ASSESSMENT OF STRESSOR IMPACTS ON STREAMS IN THE LOS PADRES NATIONAL FOREST USING BENTHIC MACROINVERTEBRATE INDICES

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SYNOPSIS

The objectives of this project were to:

- Evaluate the effect of physical stressors on streams in the Los Padres National Forest by:
  1. Determining stream condition using the Southern California Index of Biotic Integrity (IBI)
  2. Examining the impact of four anthropogenic stressors (grazing, mining, recreation, roads) and the dominant local disturbance regime, fire
  3. Performing statistical analyses to explore potential relationships between IBI scores and physical stressors, both individually and collectively
- Make management recommendations to the US Forest Service based on these results
- Make recommendations to improve current monitoring techniques to ensure better data quality and availability

GEOGRAPHIC SETTING

Los Padres National Forest (LPNF):
•managed by the United States Forest Service (USFS)
•covers 1.75 million acres
•spans 220 miles
•split into 2 land divisions (north & south)
•2 dominant landscapes: chaparral (~70%) and forested lands (~30%)
•habitat types include: mixed evergreen forests, oak woodland, pinyon-juniper woodland, and conifer forest

81 total sample points, 2 datasets from:
•United States Forest Service
•California Dept of Fish & Game

INDEX OF BIOTIC INTEGRITY

The Index of Biotic Integrity (IBI) is a bioassessment tool which uses living organisms to evaluate the condition of lakes, rivers, and streams, and accurately reflects the health of the ecosystem.

Organisms in a water body reflect changing water conditions because they accumulate the effects of a wide range of biogeochemical factors. As water conditions change, the communities of organisms shift to reflect new environmental conditions.

Benthic macroinvertebrate (BMI) assemblages generally reflect short term and local environmental impairment.

BMI's are:
•invertebrates that dwell on the bottom of rivers, lakes, and streams (insects, snails, worms, crustaceans, etc.)
•sensitive to physical and chemical characteristics such as sediment load, water temperature, carbon input, sunlight input, and current velocity

The SoCal IBI is based on BMI characteristics such as taxa type, pollution tolerance, and feeding habits and mechanisms

Southern California IBI: 7 biological metrics evaluate the BMI community
•coleoptera taxa
•EPT taxa (ephemeroptera, plecoptera, trichoptera)
•predator taxa
•% collector individuals
•% intolerant individuals
•% noninsect taxa
•% tolerant taxa

Each metric can receive a score of up to 10 (10 as best), for a potential cumulative score of 70. This cumulative score is adjusted to a scale of 100, and is associated with one of 5 stream conditions ranging from very poor to very good.

80-100	Very Good
60-79	Good
40-59	Fair
20-39	Poor
0-19	Very Poor

STRESSORS

Fire
•Effect: Sediment pulses from post-fire erosion provide nutrients to streams. Massive pulses of sediment can surpass a stream's capacity to filter out the contaminants
•Extent: Dependent on the intensity of burn and physical landscape characteristics such as slope, the erosive capacity of soils, and land cover

Grazing
•Effect: Potentially adverse effects on streamside vegetation composition, bank stability, and can introduce fecal coliform bacteria and increase nitrogen loads
•Extent: Dependent on periodicity of grazing, the proximity to streams, the number of cattle per allotment, and physical landscape characteristics

Mining
•Effect: Can increase sediment and chemical loading in streams
•Extent: Dependent on chemical composition of geologic material, proximity to stream, type of mining, and physical landscape characteristics

Recreation
•Effect: Can increase the amount of sediment, trash, pathogens, and other pollution left behind by the public to be transported streams
•Extent: Dependent on recreation type, intensity of use, and physical landscape characteristics

Roads
•Effect: Can accumulate soil sediment, salt, and automotive pollutants which can be transported to streams
•Extent: Dependent on road type, intensity of use, and physical landscape characteristics

STATISTICAL ANALYSIS

Tests	Results
Initially evaluate data Chi-squared (X2): IBI condition vs. Stressor level	Chi-squared analysis showed a significant relationship between IBI score and recreation, and suggested a relationship between IBI score and grazing.
Determine IBI dependence on geographic variability ANOVA and linear regression	IBI score regressed on each location variable showed that sub-basin, forest district, latitude, and ecosystem type had a significant effect on IBI score. These four variables explained 28% of the variability in IBI score. Sub-basin alone explained 26% of the variability, and was used as a covariate in further analysis of the stressors.
Analyze impact of stressors Multiple regression	Fire, grazing, mining and roads had a significant effect on IBI score (table 2).
Analyze stressor interactions "Step-down" approach to a multiple regression model with multiplicative stressor interactions	With the addition of pairwise interactions to the model, fire, grazing, mining and roads had a significant effect on IBI score. Grazing had a significant interaction with each of the other four stressors. Recreation and fire also interacted significantly (table 3). This interactive model explains more of the variance in IBI score than the model representing stressors alone (table 2).

Stressor	df	X^2	prob.
Fire	4	1.128	0.8898
Grazing	4	7.571	0.1086
Mining	2	1.270	0.5300
Recreation	2	16.013	**0.0003**
Roads	4	2.987	0.5600

Table 1: Chi-square analysis; IBI score vs. Stressor Level

Variable	Coefficient	p
Sub-basin		**<.0001**
Fire	-0.18	**0.0231**
Grazing	-0.17	**0.0073**
Mining	0.17	**0.0365**
Recreation	0.02	0.8346
Roads	-0.25	**0.0563**
R^2 = .48	adjusted R^2 = .39	

Table 2: Empirical model to predict IBI scores via stressors alone

Variable	Coefficient	p
Intercept	88.70	<.0001
Sub-basin		**<.0001**
Fire	-0.31	**0.0274**
Grazing	-0.58	**0.0586**
Mining	0.30	**0.0005**
Recreation	-0.06	0.7850
Roads	-0.31	**0.0337**
Grazing*Fire	-0.01	**0.0044**
Grazing*Mining	-0.02	**0.0517**
Grazing*Recreation	-0.03	**0.0060**
Grazing*Roads	0.03	**0.0113**
Recreation*Fire	0.02	**0.0113**
R^2 = .58	adjusted R^2 = .48	

Table 3: Empirical model to predict IBI scores via stressor indices and pairwise interactions

RESULTS & DISCUSSION

Multiple regression IBI model: includes significant pairwise interactions

IBI = Sub-basin intercept – 0.58**Grazing** – 0.06**Recreation** + 0.30**Mining** – 0.31**Roads** – 0.31**Fire** + 0.02**Recreation** (**Fire**) – 0.02**Grazing** (**Mining**) – 0.01**Grazing** (**Fire**) + 0.03**Grazing** (**Roads**) – 0.03**Grazing** (**Recreation**)

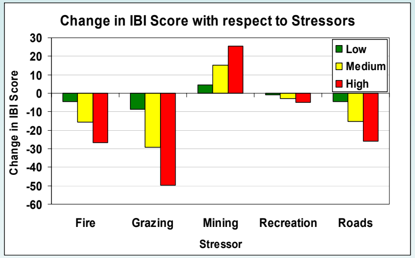
Model Accuracy Analysis: Comparison of the predicted IBI to the observed IBI scores showed an average 16% error for the LPNF. The model is a useful tool for predicting IBI scores when levels of stress in a watershed are known.

Real world values corresponding to representative index values of low, medium, and high stress.

Stressor	Low	Medium	High
Fire *	15 Index value	50 Index value	85 Index value
Grazing	allotments in 15% of sub-watershed	allotments in 50% of sub-watershed	allotments in 85% of sub-watershed
Mining	1.19 sites/ 1000 hectares	3.97 sites/ 1000 hectares	6.74 sites/ 1000 hectares
Recreation	0.34 sites/ 1000 hectares	1.12 sites/ 1000 hectares	1.90 sites/ 1000 hectares
Roads	23.51 roads/ 1000 hectares	78.37 roads/ 1000 hectares	133.22 roads/ 1000 hectares

*The fire index accounts for the time since a fire and the area burned (scale of 0-100).

The model output demonstrates that physical stressors have an impact on IBI scores, which reflect stream health.



•**Fire**: high intensity fire events have the potential to drop IBI condition one category (20 point decline in IBI score).
•**Grazing**: exhibits the largest potential to change IBI score (up to 50 points). This is due to its high level of interaction with all other stressors.
•**Mining**: our model showed that mining increases IBI score. This could be due to the lack of other stressors in mining areas.
•**Recreation**: an insignificant stressor in our model. Showed a small effect on IBI score.
•**Roads**: areas with high road density can cause decreases in IBI scores of approximately 25 points. This is enough to drop IBI condition at least one category.

RECOMMENDATIONS

Management Recommendations
•Grazing should be aggressively managed because it has the greatest effect on IBI scores and strong interactions with each of the other stressors. Allotments should be limited to 15% of the sub-watershed.
•The Forest Service aggressively manages wildfires. Continuing these efforts is extremely important for the protection of stream health.
•Current management practices for mining and recreation appear sufficient.
•Roads should be managed at or below 78 roads per 1000 hectares of forest.

Figure 2: Sub-watersheds highly impacted by stressors in red, minimally impacted in green

Sampling Recommendations
•Select a minimum number of sampling points based on the presence of multiple significant stressors (figure 2).
•The sampling approach should be based on a watershed boundaries. The upstream stressor effects that change IBI scores are not necessarily limited to forest boundaries, but are limited to watershed boundaries.
•Sample sites over time to increase understanding of trends and temporal change associated with stressors.
•Sample sites before and after any land use change to improve the identification of stressor impact on streams.
•Use a consistent sampling protocol to ensure comparable datasets. Based on ease and prevalence of use, we suggest using the California Stream Bioassessment Procedures (CSBP).
•Collect Physical/Chemical Data (DO, pH, TSS, Temperature, Flow, Turbidity, Nitrogen, Phosphorus)
•Use Volunteers to decreases costs and increase the number of sample sites.

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