Modeling the alternative approaches to stream classification

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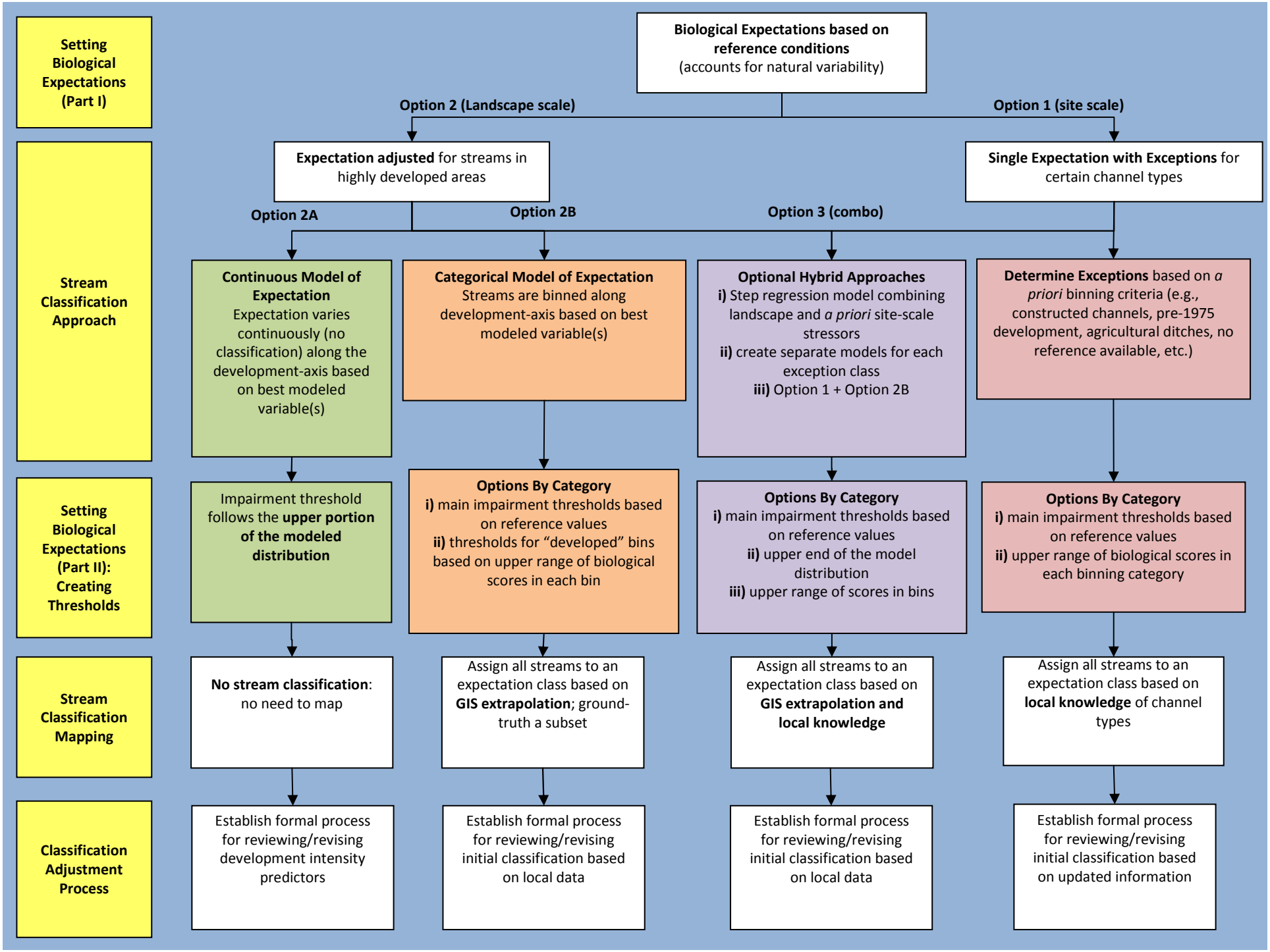
USGS

4/20/11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Option 2 (Landscape scale)
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Single Expectation with Exceptions for certain channel types
Option 2A
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Approach:

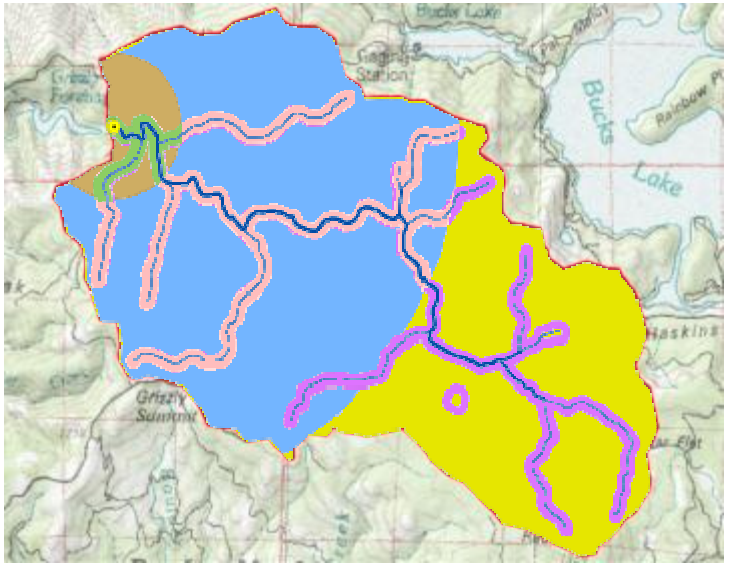
- Focus on SMC-Xeric region
  - Based on strong gradient
  - data density (allows for subsetting)
- Stepwise multiple linear modeling
- Response variable(s):
  - So. Cal. IBI, O/E, EPT richness
- "Best model" determined from
  - Adjusted R^2
  - AIC: Akaike Information Criterion
    - Models with AIC within 2 points are equally plausible

Data Reduction

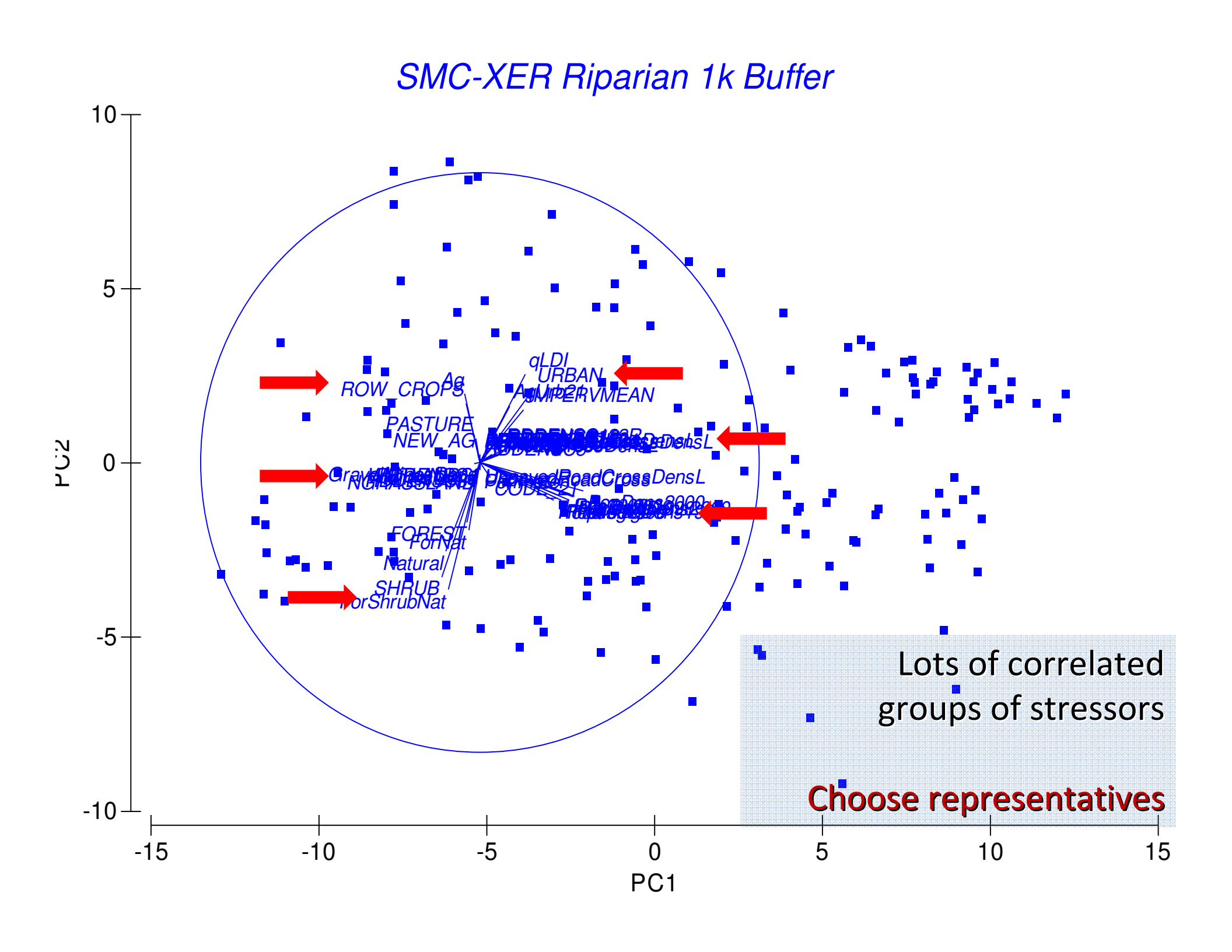
- Methods
  - Correlation, PCA, Random Forest
- GIS scale selection
- Winnowing process
  - Original 167 variables reduced to 44 (~25% left)
    - Reach
    - riparian 1k
    - watershed
  - Secondary data reduction with Random Forest on 44 variable set

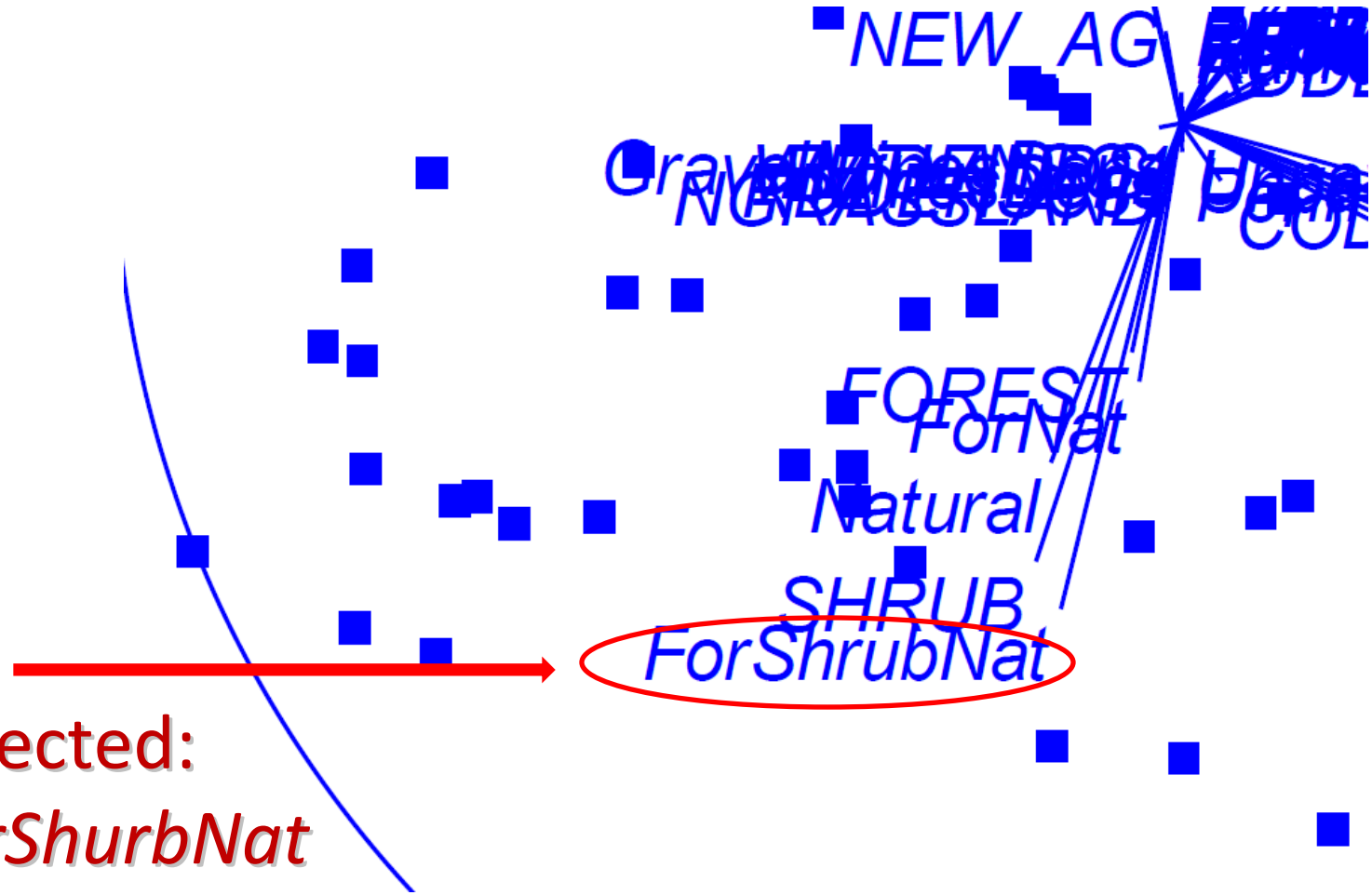
Deciding which GIS scales to model

- Initial decision to use Watershed scale info (WS)
- Want the scale most different from WS
  - Used Primer routine-RELATE to test for similarity between WS and other scales of GIS information



Resemblance Matrix A	Resemblance Matrix B	Rho	scale
WS	1k	0.323	1k radial clip
WS	5k	0.541	5k radial clip
WS	r1k	**0.270**	1k riparian buffer
WS	r5k	0.461	5k riparian buffer
WS	rWS	0.852	WS riparian buffer


SMC-XER Riparian 1k Buffer
10
5
0
-5
-10
PC2
-15
-10
-5
0
5
10
15
PC1
qLDI
URBAN
Ag
ROW_CROPS
PASTURE
NEW_AG
FOREST
ForNat
Natural
SHRUB
NonShrubNat
Lots of correlated
groups of stressors
Choose representatives



Selected:
ForShurbNat

Reach level 'Surrogates'

Model Variable	Surrogates	
COND	*ALK*	*CL*
NTL	*CL*	
Elevation	*XSLOPE*	
P_SAFN	*Log Rel. Bed Stab.*	
W1_HALL	*general disturbance*	
Precipitation(PPT)	*PRISM-general climate*	
Temperature (TEMP)	*PRISM-general climate*	

SMC-XER:

Correlation of Biotic Indicators (Spearman's)

	O_E_0	O_E_05	IBI_Score	EPT
O_E_0	1			
O_E_05	0.85	1		
IBI_Score	0.79	0.63	1	
EPT	0.81	0.69	0.72	1

- Responses are relatively highly correlated
- Perform differently in the models

SMC-XER- Variables for Modeling Effort

Bio-Indicators	Reach	Riparian 1k	Watershed
O_E_0	COND	r1k_PC1	ws_PC1
O_E_0.5	NTL	r1k_Ag	ws_Ag
So. Cal. IBI Score	Elevation	r1k_CODE_21	ws_CODE_21
EPT Richness	P_SAFN	r1k_URBAN	ws_URBAN
	W1_HALL	r1k_qLDI*	ws_qLDI*
	PPT	r1k_AgUrb21	ws_AgUrb21
	TEMP	r1k_ForShrubNat	ws_CanalPipe24kPer
		r1k_HousingDens2000	ws_DamDensArea
		r1k_IMPERVMEAN	ws_ForShrubNat
		r1k_PASTURE	ws_GravelMinesDens
		r1k_PavedRoadCross	ws_GRAZING
		r1k_PopDens2000	ws_HousingDens2000
		r1k_RDDENSC1234	ws_IMPERVMEAN
		r1k_RoadRailroadCross	ws_LengthNoPipe24k
		r1k_ROW_CROPS	ws_MinesDens
		r1k_WETLANDS	ws_PASTURE
			ws_Pipe24k
			ws_PopDens2000
			ws_RDDENSC1234
			ws_ROW_CROPS
			ws_WETLANDS

**** qLDI = ∑[(Code21 *2)+(AG*6)+(URBAN*8.5)]***
-Coefficient values modified from Brown and Vivas (2005)

Secondary data reduction phase

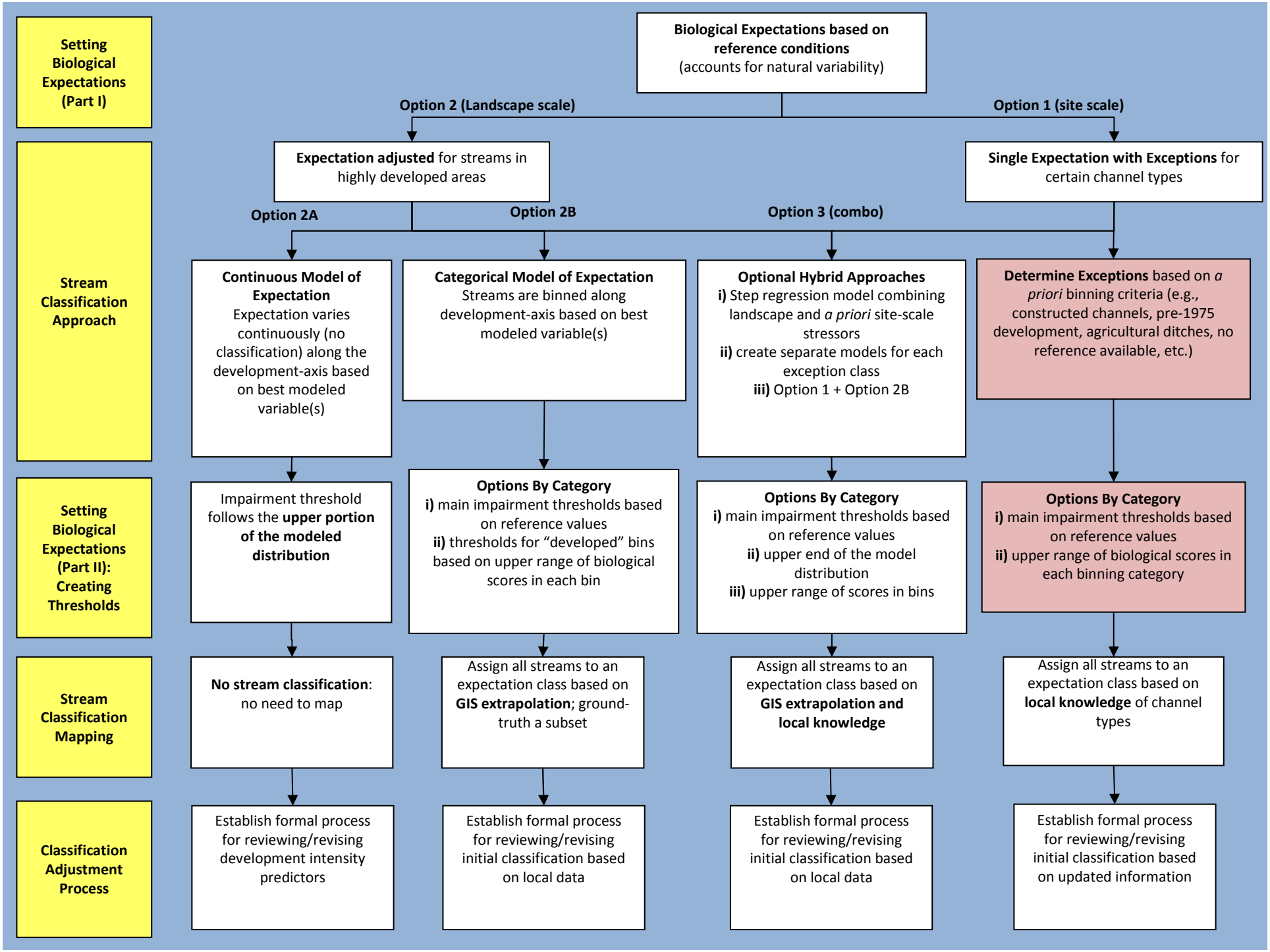
IBI, OE, EPT,& OE_0.5

Random Forest

Used the top 20 variables to start the modeling process

So. Cal. IBI Score **(56% var exp)**		**O/E (46% var exp)**	
r1k_AgUrb21	17.84	P_SAFN	19.23
ws_IMPERVMEAN	17.45	r1k_URBAN	17.83
ws_RDDENSC1234	17.12	r1k_AgUrb21	17.45
ws_URBAN	17.04	r1k_qLDI	16.59
r1k_qLDI	16.78	r1k_IMPERVMEAN	16.38
ws_AgUrb21	16.75	ws_URBAN	15.54
ws_qLDI	16.35	ws_qLDI	14.72
ws_HousingDens2000	14.98	ws_IMPERVMEAN	14.69
r1k_IMPERVMEAN	14.91	NTL	13.33
PPT	14.18	ws_ForShrubNat	12.99
ws_ForShrubNat	13.88	ws_AgUrb21	12.35
ws_PopDens2000	13.49	ws_RDDENSC1234	11.57
ws_CODE_21	13.45	COND	10.72
COND	12.84	TEMP	10.64
r1k_URBAN	12.66	PPT	9.93
Elevation	11.75	r1k_ForShrubNat	9.89
W1_HALL	11.48	r1k_PC1	9.70
r1k_ForShrubNat	9.96	ws_HousingDens2000	9.61
r1k_PopDens2000	9.82	ws_PopDens2000	8.91
NTL	9.19	ws_DamDensArea	8.88
r1k_RDDENSC1234	8.61	ws_GRAZING	8.50
r1k_HousingDens2000	8.32	r1k_HousingDens2000	8.14
r1k_PC1	8.18	ws_LengthNoPipe24k	7.87

MODELING THE ALTERNATIVE APPROACHES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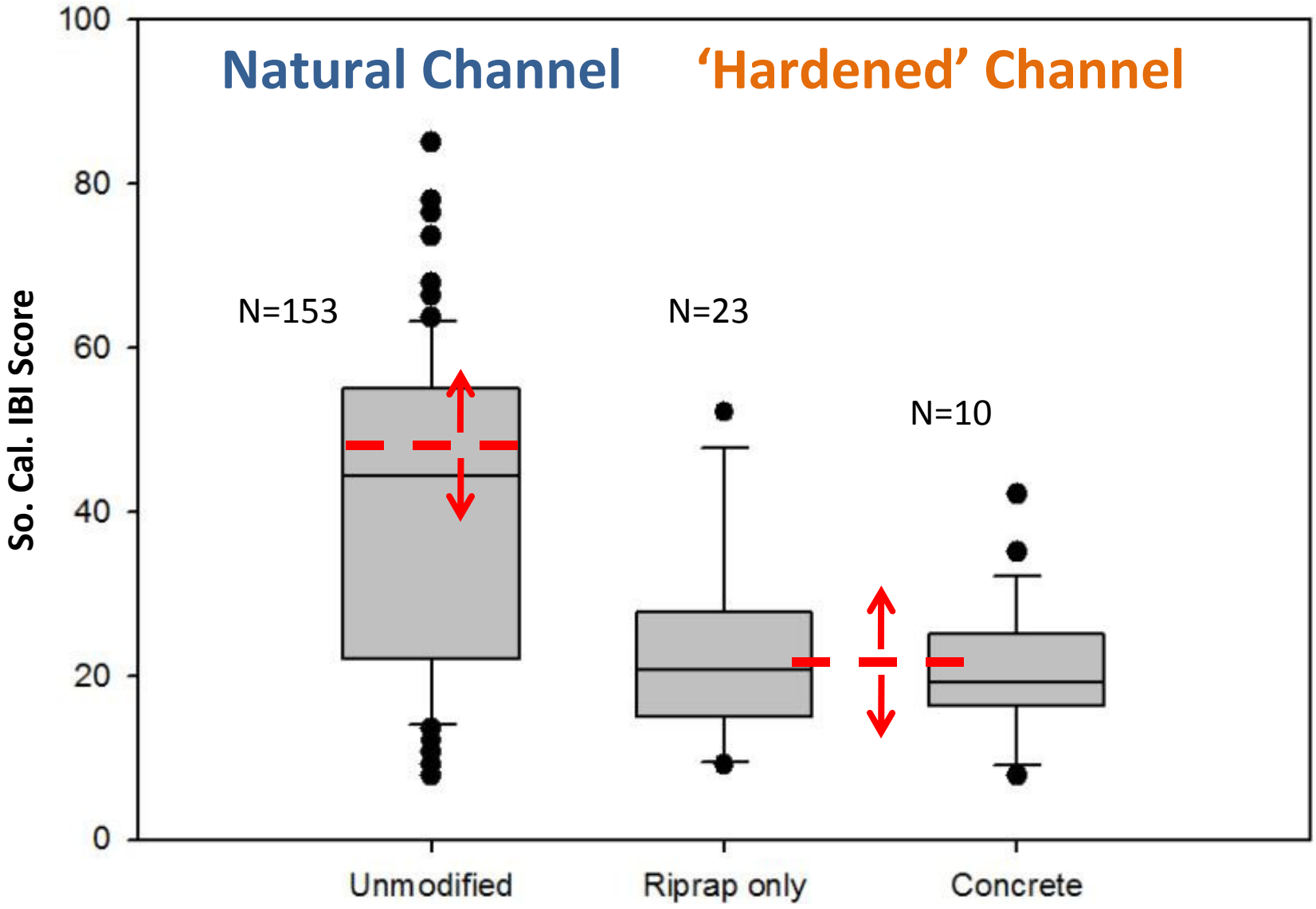
Option-1 Site scale

- Single expectation with exceptions for certain channel types

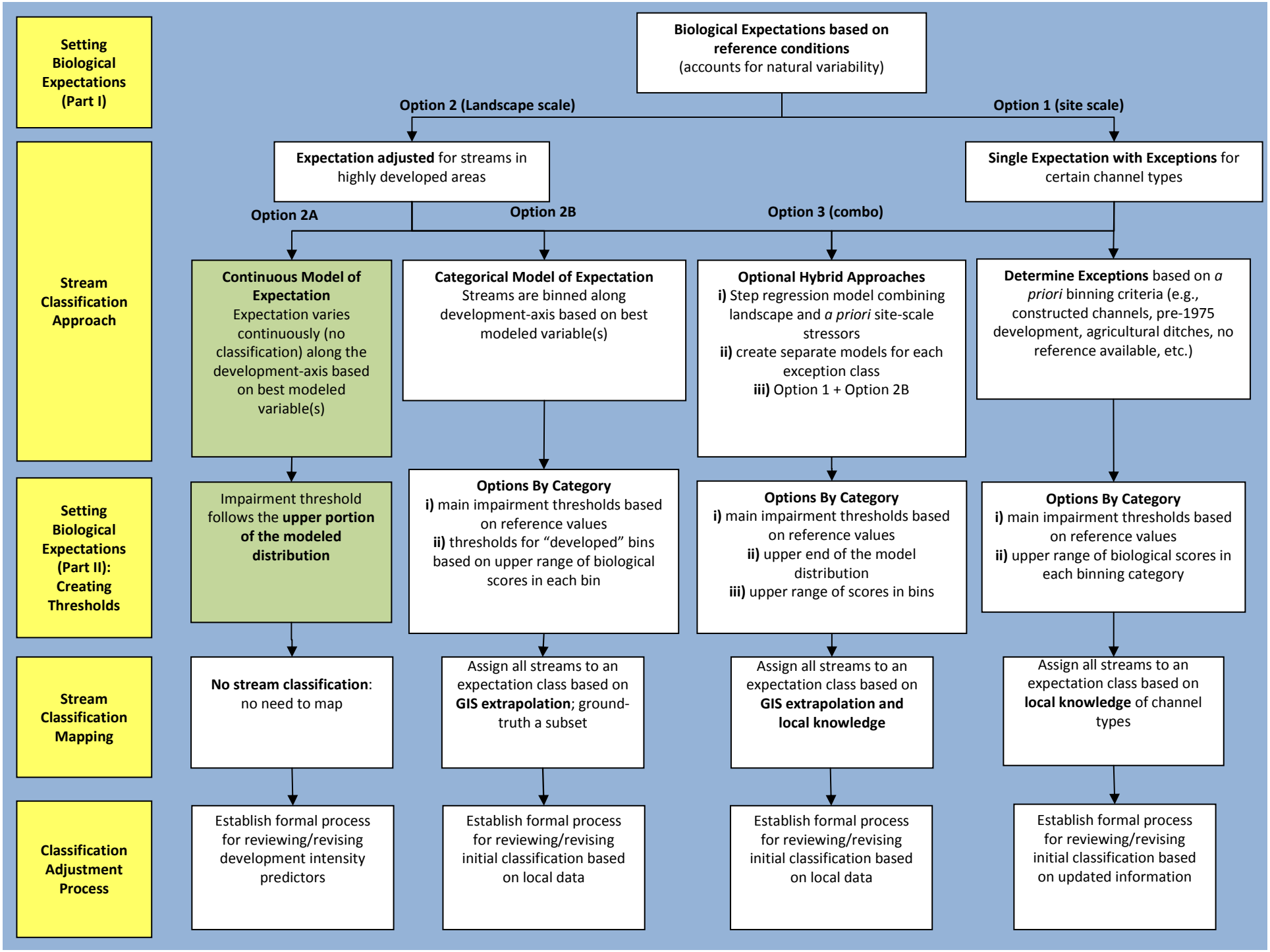
- Exceptions are based on *a priori ,* likely non-technical decisions
  - Concrete lined, Ag ditches, etc.

Example Site Scale Approach using *a priori* Stream Classification from So. Cal. (SMC)



Lesson learned from option 1

- Simple: If we the had data in hand we could do it tomorrow
- We do not really have this data
  - Categories like this are not available in data or GIS coverages
  - This “estimate” is used later in the modeling because it is the best we have
- Where is the threshold?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Continuous Model of Expectation 2A

- Expectation varies continuously (no classification) along the development-axis based on best modeled variable(s)

- Impairment threshold follows the upper portion of the modeled distribution

MODELING OUTPUTS FOR BEST MODELS USING ALL VARIABLES

So. Cal. IBI Score &
EPT Richness

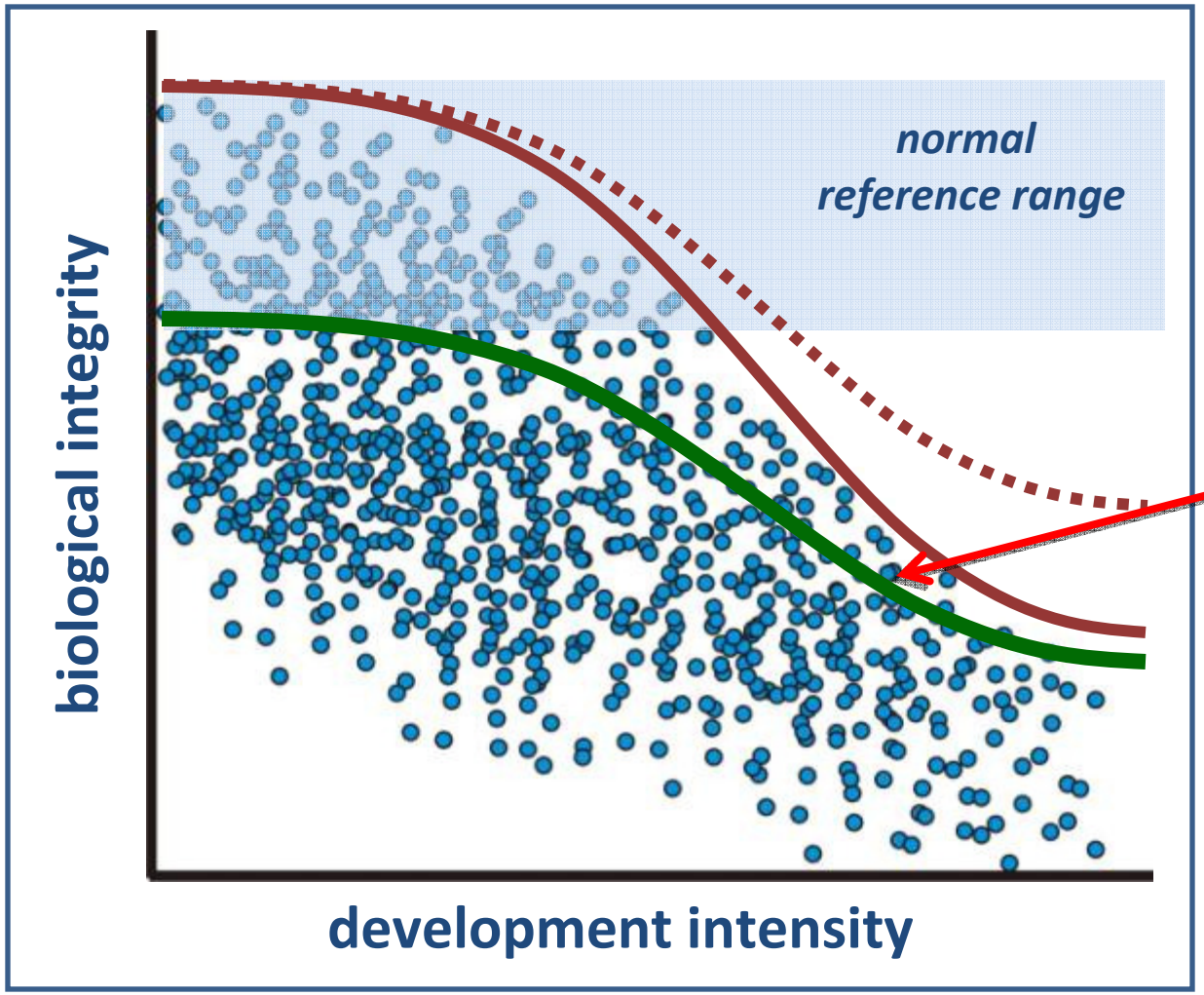
SMC-XER EPT Richness

Variable	adj-R2	AIC	reach	1k riparian	watershed
r1k_qLDI	0.3729	370.4		x	
r1k_IMPERVMEAN	0.3684	371.73		x	
r1k_URBAN	0.3628	373.38		x	
r1k_AgUrb21	0.3348	381.35		x	
ws_URBAN	0.2999	390.88			x
r1k_qLDI + ws_URBAN + NTL	**0.426**	**355.91**	**x**	**x**	**x**
ws_qLDI + r1k_IMPERVMEAN + ws_RDDENSC1234	0.4249	356.25		x	x
r1k_qLDI + r1k_URBAN + ws_qLDI	0.4226	356.99		x	x
r1k_qLDI + ws_URBAN + Elevation	0.4221	357.17	x	x	x
r1k_qLDI + ws_URBAN + ws_IMPERVMEAN	0.4218	357.27		x	x
r1k_IMPERVMEAN + ws_qLDI + NTL + ws_RDDENSC1234	**0.4346**	**354.07**	**x**	**x**	**x**
r1k_qLDI + ws_URBAN + NTL + Elevation	0.4343	354.18	x	x	x
r1k_qLDI + r1k_URBAN + ws_qLDI + NTL	0.4327	354.69	x	x	x
r1k_qLDI + r1k_URBAN + ws_URBAN + NTL	0.4325	354.76	x	x	x
r1k_qLDI + ws_URBAN + ws_IMPERVMEAN + NTL	0.4318	354.99	x	x	x

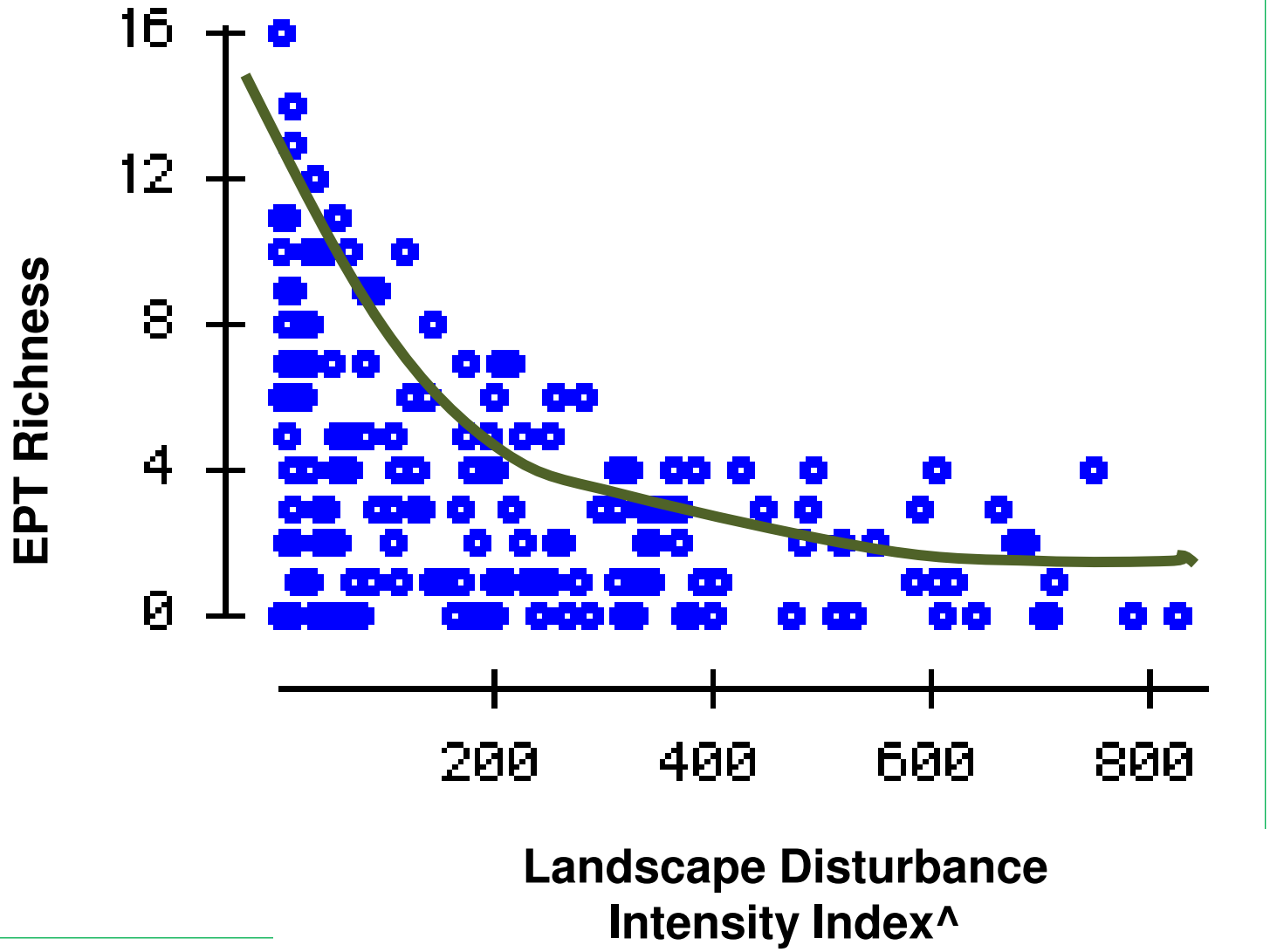
SMC-XER SO.CAL. IBI Score

Variable	adj-R2	AIC
ws_URBAN	0.4635	962.82
ws_qLDI	0.4581	964.68
ws_IMPERVMEAN	0.4266	975.21
r1k_qLDI	0.4129	979.58
ws_AgUrb21	0.4106	980.33
r1k_AgUrb21+ws_IMPERVMEAN+ws_URBAN	0.5519	931.31
ws_IMPERVMEAN+ws_URBAN+r1k_qLDI	0.5516	931.43
r1k_AgUrb21+ws_URBAN+PPT	0.5506	931.84
ws_URBAN+r1k_qLDI+COND	0.5502	932.03
ws_URBAN+ r1k_qLDI+PPT	0.5497	932.23
r1k_AgUrb21+ws_IMPERVMEAN+ws_URBAN+PPT	**0.566**	**926.35**
r1k_AgUrb21+ws_IMPERVMEAN+ws_URBAN+Elevation	0.5652	926.67
ws_IMPERVMEAN+ws_URBAN+r1k_qLDI+PPT	0.5644	927.04
ws_IMPERVMEAN+ws_URBAN+r1k_qLDI+Elevation	0.5631	927.57
ws_IMPERVMEAN+ws_URBAN+r1k_qLDI+COND	0.5617	928.17

Continuous Threshold



Real data example with one variable

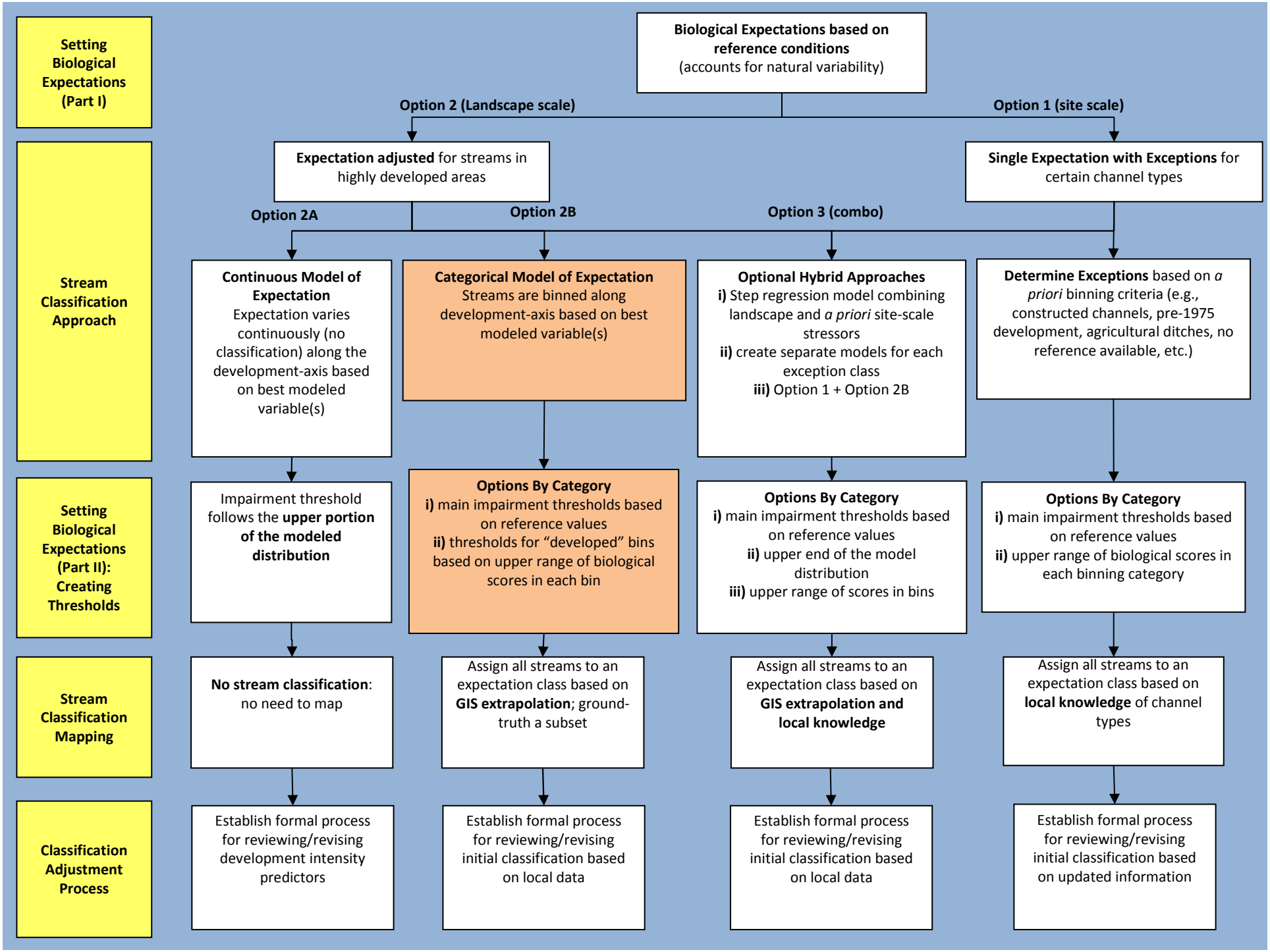


*qLDI = ∑[(Code21 *2)+(AG*6)+(URBAN*8.5)]*

- Coefficients values modified from Brown and Vivas 2005

Lessons learned from Option 2A

- Modeling continuous data is feasible with the data available
- Model selected the best fit parameters
  - Urban and Ag land uses, imperviousness
- Better to include more or fewer variables in the models?
  - Tradeoffs between complexity and precision
- Identifying thresholds using the upper end of the biological distribution appears achievable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Categorical Model of Expectation-2B

- Streams are binned along development-axis based on best modeled variable(s)

- Options By Category
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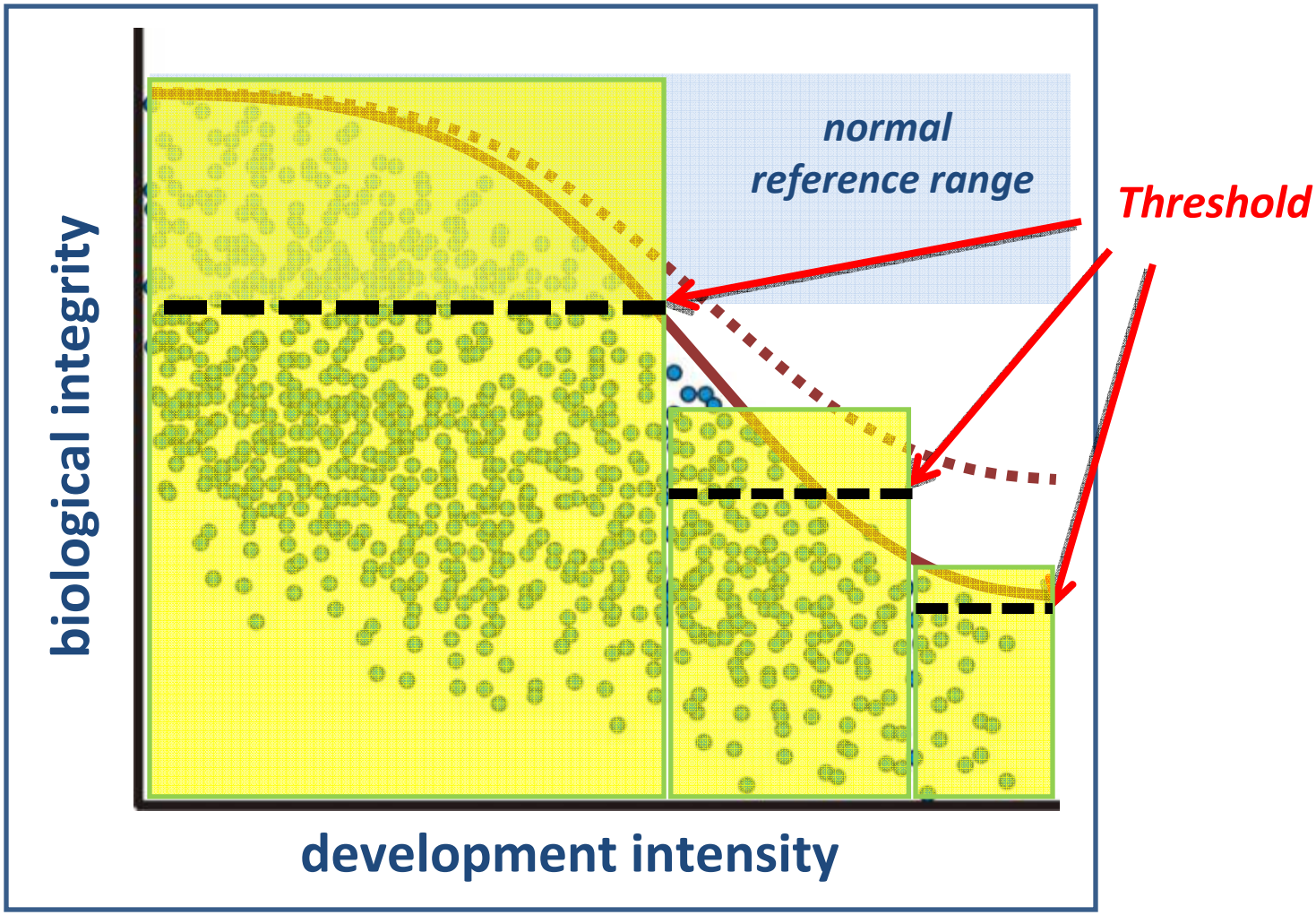
normal
reference range
Threshold
biological integrity
development intensity

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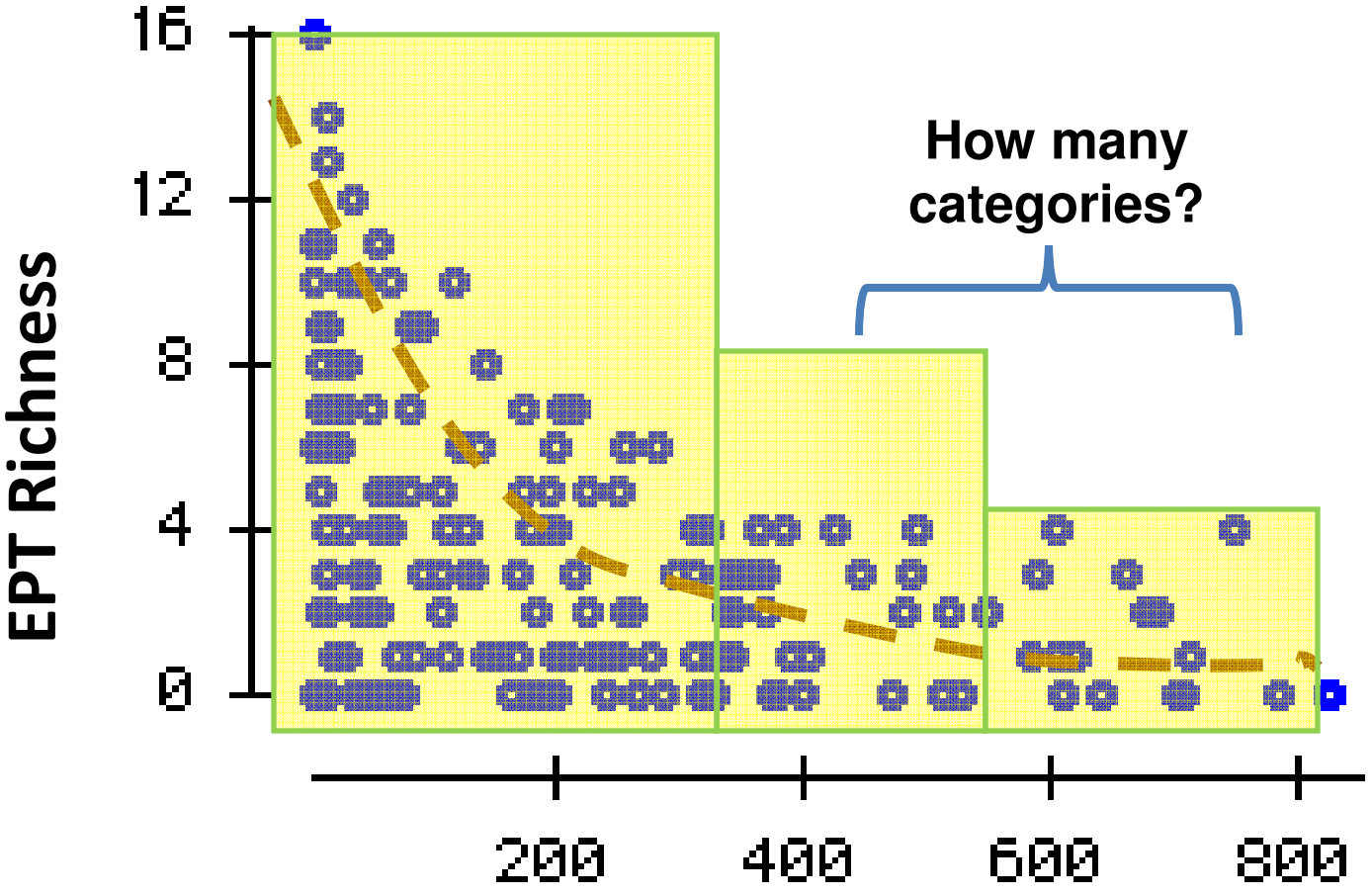

*^qLDI = ∑[(Code21 *2)+(AG*6)+(URBAN*8.5)]*

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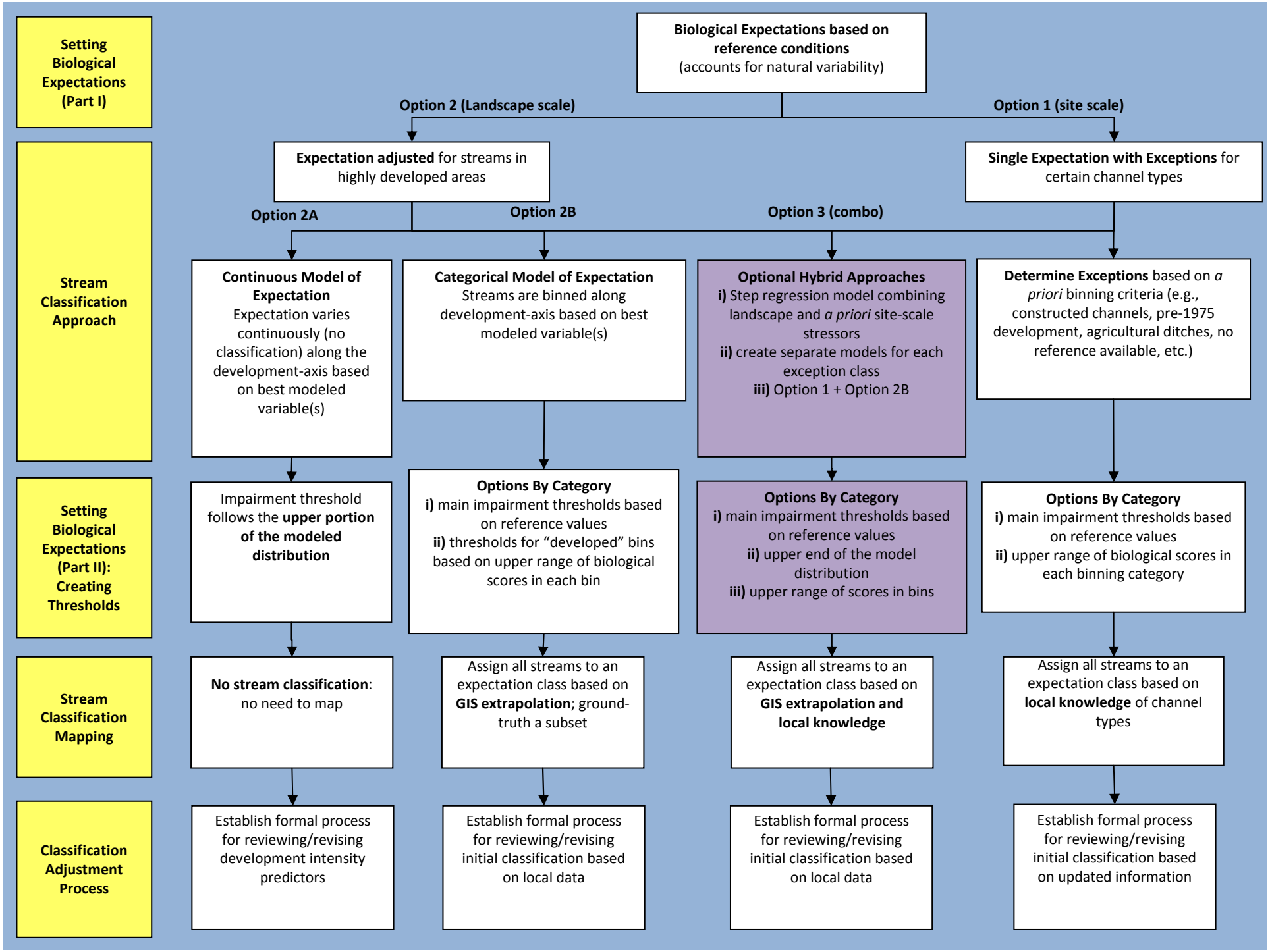
Lessons Learned from Option 2B

- Similar lessons from 2A
  - Expectations are all model driven
- Not clear where to divide bins
  - Likely requires consensus based exercise
- Criteria for selecting thresholds are less clear than 2A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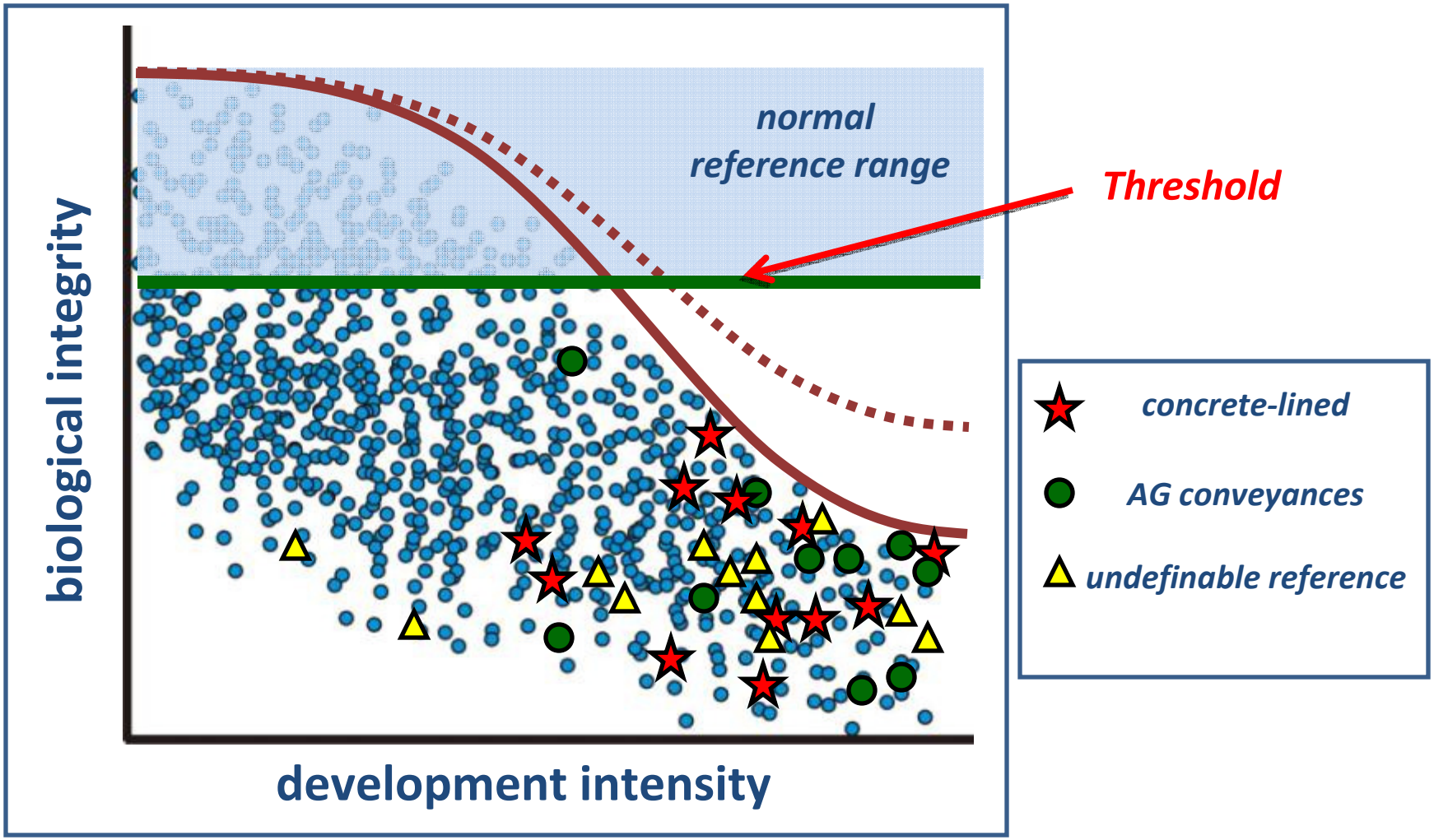
Hybrid Approaches-option 3 (combo) Requires Choices

- **i)** Create separate models for each exception class
- **ii)** Option 1 + Option 2B
- **iii)** 'Step' regression model combining landscape and *a priori* site-scale stressors
  - Initial model based on landscape variables
  - Then force reach scale habitat variables

Single Standard + Exceptions



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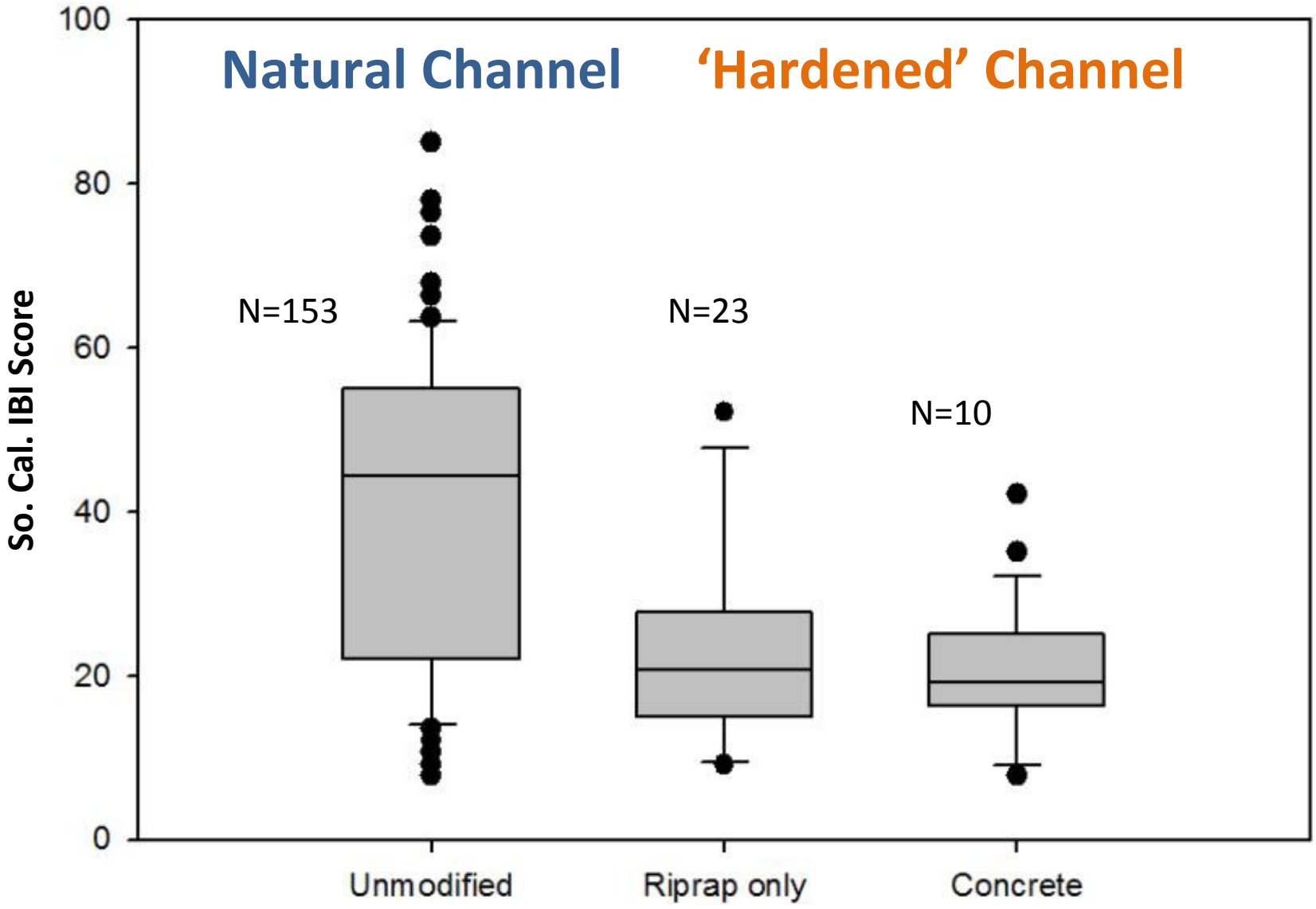
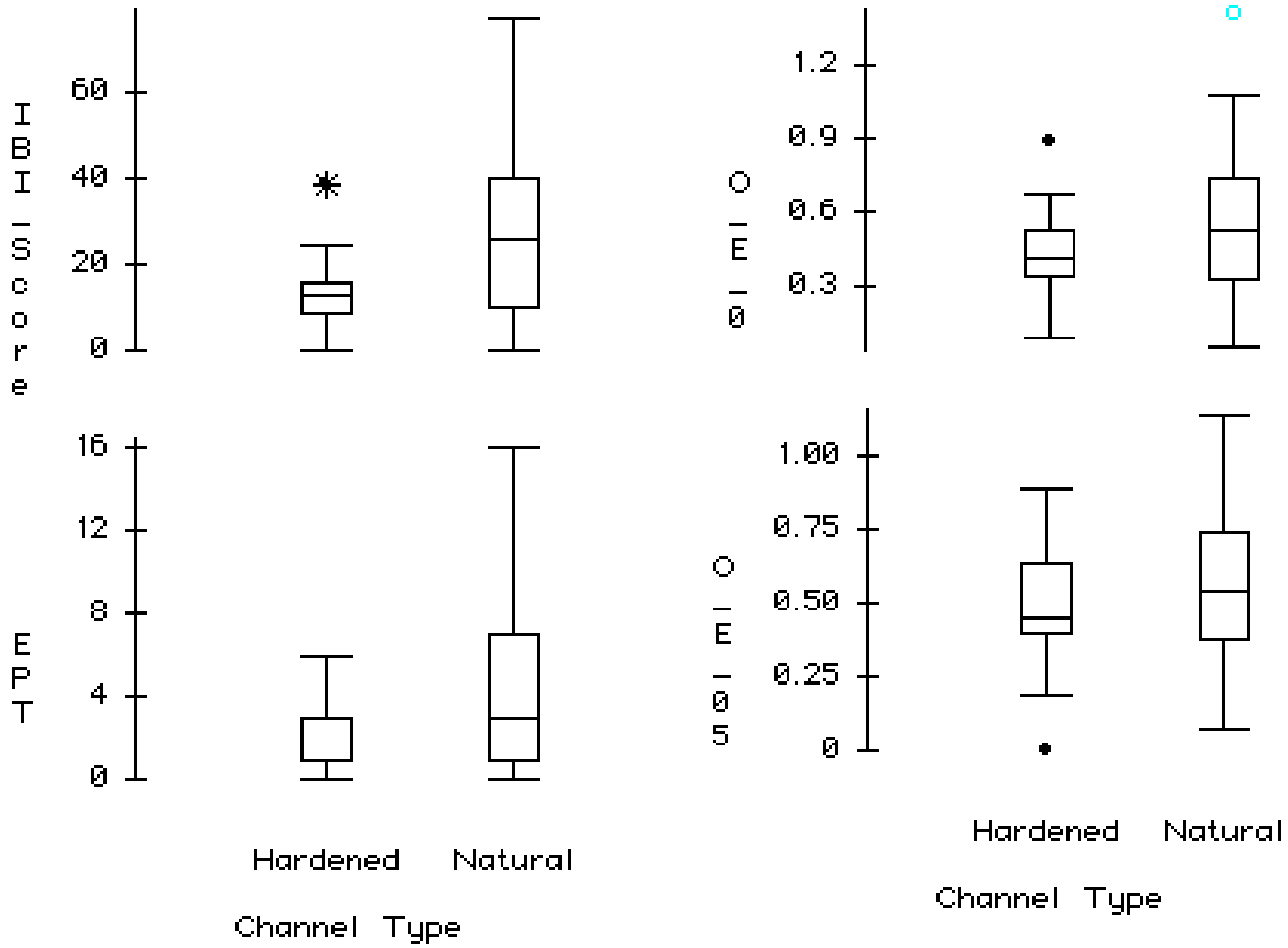
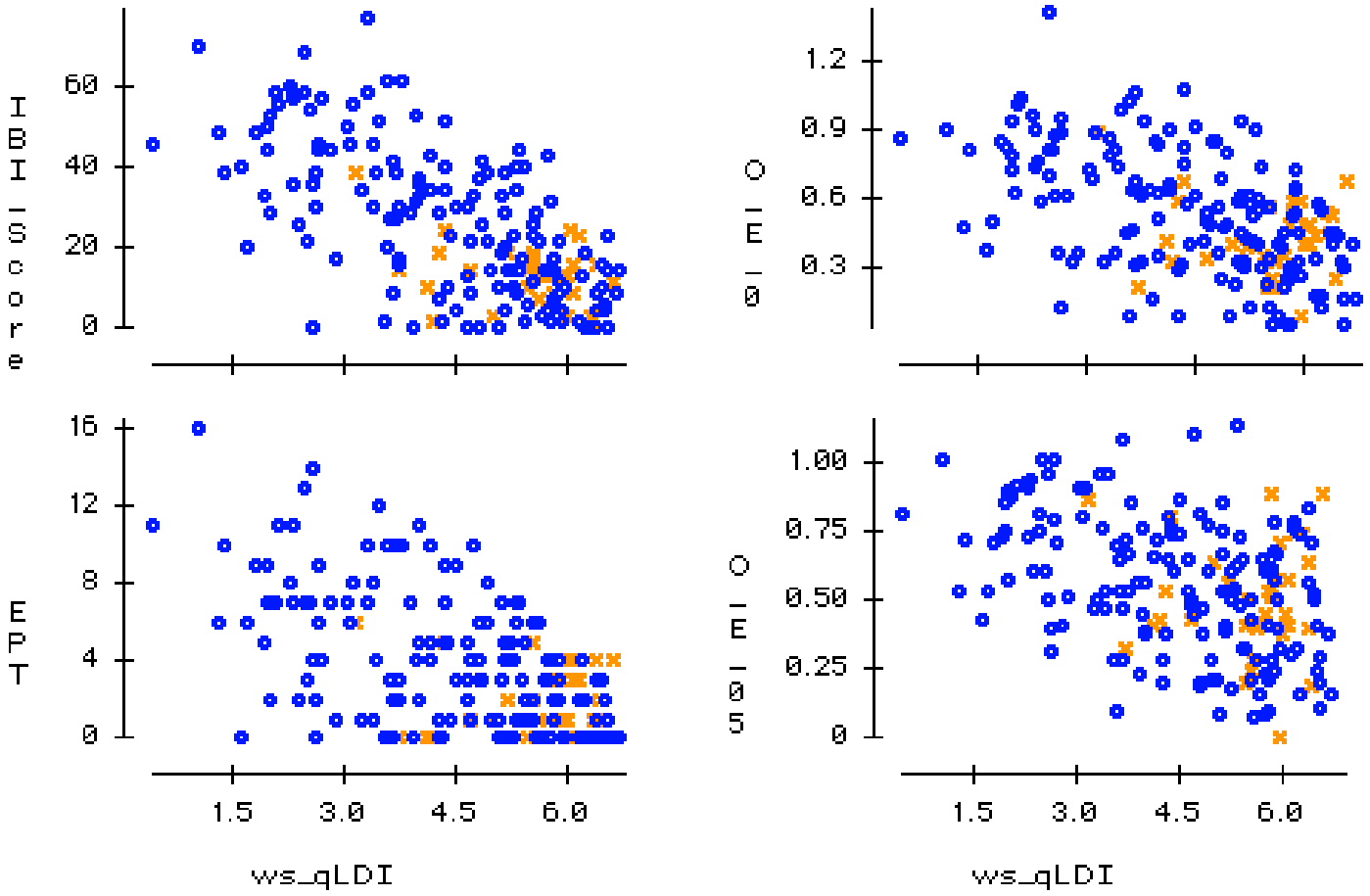


Bioindicators by Channel Type

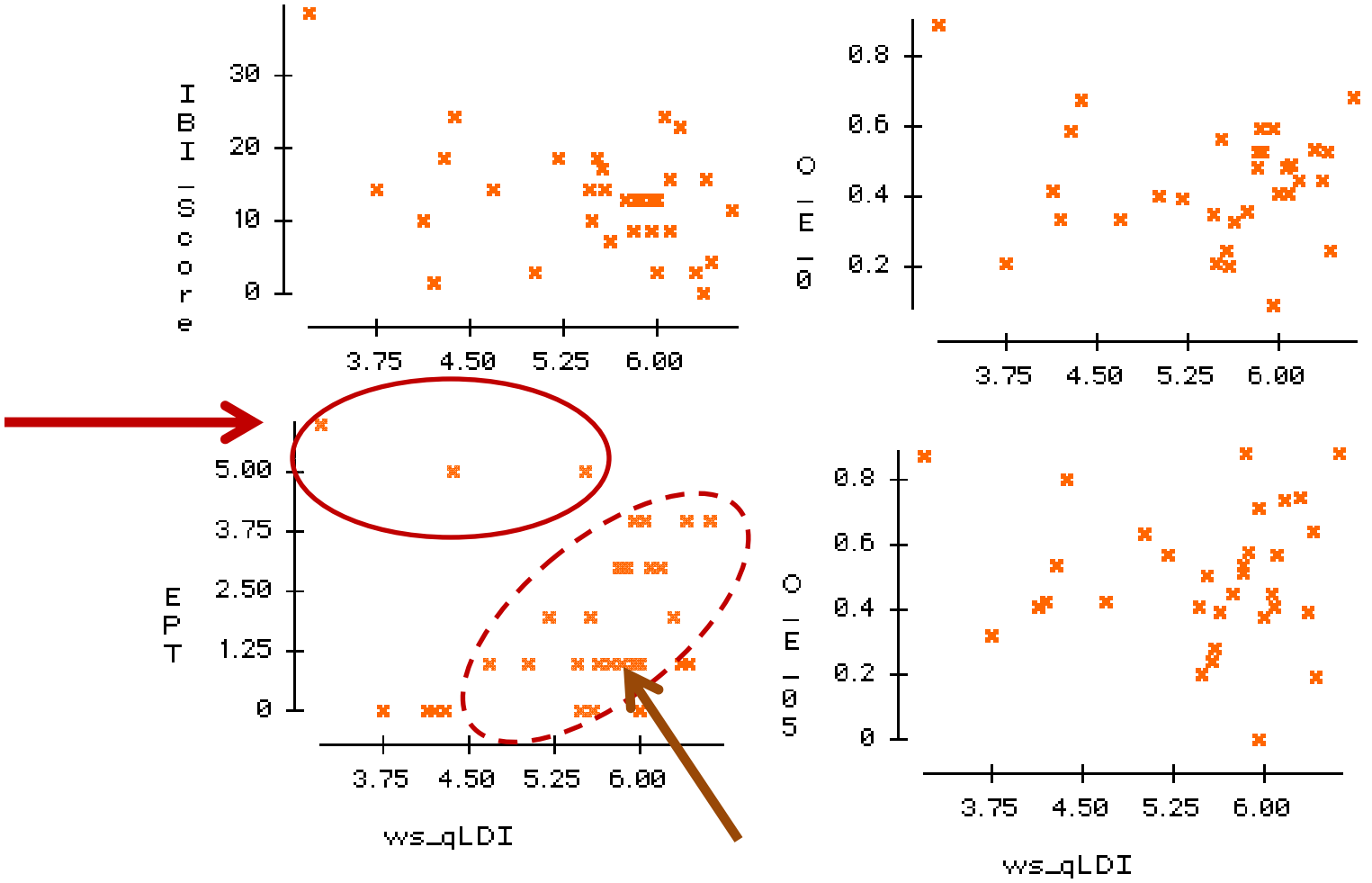


Bioindicator vs qLDI(log transformed)

(x-Hardened, o-Natural)



Hardened Channels



Separate models for Hardened Streams

Variable	adj-R2	AIC
r1k_URBAN	0.1688	131.33
r1k_qLDI	0.1259	132.99
r1k_IMPERVMEAN	0.1083	133.65
PPT + r1k_URBAN	0.2995	126.6
ws_DamDensArea + r1k_URBAN	0.2791	127.55
PPT + r1k_qLDI	0.2558	128.6
r1k_URBAN+ws_AgUrb21+ws_DamDensArea	**0.4717**	**118.18**
r1k_IMPERVMEAN+ws_AgUrb21+ws_DamDensArea	0.4272	120.84
r1k_qLDI+ws_RDDENSC1234+ws_DamDensArea	0.4196	121.28
r1k_URBAN+ws_AgUrb21+ws_DamDensArea+r1k_PavedRoadCross	**0.5109**	**116.47**
ws_PopDens2000+r1k_URBAN+ws_AgUrb21+ws_DamDensArea	**0.4821**	**118.36**
r1k_URBAN+ws_HousingDens2000+ws_AgUrb21+ws_DamDensArea	0.4788	118.57

SOCAL IBI Model w/Hardened Channels removed

Variable	adj-R2	AIC
ws_URBAN	0.4414	810.04
ws_qLDI	0.437	811.24
ws_IMPERVMEAN	0.4058	819.5
ws_URBAN+r1k_AgUrb21	0.5137	789.81
ws_URBAN+r1k_qLDI	0.5116	790.47
r1k_AgUrb21+ws_IMPERVMEAN	0.4936	796
ws_URBAN+r1k_AgUrb21+ws_IMPERVMEAN	0.5276	786.37
ws_URBAN+ws_IMPERVMEAN+r1k_qLDI	0.525	787.2
ws_URBAN+r1k_AgUrb21+PPT	0.5245	787.36
ws_URBAN+r1k_AgUrb21+ws_IMPERVMEAN+Elevation	**0.5458**	**781.3**
ws_URBAN+ws_IMPERVMEAN+r1k_qLDI+Elevation	0.5414	782.79
ws_URBAN+r1k_AgUrb21+ws_IMPERVMEAN+PPT	0.5389	783.61

Best So. Cal. IBI model with alternative scenarios

Variable	adj-R2
All data	
r1k_AgUrb21+ws_IMPERVMEAN+ws_URBAN+PPT	0.566
Hardened Channel Removed	
ws_URBAN+r1k_AgUrb21+ws_IMPERVMEAN+Elevation	0.5458
Only Hardened Channels	
r1k_URBAN+ws_AgUrb21+ws_DamDensArea	0.4717

SOCAL IBI model with added reach scale habitat variable

- **iii)** 'Step' regression model combining landscape and *a priori* site-scale stressors
- ***Added variables: W1_HALL and P_SAFN***

Variable	adj-R2	AIC
r1k_AgUrb21+ws_IMPERVMEAN+ws_URBAN+PPT	0.566	926.35
r1k_AgUrb21 + ws_IMPERVMEAN + ws_URBAN + PPT + W1_HALL	0.5721	924.65
r1k_AgUrb21 + ws_IMPERVMEAN + ws_URBAN + PPT + P_SAFN	0.5636	928.34

Lessons learned from Option 3

- Creating separate models for different classes is improbable
  - Sample size marginal even for our well sampled region
  - Results produced counter-intuitive biological responses

- Pulling out exceptional classes and assigning *a priori* expectations has potential
  - Same numerous challenges as option 1

- Landscape models with 'forced' site scale variables could yield slightly better models
  - Adds more complexity to deal with later
  - Need to agree on site-scale variables
  - Not all sites have site level data

Questions for the Panel

- Which approach/option do you think is best?
- Can you recommend improvements on the preferred option?
- What are some outcomes you would like to see at our next meeting?