Constraints on biological integrity in streams in developed landscapes

Presentation to Science Panel

April 19, 2017

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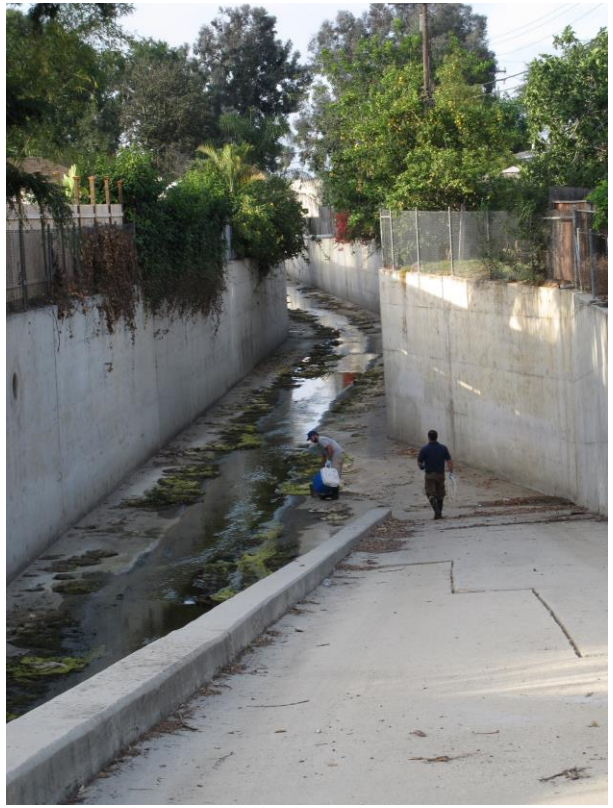
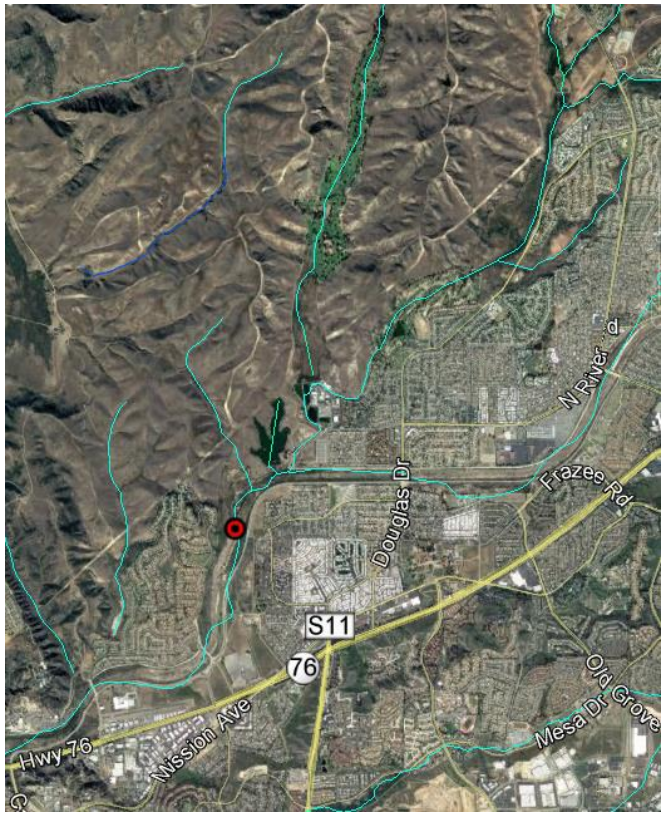
Policy context and goals

- The Water Boards are committed to exploring options for managing streams with constrained biological integrity
  - E.g., different priorities or timeframes for improvements
  - “Alternative thresholds unlikely”
- Management options will be discussed during policy development, but may not be set within this policy.
- We will develop one way of screening streams that may be constrained by landscape development.
  - Statewide screening based on GIS
  - Field visits and other data may also play a role
  - Screening is a starting point, not the final word.

Two ways to identify constrained streams: Channels vs Landscapes



Modified channel

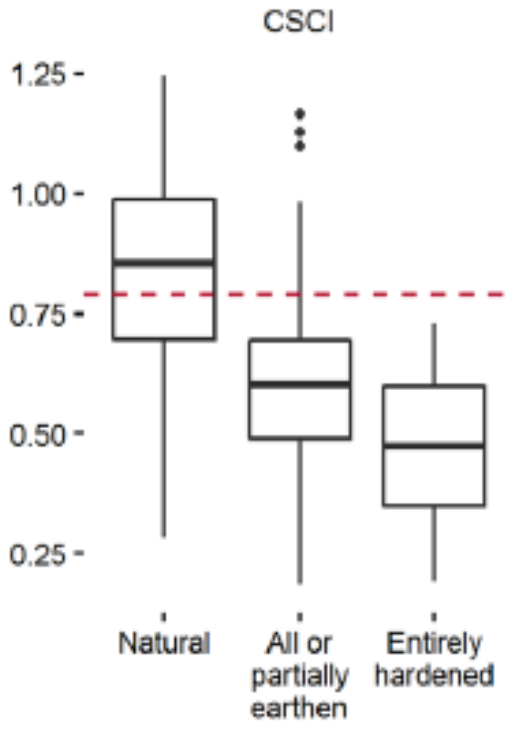


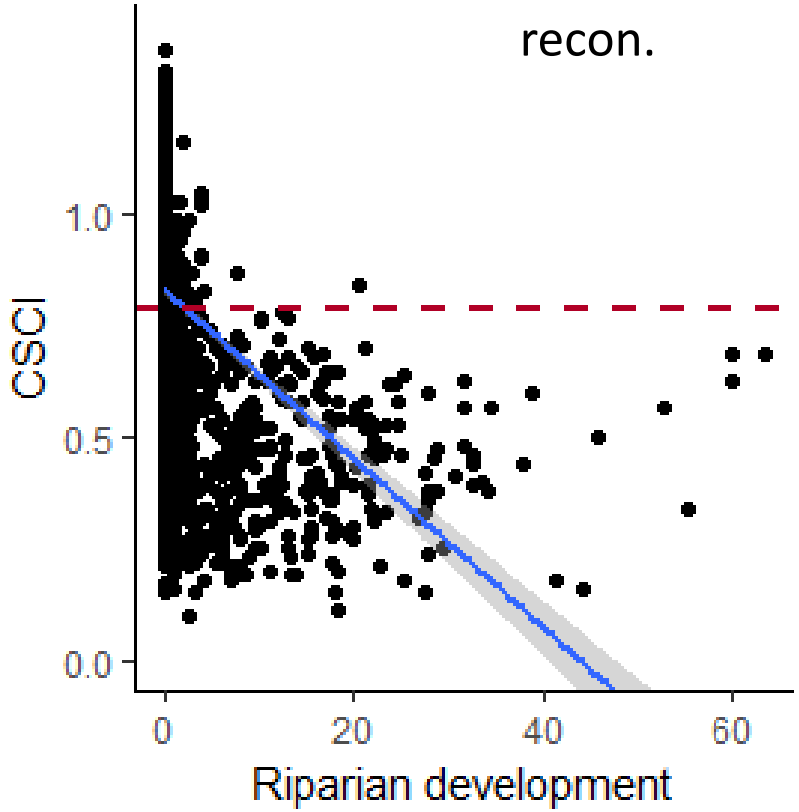
Developed landscape

- Field determination vs. GIS
- Harder to map channel mod
- Channel mod may define the problem too narrowly
- Both approaches have strengths, but landscape approach is better for screening and statewide application

Development can constrain biological integrity

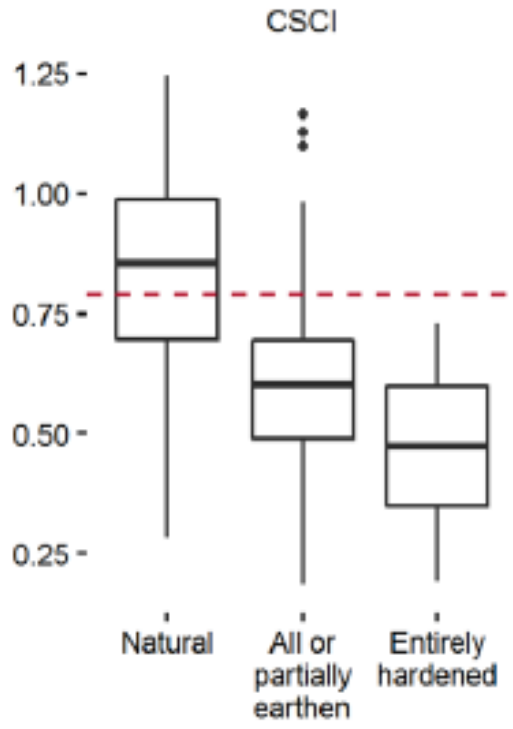
- Pilot study on ~500 sites in SoCal region.
- Channel status determined in field visits or desktop recon.

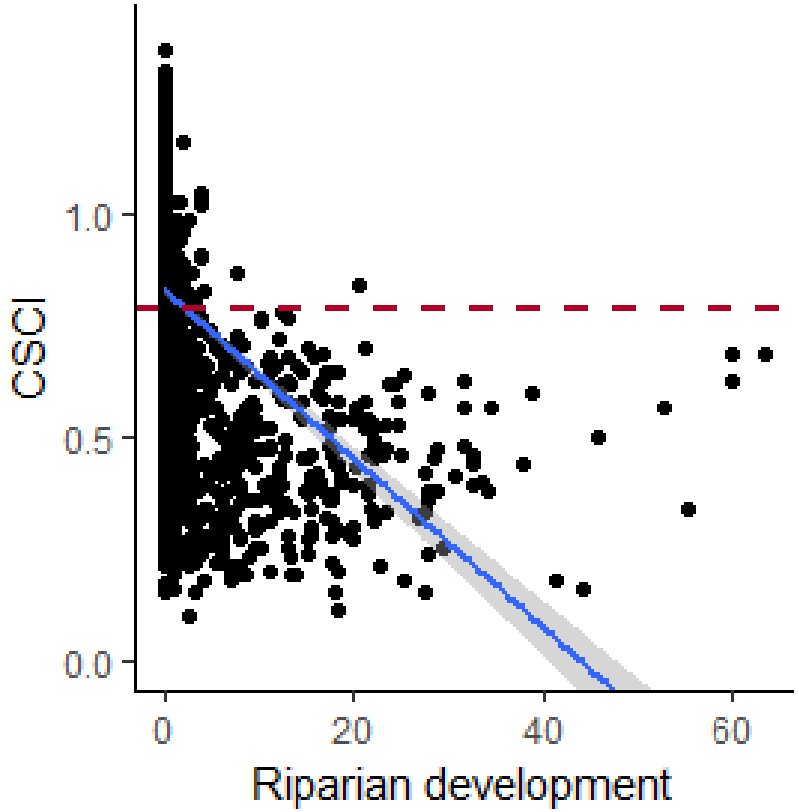


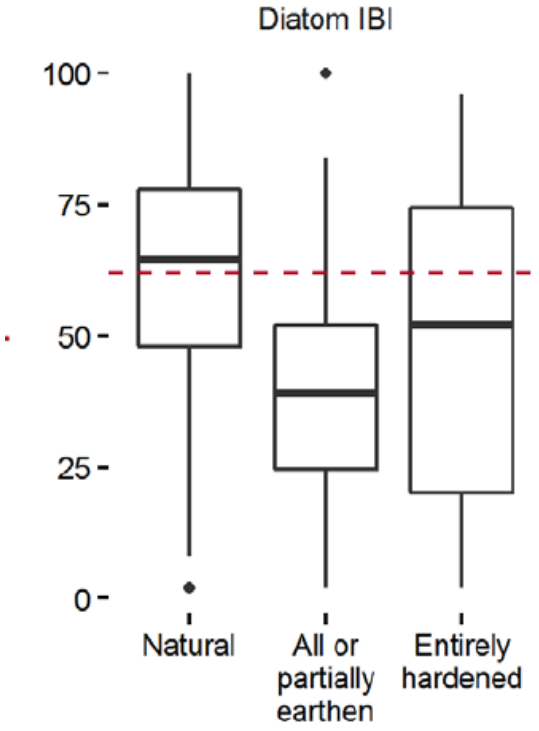


High scores (above threshold) rarely, if ever, seen in certain stream types

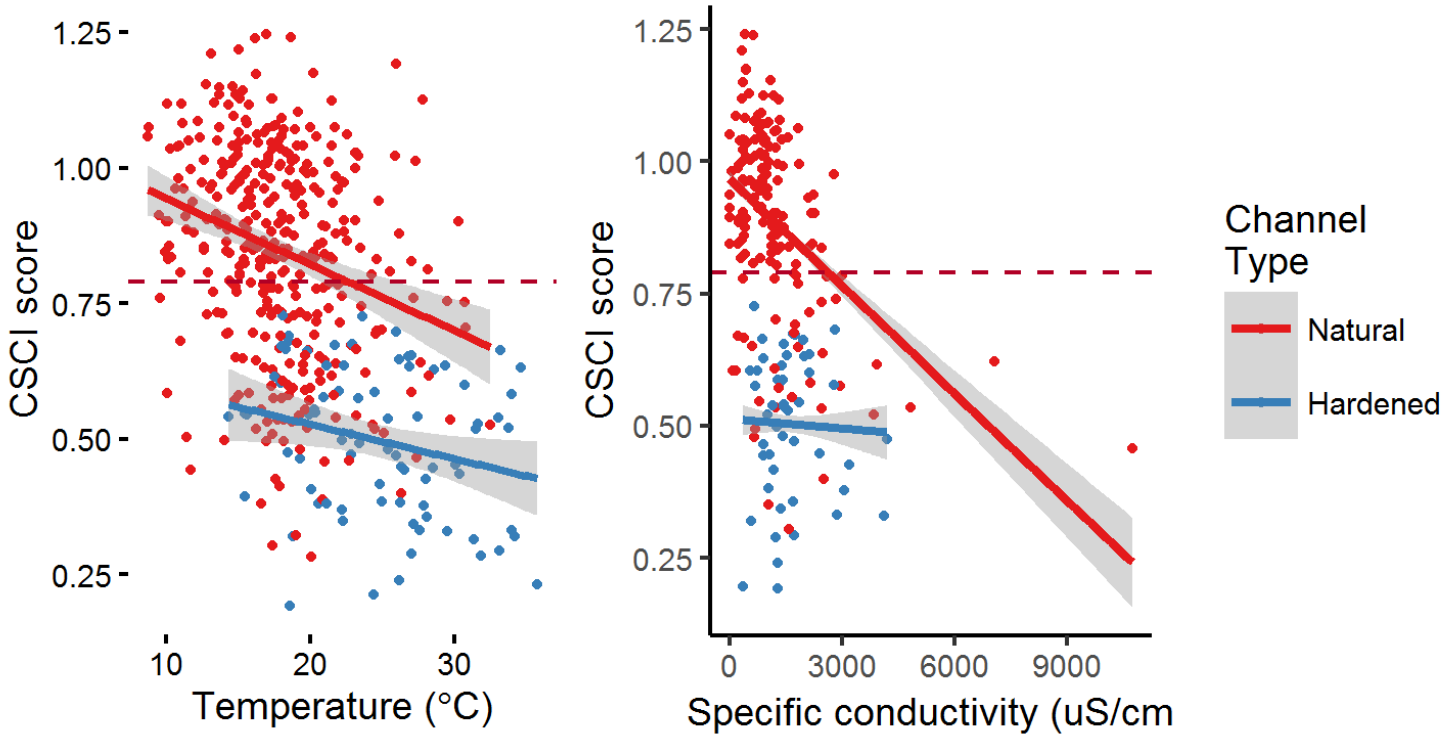
Development can constrain biological integrity (bugs more so than algae)





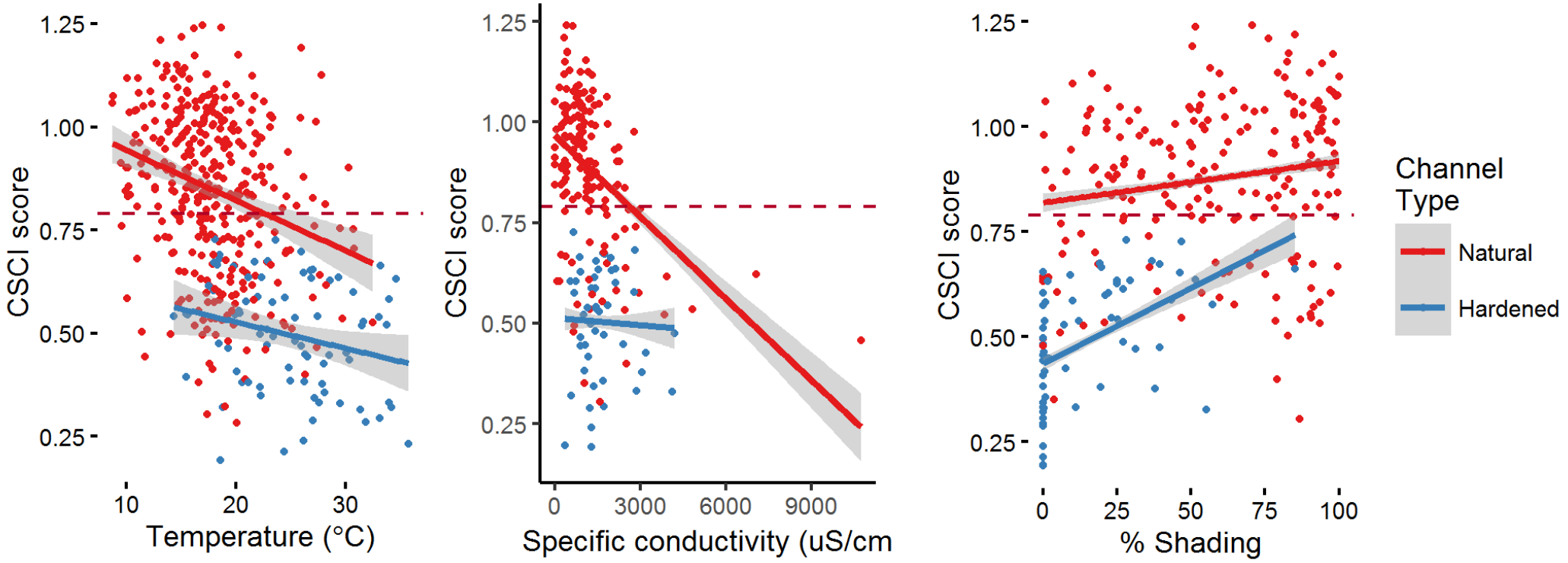


Dampened response to WQ gradients



Improving WQ may not protect bio-integrity

Dampened response to WQ gradients



(although some factors show a strong influence)

Tentative definition of developed landscapes

Landscapes where developed land uses are likely to limit CSCI scores

(…and ASCI scores)

Approach

- Build a model to predict ranges of CSCI scores associated with land use gradients
  - Select land use parameters (e.g., urban or ag land cover)
  - Use national STREAMCAT database of watershed characteristics: Easy statewide applicability
  - Quantile random forest: Provides *range* of likely CSCI scores in different landscapes
- Identify landscapes where statewide “default” assessment endpoints are *unlikely* to be met

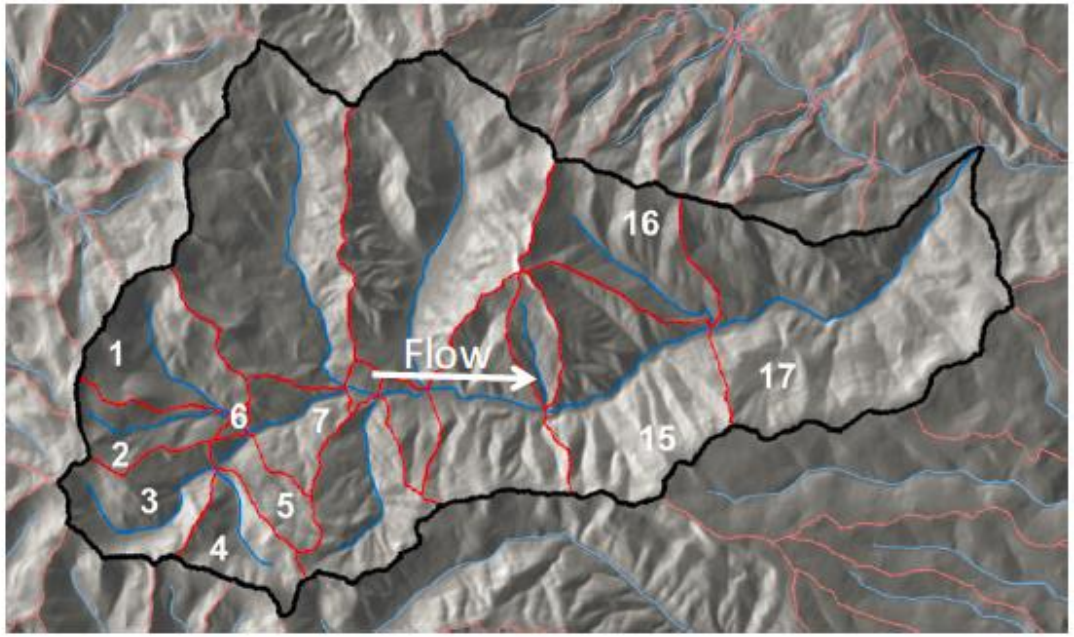
Three key factors in modeling decisions

1. Model development: What kinds of variables should we include?
2. Model application: What thresholds to use for identifying likely “high” or “low” scoring streams?
3. Model application: What likelihoods for defining “likely” or “unlikely”?

- Tech team is evaluating these decisions with Regulatory Advisory Group on an iterative basis

Predictor data source: STREAMCAT

- Nearly all stream segments from NHD+ (1:100k scale) represented
- Lots of data calculated for each watershed and catchment
  - Metrics also calculated for 100-m riparian buffers
- STREAMCAT makes it easy to explore statewide landscape models on a large scale



Types of data in STREAMCAT

- Natural variables (e.g., geology, climate, watershed area)
  - These DON'T affect CSCI scores! No need to include in models.
- Stressor variables
  - These DO affect CSCI scores
  - Some reflect transient impacts (e.g., pesticide)
  - Some reflect long-term impacts (e.g., landcover)
  - Some are debatable, especially in rural settings (e.g., roads, dams, imperviousness, mines)
- Different variables are good for different models and applications
  - Is it appropriate to include transient stressors in modeling landscape constraints?
- Tech team has preliminary classifications, currently being vetted with Regulatory Advisory Group

Channelization/Armoring

- Poorly characterized in STREAMCAT, other GIS sources
- Statewide, NHD-registered data not available

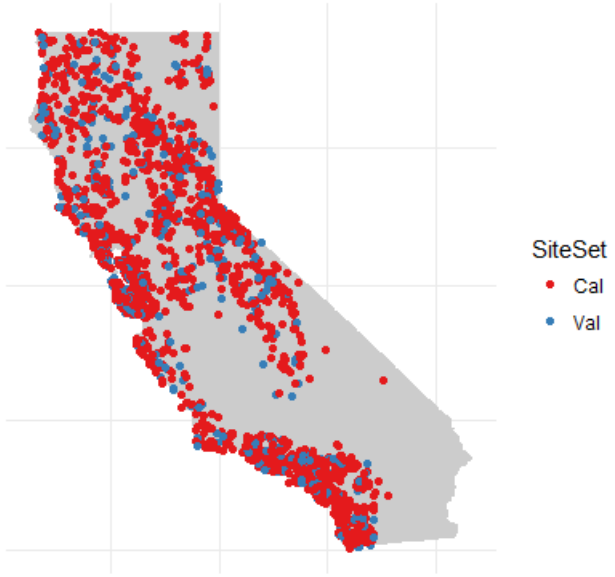
But is this a problem?

- Many armored streams are captured by other variables (e.g., riparian landcover)
- May be better addressed after landscape-scale screening with field data (e.g., physical habitat data)

Building the models

Preliminary work:

- 3252 sites, split 80% calibration 20% validation
  - Stratified by 6 PSA regions
  - Each region further stratified into quartiles by watershed imperviousness
- Where multiple samples are available, only one randomly selected for modeling



Impervious quartiles

Region	Q1	Q2	Q3
North Coast	0.02	0.07	0.15
Chaparral	0.09	0.28	3.35
South Coast	0.16	1.15	10.30
Central Valley	0.35	1.11	10.15
Desert-Modoc	0.06	0.13	0.21
Sierra Nevada	0.04	0.15	0.29

Based on RG and SG feedback….

“Core” candidate predictors:

- NHD+ Canal density
- NLCD land-cover (aggregated to urban and ag)
- Density of roads and road crossings

Additional/alternative candidate predictors we may explore:

- NLCD (urban and ag, not aggregated)
- Mine density
- Dam storage
- Atmospheric deposition (Nitrogen, Sulfur)

Model training

- Recursive feature elimination in caret package in R
- Evaluate all possible models with 5 to 15 candidate predictors
- Pick the “best” (lowest RMSE) model for each model size, and the overall best
- Pick the simplest model with RMSE within 1% of the overall best.

Example

Variables	RMSE	% of best	Selected
5	0.1769	2.1	
6	0.1763	1.8	
7	0.1751	1.1	
8	0.1756	1.4	
9	0.1745	0.8	Selected
10	0.1740	0.5	
11	0.1732	0	Best
12	0.1737	0.3	
13	0.1740	0.5	
14	0.1740	0.5	
15	0.1741	0.5	

So far, investigations show:

- Not a big difference among models (all pseudo-R^2 between 0.54 and 0.58)
- Variables that occur in rural areas (e.g., low-density urban, ag, road density, atmospheric deposition) are more influential than variables that are restricted to heavily developed areas (e.g., high-density urban)

Variable	Core	Core-Plus
Land use		
PctImp2006Cat	Sel	Sel
PctImp2006Ws	Rej	Rej
PctImp2006CatRp100	Rej	Rej
PctImp2006WsRp100	Sel	Rej
TotUrb2011Ws	Sel	Rej
TotUrb2011Cat	Rej	Rej
TotUrb2011WsRp100	Sel	Rej
TotUrb2011CatRp100	Rej	Rej
TotAg2011Ws	Sel	Sel
TotAg2011Cat	Rej	Rej
TotAg2011WsRp100	Sel	Sel
TotAg2011CatRp100	Rej	Rej
Non-native veg cover		
PctNonAgIntrodManagVegCat	NC	Sel
PctNonAgIntrodManagVegWs	NC	Sel
PctNonAgIntrodManagVegCatRp100	NC	Sel
PctNonAgIntrodManagVegWsRp100	NC	Sel
Mines		
MineDensCat	NC	Rej
MineDensWs	NC	Rej
MineDensCatRp100	NC	Rej
MineDensWsRp100	NC	Rej

Variable	Core	Core-Plus
Roads		
RdDensCat	Rej	Rej
RdDensWs	Sel	Sel
RdDensCatRp100	Rej	Rej
RdDensWsRp100	Rej	Rej
RdCrsCat	Rej	Rej
RdCrsSlpWtdCat	Rej	Rej
RdCrsWs	Sel	Rej
RdCrsSlpWtdWs	Sel	Sel
Atmospheric deposition		
NH4_2008Ws	NC	Sel
NO3_2008Ws	NC	Sel
InorgNWetDep_2008Ws	NC	Sel
SN_2008Ws	NC	Sel
Hydrology		
CanalDensCat	Rej	Rej
CanalDensWs	Sel	Rej
DamDensCat	NC	Rej
DamDensWs	NC	Rej
DamNrmStorM3Cat	NC	Rej
DamNrmStorM3Ws	NC	Rej

Rejected

Selected

Not considered

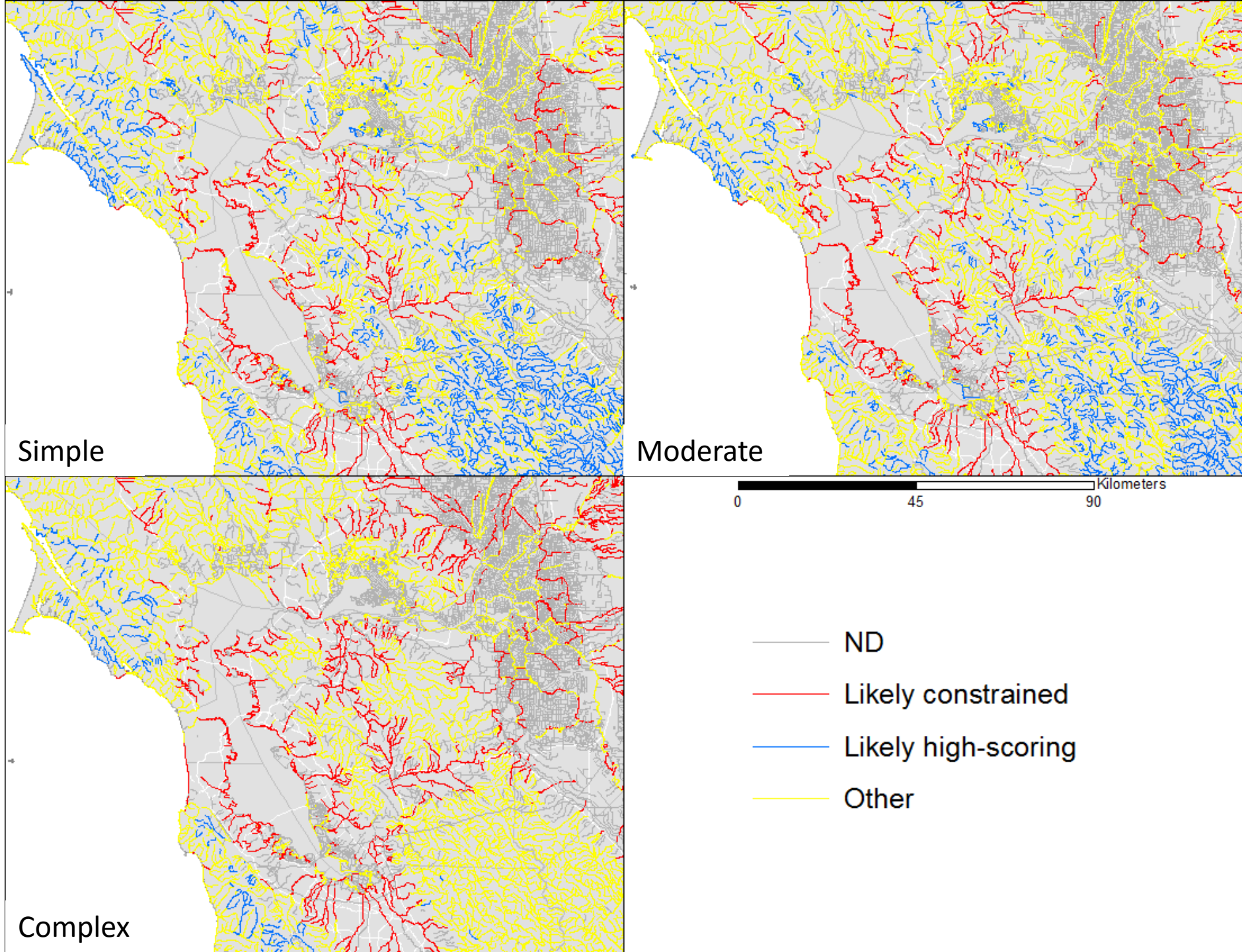
What are the outcomes of these models?

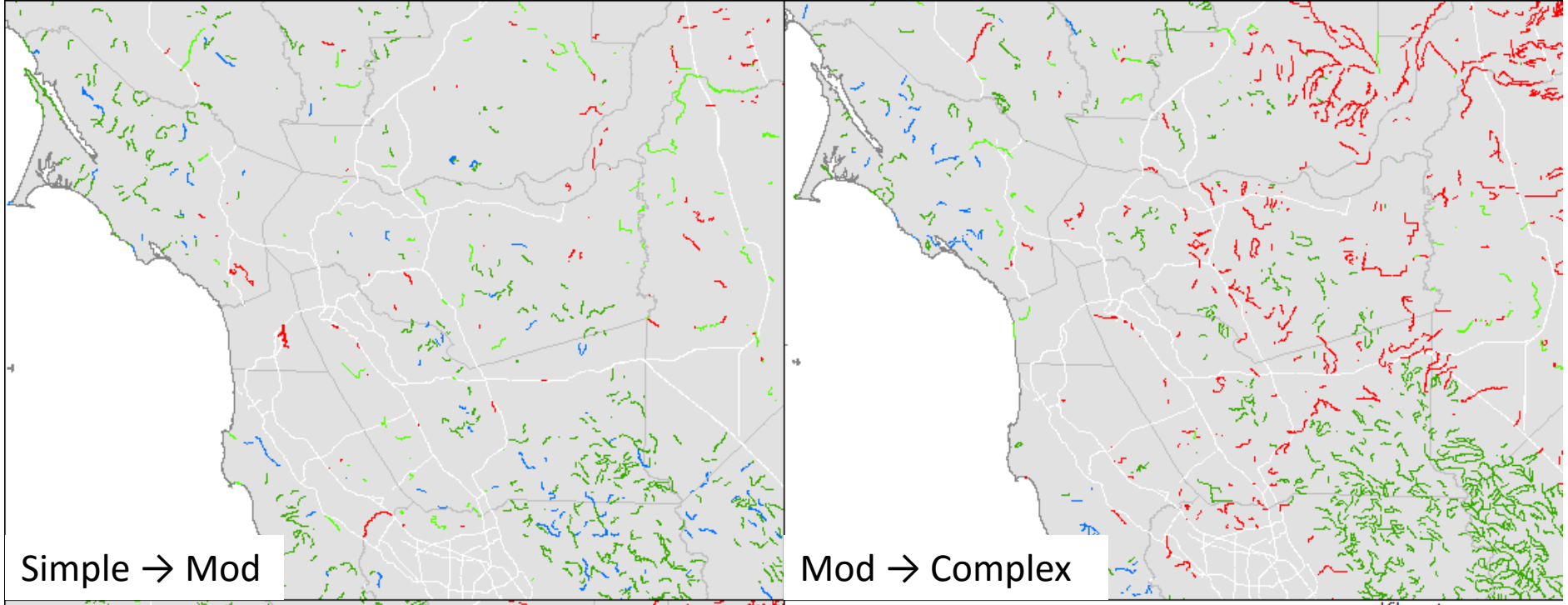
- Outcomes allow classification and identification of stream types:
  - Likely constrained: <10% chance of scores over decision point (e.g., 0.79)
  - Likely high-scoring: <10% chance of scores under decision point
- Alternatively, you could tweak model parameters to simulate optimal management
  - E.g., assume effective imperviousness can be reduced 50%
  - May not be realistic
- While more complex models identify the greatest number of constrained streams/lowest number of high-scoring streams, this can be changed with different classification schemes.

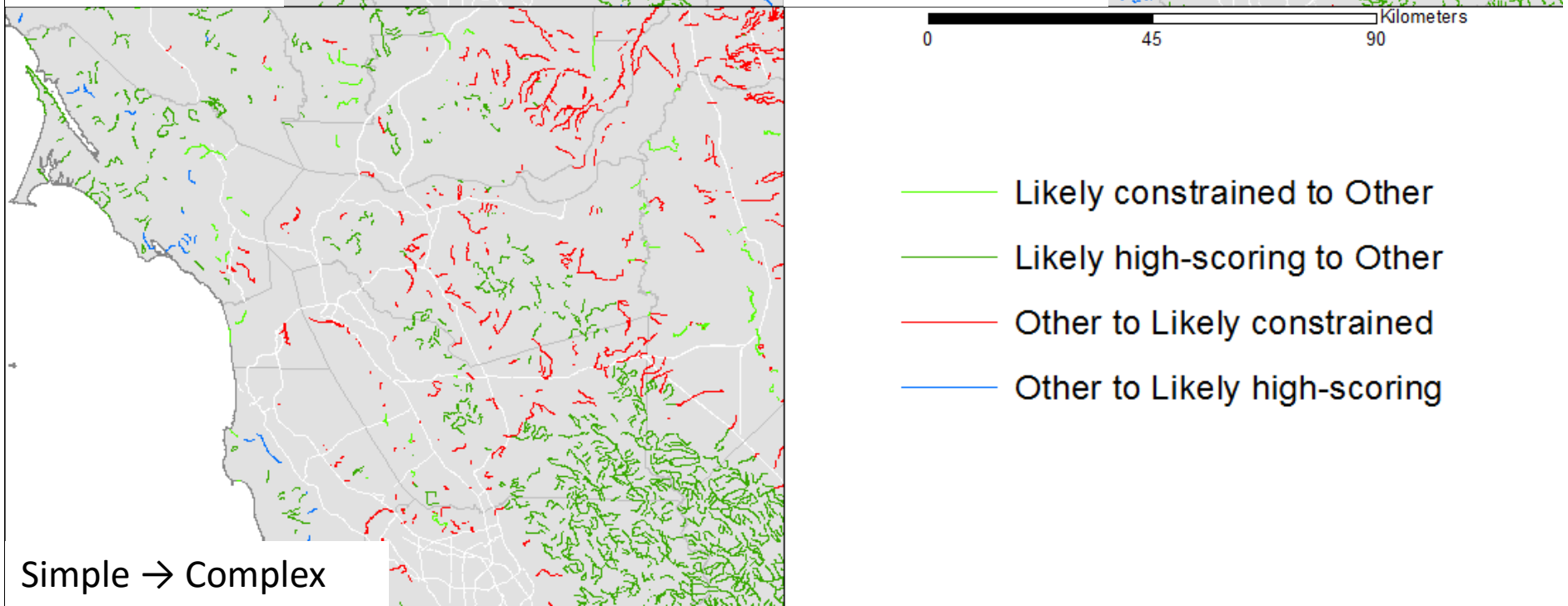
We want a classification scheme that reflects our assumptions/values, not one that produces the map we like best

Example maps (from previous analyses)

- Maps showing classifications for the Bay Area for 3 different types of models
  1. Likely low-scoring / constrained
  2. Likely high-scoring
  3. Other
  4. Not determined
- Maps showing disagreements among models in the Bay Area
  - Simpler model vs more complex model
    1. Likely constrained to other
    2. Likely high scoring to other
    3. Other to likely constrained
    4. Other to likely high scoring


Simple
Moderate
Complex
Kilometers
0
45
90
ND
Likely constrained
Likely high-scoring
Other


Simple → Mod
Mod → Complex
Kilometers
0
45
90


Simple → Complex
Likely constrained to Other
Likely high-scoring to Other
Other to Likely constrained
Other to Likely high-scoring

There are many potential applications of these models

Highlighted in Belluci et al. (2013) models of Connecticut streams, and in discussions with advisory groups:

- Lines of evidence in 305b/303d assessments
- Identifying high-quality streams
- Targeting of “underperforming” sites for follow-up monitoring
- Benchmarks for anti-degradation where only 1 sample is available

Water board will explore these options with advisory groups

Next steps

- Refine and validate models (now through May)
  - Incorporate feedback from advisory groups
  - Simplify and test models with validation data
  - Repeat with ASCI (Late Summer)
- Produce and distribute maps/data (May)
  - Create interactive interfaces to explore products and impact of design decisions
- Discuss outcomes with advisory groups (Summer)
- Produce report (Late Summer/Fall)

Questions for panel

- Is this a valid approach to screening streams where bio-integrity may be constrained?
- What factors affecting stream condition are these models likely to miss?
- Any pitfalls we should watch for?

Types of variables we may include in models

Simple	Moderate	Complex
Urban land cover (NLCD 2011) Ag land cover (NLCD 2011) Canal density (NHD+)	All CDLmin variables Mine density Dam density and storage Road density Road crossings	All CDL and CDLmin variables Impervious surfaces (NLCD 2006) Fertilizer applications Pesticide applications (1997) Non-native veg cover Forest loss Fire perimeters Aerial deposition of N, S
Just a few “permanent” stressors. Best for identifying constraints?	Includes some “debatable” stressors.	Includes “transient” stressors. Best for predicting CSCI scores?