



Exposing the bare bones of Intactness Models COP/UT 2014 REA

Assumptions, Uncertainty, and
Sensitivity Analyses





“All models are wrong but some are useful.”
(*George Box - statistician*)

- Uncertainty is inherent in models:
 - Abstractions of reality
 - Inadequate data
 - Incorrect assumptions
 - Variability in natural processes
- This ppt aims to show how the intactness models might be useful.



Outline

- How does the intactness model work? A brief intro to the fuzzy logic process
- What are the assumptions behind the model?
- What happens if we change some input values and operators?
 - Does the model crash and burn? Or stay robust?
 - Spoiler alert!! It remains stable and robust to some large changes.
- What about a reality check against future projections of input data
 - From COP 2010: urban expansion 2025?

Aquatic Intactness

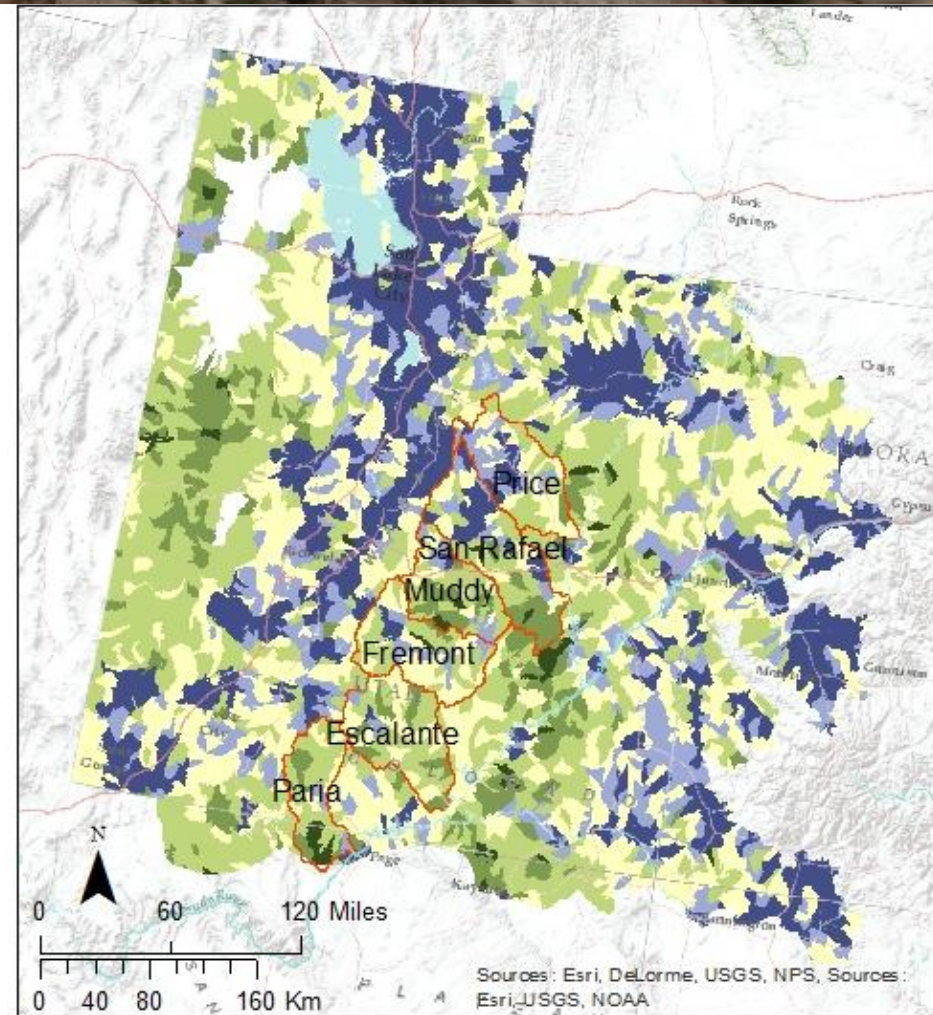
COP 2014 AI Model

COP and UT

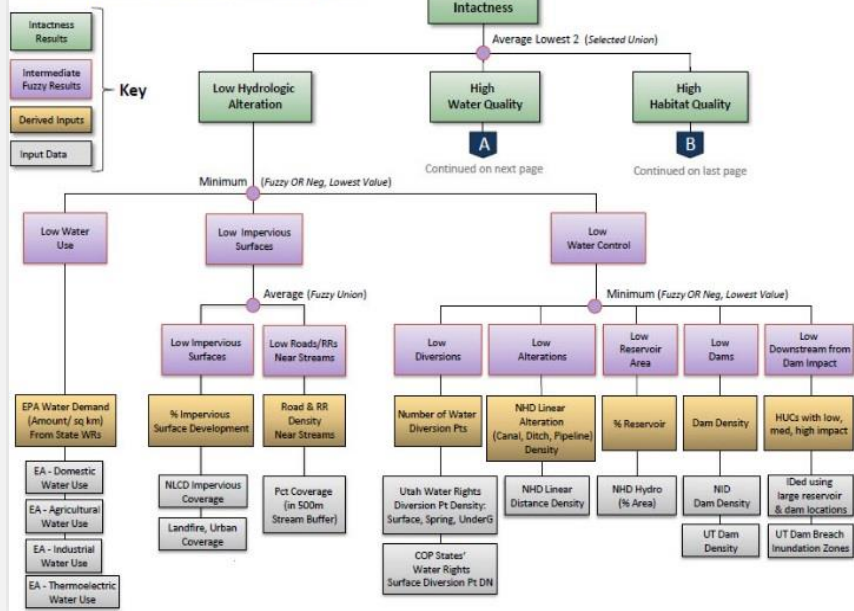
Escalante Watershed

-- a quantifiable estimate of naturalness measured on a gradient of anthropogenic influence

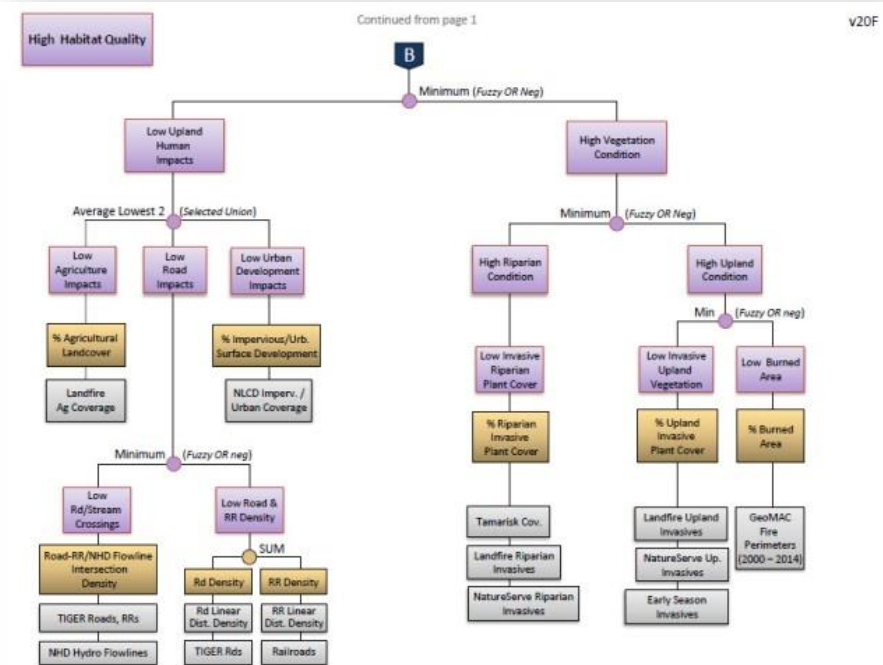
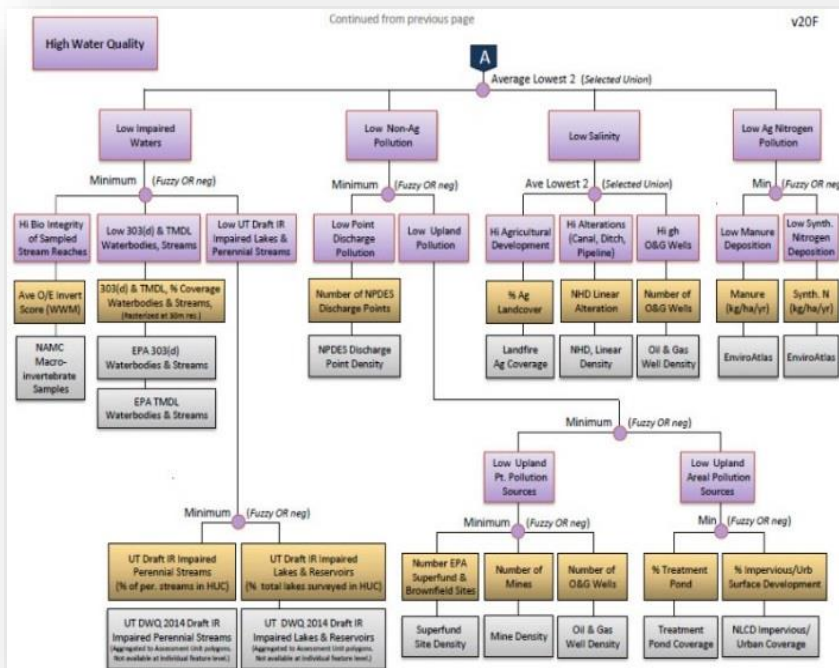
Aquatic Intactness



v20F



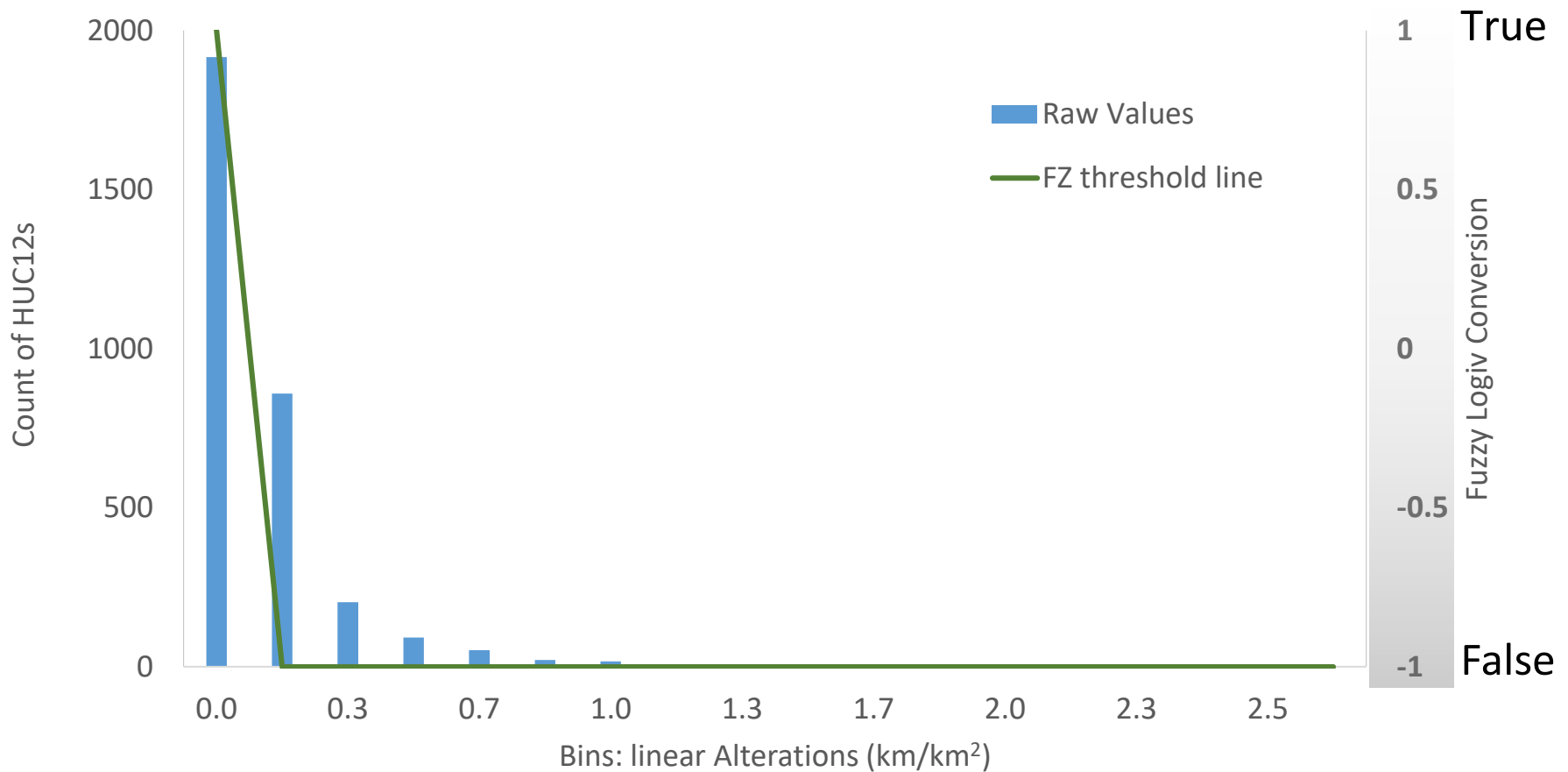
The AI fuzzy logic model structure provides a way to process and classify disparate data ...think of it as a reasoning tool to determine relative intactness between sub-watersheds



Fuzzy data conversion (domain -1 to +1)

NHD Linear Alterations Density Frequency (km/km²)

Frequency of NHD Alterations for HUC12s in COP2014





Intactness Model Assumptions

Examining assumptions helps us to:

- Gage uncertainty/sensitivities in intactness model results
- Determine reliability of model when compared to other landscape assessments
- Are differences due to:
 - Model specs
 - Data inputs



Intactness Model Assumptions

1. Data Inputs

- A. The inputs are necessary and sufficient to determine intactness
- B. The spatial arrangement of an impact within a watershed is insignificant
- C. It is OK to combine disparate data inputs from different sources and in different numerical domains and units into the continuous domain of -1 (false) to +1 (true)



Intactness Model Assumptions

2. Data Details

- A. Data quality (accuracy) affects model performance
- B. Data spatial scale/resolution/grain affect the model results
- C. Each data input may have its own specific assumptions



Intactness Model Assumptions

3. Model

- A. It is assumed that fuzzy logic operators can be used to capture the relationship between the condition of upland and upstream patterns, processes, land uses (data inputs) and intactness
 - A. Model best used in a comparative sense for scenarios or alternatives
- B. The linear interpolation function for assigning raw data values between false and true thresholds is appropriate (v. other functions)
- C. It is appropriate to assign true and false threshold values based on expert opinion, the scientific literature, and the statistical distribution of data

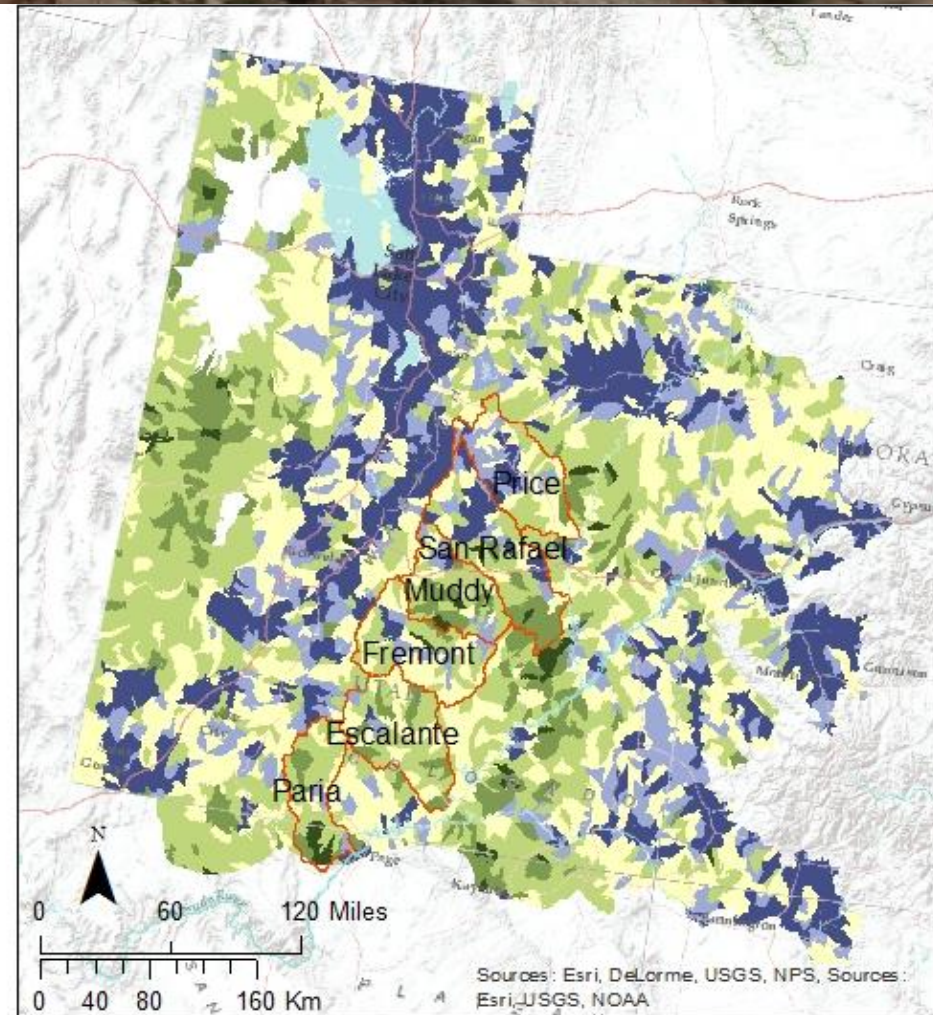
Understanding Model Assumptions helps us to:

- Understand the model further
- Understand how we can change the model to assess model sensitivities and stability

Sensitivity Analysis of Aquatic Intactness Inputs

COP 2014 AI Model
COP and UT
Escalante Watershed

Aquatic Intactness





Sensitivity Analysis

1. How does the model respond if different values are used for some factors?
 - Sensitivity Analyses quantify the impacts of:
 - Possible future alternatives
 - Data errors in the model
2. How does the model respond to altered operators?



Objectives of Sensitivity Analysis (SA)

- To determine the uncertainty and robustness of the AI model
- To determine which raw datasets drive the AI model:
 - By determining which data sets have the most influence overall
 - By individually varying the influential raw data sets
- Areas of Interest
 - The COP-UT broader extent of COP2014
 - Escalante and Price watersheds

3 Methods used to determine which factors will be used to calculate SA

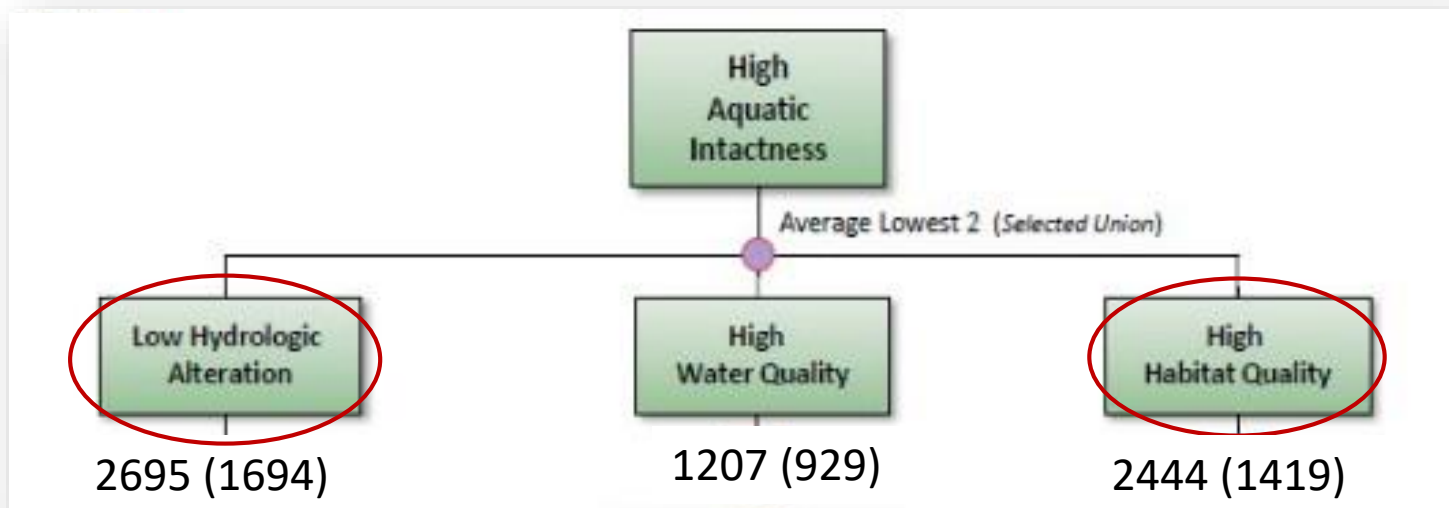
Method 1: Determine the number of HUC 12s influenced by different inputs at each tier of the fuzzy logic model

- For COP2014 – influential factors are Impervious Surfaces, Linear Alterations, Diversions, Agriculture

Key

Influential
factor used in
AI SA

HUC12s
(# HUC12s
resulting in 3 low
AI classes)

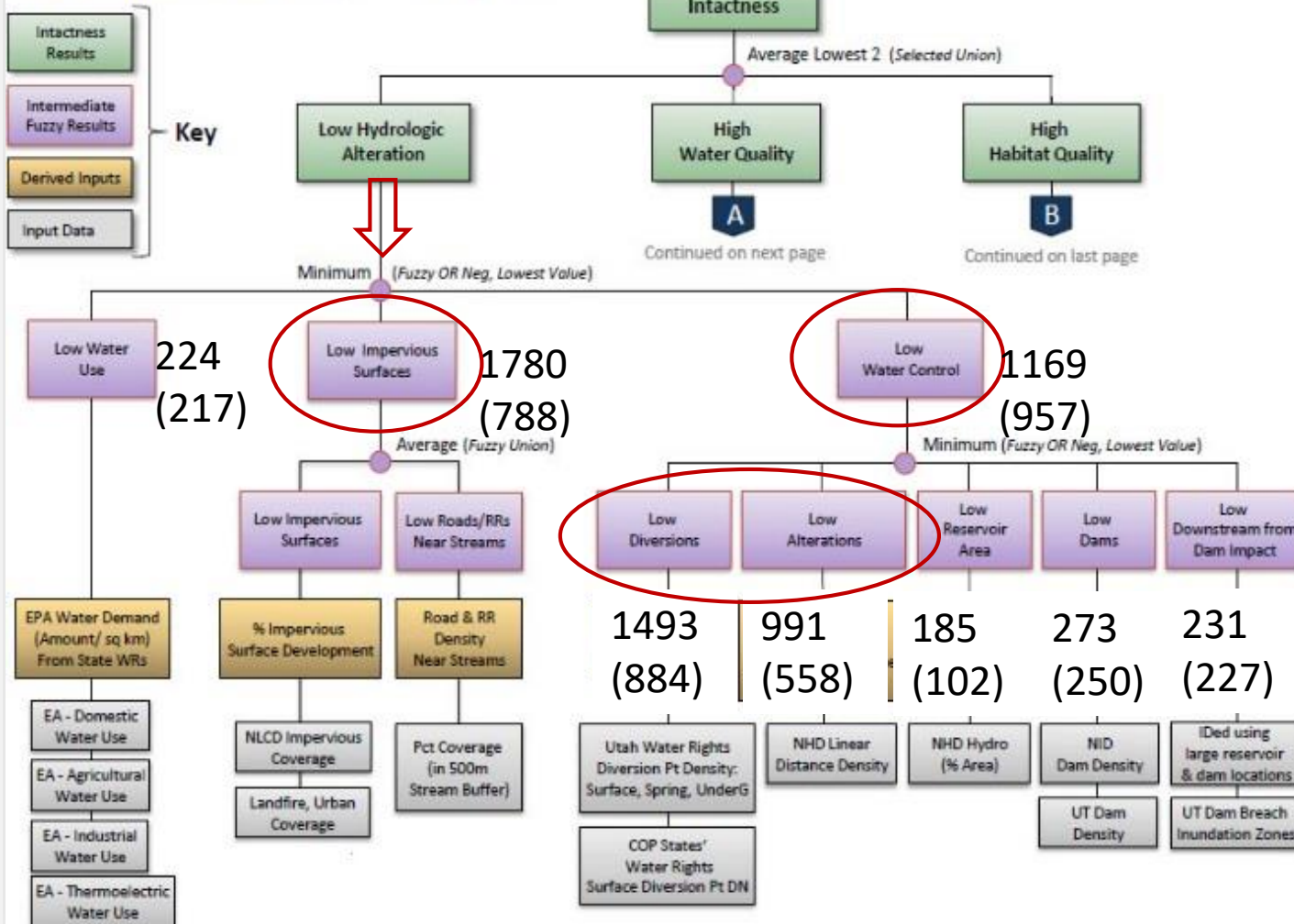


Aquatic Intactness Model

Key

Utah & Colorado Plateau Aquatic Intactness Model, 12-Digit HUC

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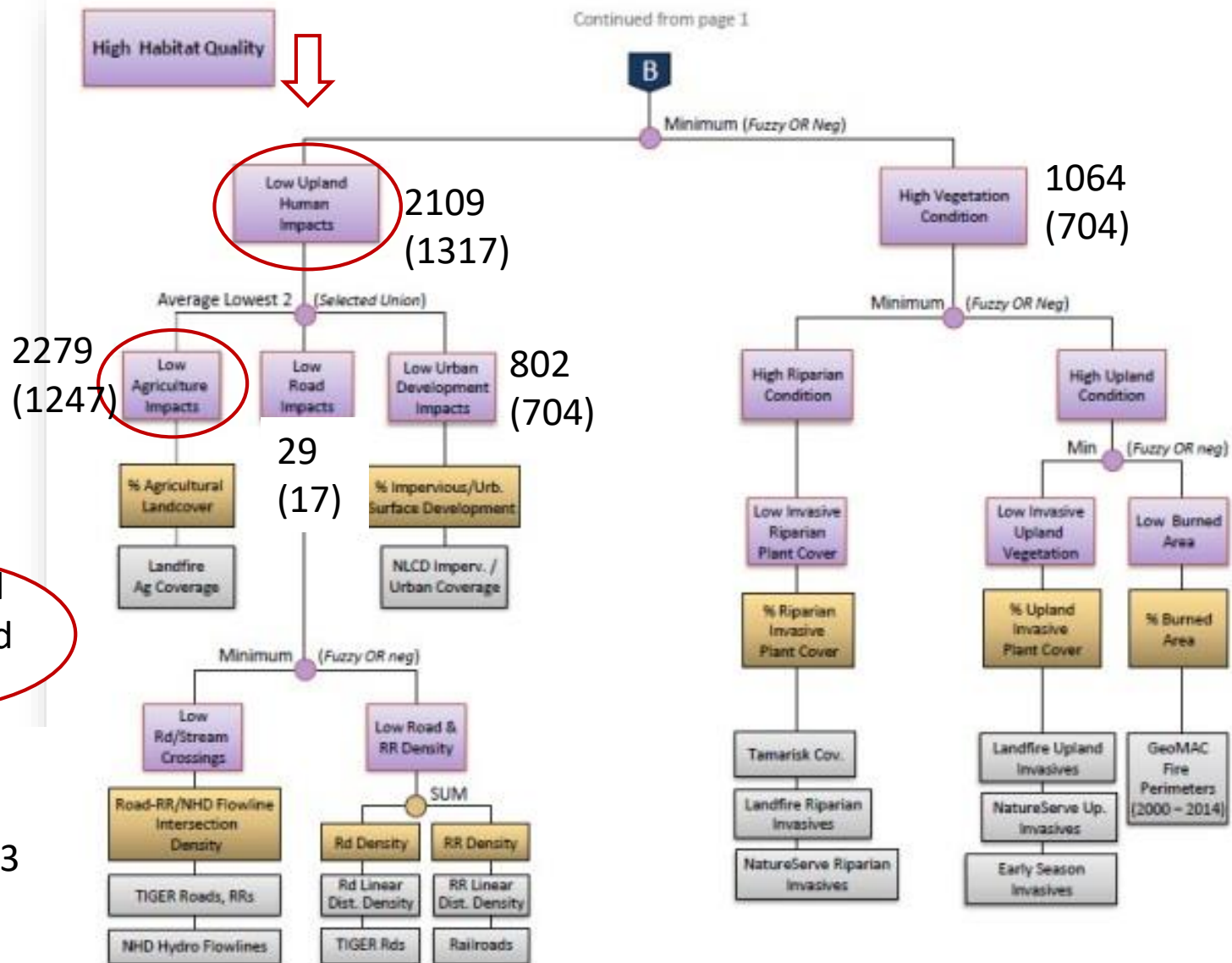
Influential factor used in AI SA

HUC12s
(# HUC12s resulting in 3 low AI classes)

Aquatic Intactness Model

Continued from page 1

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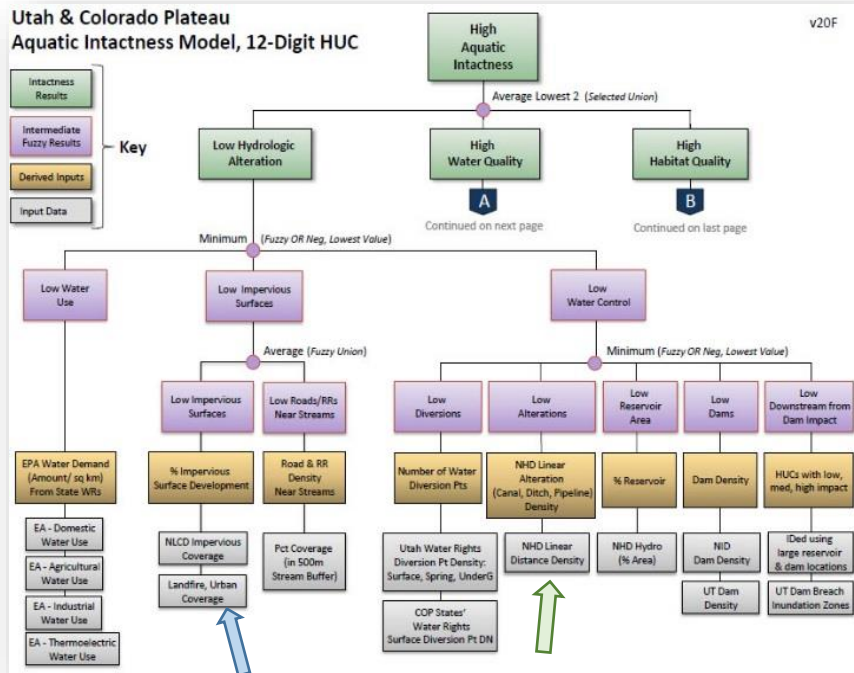


Key

Influential factor used in AI SA

HUC12s
(# HUC12s resulting in 3 low AI classes)

Utah & Colorado Plateau Aquatic Intactness Model, 12-Digit HUC

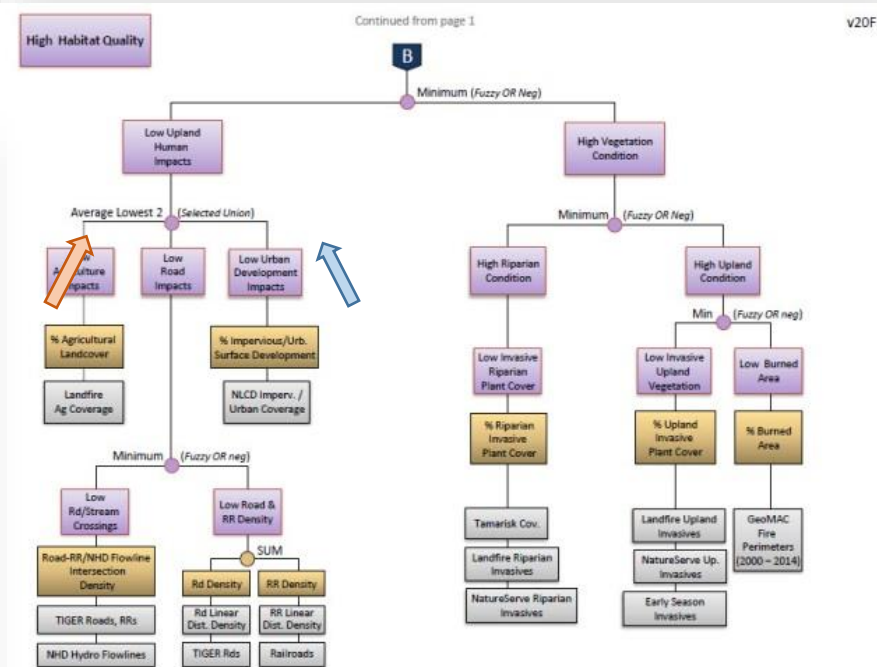
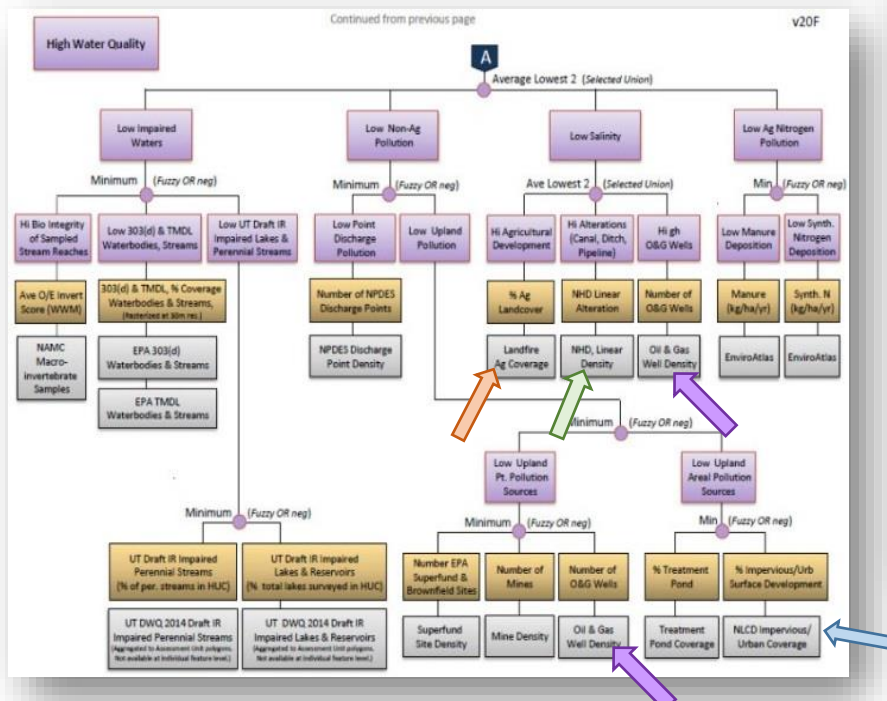


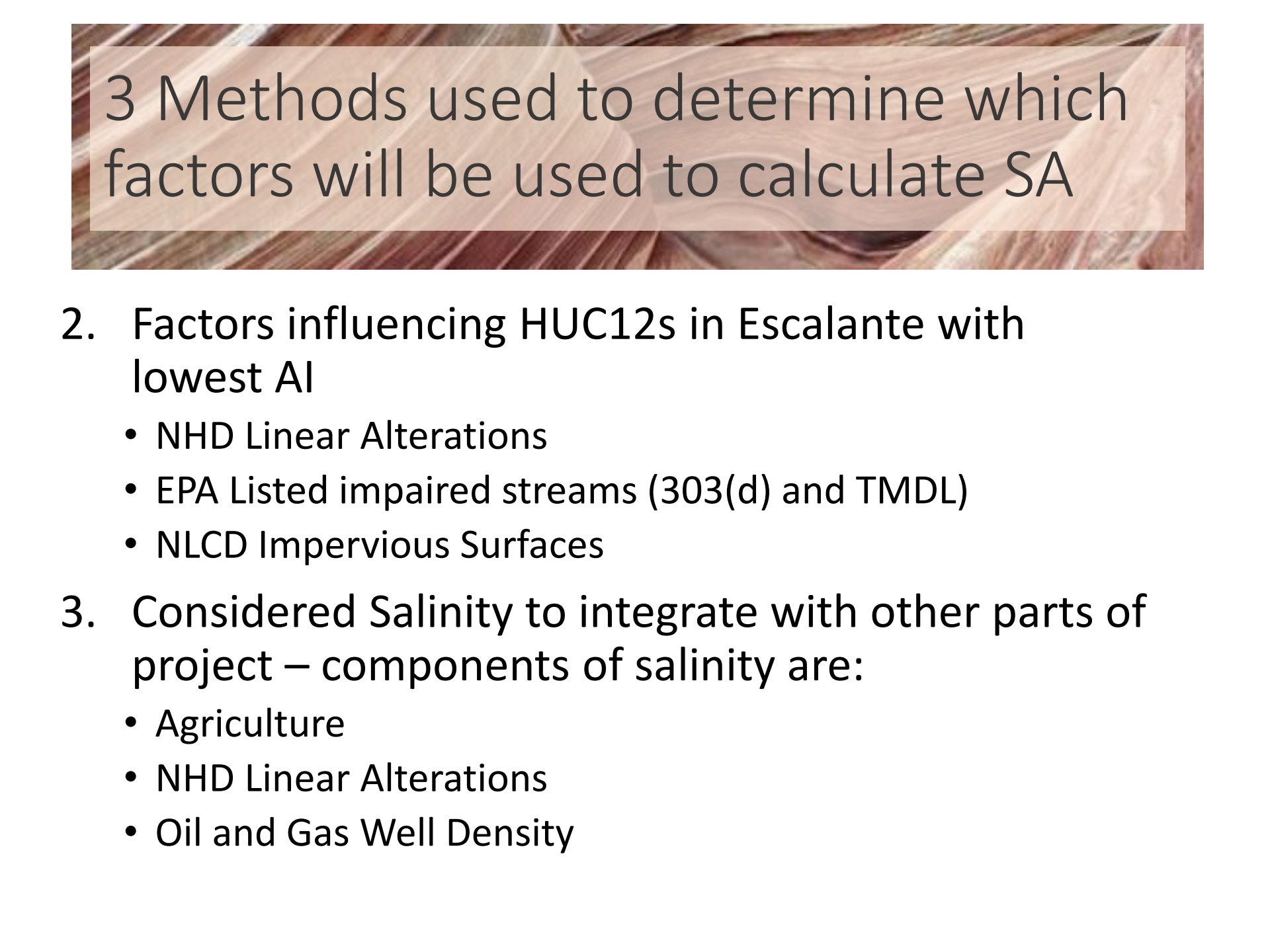
Duplicate inputs are shown using arrows:



impervious agriculture linear alterations oil & gas

When values are varied for an input with duplicates, all duplicates throughout the model are varied by the same amount to simulate reality more closely.



The background of the slide is a photograph of a river with a sandy, light-colored bed and some green vegetation on the banks. A semi-transparent rectangular box is overlaid on the top half of the image, containing the title text.

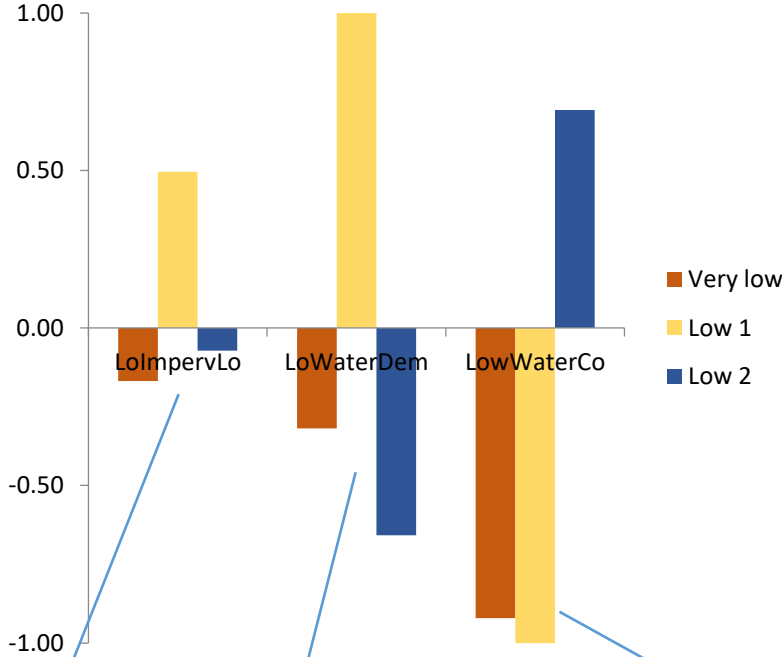
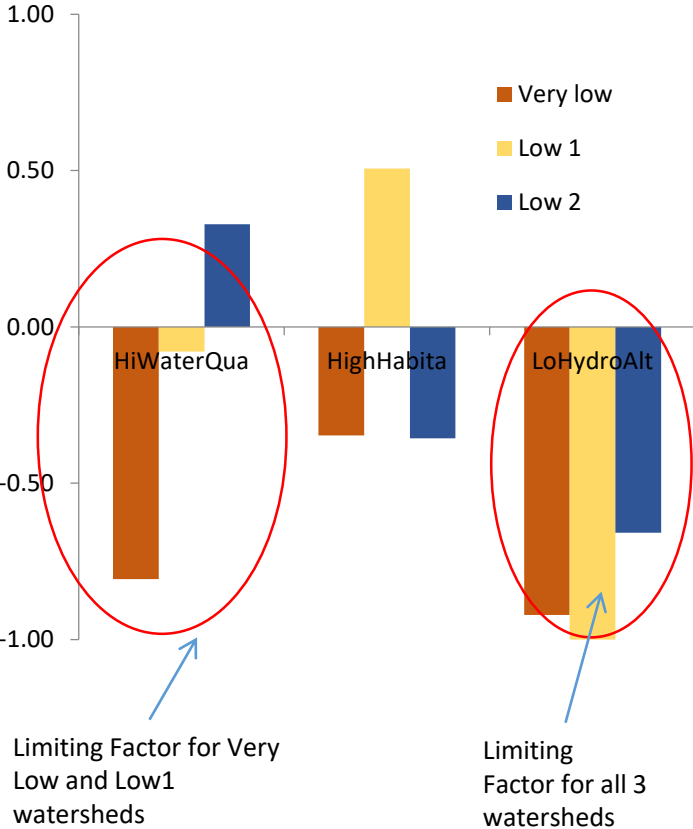
3 Methods used to determine which factors will be used to calculate SA

2. Factors influencing HUC12s in Escalante with lowest AI
 - NHD Linear Alterations
 - EPA Listed impaired streams (303(d) and TMDL)
 - NLCD Impervious Surfaces
3. Considered Salinity to integrate with other parts of project – components of salinity are:
 - Agriculture
 - NHD Linear Alterations
 - Oil and Gas Well Density

AI Component values for 3 HUC 12s with lowest AIs in Escalante

AI Components: Water Quality, Habitat, and Hydrologic Alterations

Hydro Alterations Components:
Impervious Surfaces, Water Demand/Use, Water Control



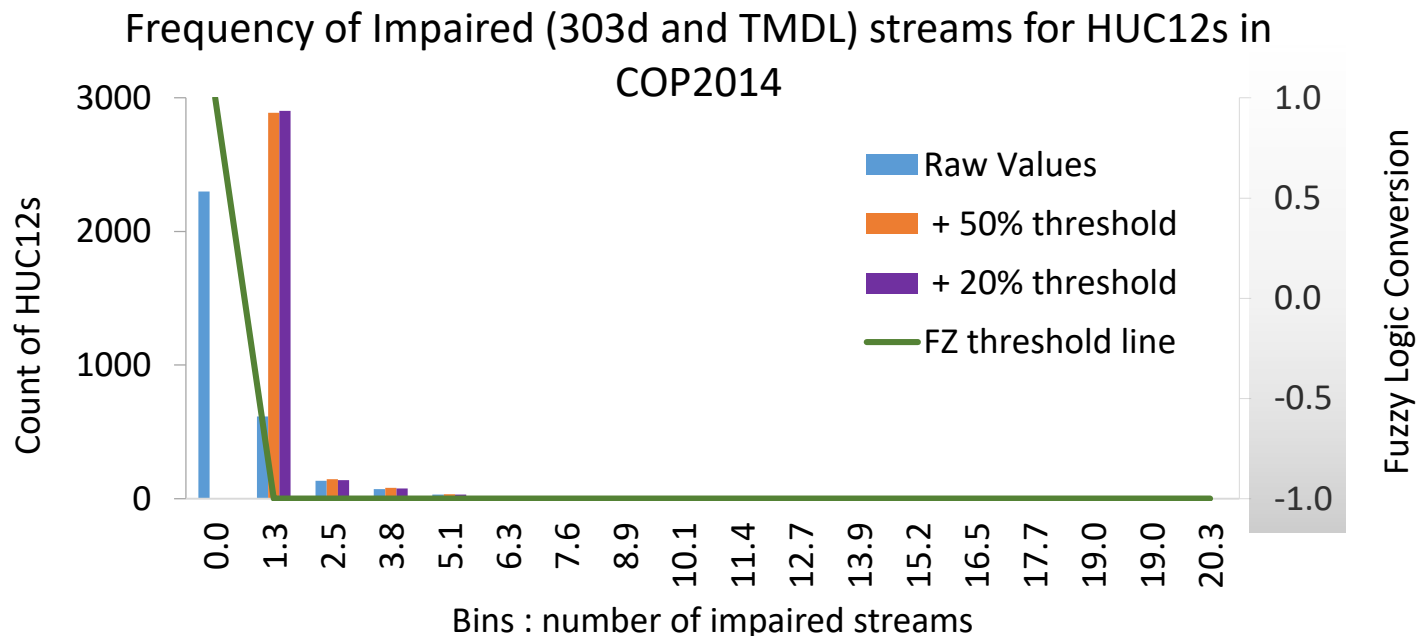
Impervious Surfaces & Roads & Railroads near Streams

Water Demand: Domestic, Ag, Ind, Thermoelectric

Water Control: Diversions, Alterations, Reservoir Area, Dams, Downstream of Dam

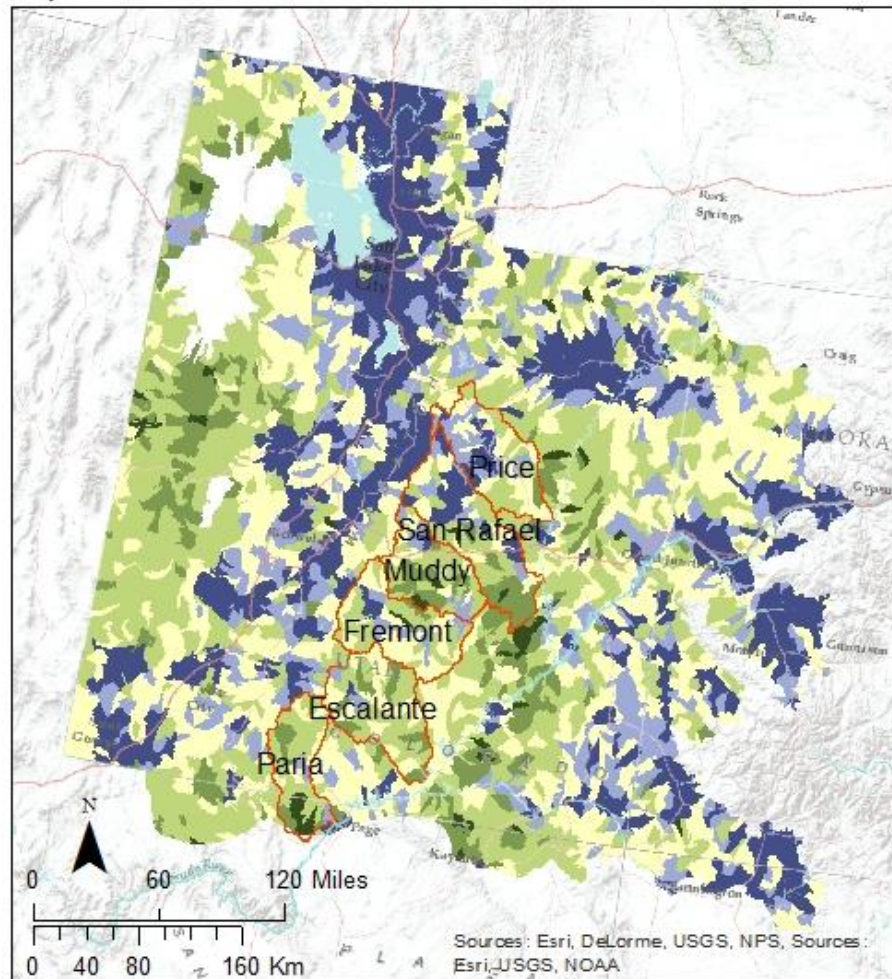
Methods considered for SA

- $\pm X\%$ of the raw data (many 0's and -ve values)
- ± 1 std dev of raw data (not normally distributed)
- Found nothing specific to FZ logic models in the scientific lit
- $\pm 20\%$ & $\pm 50\%$ of value of raw data at false threshold

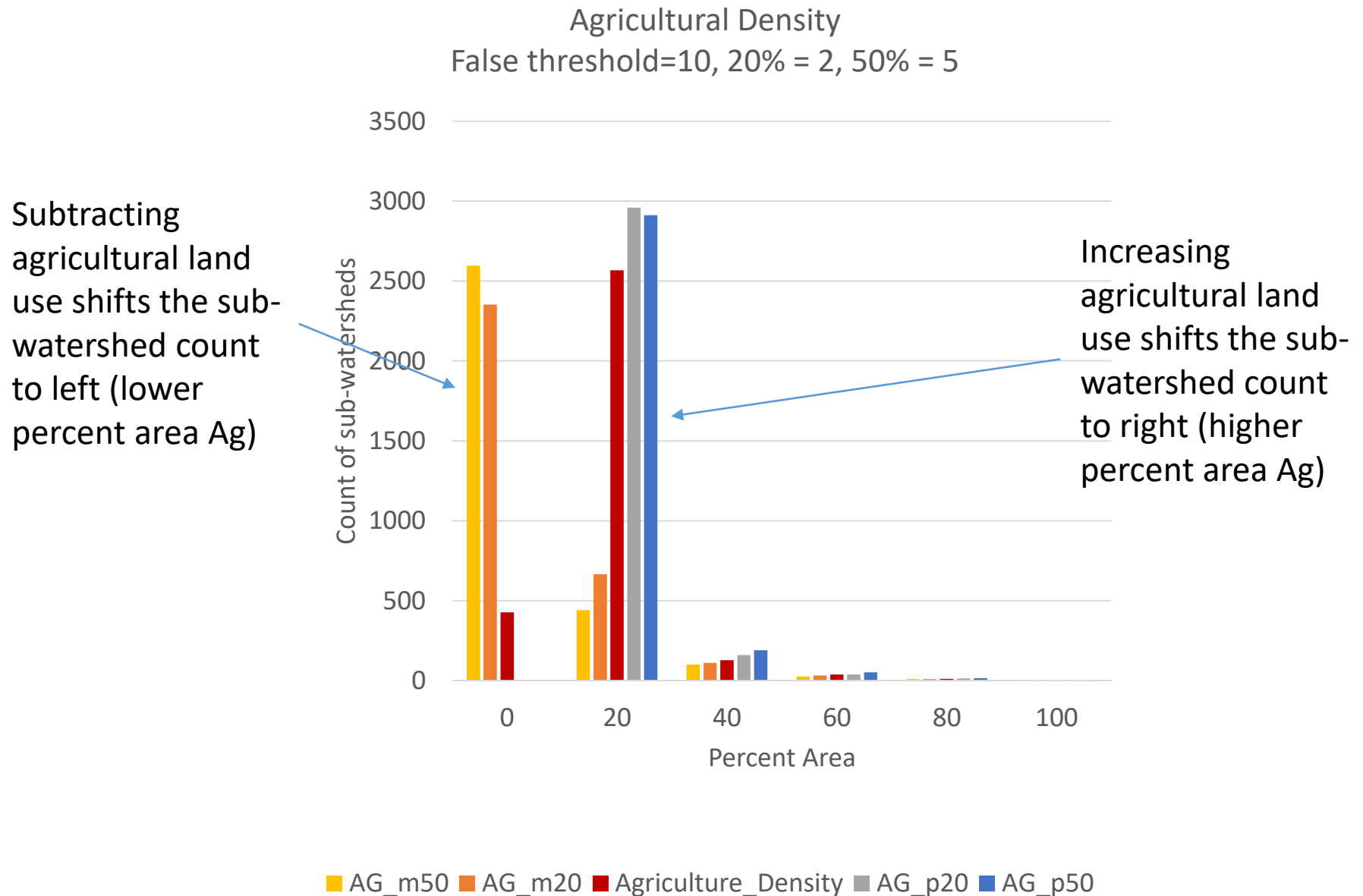


COP 2014 Aquatic Intactness

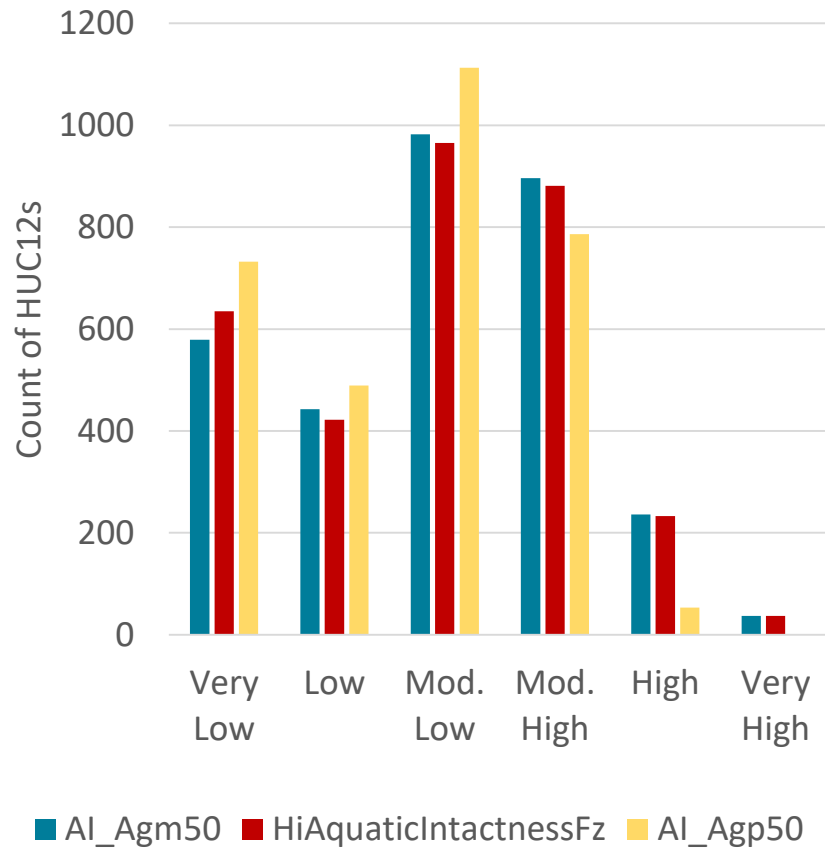
Aquatic Intactness



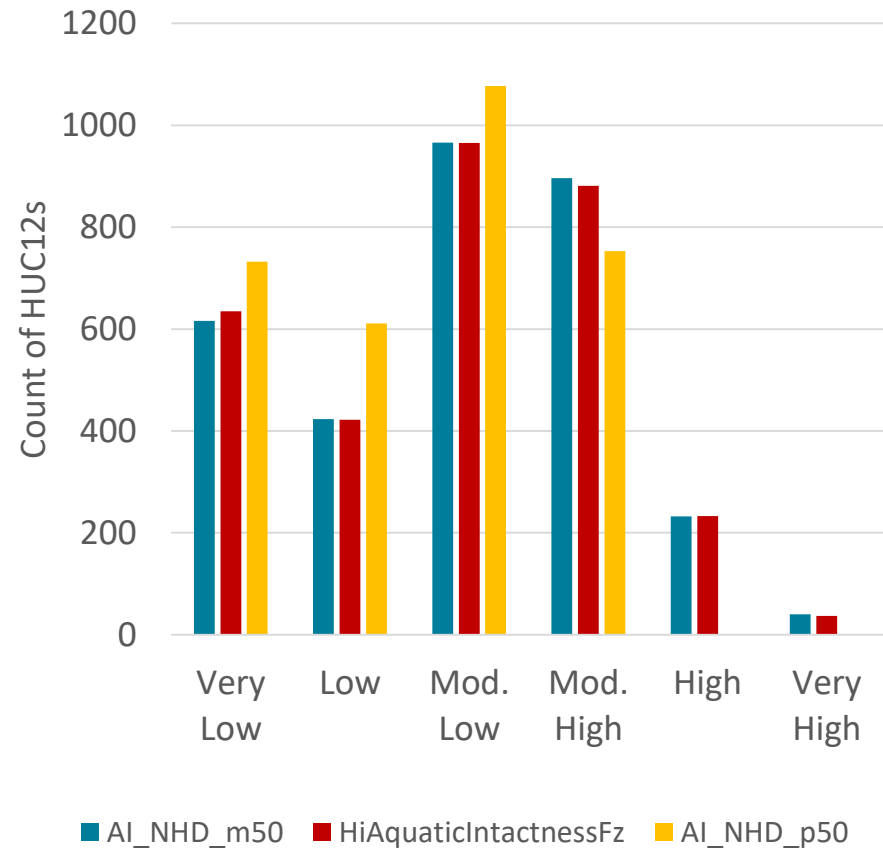
Raw data $\pm 20\%$ and $\pm 50\%$ false thresholds



COP2014 AI Sensitivity Analysis NHD Agriculture $\pm 50\%$

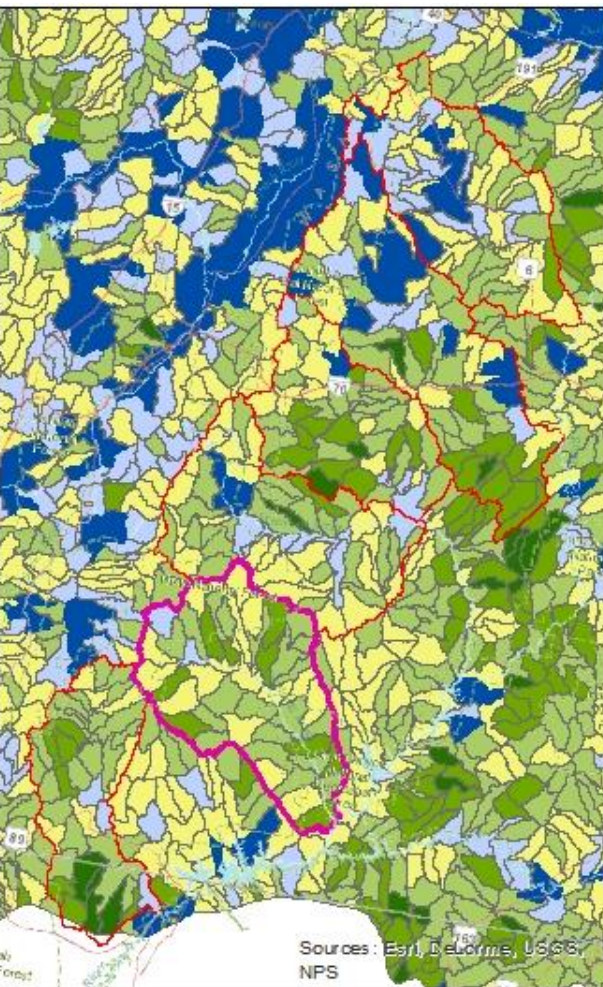


COP2014 AI Sensitivity Analysis NHD Linear Alterations $\pm 50\%$

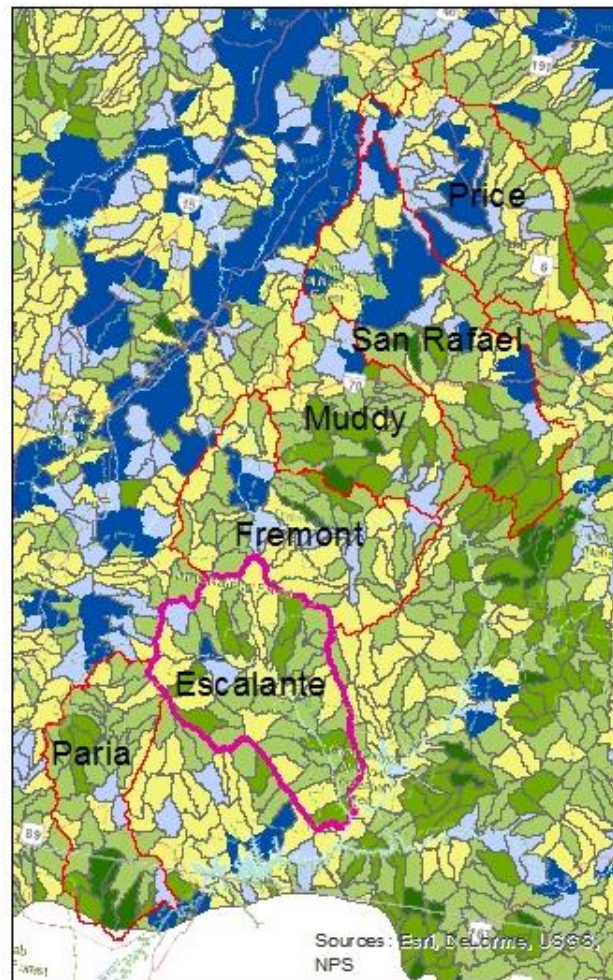


Effects of modelled changes in agriculture on AI

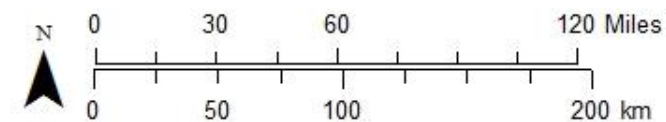
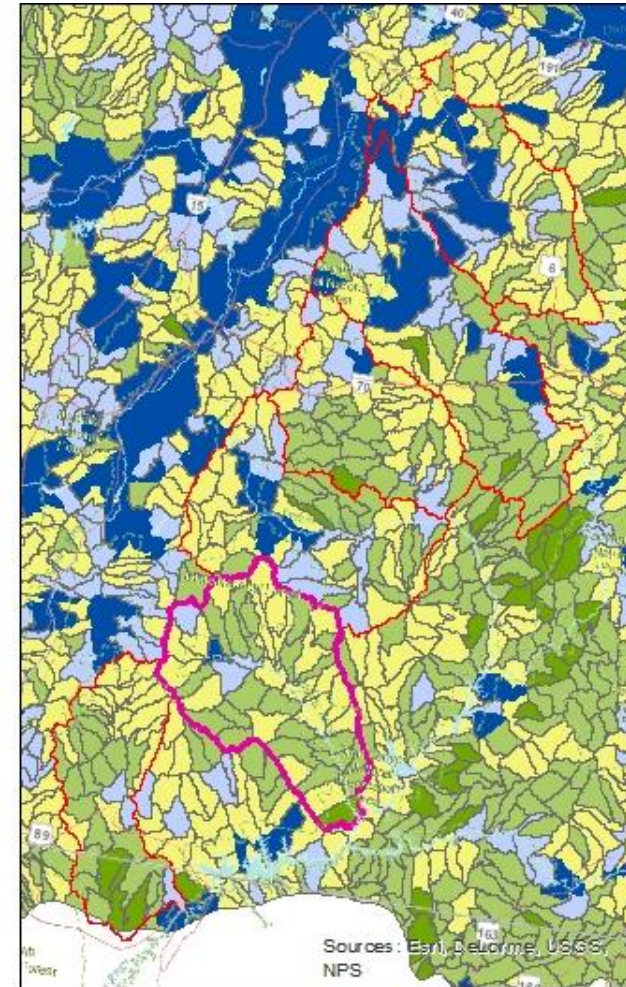
Agriculture -50%



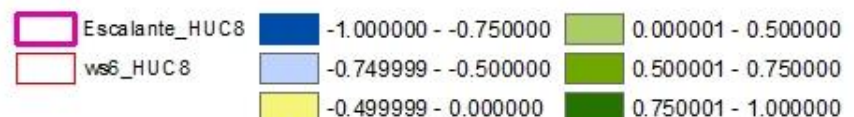
Original Agriculture Values



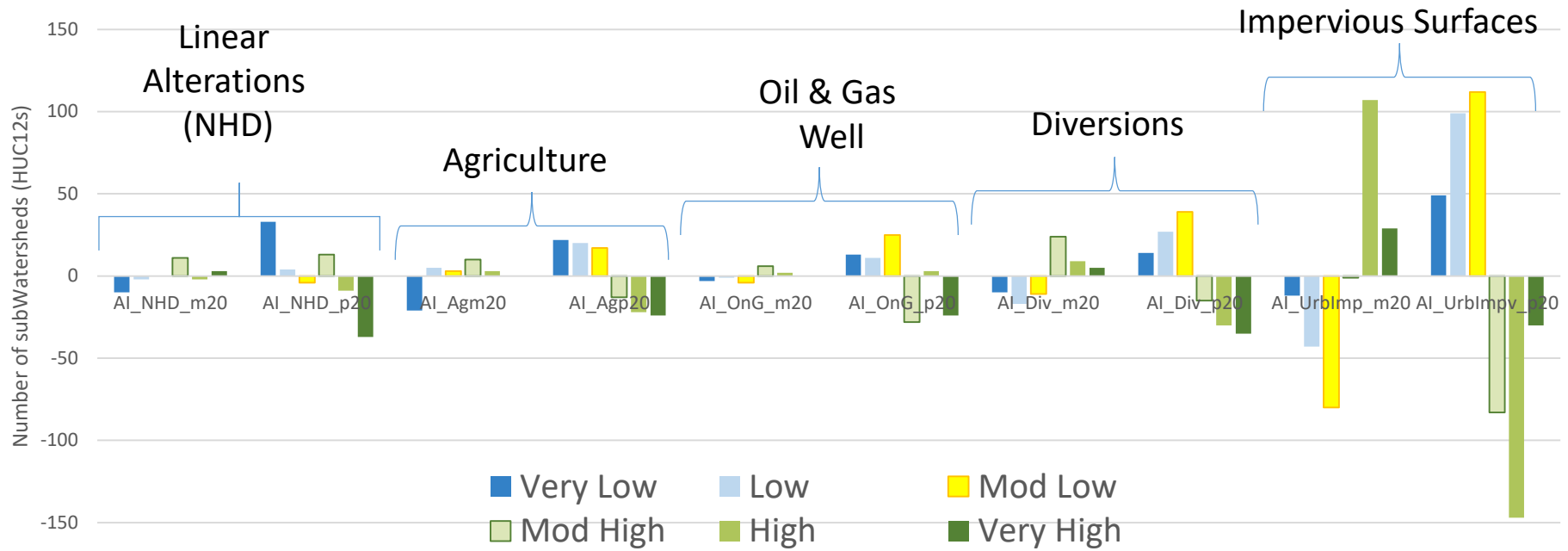
Agriculture +50%



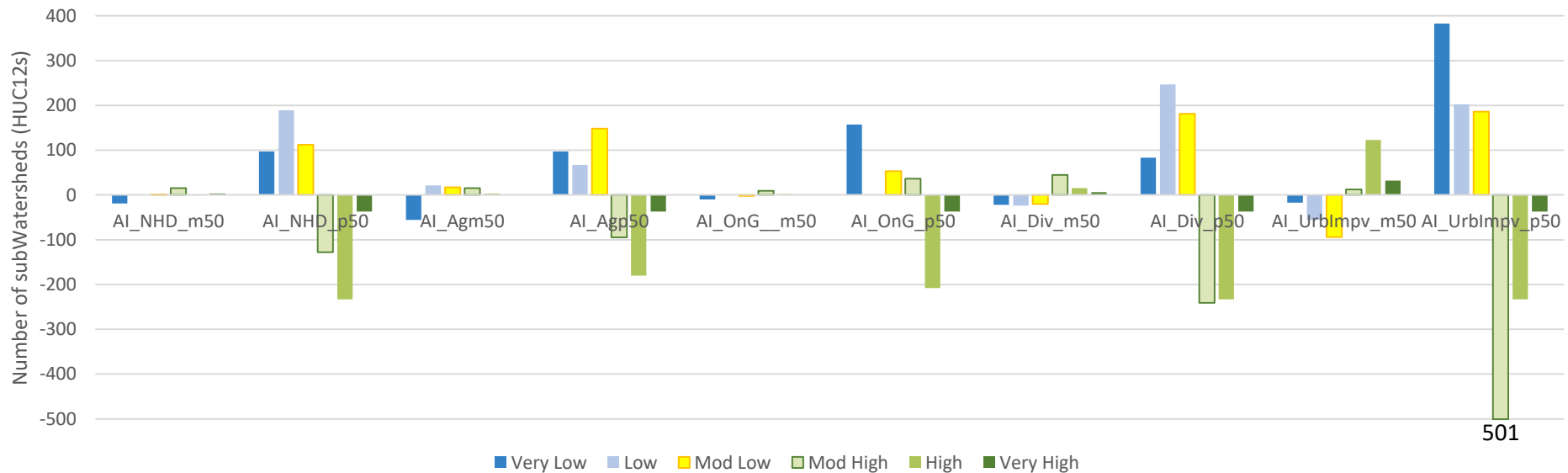
Aquatic Intactness



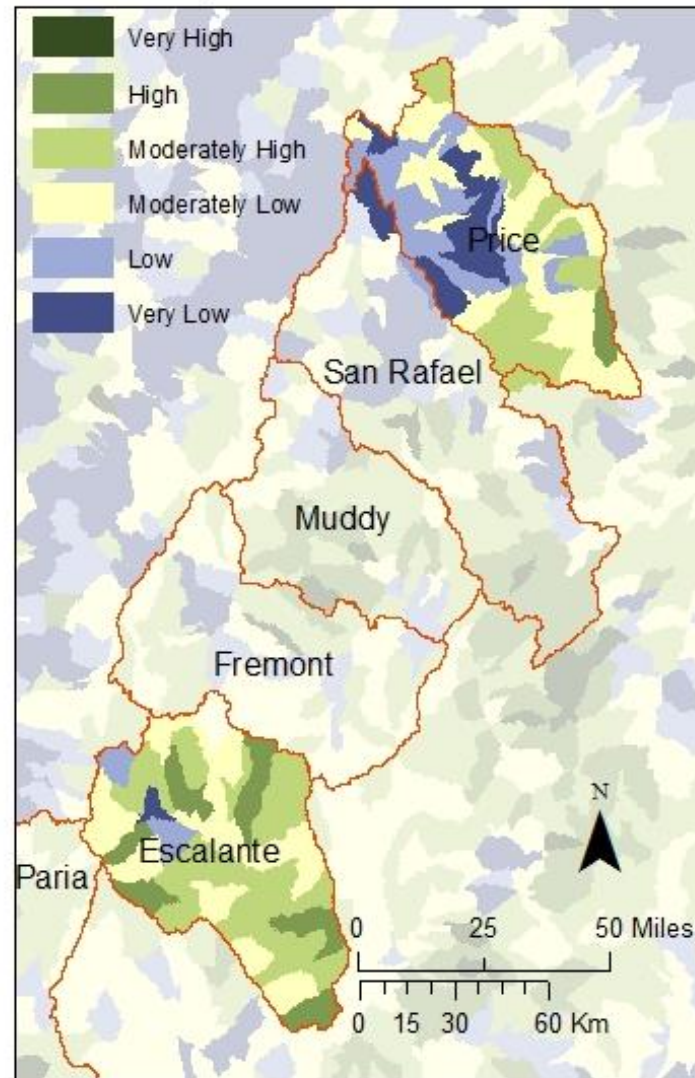
Changes in Number of HUC12s in AI classes after $\pm 20\%$ adjustments



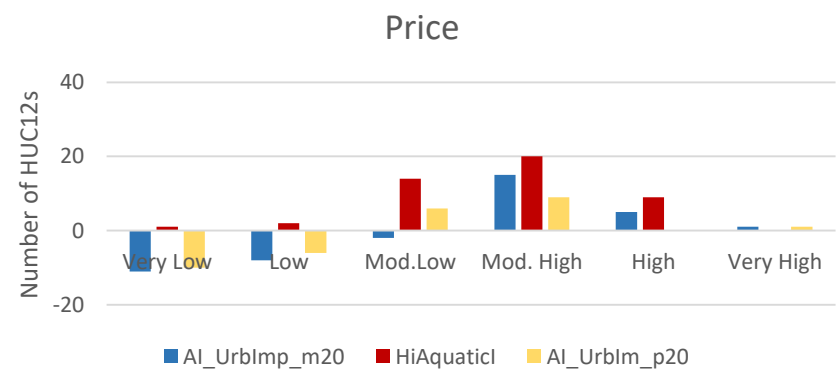
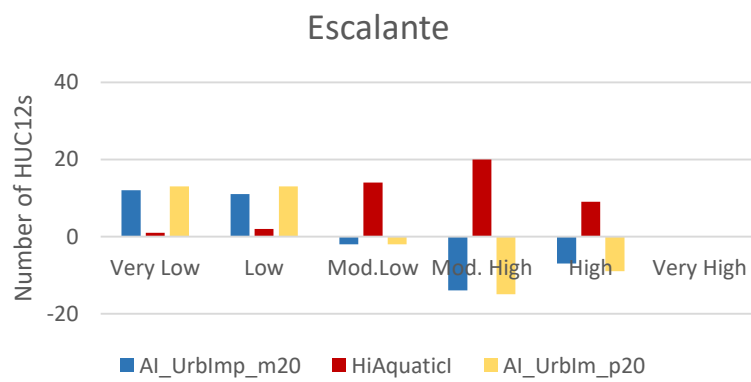
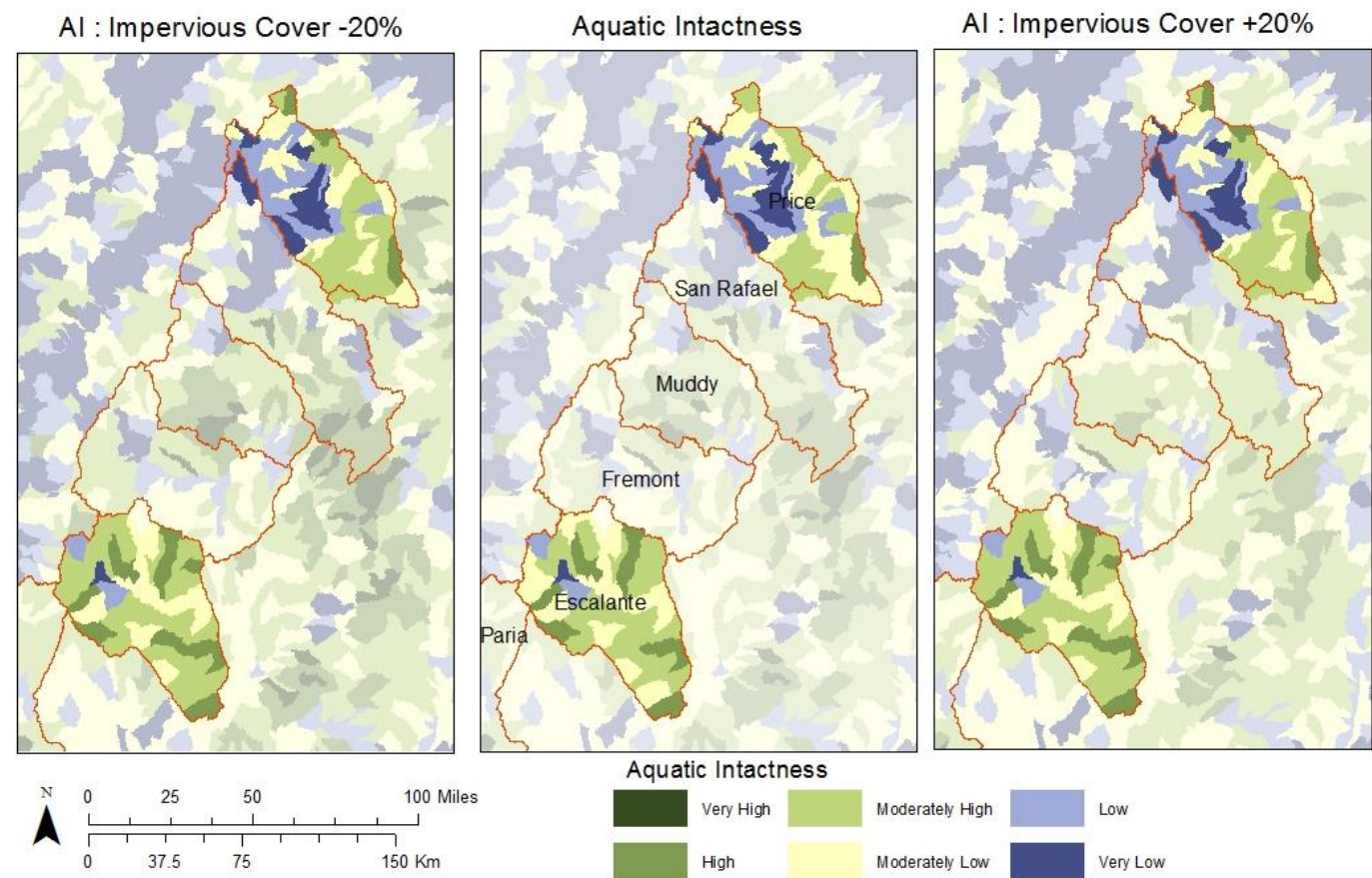
Changes in Number of HUC12s in AI classes after $\pm 50\%$ adjustments



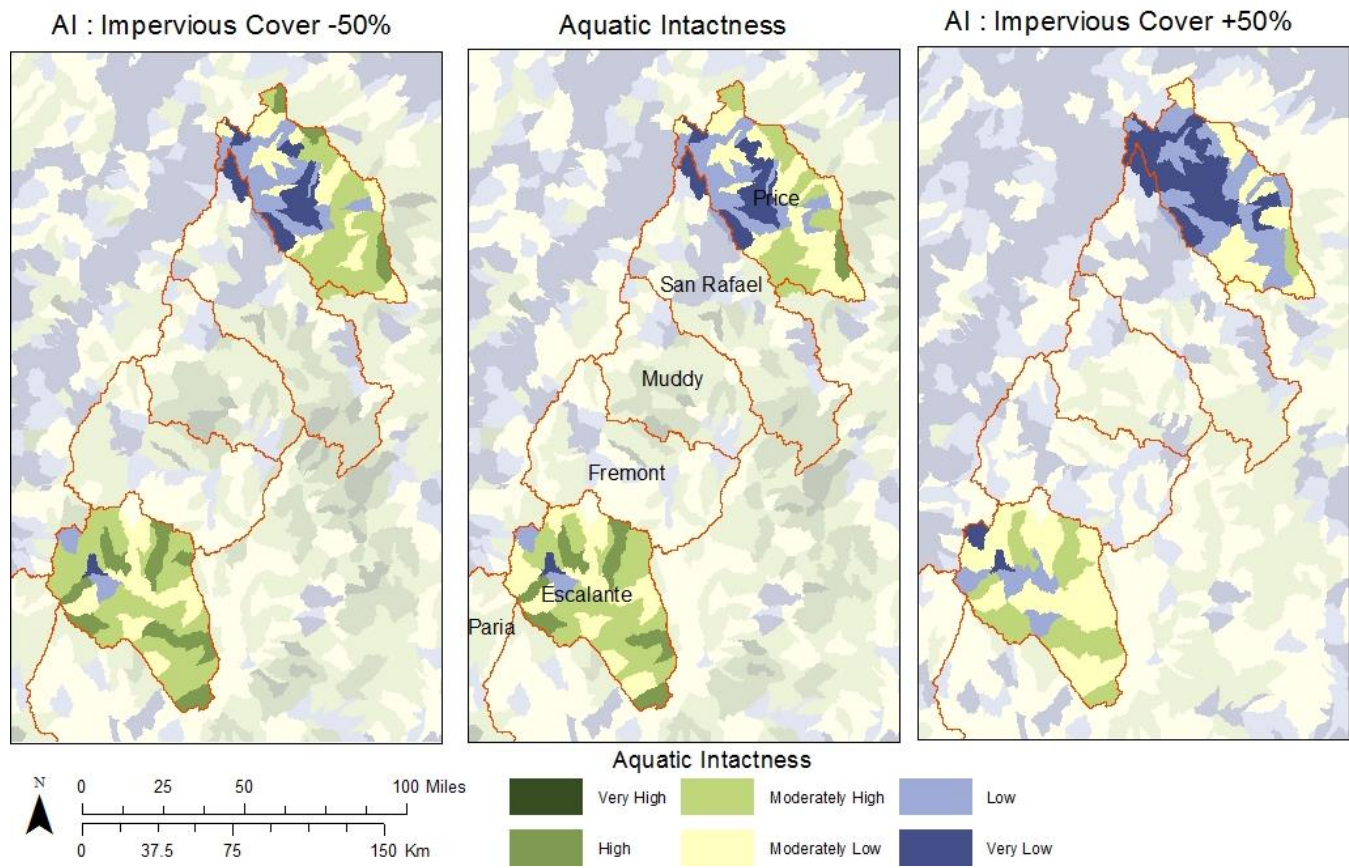
AI Comparison of Escalante and Price 4th field HUCs



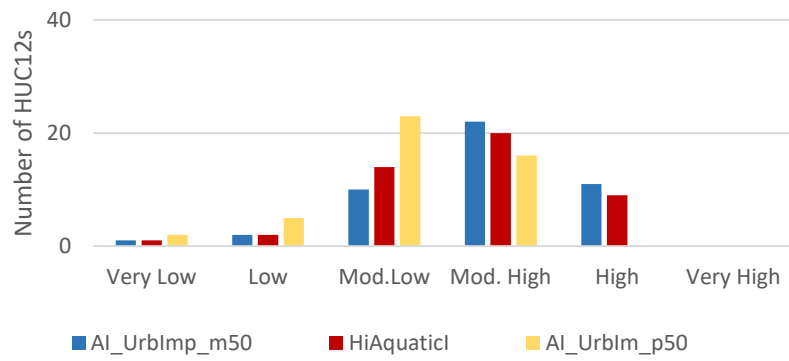
Changes in AI due to $\pm 20\%$ adjustments: Impervious Surfaces



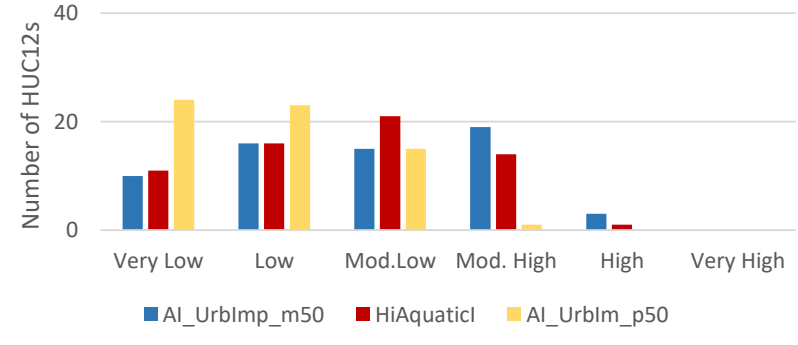
Changes in AI due to $\pm 50\%$ adjustments: Impervious Surfaces



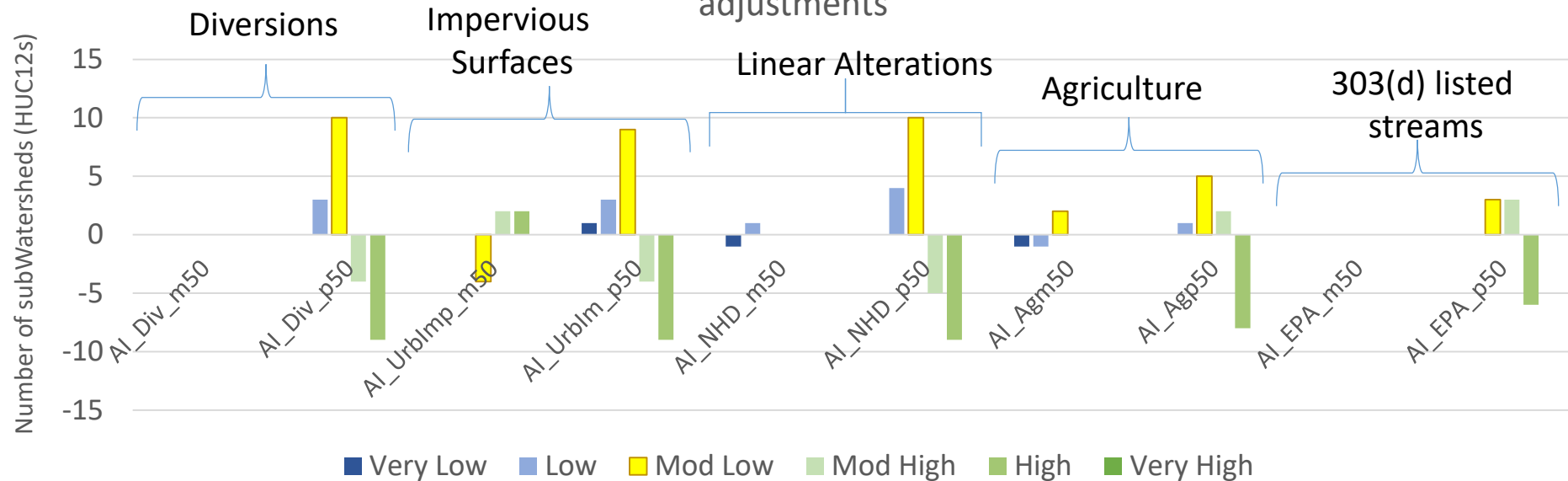
Escalante



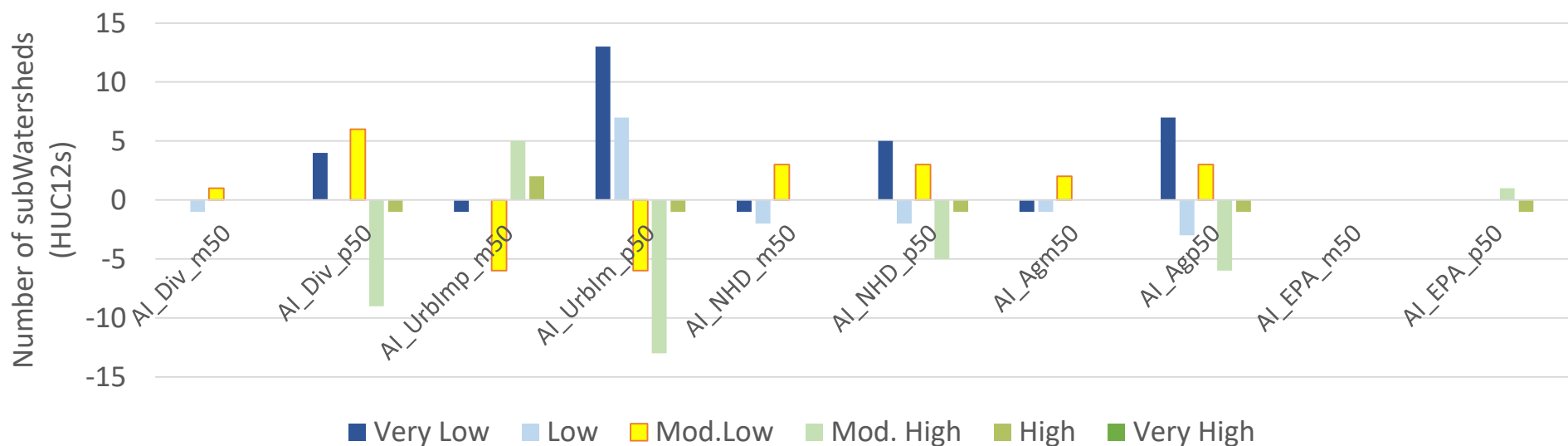
Price



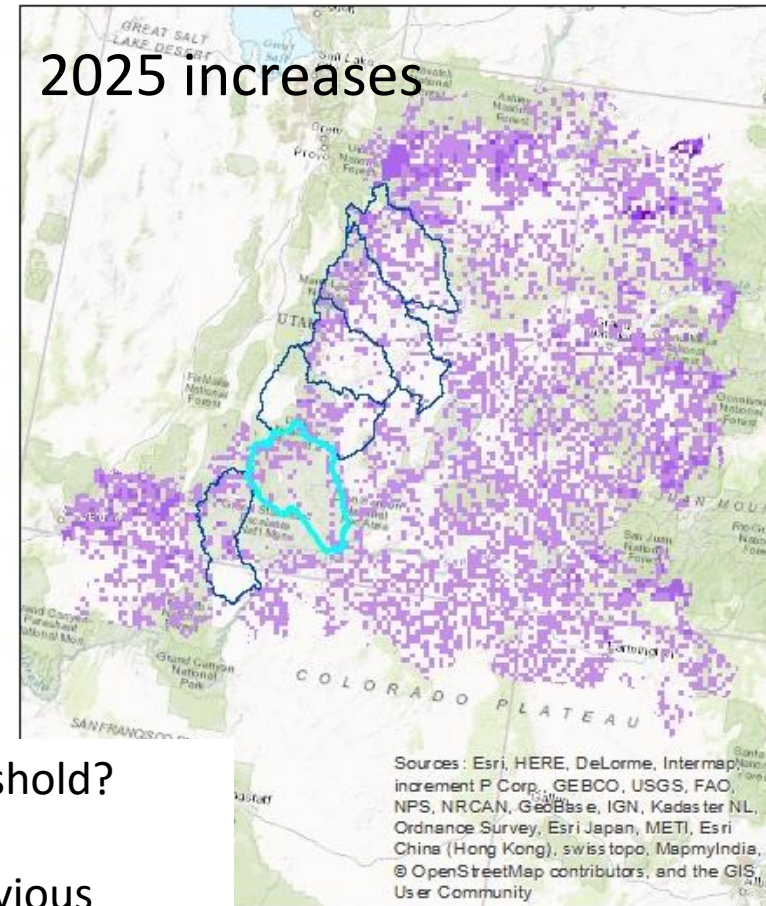
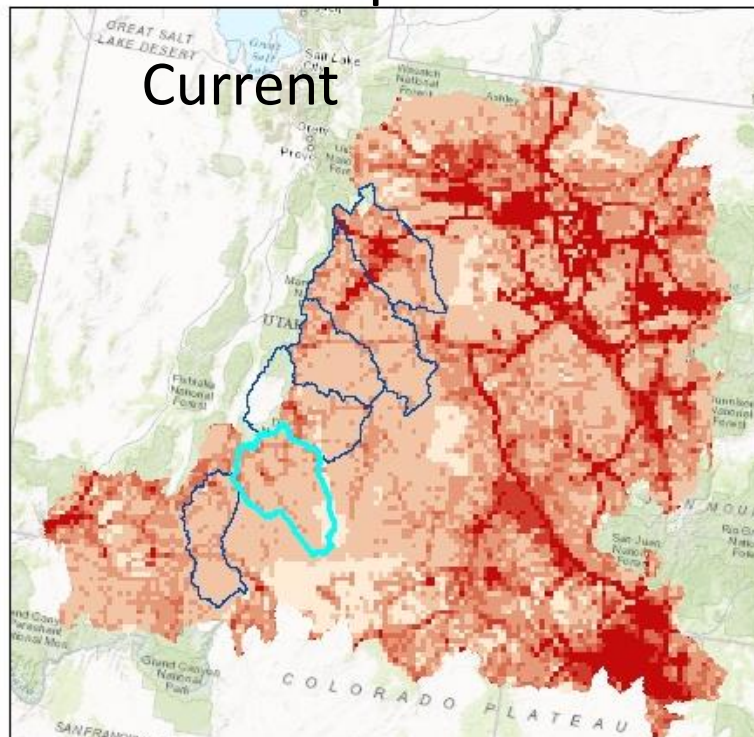
Escalante Watershed: Changes in Number of HUC12s in AI classes after $\pm 50\%$ adjustments



Price Watershed: Changes in Number of HUC12s in AI classes after 50% adjustments



Reality Checking the Sensitivity Analyses using Urban Expansion Data



- How realistic are increases of 20% and 50% over threshold?
 - Are they too large? Too small?
 - Data changes = 70% and 170% increase in impervious cover/sub-watershed
- COP 2010 REA (2025) urban expansion:
 - Increased by up to 3%
- Much smaller changes predicted v. used in SA



Altering Operators in the AI model

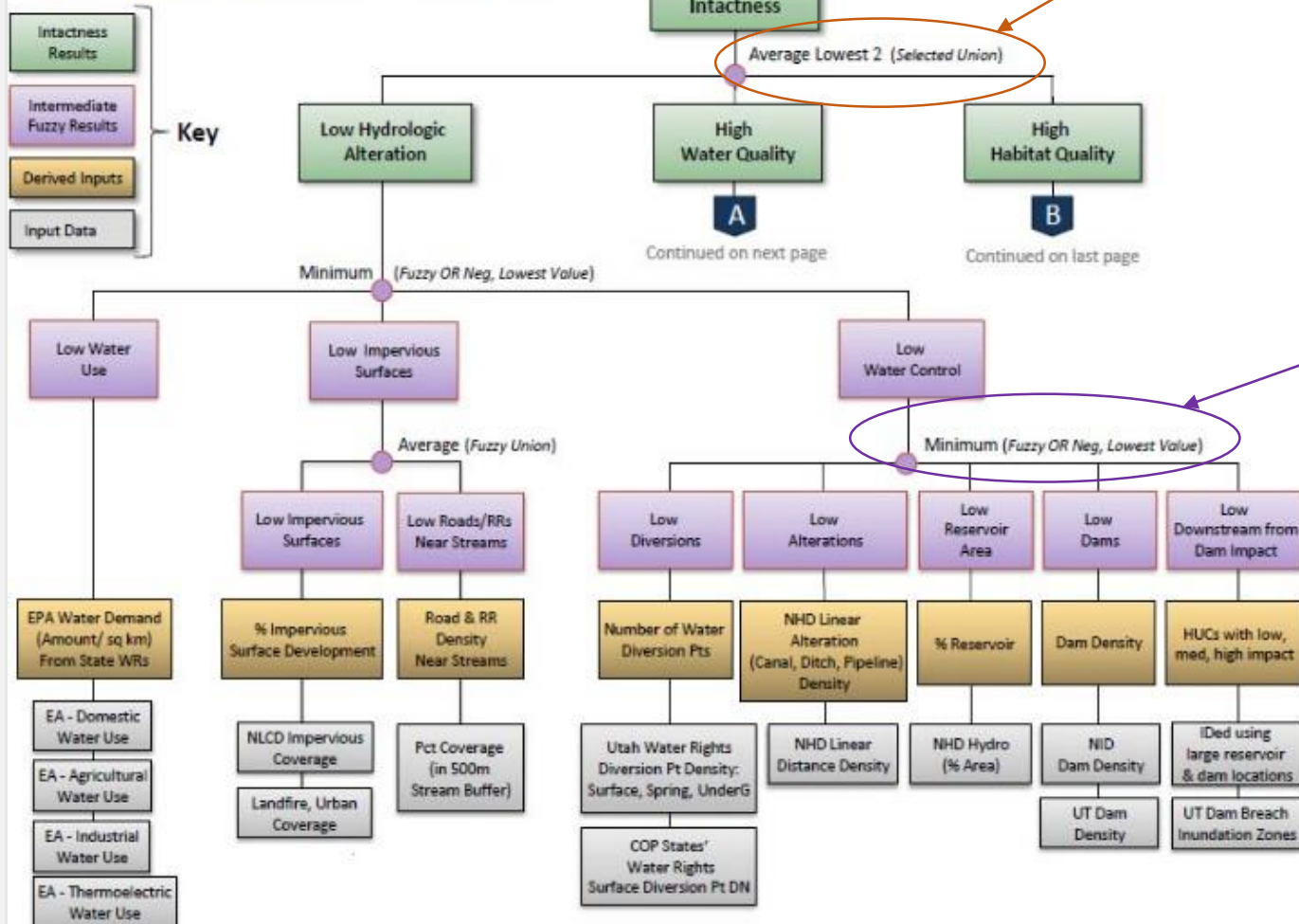
- AI model is generic i.e., not specific to any species
- Across the model many operators are averages, accounting for several different types of inputs
- Operators can be changed to emphasize inputs that affect certain species
- We changed 2 operators to test how the model responds...

How does the AI model respond to 2 altered operators?

Changed to the minimum of input factors

Utah & Colorado Plateau Aquatic Intactness Model, 12-Digit HUC

v20F

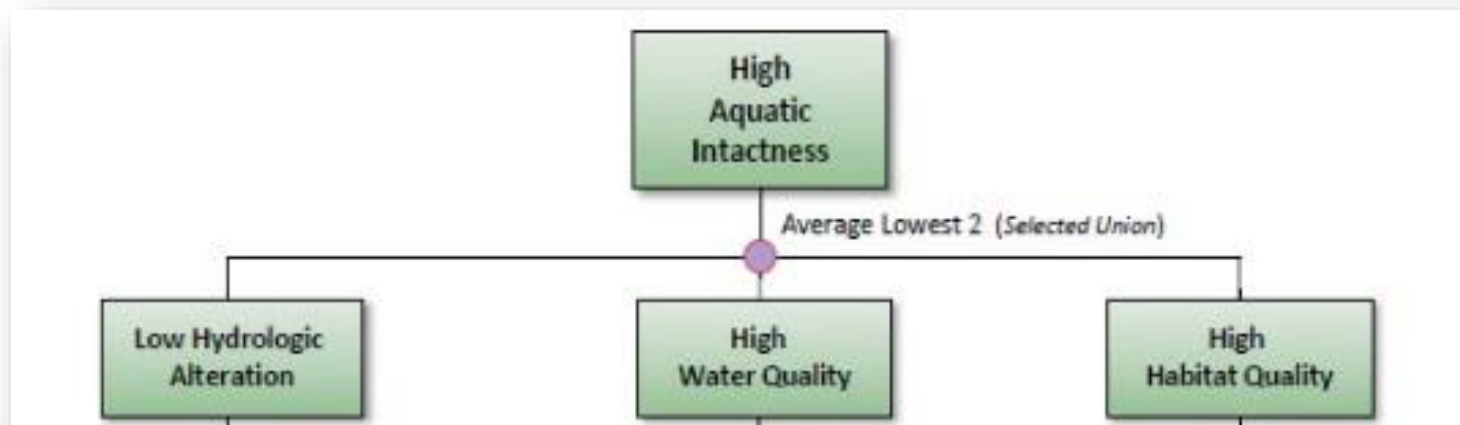


Changed to the average of 2 lowest input factors

Examples of Fuzzy Logic Operators (1 of 2)

- Selected Union

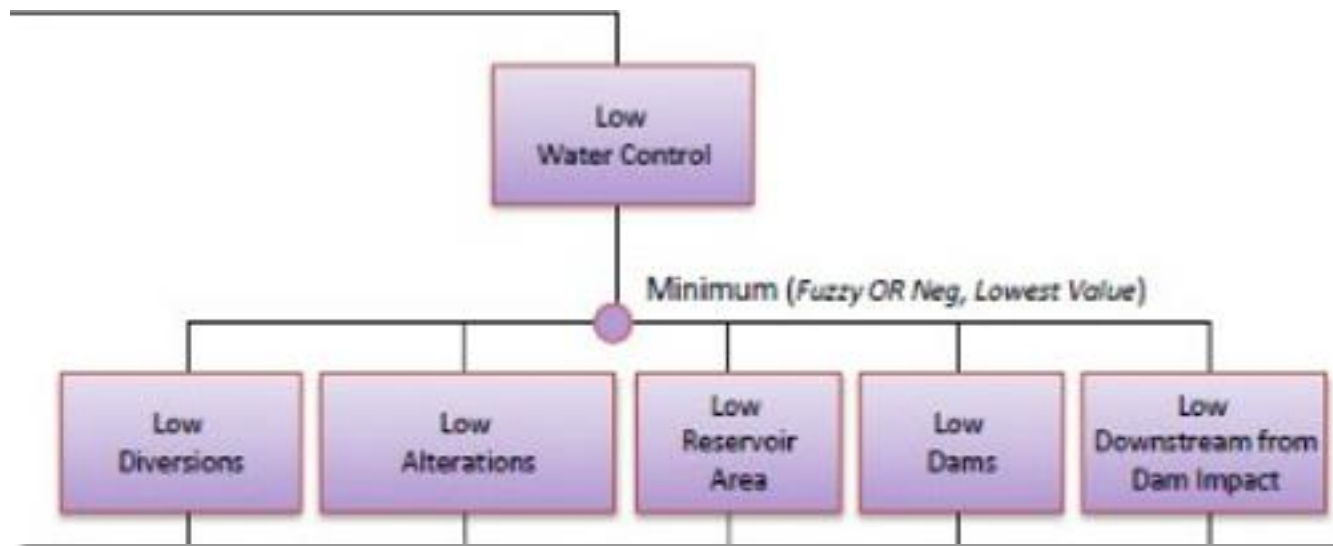
- Averages a subset of several inputs
- Use when some of several input conditions (but not all) may influence an output condition
- Average calculation may moderate more extreme inputs
- Changed to the minimum of the 3 input factors



Examples of Fuzzy Logic Operators (2 of 2)

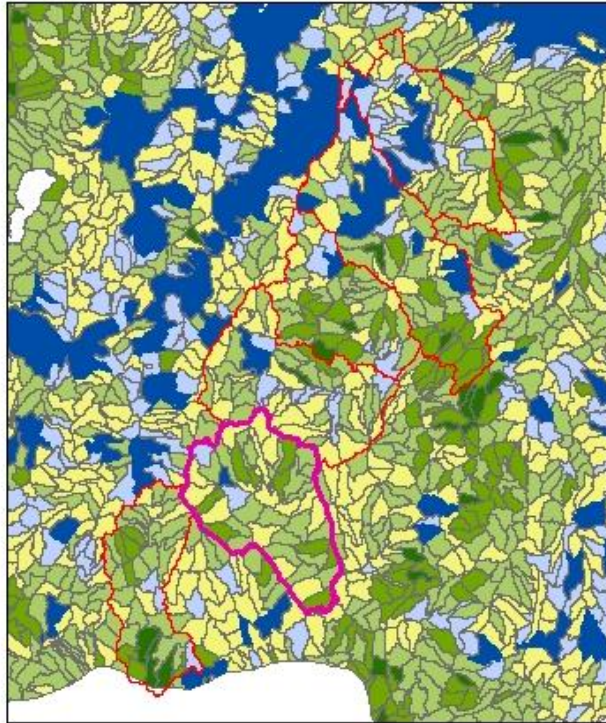
- Fuzzy Or Neg

- Gets the minimum value of a list of inputs
- Use when all inputs contribute to the output condition
- May result in more extreme low values
- Changed to the average of 2 lowest input factors

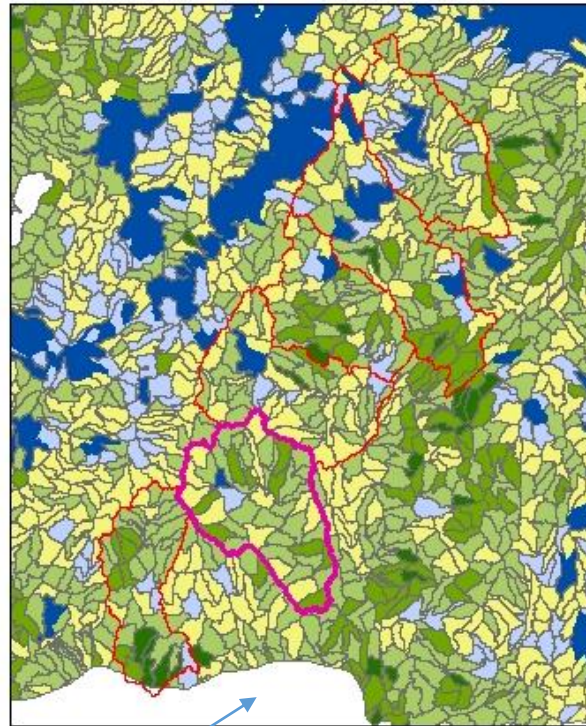


How does the AI model respond to 2 altered operators?

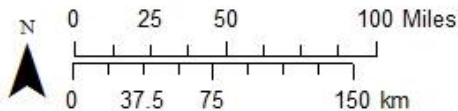
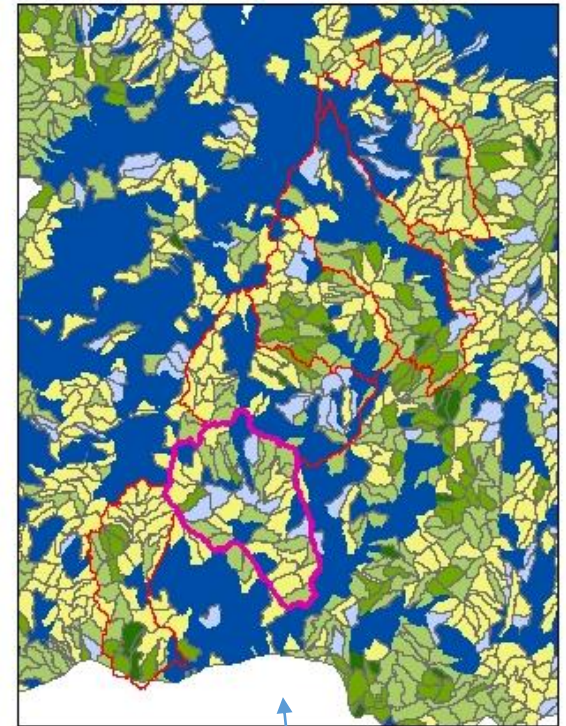
Aquatic Intactness



Aquatic Intactness- Select Union



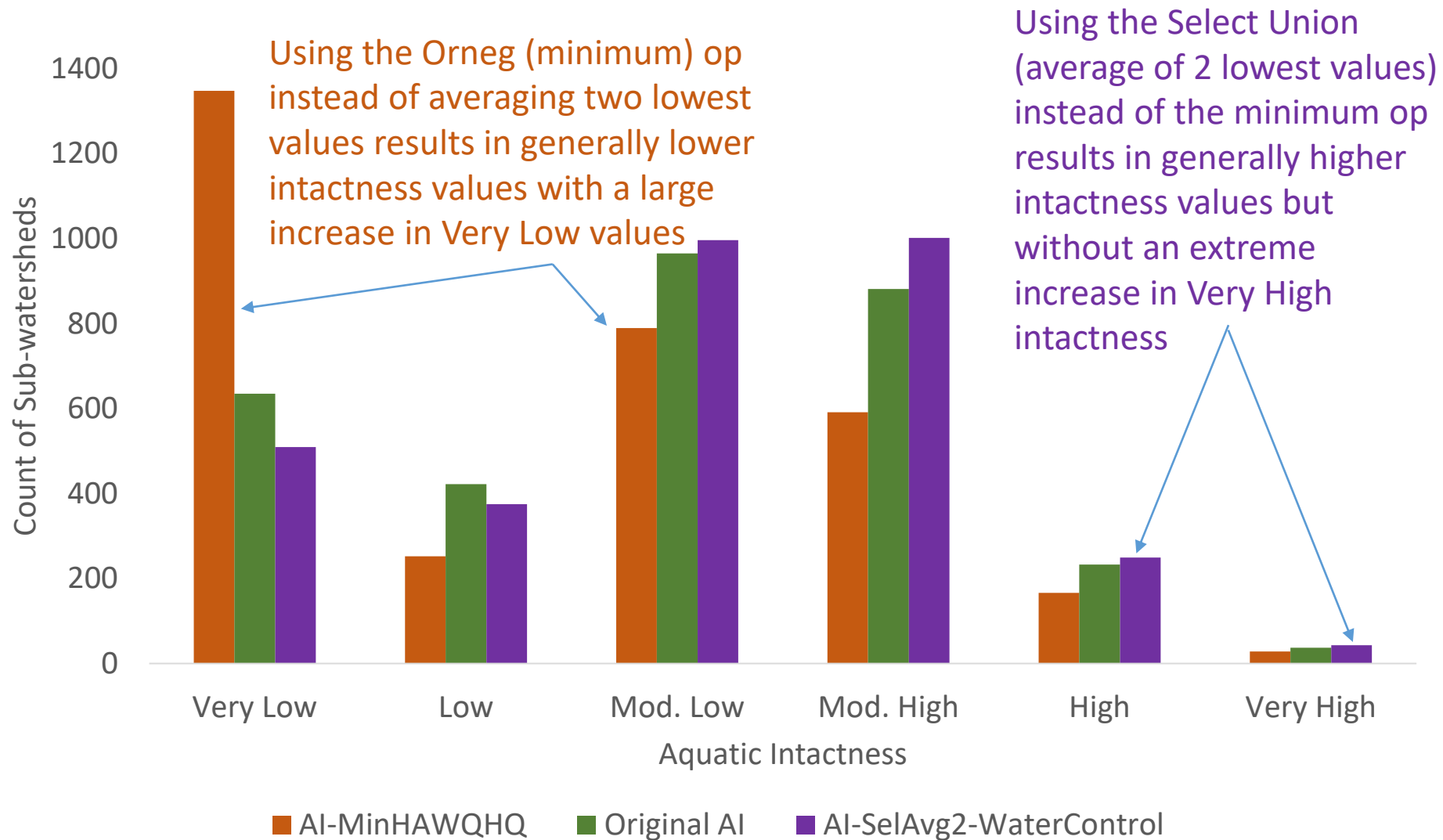
Aquatic Intactness - OrNeg



A few sub-watersheds at higher Intactness (greens); fewer lower intact watersheds (blues) – less extreme results

Many more sub-watersheds at Very Low Intactness (blues) – more extreme results

How does the AI model respond to 2 altered operators?
- check out the number of sub-watersheds in each intactness class





What does it all mean?

- **Assumptions** are complex but helpful to get to know the model in detail, understand model stability, what we can change in the SA
- **SA** process may be useful for exploring scenarios of alternative land uses
 - i.e., early loss of highly intact watersheds may indicate the need for conservation or a different alternative
- **Reality Check:** The SA changes of 20% and 50% over threshold are unlikely to occur but they indicate model stability and robustness to very large changes
- Intactness is a generic tool useful at broad scales – basin or regional
 - It may be altered to be species-specific



The End