This methods document was crafted to be a reference for Jefferson Land Trust and North Olympic Land Trust as they implement the results of this spatial planning in their strategic conservation and stewardship work. It is a detailed outline of the way in which data was used in the process of determining resilience within the landscape and is not otherwise drafted with an eye toward interpretation or other outreach purposes. Jefferson Land Trust, North Olympic Land Trust, and CORE GIS have decided to offer this document to those who may be able to gain some helpful reference from it.

Climate Resilience Spatial Planning: GIS Methods

Jefferson Land Trust and North Olympic Land Trust
Prepared by CORE GIS
Last updated: April 30, 2021

Project Overview

The Jefferson and North Olympic Land Trusts partnered together to obtain funding for a detailed spatial analysis focused on identifying lands that are most likely to retain their conservation values when considering all the implications of a warming and changing climate. We worked closely with both organizations to gather, process, analyze, and present a wide range of data organized around four pillars:

- Habitat & Biodiversity
- Working Farms
- Working Forests
- Community

This document describes the data sources, GIS methods, and outputs that were produced over the course of this project.

Data Sources

A comprehensive list of data sources with URLs for all layers used in the analyses described below are documented in a Google Sheet located here and included as an appendix to this document, current as of 1/13/2021.

Methods

Climate Change Data

In addition to the four pillars, we analyzed and mapped a variety of climate change data to provide background and context to the study.

We mapped a variety of datasets that forecast changes over time due to climate change:

- Changes to Summer & Winter Stream Flow
    - Daily runoff and baseflow from the Variable Infiltration Capacity (VIC) macroscale hydrologic model were used to estimate historical and projected future stream flow metrics for stream segments in the Western U.S. This dataset updates the previous Western U.S. Stream Flow Metric Dataset. VIC is a fully-distributed and largely physically-based model that balances surface energy and water fluxes. Infiltration, runoff, and baseflow processes are based on empirically derived relationships (Liang, Lettenmaier, Wood, & Burges, 1994) and characterize the average conditions over each grid cell. For the projected climate scenarios, meteorological data from global climate models (GCMs) for the 2040s and 2080s associated with the A1B greenhouse gas emissions trajectory (Parry et al., 2007) were used.
- Changes to Summer Stream Temperature
    - Data were queried from the NorWeST database for all years at sites where August temperatures had been recorded multiple times daily during at least 90% of the month's days and these recordings were averaged to create a mean AugTw metric. We focused on August because the summer is critical for growth and survival of many aquatic species in the western U.S. and this metric is strongly correlated with other commonly used summer temperature metrics (Dunham et al., 2005; Isaak & Hubert, 2001).
- Sea Level Rise Projection (NOAA bathtub model):
    - These data were produced at one-foot intervals and show how much of the landscape would be inundated, however there is no estimate of likelihood or timing for any of the inundation rasters. In order to have an estimate of timing, this data needs to be integrated with the probabilistic modeling conducted by Miller et al that incorporates uplift and subsidence as well as GCMs to generate a range of probabilities for a given amount of sea level rise within discrete reaches. We did not obtain the reach data from these researchers prior to the conclusion of this project.
- Date of Freeze 2071-2090

- Average date of freeze (that is, the first day that temperatures drop below zero, ending the annual frost-free season) in the contiguous United States, for the historical (1975-2005) and future (2071-2090, RCP 8.5) time periods, and for the absolute change between these.

Water Retention Index

The Water Retention Index (WRI) is a composite indicator which takes into account parameters reflecting potential water retention in vegetation, water bodies, soil and underlying aquifers, as well as the influence of slope and artificially sealed areas (also called impervious surfaces). While this is not a pillar, the Water Retention Index (WRI) is used as an input to identify opportunities for Working Farms and Working Forests. We followed the methodology in Vandecasteele et al (2018), using six inputs:

Retention in vegetation: mapped using Leaf Area Index, defined as half of the total leaf surface area per unit of horizontal ground surface area, we are using unpublished data from Mutlu Özdoğan at the University of Wisconsin
Retention in surface waterbodies: we are using the percentage of surface water bodies within each catchment as a proxy since we do not have ready access to volume; we used waterbodies from the National Hydrography Dataset from the USGS
Retention in soil: we mapped soil available water contact from the USDA NRCS gSSURGO dataset, generated using texture, bulk density, organic carbon content, and soil depth
Retention in groundwater: we rated the permeability of lithology using the 1:100,000 Washington geology map with ratings for each class provided by Michael Machette (a retired USGS geologist) based on lithology and predominant flow mechanism
Slope factor: extracted from USGS ⅓ arc-second digital elevation data
Soil Sealing: impervious surfaces extracted from the NOAA C-CAP landcover dataset

These six variables were normalized to a scale of 1-10, added and divided by six to generate a water retention index.

Habitat & Biodiversity

Objectives: *identify lands and features that are most likely to retain their ecological integrity, as well as connecting corridors and other landscape features that support existing and migrating biodiversity*

We sought to meet these objectives by identifying opportunity areas for conserving biodiversity in highly resilient landscapes. The mapped opportunity areas possess the following characteristics:

- High terrestrial climate resilience
- Identified by State and Federal agencies as important for terrestrial and aquatic species and habitats right now
- Contain important marine and nearshore habitats now and into the future
- Provide, complete, or augment important movement corridors
- Are on private land

These areas were identified by analyzing several datasets:

1. The Nature Conservancy's Resilient Terrestrial Landscapes in the Pacific Northwest
2. Washington Department of Fish and Wildlife Crucial Habitat Assessment Tool (CHAT)
3. USGS Protected Areas Database
4. Nearshore habitats and tidal wetlands
5. Landscape resistance

The Nature Conservancy Climate Resilience Data consists of several layers that were used to characterize the likelihood that a given area can maintain functioning ecosystems and ecological processes under a range of different future climatic conditions. Each of these layers were summarized within the CHAT hexagons.

LAND FACETS
Protecting geographically dispersed, representative examples of each and every geophysical setting will likely protect areas that will foster a diversity of biota in the future — albeit a different biota than those areas would protect today

TOPOCLIMATE DIVERSITY
Microclimate diversity connotes the range of temperature and moisture regimes available to species as local habitats: where this diversity is greatest, there is the most potential for some areas to deviate from the regional climatic norm, and to act as refugia under climate change scenarios.
Heat Load Index (HLI) provided a relative indication of temperature experienced on the ground, and the second, Compound Topographic Index (CTI) describes relative variation in water availability.

LANDSCAPE PERMEABILITY
A highly permeable landscape is needed to maintain ecological processes, genetic diversity and adaptation potential of populations, and the ability of species to move as the climate changes.

RESILIENCE
Topoclimate diversity and high terrestrial permeability were used to generate resilience.

NORMALIZED CURRENT FLOW
This broad-scale landscape connectivity analysis identifies areas likely to facilitate ecological flow — particularly movement, dispersal, gene flow, and distributional range shifts for terrestrial plants and animals — over large distances and long time periods. This map represents OmniScape current flow normalized by regional flow potential. Regional Flow Potential indicates how much current flow would be expected in the absence of barriers, and is proportional to the amount of natural land within the focal window. This helps to distinguish

1) broad, intact areas where movement is diffuse or largely unrestricted;
2) channeled areas or pinch points where further habitat loss could isolate natural areas, and
3) areas where flow is impeded by barriers.

WDFW CHAT (Crucial Habitat Assessment Tool) consists of hexagons that are ranked for terrestrial and aquatic conservation priority. The priority rankings are based on a wide range of input data, including individual aquatic and terrestrial species distributions, habitat models, large intact blocks of habitat, connectivity, habitat integrity, and Federal and State rankings of species of concern. In addition to the Crucial Habitat Rankings, we were able to obtain the underlying data for each hex, which is accessible via a table relate.

Opportunity Areas
Shoreline Conservation Opportunity areas: Shoreline analysis and prioritization

- Using DNR shorezone data on habitat:
  - Kelp
  - Floating Kelp
  - Salt Marsh
  - Seagrass

  - Surfgrass
- Restricting that set to resilient lands;
- Incorporating with human impacts:
  - Percent Shoreline Modifications
  - Number of structures within 150 m of shoreline
- Optimizing for:
  - Private ownership
  - Adjacency to resilient lands
  - Good current habitat conditions
  - Low percent modifications
  - No buildings present within 150 m

Habitat and Biodiversity Conservation Opportunity areas were identified using CHAT hexagons that meet all of the following criteria:

- Less than 100% public lands
- More than 50% covered by resilient lands identified by TNC
- Resilience score greater than or equal to 80
- Crucial Habitat Rank of 1 or 2
- Low resistance to animal movement

GNN Data (Forest Characteristics)

The Landscape Ecology, Modeling, Mapping and Analysis group (LEMMA) is a partnership between the US Forest Service and Oregon State University. They produce the Generalized Nearest Neighbor (GNN) dataset of hundreds of forest characteristics, and we have downloaded several of these for the use of NOLT & JLT:

Layer	Units	Description
Age_dom_2017.tif:	years	Basal area weighted stand age based on field recorded or modeled ages of dominant/co-dominant trees
Bac_ge_3_2017.tif	m^2/ha	Basal area of live conifers >=2.5 cm dbh
Bah_ge_3_2017.tif	m^2/ha	Basal area of live hardwoods >=2.5 cm dbh

Ba_ge_3_2017.tif	m^2/ha	Basal area of live trees >=2.5 cm dbh
Bphc_ge_3_crm_2017.tif	kg/ha	Component Ratio Method biomass of live conifers >=2.5 cm dbh
bphh_ge_3_crm_2017.tif	kg/ha	Component Ratio Method biomass of all live hardwoods >=2.5 cm dbh
Bph_ge_3_crm_2017.tif	kg/ha	Component Ratio Method biomass of all live trees >=2.5 cm dbh
Cancov_2017.tif	percent	Canopy cover of all live trees: calculated using methods in the Forest Vegetation Simulator for Inventory plots; sum of ocular estimates for Ecology plots
Cancov_con_2017.tif	percent	Canopy cover of all conifers: calculated using methods in the Forest Vegetation Simulator for Inventory plots; sum of ocular estimates for Ecology plots
Cancov_hdw_2017.tif	percent	Canopy cover of all hardwoods: calculated using methods in the Forest Vegetation Simulator for Inventory plots; sum of ocular estimates for Ecology plots
Conplba_2017.tif	none	Conifer tree species with plurality of basal area (alphanumeric PLANTS code)
Covcl_2017.tif	none	Cover class, based on CANCOV, modified slightly from O'Neil et al. (2001)
Fortypba_2017.tif	none	Forest type, which describes dominant tree species (based on basal area) of current vegetation. Alpha code comprised of one or two hyphenated species codes (from 2000 PLANTS database).
Hdwplba_2017.tif	none	Hardwood tree species with plurality of basal area (alphanumeric PLANTS code)
Mndbhba_2017.tif	cm	Basal-area weighted mean diameter of all live trees
Qmd_dom_2017.tif	cm	Quadratic mean diameter of all dominant and codominant trees
Sizecl_2017.tif	none	Size class, based on QMD_DOM and CANCOV, modified slightly from O'Neil et al. (2001)
Stndhgt_2017.tif	m	Stand height, computed as average of heights of all dominant and codominant trees
Tphc_ge_3_2017.tif	trees/ha	Density of live conifers >=2.5 cm dbh
Tphh_ge_3_2017.tif	trees/ha	Density of hardwoods >=2.5 cm dbh
Tph_ge_3_2017.tif	trees/ha	Density of live trees >=2.5 cm dbh
Treeplba_2017.tif	none	Tree species with plurality of basal area (alphanumeric PLANTS code)
Vphc_ge_3_2017.tif	m^3/ha	Volume of live conifers >= 2.5 cm dbh
Vphh_ge_3_2017.tif	m^3/ha	Volume of live hardwoods >= 2.5 cm dbh

Working Farms

Objectives: identify agricultural lands that are most likely to retain their robust productive capacity for food and fiber, and which of these areas are most likely to continue to have adequate water supplies

We sought to meet these objectives by mapping the extent of current agricultural land use activity, productivity/versatility/resilience, and water retention, and then analyzed underlying ownership patterns to help identify conservation opportunities.

We used these datasets to map opportunity areas:

1. Washington State Department of Agriculture (WSDA) agricultural land use field boundary data
2. USDA Cropscape 2019
3. American Farmland Trust Productivity, Versatility and Resilience (AFT PVR)
4. Water Retention Index (detailed above)
5. Parcel boundaries and ownership data for Jefferson and Clallam counties

The AFT PVR data is itself the end product of an analysis that synthesizes multiple data sources, as follows:

- PRODUCTIVITY is output per unit of input (often measured as crop yield per acre). The highest productivity occurs where climate and soil conditions are most conducive to plant growth. In addition, certain factors favor production of perishable food crops, such as special microclimates or length of growing season.
- VERSATILITY is the land's ability to support production of a wide range of crops. It is mainly assessed in terms of soil characteristics and climate.
- RESILIENCE is the land's ability to adapt to extreme weather events while still producing food and other agricultural products and providing ecosystem services over time. Resilience depends on the same factors that determine productivity, especially soil properties and topography.

Processing Steps

We identified parcels with high PVR and high WRI as follows:

- Summarized PVR and WRI within all ag parcels using Zonal Statistics as Table
- Assigned MEAN in a new attribute for each attribute

- Highest quartile of PVR in WA is >= 0.37
- Highest quartile of WRI in this project area is >=6.8
- Selected all parcels where [public =0 AND AFT_PVR >=0.37 AND WRI_mean >= 6.8]

Within the parcels that were selected for containing both high PVR and high WRI, we dissolved boundaries on common ownership, then summarized the number of parcels within those common ownerships. This information might be useful in further prioritizing farmland based on the potential threat of conversion to non-agricultural land uses.

Working Forests

Objectives: Identify working forest lands that are most likely to retain robust productivity for long-term timber production and other ecological services, map opportunity areas for increasing carbon sequestration over time, under a range of different management scenarios; analyze development potential within working forests

We sought to meet these objectives by identifying forests that possess these characteristics:

- High climate resilience/topoclimatic diversity (TNC Terrestrial Resilience)
- Suitable site class (WA DNR Siteclass data)
- High water retention index (WRI: Leaf Area Index, Surface Water Bodies, Soil Available Water Content, Permeability of Lithology, Slope Factor, Impervious Surfaces)
- High potential carbon sequestration (USGS Land Carbon)

We used zoning and Assessor data to stratify working forest parcels into four categories:

- Inside forest zoning, designated forestland
- Inside zoning, not designated forestland
- Outside zoning, designated forestland
- Outside zoning, not designated forestland

We used these datasets to create a continuous surface for identify working forest opportunity areas:

1. Washington DNR Siteclass
2. Water Retention Index
3. USGS Carbon Flux Potential

We transformed the Water Retention Index from 0-20 to 0-100 by multiplying by 10; result is wri_100

We converted the DNR Siteclass ordinal categories (I, II, III, IV, V, etc.) to a scored raster as follows:

I: 100
II: 80
III: 60

IV: 40
V: 20
All else: 0

We rescaled the USGS carbon flux potential from its original range to 0-100:

"landcarbon_flux_2020_2050_SUM_resamp_270_v2" * (100/19608)

Processing Steps:

- We added together resilience density, WRI, siteclass, and carbon flux, then divided by 4 to generate a continuous surface ranked on a scaled of 1-100 (**forest_priority_surface_v1**)
- Next, we masked that raster to the extent of working forests (**forest_priority_surface_v2**)
- Then ran focal mean with a 6 pixel moving circular window (**forest_priority_surface_v2_focal_6x6**)
- Finally, we masked to the extent of working forest parcels using all_forest_parcels_merge_v2_mask to create **forest_priority_surface_v3**
- From that raster, we extracted values >= 52.4
- Reclassified that output into a 0/1 binary raster
- Converted the reclassified raster to polygons, **forest_priority_v3_generalized_poly**, then erased all polys less than 40 acres

Community

Objectives: identify natural areas, open spaces, scenic vistas, and recreational amenities that support the quality of life of visitors and residents; identify areas that are most appropriate for new and continued development or increased density; identify areas that are most suited for water retention

Methods Used for Identifying Community Conservation Opportunity Areas

To find areas that present opportunities for community conservation, we selected parcels that meet the following criteria:

- Highly visible areas that are within two miles of a population center, undeveloped, and privately owned;
- Areas that have channelized or intensified flow in the Normalized Current Flow layer;
- Undeveloped shorelines (either marine or riverine) that are private, within 2 miles of City/UGA/LAMIRD/etc;
- Parcels that are part of, contain, or intersect greenbelts/trails

This iteration resulted in clallam_community_opportunities_v4 and jefferson_community_opportunities_v4. These were manually edited by Erik and Michele to add/remove parcels. We used this version to update the two feature classes containing parcels with attributes (described below).

Development Status: Development status was mapped by determining if a parcel is developed and comparing the size of the parcel to the minimum lot size for its zoning. We downloaded the Microsoft building footprints from 2018 and assigned these to one of three categories: city, UGA, or unincorporated.

We researched the max/min density per zone for Clallam and Jefferson Counties, then determined development category and potential new lots as follows:

Fully Developed
Parcels that are at or below the minimum lot size and contain one or more buildings; these parcels cannot be subdivided or host a new structure under current zoning:

ACRES_GIS <= max_density AND building_count>0

Developable
Parcels that are at or below min lot size and do not have a building; these parcels can be developed but not subdivided:

(ACRES_GIS < (max_density*2)) AND building_count=0

Divisible
Parcels are >= 2x the max density size in acres; the number of potential new lots is the FLOOR of GIS_Acres/max_density, minus one, to account for the existing parcel from which the new parcels are created

ACRES_GIS >= min_lot_size*2

the number of potential new lots is the FLOOR of GIS_Acres/max_density, minus one, to account for the existing parcel from which the new parcels are created

(math.floor(!ACRES_GIS!/ !min_lot_size!))-1

Used the Create Random Points tool to distribute potential new lots within parcels using the pot_new_lots field

Development Likelihood: we generated a score for the likelihood of future development for parcels in the unincorporated portions of Clallam and Jefferson Counties. We did not include incorporated cities or UGAs because of the complexity and time involved in interpreting the individual zoning ordinances or related development regulations for the individual municipalities.

We combined land value; proximity to Cities, UGA, LAMIRDs, Port Ludlow, or RVCs; the percentage of surrounding development; percent slope; and development status, scoring each as follows:

Land Cost per Acre (rounded quintiles)
4 = more than $72,000
3 = $36,000 - 72,000
2 = $18,000 - 36,000

1 = $6,000 - 18,000
0 = Less than $6,000

Proximity to Cities/UGAs/Etc (Euclidean distance)
4 = Inside or adjacent to the UGA, LAMIRD, Port Ludlow, or RVC
3 = 0.1 - 0.5 miles
2 = 0.6 - 2 miles
1 = 2.1 - 5 miles
0 = More than 5

Percentage Surrounding Development
Using the parcels in the merge_v1_eucallo feature class (which consists of parcels that have been 'grown' so they cover any gaps between parcels due to ROW) we created a field called DEV where 0 represents an undeveloped parcel and 1 represents a developed parcel. We used the Polygon Neighbors tool with [Gridcode] as the source field (the Gridcode field is identical to the UniqueID field) to determine the number of unique parcels bordering each parcel. We joined a table consisting of the UniqueID and DEV fields to the table produced by the Polygon Neighbors tool, using the nbr_gridcode as the join field. This tells which of the neighbor polygons are developed. Finally, we summarized the DEV field in the joined table to create the

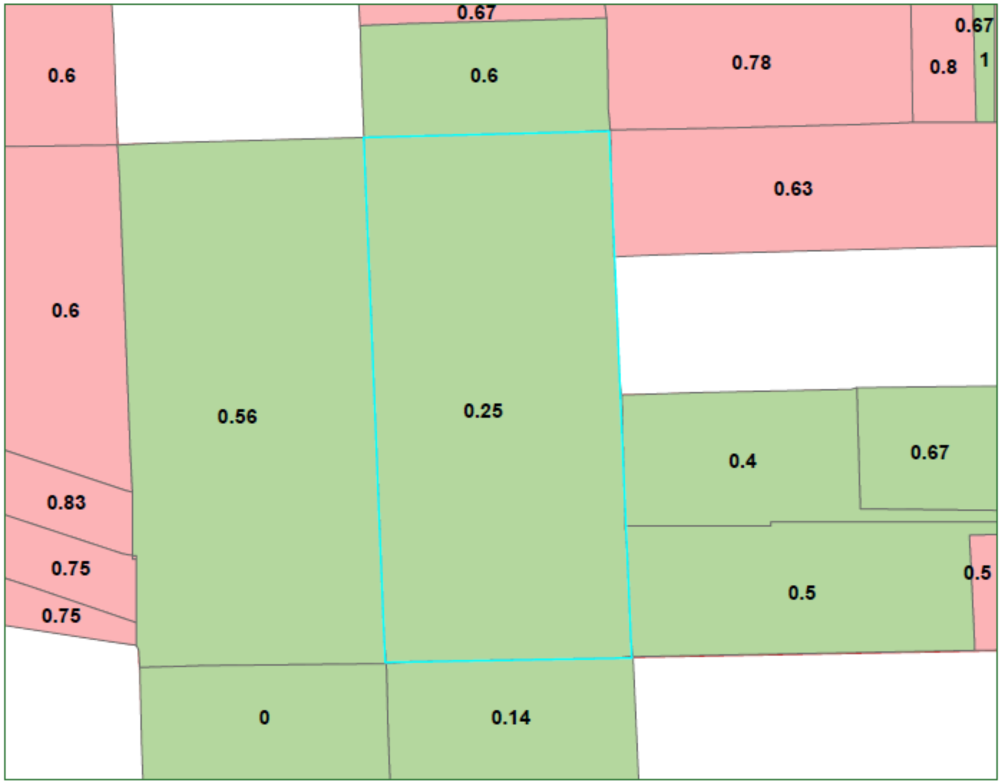
table tbl_SUM_polygon_neighbors_src_gridcode_by_DEV, which lists the UniqueID (src_gridcode), the total number of parcels bordering each source parcel (Count_src_gridcode), and the number of those parcels that are developed (Sum_DEV).
Please see the sample illustration at right for a visual explanation of this process. Note that parcels adjoining corners are considered adjacent for the purposes of this analysis.

4 = 80.1 - 100%
3 = 60.1 - 80%
2 = 40.1 - 60%
1 = 12.6 - 40%
0 = 0 - 12.5%

Percent Slope
4 = 0 - 3%
3 = 3.1 - 8%
2 = 8.1 - 15%
1 = 15.1 - 25%
0 = More than 25%
Breakpoints derived from
http://landuselaw.wustl.edu/ssprotection.htm

Development Status
4 = Undeveloped
3 = Divisible into 4+ lots
2 = Divisible into 2-3 lots
1 = Divisible into 1 lot
0 = Fully Developed

We produced and revised weighted scores, this is v3:
- Assessed Land Value per Acre [0.35]
- Percent Surrounding Developed Parcels [0.25]
- Presence within/Proximity to UGAs [0.2]



In this example, green parcels are undeveloped and red parcels are developed. The source parcel is highlighted in cyan. It is surrounded by eight parcels (two of which are on the NE and SW corners) of which two are developed, yielding a percent surrounding development score of 25%.

- Potential Development per Parcel [0.15]
- Average Slope within Parcel [0.05]

The final result ranks each parcel based on the likelihood of future development.

We used these same parcel layers to measure a variety of characteristics and identify which parcels intersect potential opportunity areas.

The two feature classes are:
\data\analysis\community_conservation.gdb**clallam_parcels_surrounding_dev_analysis**
And
\data\analysis\community_conservation.gdb**jefferson_parcels_surrounding_dev_analysis**

Each of these parcel layers contains the following attributes:

city_uga	1 = parcel is within City/UGA; 0 = parcel is outside City/UGA
bldg_count	Number of buildings within parcel
residential_allowed	1 = residential uses allowed under zoning
units_per_acre	Number of units per acre allowed under current zoning
min_lot_size	Minimum lot size under current zoning
include_in_analysis	Flag for including or excluding parcels from development analysis
dev_category	Indicates whether parcel is fully developed, developable, or divisible
pot_new_lots	Number of new lots that could potentially be subdivided from current parcel
pot_new_lots_flr	Floor of the number of potential new lots
ACRES_GIS	Parcel acres
Hectares	Parcel hectares
CF80_redo	Flag for redoing development analysis of CF80 zone
min_lot_size_float	Floating point minimum lot size
port_ludlow	Flag for presence within Port Ludlow
AFT_PVR	Mean Productivity, Versatility, and Resilience score

NEAR_FID	Internal feature ID of nearest city/UGA polygon
NEAR_DIST	Distance to nearest city, UGA
NEAR_GAP1and2	Distance in feet to nearest public land with GAP status 1 and 2
NEAR_GAP123	Distance in feet to nearest public land with GAP status 1, 2 or 3

The GAP Status Code is a measure of management intent to conserve biodiversity defined as:
Status 1: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, intensity, and legacy) are allowed to proceed without interference or are mimicked through management.
Status 2: An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive uses or management practices that degrade the quality of existing natural communities, including suppression of natural disturbance.
Status 3: An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type (e.g., logging, Off Highway Vehicle recreation) or localized intense type (e.g., mining). It also confers protection to federally listed endangered and threatened species throughout the area.
Status 4: There are no known public or private institutional mandates or legally recognized easements or deed restrictions held by the managing entity to prevent conversion of natural habitat types to anthropogenic habitat types. The area generally allows conversion to unnatural land cover throughout or management intent is unknown.

cost_per_acre_land	Cost in dollars per acre based on assessed value
SLR_01	Percentage of parcel inundated under 1' sea level rise
SLR_02	Percentage of parcel inundated under 2' sea level rise
SLR_03	Percentage of parcel inundated under 3' sea level rise
SLR_04	Percentage of parcel inundated under 4' sea level rise
SLR_05	Percentage of parcel inundated under 5' sea level rise
SLR_06	Percentage of parcel inundated under 6' sea level rise
SLR_07	Percentage of parcel inundated under 7' sea level rise

SLR_08	Percentage of parcel inundated under 8' sea level rise
SLR_09	Percentage of parcel inundated under 9' sea level rise
SLR_10	Percentage of parcel inundated under 10' sea level rise
vdep	Vegetation Departure from Historic Fire Regime (from USGS Landfire). Lower scores represent landscapes still within the natural or historical range of variation; intermediate scores represent landscapes that are moderately outside the natural or historical range of variation; and high scores represent landscapes that are far outside of the natural or historical range of variation. According to the USFS: "Fire regimes have been significantly altered from their historical range. The risk of losing key ecosystem components is high. Fire frequencies have departed from historical frequencies by multiple return intervals. This may result in dramatic changes to one or more of the following: fire size, intensity, severity, and landscape patterns. Vegetation attributes have been significantly altered from their historical range." *Condition Class I.A: VDEP between 0 and 16 (Very Low Departure)* *Condition Class I.B: VDEP between 17 and 33 (Low to Moderate Departure)* *Condition Class II.A: VDEP between 34 and 50 (Moderate to Low Departure)* *Condition Class II.B: VDEP between 51 and 66 (Moderate to High Departure)* *Condition Class III.A: VDEP between 67 and 83 (High to Moderate Departure)* *Condition Class III.B: VDEP between 84 and 100 (High Departure)*
WUI	Presence within the Wildland Urban Interface (Clallam only)
INT_WSDA_2019	The parcel intersects field boundaries from the 2019 Washington State Department of Agriculture
Cropscape2019_INT	The parcel intersects Cropscape data
public	Public =1, Private =0
current_ag	Whether a parcel is currently being used for agricultural activity
potential_ag	Parcels that could be used for agricultural activity
wri_mean	Mean Water Retention Index score for the parcel
Shape_Length	parcel perimeter in linear feet
Shape_Area	parel area in square feet
dev	1 = developed, 0 = not developed
unique_id	unique key created by CORE GIS to ensure clean joins of tabular outputs
pct_surr_dev	percentage of surrounding parcels that are developed
near_UGA_miles	Distance in miles to nearest city, UGA

pct_slope	Average percent slope of parcel
land_val_score	Score of 0 - 4 based on land cost per acre
UGA_score	Score of 0 - 4 based on proximity to nearest city, UGA, LAMIRD, RVC, Port Ludlow
surr_dev_score	Score of 0 - 4 based on percent surrounding development
pct_slope_score	Score of 0 - 4 based on percent slope within parcel
dev_status_score	Score of 0 - 4 based on development status of parcel
dev_prob_unwt	Unweighted linear summation of development probability
dev_prob_wt	Weighted development probability score
dev_notes	Notes about development type
near_UGA_RVC_miles	Distance to nearest UGA, city, or RVC
UGA_RVC_score	Score of 0 -4 based on distance to nearest UGA, RVC, etc
dev_prob_unwt_v2	Second version of unweighted development probability score
dev_prob_wt_v2	Second version of weighted development probability score
working_forest	1 = working forest, 0 = not working forest
working_forest_not_DF	1 = working forest outside of designated forest land
dev_prob_wt_v3	Third (and final) version of weighted development probability score
pot_DUs	Potential number of dwelling units under current zoning
new_DUs_2050	Number of dwelling units distributed within the parcel per methods described below
hab_biod_rollup	Parcel intersects opportunity areas for habitat and biodiversity
shoreline_opportunity	Parcel intersects opportunity areas for shoreline habitats
farm_rollup	Parcel intersects opportunity areas for working farms
forest_rollup	Parcel intersects opportunity areas for working forests
visible_rollup	Parcel intersects high visibility areas based on viewshed analysis
stream_length	Length of channel (of any type) within the parcel
shoreline length	Length of marine shoreline within parcel
lake_area	Area of lakes/ponds on parcel
shoreline access	Binary flag indicating whether a parcel has shoreline access (1) or not (0)
pct_chnl_imp	Percentage of parcel that contains channelized or impeded flow
river_length	Length of river channel in the parcel
comm_rollup_v3	Binary flag indicating if the parcel was included in the 3rd iteration of the community conservation analysis

comm_rollup_shoreline	Undeveloped shoreline (marine or river), private, undeveloped, within 2 miles of City/UGA/etc. Parcels with a 1 in the [comm_rollup_shoreline] field meet these criteria
comm_rollup_vis	Highly visible areas, private land, undeveloped, within 2 miles of City/UGA, and contain at least some channelized areas. Parcels with a 1 in the [comm_rollup_vis] field meet these criteria
comm_rollup_flow	Channelized areas. Within 2 miles of City/UGA, undeveloped, private, contains some channelized area. Any parcel with a 1 in the [comm_rollup_flow] meets this criteria
pct_channeled	Percentage of parcel that contains channelized flow
comm_rollup_v4	Binary flag indicating if the parcel was included in the 4th iteration of the community conservation analysis
comm_rollup_v5	Binary flag indicating if the parcel was included in the 5th and final iteration of the community conservation analysis

Distributing Projected Population Growth

We used population projections from the Washington Office of Financial Management in conjunction with the modeled likelihood of future development to distribute hypothetical ‘housing’ within undeveloped and subdividable parcels. The 2017 GMA Projects - High Series project an increase of 24,602 people in Clallam County and 21,491 people in Jefferson County between 2017 - 2050. We measured the current ratio of housing units within City/UGA and unincorporated portions of both counties, and maintained that ratio into the future. The current household size in both counties is approximately 1.5 people, which we used to calculate the number of new dwelling units needed within unincorporated areas to accommodate growth. This works out to 8,363 new units in Clallam, or approximately 32% of the available capacity, and 8,353 new units in Jefferson, which is approximately 64% of the available capacity.

Viewshed analysis: we conducted an analysis of the most visible areas in the most heavily populated areas of Clallam and Jefferson Counties. We extracted main roads for a subset of watersheds that reflect where the majority of the population in each county lives, ensuring there was ample overlap between the two analysis areas. We then distributed points along those roads at 1/2 mile intervals. Using Model Builder, we iterated the feature selection to run a separate viewshed analysis for each point. We repeated this process for the Olympic Discovery Trail (ODT). We combined the results using Mosaic to New Raster with the Operator set to SUM, so the result values indicate the number of observer points that can see each cell. We smoothed the results using Focalmean with a 4x4 circle, then extracted the highest quintile, and converted the results to generalized polygons.

Pending Data Sources

Datasets that were not completed or obtained prior to the completion of this project:

- WSDOT cougar and fisher connectivity models (Glen Kalisz, WSDOT): this dataset was still under review in November when the roll-ups for the four pillars were completed, and completion was not anticipated until the first of the year at the earliest. Leadership on this project transitioned from Glen Kalisz (WSDOT) and Dan Craver (USFWS) to Jeffrey Azerrad (WDFW), which may also have slowed the process of refinement and completion. This dataset will be useful because the cougar connectivity model encompasses the entire peninsula from coastline to summit, unlike the earlier versions of generalized connectivity models that stopped at arbitrary locations (for example, there is no data east of State Route 19 in Jefferson County)
- Parcel-based assessment of threat from Sea Level Rise (Ian Miller, UW): the SLR data produced by Ian Miller's group and currently viewable via web interface assigns probabilities of a certain amount of sea level rise over a certain period of time. These forecasts are determined for a specific section or reach of coastline, however, they are not spatially explicit and do not show exactly where inundation might occur under the different scenarios. I made two requests for the reach data so we could assign explicit inundation within a reach based upon their forecasts but never heard back. This data would be useful because it would provide a timeframe and a likelihood for impacts from sea level rise.
- Parcel-based assessment of threat from flooding, sea level rise from the First Street Foundation: this is newly released data viewable here. We submitted a request for access to the API in July, and received this reply from Sara Chadwick (sara@firststreet.org):

> *Thanks for your interest in the First Street Foundation Flood Model and our data. We appreciate your patience, as we have received a very high volume of inquiries since our product launch, and we are still working through licensing, pricing, and logistics issues related to how a public sector or nonprofit entity may best access and use our data.*
>
> *We also recognize that many public sector entities may be willing to work with us to share their information related to local flood data, adaptations, and flood impacts that can be used to improve the accuracy and utility of the First Street Flood Model. We are grateful for any information that can be shared, and are in the process of organizing our limited staff to be able to engage efficiently.*

We attended a webinar hosted by First Street in November and did not receive any new information about when (or if) they are planning to allow non-profits access to their API and data.

This data would be useful because it incorporates flood risk from both freshwater and marine flooding as well as projected sea level rise, and evaluates the risk to individual structures.

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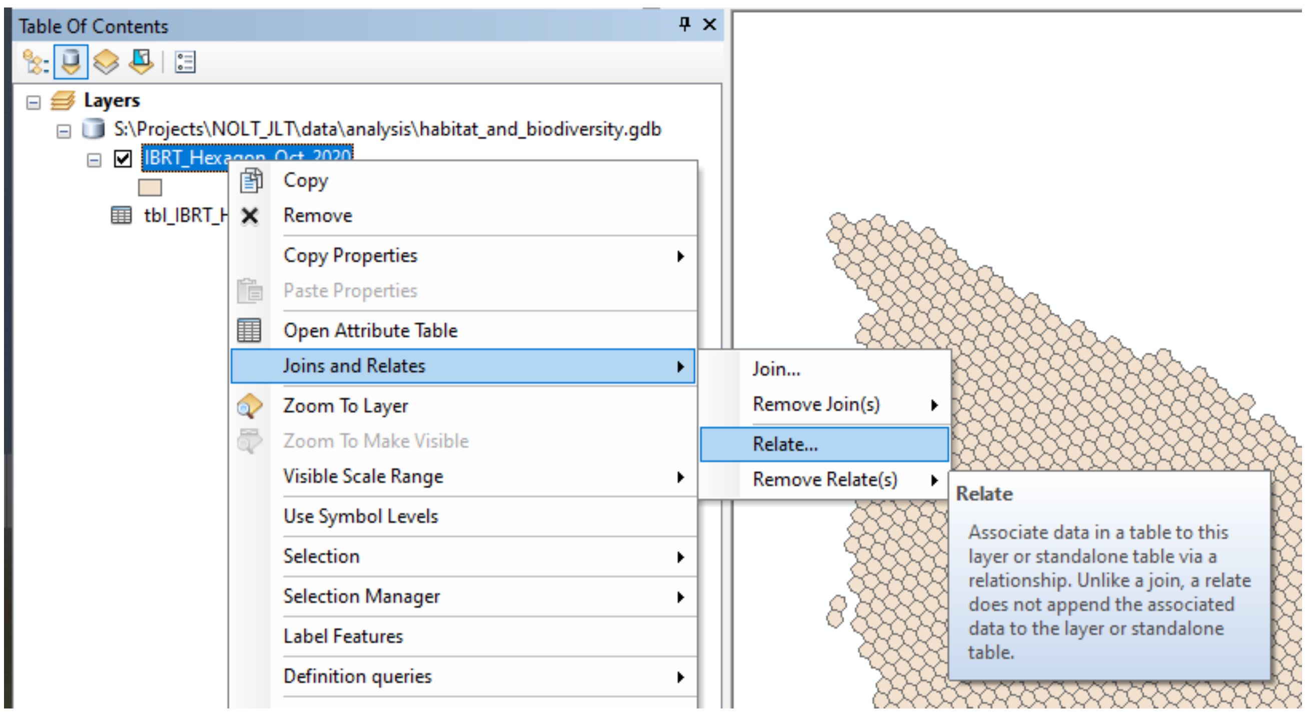
How To

Establishing the relate between the Crucial Habitat Assessment Tool and the hexagons:

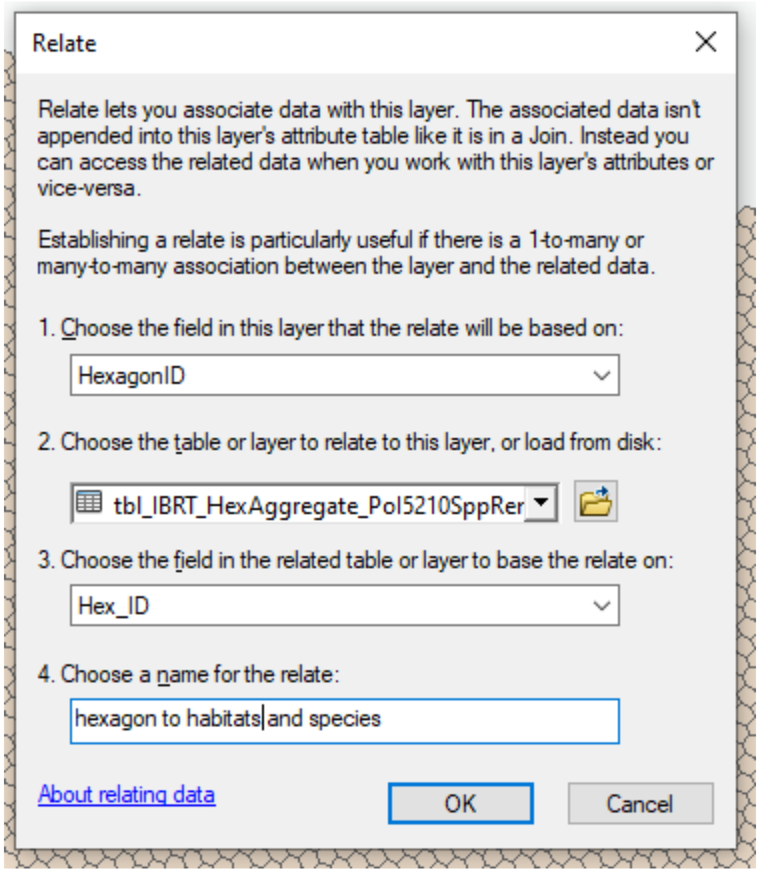
The hexagon data layer is located here:
NOLT_JLT\data\analysis\habitat_and_biodiversity.gdb
The feature class name is **IBRT_Hexagon_Oct_2020**

The corresponding tabular data is located in the same GDB, and is called **tbl_IBRT_HexAggregate_PoI5210SppRemoved_20201012**

The attribute table from the hexagons is related to the tabular data on the field HexagonID, and the tabular data is related on the field Hex_ID.



Establish the relate by right clicking on the hexagon feature class layer and choosing Joins and Relates-->Relate...



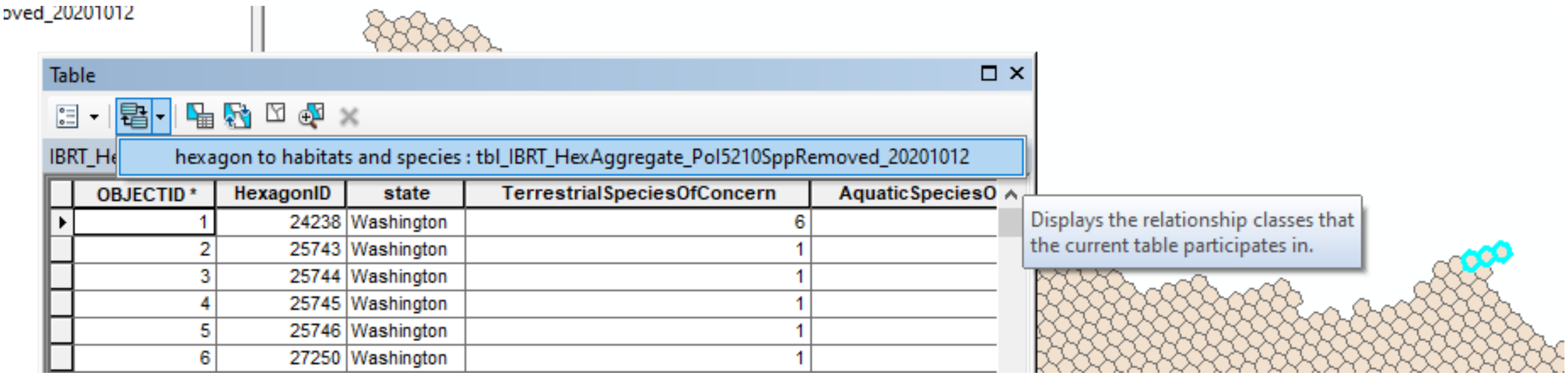
1. In the dialogue box that appears, for “Choose the field in this layer that the relate will be based on”, select HexagonID in the drop-down

2. Choose the table **tbl_IBRT_HexAggregate_Pol5210SppRemoved_20201012**

3. Select Hex_ID for the table relate field

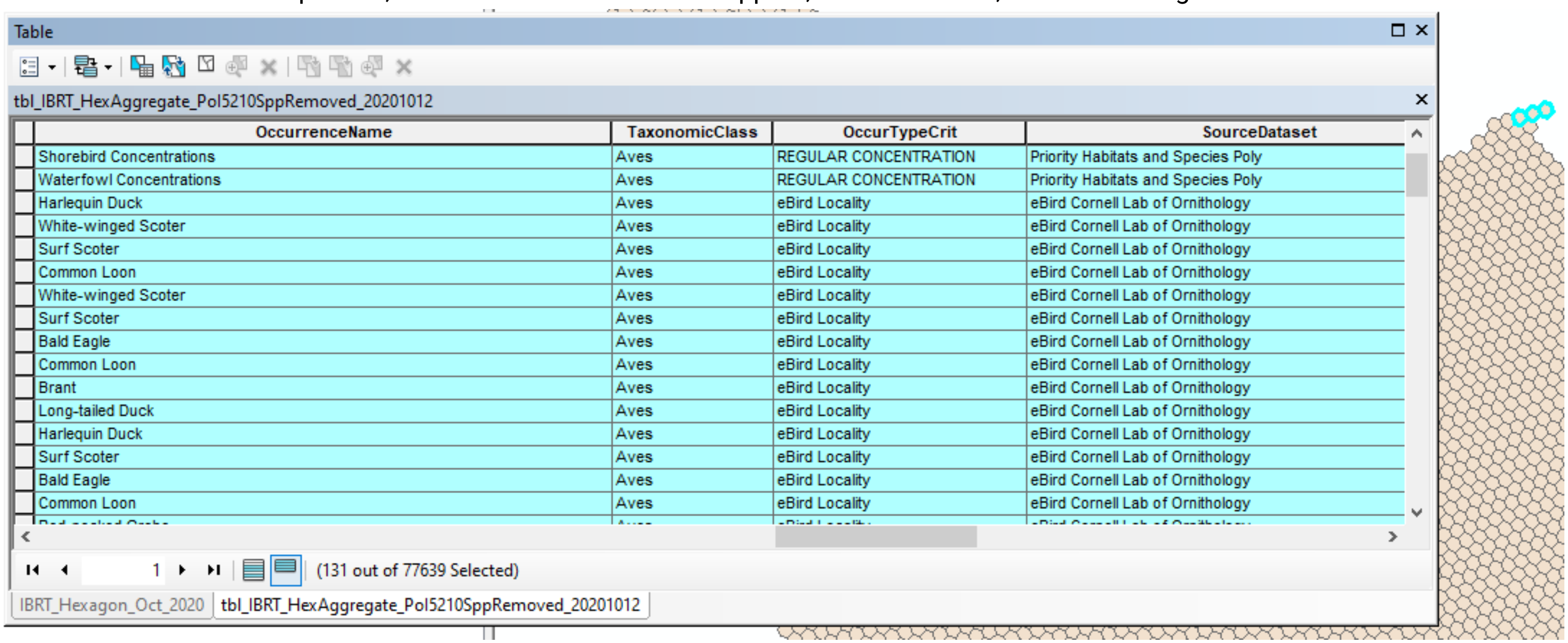
4. Give the relate a meaningful name

The relate must be activated by ‘pushing’ the relate either from the hexagons or from the tabular data. In the example below, we selected three hexagons, then clicked on the ‘related tables’ button, which will show the name of the relate specified in the previous step



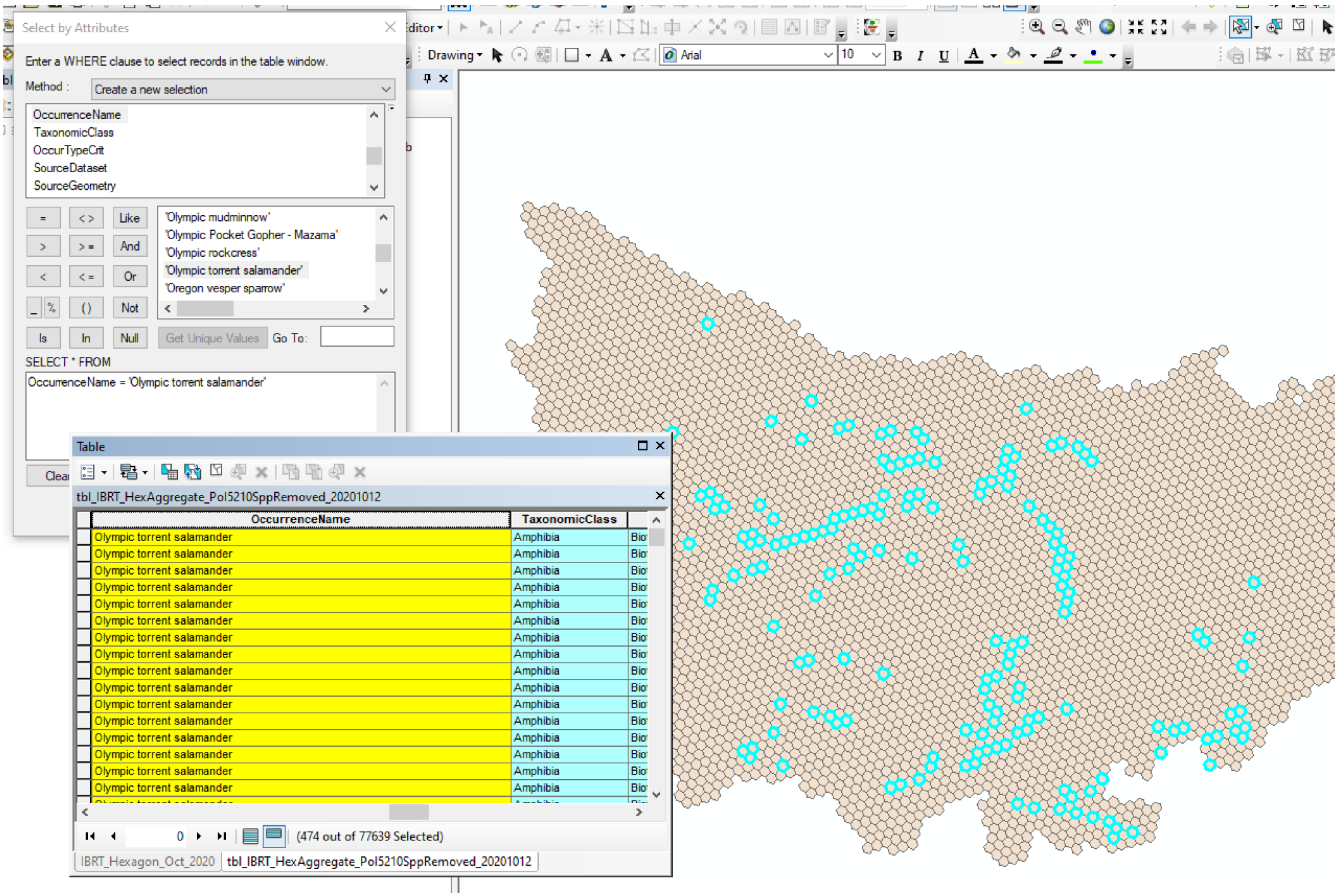
OBJECTID *	HexagonID	state	TerrestrialSpeciesOfConcern	AquaticSpeciesO
1	24238	Washington	6	
2	25743	Washington	1	
3	25744	Washington	1	
4	25745	Washington	1	
5	25746	Washington	1	
6	27250	Washington	1	

Once the relate has been pushed, the related tabular data will appear; in this instance, the three hexagons are related to 131 records

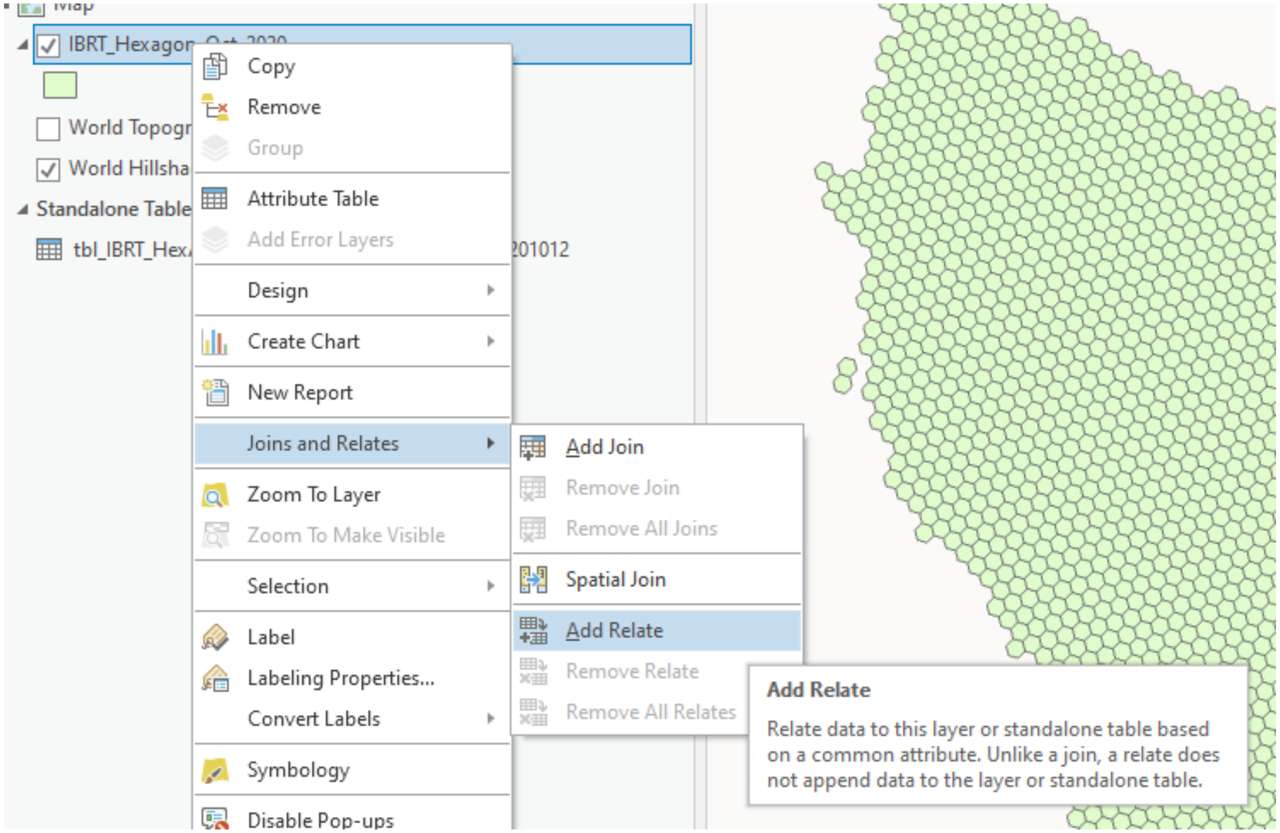


OccurrenceName	TaxonomicClass	OccurTypeCrit	SourceDataset
Shorebird Concentrations	Aves	REGULAR CONCENTRATION	Priority Habitats and Species Poly
Waterfowl Concentrations	Aves	REGULAR CONCENTRATION	Priority Habitats and Species Poly
Harlequin Duck	Aves	eBird Locality	eBird Cornell Lab of Ornithology
White-winged Scoter	Aves	eBird Locality	eBird Cornell Lab of Ornithology
Surf Scoter	Aves	eBird Locality	eBird Cornell Lab of Ornithology
Common Loon	Aves	eBird Locality	eBird Cornell Lab of Ornithology
White-winged Scoter	Aves	eBird Locality	eBird Cornell Lab of Ornithology
Surf Scoter	Aves	eBird Locality	eBird Cornell Lab of Ornithology
Bald Eagle	Aves	eBird Locality	eBird Cornell Lab of Ornithology
Common Loon	Aves	eBird Locality	eBird Cornell Lab of Ornithology
Brant	Aves	eBird Locality	eBird Cornell Lab of Ornithology
Long-tailed Duck	Aves	eBird Locality	eBird Cornell Lab of Ornithology
Harlequin Duck	Aves	eBird Locality	eBird Cornell Lab of Ornithology
Surf Scoter	Aves	eBird Locality	eBird Cornell Lab of Ornithology
Bald Eagle	Aves	eBird Locality	eBird Cornell Lab of Ornithology
Common Loon	Aves	eBird Locality	eBird Cornell Lab of Ornithology

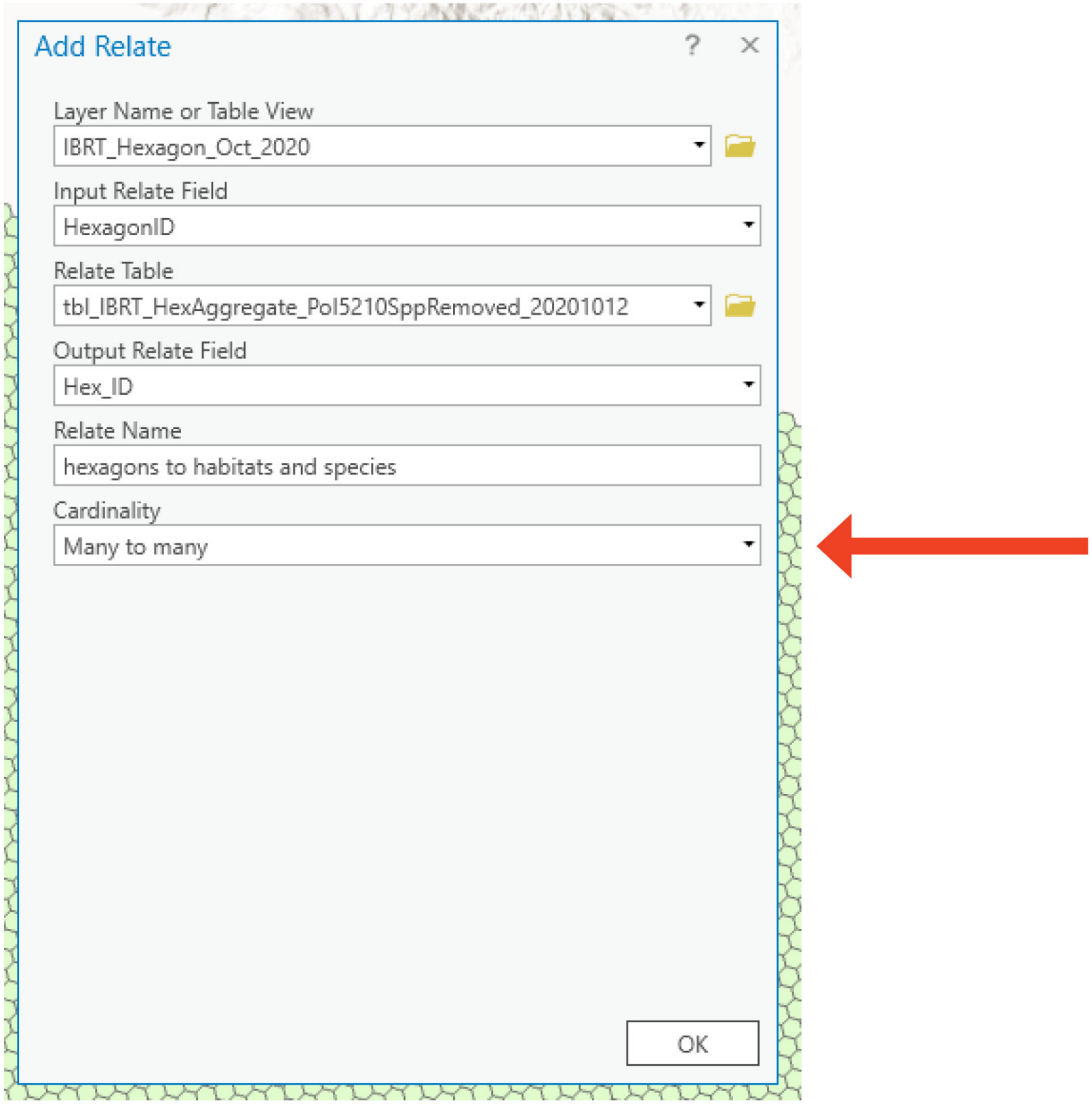
The relate can also work in the opposite direction. Querying on a particular OccurrenceName, then pushing the relate back to the hexagon layer will show the distribution of that occurrence. For example, selecting OccurrenceName = 'Olympic torrent salamander' and then pushing the relate will return the following:



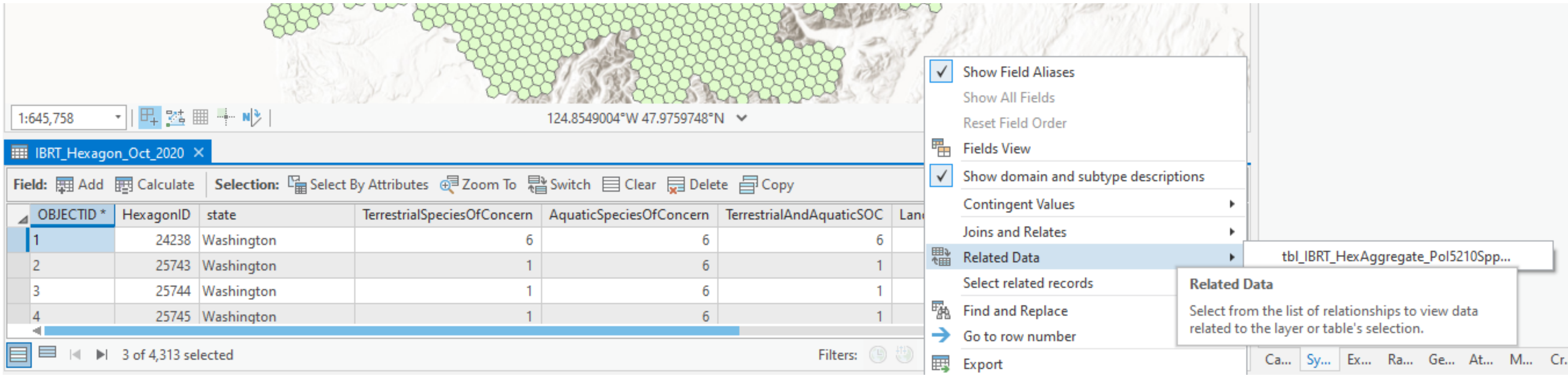
In Pro, the process is largely the same:



The primary difference is you must specify the 'cardinality' of the relate, which describes how the data related to each other. In this particular case, the cardinality is many-to-many, since every hexagon contains many habitats & species, and almost all habitats & species are present in many different hexagons.


Add Relate
Layer Name or Table View
IBRT_Hexagon_Oct_2020
Input Relate Field
HexagonID
Relate Table
tbl_IBRT_HexAggregate_Pol5210SppRemoved_20201012
Output Relate Field
Hex_ID
Relate Name
hexagons to habitats and species
Cardinality
Many to many
OK

The relate is pushed by clicking on the three-line 'hamburger' menu on the upper right of the attribute table, choosing 'related data' and clicking on the name of the relate:



Similarly, selecting attributes in the tabular data and pushing the relate to the hexagon layer will return hexagons where the selected occurrence name is present.