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Biotic Integrity of Watersheds

ABSTRACT

The biological health of one hundred Sierra Nevada watersheds was evaluated using an Index of Biotic Integrity (IBI). The IBI scores indicated that the biological communities of seven of the watersheds were in excellent condition, thirty-six were in good condition, forty-eight were in fair condition, and nine were in poor condition. The biggest factors contributing to low IBI scores were large dams and introduced fishes, although factors affecting local stream habitats, especially roads and activities associated with roads, were also important. All watersheds in the Sierra Nevada have experienced at least some loss of biotic integrity through the loss or decline of native organisms, but many have considerable potential for recovery.

INTRODUCTION

The Sierra Nevada can be divided into hundreds of small watersheds, which in turn are subdivisions of larger watersheds. All streams on the west side of the range are ultimately part of the Sacramento–San Joaquin watershed, while on the east side, all streams ultimately flow into the Great Basin, in three discrete drainages (Lahontan, Mono, and Owens). In many respects, watersheds are good units on which to base conservation efforts, especially for aquatic organisms, because they are relatively easy to define and because they can contain a wide variety of habitats and species, depending on the watershed's size. For aquatic organisms, watersheds are often the landscape unit in which evolution of distinct taxa takes place, because of the difficulty many aquatic organisms have in moving from one watershed to another (Moyle 1976a; Moyle et al. 1996). This chapter identifies watersheds in the Sierra Nevada that are still dominated by native aquatic species and communities and that contain a wide variety of habitats, rare habitats, or both. The watersheds with high scores for biotic integrity may be logical places to focus large-scale conservation efforts.

INDEX OF BIOTIC INTEGRITY

The biological health of Sierra Nevada watersheds can be measured using a broad-scale Index of Biotic Integrity (IBI). Indices of biotic integrity are measures of the health of streams and have been developed as an alternative to physical and chemical measures of water quality (Karr 1981; Karr et al. 1986; Regier 1993). The early work on IBIs was largely funded by the U.S. Environmental Protection Agency (EPA) with the purpose of developing a rapid-assessment tool to help the EPA carry out the mandates of the Clean Water Act. The basic idea is to combine a number of measures of the structure and function of fish communities into an index, on the assumption that the responses of an integrated community of fishes to changes in the environment would reflect both major environmental insults (e.g., a pesticide spill) and more subtle long-term effects, such as chronic non-point-source pollution and changes in land use.

Biotic integrity is defined as "the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region" (Karr and Dudley 1981). An IBI is a method of measuring this complex idea, and IBIs can be developed independently for different regions or streams. IBIs are now widely used in the eastern United States, where fish communities are complex and largely made up of native species (Miller et al. 1988). For eastern streams it is possible to develop an IBI that uses ten to twelve different measures (metrics) in the creation of the final index (Karr et al. 1986).

In California, the small number of native fishes in most

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streams makes development of complex IBIs with numerous metrics (independent measures of the nature of the fish assemblage) difficult (Miller et al. 1986). In fact, two measures, number of native fish species and abundance of native fishes, provided much of the information needed to determine biotic integrity as defined previously (Moyle et al. 1986). In Sierra Nevada streams, if the fish communities are intact, the stream is likely to have a fairly natural hydrograph and the watershed is likely to be in reasonably good condition (Baltz and Moyle 1993). Native fishes, however, are only part of the biotic integrity picture, especially in relation to water quality, so we developed an IBI for Sierra Nevada watersheds that takes into account not only native fish assemblages but also the abundance of native frogs, the presence of anadromous fish, and the effects of the widespread introductions of trout into high-elevation streams. Ideally, this IBI should also include metrics based on invertebrates, but our knowledge of their distribution and abundance is too poor at this time to use them. It is worth noting that the IBI that we present here is designed to cover bigger watersheds than those for which most IBIs are designed. IBIs tend to be designed to evaluate specific types of streams or stream habitats. We are currently developing such specific IBIs for Sierra Nevada streams.

METHODS

The first problem to be resolved for this analysis was which watershed scale to use. The Calwater numbering system for watersheds, for example, breaks each major drainage basin (e.g., the Central Valley) into major tributary systems, labeled Hydrologic Units (HUs). Each HU is divided into Hydrologic Areas (HAs), which are divided into Hydrologic Subareas (HSAs), which in turn are divided successively into Super-Planning Watersheds and Planning Watersheds. There are thousands of watersheds in the latter two categories, so using them as the unit of analysis would both be difficult and have a high degree of redundancy. We chose as the basic unit of analysis, therefore, the HSA, using HAs or even HUs if the watersheds were too small to subdivide further. This choice resulted in one hundred watersheds being used in the evaluation, covering the entire mountain range (figure 34.1). The watersheds range in area from 4,816 ha (11,895 acres) (a partial drainage on the California-Nevada border) to 382,669 ha (945,192 acres) (the Upper Owens drainage). However, most (62%) of the analysis watersheds are between 15,000 and 90,000 ha (37,050 and 222,300 acres) in area; 28% are larger than 90,000 ha and 10% are smaller than 15,000 ha. Typical watersheds within these categories were the forks of large rivers (e.g., the South Yuba River) or independent drainages of modest size (e.g., Deer Creeks in Tehama, Placer, and Tulare Counties). An additional thirty-four watersheds were not evaluated because of inadequate information on their aquatic biota. These watersheds are all at low elevations, most are small in size, and most seem to lack permanent water (figure 34.2). Nine of these watersheds mark the southern end of the SNEP area, twenty-two are in the foothills along the western edge of the boundary, and three are along the California-Nevada border.

The IBI developed for this analysis includes six metrics (table 34.1), each rated on a scale of 1 to 5, where 1 is low (poor) and 5 is high (good). The six metrics were added and standardized to a 100-point scale, because not all metrics could be used in all drainages. The following is an explanation of each metric.

Native ranid frogs: The foothill yellow-legged frog, mountain yellow-legged frog, and Cascade frog appear to be the amphibians most sensitive to environmental change. Their disappearance from much of their native habitat in the Sierra Nevada is a cause for concern, and their presence in a watershed is an indication that high-quality aquatic and riparian habitats still exist. We scored watersheds for this metric using information presented in Jennings 1996, Jennings and Hayes 1994, personal communications with M. R. Jennings, and observations by Moyle and his graduate students.

Native fishes: The native fishes of the Sierra Nevada are highly adapted to the natural flow regimes, and they tend to become depleted if the regimes are changed, especially by dams. Scores for this metric are based on field notes, University of California, Davis, stream surveys (Moyle et al. 1996), and studies such as Moyle and Nichols 1974 and Brown and Moyle 1993. Another important source of information was the data sheets of the Wild Trout Program of the California Department of Fish and Game. In many instances, agency biologists familiar with the watershed were consulted as well.

Native fish assemblages: One of the best indications of high-quality aquatic environments is the presence not only of native species but also of groups of species co-occurring in their natural assemblages of three to six species. Some of the native fishes can persist indefinitely in altered habitats and in the presence of exotic fishes, while others cannot. We scored this metric largely from information from the same sources as were used for the previous metric.

Anadromous fishes: Salmon, steelhead, and lamprey were important parts of the aquatic ecosystems at low to middle elevations in west-side Sierra Nevada streams, from the Kings River (Fresno County) north. Their exclusion by dams from much of their former habitat has significantly altered the stream communities of which they were once part. We scored this metric based on estimates of past and present distribution and abundance as presented in Yoshiyama et al. 1996.

FIGURE 34.1

Watersheds selected for IBI analysis in the SNEP core area.

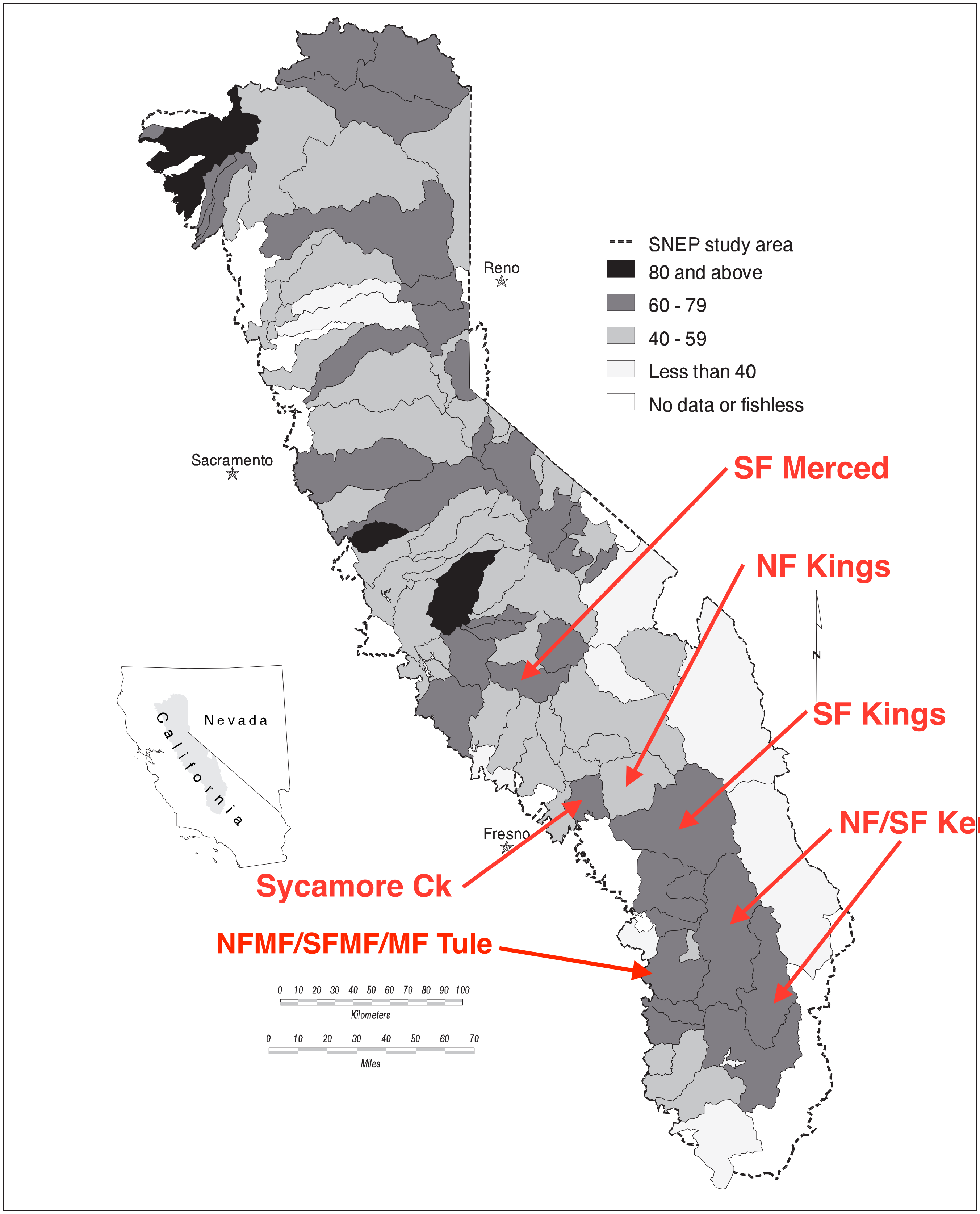

FIGURE 34.2

IBI ratings for Sierra Nevada watersheds.

TABLE 34.1

Metrics and scoring system for an Index of Biotic Integrity for Sierra Nevada watersheds.

Aquatic Community	Metrics
I. Native ranid frogs	1. Absent or rare 3. Present 5. Abundant and widely distributed
II. Native fishes	1. Absent or rare *or* introduced where not native 3. Present in much of native range 5. Abundant in most of native range
III. Native fish assemblages (excluding trout-only assemblage)	1. Largely disrupted 3. Present but scattered or containing exotic species 5. Largely intact
IV. Anadromous fishes (if historically present)	1. Absent or rare 3. Present mainly below dams or uncommon 5. Found in original range
V. Trout	1. Range greatly expanded, mixture of non-native and native species *or* range greatly reduced 3. Range expanded but includes native species *or* range about the same but native populations reduced, exotics present 5. Mostly native species in original range
VI. Stream fish abundance	1. Substantially lower than presumed historic levels *or* widespread and abundant in originally fishless areas 3. Somewhat lower overall than historic levels *or* present in fishless areas 5. About the same as or higher than historic levels

IBI score = [Total points possible/number of metrics] x 20
80–100 Aquatic communities in very good to excellent condition
60–79 Aquatic communities in good condition
40–59 Aquatic communities in fair condition
<40 Aquatic communities in poor condition

Trout: Rainbow and cutthroat trout were native to the Sierra Nevada, generally at elevations below 1,600 m (5,250 ft). However, a large region at high elevations was fishless until trout were introduced there by Euro-Americans. In addition, many of the trout introduced were not native to California. Because trout are now the dominant predators in the streams and lakes in which they were introduced, it is assumed that their introduction has had a significant negative effect on aquatic biodiversity. We scored this metric based on information sources similar to those used for the native fish metrics and on Knapp 1996.

Stream fish abundance: Often water projects and watershed alterations not only change the species composition of streams but also reduce the total biomass and abundance of fish, including non-native species. This metric is based on the same sources of information as the native fish metric.

Other analyses: To look for factors associated with high or low IBI scores, we determined the following variables for each watershed, based on a geographic information system (GIS) analysis of square landscape units (pixels) 1 ha (10,000 m^2 [2.47 acres]) in area:

- Dams: percentage of total hectares in each watershed that contain a dam of any size.
- Reservoirs: total capacity of reservoirs in the watershed, in acre-feet.
- Diversions: percentage of total hectares in each watershed containing a water diversion of any size. This figure is based on water rights filings and thus includes many small diversions and diversions that may not be active.
- Roads: percentage of hectares containing at least one road.
- Roads and streams: percentage of hectares containing both a road and a stream.
- Roadless area: percentage of watershed in areas that contain no roads and that are also at least 1,000 ha (2,470 acres) in area and are 0.2 km (0.125 mi) from a road.
- Fishless area: percentage of watershed that was presumably without fish historically, based on the map drawn for this chapter.
- Mean elevation: average elevation of hectares within the watershed.

The complete data set developed is presented in appendix 34.1. Once the data had been gathered, they were analyzed using principal components analysis. The purpose of the analysis was to determine the degree to which each of the eight variables, or a combination of them, seemed to influence IBI scores.

RESULTS

The IBI scores indicated that seven of the one hundred watersheds had aquatic communities in excellent condition (IBI values of 80–100) (figure 34.2; appendix 34.1). Another thirty-six had aquatic communities in good condition (IBI values of 60–79), while forty-eight had aquatic communities in fair condition (IBI values of 40–59) and nine had aquatic communities in poor condition (IBI values less than 40). Of the seven watersheds with the highest scores, three stand out with scores greater than 90: Deer Creek and Mill Creek (Tehama County) and the Clavey River (appendix 34.1). These watersheds contain intact native fish and amphibian faunas, and the biotic communities are still largely governed by natural processes.

Deer and Mill Creeks are highly unusual in that they both support runs of spring-run chinook salmon. There are three clusters of watersheds with high IBI scores: (1) the Deer–Mill–Antelope Creek and associated small watersheds in Tehama County, (2) the North Fork Calaveras and Clavey Rivers in the western central Sierra Nevada, and (3) the upper Kings and Kern River watersheds in the southern part of the range. Streams in the Tehama cluster flow through rugged volcanic terrain with low accessibility until recently; the streams were also too small to make large dams viable, generally. The western central cluster consists of medium-sized tributaries to larger, highly developed rivers that have managed to maintain much of their native fish fauna. The upper Kings and Kern watersheds are high-elevation watersheds with steep terrain and low accessibility. Most of their area is in either national parks or wilderness areas. Despite their high IBI scores, all of these watersheds have been altered by human activity, but less so than other watersheds in the Sierra Nevada, as indicated by their moderate scores for variables related to diversions and roads (table 34.2). None, however, contain large dams, so the natural hydrologic regimes are still intact.

Watersheds that received low scores are (1) low- to middle-elevation drainages that have been dammed and diverted and so tend to be dominated by introduced fishes and frogs and/or to have greatly diminished native fish and amphibian populations; (2) high-elevation watersheds that have lost most of their frogs and that are dominated by non-native trout; or (3) small, low-elevation watersheds that have been highly altered by human activity (urbanization, agriculture, mining, etc.), as indicated by high scores for variables related to dams, diversions, and roads (appendix 34.1).

Correlation analysis indicated that the IBI score was negatively correlated ($p < 0.05$) with the percentage of hectares containing dams (–0.22), reservoir capacity (–0.27), the percentage of hectares containing roads associated with streams (–0.22), and the percentage of the watershed that was historically fishless. This is not surprising, given that a low IBI score at high elevations would be strongly influenced by the presence of trout in naturally fishless areas, while a low score at low elevations would be related to the presence of major dams or road systems. This dichotomy is reflected in the results of the principal components analysis, which produced two factors with eigenvalues greater than 1.00 (table 34.2). Factor 1, explaining 42% of the variance, had only a moderate negative loading on the IBI score but was strongly positively loaded on the two road variables and strongly negatively loaded on mean elevation and the percentage of the watershed that was historically fishless. In factor 2, explaining 17% of the variance, the IBI score had a high negative loading while the percentage of hectares containing dams, reservoir capacity, and the percentage of the watershed that was historically fishless had high positive loadings.

TABLE 34.2

Factors created by the principal components analysis of variables related to the biotic integrity of Sierra Nevada watersheds.

Variable	Factor 1	Factor 2
Index of Biotic Integrity	–0.2242	–0.6065
Percentage of hectares containing dams	0.4245	0.5541
Reservoir capacity	0.2841	0.5414
Percentage of hectares containing diversions	0.5876	–0.2625
Percentage of hectares containing one or more roads	0.8606	0.1116
Percentage of hectares containing a road and a stream	0.8598	0.1644
Percentage of watershed that is roadless	–0.8997	0.0293
Percentage of watershed that is historically fishless	–0.5394	0.5541
Mean elevation	–0.7340	0.3865
Eigenvalue	3.7754	1.5434
Percentage of variance	42%	17%

DISCUSSION

The analysis of the IBI rating indicates that major dams at low to middle elevations and the introduction of fish at high elevations have had the greatest negative effects on lowering biotic integrity. These two factors are so dominant that they tend to obscure the effects of watershed degradation, as reflected in the variables related to the abundance of roads. For example, the historically fishless areas are also mostly wilderness areas and national parks today, and so have low numbers of roads, yet the presence of introduced fish greatly reduces the biotic integrity of the waters within these areas. In general, the watersheds with the highest IBI scores are at intermediate elevations, are without major dams, and have low to intermediate scores for variables related to human disturbance (roads, diversions).

The importance of dams and introduced species in reducing biotic integrity does not mean that other factors are not important, especially for smaller watersheds or for individual situations. Streams that are subject to high levels of sedimentation from numerous or poorly constructed roads, from mining, or from logging on steep hillsides will have reduced diversity of aquatic organisms, as will streams that have had their channels heavily modified for flood control or other purposes (e.g., Moyle 1976b). Streams heavily polluted by acidic water leaching out of an abandoned mine can have a very low diversity of organisms. Most of these factors, however, are likely to be more localized in their effects and reversible, often just by a cessation of the problem-causing activity. The native fish populations in particular have a high capacity to bounce back from being decimated (Moyle et al. 1983). For example, many small tributaries to the South Yuba River were devastated by hydraulic mining in the nineteenth century yet today show a high degree of recovery of their native fish and amphibian faunas (Gard 1994; P. Randall, unpublished data). Species of fish that are missing from the local fauna appear to have been unable to reinvade because a combination of dams and introduced predators has made the movement of native fish in the main river difficult or impossible (Gard 1994). Reintroduction of the missing native fishes into some streams is now being considered (W. Frizzel, State Parks and Recreation, conversation with the authors, 1995).

Although the results of this analysis fit with other, even more subjective indicators of watershed health, they should nevertheless be treated with caution for a number of reasons.

- The information available to create an IBI score was limited for some watersheds, and the scoring was done by just one person, although many people, field notes, and references were consulted during the scoring process.
- The IBI scores essentially compare the present fish and amphibian assemblages to the presumed pre-Euro-American assemblages; the systems most resembling the original systems obtained the highest IBI values. All aquatic ecosystems in the Sierra Nevada have been altered to one degree or another, so even the highest-rated watersheds are far from pristine. Thus, a different value system, one that was more accepting of the changes, would result in different scores. For example, if it was assumed that the streams at high elevations should be rated positively on the basis of their ability to support large, fishable populations of wild trout, a number of high-elevation watersheds would receive higher IBI scores than they did under the scoring system used here. From the point of view of biotic integrity as defined in the introduction to this chapter, originally fishless streams and lakes that are now dominated by introduced trout must be considered as highly altered ecosystems. The presence of fish eliminates most of the large invertebrates and amphibians that once dominated these waters.
- A major factor lowering many of the scores was the scarcity or absence of native frogs from the watershed. The causes of frog declines (e.g., introduced diseases) are controversial and may have had little effect on the rest of the native biota. Nevertheless, frogs *were* once important parts of all aquatic ecosystems of the Sierra Nevada, and their absence lowers biotic integrity.
- The IBI does not consider aquatic invertebrates that may have disappeared from some areas where native fish and amphibians still exist. Invertebrates are likely to be particularly sensitive to land-use practices (road building, enclosure of springs, logging, grazing, etc.) that can cause extinctions of highly specialized endemic species that live in limited habitats (Erman 1996).
- Many of the one hundred watersheds analyzed here are very large in area and may have smaller watersheds within them that would score significantly higher or lower if treated individually. For example, the North Fork of the Kings River received a mediocre IBI score (52) because it has been dammed for hydroelectric production, has been highly roaded from logging and recreational use, and has had its high-elevation waters filled with non-native trout. Within this drainage, however, is Rancheria Creek, a relatively inaccessible watershed that is one of the most undisturbed in the Sierra Nevada (E. Beckwitt, conversation with the author, 1995). At the opposite extreme is the Clavey River watershed (IBI score = 92), which has a number of small diversions in the upper watershed, has been heavily grazed and logged in places, and is only 26% in roadless areas. The stream nonetheless retains an abundant native fish fauna, with no exotic species, especially in the rugged lower canyon (S. Matern and M. Marchetti, unpublished field notes, 1993). Access to much of the Clavey River itself is limited because its north-south orientation means that few roads cross it, but none run parallel to it for a long distance (unlike most other major Sierra Nevada streams).

CONCLUSIONS

All aquatic ecosystems in the Sierra Nevada have lost biotic integrity to a greater or lesser degree. More than half (58%) of the watersheds, however, have been rated as having their native aquatic biota in poor to fair condition. Many of the processes that have contributed to the loss of biotic integrity have slowed down (e.g., the planting of trout, dam construction), and a number of waters are receiving special protection in national parks, as wild and scenic rivers, or through other actions (e.g., coordinated resource-management programs). There are still a few watersheds that are in remarkably good condition and many others that retain a good share of their original aquatic biota. However, there is no evidence that the overall trend in loss of biotic integrity that the waters of the Sierra Nevada have experienced over the past 150 years has been reversed, although it may have slowed down somewhat. There is every reason to suspect that the loss is continuing as new environmental problems related to human population growth are substituted for the old problems related to heavy exploitation of the landscape and as exploitation (e.g., grazing) continues, even if at reduced levels compared to those of twenty-five or fifty years ago.

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APPENDIX 34.1

Variables Used in Analyzing Factors Affecting the Biotic Integrity of Watersheds (Arranged from Lowest IBI to Highest)

Name	Cal Water No.	Area (ha)	Mean Elevation	IBI	% Dams	Reservoirs (acre-ft)	% Diversions	% Roads	% Roads and Streams	% Roadless	% Fishless
Yokohl Cr.	553.50	27372	469.3	25	0.00	0	0.95	6.95	3.14	43.7	0.0
S. Yuba	517.30	92737	1492.4	30	3.13	227282	1.88	15.30	6.50	39.8	63.9
Daulton	539.20	28633	244.0	30	1.05	240182	1.64	8.75	5.48	42.3	0.0
Tehachapi	556.10	114518	1230.7	32	0.09	764	0.40	12.33	10.31	52.1	0.0
M. Yuba	517.40	54625	1416.2	33	0.92	54534	1.59	17.83	6.04	28.3	46.0
N.Fk.San Joaquin	540.60	65231	2766.9	36	0.00	0	0.08	0.57	0.21	96.9	100.0
Mono	601.00	174723	2428.4	36	0.57	87670	0.67	4.57	2.08	67.5	86.1
Upper Owens	603.20	382669	2121.7	36	0.21	42842	0.61	5.33	3.43	76.0	30.1
Lower Owens	603.30	331606	1761.3	36	0.03	46600	0.34	5.71	3.28	76.1	29.3
S.Fk. American	514.30	207832	1372.9	40	1.40	328037	2.58	19.90	9.76	28.9	38.9
N.Fk. Feather	518.40	238915	1598.7	40	0.59	1506087	0.80	14.36	5.73	33.4	0.0
L. Stanislaus	534.22	65305	560.4	40	1.69	2401459	1.06	15.53	10.12	21.1	0.0
Huntington Lk.	540.50	34647	2388.3	40	1.16	91016	1.41	11.96	5.31	52.1	82.4
Five Dog Cr.	555.40	22557	625.1	40	0.00	0	2.35	12.64	7.67	11.9	0.0
Mammoth Cr.	603.10	98451	2496.3	40	0.20	183570	0.94	13.59	6.10	46.7	47.4
Long Valley Cr.	637.10	154134	1473.1	40	0.07	140	0.58	11.29	3.32	40.1	0.0
N.Fk.E.Br.Feather	518.50	265413	1631.1	43	0.23	30396	0.76	14.27	8.22	31.9	0.0
N.Fk.Stanislaus	534.50	71098	1850.7	43	1.41	200833	0.66	16.66	8.93	41.0	76.3
Lower Merced	537.10	17016	214.9	43	0.59	9730	1.00	12.06	5.76	33.0	0.0
Redinger	540.30	26008	1375.2	43	1.15	171276	2.34	17.76	6.00	13.0	7.4
Mammoth Pool	540.40	209525	2502.2	43	0.38	313286	0.29	5.11	2.12	79.5	82.1
Clark Fork	534.60	17684	2487.0	44	0.00	0	0.17	1.64	1.36	95.4	100.0
Mid. Kern	554.10	71187	1249.1	44	0.14	15	2.66	9.83	5.48	67.1	0.0
M.Fk. American	514.40	159523	1498.3	47	0.82	448335	1.23	15.67	5.02	45.2	69.2
U. Bear	516.30	73125	705.3	47	1.23	77885	1.61	30.03	17.15	3.1	17.2
Lower Dry Cr.	517.12	13256	222.9	47	0.76	57000	1.74	16.16	15.47	12.1	0.0
Upper Dry Cr.	517.13	18643	659.2	47	2.68	1994	1.88	18.42	10.30	15.5	0.0
Lower Yuba	517.14	14374	510.0	47	2.09	1041505	1.74	16.76	11.14	21.1	0.0
Willow Cr.-SJ	540.20	33734	1500.3	47	0.89	45598	1.22	17.95	5.63	36.9	50.3
Sutter Cr.	532.40	54874	522.9	48	1.46	24517	2.75	15.70	14.25	16.0	0.0
U. Tuolumne	536.60	127114	2612.1	48	0.16	360115	0.02	0.82	0.36	96.1	95.6
N. Lk. McClure	537.21	19628	585.2	48	0.51	520	1.32	13.43	8.10	24.2	8.9
S. Lk. McClure	537.21	10640	585.2	48	0.00	0	0.66	8.56	3.47	62.4	0.0
Fresno R.	539.30	61064	777.7	48	0.49	966	2.52	17.58	5.09	23.6	9.0
Finegold Cr.	540.10	55058	588.8	48	0.55	524769	1.74	15.25	7.19	29.0	0.6
S.Fk. Feather	518.20	32813	1233.8	50	2.13	169012	0.61	22.27	7.50	18.1	51.6
N.Fk.W.Br.Feather	518.60	36769	1230.5	50	0.82	14927	2.80	14.86	7.04	29.6	0.0
Yosemite	537.50	49320	1935.2	52	0.00	0	0.26	6.32	3.93	76.9	45.6
N. Fk. Kings	552.33	100089	2376.6	52	0.40	242913	0.42	7.18	2.08	72.1	89.1
Poso Cr.	555.50	68691	1037.4	52	0.00	0	2.43	10.89	5.29	44.7	0.0
L.E.Fk. Walker	630.30	36162	2317.9	52	0.00	0	1.66	5.12	3.82	78.1	12.7
Slinkard Cr.	631.20	7836	2056.1	52	0.00	0	2.93	5.00	1.78	80.9	0.0
Desert Cr.	631.30	5762	2855.7	52	1.74	640	0.52	1.84	0.70	93.4	0.0
L.W.Fk. Carson	633.10	11638	2031.2	52	0.00	0	0.95	7.98	4.39	65.5	0.0
N. Tahoe	634.20	26642	2193.2	52	0.75	732070	2.48	21.27	7.70	41.6	33.9
N. Yuba	517.50	125798	1492.2	53	0.72	2568	1.50	17.97	6.64	35.7	53.0
S.Fk.Calaveras	533.30	46275	655.3	53	1.08	1715	1.73	16.33	11.65	32.2	14.6
S.Fk.Stanislaus	534.30	27733	1700.2	53	1.08	24660	0.76	15.33	9.96	42.1	69.7
M.Fk.Stanislaus	534.40	73638	2068.1	53	0.82	150334	0.49	10.55	5.39	61.0	86.8
Lower Kings	552.20	31276	398.6	53	0.32	900	0.83	10.34	6.71	54.2	0.0
L. Tuolumne	536.30	72867	576.5	56	1.37	17633	1.34	15.50	9.06	24.4	0.9
Cherry Ck.	536.50	60670	2181.8	56	1.81	305358	0.23	2.91	1.15	87.2	94.9
N.Fk.M.Fk.Tule	555.11	10463	1986.4	56	0.00	0	0.57	5.93	1.34	83.4	80.0
L.W. Walker	631.10	32886	2074.2	56	0.00	0	0.94	5.38	3.74	71.8	2.2
Indian Ck.	632.20	4816	1834.4	56	4.14	6860	0.00	6.73	5.59	59.3	0.0
S. Tahoe	634.10	34166	2303.7	56	0.88	2384	2.43	16.44	6.35	60.3	13.9
E.Fk. Chowchilla	539.11	60118	662.8	58	0.17	130	3.43	10.77	3.99	47.2	0.0
Big Chico Cr.	509.14	18689	943.6	60	0.00	0	1.87	13.63	5.67	36.7	0.0
Paynes Cr.	509.65	7707	373.8	60	0.00	0	0.00	8.43	2.33	59.5	0.0
Cosumnes	532.20	163766	824.4	60	0.98	48556	2.20	21.20	12.05	11.0	9.7

Name	Cal Water No.	Area (ha)	Mean Elevation	IBI	% Dams	Reservoirs (acre-ft)	% Diversions	% Roads	% Roads and Streams	% Roadless	% Fishless
Little Truckee	536.00	49215	2033.2	60	0.41	245000	0.67	15.62	7.30	23.6	10.4
Mid.Tuolumne	536.70	18750	1879.7	60	0.00	0	0.64	11.02	3.47	61.3	90.9
M. Fk. Kaweah	553.43	26633	2274.7	60	0.00	0	0.04	0.65	0.30	97.4	99.3
Tule R.	555.12	90865	1119.0	60	0.11	325	1.69	10.09	4.88	57.0	27.5
L. Tahoe	634.30	34792	1949.0	60	0.29	6800	1.78	0.09	0.17	0.0	0.0
Susan R.	637.20	147323	1525.8	60	0.75	35129	0.38	12.43	5.35	30.5	0.0
M.Fk. Feather	518.30	291916	1652.7	63	0.27	140996	0.53	13.98	6.64	39.3	12.3
S.Fk.Merced	537.40	62332	1859.2	63	0.00	0	0.45	6.75	2.39	71.4	44.9
Upper Mokelumne	532.60	150067	1611.4	64	0.93	227077	0.89	15.43	8.61	42.8	64.4
U. Yosemite	537.60	59320	2697.1	64	0.00	0	0.00	0.77	0.40	96.5	92.7
Mariposa	538.00	91822	390.9	64	0.65	26955	1.44	9.85	5.03	40.8	0.0
N. Fk. Kaweah	553.41	87928	1683.5	64	0.34	943	1.21	6.20	2.09	78.9	70.7
U.E.Fk. Walker	630.40	40652	2659.5	64	0.49	3500	1.11	2.27	2.02	92.1	23.4
U.E.Fk. Walker	630.40	15867	2659.5	64	0.00	0	2.14	5.39	2.77	78.4	46.2
Upper W.Walker	631.40	58923	2637.9	64	0.34	1385	0.51	4.32	3.22	83.0	47.0
E.Fk. Carson	632.10	84528	2351.4	64	0.95	7058	0.52	2.77	2.83	89.5	26.7
U.W.Fk. Carson	633.20	16448	2457.4	64	3.04	2630	0.49	8.16	4.98	71.3	8.2
Truckee	635.20	56456	2031.4	64	1.06	102570	0.97	20.36	9.69	31.4	15.2
Little Chico	521.20	7191	496.0	67	1.39	26	1.39	10.33	1.39	21.3	0.0
Butte Cr.	521.30	39986	1090.8	67	0.75	14680	2.33	16.81	7.00	30.6	0.0
N.Fk.Merced	537.30	65098	908.0	67	0.31	315	1.08	14.69	8.69	36.8	32.8
Sycamore Ck.	552.31	43047	922.9	68	0.00	0	1.77	11.35	5.71	53.9	10.2
Deer Cr.-SJ	555.20	29676	995.7	68	0.00	0	3.27	8.24	3.84	66.0	0.0
White R.	555.30	34026	643.3	68	0.00	0	0.71	13.02	5.38	28.7	0.0
Willow Cr.	637.40	163216	1589.4	68	0.43	10863	1.01	5.67	2.17	75.3	0.0
S.Fk.Tuolumne	536.80	23338	1658.9	72	0.00	0	0.39	14.59	3.51	48.0	94.6
S. Fk. Kaweah	553.42	22411	1520.1	72	0.00	0	1.65	4.06	1.52	83.3	45.7
S. Fk. Kern	554.23	137361	2347.5	72	0.00	0	0.81	3.11	1.30	88.5	2.2
Eagle Lk	637.30	111352	1788.9	72	0.00	0	0.48	14.87	2.38	16.4	0.0
N.Fk. American	514.50	89989	1302.6	73	1.44	33067	0.93	17.04	7.66	47.8	42.1
S. Fk. Kings	552.34	247075	2601.5	76	0.08	2780	0.14	2.84	1.03	88.8	74.9
Kernville	554.22	177969	1570.6	76	0.00	0	1.45	9.21	5.25	69.5	0.0
N. Fk. Kern	554.24	217331	2625.7	76	0.00	0	0.15	3.10	0.82	87.7	35.4
Pine Cr.	509.16	28057	491.7	80	0.00	0	0.57	3.21	1.60	78.0	0.0
Dye Cr	509.62	10529	364.5	80	0.00	0	0.10	12.20	1.43	31.5	0.0
Antelope Cr.	509.63	37439	950.5	80	0.27	70	1.44	11.85	4.65	51.4	0.0
N.Fk.Calaveras	533.20	31729	637.8	80	0.95	918	1.95	12.37	9.27	49.8	4.0
Clavey R.	536.40	92978	1408.9	92	0.43	8180	0.85	20.32	8.87	26.2	60.9
Deer Cr.	509.20	53975	1273.0	93	0.00	0	0.65	14.72	4.48	46.2	0.0
Mill Cr.	509.42	33863	1204.1	93	0.00	0	0.38	7.89	1.77	71.4	0.0