# Causal Assessment Evaluation and Guidance for California Appendix A - Garcia River Causal Assessment Case Study

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### Case Definition

This appendix documents a causal assessment to determine the cause of biological impairment at a site sampled along the inner gorge of the Garcia River in 2008. The causal assessment method used was the USEPA Causal Analysis/Diagnosis Decision Information System (CADDIS: http://www.epa.gov/caddis). The Garcia River is located on the Mendocino Coast of northern California and is an example of a watershed where timber harvest has been the predominant land use for the last 150 years. Two major waves of timber harvest occurred historically: the first wave occurred in the 1880s and was largely restricted to the lower river and its riparian zones, as the steeper interior watershed was inaccessible with the technology of that time. A second wave in the 1950s began in response to the post-WWII housing boom and the availability of better logging machinery. This second wave resulted in much of the watershed being cleared of vegetation, the construction of a vast network of roads and skid trails on steep erodible slopes, and a legacy of erosion, sedimentation, and habitat loss in stream channels that dramatically depressed native salmonid populations. The area also supported diverse farming and ranching activities before, during and between the years of timber cutting, and several thousand acres of harvested timberland were converted to range land throughout the 20$^{th}$ century.

In 1993, the Garcia River was listed as impaired for elevated temperature and sedimentation per section 303(d) of the Clean Water Act. In 2002, a Sediment Total Maximum Daily Load (TMDL) Action Plan, which sought to reduce controllable human-caused sediment delivery to the river and its tributaries, was adopted into the river's larger basin plan. Today, property owners on two-thirds of the land area in the watershed are participating in the TMDL Action Plan; half of that area (one-third of the total watershed) is managed by The Conservation Fund as a sustainable working forest, called the Garcia River Forest (GRF), with a conservation easement owned by The Nature Conservancy (TNC). A probabilistic monitoring program was implemented in 2007 by TNC to assess salmonid habitat and measure progress towards meeting GRF management goals. The North Coast Regional Water Quality Control Board (NCRWQCB) collaborated with TNC to expand sampling to areas outside of the GRF and to use collected data to assess the effectiveness of TMDL compliance efforts.

In this case study, benthic macroinvertebrates were utilized as the biological indicator and were interpreted with the North Coast Index of Biotic Integrity ('NorCal IBI'). Twelve sites sampled in 2008 along a 7km section of the Garcia mainstem inner gorge had IBI scores indicative of biological impairment or were just above the impairment threshold. Site 154 had the lowest IBI score of the 12 inner gorge sites (IBI score = 36; 16 points below the impairment threshold of 52) and was defined as the case site. Two comparator sites with IBI scores above the impairment threshold were defined: site 218 (200 meters downstream of site 154) and site 223 (1200 meters upstream of site 154). Specific biological effects observed at site 154 relative to upstream and downstream comparators included: a decrease in EPT richness, a decrease in percent predator individuals, an increase in percent non-insect taxa, and an increase in dominance by oligochaete worms and chironomid midges.

## List of Stakeholders

Stakeholders in this causal assessment were the NCRWQCB (represented by Jonathan Warmerdam) and TNC (represented by Jennifer Carah). Other participants included Andrew Rehn and Jim Harrington (CDFW), Scot Hagerthey and Sue Norton (EPA), Ken Schiff and Dave Gillett (SCCWRP), and Michael Paul (Tetra Tech).

## Data Resources and Inventory

The NCRWQCB and TNC adopted field protocols for benthic macroinvertebrate (BMI) sampling and measuring physical habitat that were developed by the USEPA for a stream survey across 12 western states, including California, conducted 2000-2003 (see Peck et al. 2006). The same protocols also were adopted by California's statewide monitoring program from 2004-2007. Many of the endpoint variables derived from the EPA's physical habitat surveys are directly related to numerical endpoints specified in the Garcia River's sediment TMDL Action Plan. Data from "within the case" came from the 12 inner gorge sites mentioned above, including the case site 154 and its two comparator sites. Data from "outside the case" came from North Coast regional surveys conducted from 2000-2007 (n = 123 sites) and from 30 of the 56 probability sites that were sampled by TNC in the Garcia watershed in 2008. The latter were included to improve applicability of regional stressor-response evaluations to the Garcia watershed, and brought the total number of sites for regional analyses to 153.

## Candidate Causes

### Sedimentation

- for example, increased embeddedness; increased sand + fine substrate

### Increased Temperature

- related to channel alteration, flow alteration and riparian removal

### Altered Flow Regime

- for example, increased peakflow; decreased baseflow; change in surficial flow

### Physical Habitat

- for example, decreased woody debris, decreased in-stream habitat; change in pool/riffle frequency, increased glide habitat

### Pesticides, Nutrients and Petroleum

- Concentrations in the water column all possibly related to illegal marijuana gardens in upper watershed. **Note**: specific conductivity was eventually used a surrogate variable for nutrients and pesticides

### Decreased Dissolved Oxygen

- Related to warming, lower turbulence, increased glide habitat, increased width-to-depth ratio

### Change in pH

## Diagnosed and Refuted Stressors

Sedimentation and loss of habitat are at least partially responsible for the degraded biological community at case site 154. In 2008, comparator sites (especially 223) were less embedded and

had less sand + fines + fine gravel substrate than the case site. Greater habitat diversity was also observed at comparator sites (especially site 223) than at the case site, including more in-stream cover, more fast water (riffle) habitat, less glide habitat (case site 154 was dominated by glide habitat in 2008), greater variation in depth, and more optimal pool-riffle frequency.
All of the inner gorge sites, including case site 154, appear impacted by similar causal processes related to historical land use, especially road building and timber harvest, such that sedimentation and loss of habitat occurred on a watershed scale. The observed differences in sedimentation and physical habitat between the case site and comparators are consistent with causal pathways related to legacy effects from historical timber harvest/road building affecting the entire inner gorge, and site 223 being a higher gradient, more constrained reach that transports sediment downstream and is therefore somewhat recovered physically. Stressor-response relationships between several BMI metrics and sediment variables or physical habitat variables using available regional data also helped establish causal inference.

Conductivity (as a surrogate for nutrients and pesticides), changes in pH and altered flow regime were found to be unlikely contributors to poor biological condition at the case site relative to upstream and downstream comparators because observed differences in stressor values (if any) did not seem to be great enough to have ecological relevance between sites. Causal pathways linking current forestry practices or marijuana cultivation were not observed for case site 154. Comparator sites were within close proximity, so there was little opportunity for those human activities (e.g., localized water withdrawal for irrigation of marijuana) to have a differential effect between the case site and its comparators in 2008.

## Unresolved Stressors

Longer term measurements of dissolved oxygen and temperature are needed for thorough evaluation of these candidate stressors, although certain channel alterations related to historical timber harvest contribute necessary links in causal pathways. For example, site 154 had lower mean depth, lower pool depth, and higher width/depth ratio than comparators, which could increase average temperature. The case site also had a lower spot measurement of dissolved oxygen than the comparators and the value (6.4 mg/L) was below the minimum coldwater standard of 7 mg/L. However, we did not wish to list lowered dissolved oxygen as a likely contributor based on a single grab sample that was collected at a different time of day than similar samples from other sites. No data were available to allow diagnosis of nutrients, pesticides or petroleum as possible causes.

## CASE DEFINITION

### Waterbody Description and Setting[1]

The Garcia River is located on the Mendocino Coast in northern California and drains a small- to medium- size watershed of 73,223 acres (approximately 115 square miles; Figure 1). From its headwaters at 1,500 to 2,000 feet above sea level, the Garcia flows primarily east to west until intersecting the San Andreas Fault, where it turns abruptly northwestward and finally discharges to the ocean at Point Arena. Pre-Columbian land cover in the watershed was dominated by late seral ('old growth') forests of coastal Douglas fir and Coast Redwood, interspersed with mixed conifer-deciduous forest, grassland and chaparral. However, the predominant human land use in the watershed for the last 150 years has been timber harvest and little old growth remains. Early logging (1860's – 1915) occurred mostly within riparian zones along the lower river because technologies that allowed access to steeper interior slopes (e.g., tractors and semi-trucks) were not available. Although spatially restricted, early logging probably had substantial impacts on the lower river, which was dammed for eight months each year to provide a corridor for transport of logs downstream to sawmills and then to ships waiting at the coast for export.

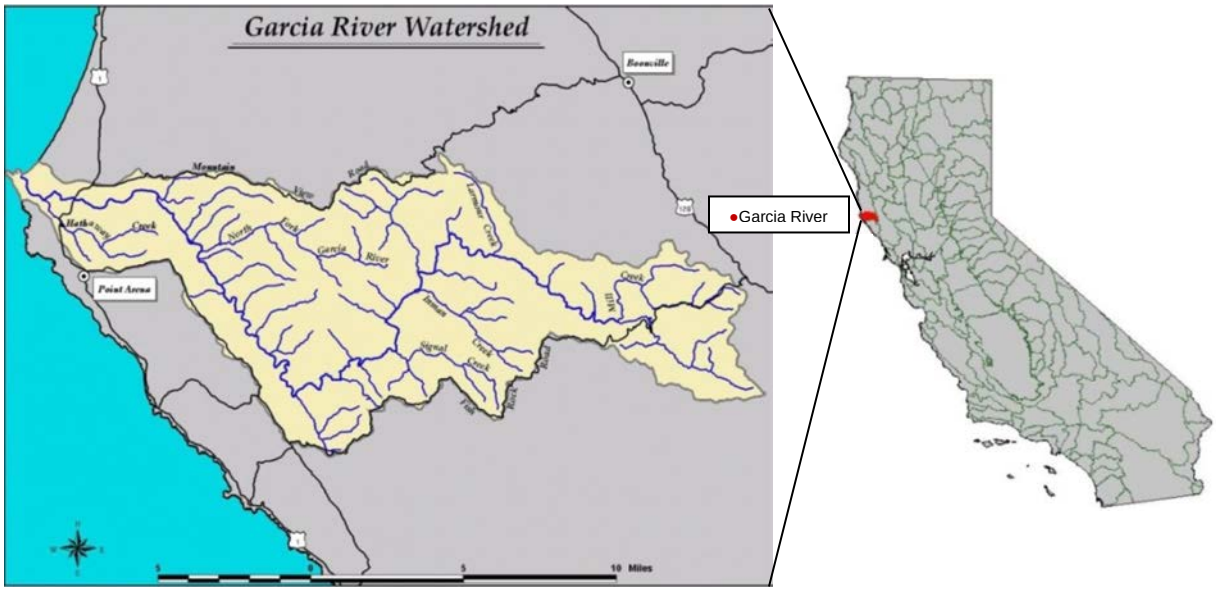


**Figure 1. Map of the Garcia River Watershed.**

In the 1950's, the post-WWII housing boom created a huge demand for raw lumber. Improved technologies allowed access to steeper, interior portions of the watershed and the river was no longer relied on as the primary means of transporting felled logs. Instead, vast networks of roads and skid-trails were constructed to allow removal of trees from the entire landscape via tractors and trucks (Figure 2). Small tributaries of the Garcia River often had their flood channels

[1] Much of the introductory material in this report came from previous presentations by stakeholder Jonathan Warmerdam (North Coast Regional Board) or from the Garcia River TMDL Action Plan prepared by North Coast Regional Board staff (see References).

converted into roads or were used as waste dumps for unusable slash. By the late 1960's, most of the watershed was logged. Renewed logging of regenerated (secondary growth) forests occurred on 52% of the basin area from 1987 to 1997. The area also supported diverse farming and ranching activities before, during and between the years of timber cutting, and several thousand acres of harvested timberland were converted to range land between the 19th and early 20th century. In-channel gravel mining also was common on the mainstem Garcia from the 1960's through the mid 1990's.

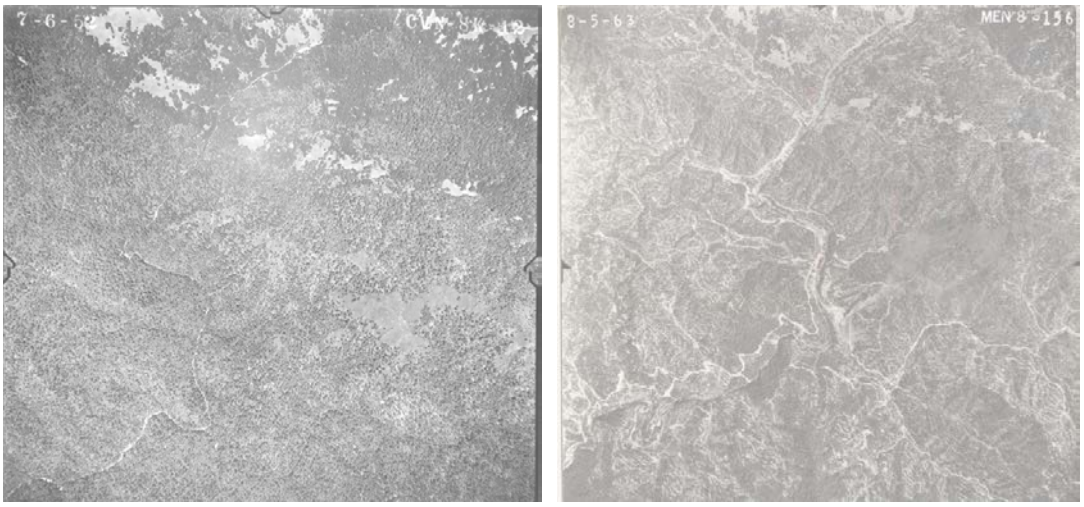


**Figure 2. Before-and-after aerial photographs of the Garcia River near the Inman Creek confluence in 1952 (left), and in 1963 (right). The left photo shows approximately 30 square miles; the right photo shows approximately 48 square miles. Note in the right photo the large areas of deforestation and networks of roads and skid trails.**

In 2004, The Conservation Fund purchased one-third of the upper Garcia watershed (nearly 24,000 acres). Most of the property, called the Garcia River Forest (GRF), is currently managed as a sustainable working forest, while The Nature Conservancy (TNC) owns a conservation easement that protects the forest from future development and designates one-third of the property as a forest reserve. Land ownership in the remaining upper watershed is a mixture of industrial timber holdings, private timber holdings, and large and small private ranches; the percentage of land cover classified as either urban or agricultural in the upper watershed is nearly zero (based on 2006 National Land Cover Dataset). Illegal marijuana gardens are an increasing problem throughout the watershed because growers trespass, remove native vegetation, and impound tributaries for water diversion and sometimes mix fertilizer and pesticides within stream channels. The river's lower coastal plain (roughly the lower 3.5 miles of the drainage) has long been converted to agriculture, although the 1132-acre Stornetta Public Lands are managed by the Bureau of Land Management as a nature preserve that encompasses the Garcia River estuary and portions of the riparian corridor near the river's mouth.

## Statement of Biological Impact

Negative environmental impacts from decades of intensive industrial timber management were substantial. Deforestation coupled with networks of fragile roads constructed on highly erodible slopes led to excessive sedimentation throughout the watershed. Today, 3 of the 4 salmonid

species native to the Garcia (i.e., Pink, Chinook and Coho salmon) are endangered or extirpated from the watershed due to loss of spawning habitat, while steelhead survive but are threatened[2]. The Garcia River was 303d[3] listed in 1996 for sediment and temperature impairment, and in 2002, a Total Maximum Daily Load (TMDL) action plan was adopted into the Water Quality Control Plan for the North Coast Region to reduce controllable human-caused sediment delivery to the river. Property owners of two-thirds of the land area in the watershed are currently participating in the TMDL action plan.

A probabilistic monitoring program was implemented in 2007 by TNC to assess salmonid habitat and measure progress towards meeting GRF management goals. The North Coast Regional Water Quality Control Board (NCRWQCB) collaborated with TNC to expand sampling to areas outside of the GRF and to use collected data to assess the effectiveness of TMDL compliance efforts (Figure 3). Data from this monitoring led to the case definition for the case study presented here. Benthic macroinvertebrates (BMIs) were the primary biological indicator utilized by the Garcia monitoring program; BMI data were interpreted with the North Coast Index of Biotic Integrity ('NorCal IBI'; Rehn et al. 2005). The NorCal IBI is a multi-metric index scored on a 0 to 100 point scale, with higher scores indicating better biological condition and scores $\leq$52 indicating biological impairment. IBI scores at tributary sites throughout the watershed were generally in good condition with a few exceptions in 2007-2008, but IBI scores at mainstem river sites tended to be in poorer condition (Figure 3). In particular, 12 sites that were sampled along a 7km section of the inner gorge in 2008 all had IBI scores indicative of impairment or just above the impairment threshold (Figure 4). Site 154 had the lowest IBI score of the 12 inner gorge sites in 2008 (IBI = 36) and was defined as the case site, i.e., for the purposes of this causal assessment, the evaluation was limited to identifying the cause of the poor IBI score at site 154.

[2] Preservation of coldwater habitat, migration of aquatic organisms, fish spawning and development, and commercial and sport fishing are among 12 beneficial uses designated for the Garcia River (see NCRWQCB, 2000).
[3] Section 303d of the Clean Water Act (1972) requires States to provide Congress with a list of impaired waterbodies including the causal pollutant(s) for each listed waterbody.

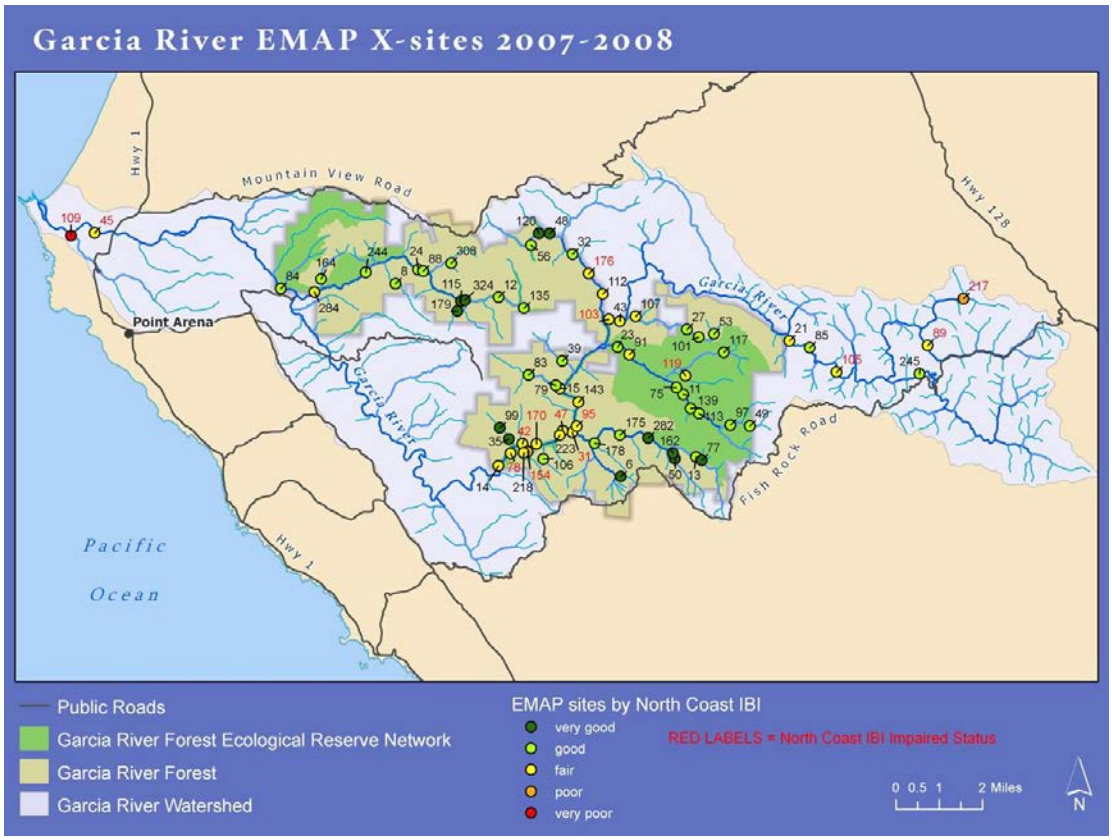


**Figure 3. Probability sites sampled by TNC and NCRWQCB in 2007-2008.**

## List of Comparator Sites (and Rationale)

Two comparator sites were selected for this case study: Site 218 was immediately downstream of the case site and had an IBI score of 53; site 223 was 1200 meters upstream of the case site and had an IBI score of 56 (Figure 4). The two comparators were selected because, while not in "good" condition, IBI scores at those sites were above the biological impairment threshold. In addition, because the comparator sites were in close proximity to the case site, it was reasoned that they would have similar environmental conditions as the case site except for the causal agent(s) that led to impairment at site 154, and therefore would facilitate successful diagnosis. Specific biological effects observed at site 154 relative to upstream and downstream comparators included: a decrease in EPT richness, a decrease in percent predator individuals, an increase in percent non-insect taxa, and an increase in dominance by oligochaete worms + chironomid midges (Table 1).

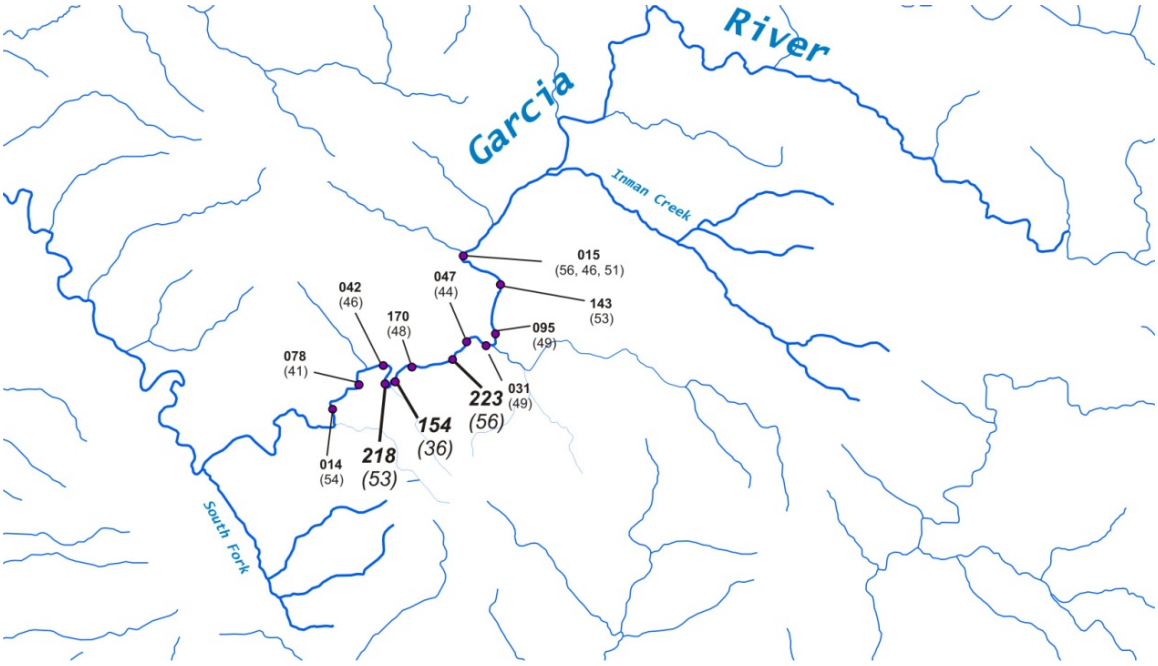


**Figure 4. Map of 12 probability sites sampled in 2008 along a 7-km section of the inner Garcia gorge between Inman Creek and the South Fork (site identifiers listed in bold; IBI scores listed in parentheses, labels for case and comparator sites in larger font). All 12 sites had IBI scores indicative of impairment or just above the impairment threshold (IBI = 52). Site 154 had the lowest IBI score (IBI = 36) and was defined as the case site. Sites 218 and 223 were downstream and upstream comparators, respectively.**

**Table 1. Raw values of individual NorCal IBI metrics (Rehn et al. 2005) for the case site and comparators in 2008.**

| Site | EPT Richness | Coleoptera Richness | Diptera Richness | % Intolerant Individuals | % Non-gastropod Scrapers | % Predator Individuals | % Shredder Taxa | % Non-insect Taxa |
|---|---|---|---|---|---|---|---|---|
| 218 (downstream) | 13 | 4 | 6 | 7 | 9 | 10 | 12 | 21 |
| 154 | 9 | 3 | 5 | 6 | 8 | 6 | 7 | 30 |
| 223 (upstream) | 13 | 4 | 6 | 9 | 18 | 19 | 6 | 24 |

## LIST OF STAKEHOLDERS

The North Coast Regional Water Board (represented by Jonathan Warmerdam) and the Nature Conservancy (represented by Jennifer Carah) were the primary stakeholders in this case study and represented the combined interests of both water quality regulators and the regulated community in the Garcia River watershed. Other participants included Andrew Rehn and Jim Harrington (CDFW) Scot Hagerthey and Sue Norton (EPA), Ken Schiff and Dave Gillett (SCCWRP) and Michael Paul (Tetra Tech).

## CANDIDATE CAUSES

Causal assessment participants proposed 7 candidate causes for biological impairment at case site 154 during a workshop held in Costa Mesa, CA in February 2012. Conceptual diagrams linking a candidate cause with potential sources and effects were developed for 4 causes with available data sources (i.e., flow alteration, physical habitat alteration, increased sediment, increased temperature, Figures 5 through 8). Sources were limited to historical timber harvest practices, current timber harvest practices, marijuana cultivation and low-level residential use. The general format of the conceptual diagrams depicts sources and contributing landscape changes near the top of the figure, leading down the diagram to steps in the causal pathway, proximate stressors, modes of action, and concluding with observed biological responses at the bottom. Diagrams and narratives for the Garcia River were modified and adapted from the general diagrams and narratives available through CADDIS (http://www.epa.gov/caddis/ssr_home.html).

Some of the candidate causes (e.g., Physical Habitat) are generalized data types, measured in multiple ways during stream surveys, and therefore include several individual variables that may affect biological condition alone or in concert with other variables. For brevity, the names of broader stressor categories are listed here with a few example measures for each. The full list of individual stressors that were measured and used in data analyses is given in supporting tables at the end of this document.

### Sedimentation

Roads, skid trails, and associated landslides are recognized as the most significant anthropogenic sources of sediment delivery to the Garcia River watershed. Devegetation on a watershed scale from historical or current timber harvest, or on a more local riparian scale from marijuana

cultivation and small-scale ranching can greatly alter sediment budgets (i.e., the supply, movement, and retention of mineral and organic particles of all sizes). These land use activities can cause increased channel embeddedness, increased sand + fine substrate, increased water turbidity, etc., leading to adverse affects on aquatic biota like loss of spawning habitat, effects on salmonid feeding abilities, and suffocation of BMIs by fines.

## Increased Temperature

Human activities like removal of riparian vegetation for forestry or marijuana production can directly cause increased stream temperature through decreased shading, or more indirectly through water extraction, bank erosion, increased width-to-depth ratio and greater heating of shallower water, leading to negative affects on cold-water stream biota.

## Altered Flow Regime

Current land use practices could alter flows through surface or ground water withdrawals, whereas historical timber harvest could alter flows through changes in channel structure that greatly alter discharge patterns (e.g., increased peak flow and decreased base flow), water velocity, and water depth leading to negative affects on stream biota.

## Physical Habitat

Historical and current land use practices could decrease vegetation in the watershed and riparian zones, thereby decreasing woody debris input to the stream while increasing watershed erosion and sediment delivery to the stream. Filling in of pools by sediment, changes in pool/riffle frequency, increased glide habitat and decreased depth and substrate variability could have adverse effects on stream biota.

## Pesticides, Nutrients and Petroleum

Concentrations of pesticides, petroleum or nitrogen in the water column or sediment all possibly relate to marijuana production in the upper watershed. Negative biotic effects would be direct toxicity through exposure or indirect mortality through eutrophication, increased biological oxygen demand and oxygen depletion. **Note**: conductivity was eventually used a surrogate variable for nutrients and pesticides.

## Decreased Dissolved Oxygen

Human related activities such as septic tank discharges or fertilizer applications associated with marijuana production could increase chemical or biological oxygen demand, resulting in reduced dissolved oxygen concentrations and negative effects on aquatic biota (e.g., cause respiratory stress). Land use activities that alter in-stream channel conditions (e.g., decreased fast water habitat, increased width-to-depth ratios) could decrease aeration, while decreased shading through removal of riparian vegetation could cause increased stream temperature and decreased dissolved oxygen, leading to respiratory stress of stream biota.

## Change in pH

Changes in pH were hypothesized to have causal pathways related to chemical inputs from marijuana production that would alter hydrogen ion concentration directly.

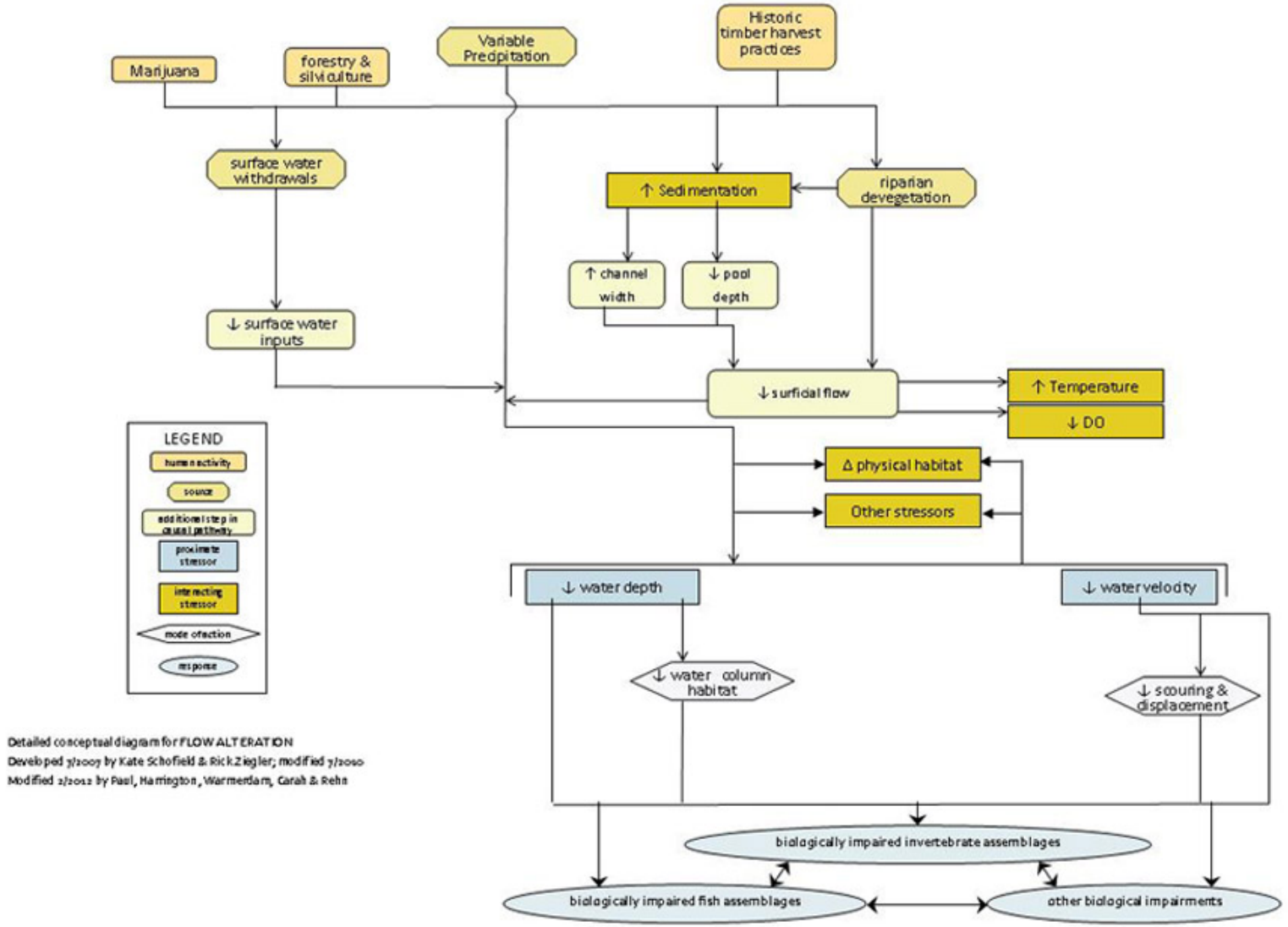


**Figure 5. Flow alteration conceptual diagram.**

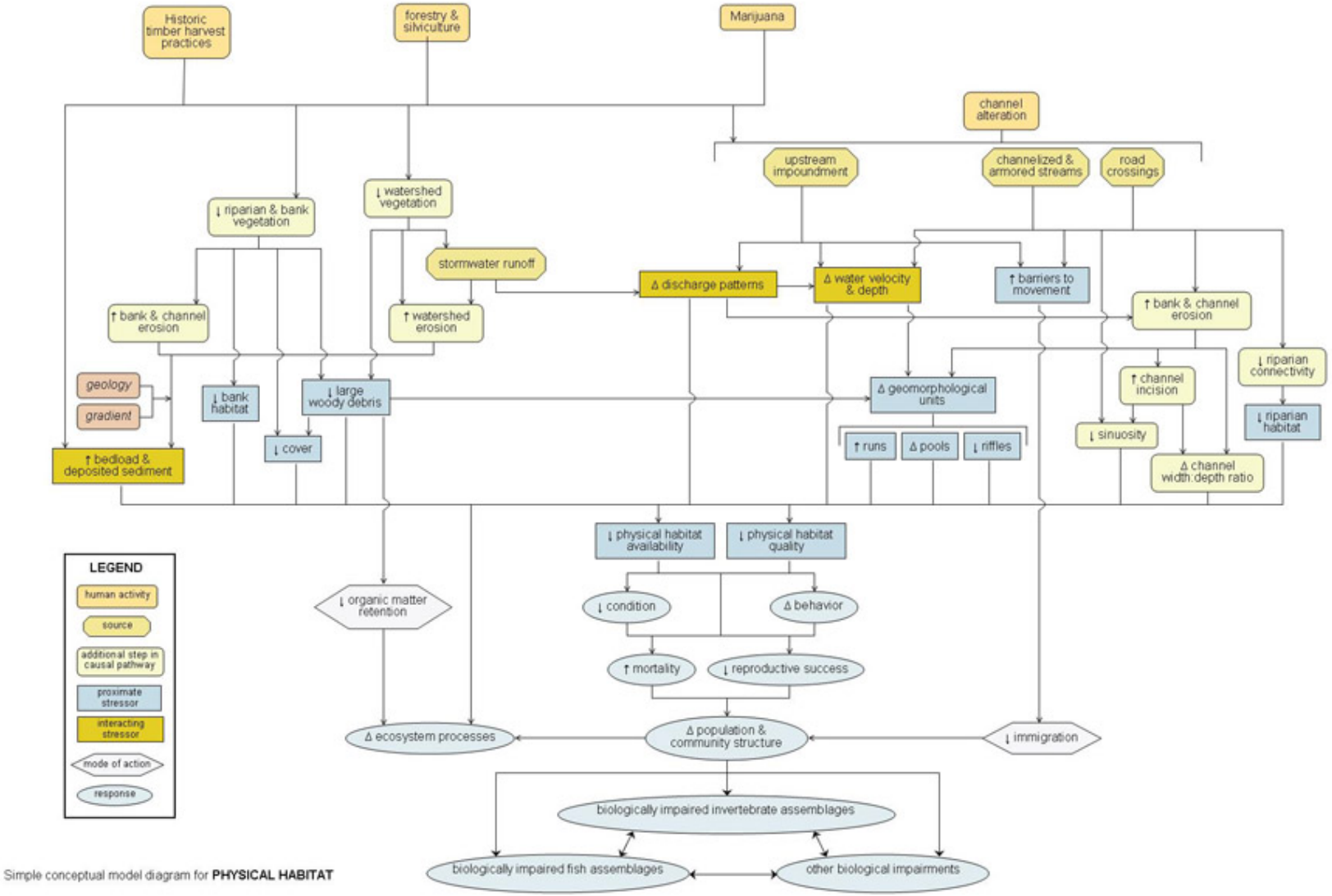


**Figure 6. Physical habitat conceptual diagram.**

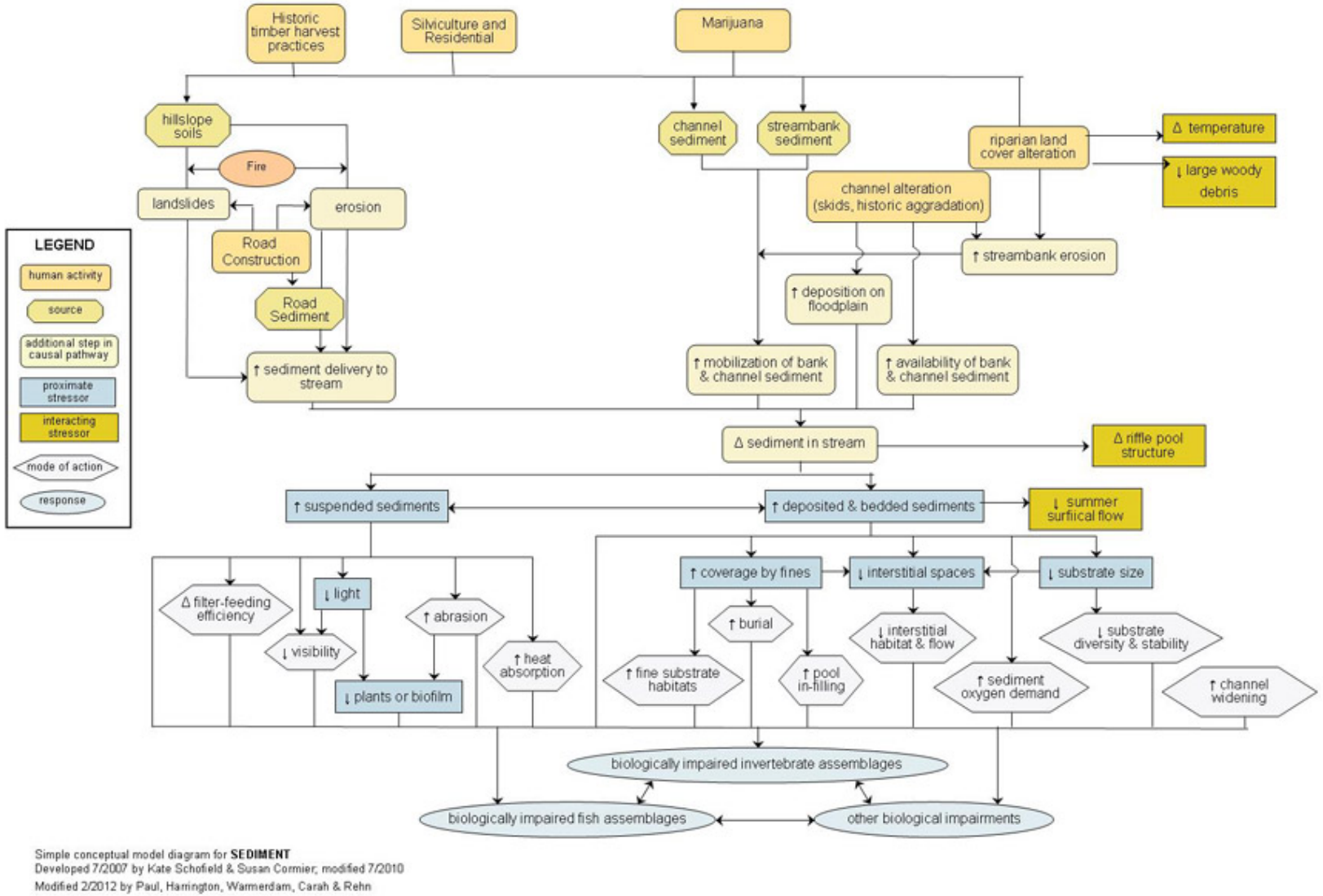


**Figure 7. Increased sediment conceptual diagram.**

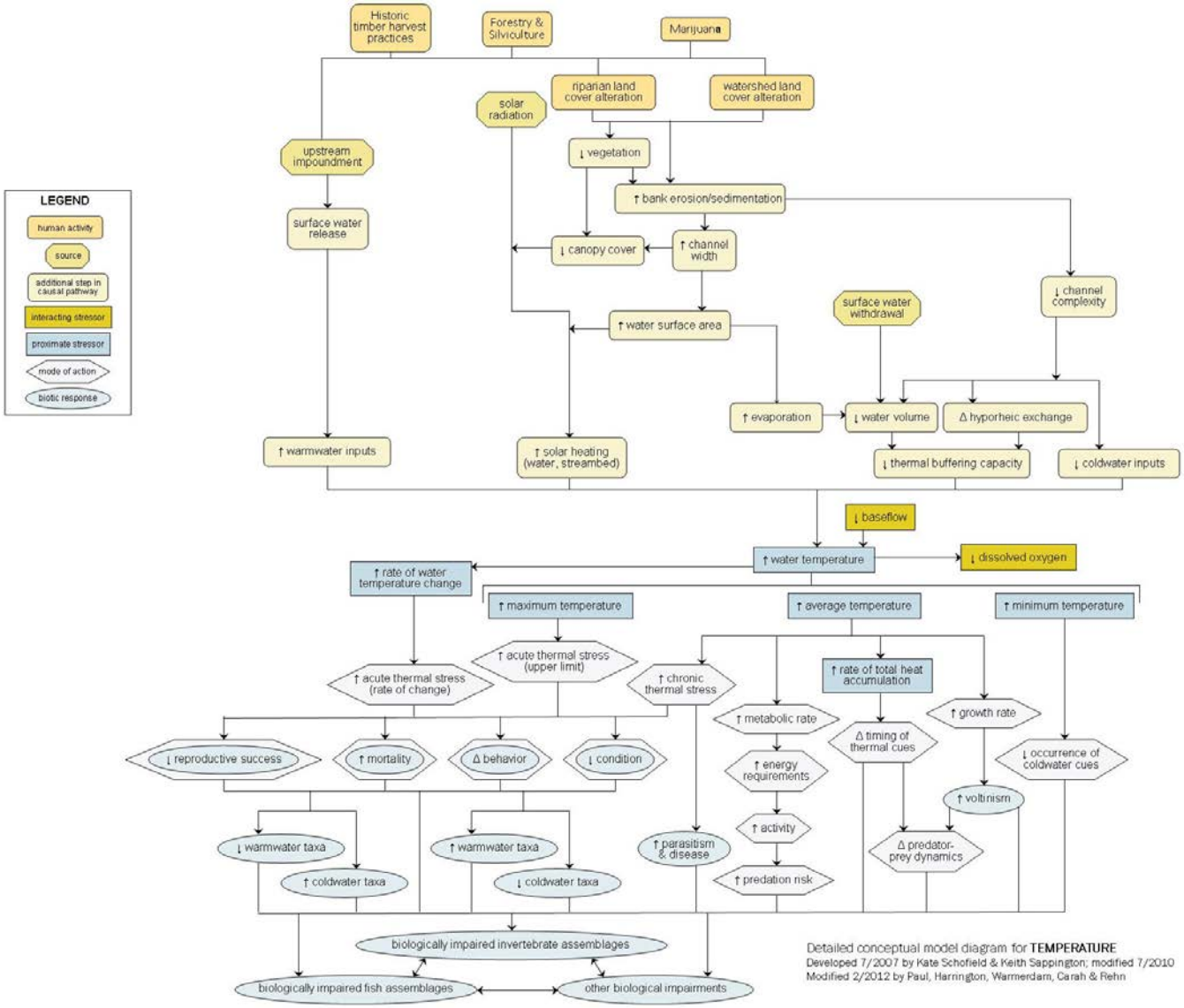


**Figure 8. Increased temperature conceptual diagram.**

## Data Inventory

The NCRWQCB and TNC adopted field protocols for sampling BMIs and measuring physical habitat that were developed by the USEPA's *Western Environmental Monitoring and Assessment Program* (WEMAP), a stream survey of 12 western states, including California, conducted in 2000-2003 (Kauffman et al. 1999; Peck et al. 2006). Many of the endpoint variables derived from WEMAP's physical habitat surveys are directly related to numerical endpoints specified in the Garcia River Sediment TMDL Action Plan. The California State Water Board also adopted WEMAP protocols for their statewide surveys, known as CMAP, which from 2004-2007 continued the WEMAP probabilistic sampling design throughout California. Both the WEMAP and CMAP programs sampled North Coast streams as part of larger statewide survey designs. Common data format between these larger-scale programs and the Garcia River monitoring program greatly facilitated compilation of survey results for analysis of stressor-response across the North Coast region (described below in *Data Analysis: Stressor-Response From Elsewhere*). Thirty of the 56 TNC sites sampled in 2008 were randomly selected for inclusion in the larger regional data set to improve applicability of regional stressor-response evaluations to the Garcia watershed. Stream temperature, pH, dissolved oxygen (DO), conductivity, and discharge in all surveys were point-in-time measurements taken during sampling and do not reflect longer-term averages. WEMAP and CMAP collected basic nutrient data but the Garcia program did not. A summary of data types is provided in Table 2 below.

**Table 2. Summary of sites from Garcia watershed monitoring in 2008 and North Coast regional monitoring in 2000-2007 selected for use in causal assessment.**

| Evidence Type | # Sites | Source | Year(s) Sampled | Data Type | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | BMIs | PHAB | Sediment | Temp | pH | DO | Conductivity | Flow | Nutrients | Petroleum, Pesticides |
| **Spatial-Temporal Co-Occurrence** | | | | | | | | | | | | | |
| *Case +* *2 Comparators* | **3** | TNC | 2008 | yes | yes | yes | yes | yes | yes | yes | yes | no | no |
| **Stressor Response from the Field** | | | | | | | | | | | | | |
| *Data from Within Case* | **12** | TNC | 2008 | yes | yes | yes | yes | yes | yes | yes | yes | no | no |
| *Data from Outside Case* | **153** | WEMAP, CMAP, TNC | 2000-2008 | yes | yes | yes | yes | yes | yes | yes | yes | yes/no | no |

## Data Analysis

Available data supported use of four different lines of evidence in the Garcia River case study (Table 2; also see accompanying guidance document and EPA's CADDIS website for description of evidence types and scoring: http://www.epa.gov/caddis/). For data analyses within the case, the lines of evidence used were: 1) spatial-temporal co-occurrence, 2) causal pathways, and 3) stressor-response from the field. For data analyses outside the case, the single line of evidence used was stressor-response from the field. In the sections below, only select examples of scoring are given to illustrate where data for different evidence types either supported or weakened each candidate cause as the cause of impairment. Full scoring tables for each line of evidence can be found at the end of this appendix (Tables 6-10).

### Data Analysis within the Case: Spatial-Temporal Co-Occurrence

Several physical habitat (PHAB) and sediment variables were scored a "+; somewhat supporting" for the spatial-temporal co-occurrence line of evidence, especially for site 154 against comparator site 223 (Table 3). For example, glide habitat is less supportive of rich BMI assemblages than fast water habitat (e.g., riffles). Therefore, the greater abundance of glide habitat at site 154 than at either comparator site at the time BMI samples were taken is supportive of increased glide habitat as a cause of impairment at site 154. By contrast, decreased baseflow at the case site compared to comparators was also a candidate cause for impairment, but the case site had a *higher* discharge than either of the comparators at the time of sampling. Therefore, discharge (cfs) was scored a "---; strongly weakening" for the spatial-temporal co-occurrence line of evidence (Table 4).

**Table 3. Spatial-temporal co-occurrence strength of evidence: select examples of supporting signal for PHAB and sediment variables as causes of impairment at site 154 (especially against comparator 223 where supporting signal is more consistent). % Difference = [(impaired value-reference value]/reference value]*100%.**

| Candidate Cause | Site 154 | Site 218 | % Difference | SOE Score | Site 223 | % Difference | SOE Score |
|---|---|---|---|---|---|---|---|
| Instream habitat diversity | 0.29 | 0.28 | 2% | --- | 0.54 | -46% | + |
| % glide habitat | 51 | 17 | 200% | + | 26 | 96% | + |
| Glide count (# transects) | 8 | 4 | 100% | + | 2 | 300% | + |
| % fastwater habitat | 14 | 11 | 27% | --- | 23 | -39% | + |
| Standard deviation of depth | 25 | 81 | -69% | + | 49 | -49% | + |
| % sand + fines + fine gravel | 25 | 30 | -17% | --- | 9 | 178% | + |
| % embedded | 59 | 59 | 0% | --- | 36 | 64% | + |
| Epifaunal substrate | 11 | 12 | -8% | 0 | 16 | -31% | + |

**Table 4. Spatial-temporal co-occurrence strength of evidence: select examples of non-supporting signal for causes of impairment at site 154. % Difference = [(impaired value-reference value]/reference value]*100%.**

| Candidate Cause | Site 154 | Site 218 | % Difference | SOE Score | Site 223 | % Difference | SOE Score |
|---|---|---|---|---|---|---|---|
| Woody debris volume in wetted channel | 0.48 | 0 | | --- | 0 | | --- |
| % dry channel | 0 | 0 | | --- | 0 | | --- |
| Discharge (cfs) | 15 | 5 | 200% | --- | 7 | 114% | --- |
| Temperature (°C) | 17.2 | 19.3 | -11% | --- | 18.3 | -6% | --- |

### Within the Case Data Analysis: Stressor Response from the Field

Bivariate scatterplot relationships were derived using data from all 12 sites sampled in 2008 along the inner gorge of the Garcia River between Inman Creek and the South Fork (approximately 7 km as the fish swims; Figure 4). Analyses were extended beyond the case site and its 2 comparators to increase sample size for calculating correlations, and because the same causal processes arguably have depressed IBI scores at all sites given their proximity, current (protective) management practices and historical timber harvest in the watershed. Relationships were evaluated between candidate causes (as data allowed) and IBI scores, the eight IBI metrics and taxa richness. Scoring was based on strength of Pearson correlations, with strong associations having r >0.80 and weak associations having r between 0.50 and 0.80 in the expected direction (either positive or negative) and without sample inconsistencies (i.e., values at case and comparator sites also were in the expected direction and consistent with overall patterns across sites).

Stressor-Response from the Field (Within the Case) provided limited information as a line of evidence because very few relationships showed a strong, consistent effect gradient when biological variables were plotted against proximate stressor candidates (Table 8). When stronger relationships were seen, some were interpretable and followed expected patterns, but others were difficult to interpret or showed unexpected patterns (Figure 9). Stressor-response relies on a gradient of environmental variability across sites. Since all sites along the inner gorge have been similarly impacted by historic land use on a watershed scale (which their IBI scores seem to indicate), very little gradient in habitat conditions may currently exist between them, as the same causal processes have led to similar impairment along this entire stretch of river. Examples of "effect gradients" may therefore be spurious results derived from data with narrow range. This line of evidence was considered to lend only weak positive support to changes in physical habitat structure as the cause of biological impairment at site 154 (see Table 5 below).

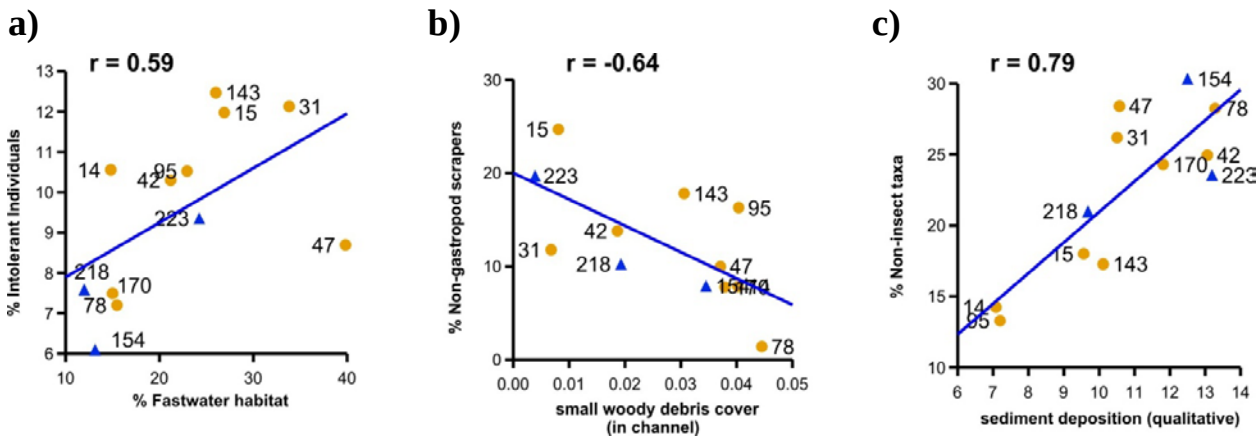


**Figure 9. Examples of: a) an expected dose-response relationship between a physical habitat variable and a BMI metric; b) a relationship difficult to interpret as there is little range in the physical habitat variable (x-axis); c) an unexpected dose-response relationship between a physical habitat variable and a BMI metric (non-insects normally become *less* abundant in a sample as habitat condition improves).**

### Outside the Case Data Analysis: Stressor Response from the Field

Bivariate scatterplot relationships were derived using data from 153 sites sampled by probabilistic monitoring programs in the North Coast region between 2000 and 2008. Thirty of the 153 sites were randomly selected from a pool of probabilistic sites from within the Garcia River watershed itself (sampled 2007-2008) to improve applicability of regional stressor-response evaluations to the case and comparator sites. Total sample size = 165 due to repeat visits at 4 sites. Relationships were evaluated between candidate causes (as data allowed) and IBI scores, the eight IBI metrics and taxa richness. Scoring was based on strength of Pearson correlations, with strong associations having r >0.80 and weak associations having r between 0.50 and 0.80 in the expected direction (either positive or negative) and without sample inconsistencies (i.e., values at case and comparator sites also were in the expected direction and consistent with overall patterns across sites).

Stressor-Response from the Field (Outside the Case) provided only weak positive support for changes to physical habitat structure as the cause of biological impairment at site 154 (see Table 5 below), again due to the very few regional relationships that showed a strong effect gradient across sites (Table 10). However, when stronger relationships were seen, they tended to be in accordance with expected metric responses to specific stressor variables (Figure 10). By contrast, sedimentation (especially embeddedness and percent sand + fine substrate) was more strongly supported as the cause by this line of evidence, i.e., a greater number of sediment measures had Pearson correlations in the right direction and greater than 0.5 as compared to physical habitat measures; thus, sedimentation was scored a '+' for this line of evidence in the final scoring table (Table 5).

**Table 5. Scoring summary for site 154 against sites 218/223. The notations of "weak" support for stressor response from the field, both from within the case and elsewhere, are explained in the text for those lines of evidence.**

| | Low DO | pH | Temp | Conductivity | PHAB | Sediment (bed) | Flow | Increased Pesticides | Increased Nutrients | Increased Petroleum |
|---|---|---|---|---|---|---|---|---|---|---|
| **Types of Evidence That Use Data From Within the Case** | | | | | | | | | | |
| Spatial-Temporal Co-Occurrence | + | 0 | 0 | +/--- overall: --- | + | ---/+ overall: + | --- | NE | NE | NE |
| Causal Pathway | + | - | + | - | + | + | + | 0 | 0 | 0 |
| Stressor Response From the Field | - | - | - | - | + (weak!) | - | - | NE | NE | NE |
| **Types of Evidence That Use Data From Elsewhere** | | | | | | | | | | |
| Stressor Response From Other Field Studies | - | - | - | - | + (weak!) | + | - | NE | NE | NE |
| **Evaluating Multiple Types of Evidence** | | | | | | | | | | |
| Consistency of Evidence | - | - | - | - | + | + | - | 0 | 0 | 0 |

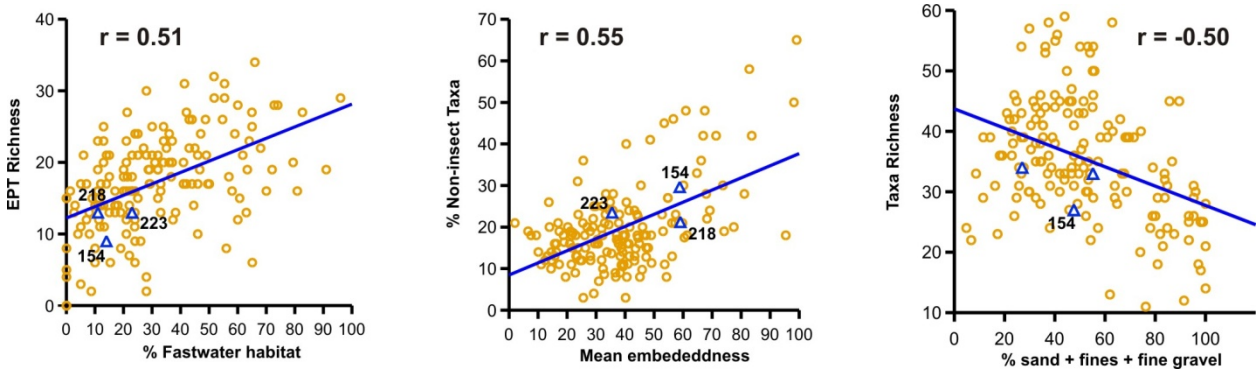


**Figure 10. Examples of stressor-response relationships from outside the case (i.e., from the entire North Coast region) that were relatively strong (p ≥ 0.5) and where BMI metric response was in the expected direction.**

## IDENTIFYING PROBABLE CAUSE

### Comments about Final Scoring in Table 5

Two candidate causes (conductivity and sedimentation) were scored differently between comparator sites 218 and 223 for the Spatial-Temporal Co-Occurrence line of evidence. Conductivity was higher at site 154 than at 218 (so was scored a '+' for that comparison), but was the same at sites 154 and 223 (so was scored a '---' for that comparison). Overall, conductivity was scored a '---' for Spatial-Temporal Co-Occurrence because the measured difference between sites 154 and 218 was small (180 vs. 200 µS/cm) and was not likely to represent an ecological difference between sites. Sedimentation of the channel bed was not supported as a cause of BMI impairment in comparison of site 154 against 218, but was supported as a candidate cause in comparison of 152 against 223 (Table 3). Overall, sedimentation was scored a '+' for spatial-temporal co-occurrence based on best professional judgment after field trips to the Garcia River in June 2012 indicated that the entire inner gorge is likely impacted by historic sedimentation (Figure 11) and that site 218 may not have been the best choice of comparator sites due to its physical similarity to site 154. Site 223 is more reflective of what natural channel conditions should look like in the Garcia as sediment is gradually transported out of the system.

Candidate causes that were scored a '+' for causal pathways all had steps deriving from historic timber harvest rather than current land use such as modern silviculture or marijuana gardens (see Tables 9a-9f at end of document for full scoring of the causal pathway line of evidence). Because of their close proximity to one another along the inner gorge (within 1.5 km), upstream land use at the watershed scale does not differ across the case site and its comparators. Therefore, in order for causal pathways linking modern forestry practices or marijuana cultivation to be present, those human activities would have to be spatially located so as to have local effects on site 154 but not on the comparators, but this was not observed to be the case.

**a)** **b)**

**Figure 11. Examples of sedimentation of the inner gorge of the Garcia River: a) an old-growth redwood stump inundated by aggraded sediment that raised channel elevation above its roots; b) a section of the Garcia at site 154 where depth varies little across the channel width due to aggraded sediments. Causal assessment team members are shown in photo 'b' for perspective of high width-to-depth ratio.**

## FINAL CONCLUSIONS: LIKELY CAUSES

| Candidate Cause | Evidence and comments |
|---|---|
| Sedimentation | Comparator sites (especially 223) were less embedded and had less sand + fines + fine gravel. Differences were consistent with causal pathways attributed to legacy effects from historical timber harvest affecting the entire inner gorge, and site 223 being a higher gradient, more constrained reach that transports sediment downstream and is somewhat recovered physically. Predicted stress-response relationships between some BMI metrics and sediment variables were observed in regional analyses. |
| Physical Habitat | Greater habitat diversity was observed at comparator sites (especially site 223) than at case site, including more instream cover, more fastwater (riffle) habitat, less glide habitat, greater variation in depth, etc. Predicted stress-response relationships between some BMI metrics and PHAB variables were observed in regional analyses. |

## FINAL CONCLUSIONS: UNLIKELY CAUSES

| Candidate Cause | Evidence and comments |
|---|---|
| Conductivity | Differences in specific conductivity values between case and comparators were neither large nor ecologically significant; no causal pathway was apparent for effect at the case site but not the comparators given their close proximity |
| pH | Differences in pH values between case and comparators were neither large nor ecologically significant; no causal pathway was apparent for effect at the case site but not the comparators given their close proximity |
| Flow (= discharge, % dry channel) | Case site had higher discharge than comparators when measured; causal pathways for water diversions or withdrawals that might affect case but not comparators were absent |

## FINAL CONCLUSIONS: UNRESOLVED CAUSES

| Candidate Cause | Evidence and comments |
|---|---|
| Dissolved Oxygen, Temperature | Longer term DO and temp measures are needed for thorough evaluation, although certain channel alterations related to historical timber harvest contribute necessary links in causal pathway (e.g., site 154 had lower mean depth, lower pool depth, and higher width/depth ratio than comparators, which could increase average temperature). The case site also had a lower spot DO measurement than the comparators, and the value was below the minimum coldwater standard of 7 mg/L. |
| Nutrients, pesticides, petroleum | No data available |

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**Table 6. Spatial-temporal co-occurrence for case (site 154) and downstream comparator (site 218). Scoring modified a bit from original EPA rules.**

Strength of evidence (SOE scoring system for spatial / temporal co-occurrence)

| Candidate Cause | Variable, units | Site 154 | Site 218 | Difference | SOE Score | Overall SOE Score | Comments |
|---|---|---|---|---|---|---|---|
| Decreased Dissolved Oxygen | Dissolved oxygen (mg/L) | 6.4 | 7.5 | -15% | + | | The + score is based on a decrease in DO at the impaired site and a minimum standard of 7.0 mg/L for coldwater streams. However, observed values are based on single grab samples collected at different times of day, and diel and nighttime DO minima data are lacking. |
| | Percent saturation (%) | | | | NE | + | |
| Δ pH | | 7.6 | 8.0 | -5% | 0 | 0 | Scored as a "0" overall despite difference in values between sites because measures were taken at different times of day w/ field titration kits of unknown accuracy, and both values are well within optimal pH conditions for macroinvertebrates. |
| Increased Temperature | Spot (°C) | 17.2 | 19.3 | -11% | --- | 0 | Scored as a "0" overall despite difference in values between sites because measures were taken at different times of day and because data are spot measures only. |
| | Continuous | | | | NE | | |
| Increased Pesticides | | | | | | NE | No pesticide data (surface water or sediment) was collected in 2008. |
| Increased Nutrients | | | | | | NE | No nutrient data was collected in 2008. |
| Increased Petroleum | | | | | | NE | No petroleum data (surface water or sediment) was collected in 2008. |
| Increased Ionic Strength | Specific conductivity (µS/cm) | 200 | 180 | 11% | + | + | |

| Candidate Cause | Variable, units | Site 154 | Site 218 | Difference | SOE Score | Overall SOE Score | Comments |
|---|---|---|---|---|---|---|---|
| Altered Physical Habitat | | | | | | | |
| ↓*Woody Debris* | Large woody debris (>0.3m) in wetted channel ($m^3$/reach) | 0.48 | 0 | | --- | | |
| | Large woody debris (>0.3m) in bankfull channel ($m^3$/reach) | 0.48 | 0 | | --- | | |
| | Woody debris >0.3m (proportional areal cover/reach) | 0.005 | 0 | | --- | --- | |
| | Woody debris <0.3m (proportional areal cover/reach) | 0.032 | 0.023 | 39% | --- | | |
| | % Wood substrate (from 105 pebble counts) | 0 | 0 | 0% | --- | | |
| ↓*Instream habitat diversity* | Instream habitat diversity (sum of proportional areal cover for 5 natural habitat types/reach) | 0.289 | 0.284 | 2% | --- | | |
| | †Riffle frequency | 11 | 10 | 10% | --- | | |
| | †Velocity/depth regime | 16 | 16 | 0% | --- | | |
| | Mean depth (cm) | 45 | 117 | -62% | --- | | |
| | Standard deviation depth | 25 | 81 | -69% | + | | |
| | Mean width/depth ratio | 57 | 24 | 138% | --- | | |
| | Mean slope (%) | 0.31 | 0.35 | -11% | 0 | | Right direction but w/in measurement error. |
| | Glide count (# transects) | 8 | 4 | 100% | + | | |
| | % Glide | 51 | 17 | 200% | + | + | |
| | % Pool | 35 | 72 | -51% | --- | | |

| Candidate Cause | Variable, units | Site 154 | Site 218 | Difference | SOE Score | Overall SOE Score | Comments |
|---|---|---|---|---|---|---|---|
| ↓*Instream habitat diversity (Continued)* | Number residual pools | 10 | 4 | 150% | + | | |
| | Residual pool max depth (cm) | 99 | 291 | -66% | --- | | |
| | Residual pool mean depth | 27 | 94 | -71% | --- | | |
| | Residual pool variance in depth (SD) | 22.3 | 76.1 | -71% | + | | |
| | % Slow | 86 | 89 | 12% | --- | | |
| | % Riffle | 9 | 9 | 0% | --- | | |
| | % Cascade | 0 | 2 | -100% | 0 | | Right direction but w/in measurement error. |
| | % Rapid | 5 | 0 | | --- | | |
| | Fast count (# transects) | 2 | 3 | -33% | + | | |
| | % Fast | 14 | 11 | 27% | --- | | |
| ↑ Sediment (suspended) | Total Suspended Solids (mg/L) | | | | NE | NE | |
| | Turbidity (NTU) | | | | NE | | |
| ↑ Sediment (bed) | % Coarse gravel (16-64mm) | 23 | 25 | -8% | 0 | | Right direction but w/in measurement error. |
| | % Fine gravel (2-16mm) | 7 | 11 | -36% | --- | | Hypothesis is that more fine gravel is bad in this system given timber legacy; leads to ↓ variability in particle size, ↓ interstitial space, ↑ embeddedness, ↑ storm mobility. |
| | % Sand and fines (<0.06-2mm) | 18 | 18 | 0% | --- | --- | |
| | % Sand+fines+fine gravel | 25 | 30 | -17% | --- | | |
| | % Embedded (from 105 pebble counts) | 59 | 59 | 0% | --- | | |
| | †Embeddedness | 11 | 10 | 10% | --- | | |
| | †Sediment deposition | 12 | 10 | 20% | --- | | |
| | †Epifaunal substrate | 11 | 12 | -8% | 0 | | Right direction but w/in measurement error. |

| Candidate Cause | Variable, units | Site 154 | Site 218 | Difference | SOE Score | Overall SOE Score | Comments |
|---|---|---|---|---|---|---|---|
| Altered Flow Regime | % Dry or subsurface | 0 | 0 | 0 | --- | --- | |
| | Discharge (cfs) | 15 | 5 | 200% | --- | | |

Difference calculations: differences are expressed as a percent = [(impaired value-reference value]/reference value]*100%.
† Indicates qualitative metrics estimated visually for the entire sampling reach as described by Barbour et al. (1999). Values for all other parameters listed under Altered Physical Habitat are averages, or counts, for the sampled reach calculated following Kauffman et al. (1999).

**Table 7. Spatial-temporal co-occurrence for case (site 154) and upstream comparator (site 223). Scoring modified a bit from original EPA rules**

Strength of evidence (SOE) scoring system for spatial-temporal co-occurrence:

\+ If the difference in stressor value between sites is leaning in the supporting direction and greater than measurement error.

0 If the difference in stressor value between sites is leaning in the supporting direction but within measurement error.

--- If the difference in stressor values between sites is in the wrong direction.

--- If the stressor values are equal.

--- If the difference in stressor value between sites is leaning in the weakening direction but within measurement error.

R Effect not present where or when candidate cause occurs, OR effect present where or when candidate cause is not, and the evidence is indisputable.

NE No evidence.

| Candidate Cause | Variable, units | Site 154 | Site 223 | Difference | SOE Score | Overall SOE Score | Comments |
|---|---|---|---|---|---|---|---|
| Decreased Dissolved Oxygen | Dissolved oxygen (mg/L) | 6.4 | 8.4 | -24% | + | | The + score is based on a decrease in DO at the impaired site and a minimum standard of 7.0 mg/L for coldwater streams. However, observed values are based on single grab samples collected at different times of day, and diel and nighttime DO minima data are lacking. |
| | Percent saturation (%) | | | | NE | + | |
| Δ pH | | 7.6 | 8.0 | -5% | 0 | 0 | Scored as a "0" overall despite difference in values between sites because measures were taken at different times of day w/ field titration kits of unknown accuracy, and both values are well within optimal pH conditions for macroinvertebrates. |
| Increased Temperature | Spot (°C) | 17.2 | 18.3 | -6% | --- | 0 | Scored as a "0" overall despite difference in values between sites because measures were taken at different times of day and because data are spot measures only. |
| | Continuous | | | | NE | | |
| Increased Pesticides | | | | | | NE | No pesticide data (surface water or sediment) was collected in 2008. |
| Increased Nutrients | | | | | | NE | No nutrient data was collected in 2008. |
| Increased Petroleum | | | | | | NE | No petroleum data ( surface water or sediment) was collected in 2008. |
| Increased Ionic Strength | Specific conductivity (µS/cm) | 200 | 200 | 0% | --- | --- | |

| Candidate Cause | Variable, units | Site 154 | Site 223 | Difference | SOE Score | Overall SOE Score | Comments |
|---|---|---|---|---|---|---|---|
| Altered Physical Habitat† | | | | | | | |
| ↓*Woody Debris* | Large woody debris (>0.3m) in wetted channel ($m^3$/reach) | 0.48 | 0 | | --- | | |
| | Large woody debris (>0.3m) in bankfull channel ($m^3$/reach) | 0.48 | 0 | | --- | | |
| | Woody debris >0.3m (proportional areal cover/reach) | 0.005 | 0 | | --- | --- | |
| | Woody debris <0.3m (proportional areal cover/reach) | 0.032 | 0.005 | 540% | --- | | |
| | % Wood substrate (from 105 pebble counts) | 0 | 0 | 0% | --- | | |
| ↓*Instream habitat diversity* | Instream habitat diversity (sum of proportional areal cover for 5 natural habitat types/reach) | 0.289 | 0.536 | -46% | + | | |
| | †Riffle frequency | 11 | 17 | -35% | + | | |
| | †Velocity/depth regime | 16 | 17 | -6% | 0 | | Right direction but w/in measurement error. |
| | Mean depth (cm) | 45 | 76 | -41% | --- | | |
| | Standard deviation depth | 25 | 49 | -49% | + | | |
| | Mean width/depth ratio | 57 | 18 | 217% | --- | | |
| | Mean slope (%) | 0.31 | 1.2 | -74% | + | | |
| | Glide count (# transects) | 8 | 2 | 300% | + | | |
| | % Glide | 51 | 26 | 96% | + | + | |
| | % Pool | 35 | 51 | -31% | --- | | |
| | Number residual pools | 10 | 9 | 11% | 0 | | Right direction; w/in measurement error. |

| Candidate Cause | Variable, units | Site 154 | Site 223 | Difference | SOE Score | Overall SOE Score | Comments |
|---|---|---|---|---|---|---|---|
| ↓*Instream habitat diversity (Continued)* | Residual pool max depth (cm) | 99 | 193 | -49% | --- | | |
| | Residual pool mean depth | 27 | 52 | -48% | --- | | |
| | Residual pool variance in depth (SD) | 22.3 | 43.2 | -48% | + | | |
| | % Slow | 86 | 77 | 12% | + | | |
| | % Riffle | 9 | 7 | 29% | --- | | |
| | % Cascade | 0 | 16 | -100% | + | | |
| | % Rapid | 5 | 0 | | --- | | |
| | Fast count (# transects) | 2 | 5 | -60% | + | | |
| | % Fast | 14 | 23 | -39% | + | | |
| ↑ *Sediment (suspended)* | Total Suspended Solids (mg/L) | | | | NE | NE | |
| | Turbidity (NTU) | | | | NE | | |
| ↑ *Sediment (bed)* | % Coarse gravel (16-64mm) | 23 | 18 | 28% | --- | | |
| | % Fine gravel (2-16mm) | 7 | 2 | 250% | + | | Hypothesis is that more fine gravel is bad in this system given timber legacy; leads to ↓ variability in particle size, ↓ interstitial space, ↑ embeddedness, ↑ storm mobility. |
| | % Sand and fines (<0.06-2mm) | 18 | 7 | 157% | + | + | |
| | % Sand+fines+fine gravel | 25 | 9 | 178% | + | | |
| | % Embedded (from 105 pebble counts) | 59 | 36 | 64% | + | | |
| | †Embeddedness | 11 | 13 | -15% | 0 | | Right direction but w/in measurement error. |
| | †Sediment deposition | 12 | 13 | -8% | 0 | | Right direction but w/in measurement error. |
| | †Epifaunal substrate | 11 | 16 | -31% | + | | |

| Candidate Cause | Variable, units | Site 154 | Site 223 | Difference | SOE Score | Overall SOE Score | Comments |
|---|---|---|---|---|---|---|---|
| Altered Flow Regime | % Dry or subsurface | 0 | 0 | 0 | --- | --- | |
| | Discharge (cfs) | 15 | 7 | 114% | --- | | |

% Difference calculations: differences are expressed as a percent = [(impaired value-reference value]/reference value]*100%.
† Indicates qualitative metrics estimated visually for the entire sampling reach as described by Barbour et al. (1999). Values for all other parameters listed under Altered Physical Habitat are averages, or counts, for the sampled reach calculated following Kauffman et al. (1999).

**Table 8. Strength of evidence (SOE) stressor-response from the field (within the case). Bivariate scatterplot relationships were derived using data from 12 sites sampled in 2008 along the inner gorge of the Garcia River between Inman Creek and the South Fork (approximately 7km as the fish swims; Figure 4). North Coast IBI scores were generally low at all 12 sites (range = 36-56; mean = 49). Analyses were extended beyond the case site and its 2 comparators to increase sample size for calculating correlations, and because the same causal processes arguably have depressed IBI scores at all sites given their proximity, current (protective) management practices and historical timber harvest in the watershed. Relationships were evaluated between candidate causes (as data allowed) and IBI scores, the eight IBI metrics and taxa richness. Scoring (see criteria at end of Table) was based on strength of Pearson correlations, with strong associations having r > 0.80 and weak associations having r > 0.50 in the expected direction (either positive or negative) and without sample inconsistencies (i.e., values at case and comparator sites also were in the expected direction and consistent with overall patterns across sites).**

**Strength of Evidence (SOE) Scoring for Stressor-Response Relationship in the Field**

++ A strong effect gradient is observed relative to exposure to the candidate cause, at spatially linked sites, and the gradient is in the expected direction.

+ A weak effect gradient is observed relative to exposure to the candidate cause, at spatially linked sites, OR a strong effect gradient is observed relative to the exposure to the candidate cause, at non-spatially linked sites, and the gradient is in the expected direction.

0 An uncertain effect gradient is observed relative to exposure to the candidate cause.

- An inconsistent effect gradient is observed relative to exposure to the candidate cause, at spatially linked sites, OR a strong effect gradient is observed relative to the exposure to the candidate cause, at non-spatially linked sites, and the gradient is NOT in the expected direction.

-- A strong effect gradient is observed relative to exposure to the candidate cause, at spatially linked sites, and the gradient is NOT in the expected direction.

NE No evidence.

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| Decreased Dissolved Oxygen | Dissolved oxygen (mg/L) | IBI Score | No apparent gradient (r = 0.12) | - |
| | | EPT Richness | No apparent gradient (r = 0.18) | - |
| | | Coleoptera Richness | r = -0.61 (weak, but in unexpected direction and low range in metric) | - |
| | | Diptera Richness | No apparent gradient (r = 0.09) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.48) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.42) | - |
| | | % Predator individuals | No apparent gradient (r = 0.43) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.3) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.05) | - |
| | | Taxa Richness | No apparent gradient (r = 0.38) | - |
| | Percent saturation (%) | | No data available | NE |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| Δ pH | | IBI Score | r = 0.55 (but low range in pH values across sites, all slightly above neutral, and low precision in measurement) | 0 |
| | | EPT Richness | No apparent gradient (r = 0.43) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.08) | - |
| | | Diptera Richness | No apparent gradient (r =- 0.36) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.38) | - |
| | | % Non-gastropod scrapers | r = 0.84 (but low range in pH values across sites, all slightly above neutral, and low precision in measurement) | 0 |
| | | % Predator individuals | No apparent gradient (r = 0.49) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.49) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.33) | - |
| | | Taxa Richness | No apparent gradient (r = 0.49) | - |
| Increased Temperature | Spot data (°C) | IBI Score | r = 0.55 (not in expected direction: regional response is unimodal with *decline* in IBI at temps > 15°C; case and comparators inconsistent w/ regional pattern | - |
| | | EPT Richness | No apparent gradient (r = 0.40) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.09) | - |
| | | Diptera Richness | No apparent gradient (r =- 0.35) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.49) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.26) | - |
| | | % Predator individuals | No apparent gradient (r = 0.17) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.26) | - |
| | | % Non-insect Taxa | r = -0.66 (weak, but not in expected direction) | - |
| | | Taxa Richness | No apparent gradient (r = 0.23) | - |
| | Continuous (°C) | | No data available | NE |
| Increased Pesticides | | | No data available | NE |
| Increased Nutrients | | | No data available | NE |
| Increased Petroleum | | | No data available | NE |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| Increased Ionic Strength | | IBI Score | No apparent gradient (r = 0.20) | - |
| | | EPT Richness | No apparent gradient (r = 0.26) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.12) | - |
| | | Diptera Richness | r = -0.54 (weak, but case and comparators inconsistent w/ pattern) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.18) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.37) | - |
| | | % Predator individuals | No apparent gradient (r = 0.21) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.40) | - |
| | | % Non-insect Taxa | r = -0.60; not in expected direction; inconsistency among case and comparators alone | - |
| | | Taxa Richness | No apparent gradient (r = 0.03) | - |
| Altered Physical Habitat† | | | | |
| ↓ *Woody debris* | Large woody debris (>0.3m) in wetted channel ($m^3$/reach) | IBI Score | No apparent gradient (r = -0.35) | - |
| | | EPT Richness | No apparent gradient (r = -0.31) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.18) | - |
| | | Diptera Richness | No apparent gradient (r = 0.05) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.23) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.47) | - |
| | | % Predator individuals | No apparent gradient (r = -0.08) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.16) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.20) | - |
| | | Taxa Richness | No apparent gradient (r = -0.25) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↓ *Woody debris (Continued)* | Large woody debris (>0.3m) in bankful channel ($m^3$/reach) | IBI Score | No apparent gradient (r = -0.38) | - |
| | | EPT Richness | No apparent gradient (r = -0.16) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.47) | - |
| | | Diptera Richness | No apparent gradient (r = 0.16) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.13) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.44) | - |
| | | % Predator individuals | No apparent gradient (r = -0.18) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.25) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.29) | - |
| | | Taxa Richness | No apparent gradient (r = -0.08) | - |
| | Large woody debris >0.3m (proportional cover/reach) | IBI Score | No apparent gradient (r = -0.35) | - |
| | | EPT Richness | No apparent gradient (r = 0.001) | - |
| | | Coleoptera Richness | r = -0.60; weak, but no real prediction and no regional pattern | 0 |
| | | Diptera Richness | No apparent gradient (r = 0.25) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.05) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.31) | - |
| | | % Predator individuals | No apparent gradient (r = -0.23) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.20) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.37) | - |
| | | Taxa Richness | No apparent gradient (r = 0.08) | - |
| | Small woody debris <0.3m (proportional cover/reach) | IBI Score | No apparent gradient (r = -0.47) | - |
| | | EPT Richness | No apparent gradient (r = -0.26) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.02) | - |
| | | Diptera Richness | No apparent gradient (r = 0.19) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.41) | - |
| | | % Non-gastropod scrapers | r = -0.64: weak, but no real prediction and no regional pattern; very low range in stressor variable | 0 |
| | | % Predator individuals | r = -0.54: weak, but no real prediction and no regional pattern; very low range in stressor variable | 0 |
| | | % Shredder Taxa | No apparent gradient (r = 0.22) | - |
| | | % Non-insect Taxa | No apparent gradient (r =-0.16) | - |
| | | Taxa Richness | No apparent gradient (r = -0.26) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↓ *Woody debris (Continued)* | % Wood substrate (from 105 pebble counts) | IBI Score | No apparent gradient (r = -0.18) | - |
| | | EPT Richness | No apparent gradient (r = -0.06) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.16) | - |
| | | Diptera Richness | No apparent gradient (r = -0.08) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.04) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.18) | - |
| | | % Predator individuals | No apparent gradient (r = -0.08) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.02) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.27) | - |
| | | Taxa Richness | No apparent gradient (r = 0.07) | - |
| ↓ *Instream Habitat Diversity* | Instream habitat diversity (sum of proportional areal cover for 5 natural habitat types/reach) | IBI Score | No apparent gradient (r = 0.13) | - |
| | | EPT Richness | No apparent gradient (r = 0.15) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.42) | - |
| | | Diptera Richness | No apparent gradient (r = 0.09) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.37) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.39) | - |
| | | % Predator individuals | (r = 0.50) | + |
| | | % Shredder Taxa | No apparent gradient (r = -0.47) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.18) | - |
| | | Taxa Richness | No apparent gradient (r = 0.32) | - |
| | Riffle frequency (qualitative) | IBI Score | No apparent gradient (r = 0.17) | - |
| | | EPT Richness | No apparent gradient (r = 0.19) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.03) | - |
| | | Diptera Richness | No apparent gradient (r = 0.29) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.30) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.13) | - |
| | | % Predator individuals | No apparent gradient (r = 0.03) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.06) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.27) | - |
| | | Taxa Richness | No apparent gradient (r = 0.37) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↓ *Instream Habitat Diversity (Continued)* | Velocity/depth regime (qualitative) | IBI Score | No apparent gradient (r = -0.31) | - |
| | | EPT Richness | No apparent gradient (r = -0.31) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.00) | - |
| | | Diptera Richness | r = 0.54 | + |
| | | % Intolerant Individuals | No apparent gradient (r = -0.40) | - |
| | | % Non-gastropod scrapers | r = -0.54: not in expected direction; little difference in stressor value at case and comparators | - |
| | | % Predator individuals | No apparent gradient (r = -0.18) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.21) | - |
| | | % Non-insect Taxa | r = 0.53; hard to predict expected direction; little difference in stressor value at case and comparators | 0 |
| | | Taxa Richness | No apparent gradient (r = -0.20) | - |
| | Mean depth | IBI Score | No apparent gradient (r = 0.33) | - |
| | | EPT Richness | No apparent gradient (r = -0.08) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.49) | - |
| | | Diptera Richness | No apparent gradient (r = 0.15) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.26) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.30) | - |
| | | % Predator individuals | No apparent gradient (r = 0.10) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.39) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.24) | - |
| | | Taxa Richness | No apparent gradient (r = -0.18) | - |
| | Standard deviation depth | IBI Score | No apparent gradient (r = 0.29) | - |
| | | EPT Richness | No apparent gradient (r = -0.06) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.43) | - |
| | | Diptera Richness | No apparent gradient (r = 0.32) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.20) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.39) | - |
| | | % Predator individuals | No apparent gradient (r = 0.01) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.46) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.20) | - |
| | | Taxa Richness | No apparent gradient (r = -0.12) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↓ *Instream Habitat Diversity (Continued)* | Mean width/depth ratio | IBI Score | No apparent gradient (r = -0.26) | - |
| | | EPT Richness | No apparent gradient (r = -0.06) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.18) | - |
| | | Diptera Richness | No apparent gradient (r = -0.15) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.02) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.24) | - |
| | | % Predator individuals | r = -0.55; weak, but expected direction is hard to predict | 0 |
| | | % Shredder Taxa | No apparent gradient (r = -0.01) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.06) | - |
| | | Taxa Richness | No apparent gradient (r = -0.12) | - |
| | Mean slope | IBI Score | No apparent gradient (r = 0.42) | - |
| | | EPT Richness | No apparent gradient (r = 0.18) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.10) | - |
| | | Diptera Richness | No apparent gradient (r = 0.28) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.33) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.23) | - |
| | | % Predator individuals | No apparent gradient (r = 0.35) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.05) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.18) | - |
| | | Taxa Richness | No apparent gradient (r = 0.19) | - |
| | Glide count (# transects) | IBI Score | No apparent gradient (r =- 0.19) | - |
| | | EPT Richness | No apparent gradient (r = 0.02) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.04) | - |
| | | Diptera Richness | No apparent gradient (r = -0.49) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.03) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.12) | - |
| | | % Predator individuals | No apparent gradient (r = -0.30) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.04) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.06) | - |
| | | Taxa Richness | No apparent gradient (r = -0.15) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↓ *Instream Habitat Diversity (Continued)* | % Glide | IBI Score | No apparent gradient (r =- 0.19) | - |
| | | EPT Richness | No apparent gradient (r = 0.31) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.07) | - |
| | | Diptera Richness | No apparent gradient (r = -0.49) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.22) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.44) | - |
| | | % Predator individuals | No apparent gradient (r = -0.26) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.39) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.10) | - |
| | | Taxa Richness | No apparent gradient (r = 0.31) | - |
| | % Pool | IBI Score | No apparent gradient (r = 0.02) | - |
| | | EPT Richness | No apparent gradient (r = -0.34) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.22) | - |
| | | Diptera Richness | No apparent gradient (r = 0.32) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.44) | - |
| | | % Non-gastropod scrapers | r = -0.51; probably in expected direction, but case and comparators not consistent | 0 |
| | | % Predator individuals | No apparent gradient (r = 0.15) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.33) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.12) | - |
| | | Taxa Richness | No apparent gradient (r = -0.44) | - |
| | % Slow (Glide + Pool) | IBI Score | No apparent gradient (r =- 0.11) | - |
| | | EPT Richness | No apparent gradient (r = -0.24) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.37) | - |
| | | Diptera Richness | No apparent gradient (r = -0.10) | - |
| | | % Intolerant Individuals | r = -0.60 | + |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.41) | - |
| | | % Predator individuals | No apparent gradient (r = -0.09) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.10) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.11) | - |
| | | Taxa Richness | No apparent gradient (r = -0.44) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↓ *Instream Habitat Diversity (Continued)* | Number residual pools | IBI Score | No apparent gradient (r = -0.16) | - |
| | | EPT Richness | No apparent gradient (r = 0.01) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.44) | - |
| | | Diptera Richness | No apparent gradient (r = -0.18) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.21) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.24) | - |
| | | % Predator individuals | No apparent gradient (r = 0.06) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.09) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.16) | - |
| | | Taxa Richness | No apparent gradient (r = 0.04) | - |
| | Residual pool max depth | IBI Score | No apparent gradient (r = 0.42) | - |
| | | EPT Richness | No apparent gradient (r = 0.05) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.44) | - |
| | | Diptera Richness | No apparent gradient (r = 0.30) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.05) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.14) | - |
| | | % Predator individuals | No apparent gradient (r = 0.16) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.21) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.13) | - |
| | | Taxa Richness | No apparent gradient (r = 0.06) | - |
| | Residual pool mean depth | IBI Score | No apparent gradient (r = 0.32) | - |
| | | EPT Richness | No apparent gradient (r = -0.02) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.49) | - |
| | | Diptera Richness | No apparent gradient (r = 0.13) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.21) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.32) | - |
| | | % Predator individuals | No apparent gradient (r = 0.02) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.42) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.29) | - |
| | | Taxa Richness | No apparent gradient (r = -0.15) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↓ *Instream Habitat Diversity (Continued)* | Residual pool variance in depth (SD) | IBI Score | No apparent gradient (r = 0.33) | - |
| | | EPT Richness | No apparent gradient (r = 0.02) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.45) | - |
| | | Diptera Richness | No apparent gradient (r = 0.27) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.18) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.36) | - |
| | | % Predator individuals | No apparent gradient (r = -0.03) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.41) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.27) | - |
| | | Taxa Richness | No apparent gradient (r = -0.05) | - |
| | % Riffle | IBI Score | No apparent gradient (r = 0.01) | - |
| | | EPT Richness | No apparent gradient (r = 0.13) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.27) | - |
| | | Diptera Richness | No apparent gradient (r = -0.14) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.38) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.22) | - |
| | | % Predator individuals | No apparent gradient (r = -0.15) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.27) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.02) | - |
| | | Taxa Richness | No apparent gradient (r = 0.19) | - |
| | % Cascade | IBI Score | No apparent gradient (r = 0.37) | - |
| | | EPT Richness | No apparent gradient (r = -0.05) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.26) | - |
| | | Diptera Richness | No apparent gradient (r = 0.17) | - |
| | | % Intolerant Individuals | No apparent gradient (r =- 0.14) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.36) | - |
| | | % Predator individuals | r = 0.71; hard to predict; driven by one dot | 0 |
| | | % Shredder Taxa | r = -0.53; makes sense ecologically, but case and comparators inconsistent with overall pattern | 0 |
| | | % Non-insect Taxa | No apparent gradient (r = -0.16) | - |
| | | Taxa Richness | No apparent gradient (r = 0.08) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↓ *Instream Habitat Diversity (Continued)* | % Rapid | IBI Score | No apparent gradient (r = -0.16) | - |
| | | EPT Richness | No apparent gradient (r = 0.15) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.30) | - |
| | | Diptera Richness | No apparent gradient (r = 0.17) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.33) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.06) | - |
| | | % Predator individuals | No apparent gradient (r = -0.23) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.08) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.27) | - |
| | | Taxa Richness | No apparent gradient (r = 0.23) | - |
| | Fast count (# transects) | IBI Score | No apparent gradient (r = 0.17) | - |
| | | EPT Richness | No apparent gradient (r = -0.17) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.16) | - |
| | | Diptera Richness | No apparent gradient (r = 0.48) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.17) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.05) | - |
| | | % Predator individuals | No apparent gradient (r = 0.32) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.31) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.11) | - |
| | | Taxa Richness | No apparent gradient (r = -0.02) | - |
| | % Fast | IBI Score | No apparent gradient (r = 0.11) | - |
| | | EPT Richness | No apparent gradient (r = 0.24) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.37) | - |
| | | Diptera Richness | No apparent gradient (r = 0.10) | - |
| | | % Intolerant Individuals | r = 0.59 | + |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.41) | - |
| | | % Predator individuals | No apparent gradient (r = 0.09) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.10) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.11) | - |
| | | Taxa Richness | No apparent gradient (r = 0.44) | - |
| | TSS (mg/L) | | No data available | NE |
| ↑*Sediment (suspended)* | Turbidity (NTU) | | No data available | NE |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↑*Sediment (bed)* | % Coarse gravel (16-64mm) | IBI Score | No apparent gradient (r = -0.05) | - |
| | | EPT Richness | No apparent gradient (r = 0.0) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.39) | - |
| | | Diptera Richness | No apparent gradient (r = 0.06) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.18) | - |
| | | % Non-gastropod scrapers | r = -0.51 (weak, but not in expected direction) | - |
| | | % Predator individuals | r = -0.53 predicted ? | 0 |
| | | % Shredder Taxa | r = 0.53 predicted ? | 0 |
| | | % Non-insect Taxa | No apparent gradient (r = -0.20) | - |
| | | Taxa Richness | No apparent gradient (r = -0.14) | - |
| | % Fine gravel (2-16mm) | IBI Score | No apparent gradient (r = 0.06) | - |
| | | EPT Richness | No apparent gradient (r = 0.08) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.12) | - |
| | | Diptera Richness | No apparent gradient (r = -0.28) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.09) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.14) | - |
| | | % Predator individuals | No apparent gradient (r = -0.02) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.10) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.007) | - |
| | | Taxa Richness | No apparent gradient (r = 0.09) | - |
| | | Taxa Richness | | |
| | % Sand & fines | IBI Score | No apparent gradient (r = -0.09) | - |
| | | EPT Richness | No apparent gradient (r = 0.06) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.29) | - |
| | | Diptera Richness | No apparent gradient (r = -0.43) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.14) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.33) | - |
| | | % Predator individuals | No apparent gradient (r = -0.38) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.19) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.25) | - |
| | | Taxa Richness | No apparent gradient (r = -0.21) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↑*Sediment (bed) (Continued)* | % Sand + fines + fine gravel | IBI Score | No apparent gradient (r = -0.03) | - |
| | | EPT Richness | No apparent gradient (r = 0.09) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.14) | - |
| | | Diptera Richness | No apparent gradient (r = -0.48) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.05) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.16) | - |
| | | % Predator individuals | No apparent gradient (r = -0.29) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.20) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.18) | - |
| | | Taxa Richness | No apparent gradient (r = -0.10) | - |
| | % Embedded (from 105 pebbel counts) | IBI Score | No apparent gradient (r = -0.01) | - |
| | | EPT Richness | No apparent gradient (r = -0.10) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.13) | - |
| | | Diptera Richness | No apparent gradient (r = -0.47) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.05) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.07) | - |
| | | % Predator individuals | No apparent gradient (r = -0.09) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.27) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.06) | - |
| | | Taxa Richness | No apparent gradient (r = -0.35) | - |
| | Embeddedness (qualitative) | IBI Score | No apparent gradient (r = -0.17) | - |
| | | EPT Richness | No apparent gradient (r = -0.07) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.17) | - |
| | | Diptera Richness | No apparent gradient (r = 0.39) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.27) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.09) | - |
| | | % Predator individuals | No apparent gradient (r = 0.06) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.17) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.43) | - |
| | | Taxa Richness | No apparent gradient (r = 0.04) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↑*Sediment (bed) (Continued)* | Sediment deposition (qualitative) | IBI Score | No apparent gradient (r = -0.38) | - |
| | | EPT Richness | r = -0.57; (weak, but not in expected direction) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.40) | - |
| | | Diptera Richness | No apparent gradient (r = 0.24) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.41) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.20) | - |
| | | % Predator individuals | No apparent gradient (r = 0.27) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.19) | - |
| | | % Non-insect Taxa | r = 0.79 ; (almost strong, but not in expected direction) | - |
| | | Taxa Richness | No apparent gradient (r = -0.46) | - |
| | Epifaunal substrate (qualitative) | IBI Score | No apparent gradient (r = -0.12) | - |
| | | EPT Richness | No apparent gradient (r = -0.11) | - |
| | | Coleoptera Richness | r = -0.51; not as predicted overall; case and comparators inconsistent w/ overall pattern (and more like predicted); range in metric small | - |
| | | Diptera Richness | No apparent gradient (r = 0.44) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.01) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.10) | - |
| | | % Predator individuals | No apparent gradient (r = 0.31) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.07) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.33) | - |
| | | Taxa Richness | No apparent gradient (r = 0.11) | - |
| Altered Flow Regime | % Dry or subsurface | | No sites had dry channel measurements | -- |
| | Discharge (cfs) | IBI Score | r = -0.60; not in expected direction | - |
| | | EPT Richness | r = -0.52; not in expected direction | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.07) | - |
| | | Diptera Richness | No apparent gradient (r = 0.26) | - |
| | | % Intolerant Individuals | r = -0.72; not in expected direction | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.45) | - |
| | | % Predator individuals | No apparent gradient (r = -0.27) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.13) | - |
| | | % Non-insect Taxa | r = 0.58; not in expected direction | - |
| | | Taxa Richness | No apparent gradient (r = -0.44) | - |

**Table 9a. Causal pathway strength of evidence (SOE) for flow, physical habitat, sedimentation, and temperature alteration. The variables below quantify riparian habitat condition in the sampling reach, or upstream land use in the watershed, for the case and comparator sites. These variables were used in conjunction with in-stream variables (defined under spatial-temporal co-occurrence in Tables 6 and 7 above) to evaluate whether steps in causal pathways (see above) were present and therefore were plausible explanations for stressor-response relationships.**

| Candidate Cause | Variable (units) | Site 154 | Site 218 | % Difference | Site 223 | % Difference | Comments |
|---|---|---|---|---|---|---|---|
| Riparian Condition or Disturbance | Proportion of reach with 3 vegetation layers (ground, mid, canopy) present | 91 | 55 | 65% | 64 | 42% | |
| | Percent riparian cover in reach; sum of 3 layers (ground, mid, canopy) | 92 | 65 | 42% | 46 | 100% | |
| | Mean mid-channel canopy density (%) | 45 | 18 | 150% | 47 | -4% | |
| | Mean canopy density measured from bank (%) | 78 | 60 | 30% | 76 | 3% | |
| | Mean proportional area of reach with overhanging vegetation | 0.16 | 0.20 | -20% | 0.12 | 33% | |
| | †Bank Stability | 15 | 15 | 0% | 18 | -17% | |
| | †Vegetative Protection | 16 | 11 | 45% | 16 | 0% | |
| | †Riparian Vegetation | 16 | 14 | 14% | 16 | 0% | |
| | †Channel Alteration | 19 | 19 | 0% | 19 | 0% | |
| | Riparian disturbance index | 0.64 | 0.4 | 60% | 0.74 | -14% | |
| | Mean Slope | 0.31 | 0.35 | -11% | 1.2 | -74% | |
| | Sinuosity | 1.1 | 1.7 | -35% | 1.1 | 0% | |
| Land Use | % Urban in upstream watershed | < 1 | < 1 | | < 1 | | Sum of low, medium and high density urban |
| | % Agriculture in upstream watershed | < 1 | < 1 | | < 1 | | Sum of row crops + pasture |
| | Road density (km/km2) in upstream watershed | 3.4 | 3.4 | 0% | 3.3 | 3% | Sum of paved, improved dirt and 4X4 roads |
| | Timber harvest (total acres since 1988) in upstream watershed | 39,642 | 40,039 | -1% | 39,014 | -2% | |

% Difference calculations: differences are expressed as a percent = [(impaired value-reference value]/reference value]*100%. † Indicates qualitative metrics estimated visually for the entire sampling reach as described by Barbour et al. (1999). Values for other riparian parameters are averages or proportions for the sampling reach calculated following Kauffman et al. (1999).

**Table 9b. Causal pathway strength of evidence (SOE) score for flow alteration in Garcia River, California.**

| **Strength of Evidence Scoring for Plausible Effect Given Stressor-Response Relationships** |
|---|
| ++ Data show that all steps in at least one causal pathway are present. |
| + Data show that some steps in at least one causal pathway are present. |
| 0 Data show that the presence of all steps in the causal pathway is uncertain. |
| - Data show that there is at least one missing step in each causal pathway. |
| --- Data show, with a high degree of certainty, that there is at least one missing step in each causal pathway. |

| **Reasoning and Comments** | **SOE Score** |
|---|---|
| **Evidence for some causal steps** - Deforestation and road construction associated with 2 waves of timber harvest in the 20th century dramatically decreased vegetative cover throughout the watershed and in riparian zones, which in turn would have increased surface runoff, increased soil erosion, decreased bank stability, etc., and would have increased sedimentation of the river channel on a watershed scale. In the conceptual diagram for flow, these primary steps are followed by hypothesized changes to channel structure, physical habitat and water depth, evidence for which was present in field data used in spatial-temporal co-occurrence analyses (Tables 6 and 7). Site visits in 2012 by the causal analysis team and regional stakeholders confirmed that large segments of the mainstem Garcia are filled by legacy sediment "plugs" that are several meters deep and continue to dictate channel structure.<br><br>Field data from 2008 show that both comparator sites have greater mean depth, greater variation in depth, greater pool depth, less glide habitat, higher width/depth ratios, etc., compared to case site 154. All of these differences are consistent with steps in the causal pathway for Flow Alteration related to channel widening, channel aggradation and decreased velocity in the case site relative to comparator sites. Thus, some steps in the causal pathway for altered flow are present.<br><br>**Ambiguous evidence** - Point discharge measurements taken in 2008 showed that site 154 had a higher estimated discharge than either of the comparator sites. However, discharge estimates reflect only a single measure in time at each site, were taken at different times of day, and were made using a qualitative method (neutral buoyant object float times).<br><br>**Evidence for a pathway not existing** - Current land use, including upstream road density and timber harvest intensity, differs by little among the case and its comparators. Also, riparian characteristics and local human disturbance at the reach scale are nearly identical between the case and its 2 comparators, and for some riparian variables (e.g., vegetative cover) the case site 154 is better than one or both comparators. No evidence for water withdrawal at site 154 compared to the comparator sites (e.g., due to local pot farming) was observed. Therefore, given the close proximity of the case and comparators sites along the inner gorge, it's hard to argue that upstream flow diversions, if they exist, would differentially affect conditions across these sites.<br><br>Flow Alteration is scored "+" as there is evidence to indicate that legacy sediment from historical timber harvest (and consequent changes to instream channel morphology) may have altered flow characteristics between the case and comparators, potentially causing the low IBI score at site 154 and along the entire inner gorge. | + |

**Table 9c. Causal pathway strength of evidence (SOE) score for physical habitat alteration in Garcia River, California.**

| **Strength of Evidence Scoring for Plausible Effect Given Stressor-Response Relationships** |
|---|
| ++ Data show that all steps in at least one causal pathway are present. |
| + Data show that some steps in at least one causal pathway are present. |
| 0 Data show that the presence of all steps in the causal pathway is uncertain. |
| - Data show that there is at least one missing step in each causal pathway. |
| --- Data show, with a high degree of certainty, that there is at least one missing step in each causal pathway. |

| **Reasoning and Comments** | **SOE Score** |
|---|---|
| **Evidence for some causal steps** - Data from 2008 show that upstream comparator site 223 is a higher gradient, more constrained reach where in-stream habitat diversity and frequency of fastwater habitat were both greater in 2008 than at case site 154. All of this is consistent with site 223 being a transport reach that is capable of moving sediment downstream and therefore shows less of a legacy effect from sedimentation caused by historical timber harvest.<br><br>**Ambiguous evidence** - Data from 2008 show that downstream comparator site 218 is very similar in most respects to case site 154, at least in terms of slope, substrate composition and lack of in-stream habitat diversity and variability. . One extra riffle was sampled at 218 compared to 154, which may have "bumped" the IBI score at 218.<br><br>**Evidence for a pathway not existing** - Current land use, including upstream road density and timber harvest intensity, differs by little among the case and its comparators. The entire river may be depauperate of woody debris, but the case and its comparators do not differ in this regard. Also, riparian characteristics and local human disturbance at the reach scale are nearly identical between the case and its 2 comparators, and in some cases the case site 154 is better than one or both comparators (for example mid-channel canopy density is 150% greater at site 154 than at site 218). Therefore, given the close proximity of these sites along the inner gorge, it's hard to argue that lack of woody debris, or current land use activities at local or watershed scales, are affecting these sites differently and causing decreased IBI scores at site 154 compared to sites 218 and 223.<br><br>Physical Habitat is scored "+" as there is evidence to indicate that legacy sediment from historical timber harvest (and consequent in-stream habitat degradation) may have caused the low IBI score at site 154 and along the entire inner gorge. | + |

## Table 9d. Causal pathway strength of evidence (SOE) score for sedimentation alteration in Garcia River, California.

**Strength of Evidence scoring for Scoring for Plausible Effect Given Stressor-Response Relationships**

++ Data show that all steps in at least one causal pathway are present.

+ Data show that some steps in at least one causal pathway are present.

0 Data show that the presence of all steps in the causal pathway is uncertain.

- Data show that there is at least one missing step in each causal pathway.

--- Data show, with a high degree of certainty, that there is at least one missing step in each causal pathway.

| Reasoning and Comments | SOE Score |
|---|---|
| **Evidence for some causal steps** - Deforestation and construction of an extensive network of roads and skid trails to haul timber from upper slopes in the 20th century dramatically decreased vegetative cover throughout the watershed and in riparian zones, which in turn would have increased surface runoff, increased soil erosion, decreased bank stability, etc., and would have increased sedimentation of the river channel on a watershed scale. Site visits in 2012 by the causal analysis team and regional stakeholders confirmed that large segments of the mainstem Garcia are filled by legacy sediment "plugs" that are several meters deep and continue to dictate channel structure.<br><br>Data from 2008 show that upstream comparator site 223 is a higher gradient, more constrained reach than the case site 154; in-stream habitat diversity was greater, variability in depth was greater, fast water habitat was more common, and substrate was less embedded and less dominated by fines, sand and fine gravel. All of this is consistent with site 223 being a transport reach that is capable of moving sediment downstream and therefore shows less of a legacy effect from sedimentation caused by historical timber harvest.<br><br>**Ambiguous evidence** - Data from 2008 show that downstream comparator site 218 is very similar in most respects to case site 154, at least in terms of slope, substrate composition and lack of in-stream habitat diversity and variability. One extra riffle was sampled at 218 compared to 154, which may have "bumped" the IBI score at 218.<br><br>**Evidence for a pathway not existing** - Current upstream land use at the watershed scale, including road density and timber harvest intensity, differs little among the case and comparator sites given their close proximity along the inner gorge. Modern silvicultural practices or roads are unlikely to have differential watershed-scales effects on these sites.<br><br>Riparian characteristics and local human disturbance at the reach scale are nearly identical between the case and its 2 comparators, and in some cases the case site 154 is better than one or both comparators (for example mid-channel canopy density is 150% greater at site 154 than at site 218). Local disturbances like pot farming were not observed at these sites and could not have increased sedimentation, and decreased IBI scores, at site 154 compared to sites 218 and 223.<br><br>Sedimentation is scored "+" as there is evidence to indicate that legacy sediment from historical timber harvest (and consequent in-stream habitat degradation) may have cause the low IBI score at site 154 and along the entire inner gorge. | + |

## Table 9e. Causal pathway strength of evidence (SOE) score for temperature alteration in Garcia River, California.

| Strength of Evidence Scoring for Scoring for Plausible Effect Given Stressor-Response Relationships |
|---|
| ++ Data show that all steps in at least one causal pathway are present. |
| + Data show that some steps in at least one causal pathway are present. |
| 0 Data show that the presence of all steps in the causal pathway is uncertain. |
| - Data show that there is at least one missing step in each causal pathway. |
| --- Data show, with a high degree of certainty, that there is at least one missing step in each causal pathway. |

| Reasoning and Comments | SOE Score |
|---|---|
| **Evidence for some causal steps** - Site 154 has a lesser mean depth, lesser pool depth, and higher width/depth ratio than the comparators, which could increase average temperature.<br><br>**Ambiguous evidence for some causal steps** - Upstream land use variables were nearly equal among these closely proximate sites, making it unlikely that watershed-scale factors influence temperature differently among them.<br><br>**Evidence for a pathway not existing** - The case site had *lower* spot temperature measurements than the comparators, but measurements were taken at different times of day and were not continuous. Without continuous, long term data, accurate assessment is prohibited. Also, riparian conditions that might facilitate stream cooling, such as canopy density and proportion of reach with woody mid and canopy layers, were greater at site 154 than at the comparators (see Table 9a).<br><br>Evidence for steps in the altered temperature causal pathway was conflicting, but was present for some causal steps, so was scored a '+'. | + |

## Table 9f. Causal pathway strength of evidence (SOE) score for dissolved oxygen in Garcia River, California

| Strength of Evidence Scoring for Scoring for Plausible Effect Given Stressor-Response Relationships |
|---|
| ++ Data show that all steps in at least one causal pathway are present. |
| + Data show that some steps in at least one causal pathway are present. |
| 0 Data show that the presence of all steps in the causal pathway is uncertain. |
| - Data show that there is at least one missing step in each causal pathway. |
| --- Data show, with a high degree of certainty, that there is at least one missing step in each causal pathway. |

| Reasoning and Comments | SOE Score |
|---|---|
| **Evidence for some causal steps -** The case site had a lower spot DO measurement than the comparators, and the value was below the minimum coldwater standard of 7 mg/L.<br><br>**Ambiguous evidence for some causal steps** - Lack of diel data and nighttime DO minima at the time of the benthic invertebrate sampling prohibits an accurate assessment. In addition, lack of nutrient data or chlorophyll *a* data from algal samples (not collected) precludes inference about those steps in the causal pathway. Comparator sites 218 and 223 both had less glide habitat than the case site, but only comparator 223 had more fast-water (riffle) habitat than the case site. Thus, a causal pathway where flow conditions such as increased riffles lead to increased aeration at the comparators but not the case site is only partially supported<br><br>Evidence for a pathway not existing | + |

**Table 10. Strength of evidence (SOE) stressor-response from the field (outside the case). Bivariate scatterplot relationships were derived using data from 153 sites sampled by probabilistic monitoring programs in the North Coast region between 2000 and 2008. Thirty of the 153 sites were randomly selected from a larger pool of probabilistic sites from within the Garcia River watershed itself (sampled 2007-2008) to improve applicability of regional stressor-response evaluations to the case and comparator sites. Total sample size = 165 due to repeat visits at 4 sites. Relationships were evaluated between candidate causes (as data allowed) and IBI scores, the eight IBI metrics and taxa richness. Scoring (see criteria at end of Table) was based on strength of Pearson correlations, with strong associations having r > 0.80 and weak associations having r > 0.50 in the expected direction (either positive or negative) and without sample inconsistencies (i.e., values at case and comparator sites also were in the expected direction and consistent with overall patterns across sites).**

**Strength of Evidence (SOE) Scoring for Stressor-Response Relationship in the Field**

++ A strong effect gradient is observed relative to exposure to the candidate cause, at spatially linked sites, and the gradient is in the expected direction.

+ A weak effect gradient is observed relative to exposure to the candidate cause, at spatially linked sites, OR a strong effect gradient is observed relative to the exposure to the candidate cause, at non-spatially linked sites, and the gradient is in the expected direction.

0 An uncertain effect gradient is observed relative to exposure to the candidate cause.

- An inconsistent effect gradient is observed relative to exposure to the candidate cause, at spatially linked sites, OR a strong effect gradient is observed relative to the exposure to the candidate cause, at non-spatially linked sites, and the gradient is NOT in the expected direction.

-- A strong effect gradient is observed relative to exposure to the candidate cause, at spatially linked sites, and the gradient is NOT in the expected direction.

NE No evidence.

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| Decreased Dissolved Oxygen | Dissolved oxygen (mg/L) | IBI Score | No apparent gradient (r = 0.17) | - |
| | | EPT Richness | No apparent gradient (r = 0.17) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.05) | - |
| | | Diptera Richness | No apparent gradient (r = 0.16) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.21) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.11) | - |
| | | % Predator individuals | No apparent gradient (r = -0.12 | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.06) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.27 | - |
| | | Taxa Richness | No apparent gradient (r = 0.12) | - |
| | Percent saturation (%) | | No data available | NE |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| Δ pH | | IBI Score | No apparent gradient (r = 0.15) | - |
| | | EPT Richness | No apparent gradient (r = 0.05) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.24) | - |
| | | Diptera Richness | No apparent gradient (r = 0.18) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.01) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.08) | - |
| | | % Predator individuals | No apparent gradient (r = 0.04) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.21) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.16), but case outside 90% confidence limits of plot | -- |
| | | Taxa Richness | No apparent gradient (r = 0.15) | - |
| Increased Temperature | Spot data (°C) | IBI Score | No apparent gradient (r = -0.24) | - |
| | | EPT Richness | No apparent gradient (r = -0.23) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.05) | - |
| | | Diptera Richness | No apparent gradient (r = -0.17) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.36) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.10) | - |
| | | % Predator individuals | No apparent gradient (r = 0.01) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.48) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.17) | - |
| | | Taxa Richness | No apparent gradient (r = -0.14) | - |
| | Continuous (°C) | | No data available | NE |
| Increased Pesticides | | | No data available | NE |
| Increased Nutrients | | | No data available | NE |
| Increased Petroleum | | | No data available | NE |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| Increased Ionic Strength | Specific conductivity (µS/cm) | IBI Score | No apparent gradient (r = -0.40), but case outside 90% confidence limits of plot | -- |
| | | EPT Richness | No apparent gradient (r = -0.41) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.12) | - |
| | | Diptera Richness | No apparent gradient (r = -0.12) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.42) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.17) | - |
| | | % Predator individuals | No apparent gradient (r = -0.21) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.19) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.37) | - |
| | | Taxa Richness | No apparent gradient (r = -0.24) | - |
| Altered Physical Habitat† | | | | |
| ↓ *Woody debris* | Large woody debris (>0.3m) in wetted channel ($m^3$/reach) | IBI Score | No apparent gradient (r = 0.23) | - |
| | | EPT Richness | No apparent gradient (r = 0.26) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.18) | - |
| | | Diptera Richness | No apparent gradient (r = 0.30) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.13) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.02) | - |
| | | % Predator individuals | No apparent gradient (r = 0.11) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.34) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.17) | - |
| | | Taxa Richness | No apparent gradient (r = 0.29) | - |
| | Large woody debris (>0.3m) in bankful channel ($m^3$/reach) | IBI Score | No apparent gradient (r = 0.26) | - |
| | | EPT Richness | No apparent gradient (r = 0.29) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.18) | - |
| | | Diptera Richness | No apparent gradient (r = 0.34) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.16) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.02) | - |
| | | % Predator individuals | No apparent gradient (r = 0.15) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↓ *Woody debris (Continued)* | | % Shredder Taxa | No apparent gradient (r = 0.39) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.19) | - |
| | | Taxa Richness | No apparent gradient (r = 0.32) | - |
| | Large woody debris >0.3m (proportional cover/reach) | IBI Score | No apparent gradient (r = 0.14) | - |
| | | EPT Richness | No apparent gradient (r = 0.22) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.03) | - |
| | | Diptera Richness | No apparent gradient (r = 0.27) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.07) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.12) | - |
| | | % Predator individuals | No apparent gradient (r = 0.10) | - |
| | | % Shredder Taxa | r = 0.54; evidence of regional gradient, but case and comparators do not follow expected pattern | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.15) | - |
| | | Taxa Richness | No apparent gradient (r = 0.22) | - |
| | Small woody debris <0.3m (proportional cover/reach) | IBI Score | No apparent gradient (r = 0.04) | - |
| | | EPT Richness | No apparent gradient (r = 0.12) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.07) | - |
| | | Diptera Richness | No apparent gradient (r = 0.22) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.00) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.14) | - |
| | | % Predator individuals | No apparent gradient (r = 0.07) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.41) | - |
| | | % Non-insect Taxa | No apparent gradient (r =-0.06) | - |
| | | Taxa Richness | No apparent gradient (r = 0.14) | - |
| | % Wood substrate (from 105 pebble counts) | IBI Score | No apparent gradient (r = 0.13) | - |
| | | EPT Richness | No apparent gradient (r = 0.17) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.04) | - |
| | | Diptera Richness | No apparent gradient (r = 0.24) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.10) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.12) | - |
| | | % Predator individuals | No apparent gradient (r = 0.22) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↓ *Woody debris (Continued)* | | % Shredder Taxa | No apparent gradient (r = 0.39) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.07) | - |
| | | Taxa Richness | No apparent gradient (r = 0.20) | - |
| ↓ *Instream Habitat Diversity* | Instream habitat diversity (sum of proportional areal cover for 5 natural habitat types/reach) | IBI Score | No apparent gradient (r = 0.19) | - |
| | | EPT Richness | No apparent gradient (r = 0.26) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.03) | - |
| | | Diptera Richness | No apparent gradient (r = 0.32) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.11) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.12) | - |
| | | % Predator individuals | No apparent gradient (r = 0.10) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.39) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.20) | - |
| | | Taxa Richness | No apparent gradient (r = 0.26) | - |
| | Riffle frequency (qualitative) | IBI Score | No apparent gradient (r = 0.46) | - |
| | | EPT Richness | No apparent gradient (r = 0.49) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.31) | - |
| | | Diptera Richness | No apparent gradient (r = 0.31) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.36) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.22) | - |
| | | % Predator individuals | No apparent gradient (r = 0.01) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.11) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.36) | - |
| | | Taxa Richness | No apparent gradient (r = 0.45) | - |
| | Velocity/depth regime (qualitative) | IBI Score | No apparent gradient (r = 0.25), but case outside confidence limits of plot | -- |
| | | EPT Richness | No apparent gradient (r = 0.22), but case outside confidence limits of plot | -- |
| | | Coleoptera Richness | No apparent gradient (r = 0.22) | - |
| | | Diptera Richness | No apparent gradient (r = 0.01) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.21) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.23) | - |
| | | % Predator individuals | No apparent gradient (r = 0.02), but case outside confidence limits of plot | -- |
| | | % Shredder Taxa | No apparent gradient (r = -0.24) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.17) | - |
| | | Taxa Richness | No apparent gradient (r = 0.16) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↓ *Instream Habitat Diversity (Continued)* | Mean depth | IBI Score | No apparent gradient (r = -0.18) | - |
| | | EPT Richness | No apparent gradient (r = -0.21) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.13) | - |
| | | Diptera Richness | No apparent gradient (r = -0.34) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.06) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r =0.12) | - |
| | | % Predator individuals | No apparent gradient (r = -0.05) | - |
| | | % Shredder Taxa | r = -0.50 | + |
| | | % Non-insect Taxa | No apparent gradient (r = 0.23) | - |
| | | Taxa Richness | No apparent gradient (r = -0.23) | - |
| | Standard deviation depth | IBI Score | No apparent gradient (r = -0.09) | - |
| | | EPT Richness | No apparent gradient (r = -0.13) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.02) | - |
| | | Diptera Richness | No apparent gradient (r = -0.26) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.04) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r =0.13) | - |
| | | % Predator individuals | No apparent gradient (r = 0.02) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.35) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.11) | - |
| | | Taxa Richness | No apparent gradient (r = -0.13) | - |
| | Mean width/depth ratio | IBI Score | No apparent gradient (r = 0.08) | - |
| | | EPT Richness | No apparent gradient (r = 0.13) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.01) | - |
| | | Diptera Richness | No apparent gradient (r = 0.08) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.10) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r =0.04) | - |
| | | % Predator individuals | No apparent gradient (r = 0.12) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.09) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.16) | - |
| | | Taxa Richness | No apparent gradient (r = 0.11) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↓ *Instream Habitat Diversity (Continued)* | Mean slope | IBI Score | No apparent gradient (r = 0.25) | - |
| | | EPT Richness | No apparent gradient (r = 0.24) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.01) | - |
| | | Diptera Richness | No apparent gradient (r = 0.28) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.29) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.26) | - |
| | | % Predator individuals | No apparent gradient (r = 0.31) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.37) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.23) | - |
| | | Taxa Richness | No apparent gradient (r = 0.21) | - |
| | Glide count (# transects) | | No data available | NE |
| | % Glide | IBI Score | No apparent gradient (r =- 0.25) | - |
| | | EPT Richness | No apparent gradient (r = -0.35) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.22) | - |
| | | Diptera Richness | No apparent gradient (r = -0.38) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.14) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.05) | - |
| | | % Predator individuals | No apparent gradient (r = -0.02) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.27) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.22) | - |
| | | Taxa Richness | No apparent gradient (r = -0.39) | - |
| | % Pool | IBI Score | No apparent gradient (r = -0.12) | - |
| | | EPT Richness | No apparent gradient (r = -0.12) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.15) | - |
| | | Diptera Richness | No apparent gradient (r = -0.04) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.15) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.06) | - |
| | | % Predator individuals | No apparent gradient (r = -0.04) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.01) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.12) | - |
| | | Taxa Richness | No apparent gradient (r = 0.01) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↓ *Instream Habitat Diversity (Continued)* | % Slow (Glide + Pool) | IBI Score | No apparent gradient (r = -0.36) | - |
| | | EPT Richness | No apparent gradient (r = -0.46) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.10) | - |
| | | Diptera Richness | No apparent gradient (r = -0.42) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.27) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.01) | - |
| | | % Predator individuals | No apparent gradient (r = -0.06) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.29) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.33) | - |
| | | Taxa Richness | No apparent gradient (r = -0.41) | - |
| | Number residual pools | IBI Score | No apparent gradient (r = 0.38) | - |
| | | EPT Richness | No apparent gradient (r = 0.33) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.09) | - |
| | | Diptera Richness | No apparent gradient (r = 0.37) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.40) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.14) | - |
| | | % Predator individuals | No apparent gradient (r = 0.24) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.48) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.38) | - |
| | | Taxa Richness | No apparent gradient (r = 0.28) | - |
| | Residual pool max depth | IBI Score | No apparent gradient (r = -0.02) | - |
| | | EPT Richness | No apparent gradient (r = -0.09) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.03) | - |
| | | Diptera Richness | No apparent gradient (r = -0.22) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.00) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.18) | - |
| | | % Predator individuals | No apparent gradient (r = 0.03) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.33) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.06) | - |
| | | Taxa Richness | No apparent gradient (r = -0.09) | - |
| | Residual pool mean depth | IBI Score | No apparent gradient (r = -0.17) | - |
| | | EPT Richness | No apparent gradient (r = -0.17) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↓ *Instream Habitat Diversity (Continued)* | | Coleoptera Richness | No apparent gradient (r = -0.09) | - |
| | | Diptera Richness | No apparent gradient (r = -0.25) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.09) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.05) | - |
| | | % Predator individuals | No apparent gradient (r = -0.02) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.32) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.16) | - |
| | | Taxa Richness | No apparent gradient (r = -0.15) | - |
| | Residual pool variance in depth (SD) | IBI Score | No apparent gradient (r = -0.04) | - |
| | | EPT Richness | No apparent gradient (r = -0.10) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.01) | - |
| | | Diptera Richness | No apparent gradient (r = -0.24) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.02) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.15) | - |
| | | % Predator individuals | No apparent gradient (r = 0.04) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.30) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.07) | - |
| | | Taxa Richness | No apparent gradient (r = -0.10) | - |
| | % Riffle | IBI Score | No apparent gradient (r = 0.35) | - |
| | | EPT Richness | No apparent gradient (r = 0.43) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.18) | - |
| | | Diptera Richness | No apparent gradient (r = 0.33) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.25) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.11) | - |
| | | % Predator individuals | No apparent gradient (r = -0.04) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.21) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.30) | - |
| | | Taxa Richness | No apparent gradient (r = 0.38) | - |
| | % Cascade | IBI Score | No apparent gradient (r = 0.18) | - |
| | | EPT Richness | No apparent gradient (r = 0.30) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.03) | - |
| | | Diptera Richness | No apparent gradient (r = 0.32) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↓ *Instream Habitat Diversity (Continued)* | | % Intolerant Individuals | No apparent gradient (r =-0.13) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.08) | - |
| | | % Predator individuals | No apparent gradient (r = 0.09) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.19) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.15) | - |
| | | Taxa Richness | No apparent gradient (r = 0.30) | - |
| | % Rapid | IBI Score | No apparent gradient (r = 0.14) | - |
| | | EPT Richness | No apparent gradient (r = 0.12) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.08) | - |
| | | Diptera Richness | No apparent gradient (r = 0.04) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.21) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.09) | - |
| | | % Predator individuals | No apparent gradient (r = -0.04) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.06) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.09) | - |
| | | Taxa Richness | No apparent gradient (r = 0.04) | - |
| | Fast count (# transects) | | No data available | NE |
| | % Fast | IBI Score | No apparent gradient (r = 0.41) | - |
| | | EPT Richness | r = 0.51 | + |
| | | Coleoptera Richness | No apparent gradient (r = 0.15) | - |
| | | Diptera Richness | No apparent gradient (r = 0.42) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.33) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.09) | - |
| | | % Predator individuals | No apparent gradient (r = 0.02) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.24) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.34) | - |
| | | Taxa Richness | No apparent gradient (r = 0.45) | - |
| ↑*Sediment (suspended)* | TSS (mg/L) | | No data available | NE |
| | Turbidity (NTU) | | No data available | NE |
| ↑*Sediment (bed)* | % Coarse gravel (16-64mm) | IBI Score | No apparent gradient (r = 0.08) | - |
| | | EPT Richness | No apparent gradient (r = 0.13) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.04) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↑*Sediment (bed) (Continued)* | | Diptera Richness | No apparent gradient (r = 0.02) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.01) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.14) | - |
| | | % Predator individuals | No apparent gradient (r = -0.08) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.03) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.15) | - |
| | | Taxa Richness | No apparent gradient (r = 0.08) | - |
| | % Fine gravel (2-16mm) | IBI Score | No apparent gradient (r = -0.35) | - |
| | | EPT Richness | No apparent gradient (r = -0.26) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.22) | - |
| | | Diptera Richness | No apparent gradient (r = -0.17) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.27) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.14) | - |
| | | % Predator individuals | No apparent gradient (r = -0.15) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.03) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.15) | - |
| | | Taxa Richness | No apparent gradient (r = -0.26) | - |
| | % Sand & fines | IBI Score | r = -0.64; evidence of regional gradient, but case is outside the 90% confidence intervals | -- |
| | | EPT Richness | r = -0.54 | + |
| | | Coleoptera Richness | No apparent gradient (r = -0.37) | - |
| | | Diptera Richness | No apparent gradient (r = -0.40) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.41) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.24) | - |
| | | % Predator individuals | No apparent gradient (r = -0.15) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.21) | - |
| | | % Non-insect Taxa | r = 0.65 | + |
| | | Taxa Richness | r = -0.49 | + |
| | % Sand + fines + fine gravel | IBI Score | r = -0.65; evidence of regional gradient, but case is outside the 90% confidence intervals | -- |
| | | EPT Richness | r = -0.53 | + |
| | | Coleoptera Richness | No apparent gradient (r = -0.38) | - |
| | | Diptera Richness | No apparent gradient (r = -0.39) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.43) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↑*Sediment (bed) (Continued)* | | % Non-gastropod scrapers | No apparent gradient (r = -0.25) | - |
| | | % Predator individuals | No apparent gradient (r = -0.18) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.18) | - |
| | | % Non-insect Taxa | r = 0.58 | + |
| | | Taxa Richness | r = -0.50 | + |
| | % Embedded (from 105 pebbel counts) | IBI Score | r = -0.59 | + |
| | | EPT Richness | No apparent gradient (r = -0.43) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.34) | - |
| | | Diptera Richness | No apparent gradient (r = -0.29) | - |
| | | % Intolerant Individuals | No apparent gradient (r = -0.44) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = -0.25) | - |
| | | % Predator individuals | No apparent gradient (r = -0.23) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.13) | - |
| | | % Non-insect Taxa | r = 0.55 | + |
| | | Taxa Richness | No apparent gradient (r = -0.38) | - |
| | Embeddedness (qualitative) | IBI Score | No apparent gradient (r = 0.37) | - |
| | | EPT Richness | No apparent gradient (r = 0.24) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.22) | - |
| | | Diptera Richness | No apparent gradient (r = 0.18) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.25) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.20) | - |
| | | % Predator individuals | No apparent gradient (r = 0.17) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.04) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.32) | - |
| | | Taxa Richness | No apparent gradient (r = 0.22) | - |
| | Sediment deposition (qualitative) | IBI Score | No apparent gradient (r = 0.34) | - |
| | | EPT Richness | No apparent gradient (r = 0.28) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.12) | - |
| | | Diptera Richness | No apparent gradient (r = 0.13) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.31) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.17) | - |

| Candidate Cause | Variable, Units | Specific Effect | Result | SOE Score |
|---|---|---|---|---|
| ↑*Sediment (bed) (Continued)* | | % Predator individuals | No apparent gradient (r = 0.06) | - |
| | | % Shredder Taxa | No apparent gradient (r = 0.01) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.32) | - |
| | | Taxa Richness | No apparent gradient (r = 0.20) | - |
| | Epifaunal substrate (qualitative) | IBI Score | No apparent gradient (r = 0.39) | - |
| | | EPT Richness | No apparent gradient (r = 0.30) | - |
| | | Coleoptera Richness | No apparent gradient (r = 0.17) | - |
| | | Diptera Richness | No apparent gradient (r = 0.17) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.33) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.20) | - |
| | | % Predator individuals | No apparent gradient (r = 0.06) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.14) | - |
| | | % Non-insect Taxa | No apparent gradient (r = -0.27) | - |
| | | Taxa Richness | No apparent gradient (r = 0.24) | - |
| Altered Flow Regime | % Dry or subsurface | | Not applicable to case and comparators; all regional correlations < ± 0.2 | NA |
| | Discharge (cfs) | IBI Score | No apparent gradient (r = 0.0) | - |
| | | EPT Richness | No apparent gradient (r = -0.14) | - |
| | | Coleoptera Richness | No apparent gradient (r = -0.09) | - |
| | | Diptera Richness | No apparent gradient (r = -0.03) | - |
| | | % Intolerant Individuals | No apparent gradient (r = 0.11) | - |
| | | % Non-gastropod scrapers | No apparent gradient (r = 0.11) | - |
| | | % Predator individuals | No apparent gradient (r = 0.04) | - |
| | | % Shredder Taxa | No apparent gradient (r = -0.33) | - |
| | | % Non-insect Taxa | No apparent gradient (r = 0.01) | - |
| | | Taxa Richness | No apparent gradient (r = -0.13) | - |