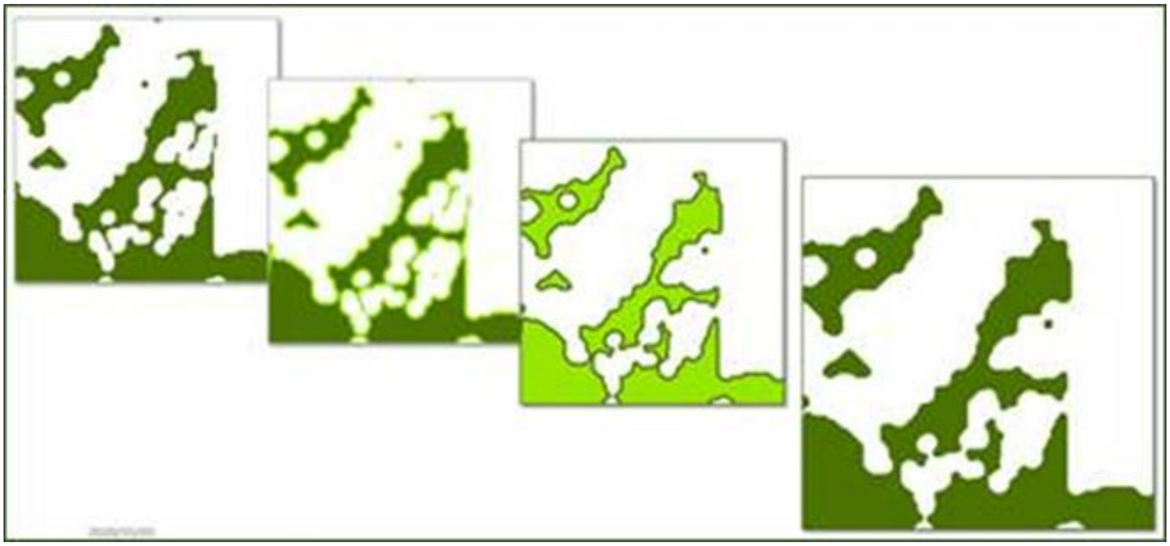

Figure B-2. Step two of NVC AA polygon smoothing procedure.

These steps were repeated for all 31 target NVC Macrogroups, resulting in many patches that overlapped with one another. These overlaps were rectified in the next section.

Separating and Defining AAs

To separate overlapping AAs produced by the patch-finding procedure, we first split the AAs into subsets based on their spatial pattern type: Linear, Very Small, Small, Medium-Small, Large, and Matrix. Additionally, there was a large "barren" subset, representing high elevation unvegetated land cover. Each subset was then 'Unioned' with itself to identify overlapping features of the same spatial pattern type. Overlaps were then eliminated by identifying the larger of the overlapping features (using a calculated Hectares field) and then erasing the overlapping portion of the larger feature with the following Python code (the with statement needs to be run twice):

```
shapes = {}

with arcpy.da.UpdateCursor("UnionLayer",["SHAPE","hectares"]) as
cur:
...     for row in cur:
...         if row[0] not in shapes.keys():
...             shapes[row[0]] = row[1]
...         else:
...             if row[1] > shapes[row[0]]:
...                 cur.deleteRow()
...             else:
...                 shapes[row[0]] = row[1]
```

We then dissolved each subset on every field except ObjectID to consolidate these changes. Next, we wanted to merge all of the different spatial pattern subsets back into one, but without creating any new overlap in the process. Beginning with 'Barren', we erased all of the areas overlapping with the largest spatial pattern type, Matrix. We then merged the resulting layer with the Matrix subset. We repeated this process in order of size, with the Linear subset merged in last, resulting in a layer containing all of the spatial pattern types with no overlapping assessment areas.

Separating Old-Growth Assessment Areas

In Ecological Integrity Assessments, AAs may be split further based on ecological or condition differences within the community. In this fashion, our next step involved separating old-growth forest patches to be assessed as separate AAs (rather than "diluting" them within larger, younger AAs). The same smoothing process described above was applied to GNN old-growth pixels (OGSI200) to generate "old-growth patches" for use in separating and defining AAs. Because this layer was derived from 2012 GNN data, we used DNR forest practices harvest data to erase timber sale boundaries occurring since 2012. We also erased areas that had burned since 2012 based on the Washington Large Fires 1973-2020 data set, with the assumption that the preponderance of these fires were stand-replacing.

We began separating these old-growth AAs by adding a new "OG" field to the merged spatial pattern type layer (resulting from the previous section) and then splitting it into a "not forest" layer and a "forest" layer. For the not-forest layer, we set the OG field equal to zero. Next, we created a 'Union' of the forest layer with the old-growth-patches layer. From that union, we found all features where the forest layer's ID was less than zero and deleted them, as these were artifacts from the old-growth smoothing that did not overlap with our forest AAs. After that, we identified the AAs that needed to be split between old-growth and non-old-growth with the following Python code:

```
AAs_that_do_Not_Need_To_Be_Split_OIDs = []
with arcpy.da.SearchCursor("_FOREST_OG_UNION",
['FID__FOREST','FID_OGSI200_patches']) as cur:
    for row in cur:
        if row[1] != -1: # if OGSIpatch is here
            if row[0] in AAs_that_do_Not_Need_To_Be_Split_OIDs:
                # this needs splitting, remove from list
                AAs_that_do_Not_Need_To_Be_Split_OIDs.remove(row[0])
            else:
                continue
        else: # below is where OGSIpatch does not exist
            if row[0] in AAs_that_do_Not_Need_To_Be_Split_OIDs:
                continue # no need to add this AA twice to the list
            else:
                AAs_that_do_Not_Need_To_Be_Split_OIDs.append(row[0])
with arcpy.da.UpdateCursor('_FOREST_OG_UNION','FID__FOREST') as cur:
    for row in cur:
        if row[0] in AAs_that_do_Not_Need_To_Be_Split_OIDs:
            cur.deleteRow()
```

The next step was to convert the union layer to single-part polygons, recalculate hectarage, and determine which patches would be reduced beyond the minimum AA size for their spatial pattern type. We only wanted to split old-growth and non-old-growth patches if the resulting AAs were not too small. To that end, we used the following Python snippet to generate layers of AAs that would be too small after splitting and another layer of AAs that would be sufficiently large after splitting:

```
newPatchesTooSmall = []
with arcpy.da.SearchCursor('__FOREST_OG_union_ToSinglePart',
["FID__FOREST","tooSmall"]) as cur:
    for row in cur:
        if row[1] == 1:
            if row[0] not in newPatchesTooSmall:
                newPatchesTooSmall.append(row[0])
arcpy.management.SelectLayerByAttribute('_FOREST_OG_union_ToSing
lePart', 'NEW_SELECTION',"FID__FOREST IN
{0}".format(str(tuple(newPatchesTooSmall) ) ) )
#export this to a new feature class
arcpy.management.SelectLayerByAttribute('_FOREST_OG_union_ToSing
lePart', 'SWITCH_SELECTION')
#export this to a new feature class
```

With those in hand, we then split the "new patches would be too small" layer into old-growth and not-old-growth sublayers that had a "merge" field to help us determine which features to merge via a dissolve. The intent here was to take these too-small patches and merge them first with old-growth patches that fully enclosed them, and secondarily with adjacent patches that were adjacent, as long as the resulting new patch did not become < 80% old-growth. We then iterated through the "too small old-growth" feature class to find features that were encompassed versus adjacent features. Warning, this script takes many days to complete when processing a statewide data set:

```
mergedObjectIDs = []
objectIDsToMerge = {}
with arcpy.da.UpdateCursor('_tooSmallPatches_OG',
["OBJECTID","Shape_Area","SHAPE@","merge","FID_FOREST"]) as
ucur:
    for urow in ucur:
        AllowableNonOGArea = urow[1]/4.0 # OG can be 80%, so
total area over 4 would be the max 20% non-OG area
        MergableObjectIDs = []
        OnePercent = AllowableNonOGArea/20 # will use this to
attempt to prevent perpetual looping

arcpy.management.SelectLayerByAttribute('_tooSmallPatches_notOG'
,'CLEAR_SELECTION')

arcpy.management.SelectLayerByLocation('_tooSmallPatches_notOG',
"WITHIN", urow[2])

arcpy.management.SelectLayerByAttribute('_tooSmallPatches_notOG'
,'SUBSET_SELECTION',"FID__FOREST = {0}".format(str(urow[4])))
        if
int(arcpy.management.GetCount('_tooSmallPatches_notOG')[0]) >0:
#if there are any enclosed features
```

```
            with
arcpy.da.SearchCursor('_5d_tooSmallPatches_notOG',["OBJECTID","S
hape_Area"],sql_clause=(None,"ORDER BY Shape_Area DESC")) as
cur:
                for row in cur:
                    if row[1] <= AllowableNonOGArea and row[0]
not in mergedObjectIDs:
                        AllowableNonOGArea -= row[1]
                        MergableObjectIDs.append(row[0])
                        mergedObjectIDs.append(row[0])
                    if AllowableNonOGArea <= OnePercent:
                        break

arcpy.management.SelectLayerByAttribute('_tooSmallPatches_notOG'
,'CLEAR_SELECTION')

arcpy.management.SelectLayerByLocation('_tooSmallPatches_notOG',
'BOUNDARY_TOUCHES', urow[2])

arcpy.management.SelectLayerByAttribute('_tooSmallPatches_notOG'
,'SUBSET_SELECTION',"FID__5b_FOREST = {0}".format(str(urow[4])))
        if
int(arcpy.management.GetCount('_tooSmallPatches_notOG')[0]) >0:
# if there are any adjacent features
            with arcpy.da.SearchCursor('_tooSmallPatches_notOG',
["OBJECTID","Shape_Area"], sql_clause=(None,"ORDER BY Shape_Area
DESC")) as cur:
                for row in cur:
                    if row[1] <= AllowableNonOGArea and row[0]
not in mergedObjectIDs:
                        AllowableNonOGArea -= row[1]
                        MergableObjectIDs.append(row[0])
                        mergedObjectIDs.append(row[0])
                    if AllowableNonOGArea<= OnePercent:
                        break
        if MergableObjectIDs != []:
            for i_d in MergableObjectIDs:
                objectIDsToMerge[i_d] = ucur[0]

            urow[3] = urow[0] # make this obID mergable with
similar

            ucur.updateRow(urow)

## # CLEAR ALL SELECTIONS then Update Non-OG layer
arcpy.management.SelectLayerByAttribute('_tooSmallPatches_notOG'
, 'CLEAR_SELECTION')
```

```
arcpy.management.SelectLayerByAttribute('_tooSmallPatches_OG',
'CLEAR_SELECTION')
with
arcpy.da.UpdateCursor('_tooSmallPatches_notOG',["OBJECTID","merg
e"]) as cur:
    for row in cur:
        if row[0] in objectIDsToMerge:
            row[1] = objectIDsToMerge[row[0]]
            cur.updateRow(row)
```

The old-growth and non-old-growth "too small" feature classes were then merged back together, keeping all assessment area fields, the merge field, the unpopulated OG field, and the remnant FID_OGSI200 field. We then iterated through the merged feature class, populating the OG field if it was an old-growth patch or if the merge field had a value, having verified above via FID__FOREST and with OBJECTIDs that these matched:

```
with arcpy.da.UpdateCursor('_smallPatches_OGandNotOG_merged',
["FID_OGSI200_patchesFinal","merge","OG"]) as cur:
    for row in cur:
        if row[0]>-1 or row[1] is not None:
            row[2] = 1
        else:
            row[2] = 0
        cur.updateRow(row)
```

After that, the "tooSmall" field and the "hectares" fields from this merged data set were reset to zero to help with dissolving everything back together. Then we dissolved the merged feature class from above on all of the assessment area fields as well as the merge field and OG field, though the FID__OGSI and FID__FOREST fields were abandoned at this point, ensuring that the dissolve did not create multipart features. Next, we returned to the feature class where OG-split feature classes were sufficiently large, and populated the OG field based on the FID__OGSI field.

```
with
arcpy.da.UpdateCursor('_NewPatches_AOK',["FID_OGSI200_patches","
OG"]) as cur:
    for row in cur:
        if row[0] > -1:
            row[1] = 1
        else:
            row[1] = 0
        cur.updateRow(row)
```

We zeroed out the "tooSmall" field and the "hectares" fields from the "new patches are sufficiently large" feature class in case some features became newly dissolvable following the upcoming merge. Next, we merged the "new patches sufficiently large" with the merged & dissolved formerly-too-small feature class, keeping all assessment area fields and the OG field, but dropping the legacy FID and "merge" fields. The merge output was then dissolved, once more, on all of the assessment area fields and the OG field.

To ensure our AAs with a Matrix spatial pattern type did not become impracticably massive, we divided these by HUC 10 watershed. A Matrix subset layer was intersected with HUC 10 watersheds from the National Watershed Boundary Data Set (https://www.usgs.gov/national-hydrography/watershed-boundary-dataset), and then the Hectares field was recalculated. We also wanted to avoid producing artificially *small* split polygons as a result of the watershed intersection, so we used the following Python snippet to identify all of the features < 5000 ha and vice versa:

```
patchesLessThan5000_obIDsToDeleteFromIntersect = []
patches5000andUp_FIDs_toDeleteFromDissolvedUnion_tomakeroom = []
with
arcpy.da.SearchCursor('UnionDissolved_IntersectedWithHUC10s',["O
BJECTID","FID__UnionDissolved","hectares"]) as cur:
    for row in cur:
        if row[2] < 5000:

patchesLessThan5000_obIDsToDeleteFromIntersect.append(row[0])
        else:
            if row[1] not in
patches5000andUp_FIDs_toDeleteFromDissolvedUnion_tomakeroom:

patches5000andUp_FIDs_toDeleteFromDissolvedUnion_tomakeroom.appe
nd(row[1])
```

Having generated those lists, we removed any "less than 5000 hectares" features from the HUC 10 intersected AA layer and also removed any features from the dissolved Matrix data set (the layer that was used to intersect the watersheds) with patches greater than 5000ha. After removing those features, we merged the dissolved Matrix layer (with the HUC 10-intersected data set to result in a final Matrix spatial pattern type layer with large patches broken up by watershed.

Lastly, we merged the final Matrix layer with the remaining spatial pattern types, merged forest and non-forest polygons into the same layer, recalculated the hectarage, and screened out any AAs that were too small for their spatial pattern type.

Appendix C: Level 1 Metrics and Weighting

Table C-1. Level 1 Metrics.

<table>
<tr><th>Landscape</th><th>NWI</th><th>NVC</th><th>Apply To</th><th>Calculation</th><th>Score Range</th></tr>
<tr><td>M1 - Landscape Connectivity</td><td colspan="2">% Natural Land Cover w/i 500m. In a Level 2 EIA (LAN1), this would need to be contiguous natural land cover. In this case, because of the coarseness of the data, we simply weighted natural land cover closer to the AA higher than on the edge of the landscape buffer. This metric is the same as in the previous Level 1.</td><td>0-500m buffers</td><td>= (0.5(%NLC 50m buffer))+(0.3(%NLC 50-250m))+(0.2(%NLC 250-500m buffer))</td><td>0 to 1.0</td></tr>
<tr><td>M2 - Landscape Land Use</td><td colspan="2">Mean Land Use Score (LU) between 50-500 meters of the AA. This metric is the same as in the previous Level 1.</td><td>50-500m buffers</td><td>= (0.65(Avg. LU 50-250m))+(0.35(Avg. LU 250-500m)</td><td>0 to 1.0</td></tr>
<tr><td rowspan="2">M5 - Landscape Structure</td><td colspan="2">This metric asks, “If 25% of the area w/i 50-500m is forested, what proportion of that forested area is mature and/or old-growth? GNN (OGSI80, OGSI200) pixels that fall within logged/disturbed/ otherwise developed land use classes in the composite land use layer were removed.</td><td rowspan="2">50-500m buffers</td><td rowspan="2">= IF > 80% of 50-500m buffer is OG, score = 1, else 0.5*(% of forest that is OGSI80 but not OGSI200 w/i 50-500m) + % of forest that is OGSI200 w/i 50-500m.

If the else calculation is used the maximum value should be 0.8</td><td rowspan="2">0 to 1.0</td></tr>
<tr><td>Only include in the roll-up if the metric would increase the overall score of the AA AND the 25% threshold is cleared.</td><td>If the “Include M5M7 If Raises Score” field == "no", include this metric in the roll-up calculation as long as a minimum of 25% of the 50-500m buffer area is forested. If “Include M5M7 If Raises Score” == "yes", only included in the roll-up if the metric would increase the overall score of the AA AND the 25% threshold is cleared.</td></tr>
</table>

<table>
<tr><td>M6 - Landscape Hydrology</td><td>This metric asks, “Does the area w/in the 50-500m buffer overlap with an NWI polygon with an ‘artificially flooded’ water regime OR non-natural special modifiers (partly drained/ditched, managed, or diked/impounded) OR overlaps with non-natural NHD feature (Dam/Weir, Gate, Lock Chamber, Reservoir, Canal/Ditch, Flume, Levee).”</td><td>Wetland Groups only, otherwise same as NWI.</td><td>50-500m buffers</td><td>= 0 if any of these criteria are met</td><td>0 or 1</td></tr>
<tr><td>Buffer</td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
<tr><td>M4 - Buffer Land Use</td><td colspan="2">Land use score (LU) w/i 50m buffer of the AA. This metric is the same as in the previous Level 1.</td><td>0-50m buffer</td><td>= Avg. LU w/i 50m</td><td>0 to 1.0</td></tr>
<tr><td rowspan="2">M7 - Buffer Structure</td><td colspan="2">This metric asks, “If 25% of the area w/i 50m buffer is forested, what proportion of that forested area is mature and/or old-growth?” GNN (OGSI80, OGSI200) pixels that fall within logged/disturbed/ otherwise developed land use classes in the composite land use layer were removed.</td><td rowspan="2">0-50m buffer</td><td rowspan="2">= IF > 80% of 50m buffer is OG, score = 1, else 0.5*(% of forest that is OGSI80 but not OGSI200 w/i 50m) + % of forest that is OGSI200 w/i 50m.

If the else calculation is used the maximum value should be 0.8</td><td rowspan="2">0 to 1.0</td></tr>
<tr><td>Only include in the roll-up if the metric would increase the overall score of the AA AND the 25% threshold is cleared.</td><td>If the “Include M5M7 If Raises Score” field == "no", then include this metric in the roll-up calculation as long as a minimum of 25% of the 0-50m buffer area is forested. If “Include M5M7 If Raises Score” == "yes", only included in the roll-up if the metric would increase the overall score of the AA AND the 25% threshold is cleared.</td></tr>
</table>

<table>
<tr><td>M8 - Buffer Hydrology</td><td>This metric asks, “Does the area w/i 50m buffer overlap with an NWI polygon with an ‘artificially flooded’ water regime OR non-natural special modifiers (partly drained/ditched, managed, or diked/impounded) OR overlaps with non-natural NHD feature (Dam/Weir, Gate, Lock Chamber, Reservoir, Canal/Ditch, Flume, Levee).”</td><td>Wetland Groups only, otherwise same as NWI.</td><td>0-50m buffer</td><td>= 0 if any of these criteria are met w/i the 50m buffer</td><td>0 or 1</td></tr>
<tr><td>CONDITION</td><td colspan="2">*Condition metrics apply to the INSIDE of the AA, not the buffered area</td><td colspan="2"></td><td></td></tr>
<tr><td>Vegetation</td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
<tr><td rowspan="2">M9 - Forest Structure</td><td colspan="2">This metric asks, “If this is a forested NVC Group or forested NWI polygon, what proportion of that forested area is mature and/or old-growth?” GNN (OGSI80, OGSI200) pixels that fall within logged/disturbed/ otherwise developed land use classes in the composite land use layer were removed.</td><td rowspan="2">Forest AAs</td><td rowspan="2">= 1 if OG polygon or if >80% of AA is OGSI200

else 0.5*(% of AA that is OGSI80 but not OGSI200) + % of AA that is OGSI200

If the else calculation is used, the maximum value should be 0.8</td><td rowspan="2">0 to 1.0</td></tr>
<tr><td>Only include in the roll-up if the metric would increase the overall score of the AA.</td><td>If the “Include M5M7 If Raises Score” field == "no", then include this metric in the roll-up calculation for forested Groups. If the “Include M5M7 If Raises Score” field == "yes", only include in the roll-up if the metric would increase the overall score of the AA.</td></tr>
<tr><td>Hydrology</td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
</table>

M10 - Hydrology	This metric asks, "Does the AA have an 'artificially flooded' water regime OR non-natural special modifiers (partly drained/ditched, managed, or diked/impounded) OR does the AA contain a non-natural NHD feature (Dam/Weir, Gate, Lock Chamber, Reservoir, Canal/Ditch, Flume, Levee)."	Applied to wetland Groups only. This metric asks, "Does the AA overlap with NWI polygons that have an 'artificially flooded' water regime OR non-natural special modifiers (partly drained/ditched, managed, or diked/impounded) OR does the AA contain a non-natural NHD feature (Dam/Weir, Gate, Lock Chamber, Reservoir, Canal/Ditch, Flume, Levee)."	NWI AAs	= 0 if any of these criteria are met w/i the AA	0 **or** 1
Soil					
M11 - Soil Disturbance	This metric asks, "Does the AA have one of the following special modifiers: partly drained/ditched, farmed, artificial substrate, spoil, or excavated."	Applied to wetland Groups only. This metric asks, "Does the AA overlap with NWI polygons that have one of the following special modifiers: partly drained/ditched, farmed, artificial substrate, spoil, or excavated."	AA	= 0 if any of these criteria are met w/i the AA	0 **or** 1
Fire					
M12 - Recent Fire	n/a	Applied to Intermountain Mesic Tall Sagebrush Steppe & Shrubland (G302) + Intermountain Mountain Big Sagebrush Steppe & Shrubland (G304) only. % of the AA that does not overlap with a major fire since 2016. Fires before 2016 (LANDFIRE date) are presumably accounted for in the landcover mapping, because LANDFIRE tends to map burned shrub-steppe as grassland.	Shrub-Steppe AAs	= proportion of area unburned	0 to 1.0
SIZE					
M13 - Comparative Size	Size of the patch relative to spatial pattern type (Table C-2).		AA	Varies by spatial pattern type.	-0.5 to 0.5

Table C-2. Wetland Ecosystem Comparative Size Metric Rating: Area by Spatial Pattern of Type.

Metric Rating	***COMPARATIVE SIZE BY PATCH TYPE (hectares)***					
Spatial Pattern Type	**Large Patch (ha)** No large patch wetlands are known to occur in Washington.	**Medium-Small Patch (ha)** (salt marsh, intertidal)	**Small Patch (ha)** (forested/shrub swamp, greasewood flat; marsh/meadow, peatland, aquatic bed, playa, interdunal, mudflat, and eelgrass)	**Very Small Patch (m^2)** (seep/spring, horizontal wet sparse, vernal pool)	**Very Small Patch (m)** (vertical wet sparse)	**Linear (length in km)** (riparian)
EXCELLENT (A)	> 125	> 50	> 10	> 300 m^2	> 20 m high	> 5 km
GOOD (B)	25-125	10-50	2-10	200-300 m^2	10-20 m high	1-5 km
FAIR (C)	5-25	2-10	0.5-2	100-200 m^2	5-10 m high	0.1-1 km
POOR (D)	< 5	< 2	0.5	< 100 m^2	< 5 m high	< 0.1 km

Table C-3. Upland Ecosystem Comparative Size Metric Rating: Area by Spatial Pattern of Type.

Metric Rating	***COMPARATIVE SIZE BY PATCH TYPE (hectares)***		
Spatial Pattern Type	**Matrix (ha)**	**Large Patch (ha)**	**Small Patch (ha)**
EXCELLENT (A)	> 5,000	> 125	> 10
GOOD (B)	500-5,000	25-125	2-10
FAIR (C)	100-500	5-25	0.5-2
POOR (D)	< 100	< 5	0.5

Table C-4. Land Use Coefficients.

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
n/a	G221	Rocky Mountain Subalpine-Montane Limber Pine - Bristlecone Pine Woodland	1	1	0	Mapping error, this type not in WA, but considered natural landcover where it is mapped
n/a	G301	Intermountain Dwarf Saltbush - Sagebrush Scrub	1	1	0	Mapping error, this type not in WA, but considered natural landcover where it is mapped
9327	G510	Interior West Ruderal Riparian Forest & Scrub	1	0.5	0	
9329	G524	Western North American Ruderal Marsh, Wet Meadow & Shrubland	1	0.5	0	
9829	G524	Western North American Ruderal Marsh, Wet Meadow & Shrubland	1	0.5	0	
n/a	G215	Middle Rocky Mountain Montane Douglas-fir Forest & Woodland	1	1	0	Range of this group is debated, but considered natural landcover where it is mapped

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
n/a	G596	Mesic Longleaf Pine Flatwoods - Spodosol Woodland	1	1	0	Mapping error, this type not in WA, but considered natural landcover where it is mapped
9307	G600	Great Basin & Intermountain Ruderal Dry Shrubland & Grassland	1	0.5	0	
9308	G600	Great Basin & Intermountain Ruderal Dry Shrubland & Grassland	1	0.5	0	
9309	G600	Great Basin & Intermountain Ruderal Dry Shrubland & Grassland	1	0.5	0	
9336	G600	Great Basin & Intermountain Ruderal Dry Shrubland & Grassland	1	0.5	0	
9328	G624	Interior Western North American Ruderal Grassland & Shrubland	1	0.5	0	
9828	G624	Interior Western North American Ruderal Grassland & Shrubland	1	0.5	0	

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
9311	G647	North Pacific Maritime Coastal Ruderal Dune	1	0.5	0	
9811	G647	North Pacific Maritime Coastal Ruderal Dune	1	0.5	0	
9326	G648	Southern Vancouverian Lowland Ruderal Grassland & Shrubland	1	0.5	0	
9826	G648	Southern Vancouverian Lowland Ruderal Grassland & Shrubland	1	0.5	0	
6731	G797	Western Interior Riparian Forest & Woodland	1	1	0	Mapping error, this type not in WA, but considered natural landcover where it is mapped
7295	n/a	Quarries-Strip Mines-Gravel Pits-Energy Development	0	0	0	
n/a	n/a	Developed & Urban	0	0	90	
7298	n/a	Developed-High Intensity	0	0	90	
7296	n/a	Developed-Low Intensity	0	0.1	37	
7297	n/a	Developed-Medium Intensity	0	0	64.5	
7299	n/a	Developed-Roads	0	0	100	
n/a	n/a	Introduced & Semi Natural Vegetation	1	0.5	0	

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
7292	n/a	Open Water	1	1	0	
7191	n/a	Recently Disturbed or Modified	1	0.3	0	
4307	n/a	Great Basin & Intermountain Ruderal Dry Shrubland & Grassland - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor
7900	n/a	Temperate Tree Developed Vegetation	0	0.2	0	
7962	n/a	Tropical & Temperate Bush Fruit & Berry	0	0.4	0	
4308	n/a	Great Basin & Intermountain Ruderal Dry Shrubland & Grassland - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor
4309	n/a	Great Basin & Intermountain Ruderal Dry Shrubland & Grassland - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor
7964	n/a	Tropical & Temperate Corn Crop	0	0.2	0	
7960	n/a	Tropical & Temperate Fruit Orchard	0	0.4	0	
7961	n/a	Tropical & Temperate Grape Vineyard	0	0.4	0	

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
7966	n/a	Tropical & Temperate Open Fallow Field	0	0.7	0	
7967	n/a	Tropical & Temperate Permanent Pasture & Hay Field	0	0.4	0	
7192	n/a	Recently Disturbed or Modified	1	0.5	0	
7193	n/a	Recently Disturbed or Modified	1	0.7	0	
7195	n/a	Recently Disturbed or Modified	1	0.5	0	
7196	n/a	Recently Disturbed or Modified	1	0.5	0	
7197	n/a	Recently Disturbed or Modified	1	0.5	0	
7198	n/a	Recently Disturbed or Modified	1	0.5	0	
7199	n/a	Recently Disturbed or Modified	1	0.5	0	
7200	n/a	Recently Disturbed or Modified	1	0.5	0	
4336	n/a	Great Basin & Intermountain Ruderal Dry Shrubland & Grassland - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
7903	n/a	Temperate Shrub & Herb Developed Vegetation	0	0.2	0	
7904	n/a	Temperate Shrub & Herb Developed Vegetation	0	0.5	0	
7901	n/a	Temperate Tree Developed Vegetation	0	0.5	0	
7902	n/a	Temperate Tree Developed Vegetation	0	0.5	0	
7920	n/a	Temperate Tree Developed Vegetation	1	0.2	0	
7921	n/a	Temperate Tree Developed Vegetation	1	0.2	0	
7922	n/a	Temperate Tree Developed Vegetation	1	0.2	0	
7923	n/a	Temperate Tree Developed Vegetation	1	0.2	0	
7924	n/a	Temperate Tree Developed Vegetation	1	0.2	0	
7941	n/a	Temperate Tree Developed Vegetation	1	0.2	0	
7942	n/a	Temperate Tree Developed Vegetation	1	0.2	0	
7943	n/a	Temperate Shrub & Herb Developed Vegetation	1	0.2	0	

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
7944	n/a	Temperate Shrub & Herb Developed Vegetation	1	0.2	0	
11	n/a	Developed-High Intensity-HRCD	0	0	100	HRCD-derived data where % impervious is 80-100% (same as LANDFIRE's Developed-High Intensity criteria). For practical purposes, this is just 100% (HRCD imperviousness is 0, 25, 50, 75, or 100, no in-betweens)
12	n/a	Developed-Low Intensity-HRCD	0	0.1	25	HRCD-derived data where % impervious is 20-49% (same as LANDFIRE's "Developed-Low" criteria). For practical purposes, this is just 25% (HRCD imperviousness is 0, 25, 50, 75, or 100, no in-betweens)
13	n/a	Developed-Medium Intensity-HRCD	0	0	62.5	HRCD-derived data where % impervious is 50-79% (same as LANDFIRE's Developed - Medium intensity criteria). For practical purposes, this is 50% and 75% (HRCD imperviousness is 0, 25, 50, 75, or 100, no in-betweens)
14	n/a	Developed-Roads-other	0	0	90	DNR + WSDOT roads 'burned' into land use raster
15	n/a	Recently Disturbed or Modified-HRCD Low	0	0.2	0	HRCD-derived data where % semi impervious is 20-49% (same as LANDFIRE's Developed-Low Intensity criteria). For practical purposes, this is just 25% (HRCD imperviousness is 0, 25, 50, 75, or 100, no in-betweens)
16	n/a	Recently Disturbed or Modified-HRCD Medium	0	0.1	0	HRCD-derived data where % semi impervious is 50-79% (same as LANDFIRE's Developed-Medium Intensity criteria). For practical purposes, this is 50% and 75% (HRCD imperviousness is 0, 25, 50, 75, or 100, no in-betweens)

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
17	n/a	Recently Disturbed or Modified-HRCD High	0	0.1	0	HRCD-derived data where % semi impervious is 80-100% (same as LANDFIRE's Developed-High Intensity criteria). For practical purposes, this is just 100% (HRCD imperviousness is 0, 25, 50, 75, or 100, no in-betweens)
18	n/a	Recently Logged - HRCD	1	0.5	0	HRCD-derived data where % tree cover decrease is 50% or greater (same threshold as LANDFIRE's Recently Logged-Tree Cover {page350 in PDF of map unit descriptions})
19	n/a	Recently Logged - DNR	1	0.7	0	DNR land logged (but not clearcut) since Fall 2016
20	n/a	Recently Clearcut-DNR	1	0.3	0	DNR land clearcut since Fall 2016
21	n/a	Developed-High Intensity-CCAP	0	0	90	Land use derived from additional CCAP data
22	n/a	Developed-Medium Intensity-CCAP	0	0	64.5	Land use derived from additional CCAP data
23	n/a	Developed-Low Intensity-CCAP	0	0.1	37	Land use derived from additional CCAP data
1002	n/a	Rocky Mountain Subalpine Dry-Mesic Spruce - Fir Forest & Woodland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1003	n/a	Northern Rocky Mountain Whitebark Pine - Subalpine Larch Woodland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1004	n/a	North Pacific Maritime Douglas-fir - Western	1	0.9	0	Intersection of existing land use class and powerline corridor

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
		Hemlock Rainforest - BPA corridor				
1005	n/a	Intermountain Basins Curl-leaf Mountain-mahogany Woodland & Scrub - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1006	n/a	Intermountain Mesic Tall Sagebrush Steppe & Shrubland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1007	n/a	North Pacific Maritime Dune & Coastal Beach - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1008	n/a	North Pacific Montane Riparian Woodland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1009	n/a	North-Central Pacific Lowland Riparian Forest - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1010	n/a	Cascadian Oregon White Oak - Conifer Forest & Woodland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1011	n/a	Developed-High Intensity-HRCD - BPA corridor	0	0	100	Intersection of existing land use class and powerline corridor

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
1012	n/a	Developed-Low Intensity-HRCD - BPA corridor	0	0	25	Intersection of existing land use class and powerline corridor
1013	n/a	Developed-Medium Intensity-HRCD - BPA corridor	0	0	62.5	Intersection of existing land use class and powerline corridor
1014	n/a	Developed-Roads-other - BPA corridor	0	0	90	Intersection of existing land use class and powerline corridor
1015	n/a	Recently Disturbed or Modified-HRCD Low - BPA corridor	0	0.1	0	Intersection of existing land use class and powerline corridor
1016	n/a	Recently Disturbed or Modified-HRCD Medium - BPA corridor	0	0	0	Intersection of existing land use class and powerline corridor
1017	n/a	Recently Disturbed or Modified-HRCD High - BPA corridor	0	0	0	Intersection of existing land use class and powerline corridor
1018	n/a	Recently Logged - HRCD - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor
1019	n/a	Recently Logged - DNR - BPA corridor	1	0.6	0	Intersection of existing land use class and powerline corridor
1020	n/a	Recently Clearcut-DNR - BPA corridor	1	0.2	0	
1021	n/a	Developed-High Intensity-CCAP - BPA corridor	0	0	90	Intersection of existing land use class and powerline corridor

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
1022	n/a	Developed-Medium Intensity-CCAP - BPA corridor	0	0	64.5	Intersection of existing land use class and powerline corridor
1023	n/a	Developed-Low Intensity-CCAP - BPA corridor	0	0	37	Intersection of existing land use class and powerline corridor
1059	n/a	Central Rocky Mountain Douglas-fir - Pine Forest - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1060	n/a	Central Rocky Mountain Ponderosa Pine Open Woodland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1064	n/a	Central Rocky Mountain Interior Western Red-cedar - Western Hemlock Forest - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1065	n/a	Central Rocky Mountain Mesic Grand Fir - Douglas-fir Forest - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1069	n/a	Rocky Mountain Lodgepole Pine Forest & Woodland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
1071	n/a	Rocky Mountain Subalpine Moist Spruce - Fir Forest & Woodland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1072	n/a	Rocky Mountain Subalpine-Montane Aspen Forest & Woodland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1080	n/a	Columbia Plateau Western Juniper Open Woodland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1088	n/a	East Cascades Mesic Grand Fir - Douglas-fir Forest - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1090	n/a	North-Central Pacific Maritime Silver Fir - Western Hemlock Rainforest - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1091	n/a	North Pacific Red Alder - Bigleaf Maple - Douglas-fir Rainforest - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1092	n/a	North-Central Pacific Western Hemlock -	1	0.9	0	Intersection of existing land use class and powerline corridor

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
		Sitka Spruce Rainforest - BPA corridor				
1094	n/a	North-Central Pacific Mountain Hemlock - Silver Fir Woodland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1117	n/a	Rocky Mountain-Great Basin Montane Riparian & Swamp Forest - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1118	n/a	Rocky Mountain-Great Basin Swamp Forest - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1144	n/a	Central Rocky Mountain-North Pacific High Montane Mesic Shrubland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1145	n/a	Central Rocky Mountain Lower Montane, Foothill & Valley Grassland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1146	n/a	Central Rocky Mountain Montane Grassland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
1147	n/a	Central Rocky Mountain Montane-Foothill Deciduous Shrubland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1149	n/a	Rocky Mountain-North Pacific Subalpine-Montane Mesic Grassland & Meadow - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1154	n/a	Southern Vancouverian Shrub & Herbaceous Bald, Bluff & Prairie - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1181	n/a	Western North American Montane Sclerophyll Scrub - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1239	n/a	Western Montane-Subalpine Riparian & Seep Shrubland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1240	n/a	Vancouverian-Rocky Mountain Montane Wet Meadow & Marsh - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
1242	n/a	Arid West Interior Freshwater Marsh - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1243	n/a	Rocky Mountain-Great Basin Lowland-Foothill Riparian Shrubland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1245	n/a	Vancouverian Freshwater Wet Meadow & Marsh - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1246	n/a	Vancouverian Wet Shrubland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1257	n/a	Temperate Pacific Salt Marsh - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1259	n/a	North American Desert Alkaline-Saline Marsh & Playa - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1281	n/a	Intermountain Semi-Desert Grassland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1282	n/a	Intermountain Semi-Desert Steppe & Shrubland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
1284	n/a	Columbia Plateau Scabland Dwarf-shrubland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1285	n/a	Intermountain Low & Black Sagebrush Steppe & Shrubland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1288	n/a	Intermountain Mountain Big Sagebrush Steppe & Shrubland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1295	n/a	North Pacific Alpine-Subalpine Dwarf-shrubland & Heath - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1296	n/a	North Pacific Alpine-Subalpine Tundra - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1313	n/a	Rocky Mountain Cliff, Scree & Rock Vegetation - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1315	n/a	North Vancouverian Montane Bedrock, Cliff & Talus	1	0.9	0	Intersection of existing land use class and powerline corridor

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
		Vegetation - BPA corridor				
1320	n/a	Intermountain Basins Cliff, Scree & Badland Sparse Vegetation - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1323	n/a	North Pacific Alpine-Subalpine Bedrock & Scree - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1330	n/a	Northern Rocky Mountain Lowland-Foothill Riparian Forest - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1333	n/a	Southern Vancouverian Dry Douglas-fir - Madrone Woodland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1684	n/a	Intermountain Sparsely Vegetated Dune Scrub & Grassland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
1731	n/a	Western Interior Riparian Forest & Woodland - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
2191	n/a	Recently Disturbed or Modified - BPA corridor	1	0.2	0	Intersection of existing land use class and powerline corridor
2192	n/a	Recently Disturbed or Modified - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor
2193	n/a	Recently Disturbed or Modified - BPA corridor	1	0.6	0	Intersection of existing land use class and powerline corridor
2195	n/a	Recently Disturbed or Modified - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor
2196	n/a	Recently Disturbed or Modified - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor
2197	n/a	Recently Disturbed or Modified - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor
2198	n/a	Recently Disturbed or Modified - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor
2199	n/a	Recently Disturbed or Modified - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor
2200	n/a	Recently Disturbed or Modified - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
2292	n/a	Open Water - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
2295	n/a	Quarries-Strip Mines-Gravel Pits-Energy Development - BPA corridor	0	0	0	Intersection of existing land use class and powerline corridor
2296	n/a	Developed-Low Intensity - BPA corridor	0	0	37	Intersection of existing land use class and powerline corridor
2297	n/a	Developed-Medium Intensity - BPA corridor	0	0	64.5	Intersection of existing land use class and powerline corridor
2298	n/a	Developed-High Intensity - BPA corridor	0	0	90	Intersection of existing land use class and powerline corridor
2299	n/a	Developed-Roads - BPA corridor	0	0	90	Intersection of existing land use class and powerline corridor
2735	n/a	Naturally Barren - BPA corridor	1	0.9	0	Intersection of existing land use class and powerline corridor
2900	n/a	Temperate Tree Developed Vegetation - BPA corridor	0	0.1	0	Intersection of existing land use class and powerline corridor
2901	n/a	Temperate Tree Developed Vegetation - BPA corridor	0	0.4	0	Intersection of existing land use class and powerline corridor
2902	n/a	Temperate Tree Developed Vegetation - BPA corridor	0	0.4	0	Intersection of existing land use class and powerline corridor

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
2903	n/a	Temperate Shrub & Herb Developed Vegetation - BPA corridor	0	0.1	0	Intersection of existing land use class and powerline corridor
2904	n/a	Temperate Shrub & Herb Developed Vegetation - BPA corridor	0	0.4	0	Intersection of existing land use class and powerline corridor
2920	n/a	Temperate Tree Developed Vegetation - BPA corridor	1	0.1	0	Intersection of existing land use class and powerline corridor
2921	n/a	Temperate Tree Developed Vegetation - BPA corridor	1	0.1	0	Intersection of existing land use class and powerline corridor
2922	n/a	Temperate Tree Developed Vegetation - BPA corridor	1	0.1	0	Intersection of existing land use class and powerline corridor
2923	n/a	Temperate Tree Developed Vegetation - BPA corridor	1	0.1	0	Intersection of existing land use class and powerline corridor
2924	n/a	Temperate Tree Developed Vegetation - BPA corridor	1	0.1	0	Intersection of existing land use class and powerline corridor
2941	n/a	Temperate Tree Developed Vegetation - BPA corridor	1	0.1	0	Intersection of existing land use class and powerline corridor

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
2942	n/a	Temperate Tree Developed Vegetation - BPA corridor	1	0.1	0	Intersection of existing land use class and powerline corridor
2943	n/a	Temperate Shrub & Herb Developed Vegetation - BPA corridor	1	0.1	0	Intersection of existing land use class and powerline corridor
2944	n/a	Temperate Shrub & Herb Developed Vegetation - BPA corridor	1	0.1	0	Intersection of existing land use class and powerline corridor
2960	n/a	Tropical & Temperate Fruit Orchard - BPA corridor	0	0.3	0	Intersection of existing land use class and powerline corridor
2961	n/a	Tropical & Temperate Grape Vineyard - BPA corridor	0	0.3	0	Intersection of existing land use class and powerline corridor
2962	n/a	Tropical & Temperate Bush Fruit & Berry - BPA corridor	0	0.3	0	Intersection of existing land use class and powerline corridor
7963	n/a	Tropical & Temperate Close Grain Crop	0	0.2	0	
2964	n/a	Tropical & Temperate Corn Crop - BPA corridor	0	0.1	0	Intersection of existing land use class and powerline corridor
7965	n/a	Tropical & Temperate Close Grain Crop	0	0.2	0	

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
2966	n/a	Tropical & Temperate Open Fallow Field - BPA corridor	0	0.6	0	Intersection of existing land use class and powerline corridor
2967	n/a	Tropical & Temperate Permanent Pasture & Hay Field - BPA corridor	0	0.3	0	Intersection of existing land use class and powerline corridor
7968	n/a	Tropical & Temperate Close Grain Crop	0	0.2	0	
2963	n/a	Tropical & Temperate Close Grain Crop - BPA corridor	0	0.1	0	Intersection of existing land use class and powerline corridor
2965	n/a	Tropical & Temperate Close Grain Crop - BPA corridor	0	0.1	0	Intersection of existing land use class and powerline corridor
4326	n/a	Southern Vancouverian Lowland Ruderal Grassland & Shrubland - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor
4327	n/a	Interior West Ruderal Riparian Forest & Scrub - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor
4329	n/a	Western North American Ruderal Marsh, Wet Meadow & Shrubland - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
2968	n/a	Tropical & Temperate Close Grain Crop - BPA corridor	0	0.1	0	Intersection of existing land use class and powerline corridor
4826	n/a	Southern Vancouverian Lowland Ruderal Grassland & Shrubland - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor
4829	n/a	Western North American Ruderal Marsh, Wet Meadow & Shrubland - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor
4311	n/a	North Pacific Maritime Coastal Ruderal Dune - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor
4811	n/a	North Pacific Maritime Coastal Ruderal Dune - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor
4328	n/a	Interior Western North American Ruderal Grassland & Shrubland - BPA corridor	1	0.4	0	Intersection of existing land use class and powerline corridor
4828	n/a	Interior Western North American Ruderal Grassland &	1	0.4	0	Intersection of existing land use class and powerline corridor

Level 1 Raster Value	Group Code	NVC Name / Land Use Name in Level 1 EIA	Natural (1) / Non-Natural (0)	Land Use Coefficient (of Raster Value)	% Impervious	Note
		Shrubland - BPA corridor				

NVC AA Attributes

Any groups/Macrogroups on this table were considered natural vegetation and had land use coefficients of 1.0. This table only has the NVC units that we used as AAs, if/when they were mapped by LANDFIRE. Note that any w/ “n/a” for the raster value were not actually mapped by LANDFIRE and thus did not get turned into AAs. These NVC Groups are current as of hierarchy V2.031

Table C-5. NVC AA attributes.

Level 1 Raster Value	Macrogroup Code	Macrogroup	Group Code	Group	Forest	Wetland	Apply Fire Metric	Spatial Pattern of AA	Minimum Patch Size of AA	Minimum Length of AA	Include only if raises score
2	M020	Rocky Mountain Subalpine-High Montane Forest	G219	Rocky Mountain Subalpine Dry-Mesic Spruce - Fir Forest & Woodland	yes	no	no	Matrix	2	n/a	yes
3	M020	Rocky Mountain Subalpine-High Montane Forest	G223	Northern Rocky Mountain Whitebark Pine - Subalpine Larch Woodland	yes	no	no	Matrix	2	n/a	yes
6069	M020	Rocky Mountain Subalpine-High Montane Forest	G220	Rocky Mountain Lodgepole Pine Forest & Woodland	yes	no	no	Matrix	2	n/a	yes
6071	M020	Rocky Mountain Subalpine-	G218	Rocky Mountain Subalpine Moist Spruce -	yes	no	no	Matrix	2	n/a	yes

Level 1 Raster Value	Macrogroup Code	Macrogroup	Group Code	Group	Forest	Wetland	Apply Fire Metric	Spatial Pattern of AA	Minimum Patch Size of AA	Minimum Length of AA	Include only if raises score
		High Montane Forest		Fir Forest & Woodland							
6072	M020	Rocky Mountain Subalpine-High Montane Forest	G222	Rocky Mountain Subalpine-Montane Aspen Forest & Woodland	yes	no	no	Matrix	2	n/a	yes
4	M024	Vancouverian Coastal Rainforest	G240	North Pacific Maritime Douglas-fir - Western Hemlock Rainforest	yes	no	no	Matrix	2	n/a	no
6090	M024	Vancouverian Coastal Rainforest	G241	North-Central Pacific Maritime Silver Fir - Western Hemlock Rainforest	yes	no	no	Matrix	2	n/a	no
6091	M024	Vancouverian Coastal Rainforest	G237	North Pacific Red Alder - Bigleaf Maple - Douglas-fir Rainforest	yes	no	no	Matrix	2	n/a	no
6092	M024	Vancouverian Coastal Rainforest	G751	North-Central Pacific Western Hemlock -	yes	no	no	Matrix	2	n/a	no

Level 1 Raster Value	Macrogroup Code	Macrogroup	Group Code	Group	Forest	Wetland	Apply Fire Metric	Spatial Pattern of AA	Minimum Patch Size of AA	Minimum Length of AA	Include only if raises score
				Sitka Spruce Rainforest							
6094	M025	Vancouverian Subalpine-High Montane Forest	G849	North-Central Pacific Mountain Hemlock - Silver Fir Woodland	yes	no	no	Matrix	2	n/a	yes
6117	M034	Rocky Mountain-Great Basin Montane Riparian & Swamp Forest	G506	Rocky Mountain-Great Basin Montane Riparian & Swamp Forest	yes	yes	no	Small	0.05	n/a	no
6118	M034	Rocky Mountain-Great Basin Montane Riparian & Swamp Forest	G505	Rocky Mountain-Great Basin Swamp Forest	yes	yes	no	Small	0.05	n/a	no
6330	M034	Rocky Mountain-Great Basin Montane Riparian & Swamp Forest	G796	Northern Rocky Mountain Lowland-Foothill Riparian Forest	yes	yes	no	Small	0.05	n/a	yes
8	M035	Vancouverian Flooded & Swamp Forest	G507	North Pacific Montane	yes	yes	no	Small	0.05	n/a	yes

Level 1 Raster Value	Macrogroup Code	Macrogroup	Group Code	Group	Forest	Wetland	Apply Fire Metric	Spatial Pattern of AA	Minimum Patch Size of AA	Minimum Length of AA	Include only if raises score
				Riparian Woodland							
9	M035	Vancouverian Flooded & Swamp Forest	G851	North-Central Pacific Lowland Riparian Forest	yes	yes	no	Small	0.05	n/a	yes
n/a	M035	Vancouverian Flooded & Swamp Forest	G853	North-Central Pacific Maritime Swamp Forest	yes	yes	no	Small	0.05	n/a	yes
6144	M048	Central Rocky Mountain Montane-Foothill Grassland & Shrubland	G305	Central Rocky Mountain-North Pacific High Montane Mesic Shrubland	no	no	no	Large	0.4	n/a	yes
6145	M048	Central Rocky Mountain Montane-Foothill Grassland & Shrubland	G273	Central Rocky Mountain Lower Montane, Foothill & Valley Grassland	no	no	no	Large	0.4	n/a	yes
6146	M048	Central Rocky Mountain Montane-Foothill Grassland & Shrubland	G267	Central Rocky Mountain Montane Grassland	no	no	no	Large	0.4	n/a	yes

Level 1 Raster Value	Macrogroup Code	Macrogroup	Group Code	Group	Forest	Wetland	Apply Fire Metric	Spatial Pattern of AA	Minimum Patch Size of AA	Minimum Length of AA	Include only if raises score
6147	M048	Central Rocky Mountain Montane-Foothill Grassland & Shrubland	G272	Central Rocky Mountain Montane-Foothill Deciduous Shrubland	no	no	no	Large	0.4	n/a	yes
6154	M050	Southern Vancouverian Lowland Grassland & Shrubland	G488	Southern Vancouverian Shrub & Herbaceous Bald, Bluff & Prairie	no	no	no	Small	0.05	n/a	no
n/a	M058	Pacific Coastal Cliff & Bluff	G554	North Pacific Coastal Cliff & Bluff	no	no	no	Small	0.05	n/a	no
7	M059	Pacific Coastal Beach & Dune	G498	North Pacific Maritime Dune & Coastal Beach	no	no	no	Large	0.4	n/a	yes
n/a	M063	North Pacific Bog & Fen	G284	North Pacific Acidic Open Bog & Fen	no	yes	no	Small	0.05	n/a	no
6245	M073	Vancouverian Lowland Marsh, Wet Meadow & Shrubland	G517	Vancouverian Freshwater Wet Meadow & Marsh	no	yes	no	Small	0.05	n/a	yes
6246	M073	Vancouverian Lowland Marsh, Wet	G322	Vancouverian Wet Shrubland	no	yes	no	Small	0.05	n/a	yes

Level 1 Raster Value	Macrogroup Code	Macrogroup	Group Code	Group	Forest	Wetland	Apply Fire Metric	Spatial Pattern of AA	Minimum Patch Size of AA	Minimum Length of AA	Include only if raises score
		Meadow & Shrubland									
n/a	M073	Vancouverian Lowland Marsh, Wet Meadow & Shrubland	G525	Temperate Pacific Freshwater Wet Mudflat	no	yes	no	Small	0.05	n/a	yes
n/a	M074	Western North American Vernal Pool	G529	Oregon-Washington-British Columbia Vernal Pool	no	yes	no	Very Small	0.005	n/a	no
6257	M081	North American Pacific Coastal Salt Marsh	G499	Temperate Pacific Salt Marsh	no	yes	no	Medium-Small	0.2	n/a	no
6259	M082	Warm & Cool Desert Alkali-Saline Marsh, Playa & Shrubland	G538	North American Desert Alkaline-Saline Marsh & Playa	no	yes	no	Small	0.05	n/a	yes
n/a	M082	Warm & Cool Desert Alkali-Saline Marsh, Playa & Shrubland	G537	North American Desert Alkaline-Saline Wet Scrub	no	yes	no	Small	0.05	n/a	yes
n/a	M093	Great Basin Saltbush Scrub	G300	Intermountain Shadscale - Saltbush Scrub	no	no	no	Linear	n/a	30	yes

Level 1 Raster Value	Macrogroup Code	Macrogroup	Group Code	Group	Forest	Wetland	Apply Fire Metric	Spatial Pattern of AA	Minimum Patch Size of AA	Minimum Length of AA	Include only if raises score
6181	M094	Cool Interior Chaparral	G282	Western North American Montane Sclerophyll Scrub	no	no	no	Small	0.05	n/a	no
n/a	M099	Rocky Mountain-Sierran Alpine Tundra	G314	Rocky Mountain-Sierran Alpine Turf & Fell-field	no	no	no	Large	0.4	n/a	yes
n/a	M099	Rocky Mountain-Sierran Alpine Tundra	G316	Rocky Mountain-Sierran Alpine Dwarf-shrubland & Krummholz	no	no	no	Large	0.4	n/a	yes
n/a	M099	Rocky Mountain-Sierran Alpine Tundra	G571	Rocky Mountain & Sierran Alpine Bedrock & Scree	no	no	no	Large	0.4	n/a	yes
6295	M101	Vancouverian Alpine Tundra	G317	North Pacific Alpine-Subalpine Dwarf-shrubland & Heath	no	no	no	Small	0.05	n/a	yes
6296	M101	Vancouverian Alpine Tundra	G320	North Pacific Alpine-	no	no	no	Small	0.05	n/a	yes

Level 1 Raster Value	Macrogroup Code	Macrogroup	Group Code	Group	Forest	Wetland	Apply Fire Metric	Spatial Pattern of AA	Minimum Patch Size of AA	Minimum Length of AA	Include only if raises score
				Subalpine Tundra							
6323	M101	Vancouverian Alpine Tundra	G319	North Pacific Alpine-Subalpine Bedrock & Scree	no	no	no	Small	0.05	n/a	yes
n/a	M109	Western North American Freshwater Aquatic Vegetation	G544	Western North American Temperate Freshwater Aquatic Vegetation	no	yes	no	Small	0.05	n/a	no
6320	M118	Intermountain Basins Cliff, Scree & Badland Sparse Vegetation	G570	Intermountain Basins Cliff, Scree & Badland Sparse Vegetation	no	no	no	Large	0.4	n/a	yes
6149	M168	Rocky Mountain-Vancouverian Subalpine-High Montane Mesic Meadow	G271	Rocky Mountain-North Pacific Subalpine-Montane Mesic Grassland & Meadow	no	no	no	Large	0.4	n/a	yes
6	M169	Great Basin-Intermountain	G302	Intermountain Mesic Tall	no	no	yes	Matrix	2	n/a	yes

Level 1 Raster Value	Macrogroup Code	Macrogroup	Group Code	Group	Forest	Wetland	Apply Fire Metric	Spatial Pattern of AA	Minimum Patch Size of AA	Minimum Length of AA	Include only if raises score
		Tall Sagebrush Steppe & Shrubland		Sagebrush Steppe & Shrubland							
6288	M169	Great Basin-Intermountain Tall Sagebrush Steppe & Shrubland	G304	Intermountain Mountain Big Sagebrush Steppe & Shrubland	no	no	yes	Small	0.05	n/a	yes
6284	M170	Great Basin-Intermountain Dwarf Sagebrush Steppe & Shrubland	G307	Columbia Plateau Scabland Dwarf-shrubland	no	no	no	Small	0.05	n/a	yes
6285	M170	Great Basin-Intermountain Dwarf Sagebrush Steppe & Shrubland	G308	Intermountain Low & Black Sagebrush Steppe & Shrubland	no	no	no	Small	0.05	n/a	yes
6281	M171	Great Basin-Intermountain Dry Shrubland & Grassland	G311	Intermountain Semi-Desert Grassland	no	no	no	Large	0.4	n/a	yes
6282	M171	Great Basin-Intermountain Dry Shrubland & Grassland	G310	Intermountain Semi-Desert Steppe & Shrubland	no	no	no	Large	0.4	n/a	yes
6684	M171	Great Basin-Intermountain	G775	Intermountain Sparsely	no	no	no	Large	0.4	n/a	yes

Level 1 Raster Value	Macrogroup Code	Macrogroup	Group Code	Group	Forest	Wetland	Apply Fire Metric	Spatial Pattern of AA	Minimum Patch Size of AA	Minimum Length of AA	Include only if raises score
		Dry Shrubland & Grassland		Vegetated Dune Scrub & Grassland							
n/a	M184	Temperate Pacific Seagrass Intertidal Vegetation	G373	Temperate Pacific Seagrass Bed	no	yes	no	Very Small	0.005	n/a	yes
6064	M500	Central Rocky Mountain Mesic Lower Montane Forest	G217	Central Rocky Mountain Interior Western Red-cedar - Western Hemlock Forest	yes	no	no	Matrix	2	n/a	no
6065	M500	Central Rocky Mountain Mesic Lower Montane Forest	G211	Central Rocky Mountain Mesic Grand Fir - Douglas-fir Forest	yes	no	no	Matrix	2	n/a	no
6088	M500	Central Rocky Mountain Mesic Lower Montane Forest	G212	East Cascades Mesic Grand Fir - Douglas-fir Forest	yes	no	no	Matrix	2	n/a	no
6059	M501	Central Rocky Mountain Dry Lower	G210	Central Rocky Mountain Douglas-fir - Pine Forest	yes	no	no	Matrix	2	n/a	no

Level 1 Raster Value	Macrogroup Code	Macrogroup	Group Code	Group	Forest	Wetland	Apply Fire Metric	Spatial Pattern of AA	Minimum Patch Size of AA	Minimum Length of AA	Include only if raises score
		Montane-Foothill Forest									
6060	M501	Central Rocky Mountain Dry Lower Montane-Foothill Forest	G213	Central Rocky Mountain Ponderosa Pine Open Woodland	yes	no	no	Matrix	2	n/a	no
n/a	M876	North American Boreal & Subboreal Bog & Acidic Fen	G515	Rocky Mountain Acidic Fen	no	yes	no	Small	0.05	n/a	no
10	M886	Southern Vancouverian Dry Foothill Forest & Woodland	G206	Cascadian Oregon White Oak - Conifer Forest & Woodland	yes	no	no	Large	0.4	n/a	no
6333	M886	Southern Vancouverian Dry Foothill Forest & Woodland	G800	Southern Vancouverian Dry Douglas-fir - Madrone Woodland	yes	no	no	Large	0.4	n/a	no
6313	M887	Western North American Cliff, Scree & Rock Vegetation	G565	Rocky Mountain Cliff, Scree & Rock Vegetation	no	no	no	Large	0.4	n/a	yes
6315	M887	Western North	G318	North Vancouverian	no	no	no	Large	0.4	n/a	yes

Level 1 Raster Value	Macrogroup Code	Macrogroup	Group Code	Group	Forest	Wetland	Apply Fire Metric	Spatial Pattern of AA	Minimum Patch Size of AA	Minimum Length of AA	Include only if raises score
		American Cliff, Scree & Rock Vegetation		Montane Bedrock, Cliff & Talus Vegetation							
n/a	M887	Western North American Cliff, Scree & Rock Vegetation	G573	Southern Vancouverian Cliff, Scree & Rock Vegetation	no	no	no	Large	0.4	n/a	yes
6242	M888	Arid West Interior Freshwater Marsh	G531	Arid West Interior Freshwater Marsh	no	yes	no	Small	0.05	n/a	yes
6239	M893	Western North American Montane Marsh, Wet Meadow & Shrubland	G527	Western Montane-Subalpine Riparian & Seep Shrubland	no	yes	no	Small	0.05	n/a	yes
6240	M893	Western North American Montane Marsh, Wet Meadow & Shrubland	G521	Vancouverian-Rocky Mountain Montane Wet Meadow & Marsh	no	yes	no	Small	0.05	n/a	yes
6243	M893	Western North	G526	Rocky Mountain-	no	yes	no	Small	0.05	n/a	yes

Level 1 Raster Value	Macrogroup Code	Macrogroup	Group Code	Group	Forest	Wetland	Apply Fire Metric	Spatial Pattern of AA	Minimum Patch Size of AA	Minimum Length of AA	Include only if raises score
		American Montane Marsh, Wet Meadow & Shrubland		Great Basin Lowland-Foothill Riparian Shrubland							
n/a	M893	Western North American Montane Marsh, Wet Meadow & Shrubland	G520	Vancouverian-Rocky Mountain Subalpine-Alpine Snowbed, Wet Meadow & Dwarf-shrubland	no	yes	no	Small	0.05	n/a	yes
5	M896	Intermountain Pinyon - Juniper Woodland	G249	Intermountain Basins Curl-leaf Mountain-mahogany Woodland & Scrub	yes	no	no	Small	0.05	n/a	yes
6080	M896	Intermountain Pinyon - Juniper Woodland	G248	Columbia Plateau Western Juniper Open Woodland	yes	no	no	Large	0.4	n/a	yes
7735	n/a	n/a	n/a	Naturally Barren	no	no	no	n/a	n/a	n/a	yes

Table C-6. Roll-up calculations.

	Nonforested wetlands	**Forested wetlands**	**Nonforested Upland (non-shrub-steppe)**	**Nonforested Upland (shrub-steppe)**	**Forested Upland**
Landscape (LAN)	=MEAN(M1, M2, M5†)*.8 + M6*.2	=MEAN(M1, M2, M5†)*.8 + M6*.2	=MEAN(M1, M2, M5†)	=MEAN(M1, M2, M5†)	=MEAN(M1, M2, M5†)
Buffer (BUF)	=MEAN(M4, M7†)*.8 + M8*.2	=MEAN(M4, M7†)*.8 + M8*.2	=MEAN(M4, M7†)	=MEAN(M4, M7†)	=MEAN(M4, M7†)
LANDSCAPE CONTEXT	=LAN*0.33+BUF*0.67	=LAN*0.33+BUF*0.67	IF Large Patch = MEAN(LAN, BUF) IF Small Patch = LAN*.33+BUF*.67	IF Matrix = LAN*.67 + BUF*.33 IF Small Patch = LAN*.33+BUF*.67	IF Matrix = LAN*.67 + BUF*.33 IF Large Patch = MEAN(LAN, BUF) IF Small Patch = LAN*.33+BUF*.67
Vegetation (VEG)	n/a	=M9†	n/a	n/a	=M9††
Hydrology (HYD)	=M10	=M10	n/a	n/a	n/a
Soil (SOI)	=M11	=M11	n/a	n/a	n/a
Fire (FIR)	n/a	n/a	n/a	=M12	n/a
CONDITION	=MEAN(HYD,SOI)	=.4*VEG†+.3*HYD+.3*SOI **OR** .5*HYD+.5*SOI	n/a	=FIR	=VEG
EIA SCORE	= LANDSCAPE CONTEXT * .6 + CONDITION *.4	= LANDSCAPE CONTEXT * .6 + CONDITION *.4	= LANDSCAPE CONTEXT	= LANDSCAPE CONTEXT * .6 + CONDITION *.4	LANDSCAPE CONTEXT * 0.6 + CONDITION * 0.4 **OR** = LANDSCAPE CONTEXT
EIA RANK	≥ 0.9 = A, ≥ 0.65 and <0.89 = B; ≥ 0.55 and <0.65 = C; <0.55 = D		≥ 0.91 = A, ≥ 0.83 and <0.9 = B; ≥ 0.35 and <0.83 = C; <0.35 = D		
SIZE	M13 A=0.25, B=.08, C= -.08, D= -.25	M13 A=0.25, B=.08, C= -.08, D= -.25	M13 IF Large Patch = A=0.33, B=.11, C= -.11, D= -.33 IF Small Patch = A=0.25, B=.08, C= -.08, D= -.25	M13 IF Matrix = A= .5, B = .17, C = -.17, D = -.5 IF Small Patch = A=0.25, B=.08, C= -.08, D= -.25	M13 IF Matrix = A= .5, B = .17, C = -.17, D = -.5 IF Large Patch = A=0.33, B=.11, C= -.11, D= -.33 IF Small Patch = A=0.25, B=.08, C= -.08, D= -.25
EO RANK SCORE (ROLL-UP)	**= EIA SCORE + SIZE**				

	Nonforested wetlands	Forested wetlands	Nonforested Upland (non-shrub-steppe)	Nonforested Upland (shrub-steppe)	Forested Upland
EO RANK	≥ 0.9 = A, ≥ 0.65 and <0.89 = B; ≥ 0.55 and <0.65 = C; <0.55 = D		≥ 0.91 = A, ≥ 0.83 and <0.9 = B; ≥ 0.35 and <0.83 = C; <0.35 = D		
† = If scored (mini roll-up conditional) **†† = If scored (final roll-up conditional)**					

Appendix D: Updated Level 1 EIA Maps

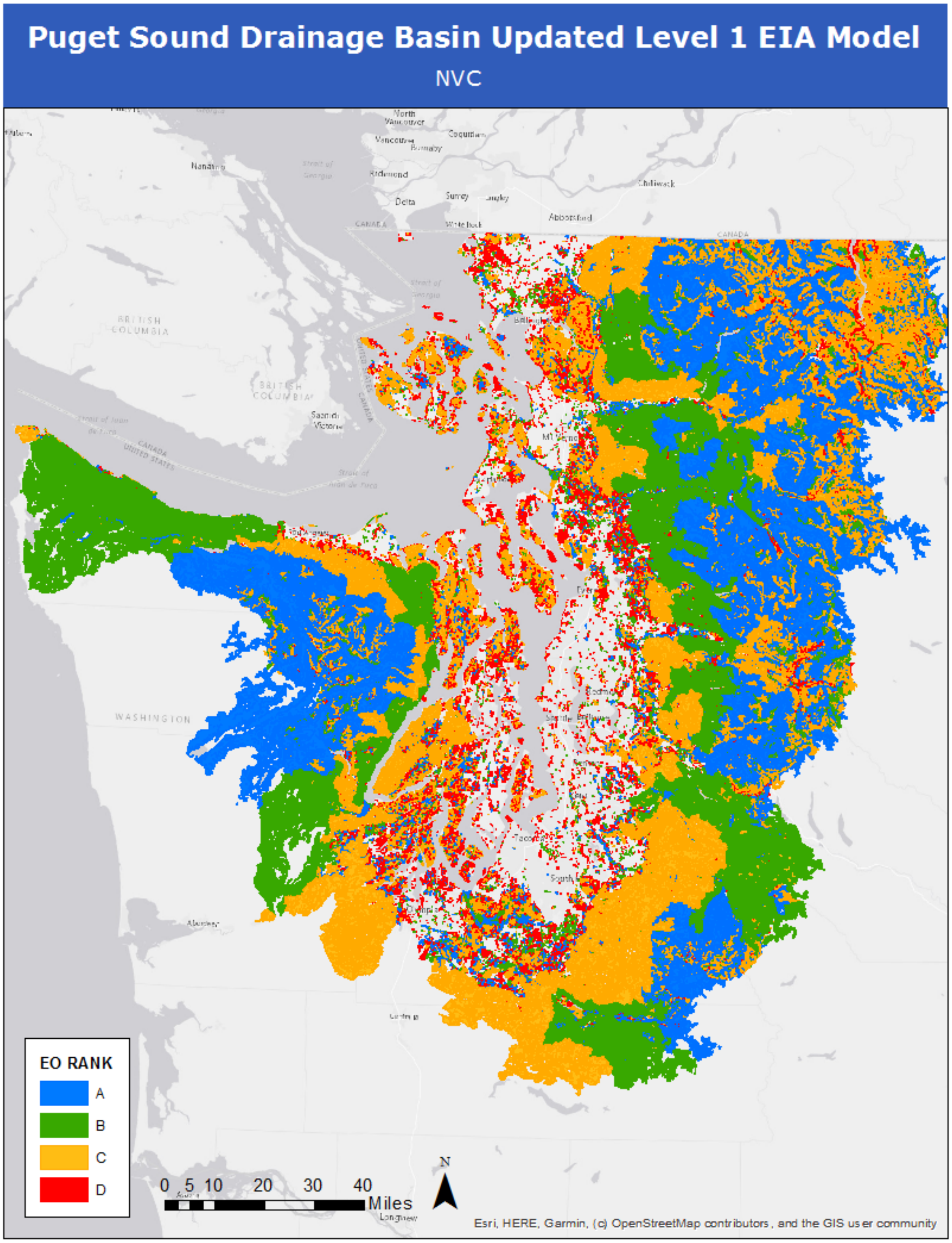

Figure D-1. Updated Level 1 Ecological Integrity Assessment of US National Vegetation Classification polygons within the Puget Sound drainage basin. A-Rank = excellent ecological integrity; B-Rank = good ecological integrity; C-Rank = fair ecological integrity; and D-Rank = poor ecological integrity.

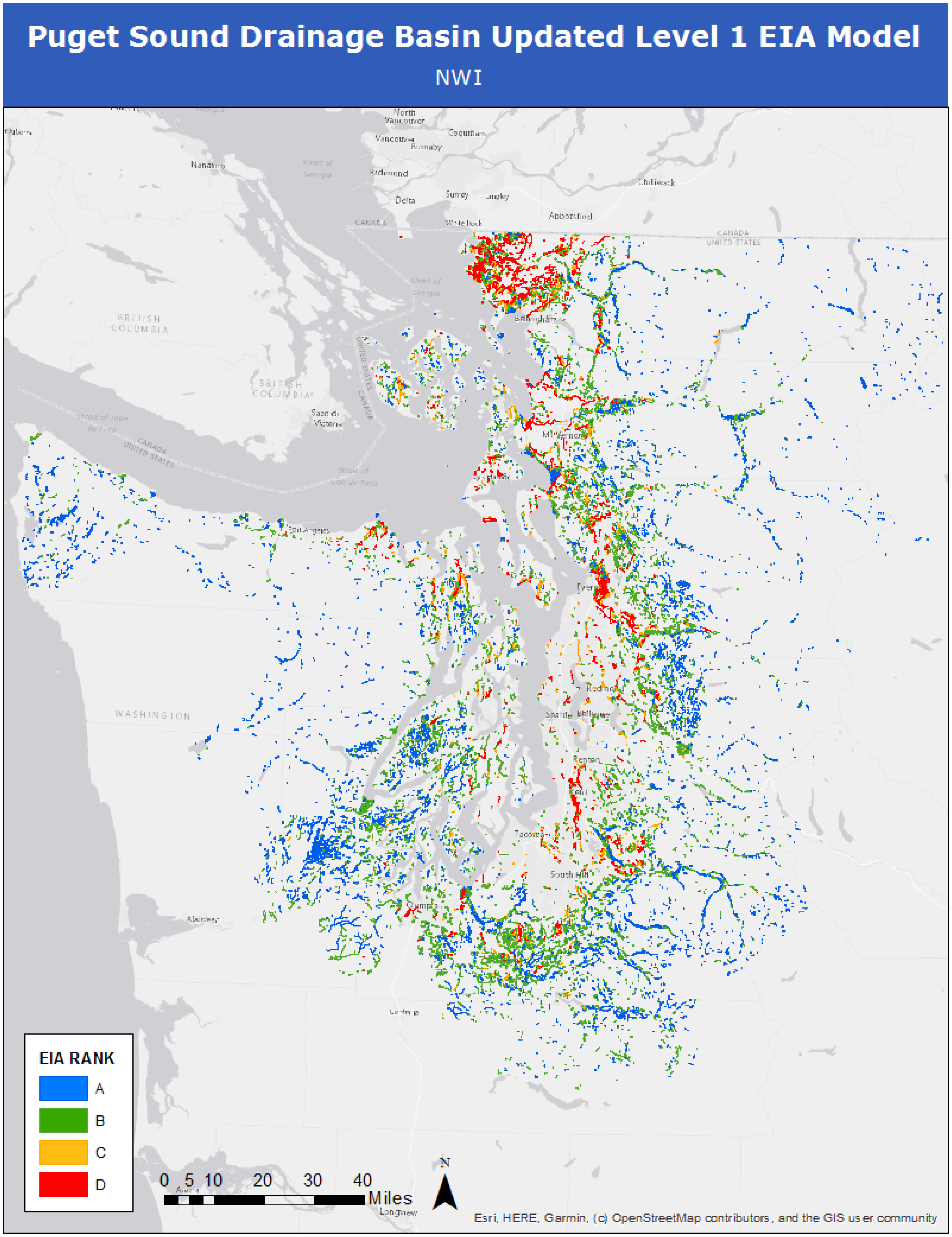

Figure D-2. Level 1 Ecological Integrity Assessment of National Wetland Inventory polygons within the Puget Sound drainage basin. A-Rank = excellent ecological integrity; B-Rank = good ecological integrity; C-Rank = fair ecological integrity; and D-Rank = poor ecological integrity.

Appendix E: Level 1 EIA Metric Correlation with Level 2 EIA Scores

NWI Level 1 EIA Metrics

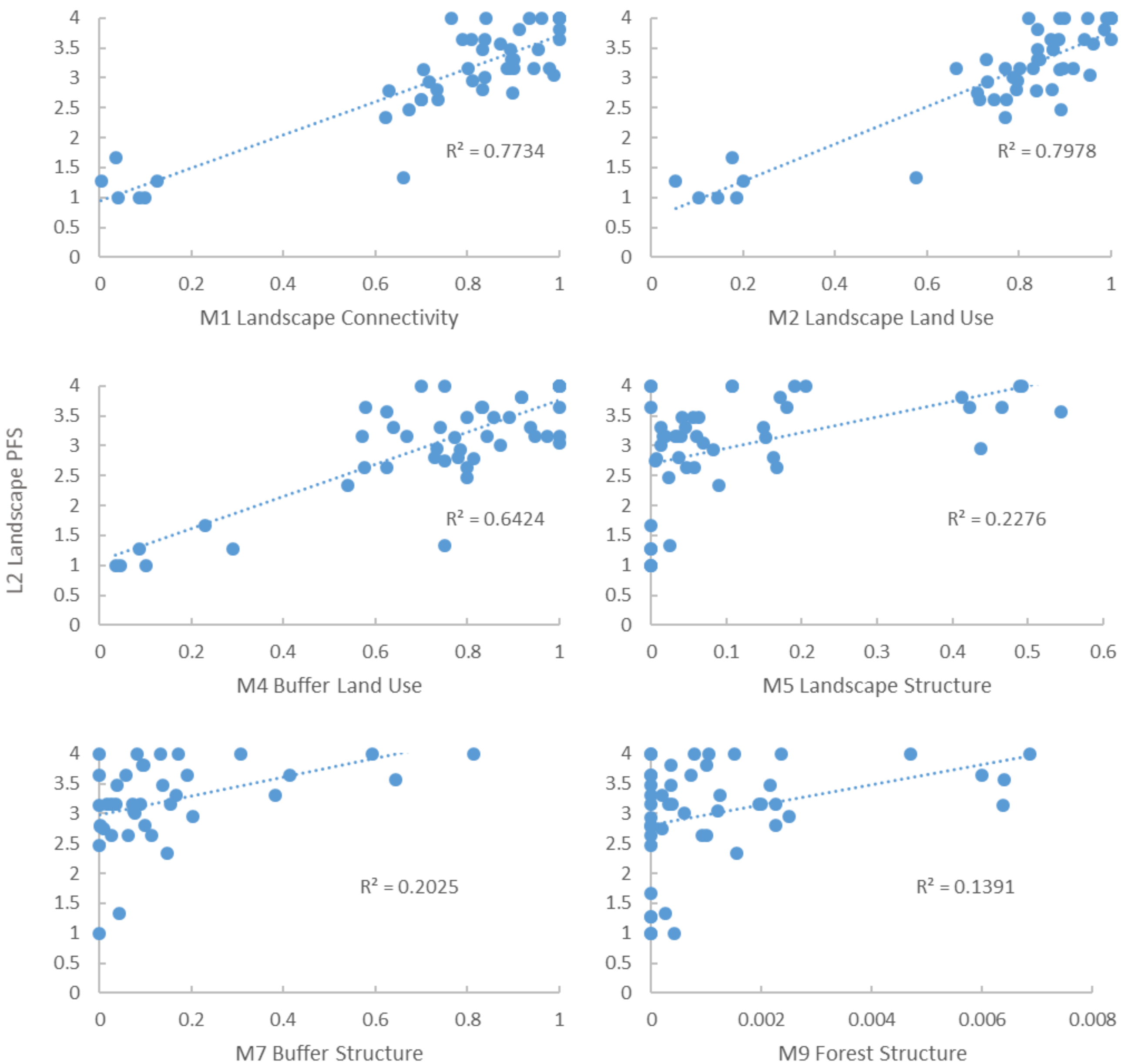

Figure E-1. NWI Level 1 EIA Metrics correlation with Level 2 EIA Landscape score ($p < 0.001$ for all).

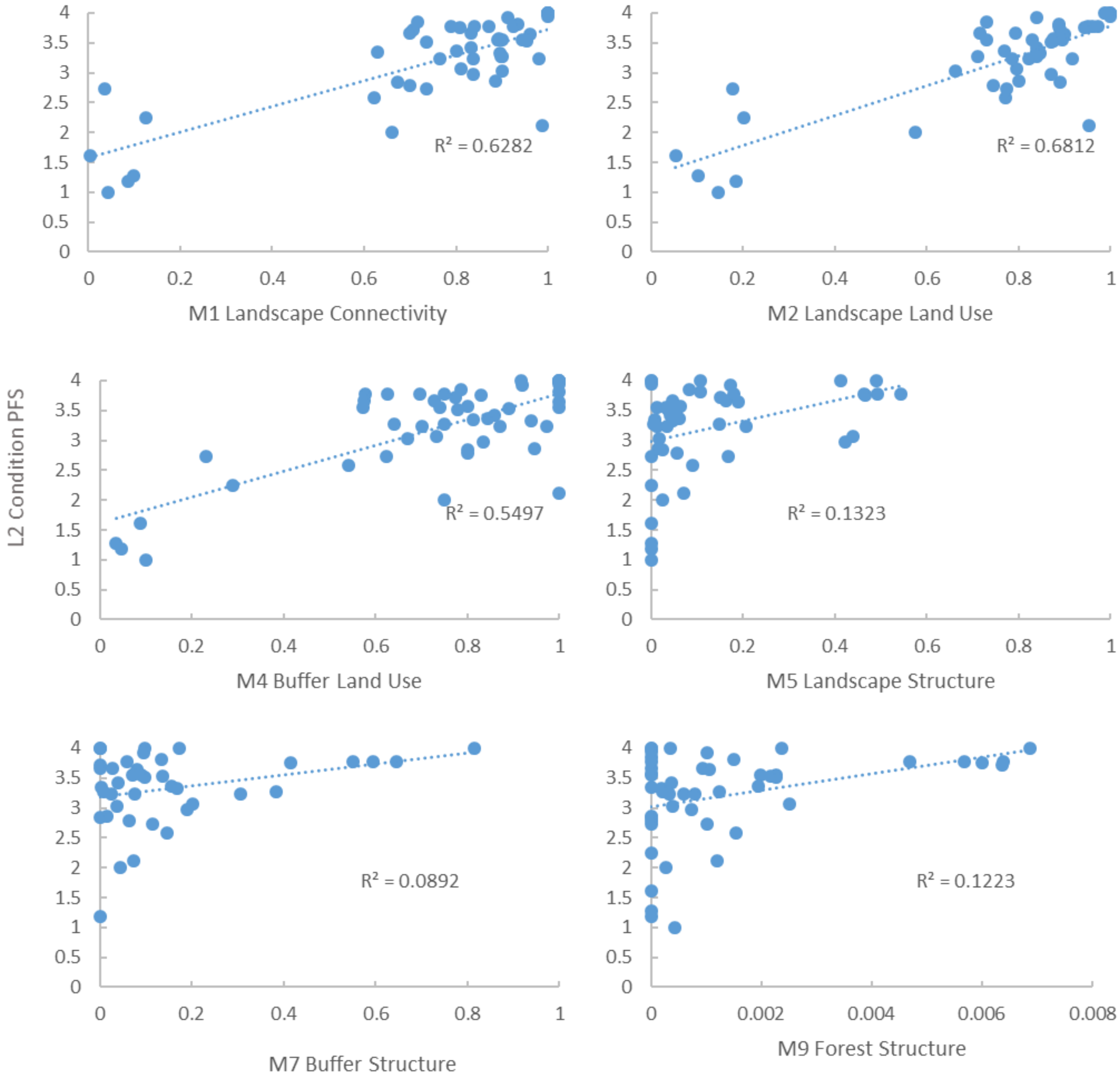

Figure E-2. NWI Level 1 EIA Metrics correlation with Level 2 EIA Condition score ($p < 0.001$ for all).

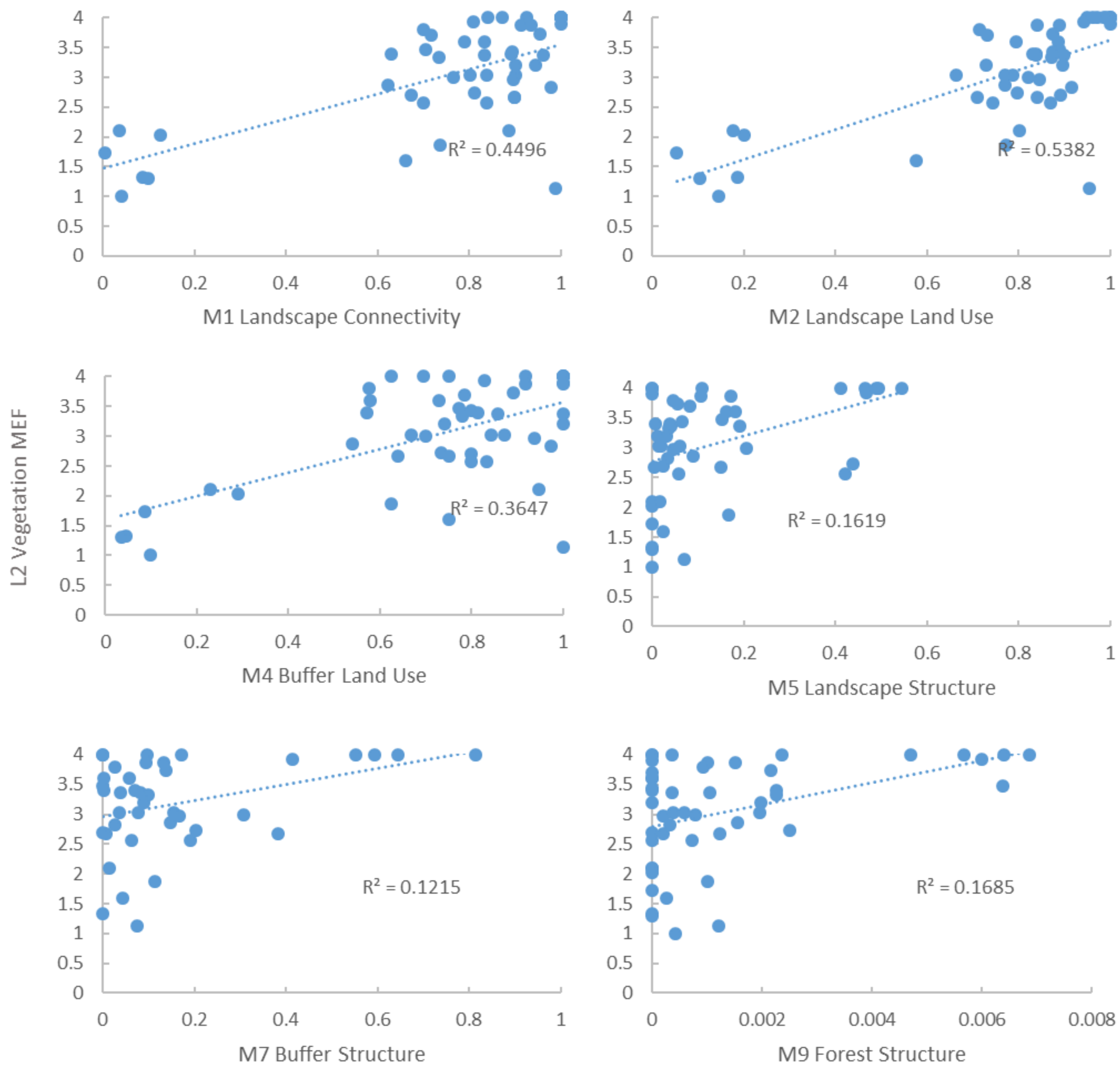

Figure E-3. NWI Level 1 EIA Metrics correlation with Level 2 EIA Vegetation MEF ($p < 0.001$ for all).

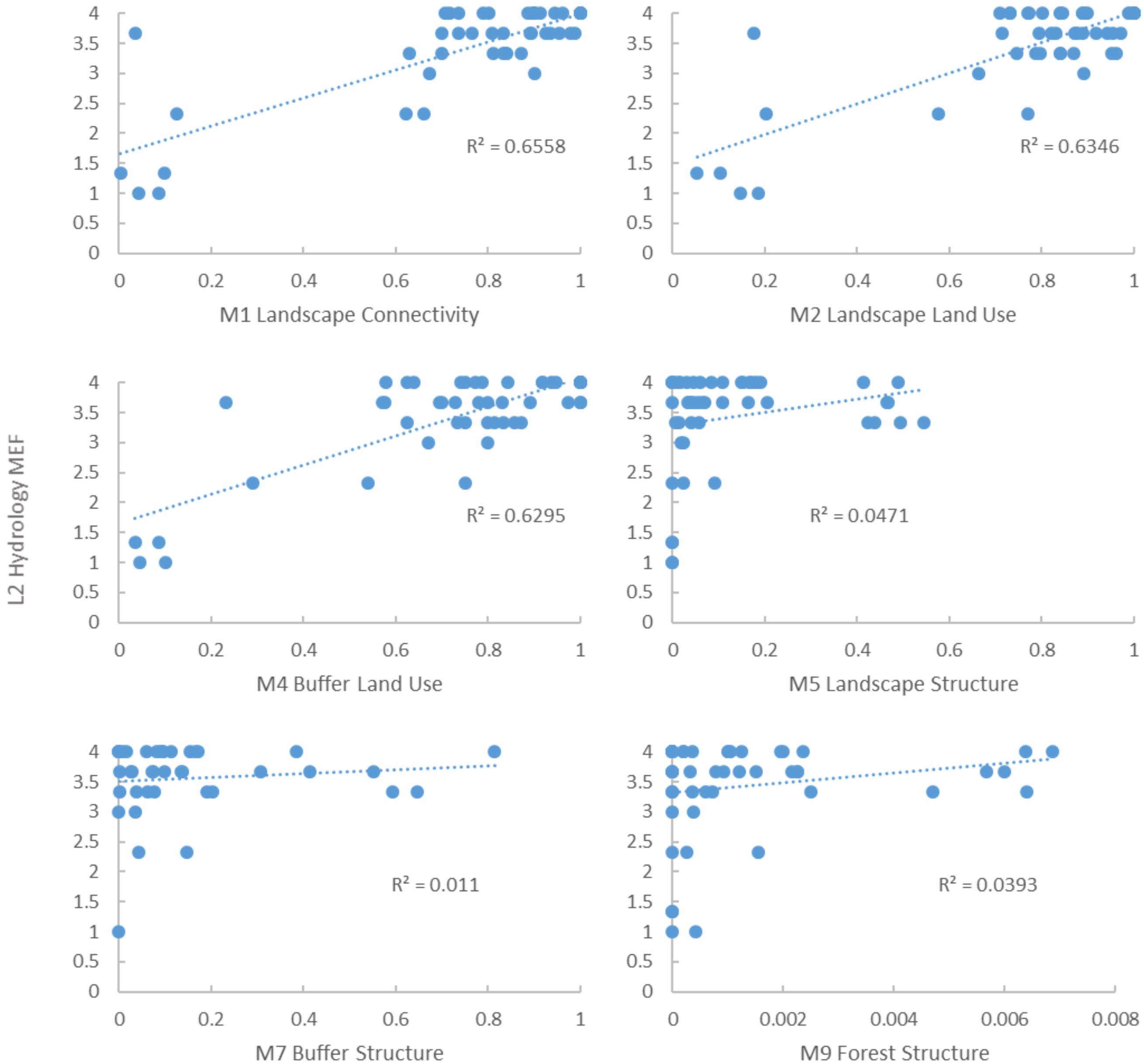

Figure NWI E-4. Level 1 EIA Metrics correlation with Level 2 EIA Hydrology MEF ($p < 0.001$ for all).

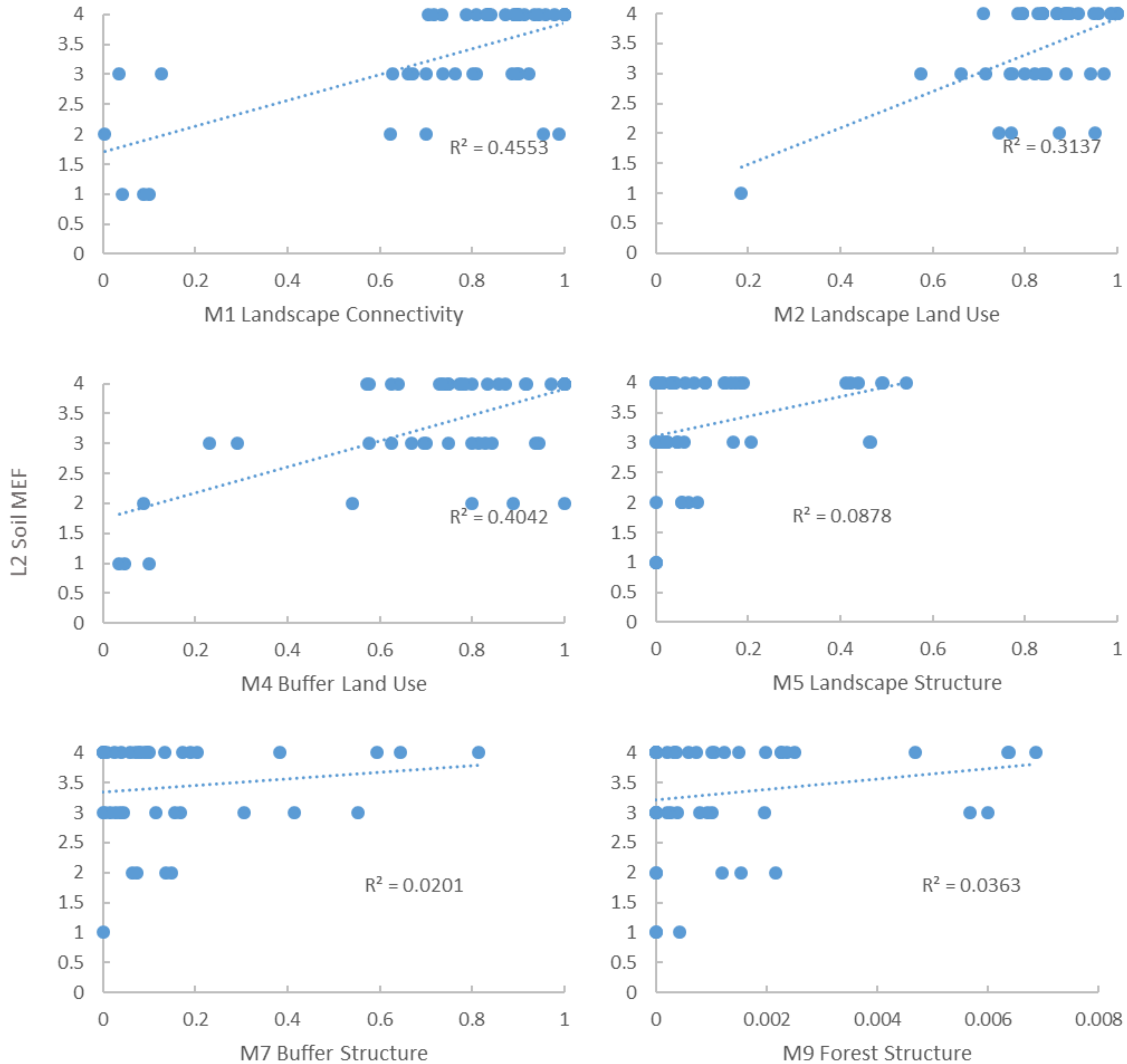

Figure NWI E-5. Level 1 EIA Metrics correlation with Level 2 EIA Soil MEF ($p < 0.001$ for all).

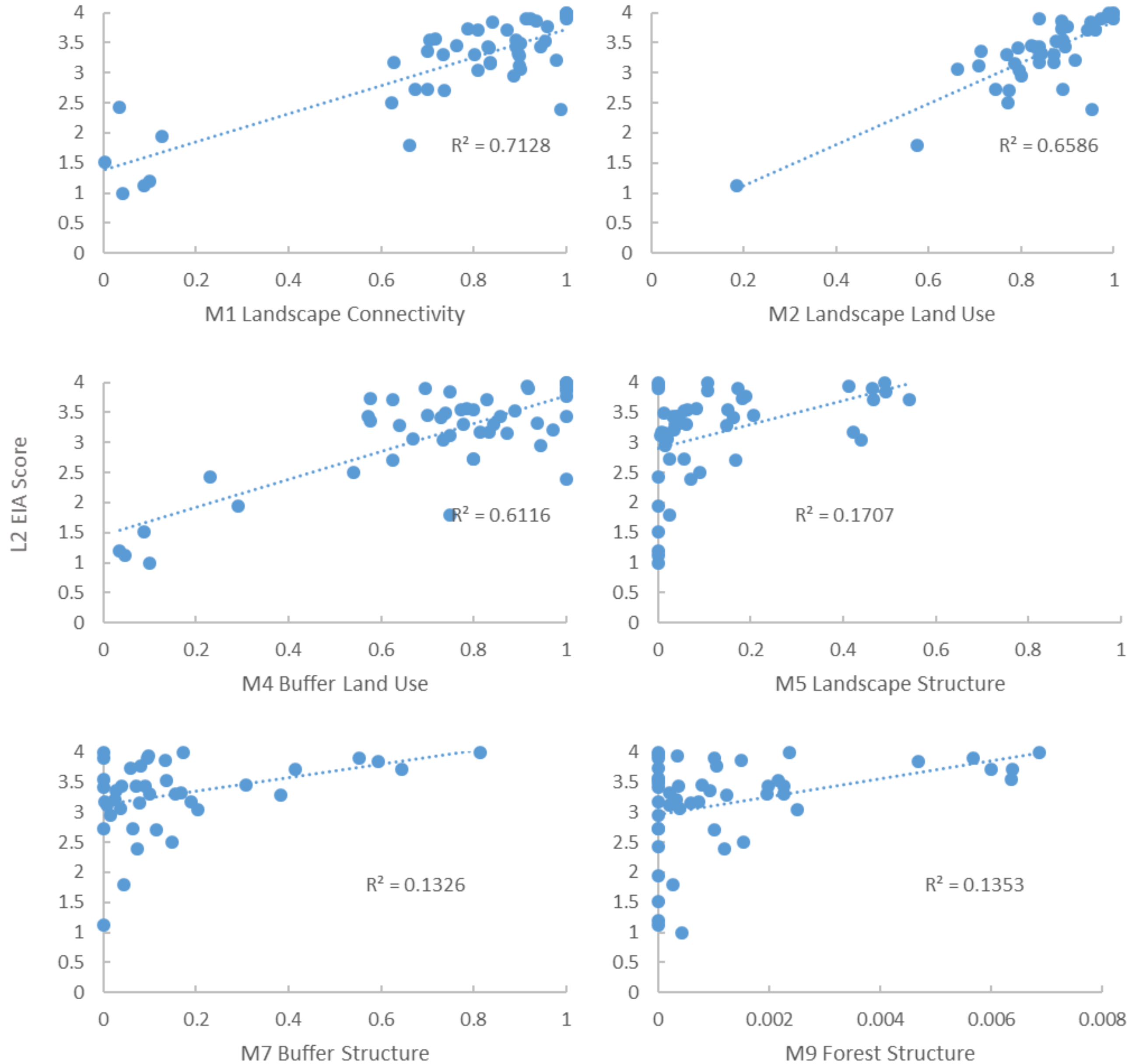

Figure NWI E-6. Level 1 EIA Metrics correlation with Level 2 EIA Score ($p < 0.001$ for all).

NVC Level 1 EIA Metrics

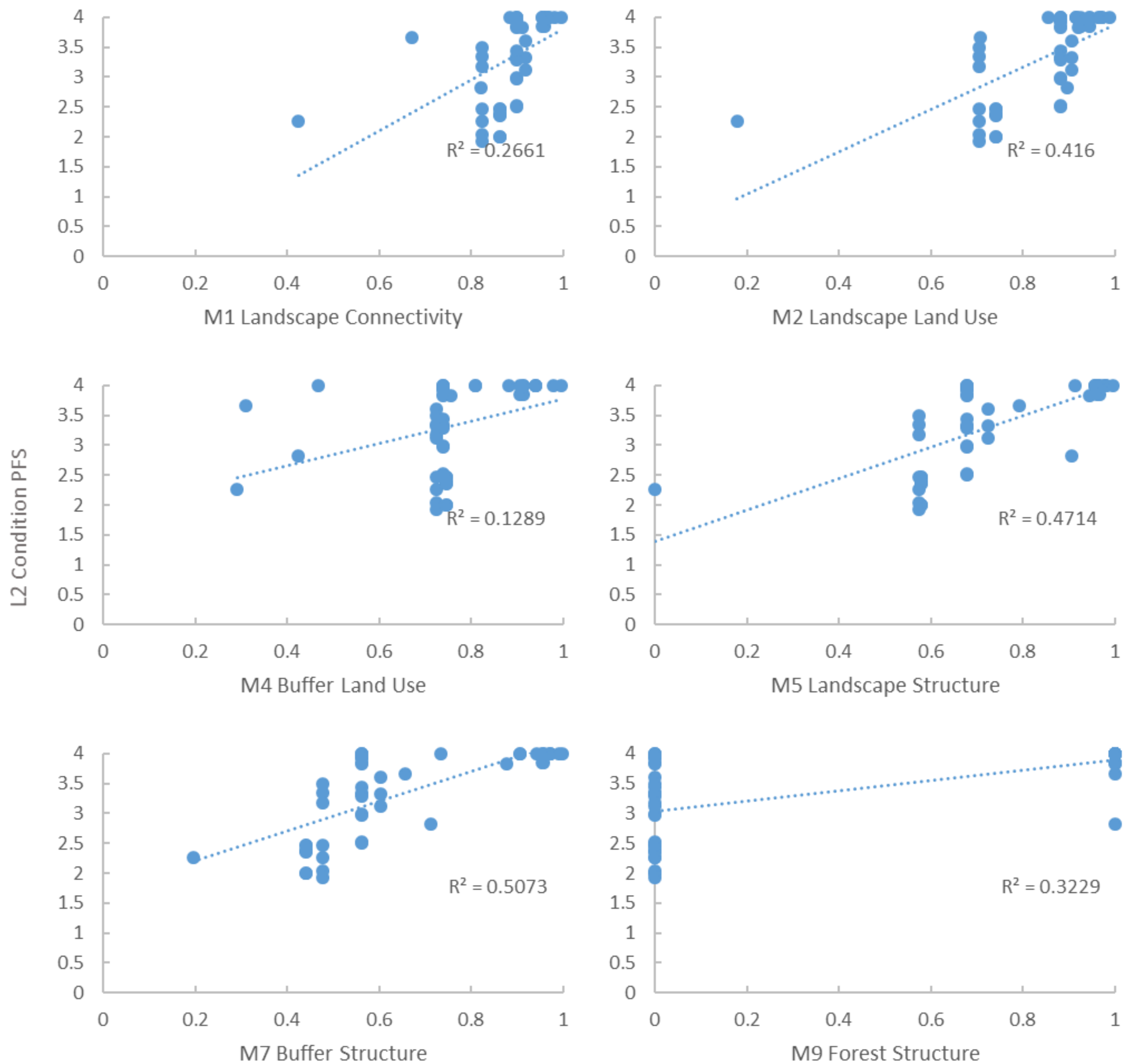

Figure E-7. NVC Level 1 EIA Metrics correlation with Level 2 EIA Condition score ($p < 0.001$ for all).

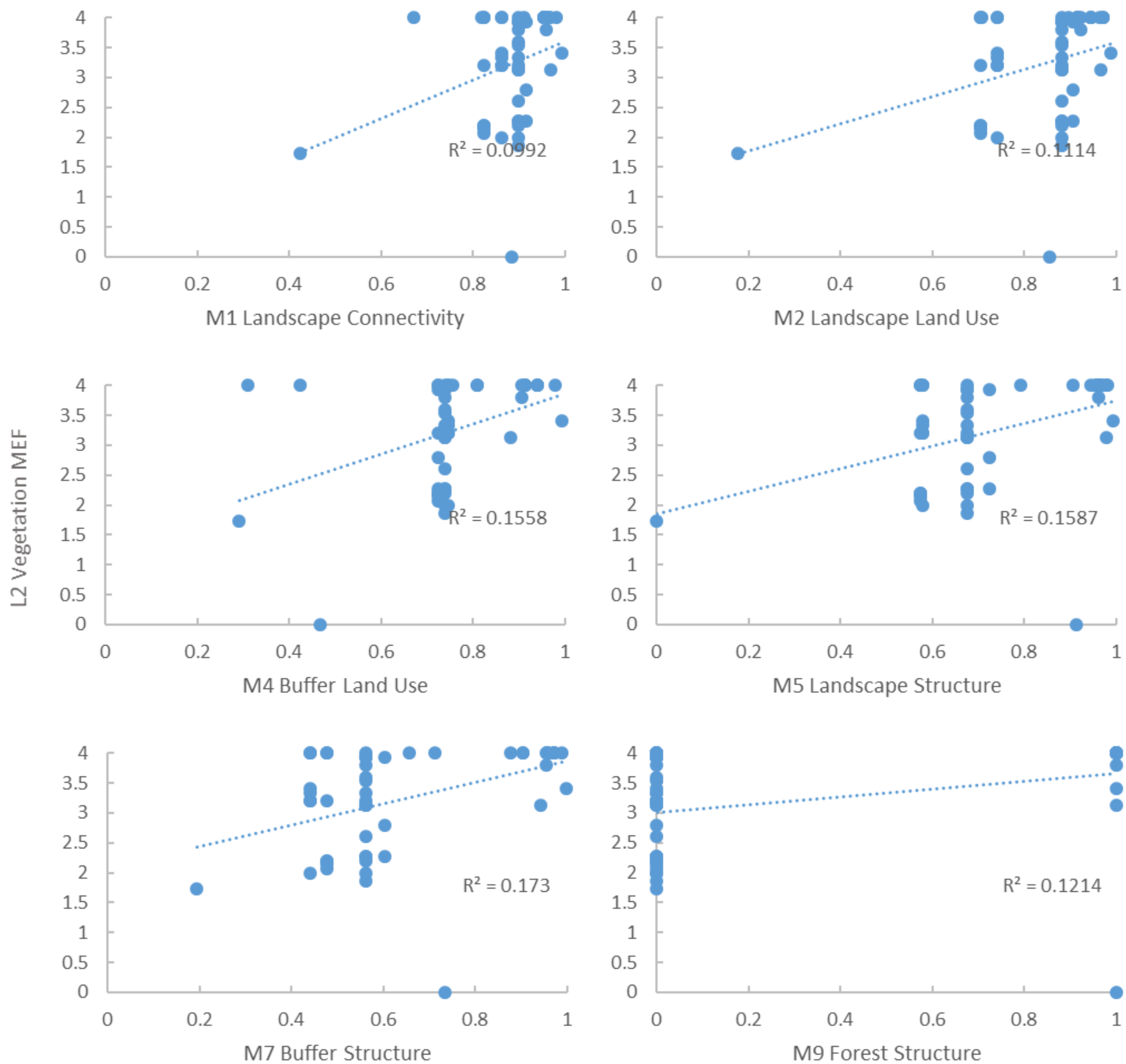

Figure NVC E-8. Level 1 EIA Metrics correlation with Level 2 EIA Vegetation MEF ($p < 0.001$ for all).

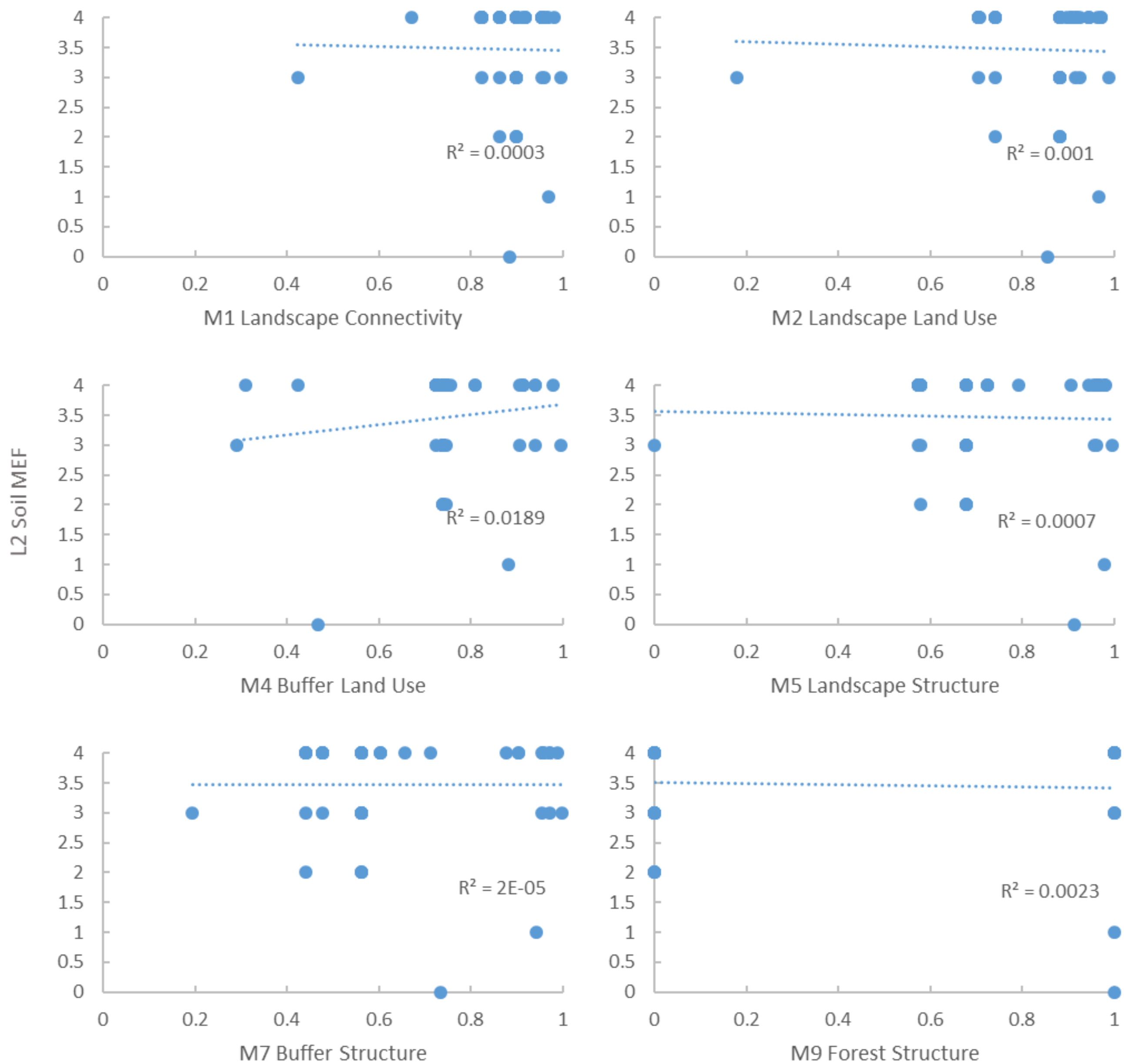

Figure E-9. NVC Level 1 EIA Metrics correlation with Level 2 EIA Soil MEF ($p < 0.001$ for all).