Prioritizing management goals for stream biological integrity within the developed landscape context

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# Supplement 1: Figures and Tables



Figure S1 Screenshots from the Stream Classification and Priority Explorer (SCAPE) tool used by the stakeholder group to interact with and use results from the landscape model. The application allowed users to visualize results of segment classifications, relative site scores for the CSCI based on the expectation, and recommend management actions for each segment type. The app is accessible at <http://shiny.sccwrp.org/scape/> (Beck [2018](#ref-Beck18c)).

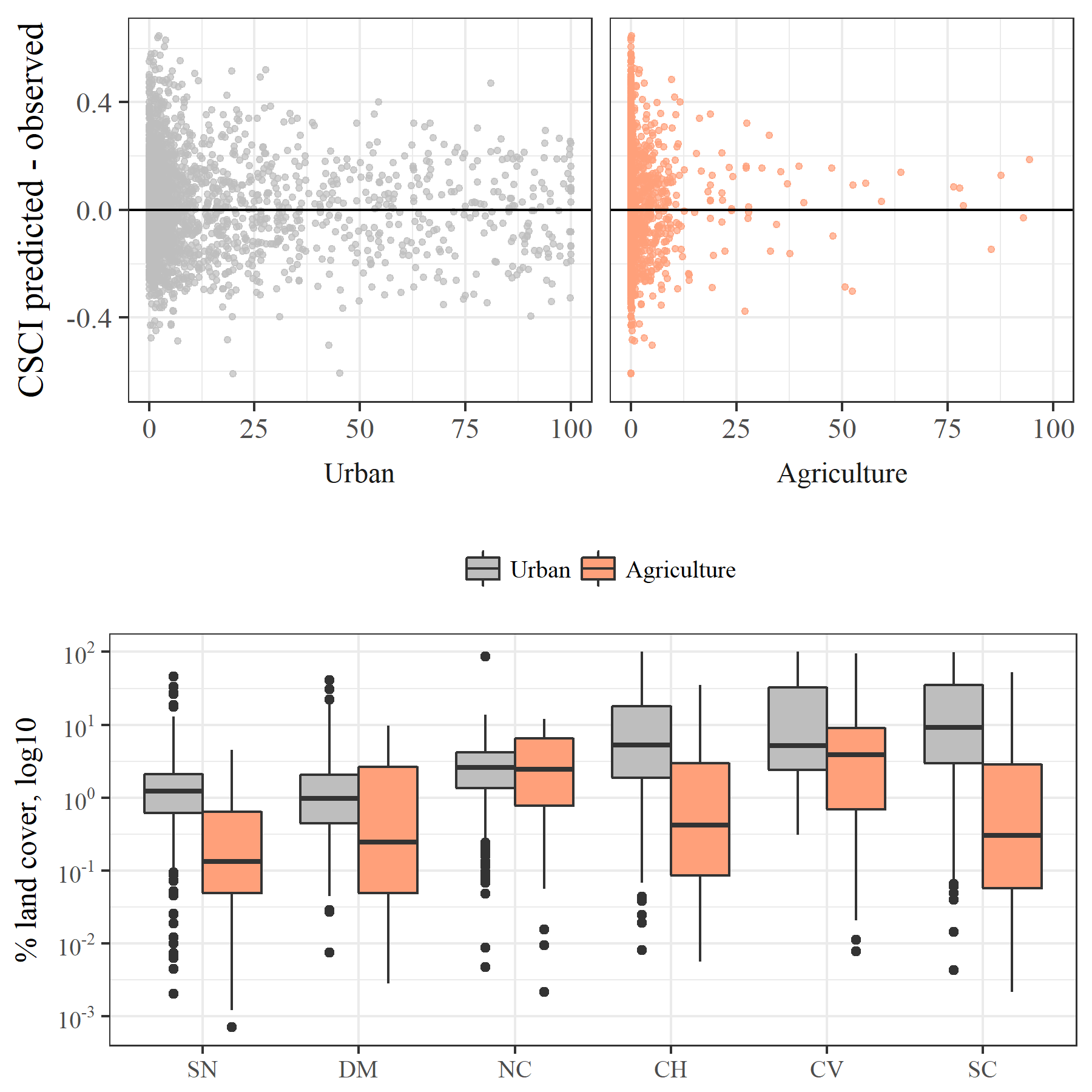


Figure S2 Model performance in relation to land cover and land cover by major regions in California. Model residuals (CSCI predicted - observed) were smaller in regions with more urban or agricultural land use (e.g., SC, CV) and larger in regions with less anthropogenic land use (e.g., SN, DM). CV: Central Valley, CH: Chaparral, DM: Deserts and Modoc Plateau, NC: North Coast, SN: Sierra Nevada, SC: South Coast.

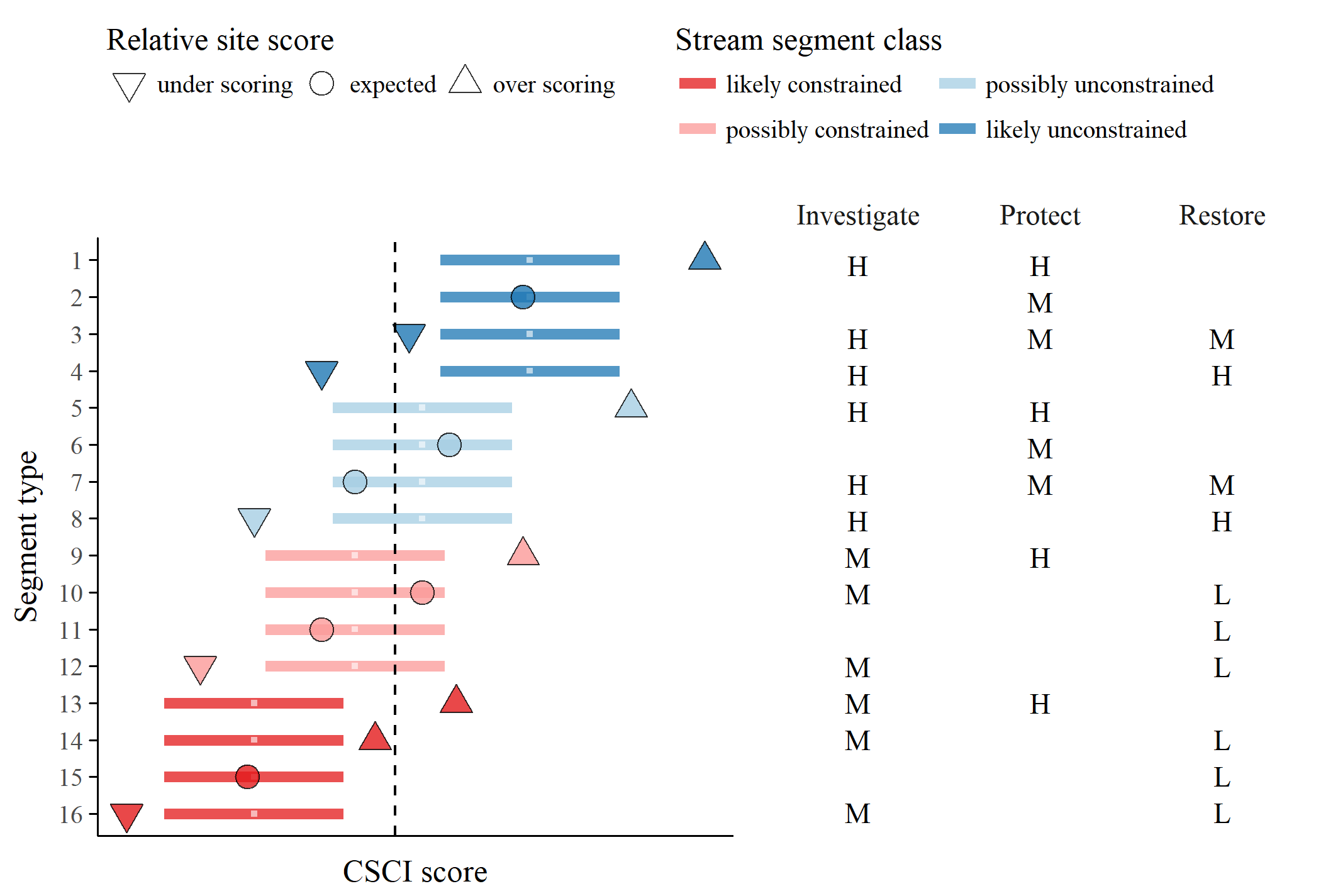


Figure S3 Template provided to stakeholders for prioritization of recommended actions for each stream type. The segment types (Table S2) relate to the stream class for the biological expectation (likely unconstrained, possibly unconstrained, possibly constrained, likely constrained), relative site score for the observed CSCI (over-scoring, expected, under-scoring), and location of the score relative to a hypothetical biological threshold (dashed line, above or below). Horizontal lines are the ranges of expected CSCI scores for a site with tick marks for the median. Priority actions defined by stakeholders are shown on the right for each stream type. Actions are generalized as investigate, protect, or monitor as high (H), medium (M), or low (L) priority. Blank cells indicate that no additional measures are recommended beyond the baseline monitoring and maintenance practiced at all sites.

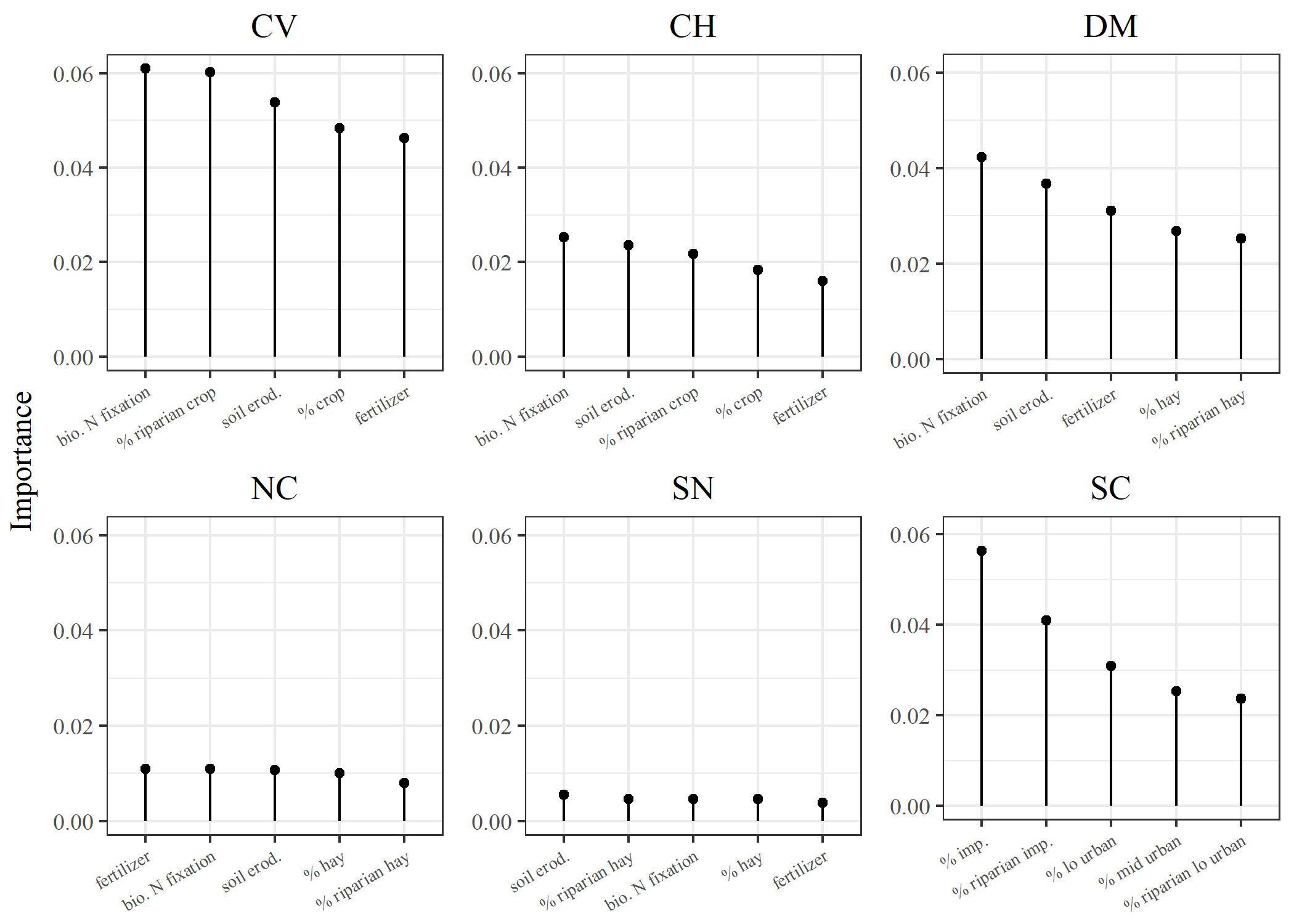


Figure S4 Factors associated with constrained and unconstrained stream segments by major regions in California. Importance measures were obtained from random forest models of 130 watershed and riparian measures of landscape and geological characteristics from the StreamCat dataset (Hill et al. [2016](#ref-Hill16)). The top five variables for each region are shown. The importance measures describe the mean decrease in prediction accuracy with exclusion of a variable across 1000 random trees for each model. Stream segment classes as possibly or likely were combined for constrained and unconstrained to evaluate the complete dataset. CV: Central Valley, CH: Chaparral, DM: Deserts and Modoc Plateau, NC: North Coast, SN: Sierra Nevada, SC: South Coast.



Figure S5 Importance measures for landscape variables used to develop the landscape model of expected stream bioassessment scores in California. Values were obtained from quantile regression models of twenty landscape measures shown in Table S1 obtained from the StreamCat dataset (Hill et al. [2016](#ref-Hill16)). The importance measures describe the percent increase in mean square error and the increase in node impurity with exclusion of a variable across all random trees for each model (Meinshausen [2017](#ref-Meinshausen17)).

Table S1 Land use variables used to develop the landscape model of stream bioassessment scores. All variables were obtained from StreamCat (Hill et al. [2016](#ref-Hill16)). The measurement scale for each variable is at the catchment, watershed, and/or riparian scale (100 m buffer) relative to a stream segment. Total urban and agriculture land use variables were based on sums of indvidual variables in StreamCat as noted in the desciption.

|  |  |  |  |
| --- | --- | --- | --- |
| Name | Scale | Description | Unit |
| CanalDensCat | catchment | Density of NHDPlus line features classified as canal, ditch, or pipeline | km/sq km |
| CanalDensWs | watershed | Density of NHDPlus line features classified as canal, ditch, or pipeline | km/sq km |
| PctImp2006Cat | catchment | Mean imperviousness of anthropogenic surfaces (NLCD 2006) | % |
| PctImp2006Ws | watershed | Mean imperviousness of anthropogenic surfaces (NLCD 2006) | % |
| PctImp2006CatRp100 | catchment, riparian | Mean imperviousness of anthropogenic surfaces (NLCD 2006) | % |
| PctImp2006WsRp100 | watershed, riparian | Mean imperviousness of anthropogenic surfaces (NLCD 2006) | % |
| TotUrb2011Ws | watershed | Total urban land use as sum of developed open, low, medium, and high intensity (NLCD 2011) | % |
| TotUrb2011Cat | catchment | Total urban land use as sum of developed open, low, medium, and high intensity (NLCD 2011) | % |
| TotUrb2011WsRp100 | watershed, riparian | Total urban land use as sum of developed open, low, medium, and high intensity (NLCD 2011) | % |
| TotUrb2011CatRp100 | catchment, riparian | Total urban land use as sum of developed open, low, medium, and high intensity (NLCD 2011) | % |
| TotAg2011Ws | watershed | Total argricultural land use as sum of hay and crops (NLCD 2011) | % |
| TotAg2011Cat | catchment | Total argricultural land use as sum of hay and crops (NLCD 2011) | % |
| TotAg2011WsRp100 | watershed, riparian | Total argricultural land use as sum of hay and crops (NLCD 2011) | % |
| TotAg2011CatRp100 | catchment, riparian | Total argricultural land use as sum of hay and crops (NLCD 2011) | % |
| RdDensCat | catchment | Density of roads (2010 Census Tiger Lines) | km/sq km |
| RdDensWs | watershed | Density of roads (2010 Census Tiger Lines) | km/sq km |
| RdDensCatRp100 | catchment, riparian | Density of roads (2010 Census Tiger Lines) | km/sq km |
| RdDensWsRp100 | watershed, riparian | Density of roads (2010 Census Tiger Lines) | km/sq km |
| RdCrsCat | catchment | Density of roads-stream intersections (2010 Census Tiger Lines-NHD stream lines) | crossings/sq km |
| RdCrsWs | watershed | Density of roads-stream intersections (2010 Census Tiger Lines-NHD stream lines) | crosssings/sq km |

Table S2 Possible site types based on stream segment classification, relative site score, and observed CSCI score. The observed score column describes where a CSCI score is observed relative to the lower and upper percentiles (e.g., 10th and 90th) of expected scores for a segment and the chosen CSCI threshold (e.g., 10th percentile of scores at reference sites or 0.79) for defining low or high values.

|  |  |  |  |
| --- | --- | --- | --- |
| Segment expectation | Relative site score | Observed score | Type |
| **likely unconstrained** | over scoring | 90th | 1 |
|  | expected | 10th to 90th | 2 |
|  | under scoring | 0.79 to 10th | 3 |
|  | under scoring | < 0.79 | 4 |
| **possibly unconstrained** | over scoring | 90th | 5 |
|  | expected | 0.79 to 90th | 6 |
|  | expected | 10th to 0.79 | 7 |
|  | under scoring | < 10th | 8 |
| **possibly constrained** | over scoring | 90th | 9 |
|  | expected | 0.79 to 90th | 10 |
|  | expected | 10th to 0.79 | 11 |
|  | under scoring | < 10th | 12 |
| **likely constrained** | over scoring | 0.79 | 13 |
|  | over scoring | 90th to 0.79 | 14 |
|  | expected | 10th to 90th | 15 |
|  | under scoring | < 10th | 16 |

# References

Beck, M. W. 2018. “SCCWRP/SCAPE: v1.0 (Version 1.0). Zenodo, <http://doi.org/10.5281/zenodo.1218121>.”

Hill, R. A., M. H. Weber, S. G. Leibowitz, A. R. Olsen, and D. J. Thornbrugh. 2016. “The Stream-Catchment (StreamCat) Dataset: A Database of Watershed Metrics for the Conterminous United States.” *Journal of the American Water Resources Assocation* 52:120–28. <https://doi.org/10.1111/1752-1688.12372>.

Meinshausen, Nicolai. 2017. *QuantregForest: Quantile Regression Forests*. <https://CRAN.R-project.org/package=quantregForest>.