

Escalante Watershed

Aquatic Intactness and Terrestrial Intactness

COP 2014 REA data

Objectives

1. ID areas of low, moderate and high intactness
2. ID limiting factors for areas of low intactness
3. ID areas with similar intactness scores and limiting factors

Start at slide 39 for explanations of data access, fuzzy logic modelling – model diagrams, logic operators, and data conversion

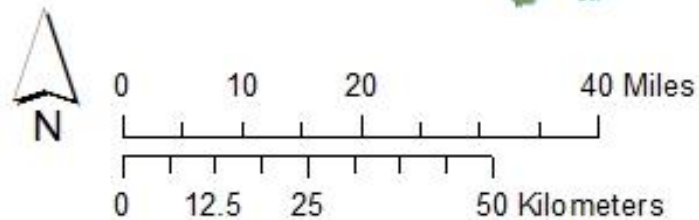
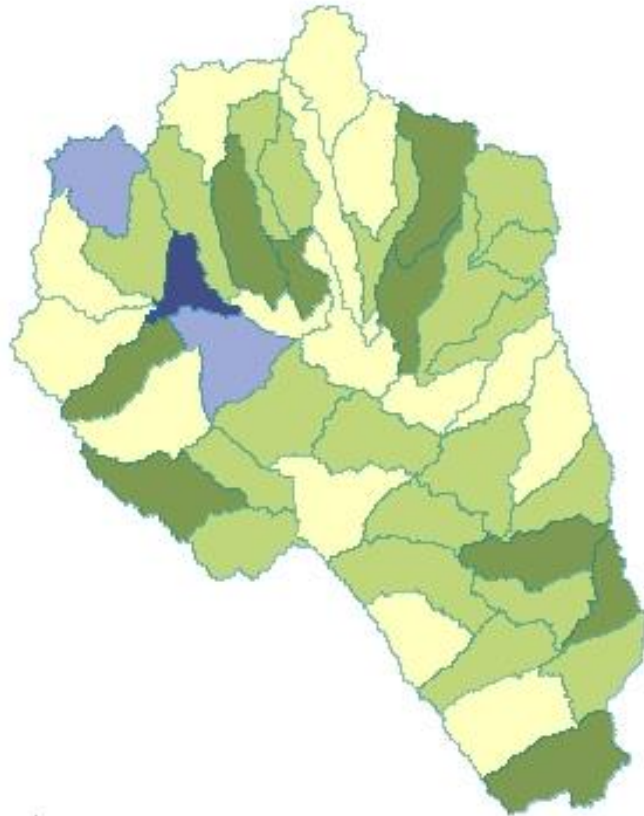
See the slide notes for more details on each slide

Colorado Plateau (COP 2010, COP 2014) Rapid Ecoregional Assessment Data Access

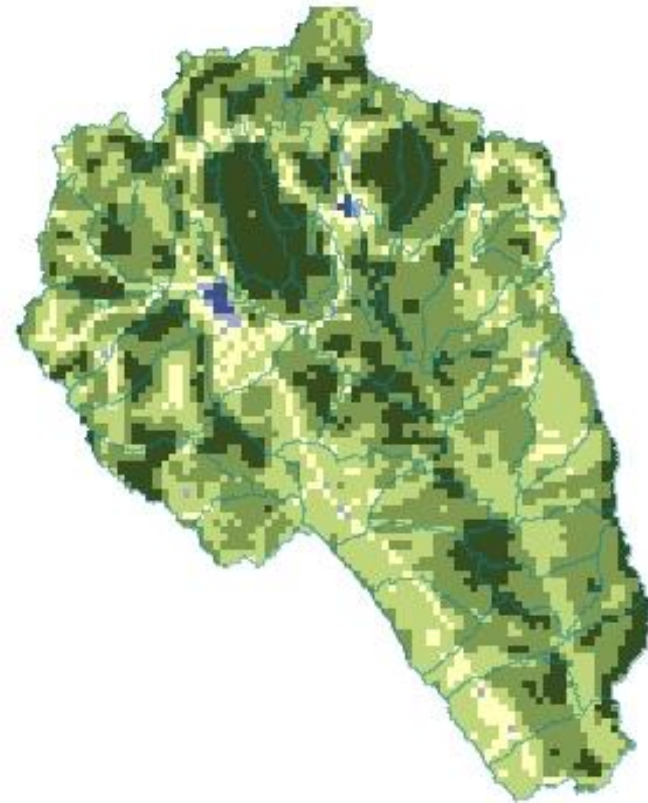
- Conservation Biology Institute (CBI) synthesized and created spatial data for the COP 2014 REA for BLM
- Data sets are accessible through:
 - BLM [Landscape Approach Data Portal](#)
 - CBI [Databasin.org](#)
- CBI's Data Basin is a website that allows mapping, data visualization, and analysis
- Data sets from both websites can be downloaded and used in ArcGIS for more complex analyses

Escalante Watershed Intactness – COP2014

Aquatic Intactness
summarized by 12 digit HUCs

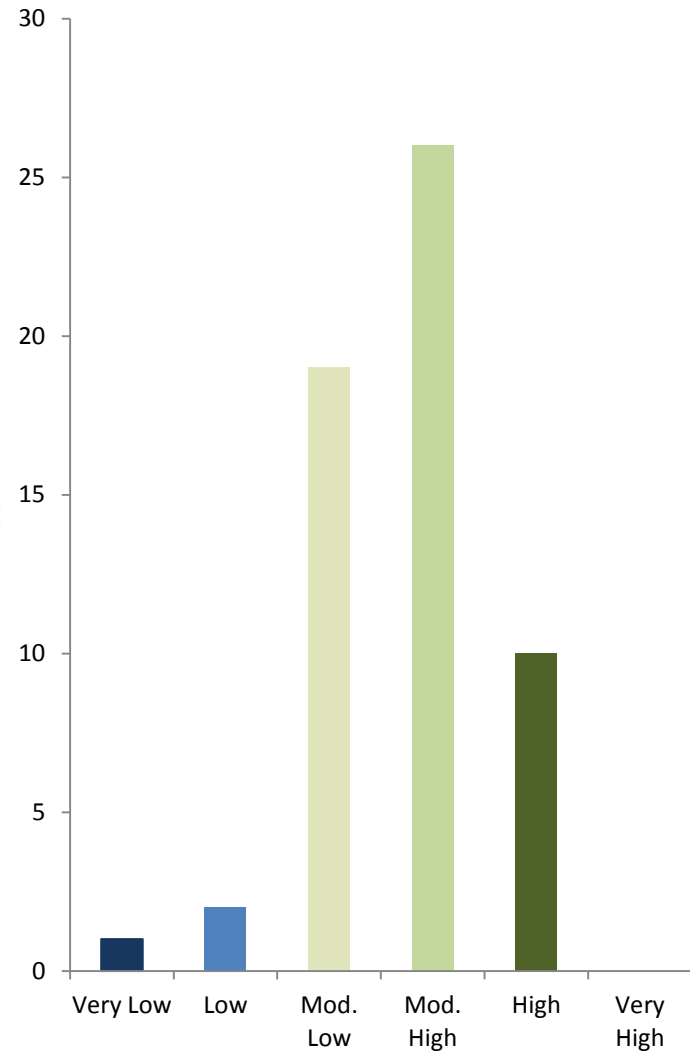
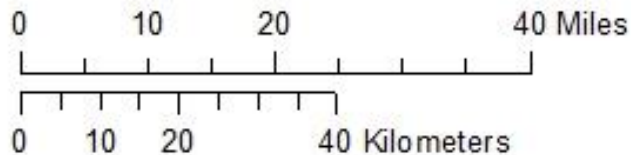
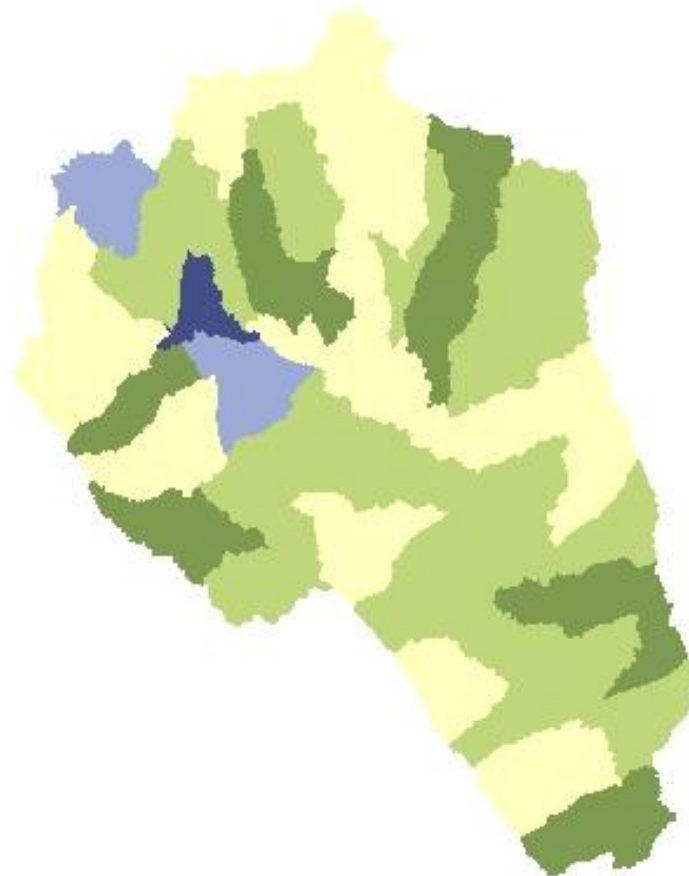


Terrestrial Intactness
summarized at 1km²



Escalante Watershed Intactness - COP 2014

Aquatic Intactness
summarised by 12 digit HUCs



Intactness

Very High

High

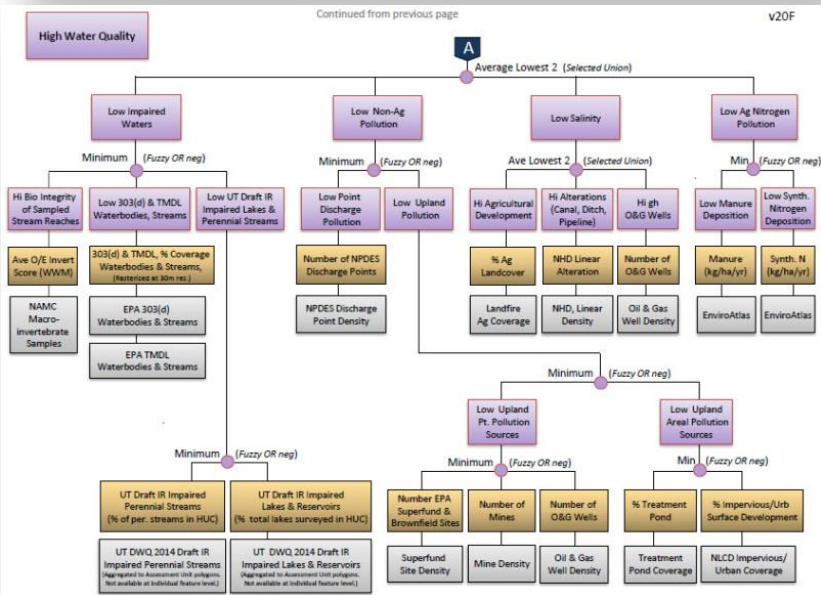
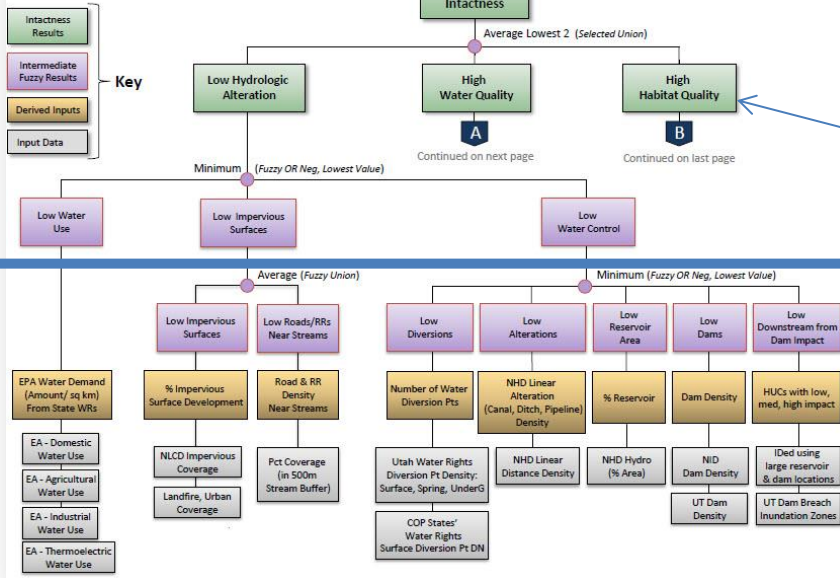
Moderately High

Moderately Low

Low

Very Low

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

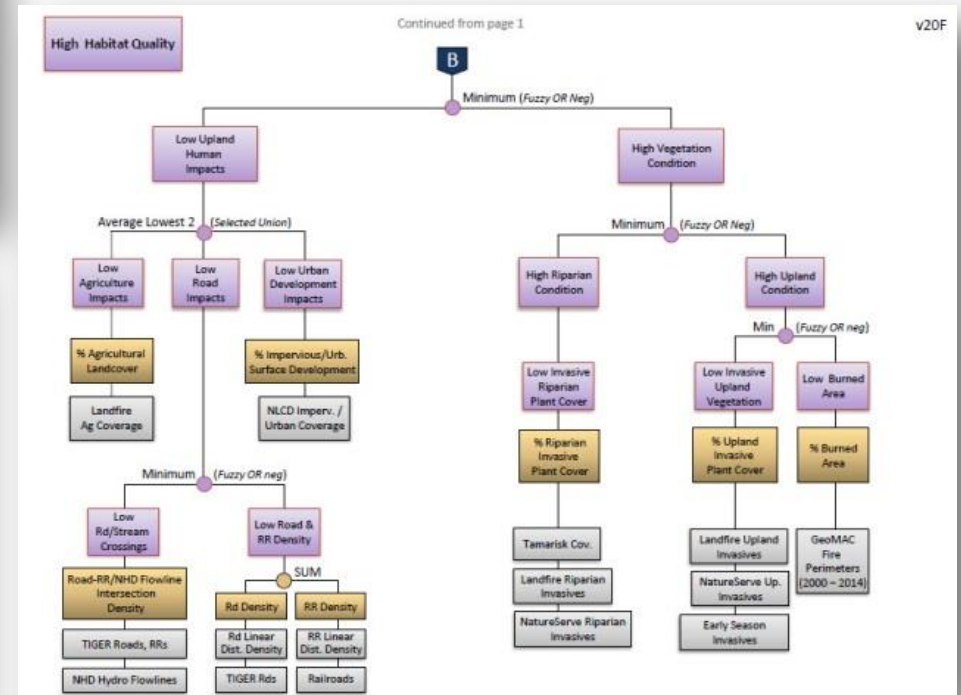


Aquatic Intactness Model

Tier2 level

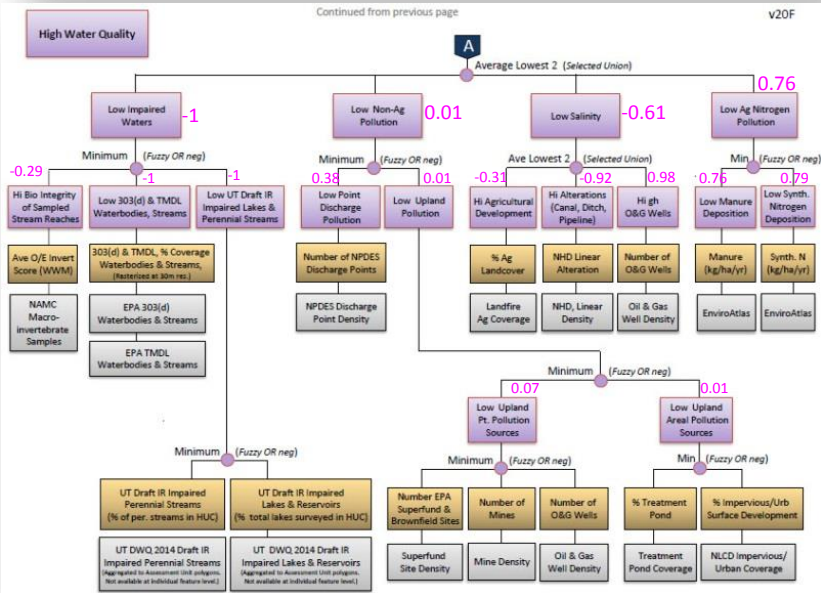
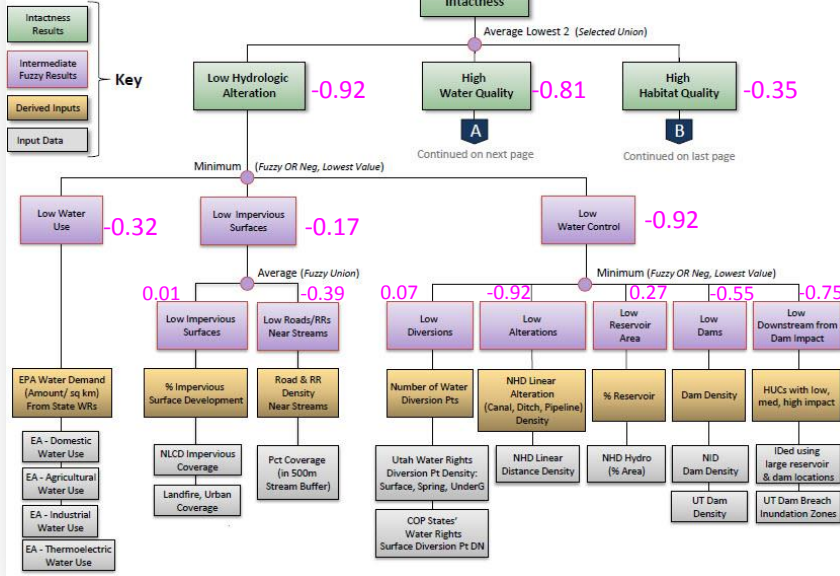
Analysis is currently to 3rd tier.

We can go further



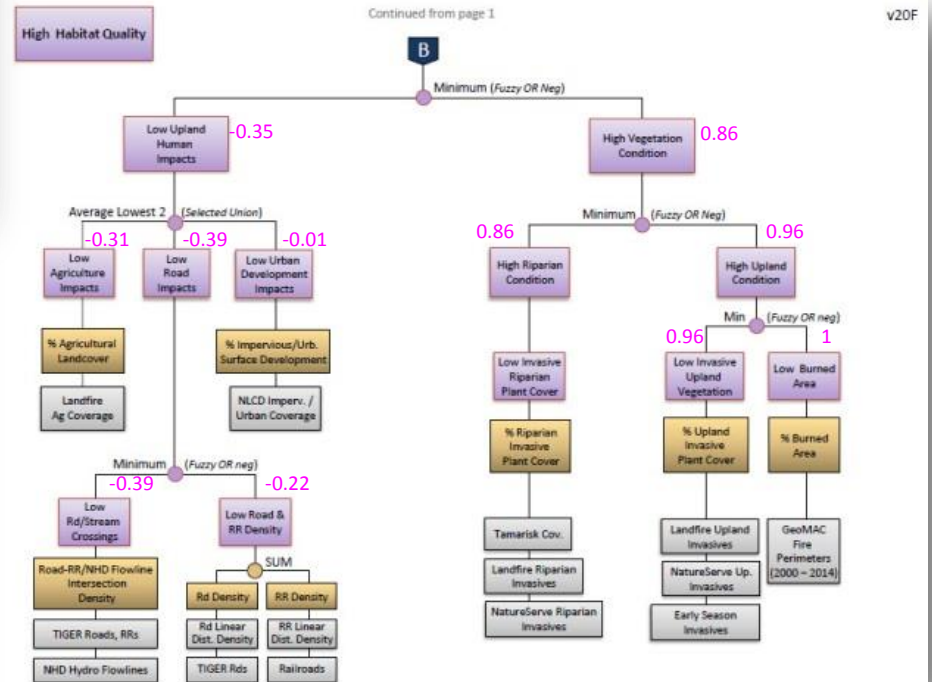
See slide notes and end slides for function explanation

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

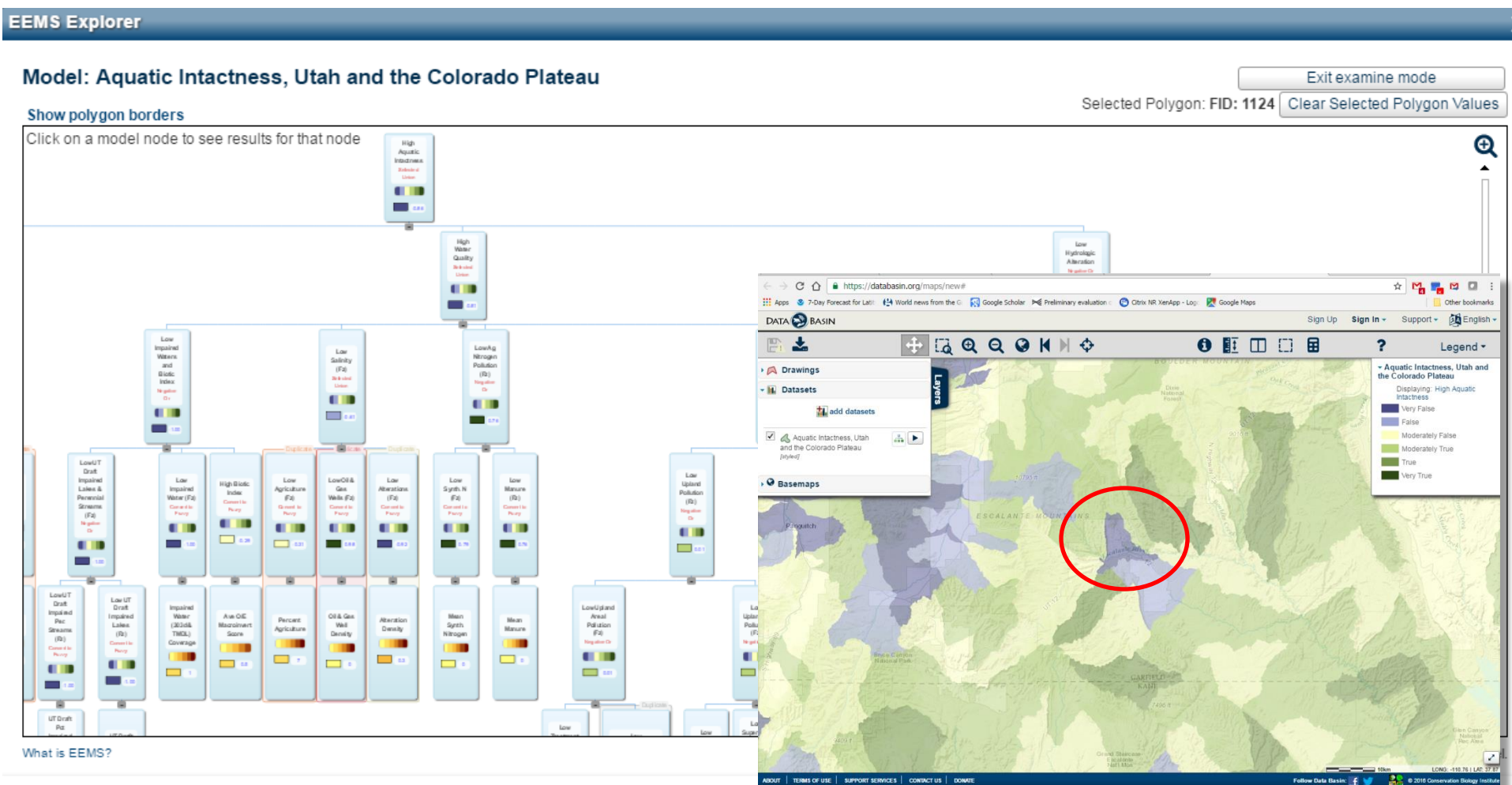


Aquatic Intactness Model

Numbers in pink are values for the watershed with the Very Low AI score, traced throughout the modeling process after data have been converted to fuzzy values.



Example of Data Basin model – Examine values at location – on map and within the model



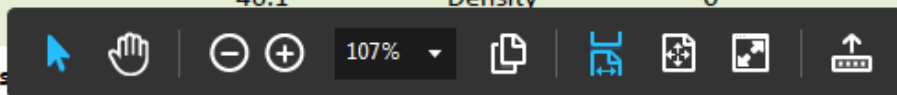
The map in Data Basin is responsive to the data input box that is selected

AI Fuzzy Logic Thresholds used to convert raw data to fuzzy values (1 of 3)

Input	Range	Data Type	True Threshold	False Threshold
Total Water Demand (Gallons per day/km ²)	0 – 83,631,875	Density	0	50,000 ²
Urban/Impervious Development	0 - 100	Percent Cover	0	10 ²
Roads and Railroads Near Streams (Coverage within 500m buffer)	0 – 22.8	Percent Cover	0	5 ²
Surface Diversions (pts/km ²)	0 – 3.5	Count	0	0.4 ²
Linear Alteration Development (Km/km ²)	0 – 2.5	Density	0	0.3 ²
Reservoir Development (Surface area coverage)	0 - 100	Percent Cover	0	5 ²
Dam Development (Pts/km ²)	0 – 0.28	Density	0	0.02 ²
Downstream Dam Impact Score	No impact, Low, Med, High	Score (Categorical)	0	High = -1 Med = -0.75 Low = -0.5

At the end of this PPT are several slides that describe how these thresholds are used to convert raw to fuzzy data.

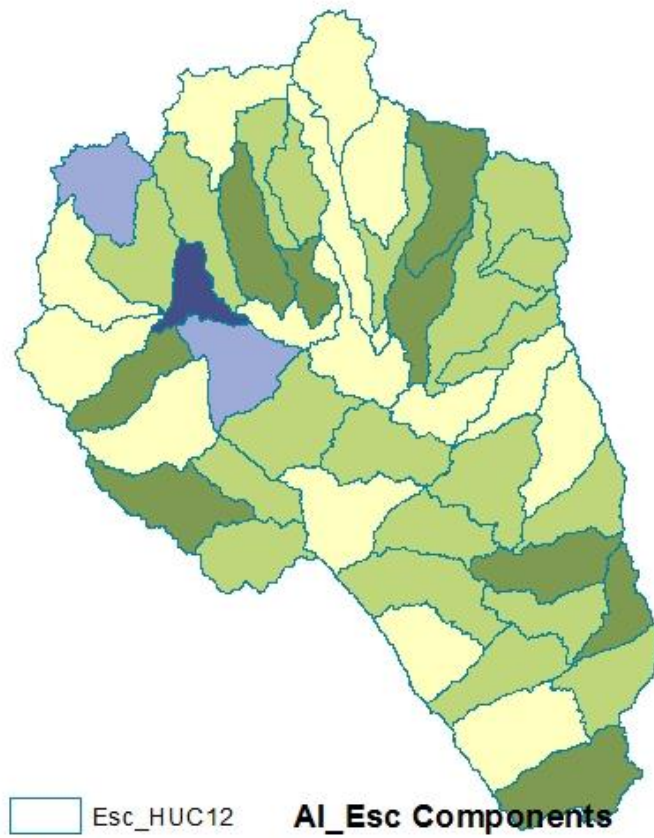
Input	Range	Data Type	True Threshold	False Threshold
EPA Impaired Waters (Streams and lakes with 303d or TMDL designations)	0 – 92.2	Percent Cover	0	0.3 ²
UT Draft IR Impaired Perennial Streams (% Impaired Perennial Streams; Assessment Unit-level data assigned to HUCs)	0 - 100	Percent Perennial Streams	0	0.3 ²
UT Draft IR Impaired Lakes & Reservoirs (% Impaired lakes of total surveyed; Assessment Unit-level data assigned to HUCs)	0 - 100	Percent of Lakes Surveyed	0	0.3 ²
EPA NPDES Discharge Sites (Pts/km ²)	0 – 2.3	Count	0	0.1 ²
Polluted EPA Sites (Pts/km ²) Superfund and Brownfield Designations	0 – 2.5	Count	0	0.01 ²
Mine Density (Pts/km ²)	0 – 2.2	Count	0	0.2 ²
Oil and Gas Well Density (Pts/km ²)	0 – 19.6	Count	0	2 ²
Treatment Pond Polygons (Surface area coverage)	0 - 100	Percent Cover	0	10 ²
Agricultural Development	0 - 100	Percent Cover	0	10 ^{2,3}
Manure Deposition (Mean kg N/ha/yr)	18.7	Density	0	2 ²
Synthetic Nitrogen Deposition (Mean kg N/ha/yr)	46.1	Density	0	3 ²
Road/Railroad-Stream Crossings (Pts/km ²)	0 – 210	Count	0	0.6 ²



Input	Range	Data Type	True Threshold	False Threshold
Road/Railroad Development (Km/km ²)	0 – 15.9	Density	0	2 ²
Invasive Riparian Vegetation	0 – 21.1	Percent Cover	0	6 ²
Invasive Upland Vegetation	0 – 92.2	Percent Cover	0	30 ²
Biotic Index, NAMC O/E Macroinvertebrate Score	0 – 1.22	Average Score	1.22	0.15 ²
Area Burned, 2000-2014	0 - 100	Percent Cover	0	20 ²

1. Used full range or full range with outliers ignored; 2. Expert opinion/ Heuristics, guided by statistical distribution of the data; 3. Taken from the literature

Aquatic Intactness



Esc_HUC12

AI_Esc

HiAquaticI

Very High

High

Moderately High

Moderately Low

Low

Very Low

AI_Esc Components

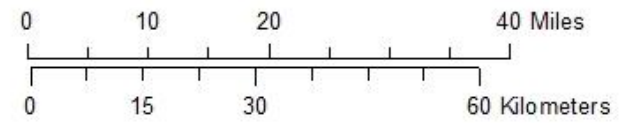
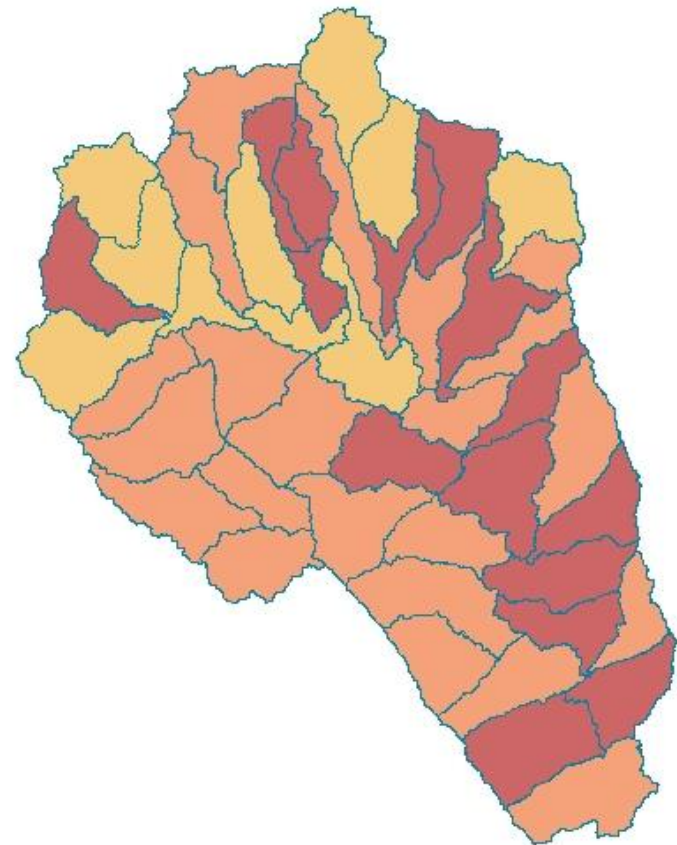
Lo2Lo_AI

HAWQ

HabHA

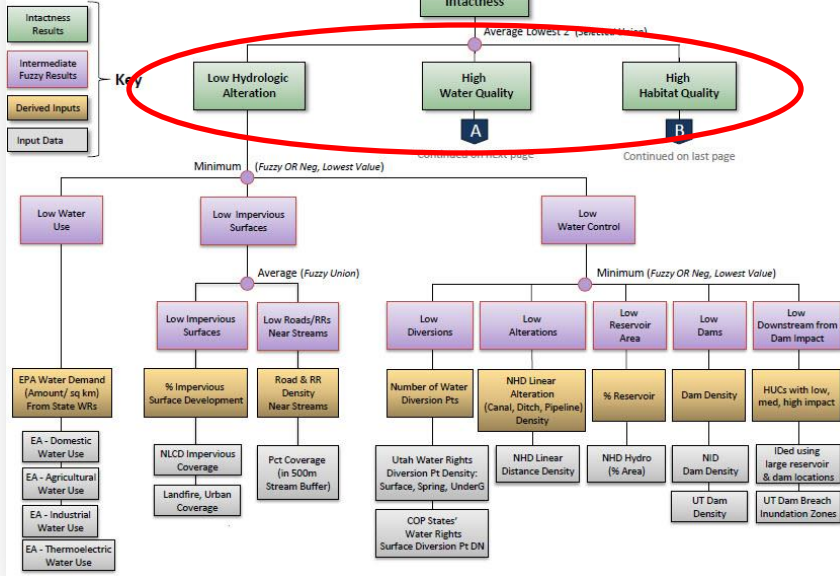
HabWQ

Components of Aquatic Intactness: Hydrologic Alteration (HA), Water Quality (WQ), Habitat (Hab)

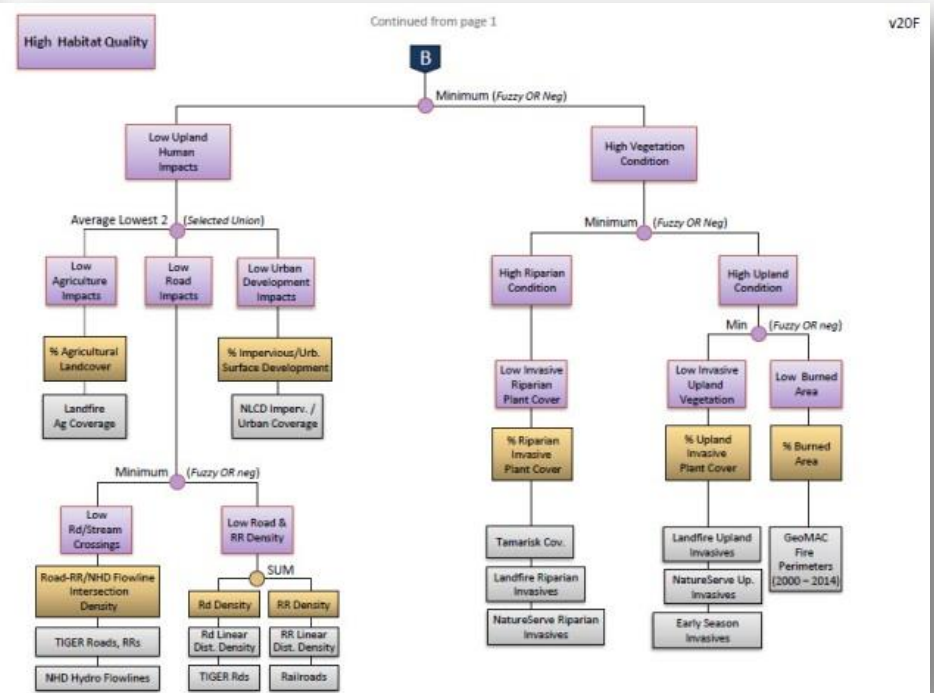
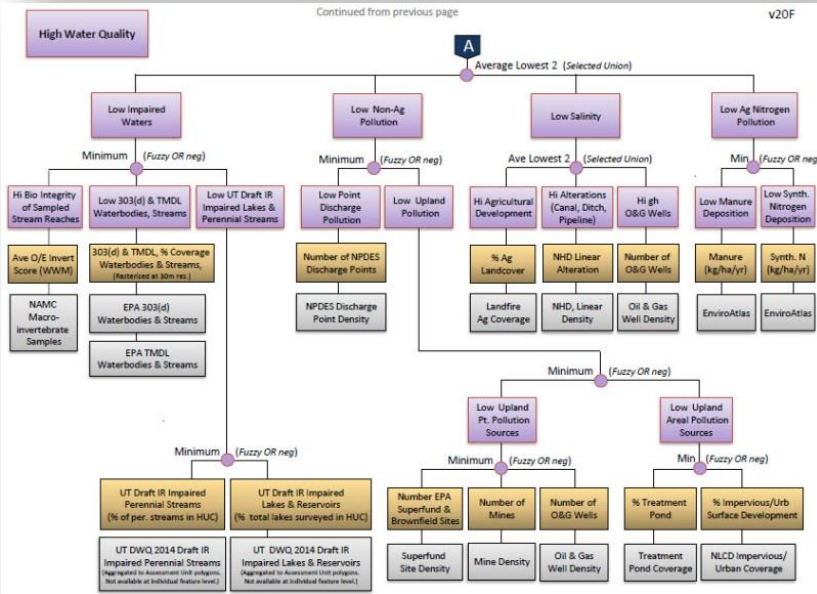


AI is the average of values from the lowest 2 components (HA, WQ, Hab)

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

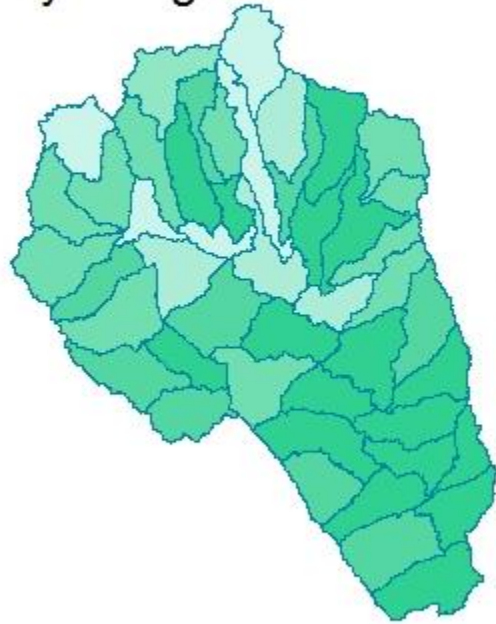


The next slide shows maps of the red-circled model components ->

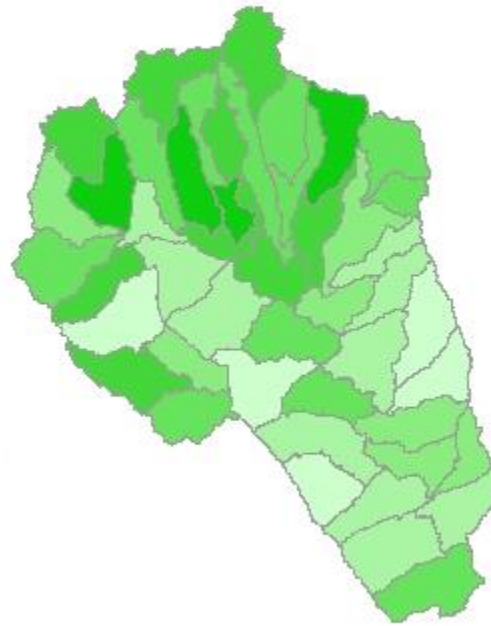


Components of Aquatic Intactness: Escalante Watershed - COP 2014

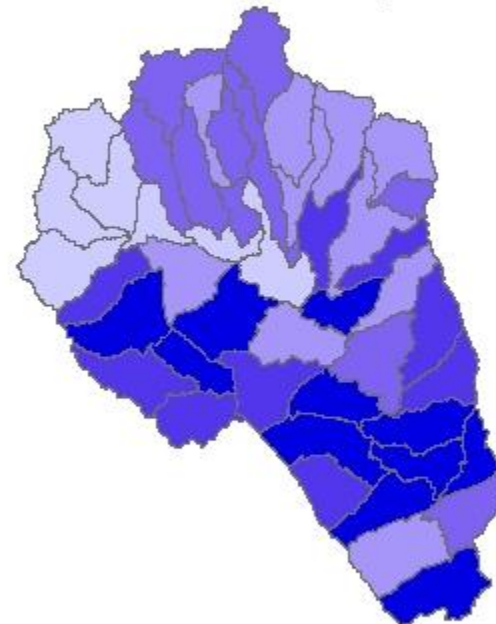
Hydrologic Alterations



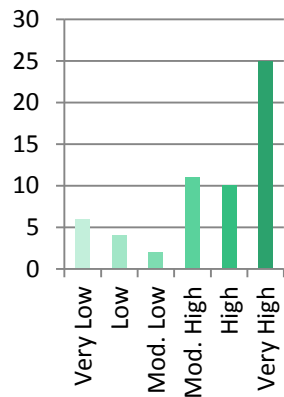
Habitat



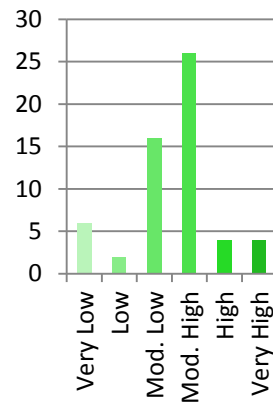
Water Quality



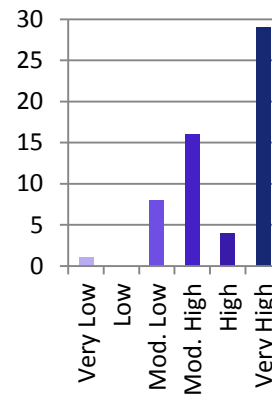
Hydrologic Alterations



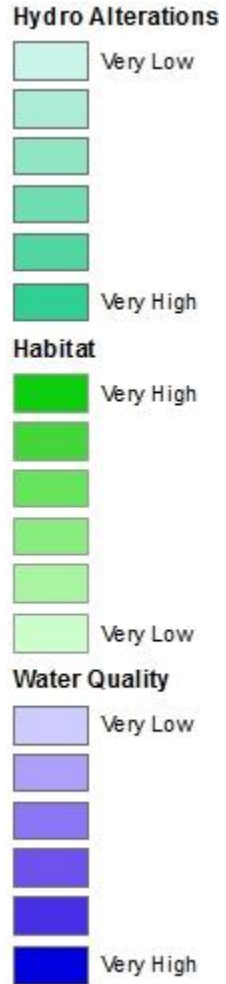
Habitat



Water Quality



0 5 10 20 Miles
0 10 20 40 Km

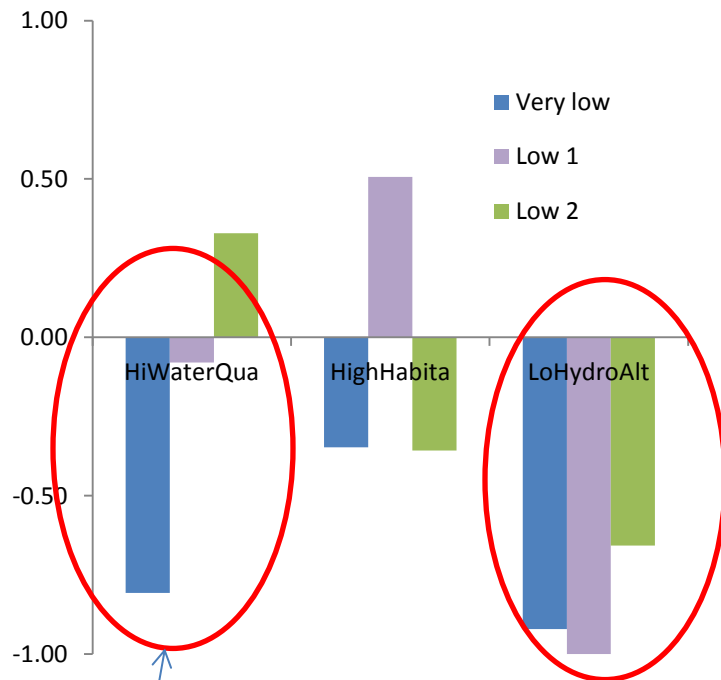


AI Component values for HUC 12s with 3 lowest AIs

(Graph series: Very Low, Low1, Low2)

AI Components: Water Quality, Habitat, and Hydrologic Alterations

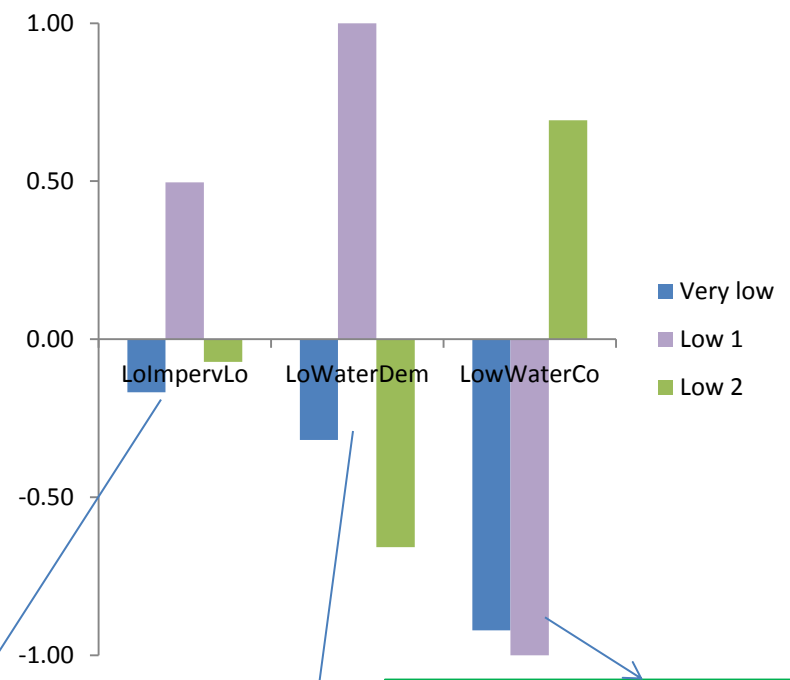
Hydro Alterations Components: Impervious Surfaces, Water Demand/Use, Water Control



Limiting Factor for Very Low and Low1 watersheds

Limiting Factor for all 3 watersheds

Impervious Surfaces & Roads & Railroads near Streams



Water Demand: Domestic, Ag, Ind, Thermoelectric

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

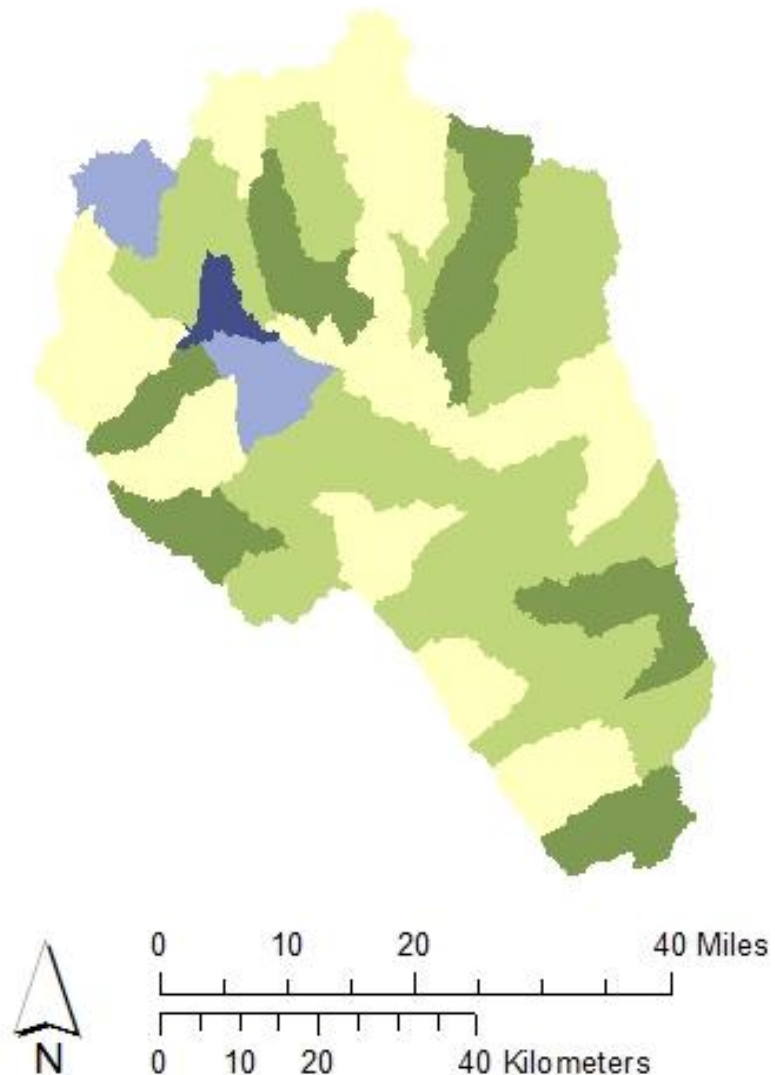
A broader look at all Low v. High scoring watersheds grouped by the three classes:

- HA/Hab and HA/WQ are used most frequently in lower AI scoring watersheds
- HA is used in 82% of the calculations of lower AI scoring watersheds

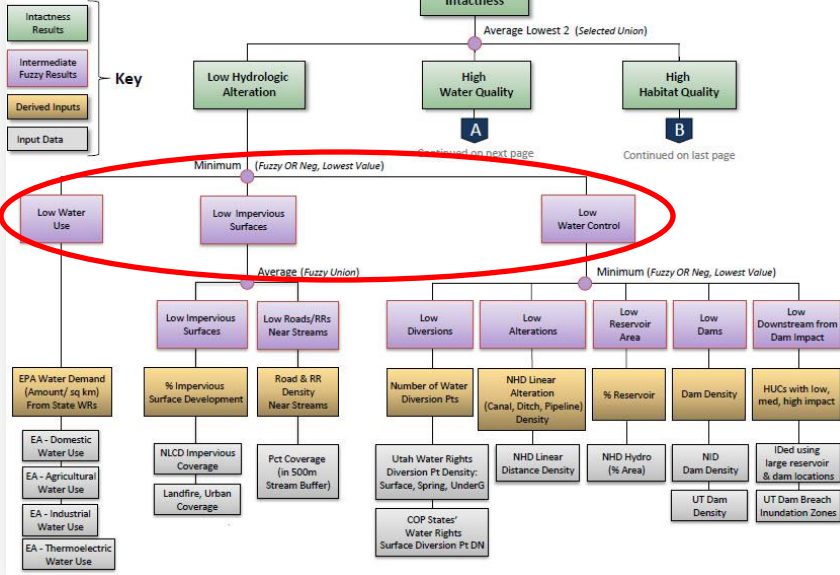
Bins	HA/WQ	HA/Hab	Hab/WQ	Total
Very Low, Low, Mod.Low	7	11	4	22
Mod. High, High	3	20	13	36

(HA = Hydrologic Alterations)

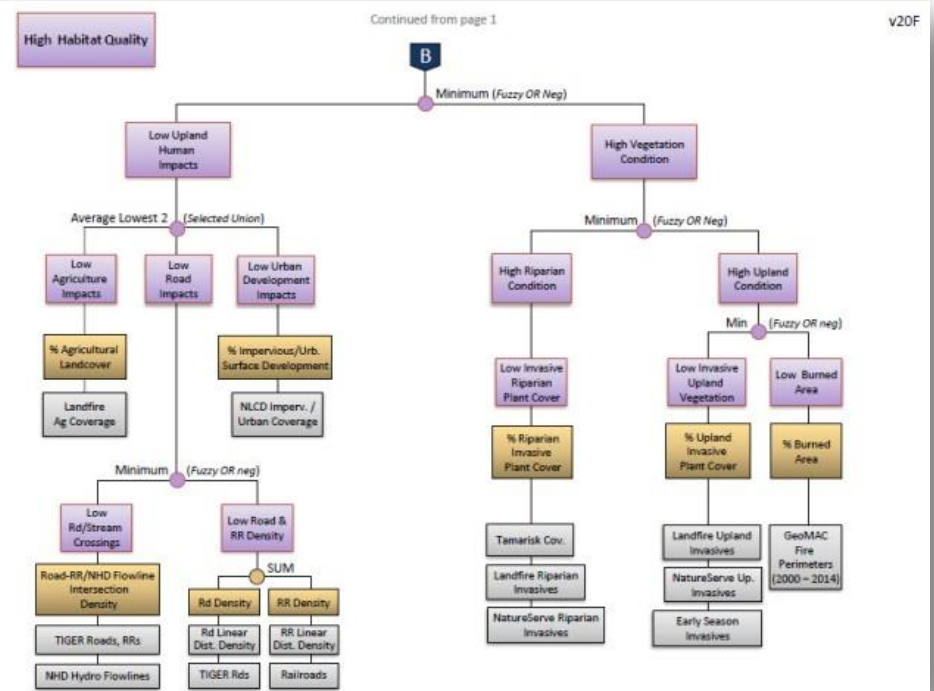
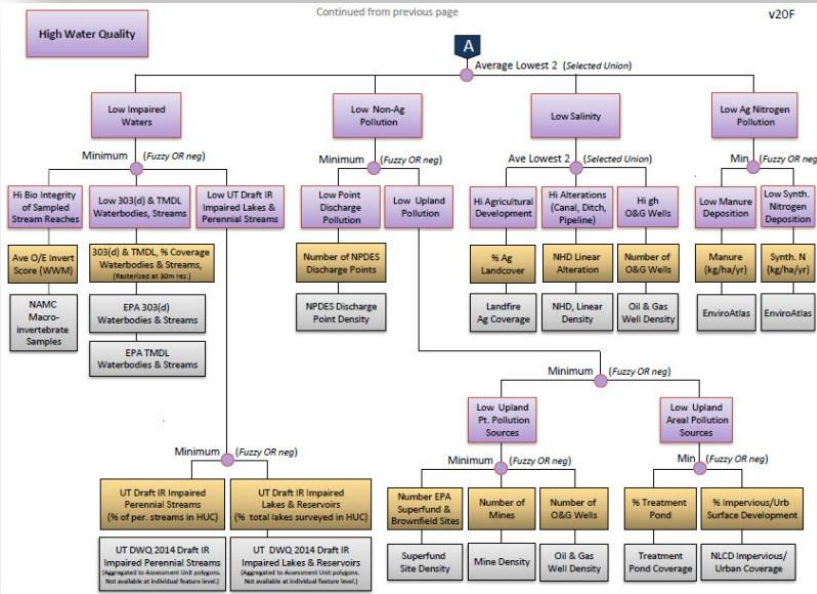
Aquatic Intactness
summarised by 12 digit HUCs



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

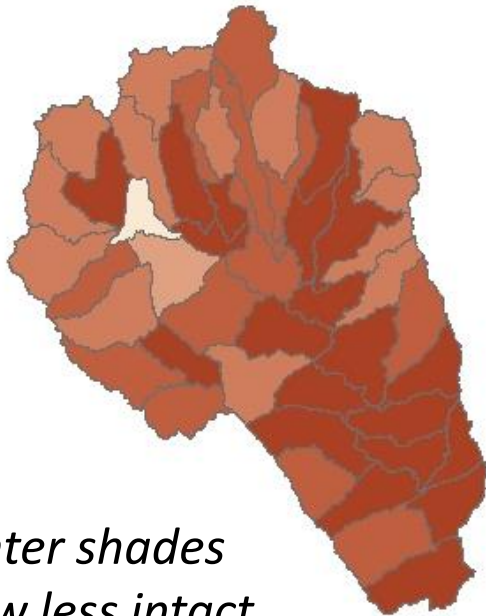


The next slide shows maps of the red-circled model components ->

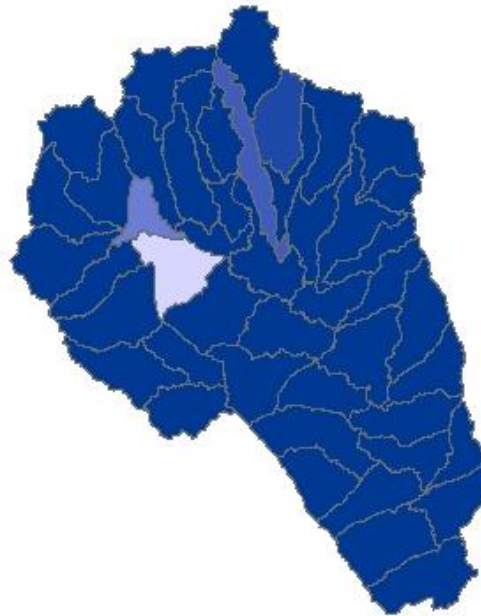


COP 2014 Components of Hydrologic Alterations within Aquatic Intactness - Escalante Watershed

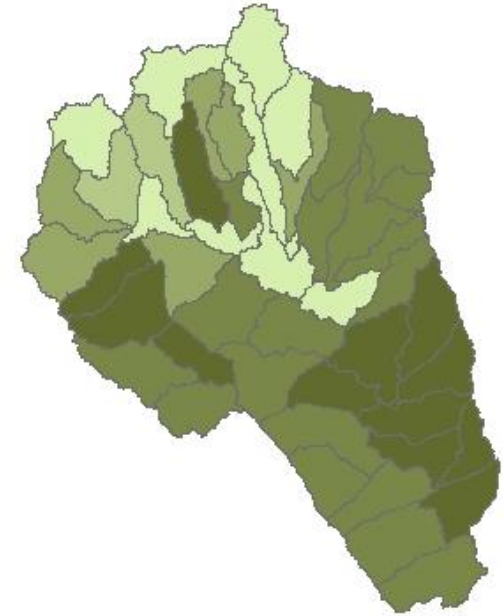
Impervious Surfaces



Water Demand

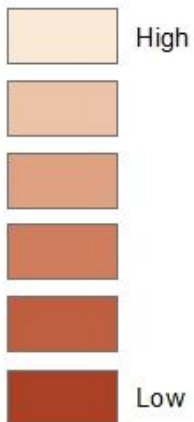


Water Control

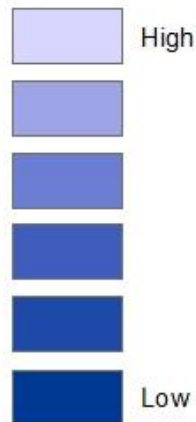


*Lighter shades
show less intact
areas*

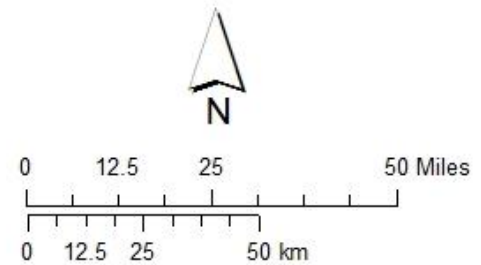
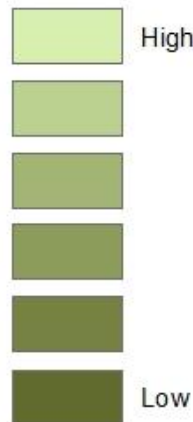
Impervious Surfaces



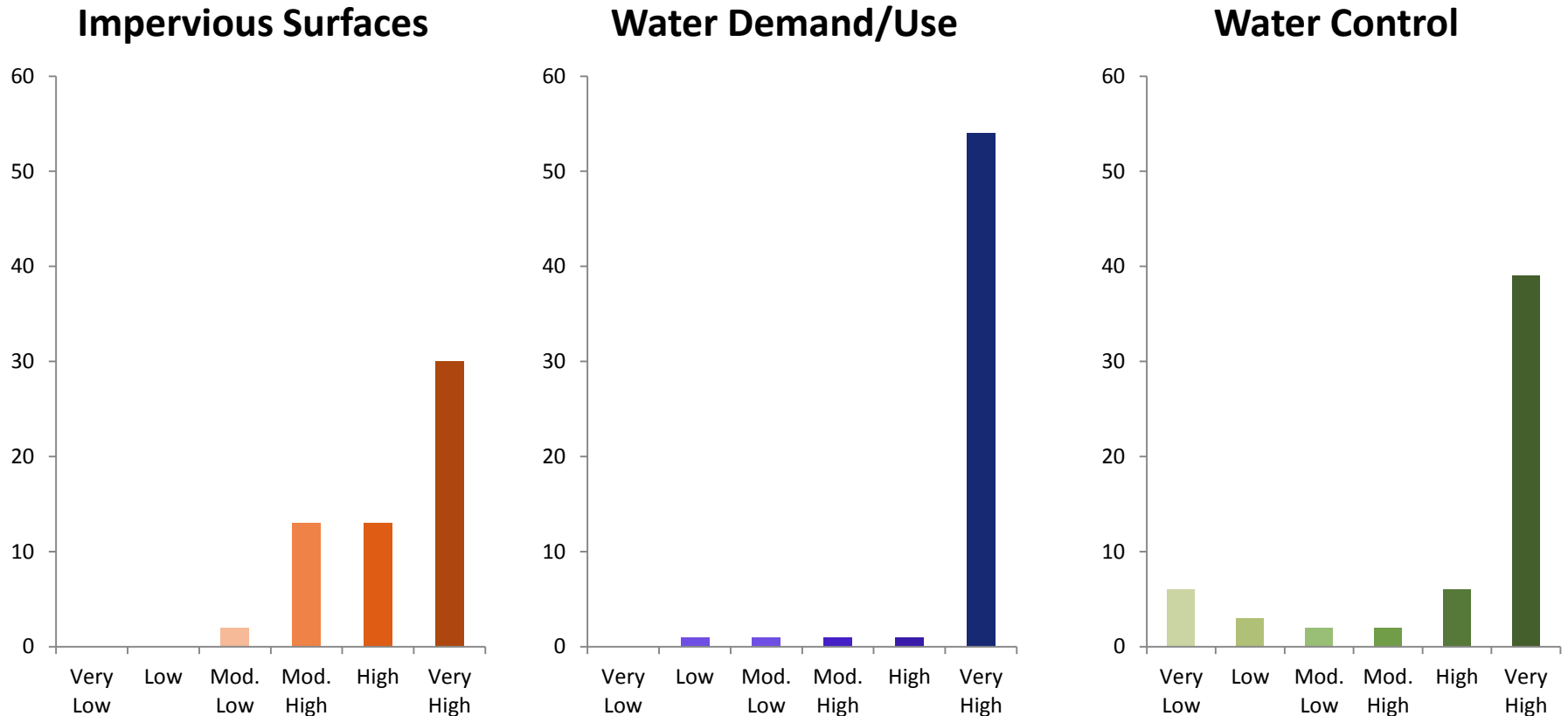
Water Demand/Use



Water Control

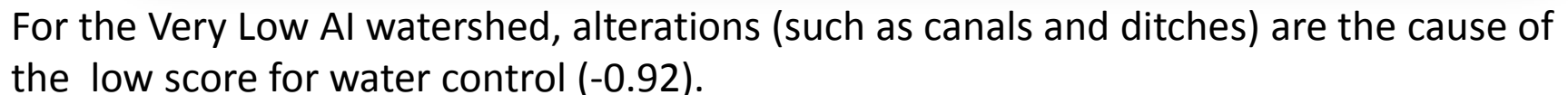


Components of Hydro Alterations: Impervious Surfaces, Water Demand/Use, and Water Control

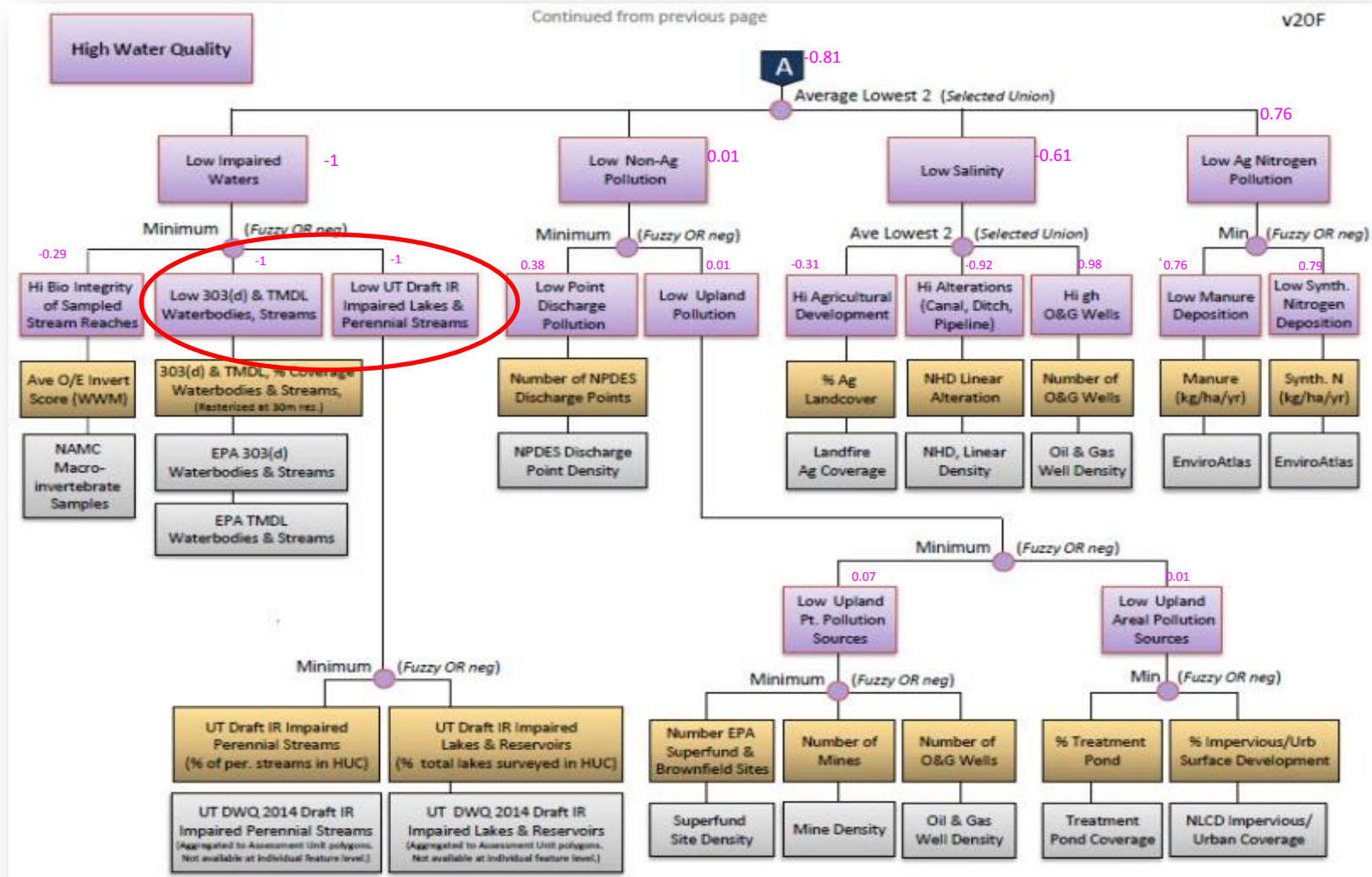


Water Control graph has more watersheds with Very Low and Low intactness scores. No watersheds score Very Low intactness for Impervious Surfaces or Water Demand. Further analyses of limiting factors would target the components of Water Control (Diversions, linear alterations, dams, reservoir area, downstream impacts of dams) – see next slide.

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



Water Quality Inputs to the Very Low AI watershed

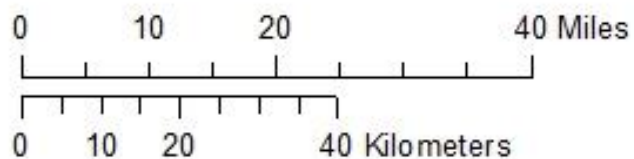
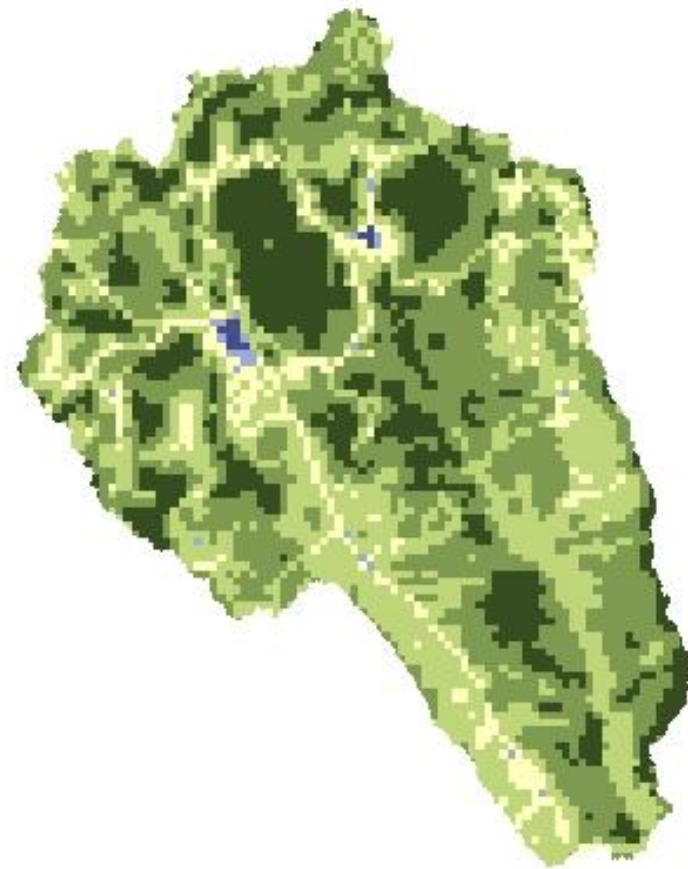
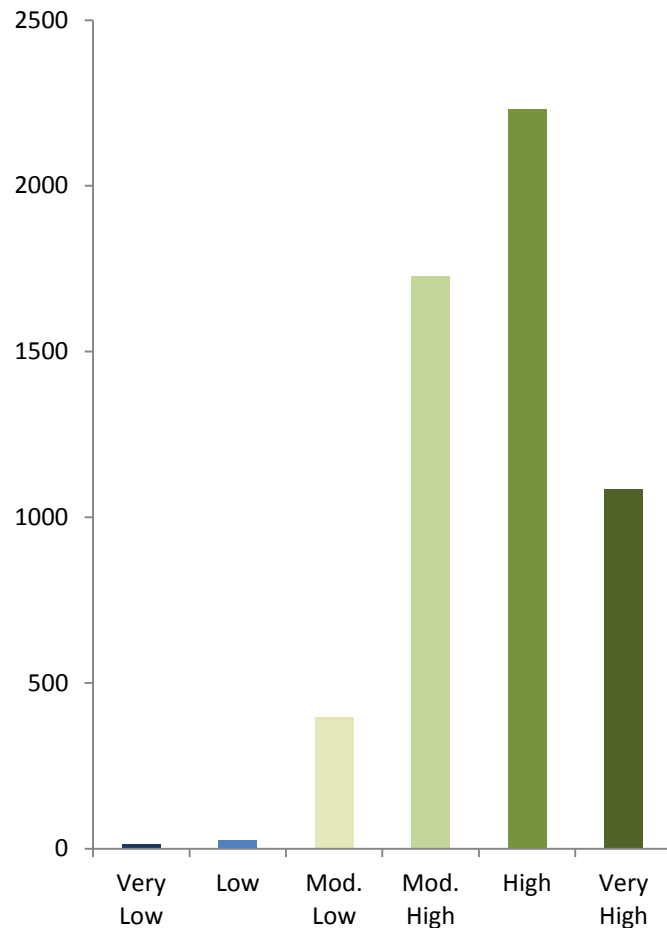


For the Very Low AI watershed, impaired waters (such as lakes, reservoirs, and streams that are 303(d) listed from EPA and state of UT) are the cause of the low score for water quality (-1.0).

Escalante Watershed Intactness - COP 2014

TI

Terrestrial Intactness
summarized at 1 km²



Intactness



Very High



High



Moderately High



Moderately Low



Low

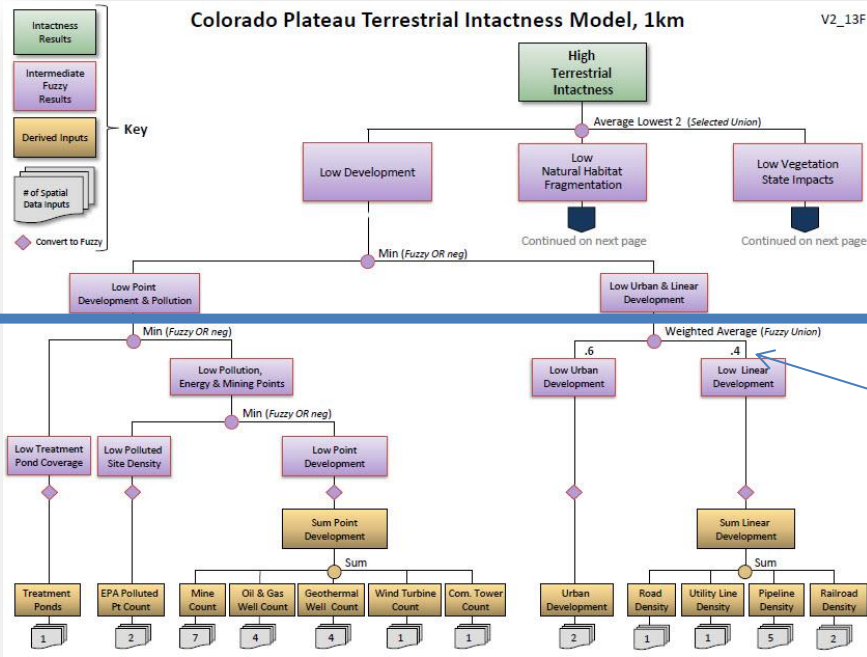


Very Low

Terrestrial Intactness Model

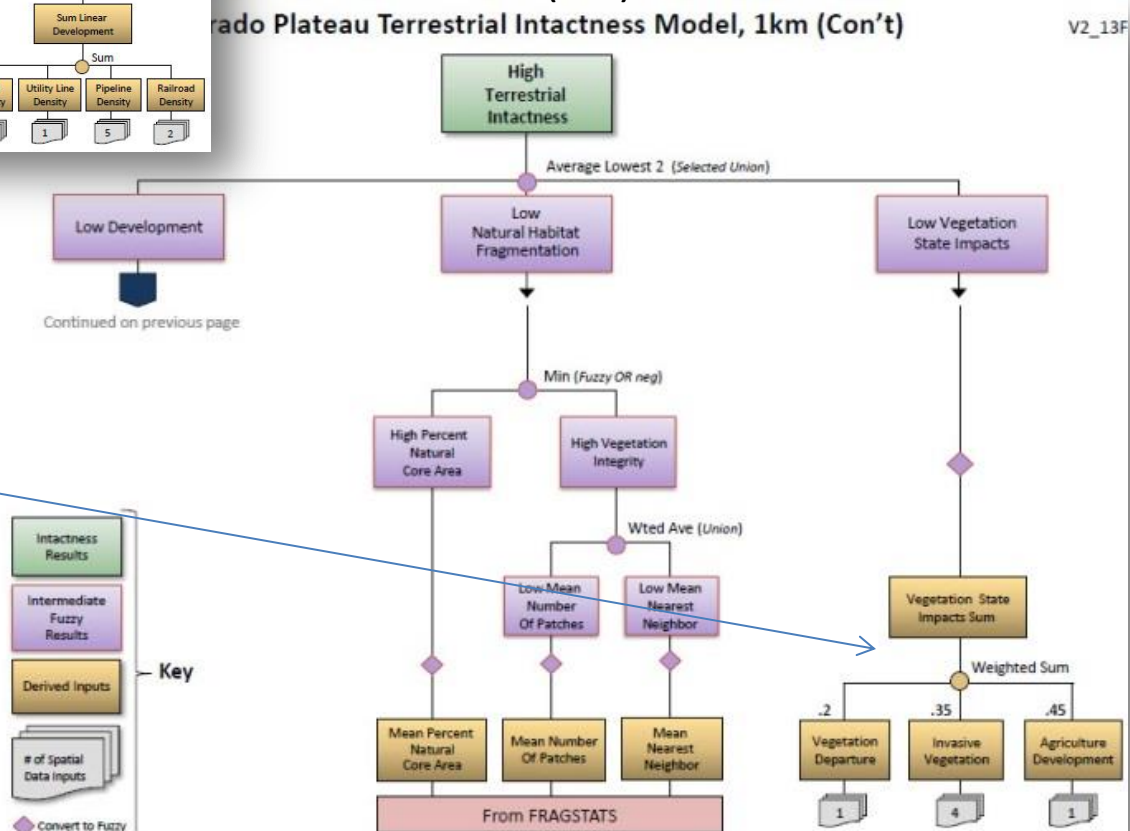
Analysis is currently to 3rd tier.
We can go further.

Weights Urban and Linear DV:
Urban DV (0.6)
Linear DV (0.4)



Weights

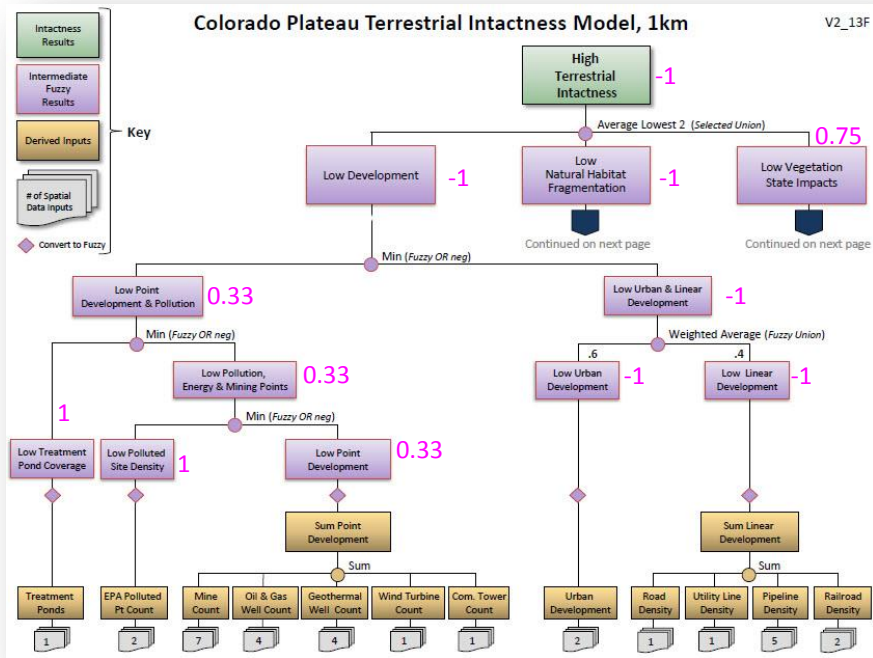
Veg State Impacts:
Veg Departure (0.2)
Invasive Veg (0.35)
Agriculture DV (0.45)



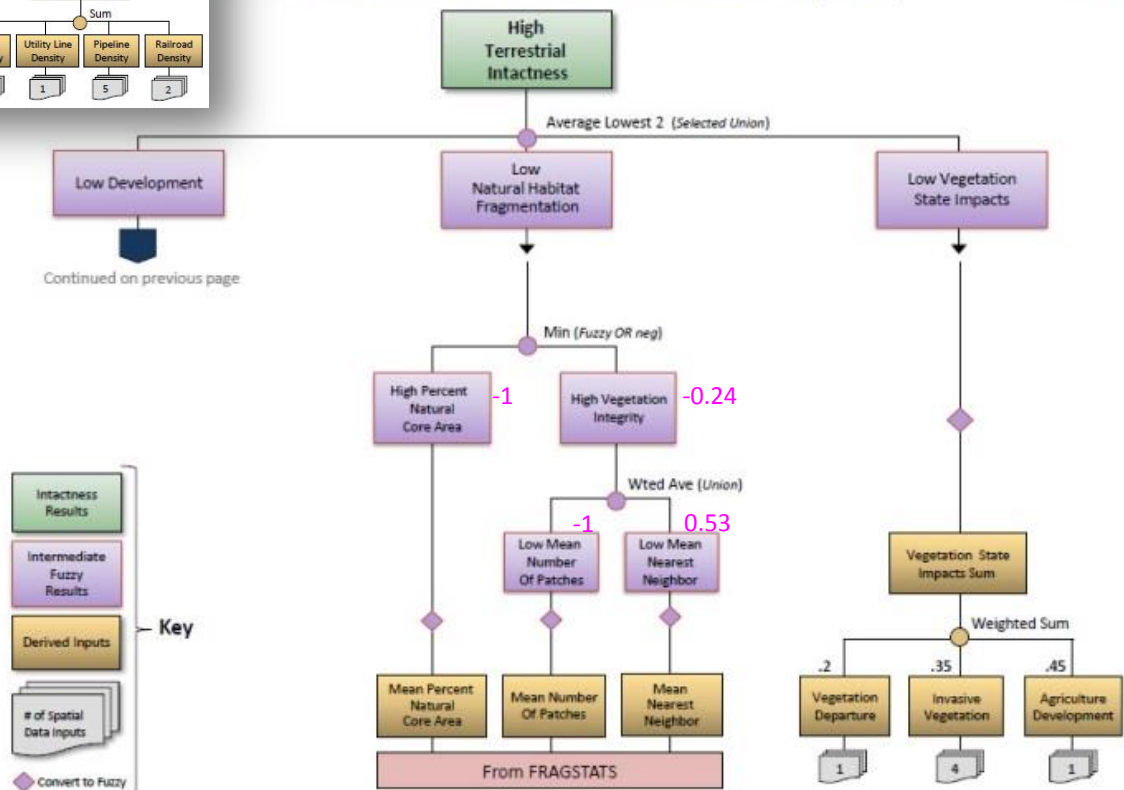
Terrestrial Intactness Model

Numbers in pink are values for the 1km² area with the Very Low TI score, traced throughout the modeling process starting at the fuzzy values.

Numbers in black are model weights.



Colorado Plateau Terrestrial Intactness Model, 1km (Con't) V2_13F



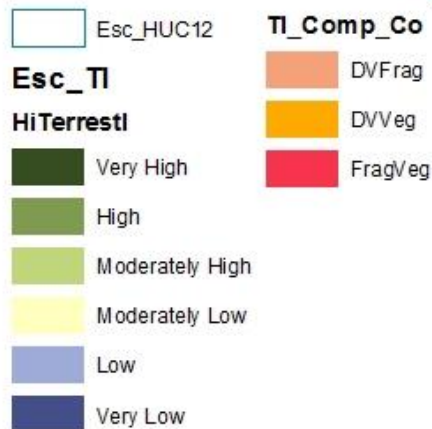
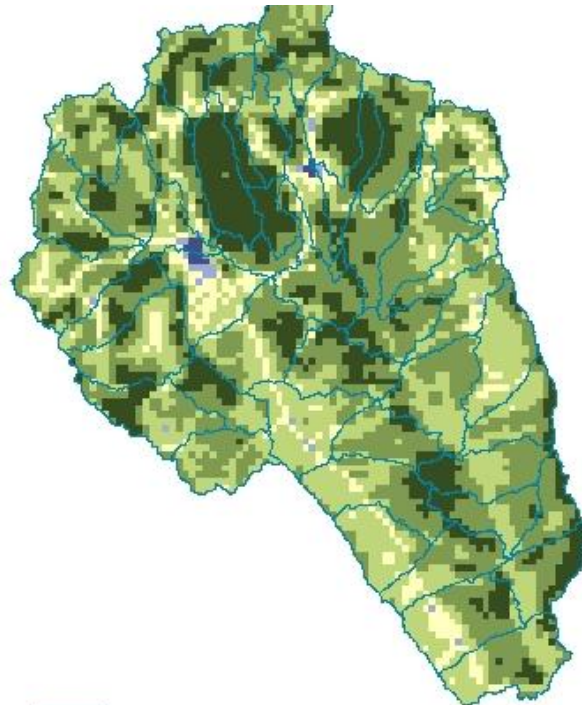
Terrestrial Intactness Fuzzy Logic Thresholds

Used to convert raw data to data between -1 and +1 for fuzzy logic model

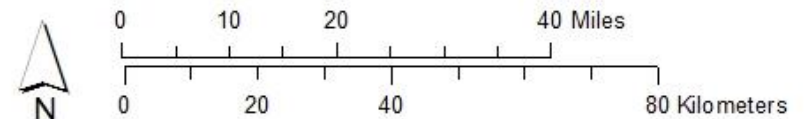
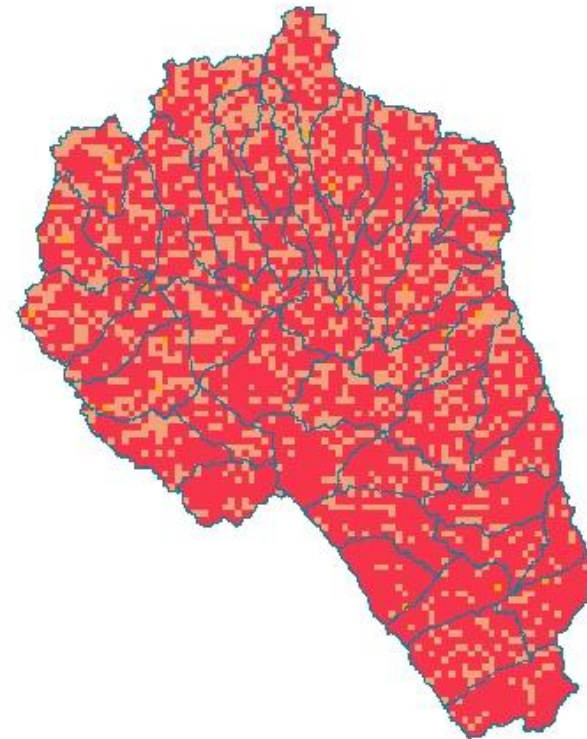
Input	Range	Mean	Standard Deviation	Data Type	1km True Threshold	1km False Threshold
Urban Development	0 - 100	2.2	5.1	Percent Cover	0	10 ²
Linear Development (km/km ²)	0 - 24	1.0	1.3	Density	0	2.5 ³
Point Development (pts/km ²)	0 - 84	0.6	2.4	Count	0	3 ²
Polluted Sites (pts/km ²)	0 - 7	0.005	0.04	Count	0	3 ²
Treatment Pond Polygons	0 - 100	0.02	0.4	Percent Cover	0	10 ²
Number of Patches	1 - 266	19	25	Count	1	60 ²
Mean Nearest Neighbor (m)	60 – 3,608	67.4	29.2	Distance	59	150 ²
Percent Natural Core Area	0 – 90	47.7	22.9	Percent Cover	90	5 ²
Vegetation State Impacts	0 – 62	12.7	8.5	Percent Cover	0	Max ¹

1. Used full range or full range with outliers ignored; 2. Expert opinion/ Heuristics, guided by statistical distribution of the data; 3. Taken from the literature

Escalante Terrestrial Intactness (COP 2014 - 1 km²)



Components of Terrestrial Intactness:
Development (DV), Habitat Fragmentation (Frag),
Veg State (Veg)



Terrestrial Intactness is calculated using the average of the 2 lower components scores from composite fields for development, habitat fragmentation, and vegetation state.

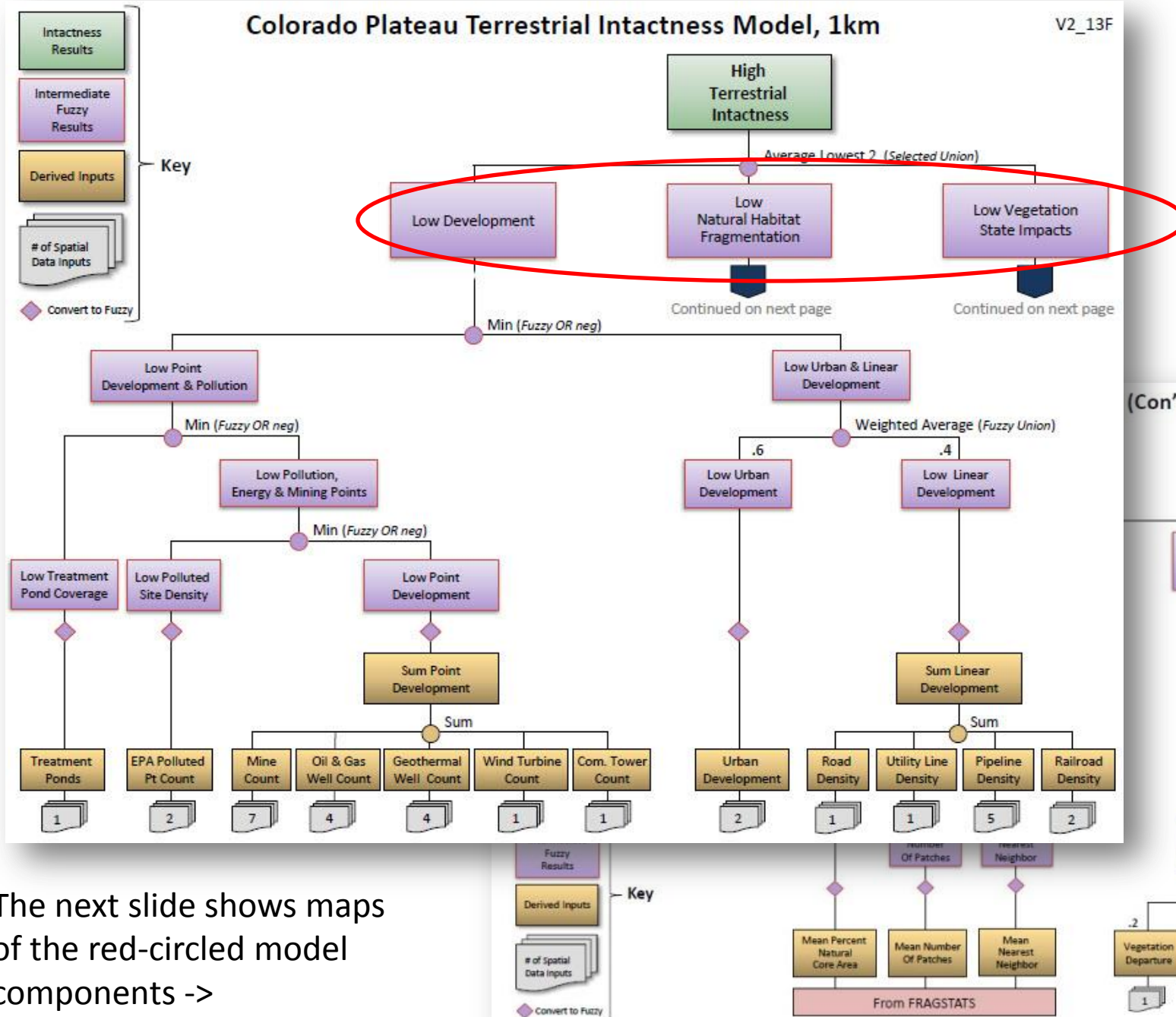
For Very Low, Low and Mod. Low TI values, DV and fragmentation both feature more frequently than Veg state.

	Very Low, Low, Mod. Low (TI)	Very High, High, and Mod. High (+TI)
Veg & Frag	31	3822
Veg & DV	0	24
DV & Frag	404	1196
total	435	5042

The lowest 10 TI values are all an average of DV and Frag data.

Colorado Plateau Terrestrial Intactness Model, 1km

V2_13F



The next slide shows maps of the red-circled model components ->

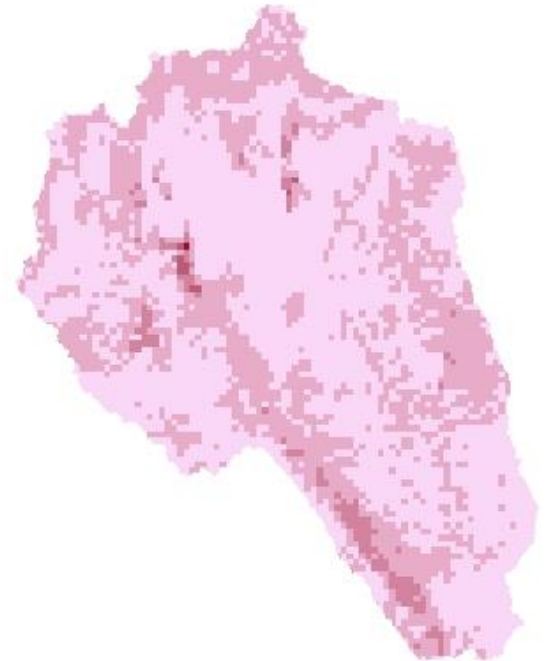
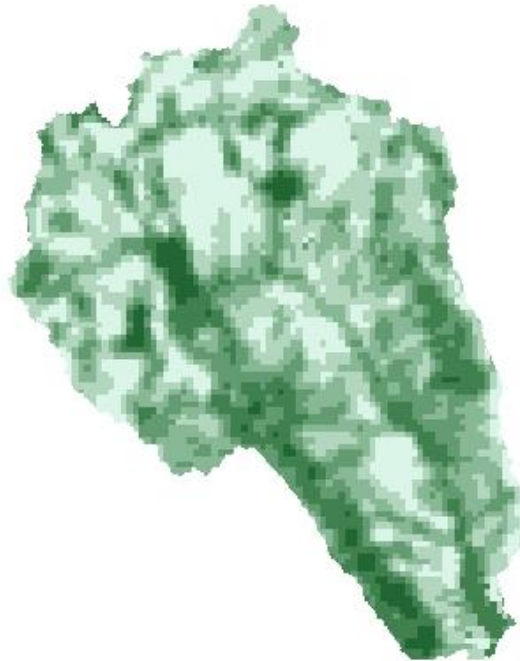
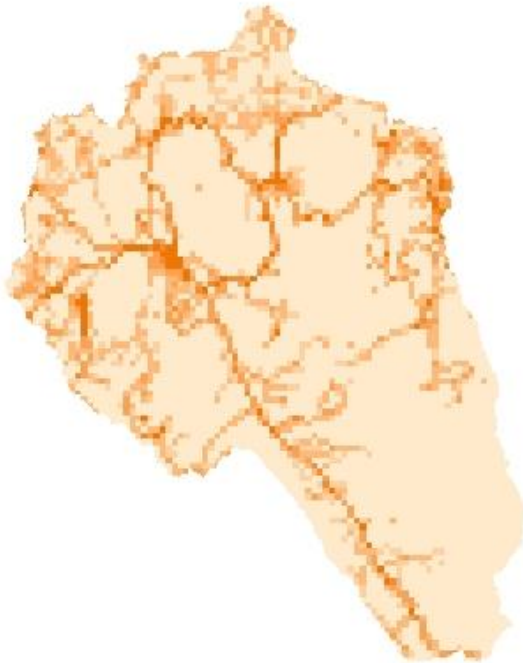
COP 2014 Components of Terrestrial Intactness

Escalante Watershed

Low DV

Low Natural Habitat Fragmentation

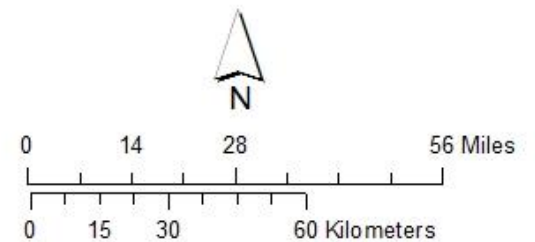
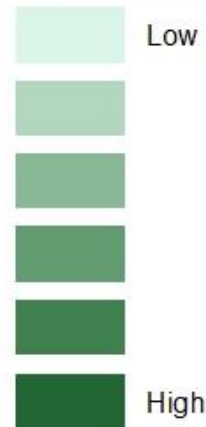
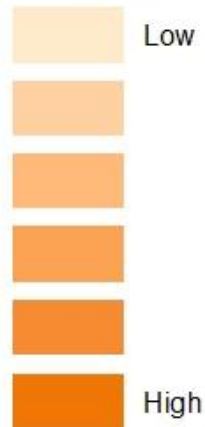
Low Veg State Impacts



Development

Habitat Fragmentation

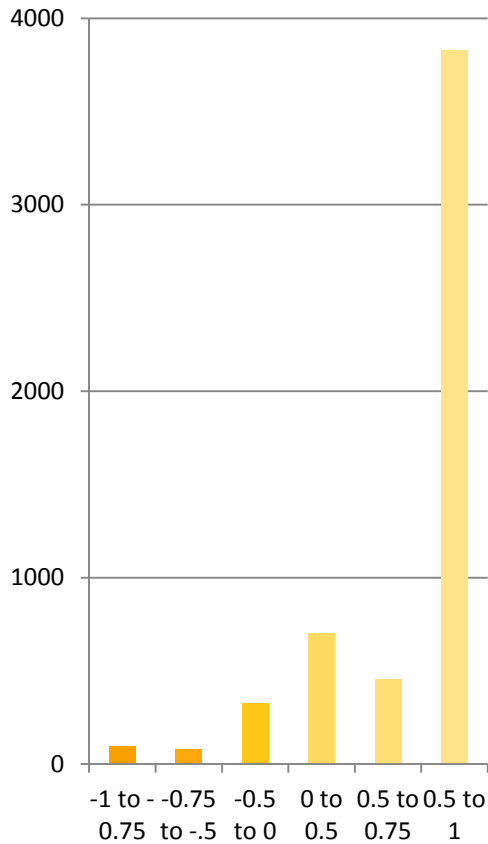
Veg State



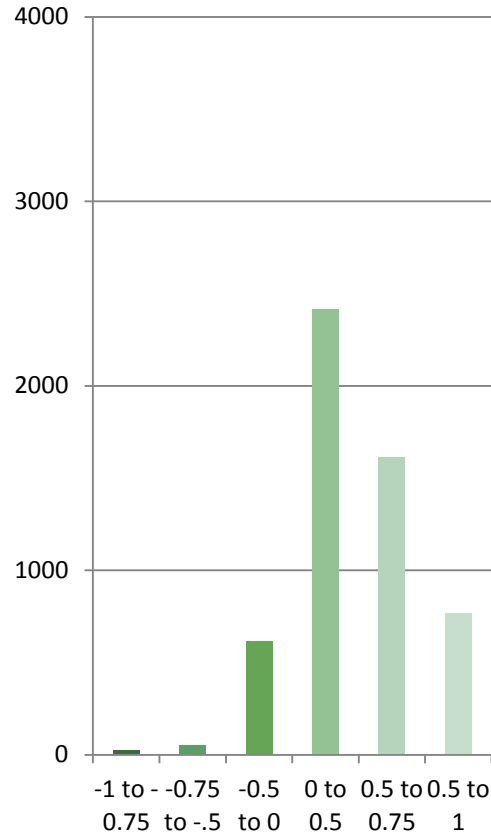
Lighter colors indicate higher intactness.

Components of Terrestrial Intactness

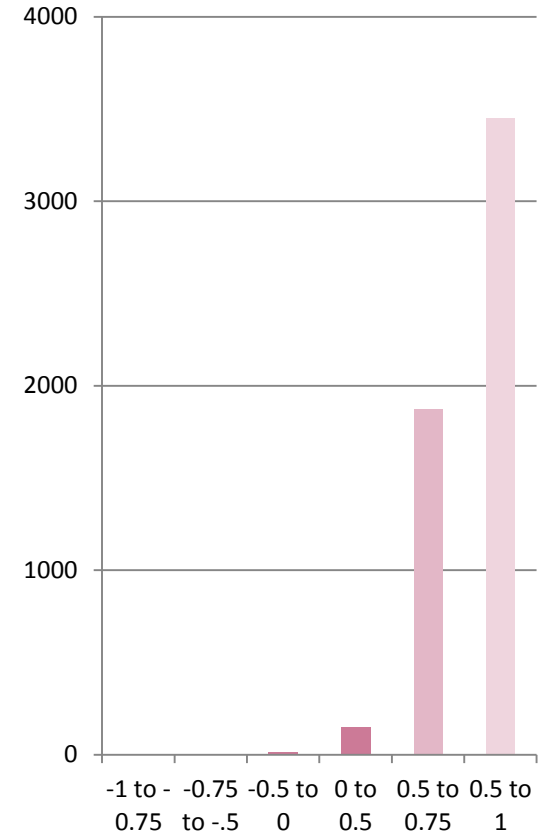
Permanent Development



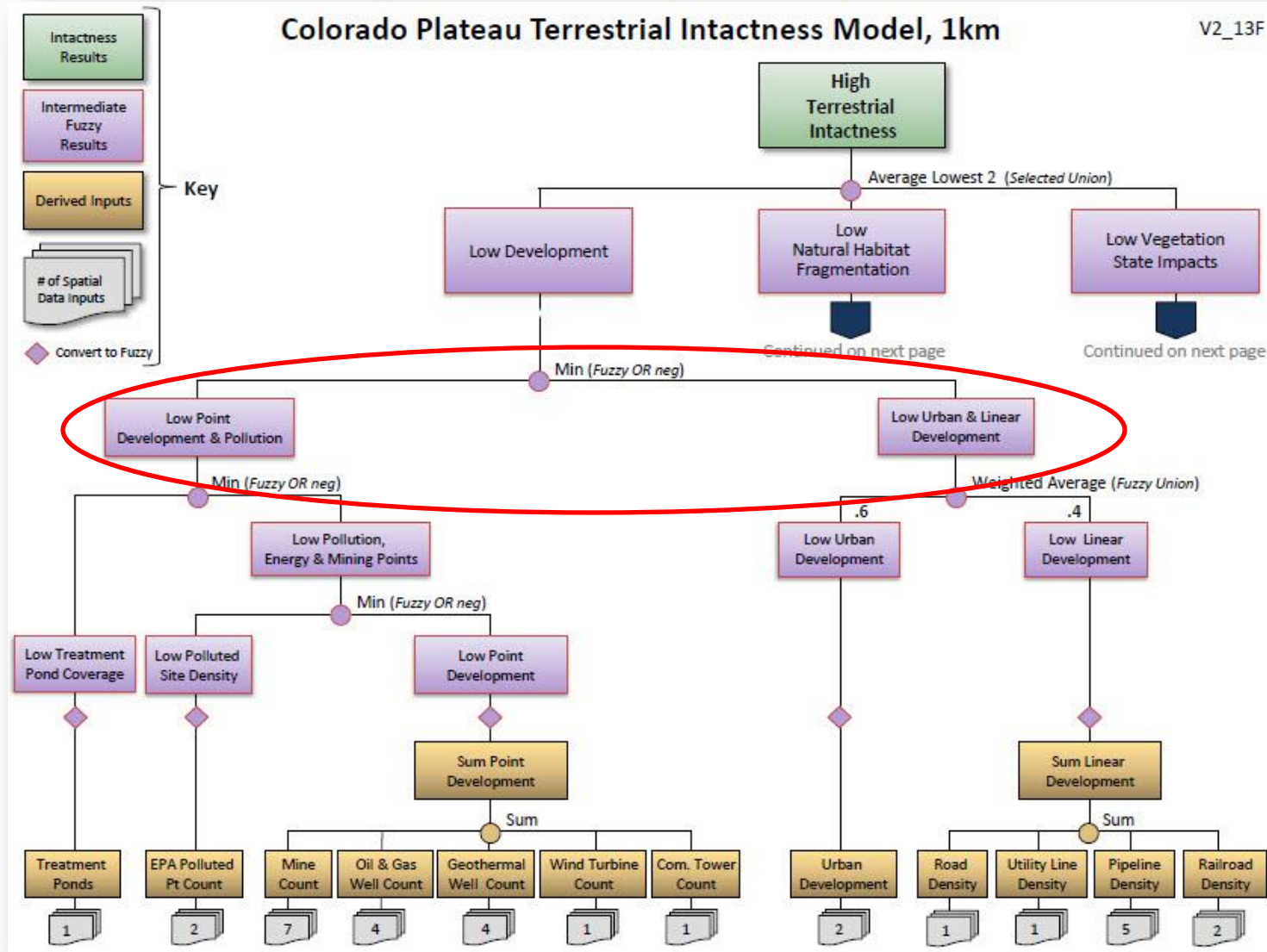
Natural Habitat Fragmentation



Vegetation State Impacts



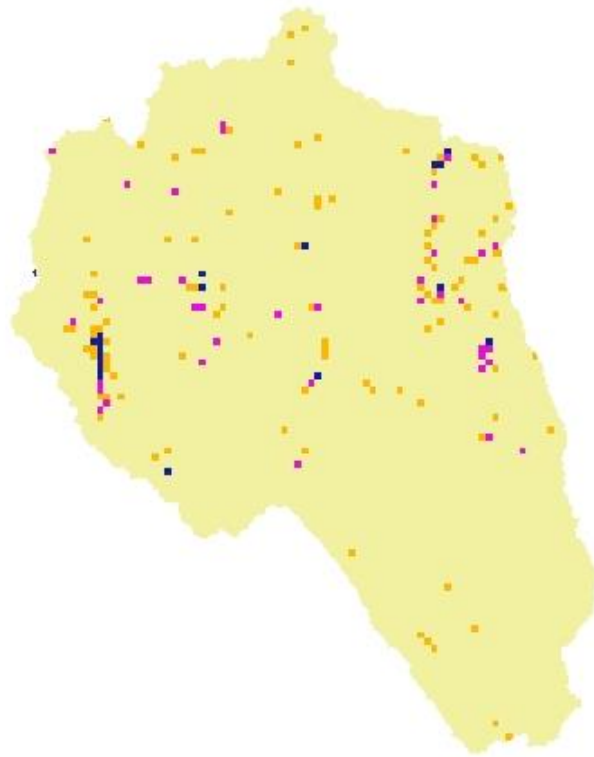
Lighter colors indicate higher intactness.



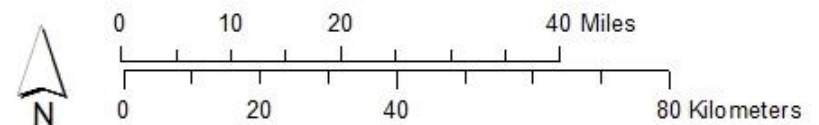
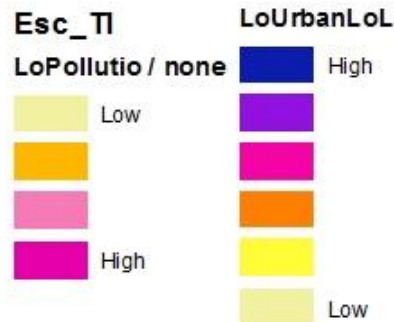
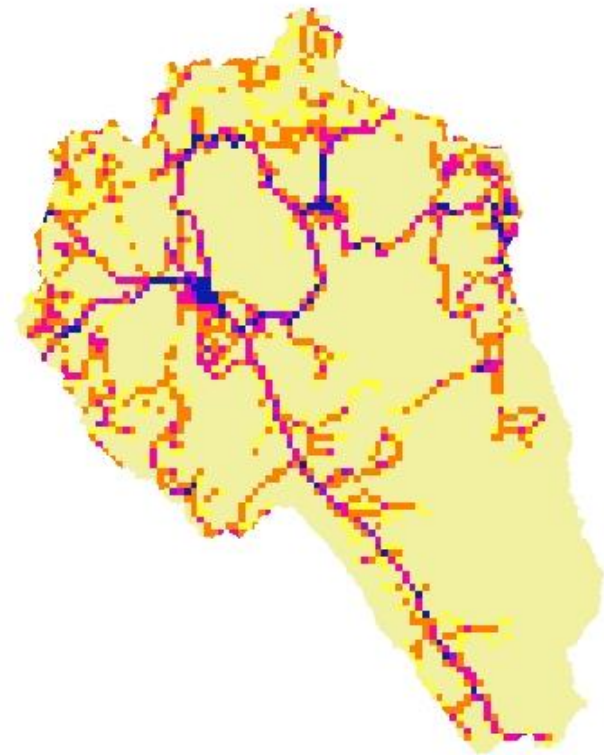
The next slide shows maps of the red-circled model components ->

COP 2014 Terrestrial Intactness - Development Component

Low point development and pollution including treatment ponds, polluted sites, energy, and mining points

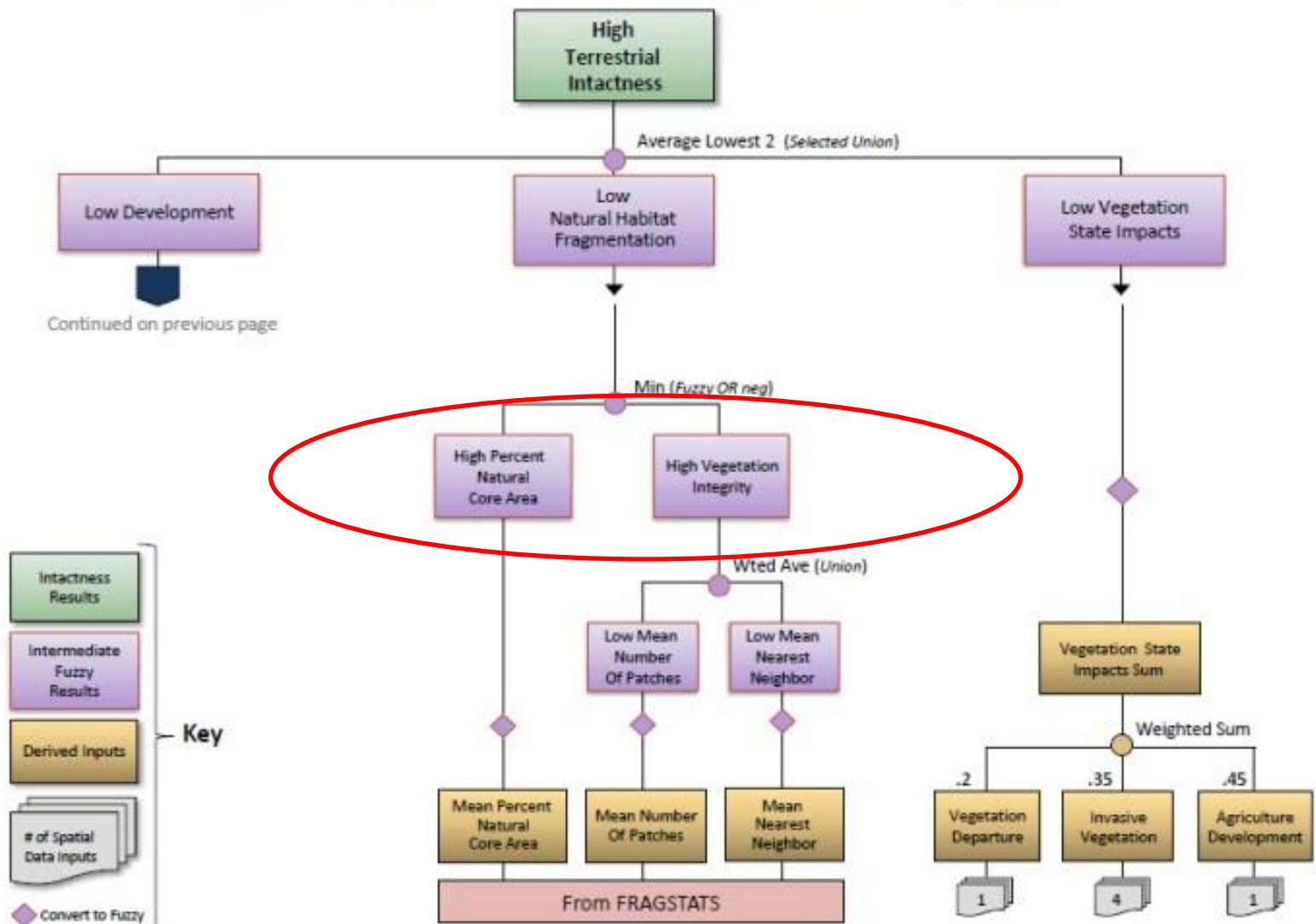


Low urban and other linear development including roads, utilities, pipeline, and railroads



Colorado Plateau Terrestrial Intactness Model, 1km (Con't)

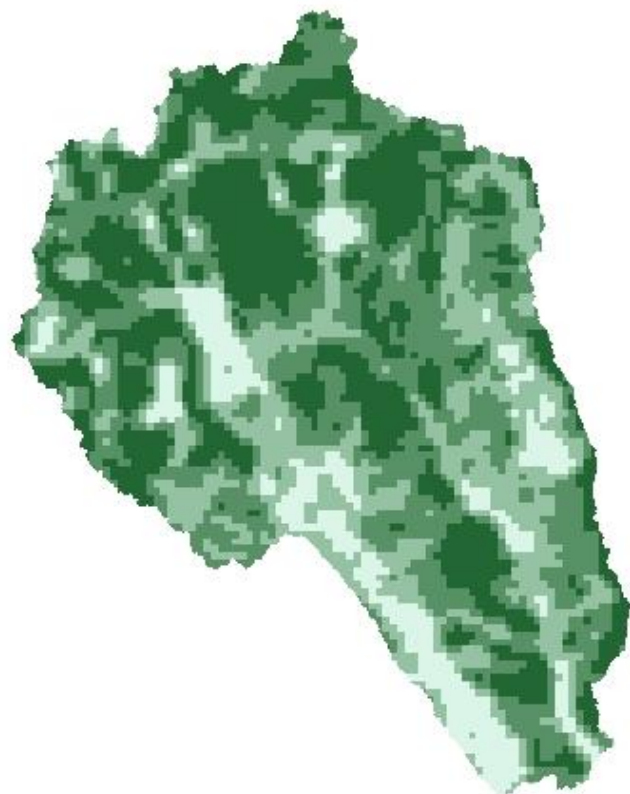
V2_13F



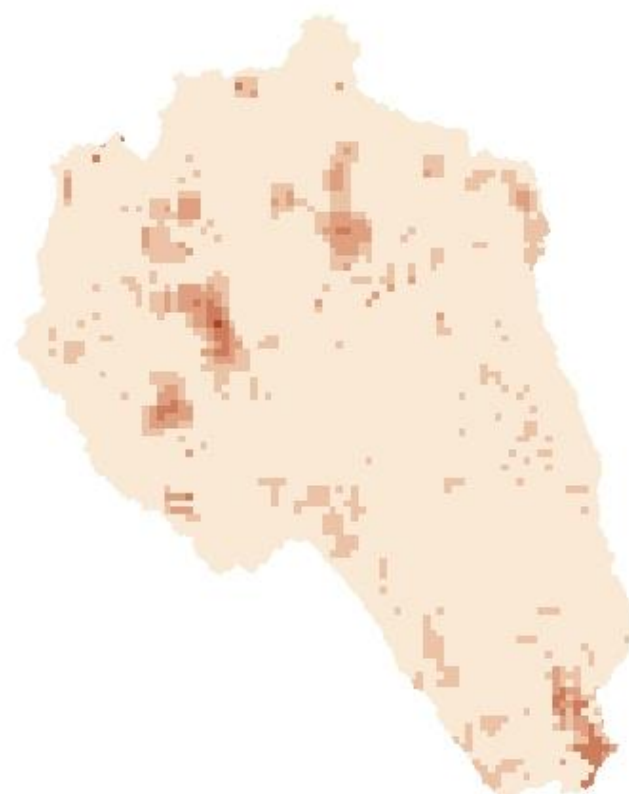
The next slide shows maps of the red-circled model components ->

COP 2014 Terrestrial Intactness - Natural Habitat Fragmentation Component

Low Percent natural core area



Landscape or veg integrity

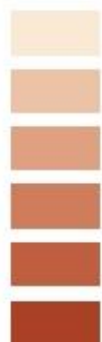


HiCoreArea / none HiLandscape / none



High

Low



High

Low



0 10 20 40 Miles

0 20 40 80 Kilometers

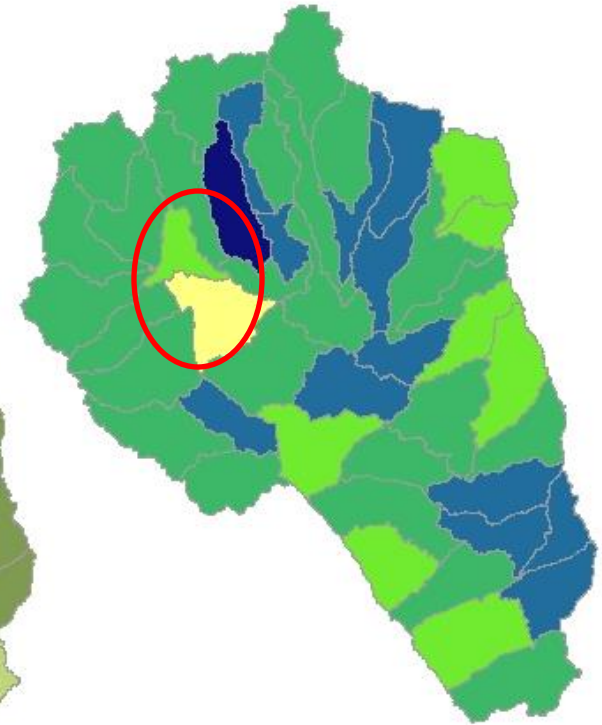
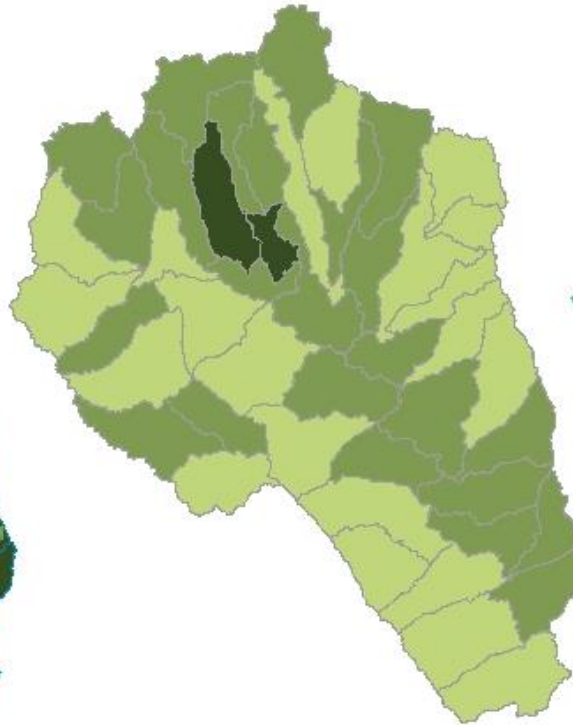
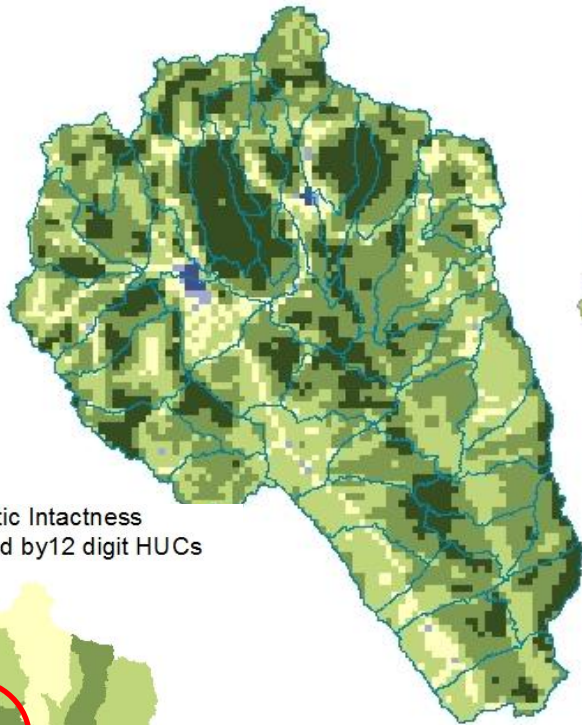
COP 2014 Terrestrial Intactness

at the scales of 1km² (left) and HUC 12 (center and right)

Escalante TI at 1 km²

Escalante TI by HUC12

Aquatic Intactness
summarised by 12 digit HUCs



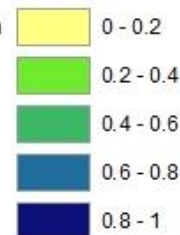
Esc_TI
HiTerrestl



Esc_HUC12
Avg_hiTI

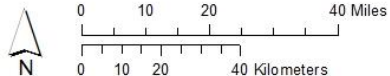


Esc_HUC12
Avg_hiTI



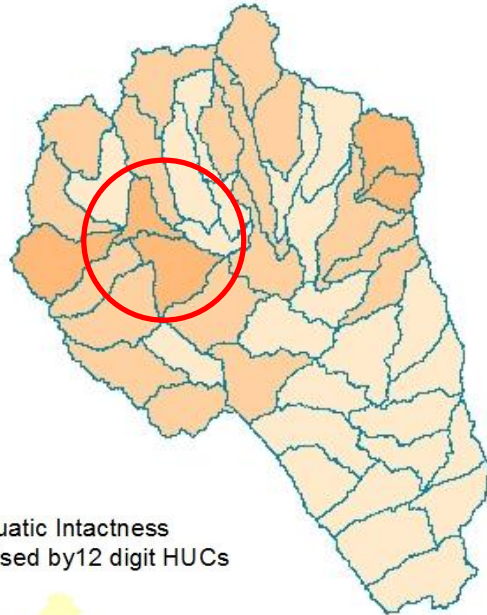
0 5 10 20 Miles

0 15 30 60 Kilometers

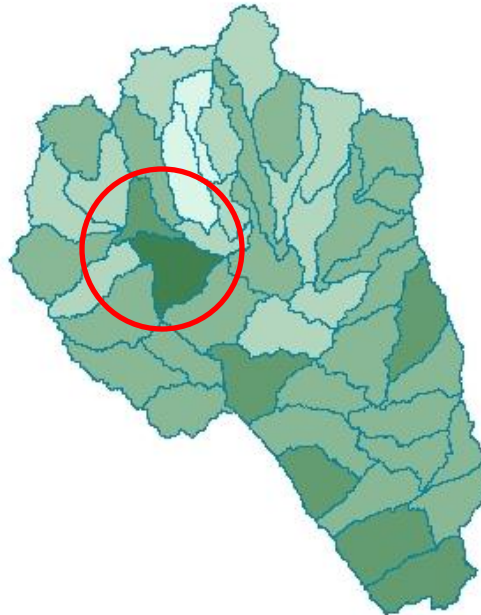


COP 2014 Components of Terrestrial Intactness Escalante Watershed. Summarized by HUC12

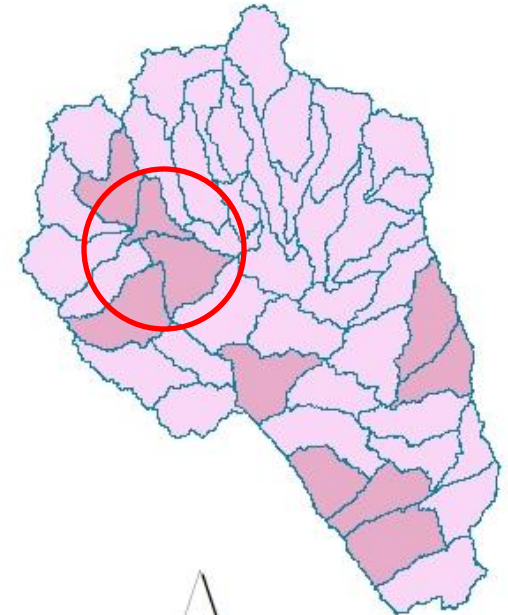
Low DV



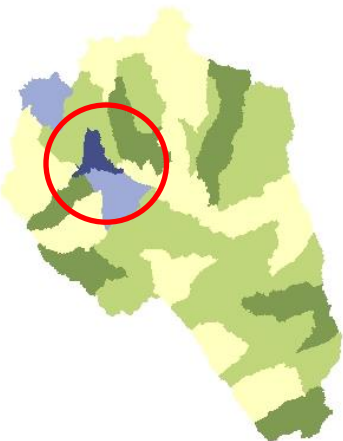
Low Natural Habitat Fragmentation



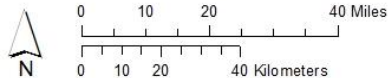
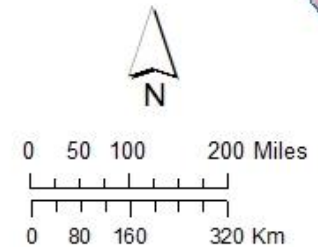
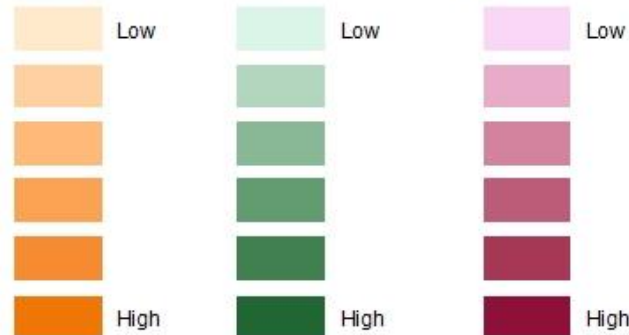
Low Veg State Impacts



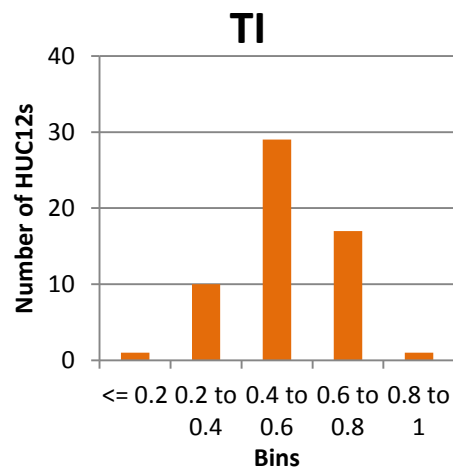
Aquatic Intactness
summarised by 12 digit HUCs



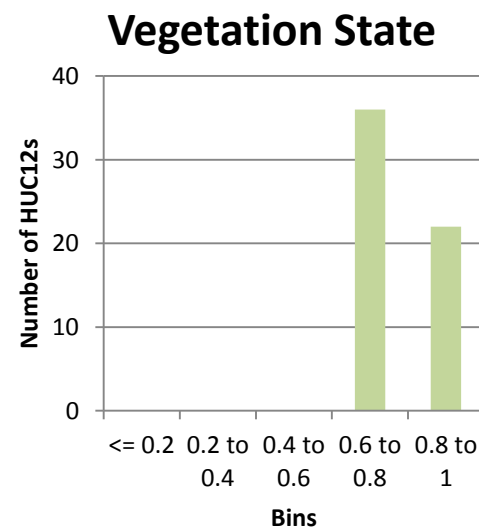
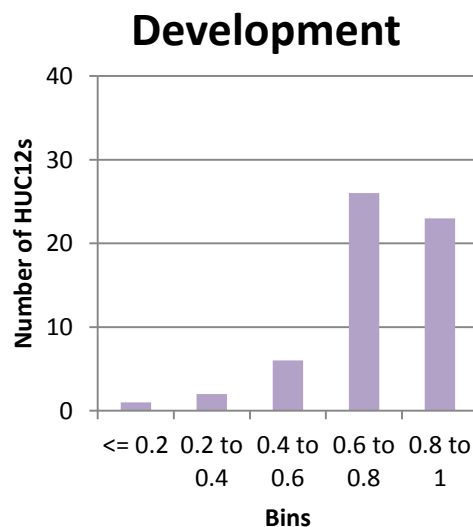
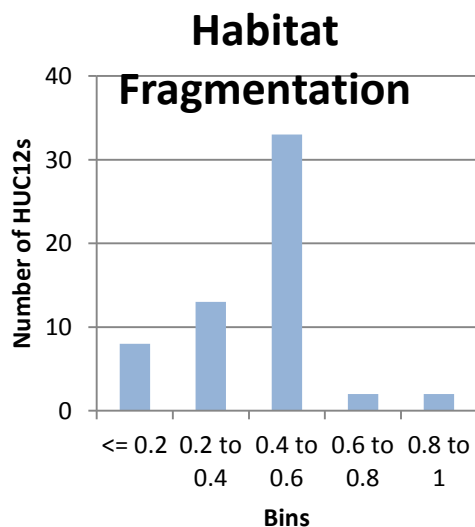
Esc_HUC12 DV Esc_HUC12 Frag Esc_HUC12 veg



Frequency Plots of TI and Components summarized at HUC12



- No negative TI or component values when summarized to HUC12s
- Vegetation state and DV contribute to Very High intactness
- Habitat fragmentation contributes most to Moderately High and High intactness
- Is the summary at this scale useful?



Comparison of TI and AI Inputs

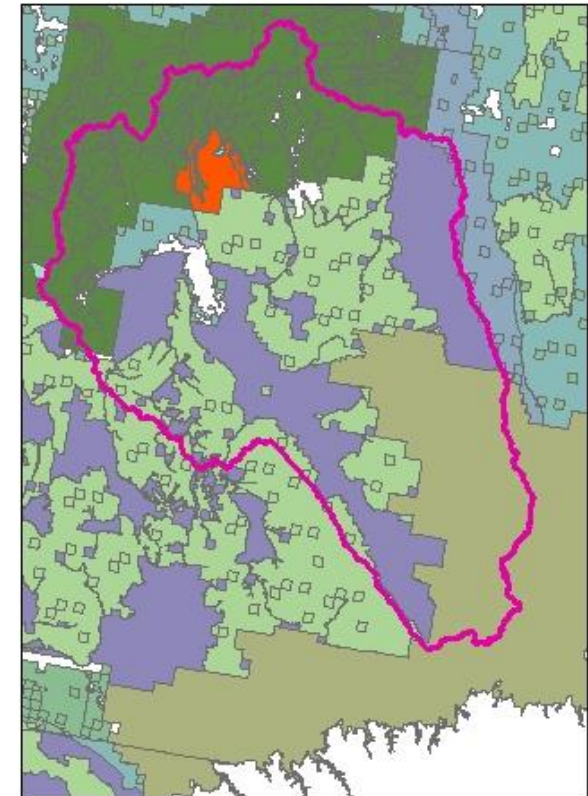
TI Inputs Tier2	TI Tier3	TI Tier4	TI Derived Inputs	AI Inputs Tier2	AI Tier3	AI Tier4	AI Derived Inputs
DV	Low Point DV and Pollution	Treatment Ponds	Treatment Ponds	Hydro Alteration	Water Use	EPA Water Demand	Domestic, Ag, Ind, Thermoelectric
		Pollution Energy & Mining (Site density & Point DV)	EPA Polluted points		Impervious Surfaces	Impervious Surfaces	Percent impervious surface DV
			Mine Count			Road & RR density near streams	Road & RR density near streams
			Oil & Gas Well Count		Water Control	Diversions	
			Geothermal Well Count			Alterations	
			Wind Turbine Count			Reservoir area	
			Com Tower Count			Dams	
	Urban and Linear DV	Urban DV	Urban DV			Downstream from dam impact	
		Linear DV	Road Density				
			Utility Line Density	Water Quality	Impaired Waters	Biotic Integrity	O/E Invert Score
			Pipeline density			303(d) listed streams & waterbodies	303(d) listed streams & waterbodies
			Railroad Density			UT draft IR impaired lakes, peren. streams	UT draft IR impaired lakes, peren. streams
					Non-Ag Pollution	Point Discharge Pollution	NPDES discharge pt count
						Upland Pollution	EPA Superfund & Brownfield Sites
Habitat Frag	Percent Natural Core Area	Mean Percent Natural Core Area	Mean Percent Natural Core Area				Mine Count
	Vegetation Integrity	Mean Number Patches	Mean Number Patches				Oil & Gas Well Count
		Mean Nearest Neighbor	Mean Nearest Neighbor				Treatment Pond
							Impervious Cover
Veg State Impacts		Vegetation State Impacts	Veg Departure		Salinity	Agricultural DV	Percent Ag Cover
			Invasive Veg			Alterations	NHD Linear Alteration
			Agriculture DV			O&G Wells	O&G Well Count
					Ag Nitrogen Pollution	Manure Deposition	Manure
						Synthetic Nitrogen Deposition	Synth. Nitrogen
				Habitat Quality	Upland Human Impacts	Agriculture Impacts	% Agricultural landcover
						Road Impacts	Rd/Stream Crossings
						Urban DV Impacts	Road & RR Density
							Percent Impervious/Surface DV Cover
					Vegetation Condition	Riparian Condition	% Riparian Invasive Plant Cover
						Upland Condition	% Upland Invasive Plant Cover
							Burned Area

Shaded cells indicate similar types of inputs used in both TI and AI but not necessarily the exact same data set.

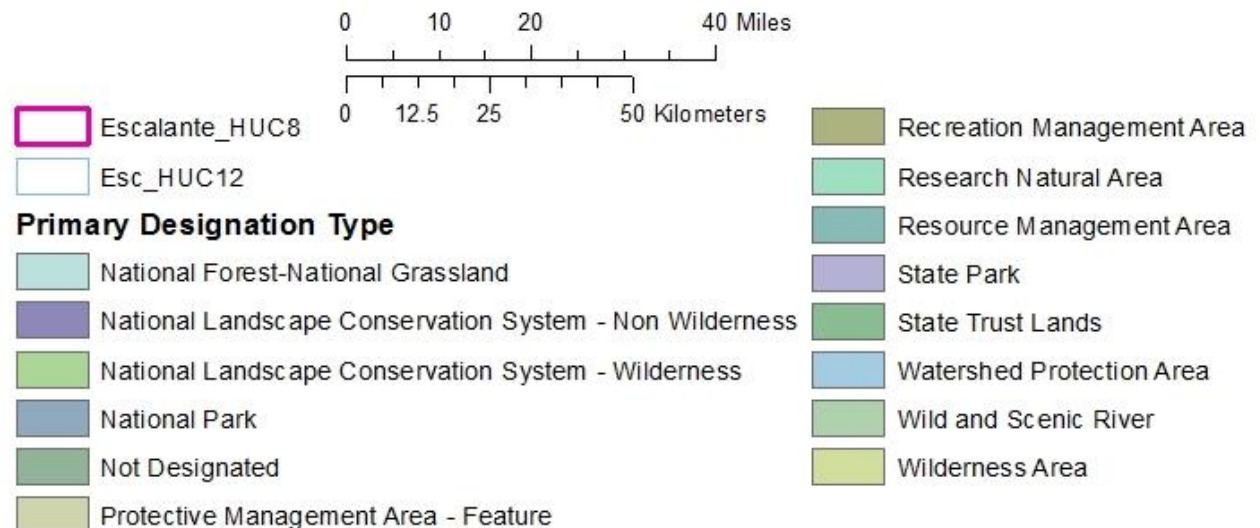
Escalante Basemap



PADUS 1.3

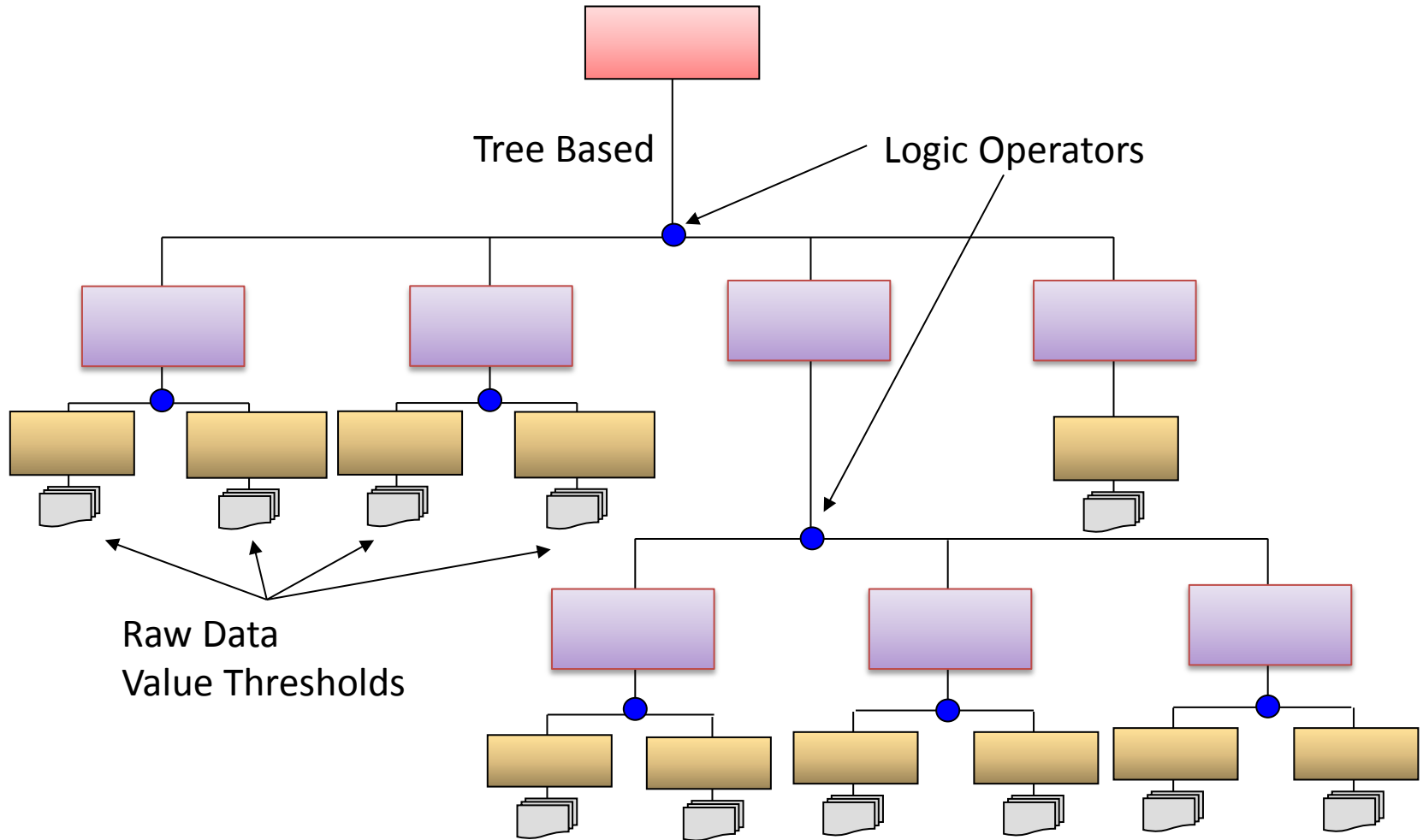


The base map and protected areas maps are shown for background and to promote discussion on the next phases.



The next several slides are to help explain fuzzy logic models, the modeling process and operators, and data conversion to enable fuzzy logic modeling.

Fuzzy Logic Modeling



Multiple factors are converted to fuzzy logic values and combined to address a question

LOGIC OPERATORS

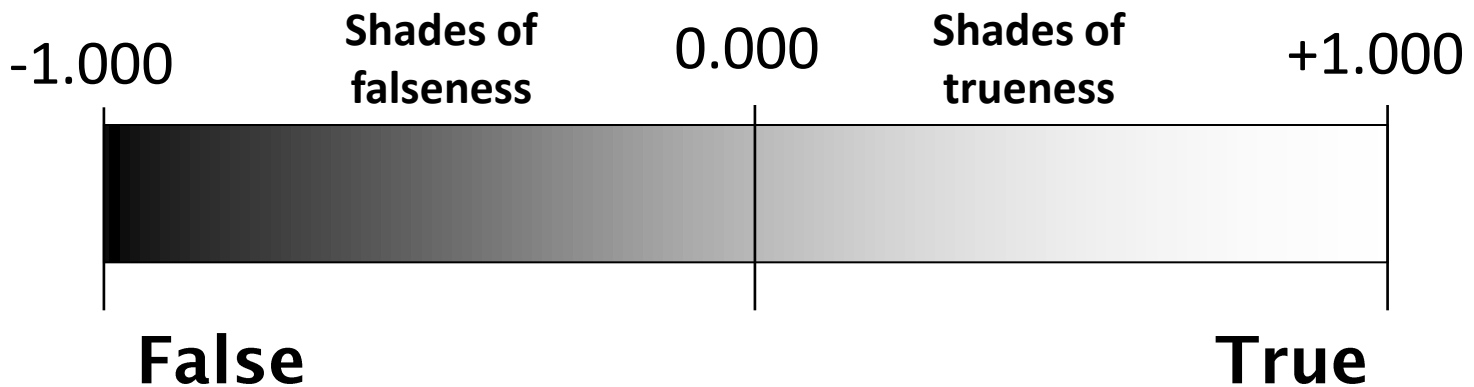
Operator	Input Data	Description
AND	Fuzzy	Finds the EMDS AND value of the inputs (maximum value). The formula is $\min + [(\text{mean} - \min) * (\min + 1) / 2]$
CONVERT TO FUZZY	Raw	Converts a field's values into fuzzy values.
DIFFERENCE	Raw	Computes the difference sum for each row of the inputs.
MAX	Raw	Finds the maximum for each row of the input fields.
MEAN	Raw	Finds the mean for each row of the input fields.
MIN	Raw	Finds the minimum for each row of the input fields.
NOT	Fuzzy	Reverses the sign of values of the input field. TRUEness and FALSEness are swapped.
OR	Fuzzy	Returns the TRUEest of the inputs.
ORNEG (NEGATIVE OR)	Fuzzy	Returns the FALSEest of the inputs values.
SELECTED UNION	Fuzzy	Finds the union value (mean) of the specified number of TRUEest or FALSEest inputs.
SUM	Raw	Arithmetic addition of two or more inputs.
UNION	Fuzzy	Returns the mean of the inputs.
WEIGHTED AND	Fuzzy	Finds the weighted EEMS AND value of the inputs (maximum value). The formula is $\min + [(\text{mean} - \min) * (\min + 1) / 2]$ where the mean is weighted.
WEIGHTED MEAN	Fuzzy	Finds the weighted mean for each row of the input fields.
WEIGHTED SUM	Fuzzy	Finds the weighted sum for each row of the input fields. Multiplies each field by its weight before adding. Like a weighted mean without the division.
WEIGHTED UNION	Fuzzy	Finds the weighted union (mean) for each row of the input fields.
XOR	Fuzzy	Finds the fuzzy EXCLUSIVE OR value of the inputs by comparing the two truest values. If both are fully true or fully false, false is returned. Otherwise it applies the formula: $(\text{truest value} - \text{second truest value}) / (\text{full true} - \text{full false})$

Based on Fuzzy Logic

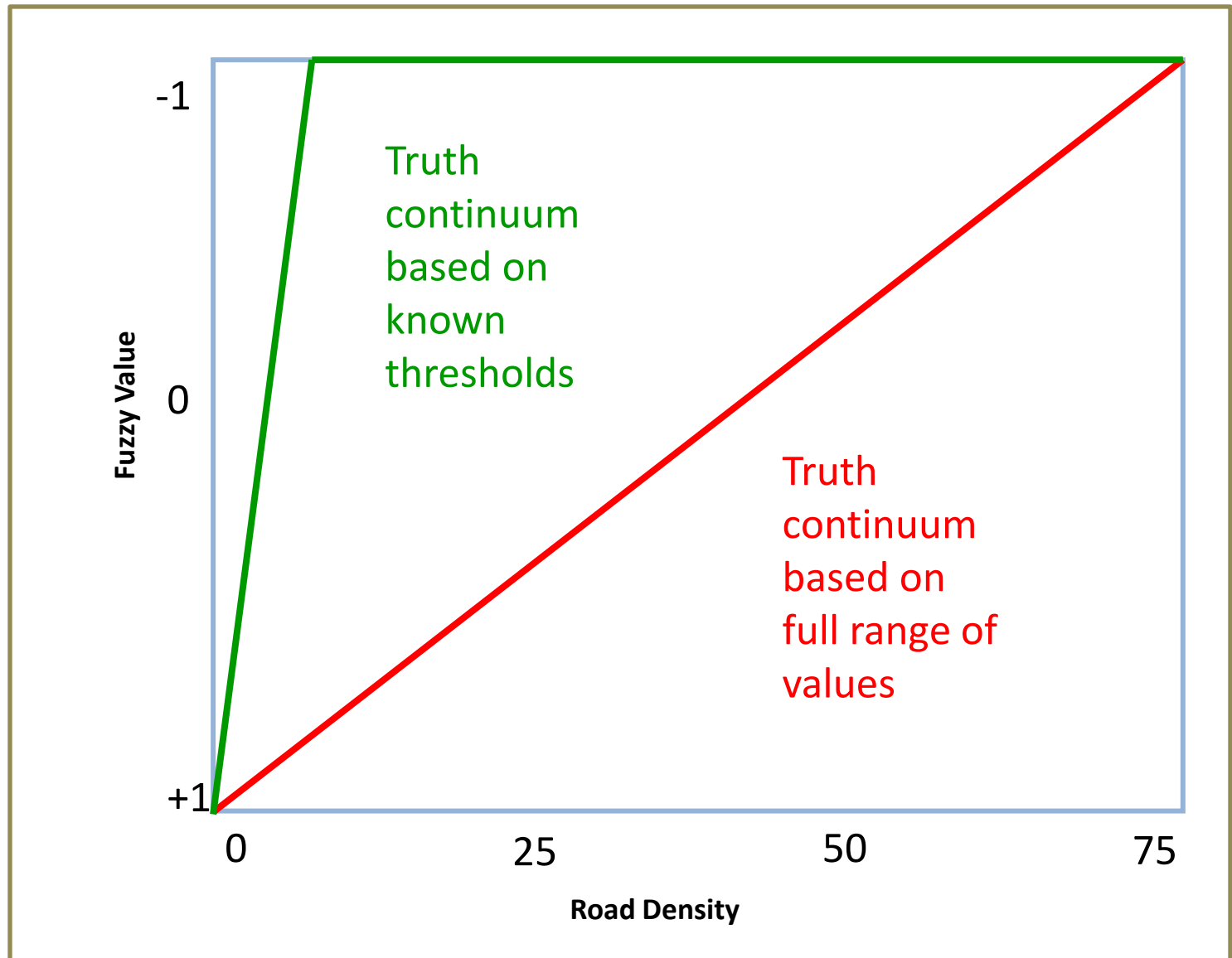
Provides a way of normalizing different types of data into a common range of values (“fuzzy values”).

e.g. High Intactness might take into account:

- Oil wells (point density)
- Roads (linear density)
- Invasive species extent (percent area)



Assigning Inputs Thresholds



Example of converting raw data to fuzzy logic values: Low Oil Well Density

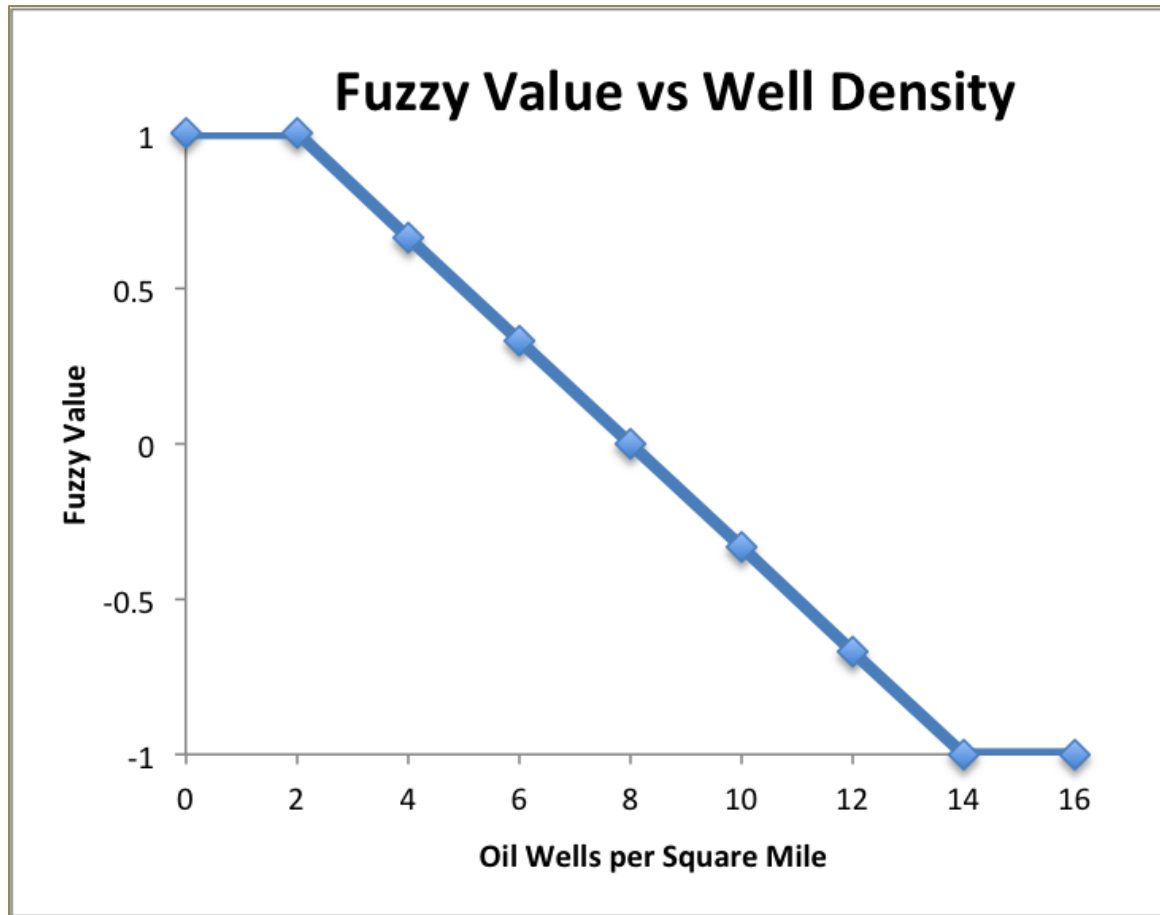
Proposition: Mapped polygon has low oil well density

TRUE threshold: 2 oil wells per mi^2

FALSE threshold: 14 oil wells per mi^2

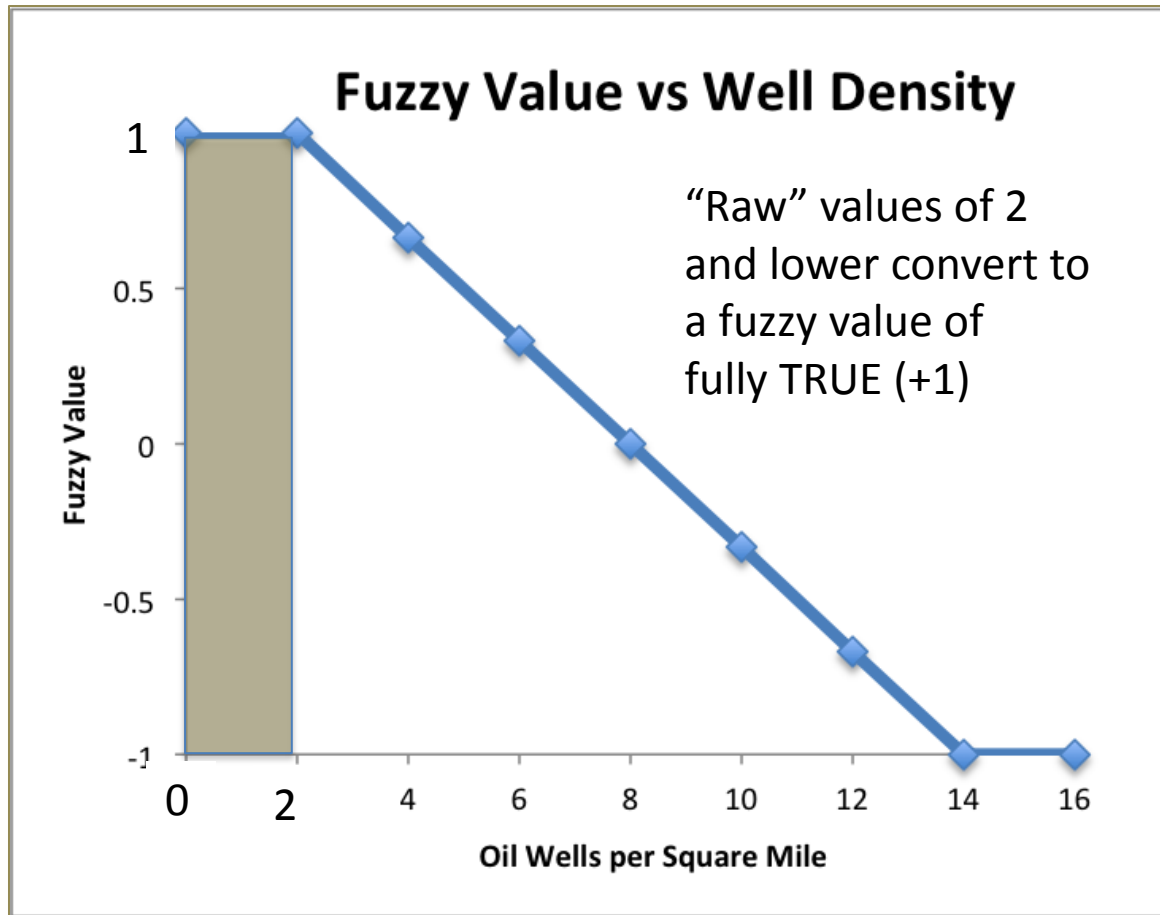
Low Oil Well Density

Real value to fuzzy value conversion



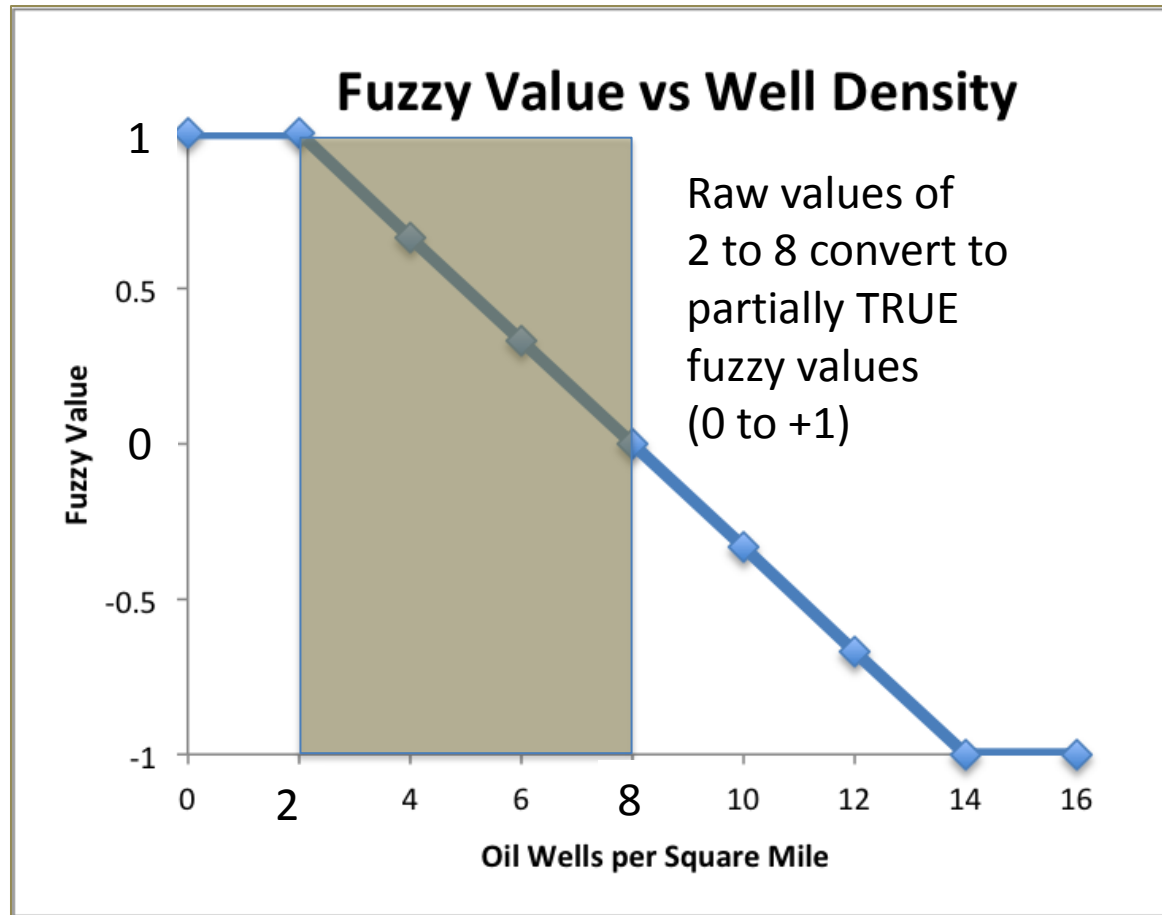
Low Oil Well Density

Real value to fuzzy value conversion



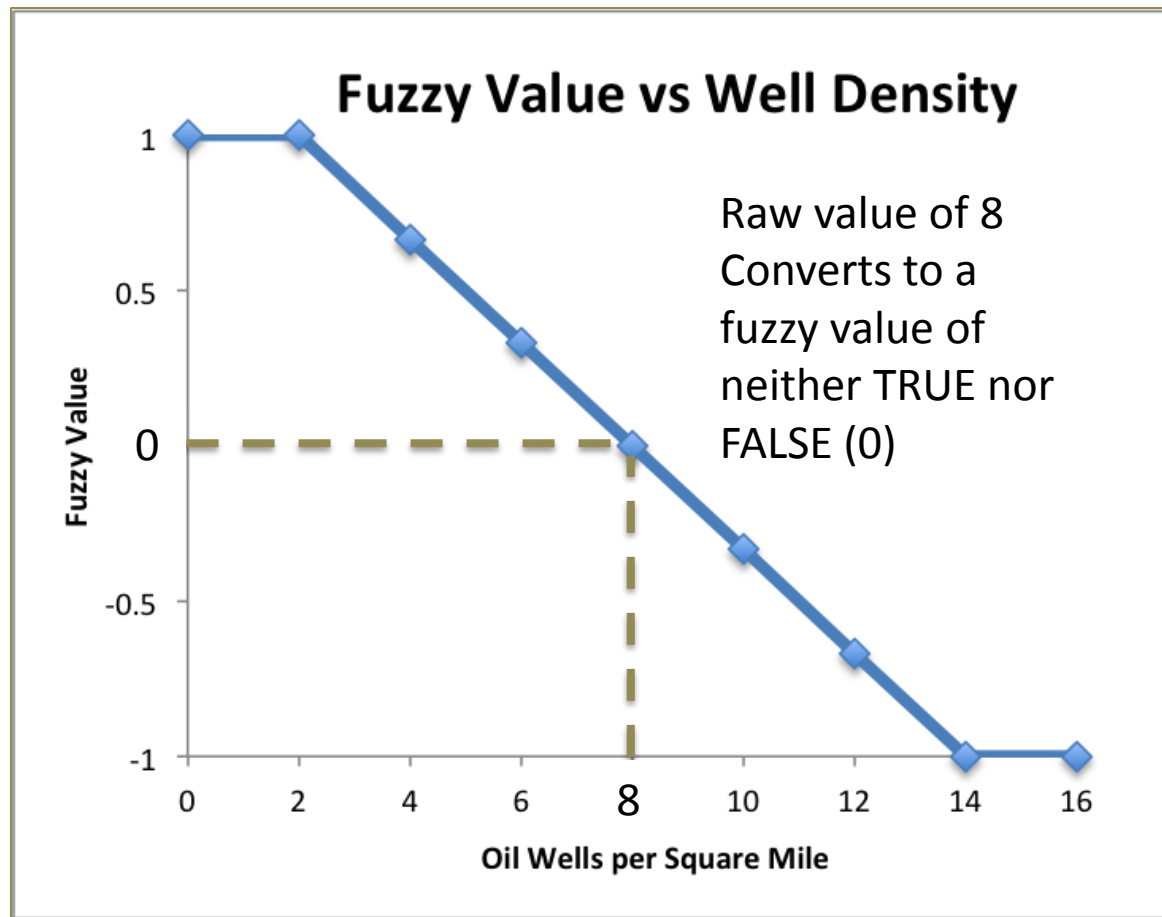
Low Oil Well Density

Real value to fuzzy value conversion



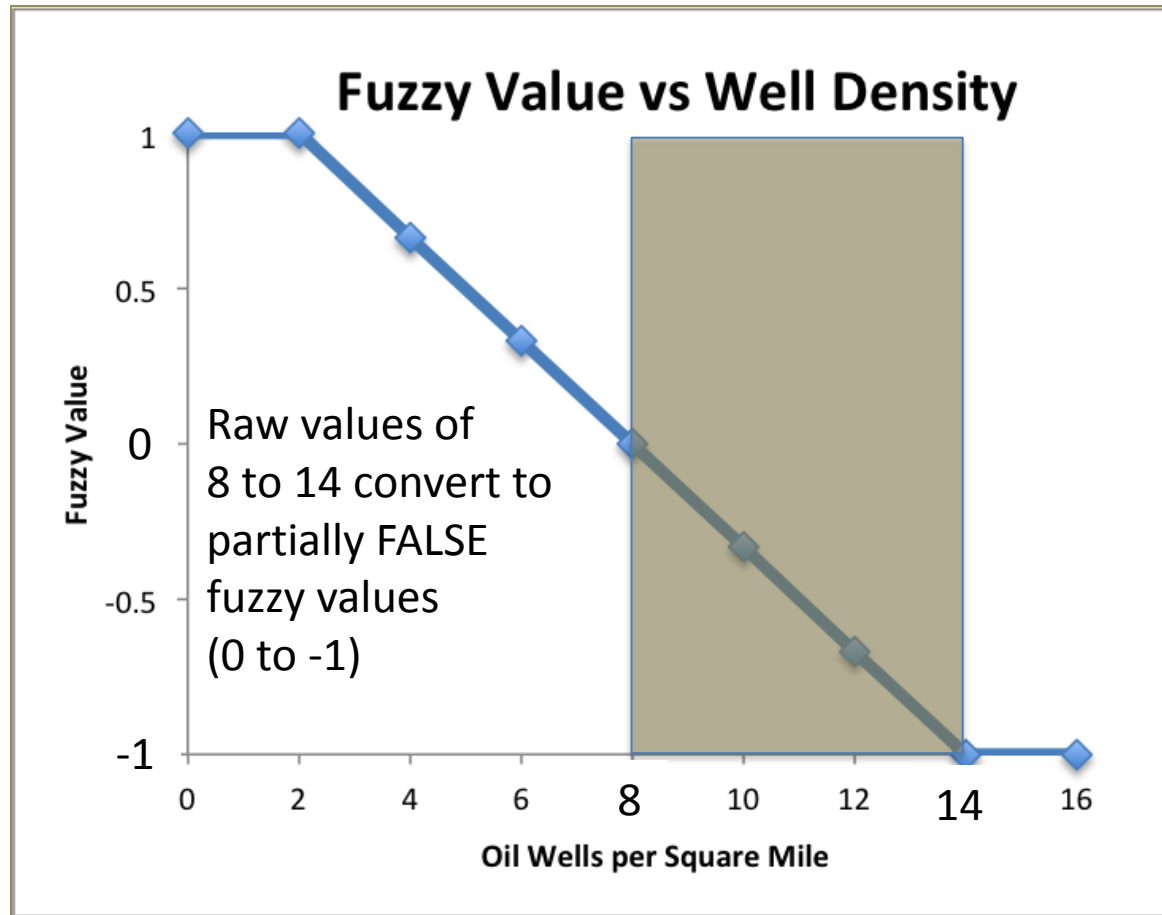
Low Oil Well Density

Real value to fuzzy value conversion



Low Oil Well Density

Real value to fuzzy value conversion



Low Oil Well Density

Real value to fuzzy value conversion

