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Potential Aquatic Diversity Management Areas

ABSTRACT

Aquatic ecosystems in the Sierra Nevada have been highly altered as the result of dams and diversions, watershed alterations, and introductions of non-native species. The native aquatic biota has declined in diversity and abundance as a result. Reversing this trend requires appropriate, systematic management of watersheds throughout the range. Assuming that maintenance of some basic set of the native biota is desirable, a number of options for watershed management are possible, ranging from biodiversity-oriented management of all watersheds to simply reacting to the need to keep species from becoming extinct. A middle series of options, presented here, focuses on designating forty-two watersheds as Aquatic Diversity Management Areas (ADMAs), whose first goal of management is the protection of aquatic biodiversity. The watersheds were chosen on the basis of size (greater than 50 km^2 [19 mi^2]), natural hydrologic regime, presence of native fish and amphibians, and representativeness. To achieve more complete protection of aquatic biodiversity, a series of small reserves (Significant Natural Areas, or SNAs) could also be established to protect special or unique habitats. Management objectives for ADMAs and potential methods for achieving the objectives are presented in two example scenarios, one involving complete watersheds and one involving public lands only.

INTRODUCTION

Aquatic ecosystems are among the most highly altered ecosystems in the Sierra Nevada. This is the result of three broadly interacting factors: (1) extensive development of the rivers to supply water and to generate power; (2) watershed alterations through activities such as logging, grazing, road building, and mining; and (3) widespread introduction of non-native species into Sierran lakes and streams. As a result, the depleted native aquatic biota continues to decline, and populations of species are increasingly isolated from one another. To reverse this trend, or at least to ensure the survival of the diverse communities of aquatic organisms found in the Sierra, ecosystems and habitats have to be protected on a systematic basis. Moyle and Yoshiyama (1994) provide a general framework for accomplishing this.

The Moyle and Yoshiyama (1994) approach has five tiers, listed in order of the ease with which they can be accomplished and in reverse order of permanence of conservation:

1. Protect threatened and endangered species.
2. Protect clusters of co-occurring native species, centering on threatened and endangered species.
3. Create a system of Aquatic Diversity Management Areas (ADMAs), watersheds or other aquatic areas in which maintenance of aquatic biodiversity is the first goal of management.
4. Implement conservation plans for all watersheds, in which protection of aquatic biodiversity is an important goal.
5. Implement bioregional (landscape) plans for integrated use by humans and other organisms of natural landscape units, usually clusters of watersheds.

The first two approaches are the principal means by which state and federal agencies approach conservation of species today. Moyle et al. (1995) present recommendations for fish species to be added to the list of threatened species in California, as well as a list of clusters of species that could be comanaged for conservation. Jennings and Hayes (1994) present similar recommendations for amphibians in California. The problem with species-oriented management is that the number of endangered species is growing faster than the ability of management agencies to protect them. Species-ori-

Sierra Nevada Ecosystem Project: Final report to Congress, vol. II, Assessments and scientific basis for management options. Davis: University of California, Centers for Water and Wildland Resources, 1996.

ented management also often does not address the root causes of the declines, especially ecosystem-level changes to the environment. The all-watershed and bioregional approaches (tiers 4 and 5) are much discussed but not implemented, because of the enormous political difficulties of doing so. Therefore the creation of a system of waters that can be managed with biodiversity as a high priority, while allowing other beneficial activities to take place, seems like a practical solution to the problem of biodiversity conservation in the immediate future.

The purpose of this chapter is to identify ADMAs that could become part of a rangewide system of waters managed to favor native aquatic organisms and to suggest management guidelines appropriate for ADMAs. The ADMAs are arbitrarily divided into two groups: large watersheds (watersheds larger than 50 km^2 [19 mi^2]) and Significant Natural Areas (SNAs). SNAs are smaller watersheds or fragments of watersheds that contain habitats or species of an exceptional nature (e.g., an endangered species, an unusually pristine stream, a rare habitat type) that are likely to need more intense management or protection than an ADMA watershed. SNAs are closer to the traditional idea of a preserve or reserve than are ADMA watersheds. Two sets of suggested guidelines are presented, one for a strategy involving entire watersheds and the other for a strategy involving only public lands.

METHODS

General Strategy

The first step in identifying potential ADMAs was to examine the available information on all watersheds. The idea was to identify watersheds that seemed to have the most potential for perpetuating native organisms in the future in all areas of the Sierra Nevada. Ideally, the ADMA system should contain a good representation of all aquatic habitat types found in the Sierra Nevada, either within ADMA watersheds or as SNAs. To achieve a balance between examining only very large watersheds (major tributary systems) and examining the thousands of Planning Watersheds in the Calwater Data Dictionary, I examined watersheds that were either Hydrologic Areas (HAs) or Hydrologic Subareas (HSAs) in the Calwater system. Potential ADMA watersheds and aquatic SNAs were identified from a variety of sources, including interviews with biologists familiar with the Sierra Nevada and field investigations. Once a potential ADMA watershed or SNA was identified, information on the area was reported in a standard fashion (table 57.1).

TABLE 57.1

Format for the ADMA watershed descriptions. Actual accounts of the forty-two watersheds selected as ADMAs are presented in Moyle et al. 1996.

ADMA Watershed

Name: Name of largest unit (stream, lake).
Drainage: Major drainage to which the watershed is tributary.
Calwater No.: Number assigned to the hydrologic unit(s) through the Calwater system.
County: All counties in which the watershed exists.
Location: Description of the location from headwaters to mouth.
Elevation Range: In meters.
Drainage Area: In square kilometers.
Description: Physical description of watershed: geomorphology, dominant vegetation, etc.
Aquatic Province: Ichthyological provinces of Moyle and Ellison 1991.
Habitat Types: Number and name of aquatic habitat types from updated version of Moyle and Ellison (1991).
Native Fishes: Common names only. If known, abundance is indicated by A (abundant), C (common), U (uncommon), or R (rare), where “abundant” indicates that the species is either widespread throughout the drainage or is found in large numbers in appropriate habitats, and “rare” indicates that only a few individuals have been observed.
Amphibians: As for native fishes.
Other Vertebrates: Species with a strong connection to aquatic or riparian habitats, especially rare, unusual, or high-visibility species (e.g., Pacific pond turtles, otters). Ubiquitous species such as black phoebes or aquatic garter snakes are not mentioned.
Invertebrates: Unusual or rare invertebrates; a general evaluation of aquatic insect abundance if possible.
Riparian Zone: Comments on the nature and condition of riparian habitats. Rare plants and animals listed if information available.
Human Impacts: Description of major anthropogenic factors that have altered the watershed or affected flows or water quality (e.g., diversions, clear-cutting, riparian grazing, hydraulic mining).
Ownership: List of principal public managers of land, in order of relative importance.
Existing Protection: Special designations already assigned to the water or watershed: Wild Trout Water, Wild and Scenic River, national park, Nature Conservancy preserve, etc.
Significant Natural Areas (Aquatic): Small areas or sub-basins within the watershed that have especially high value for the protection of aquatic biodiversity: spring systems, lakes, small tributaries, etc. These are listed separately in an SNA catalog.
Overall Quality Rating: A rating on a scale of 1 to 3, where 1 = near-pristine, native biota largely intact; 2 = altered, but in fair to excellent condition, potentially restorable to a rating of 1; 3 = natural appearing and important as a refuge for some native species, but probably irreversibly altered, usually because of a large dam or urban area. See Moyle and Yoshiyama 1994 for details. Because most ADMA watersheds have a rating of 2, this category is further scaled according to how close to pristine (2.1) or to nearly irreversibly altered (2.9) the watershed is perceived to be.
Reasons for Rating: Justification for the rating; a description of such aspects as condition of watershed, presence of rare species, and unusual abundance and diversity of native species.
IBI Score: Index of Biotic Integrity score for the watershed (range: 5–100). This is a standardized score based on six metrics (ranid frogs, native fishes, native fish assemblages, anadromous fishes, trout distribution, and stream fish abundance). A score of 80–100 indicates that the aquatic communities are in very good to excellent condition, 60–79 indicates that they are in good condition, 40–59 means that they are in fair condition, and 39 or less means that they are in poor condition.
Notes: Other information of potential use or interest to decision makers.
UC Davis survey? If yes, a survey by P. B. Moyle and/or coworkers was a major source of information.
Sources: Individuals who provided information, or references to published literature or reports.
Date: Date of latest major revision.
Compiler: PBM, Peter Moyle; PR, Paul Randall; RY, Ronald Yoshiyama.

Definitions

ADMA Watersheds

An ADMA watershed is one having a high value for aquatic biodiversity because it is rich in native aquatic species and communities and/or contains some particularly rare or unusual biotic element. In the Pacific Northwest, similar watersheds have been called key watersheds, but this term has been used mainly to refer to watersheds with exceptionally high value for the production of anadromous fishes, especially salmon and steelhead (Moyle and Yoshiyama 1994). The ADMA watershed concept is broader.

ADMA watersheds have the following six characteristics:

1. They are greater than 50 km^2 (19 mi^2) in area. This is a fairly arbitrary figure, but it represents a watershed large enough to allow most natural processes to function indefinitely and also large enough for most aquatic species within the watershed to have a low probability of extinction from random demographic events. In general, however, the larger the watershed, the better it can serve to protect aquatic biodiversity. All large watersheds in the Sierra Nevada with an Index of Biotic Integrity (IBI) score of 60 or better (Moyle and Randall 1996) are considered to be candidates for ADMA watershed status.

2. They have a natural hydrologic regime. This means that the central watercourse does not have dams or diversions on it that significantly alter the way the system operates, such as eliminating flood flows in a stream or lowering the level of a lake. It also means that the watershed has not been so severely altered that runoff patterns have changed to increase the magnitude of high-flow events or to decrease flows during low-runoff periods.

3. The waters within them are dominated by native species. As a rule of thumb, 75% of the fish found within an ADMA watershed should belong to native species. A major exception to this rule occurs in the case of trout, because non-native trout tend to interact with other organisms in a fashion similar to native trout and because non-native trout are often widespread in watersheds that would otherwise fit the ADMA watershed definition well. A major problem from a biodiversity perspective is that many high-elevation lakes and streams did not contain any fish until trout (and other fishes) were introduced into them. Thus, fishless waters, or waters that can be reclaimed as fishless waters, are especially important as ADMA watersheds.

4. The watersheds contain a wide representation of aquatic habitat types. Moyle (1996) has identified sixty-six aquatic habitat types in the Sierra Nevada. Ideally, all these habitat types should be included within an ADMA system, and each ADMA watershed should contain most of the habitat types found in that particular region. Redundancy of habitat types between ADMAs is also important, to account for localized differences in the biota, especially aquatic invertebrates.

5. The terrestrial and riparian ecosystems they contain are in reasonably good condition. "Good condition" means that the watershed has a high degree of biological integrity as outlined by Regier (1993) and Karr (1993). Because anything that happens in a watershed (e.g., erosion, pollution) tends to be magnified in the low-lying waters within it, a stream or lake in a highly disturbed watershed is likely to have a highly altered biota. This criterion has to be applied flexibly because all watersheds in the Sierra Nevada are altered to a greater or lesser degree. An ADMA watershed must at least have the potential to be restored to a state that is fairly close to its original condition, especially in terms of ecosystem processes.

6. They have other characteristics that make them special or unusual. Potential special characteristics include representativeness, uniqueness, and scientific value, and these characteristics can partially override one or more of the first four characteristics. For example, Mariposa Creek (IBI score = 64) is recommended as an ADMA watershed, even though its fish fauna has a large non-native component, because the watershed is one of the best representatives of west-side foothill streams, which in general are highly altered. Likewise, the Mono Lake watershed is recommended as an ADMA watershed, despite the fact that the streams are regulated and dominated by exotic trout, because Mono Lake itself is a unique ecosystem. It also has high scientific value in that it has been studied intensively for years, and such long-term ecological studies can give us insights into what is happening to the Sierran environment on a much larger scale. Such scientific values are among the principal reasons for also singling out Sagehen Creek and Convict Creek for inclusion as ADMA watersheds, despite their relatively small drainage areas.

Significant Natural Areas

The term Significant Natural Area (SNA) is used by the California Department of Fish and Game (CDFG) to indicate areas with unusual biological value, usually as habitat for rare or endangered species or communities. Such areas are typically small and localized. SNAs designated by the CDFG have no formal protection but can form the basis for preserves. Here the term is used to designate aquatic habitats or ecosystems that contain unusual biotic elements but that are too small to be included as ADMA watersheds. Aquatic SNAs usually need special protection because they contain especially fragile species (e.g., spring-dwelling caddisflies) and/or because they are not contained in an ADMA watershed. Because of their small size and sensitivity to disturbance, aquatic SNAs will typically have to be treated as preserves if they are to continue to maintain their unusual elements; that is, they will have to be actively protected from heavy human use. A sys-

TABLE 57.2

Potential ADMA watersheds of the Sierra Nevada region. A full description of each ADMA watershed is provided in Moyle et al. 1996.

West-Side Drainages

Sacramento River Tributaries

1. Antelope Creek
2. Dye Creek
3. Mill Creek
4. Pine Creek
5. Deer Creek
6. Big Chico Creek

Feather River Drainage

7. Yellow Creek
8. Middle Fork Feather River

Yuba River Drainage

9. Lavezolla Creek/Downey River

American River Drainage

10. North Fork American River
11. Rubicon River above Hell Hole Reservoir
12. Jones Fork of Silver Fork (above Union Valley Reservoir)
13. Rock Creek

Cosumnes River Drainage

14. Entire drainage

Mokelumne River Drainage

15. North Fork Mokelumne River

Stanislaus River Drainage

16. North Fork Stanislaus River
17. South Fork Stanislaus River above Pinecrest Reservoir
18. Rose Creek

Tuolumne River Drainage

19. Clavey River
20. South Fork Tuolumne River

Merced River Drainage

21. Entire drainage above McClure Reservoir

Upper San Joaquin Drainage

22. Mariposa Creek above Mariposa Reservoir
23. East Fork Chowchilla River
24. Finegold Creek

Kings River Drainage

25. Rancheria Creek
26. South and Middle Forks Kings River

Kaweah River Drainage

27. South Fork Kaweah River

Tule River Drainage

28. North and Middle Forks Tule River

Tulare Lake Foothill Drainages

29. Deer Creek

Kern River Drainage

30. Kern River above Isabella Reservoir
31. South Fork Kern River
32. North Fork Kern River

East-Side Drainages

Eagle Lake Drainage

33. Entire drainage, including Pine Creek

Susan River/Honey Lake Drainage

34. Willow Creek

Truckee River Drainage

35. Upper Little Truckee River
36. Sagehen Creek

Carson River Drainage

37. East Fork Carson River

Walker River Drainage

38. Buckeye Creek
39. West Walker River drainage

Mono Lake Basin

40. Mono Lake

TABLE 57.2 (continued)

Owens River Drainage

41. Owens River drainage above Crowley Reservoir
42. Convict Creek

Modoc Region[a]

Pit River Drainage

43. Mill Creek (South Fork Pit River)
44. Cedar Creek above Tule Reservoir
45. Ash Creek
46. Turner Creek

Goose Lake Drainage

47. Goose Lake

Cowhead Lake

48. Cowhead Slough

[a]Potential ADMA watersheds for the Modoc Region are included here for the sake of completeness, although they will not be discussed further in this chapter.

tem of protected aquatic SNAs would supplement a system of ADMA watersheds, helping to ensure that all native species and natural communities in the Sierra Nevada can persist. Examples of aquatic SNAs include small, isolated streams that contain remnant populations of Lahontan cutthroat trout (e.g., By-Day Creek, Mono County) and spring systems with unusual invertebrate assemblages (e.g., Bendorf Spring, El Dorado County). Many areas designated as research natural areas by the U.S. Forest Service also fit the definition of aquatic SNAs. Aquatic SNAs are not considered systematically in this chapter or in Moyle et al. 1996. This is not, however, a reflection of their importance in an overall strategy to protect aquatic biodiversity in the Sierra Nevada.

RESULTS

Forty-two potential ADMA watersheds were identified (table 57.2). They are widely distributed over the Sierra Nevada (figure 57.1). A description of each ADMA watershed is presented in Moyle et al. 1996. These watersheds contain sixty of the sixty-six major aquatic habitat types identified for the Sierra Nevada, with forty-nine of them represented two or more times. The habitats not covered by ADMAs either are lowland habitats that have been strongly affected by water diversions (e.g., Valley Floor River, Owens Lake) or are limited habitats that will need to be protected in SNAs (e.g., sphagnum bogs, Lahontan desert springs). Table 57.3 presents examples of potential SNAs.

The ADMA watersheds include habitats for most of the native fish and amphibians of the range. How well the native aquatic invertebrates are represented in the forty-two ADMA watersheds is not known, although it is likely that a high percentage of them are covered, given the distribution and size

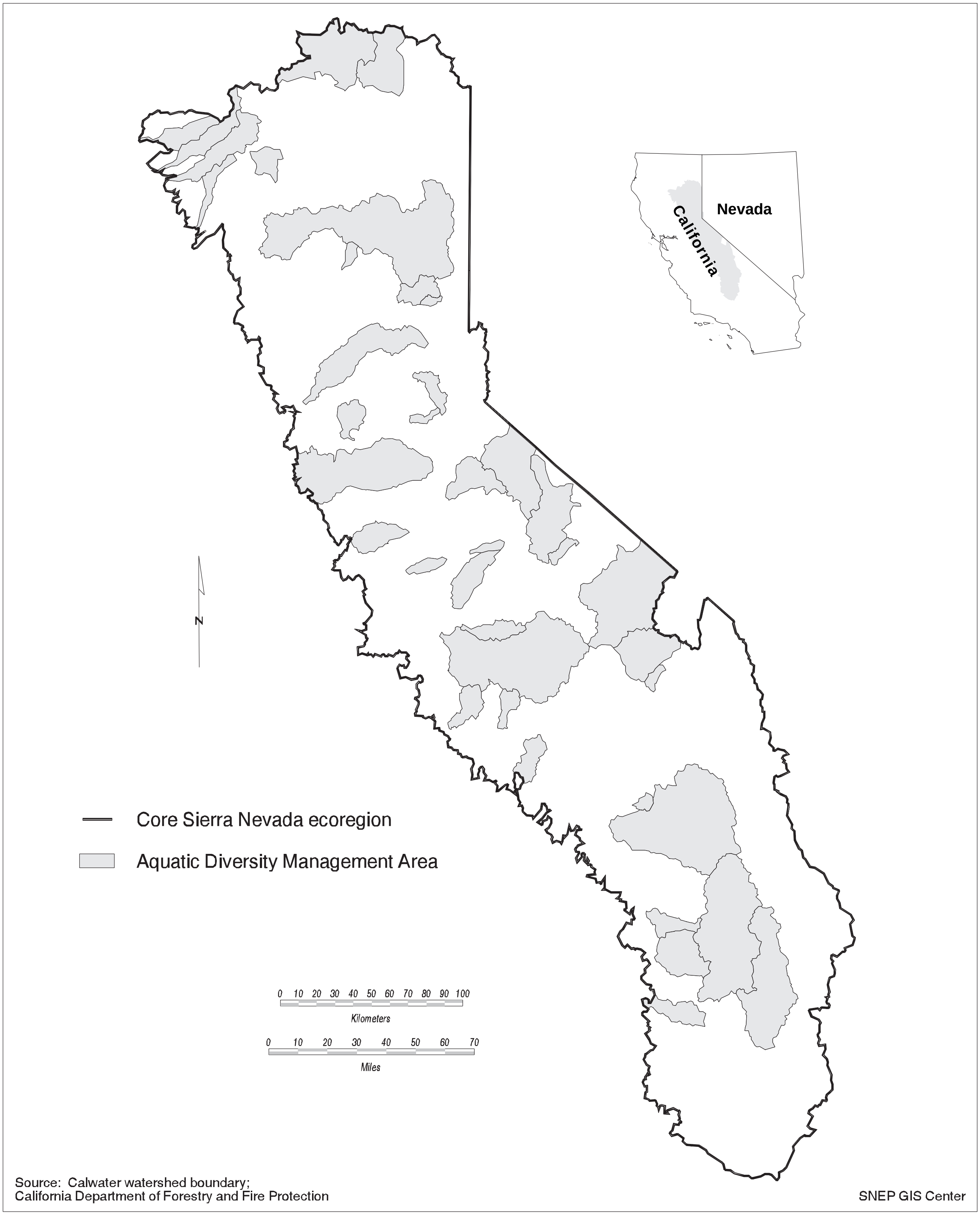

FIGURE 57.1

Potential ADMA watersheds of the Sierra Nevada region.

TABLE 57.3

Examples of potential aquatic Significant Natural Areas in the Sierra Nevada. This is not a complete list.

Name	County	Watershed	Formal Protection	Attributes
Independence Lake/Creek	Nevada	Truckee River	None	Lahontan cutthroat trout, one of few lakes with native fishes
Three Meadows	Tuolumne	Stanislaus River	None	Fishless meadow stream Amphibian breeding area
Grass Lake	El Dorado	Truckee River	Research natural area El Dorado National Forest	Sphagnum bog
Mill Creek	Plumas	North Fork Feather River	Mt. Pleasant Research Natural Area Bucks Lake Wilderness Area	Sphagnum bog High-rainfall creek
Papoose Creek	Lassen	Eagle Lake	None	Spring-fed speckled dace stream Large meadow system Amphibians and reptiles
Jackass Canyon	El Dorado	Cosumnes River	None	Intermittent fishless foothill canyon stream with endemic aquatic insects
Stump Spring	El Dorado	Cosumnes River	None	Spring with rare stoneflies
Bendorf Spring	El Dorado	Cosumnes River	None	Spring with rare stoneflies
Camp Creek	El Dorado	Cosumnes River	None	Foothill stream with native amphibians SNEP study site
Indian Creek	Tehama	Antelope Creek	Lassen National Forest Research natural area	Intact community of native fishes and amphibians Intact riparian zone
Cub Creek	Tehama	Deer Creek	Lassen National Forest Research natural area	Small tributary stream with intact riparian and aquatic communities
Green Island Lake	Plumas	North Fork Feather River	Lassen National Forest Research natural area	Bog lakes, ephemeral ponds, small streams Rich invertebrate and plant biota
The Cedars	Placer	North Fork American River	University of California Natural Reserve System	Low-order tributaries in old-growth forest, native trout
Six Bit Gulch (Horton Creek)	Tuolumne	Tuolumne River	None	Red Hills roach (fish)
Onion Creek	Placer	North Fork American River	Experimental forest	Low-order tributary stream in managed forest
Bell Meadow	Tuolumne	Clavey River	Stanislaus National Forest Research natural area	Unusual meadows and riparian areas Small creek with native trout and amphibians
Bourland Meadow	Tuolumne	Clavey River	None	Wet meadows and bogs Headwaters of Bourland Creek
Little Finegold Creek	Merced	San Joaquin River	None	Intermittent foothill stream with native fishes, including hitch
Mill Flat Creek	Fresno	Kings River	None	Major spawning stream for native fishes, amphibians
Doyle Springs	Tulare	Tule River	None	Travertine spring system Fauna unknown
Soda Springs Creek	Kern	Kern River	Golden Trout Wilderness Area	Little Kern golden trout
Mahogany Lake	Lassen	Eagle Lake	None	Fishless lake with abundant amphibians
Silver King Creek (upper)	Mono	Carson River	Carson-Iceberg Wilderness Area	Paiute cutthroat trout
White Cliff Lake	Mono	Carson River	Carson-Iceberg Wilderness Area	Isolated cirque lake with native frogs
Headwaters, Little Walker River	Mono	Walker River	Hoover Wilderness Area	Lahontan cutthroat trout
Big Dry Creek	Mono	Walker River	?	Lahontan cutthroat trout
Harvey Monroe Hall Research Natural Area	Mono	Mono Lake	Research natural area Toiyabe National Forest	Amphibians, fishless lakes Research area
New York Ravine	Sierra	North Fork Yuba River	None	Endangered caddisflies Steep, fishless stream

of many of the recommended ADMAs. For example, multiple springs and their outflows probably exist in most of the ADMAs (prominent springs have been identified in twenty-one of them), a habitat type that supports a wide variety of unusual and endemic forms. However, it is likely that a number of rare or endemic invertebrates will need to be protected in SNAs or other intensively managed areas.

MANAGEMENT OF ADMA WATERSHEDS

The key for managing ADMA watersheds is initially to halt or reduce all activities on public lands that are contributing to habitat deterioration or loss of diversity. Examples of the kinds of restrictions that could apply are given in table 57.4. Such restrictions could be relaxed once a formal analysis of the watershed's biotic and abiotic characteristics had been completed and once mechanisms were in place to allow adaptive management strategies (Lee 1993) to be worked out with consensus from stakeholder groups. This process should allow for increased flexibility in the management of these watersheds and would allow many activities, such as recreation, logging, and mining, to continue in most areas. Presumably, such activities would follow guidelines that were compatible with maintaining biodiversity, and the most intense management efforts would be focused on areas in which substantial improvements in habitats could be attained.

In ADMA watersheds covering a mixture of public and private lands, landowner and other stakeholder involvement in management is essential. Stakeholder organizations (watershed associations) seem to be an effective way to achieve this involvement, and there are now a number of models to follow (e.g., the Deer Creek Watershed Conservancy in Tehama County). Such organizations can work with environmental organizations (e.g., the Nature Conservancy and Friends of the River), public agencies, and educational institutions to develop strategies that maintain their values while also maintaining natural systems. For example, the Deer Creek Watershed Conservancy has worked out measures to protect spring-run chinook salmon and other native fishes (including a no-new-dams agreement, now in state law) in exchange for measures to protect private property from regulations regarded as intrusive (e.g., those associated with Wild and Scenic River status).

For a large watershed, it may also be desirable to have a professional stream keeper, a person paid by agencies or stakeholders or both to monitor the aquatic and riparian habitats, organize restoration activities, and generally keep everyone informed of activities within the watershed. It is important, however, to have the stream keeper focus on just one watershed, rather than be an agency scientist who has stream-keeper duties assigned as part of a larger job.

DISCUSSION

A spectrum of alternatives is available to protect aquatic biodiversity in the Sierra Nevada, of which the ADMA approach is just one. One extreme alternative is to treat all watersheds without major dams or diversions as ADMA watersheds and to manage them under guidelines such as those in table 57.4. In addition, under this alternative, all rivers below dams and diversions would be provided with flow regimes and riparian protections that offer the most benefit to aquatic life. This option would be highly desirable from the perspective of protecting aquatic biodiversity but would presumably reduce the amount of water available for out-of-stream uses as well as greatly restricting other uses of the watersheds.

Another alternative is to keep using the piecemeal system of protection that now exists and wait for crises to develop before taking major steps to protect many endangered species or unusual assemblages of organisms (if they are to be protected at all). This system will inevitably lead to increased and irreversible loss of biodiversity on the local, regional, and Sierra-wide scales and will result in many painful conflicts among diverse interests. It is also likely to lead to declines in fisheries, losses in water quality, reductions in storage capacities of reservoirs, and other consequences with direct effects on humans. A more extreme version of this alternative would be to make biodiversity protection a low priority in watershed management in general. It is likely that this alternative would result in an accelerated loss of species and biotic communities, as well as a significant loss of ecosystem services that healthy watersheds provide (e.g., clean water, high aesthetic values).

If the aquatic biodiversity of the Sierra Nevada is going to be maintained at the present level or improved, avoiding widespread extinction of species, the creation of a system of ADMA watersheds and aquatic SNAs, or an approach similar to it, would seem to be necessary. Redundancy in ADMAs and SNAs is extremely important, because if one watershed or SNA is hit by a major disaster (e.g., a severe fire), recolonization or reintroduction of the biota should be possible. Redundancy is also insurance against random extinctions that occur in isolated populations (Moyle and Sato 1991). The system of ADMA watersheds presented in this chapter should be regarded as an example of the kind of system that can be developed, rather than the only approach of this type. Many permutations and combinations of watershed protection are possible. For example, less restrictive management activities in ADMA watersheds could take place on public lands, with private lands managed for biodiversity largely through voluntary means (table 57.5). An approach of this nature would probably result in the loss of some species and habitats and slower recovery of damaged systems, but would ultimately be beneficial to aquatic and riparian life.

TABLE 57.4

Management objectives and potential methods for achieving the objectives for ADMA watersheds.[a]

I. Monitoring and management
  A. Objective: to have continuous and responsible management and monitoring of ADMA watersheds
  B. Potential methods
    1. Hire professional stream keepers to monitor and lead management efforts in streams
    2. Encourage development of watershed associations made up of landowners and other interested parties to guide watershed management
    3. Develop watershed management plans for both public and private lands that encourage adaptive management and protect biodiversity while permitting other uses
    4. Provide educational/extension programs to assist landowners in developing management strategies for private lands

II. Flows
  A. Objective: to maintain natural flow regime and natural passage for fish movements
  B. Potential methods
    1. Allow no new dams; retire old dams wherever possible
    2. Prohibit any increase in diversions within the watershed
    3. Enhance flow within range of natural flow variation (if channel used for water conveyance)
    4. Manage watershed to reduce “flashiness” of runoff
    5. Remove or modify artificial barriers to fish movement

III. Riparian areas
  A. Objectives
    1. To maintain and enhance structure of in-stream, lake, and wetland habitat
    2. To maintain natural temperature regimes in streams
    3. To provide continuous habitat for riparian-dependent native plants and animals
    4. To maintain large riparian trees
    5. To maintain native riparian vegetation
  B. Potential methods
    1. Establish 100 m buffer (streamside protection) zones on 3+ order streams and 50 m zones on 1–2 order streams or to top of canyon until watershed evaluation done
    2. Establish a 50 m buffer zone along all lakes and wetlands
    3. Eliminate grazing from riparian buffer zones, except for small, fenced access points for watering
    4. Eliminate logging from riparian zones
    5. Limit the number of road crossings to one or fewer per 10 km
    6. Keep roads out of riparian zones or locate them to minimize effects on aquatic and riparian habitats; prohibit new roads in riparian areas; reduce riparian roads by 50% in ten years
    7. Prohibit planting of non-native fishes or hatchery trout in the watershed except in areas with high public access (e.g., roadside sections)
    8. Eliminate camping or other 24-hour uses of riparian areas; develop recreational trails that minimize negative effects on riparian areas
    9. Restrict number and size of in-stream dredge mining operations; enforce laws to keep mining (and related activity) out of riparian areas
    10. Eliminate dumping of all mine spoils into riparian zones
    11. Develop incentives to keep new buildings out of riparian zones/floodplains as well as for removal of existing structures

IV. Pollution
  A. Objective: to reduce pollution from toxic materials and sediments from local sources to levels within the presumed range of natural variation
  B. Potential methods
    1. Manage the watershed to reduce sediment runoff (e.g., require proper road construction, eliminate “bad” roads, minimize grazing and logging practices that increase erosion, provide better erosion control in ski areas)
    2. Eliminate or reduce toxic drainage from abandoned mines
    3. Allow only tertiary treated sewage, if any, to be dumped into streams
    4. Prevent septic tanks and leach fields from leaking into streams
    5. Limit use of pesticides to emergencies or to situations where short-term use is needed to assist recovery of native organisms

TABLE 57.4 (continued)

V. Land use
  A. Objective: to minimize or reduce human-caused disturbance of existing terrestrial systems in the watersheds, in order to reduce human impacts on aquatic systems
  B. Potential methods
    1. Allow no net increase in road kilometers; no roads in existing roadless areas
    2. Eliminate or restrict use of off-road vehicles to highly disturbed areas (old quarries, etc.)
    3. Construct trails to minimize impacts on sensitive areas
    4. Protect all remaining spring systems (fence, remove boxes from source, etc.)
    5. Develop incentives to keep human population levels at reduced levels compared to neighboring non-ADMA watersheds
    6. Discourage development of activities likely to degrade the watershed (e.g., new ski resorts or other intensive recreation sites)
    7. Maximize cover of late successional old-growth forest
    8. Develop fire management strategies that minimize the potential for large-scale, devastating fires
    9. Create educational/extension programs to enable private landowners to maximize income and benefits from land while minimizing the impact on aquatic systems

VI. Exotic species
  A. Objective: to reduce the influence of non-native species on aquatic and riparian ecosystems
  B. Potential methods
    1. Eliminate planting of fish in high-elevation lakes
    2. Systematically eradicate trout from selected stream and lake systems in areas that were originally fishless
    3. Develop techniques for bullfrog eradication
    4. Manage streams and riparian areas to favor native organisms
    5. Reintroduce native fishes and frogs into areas from which they were extirpated
    6. Develop programs to encourage use of native fishes and other organisms on habitats on private lands, including stock ponds

VII. Salmon restoration
  A. Objective: to increase spawning areas for chinook salmon in order to increase populations and improve habitats for all stages in lowland rivers
  B. Potential methods
    1. Restore salmon to selected areas from which they were extirpated, such as the North Fork American River (over Nimbus and Folsom Dams)
    2. Actively improve spawning gravels, riparian areas, holding pools, and other habitats in degraded sections of rivers

VIII. Recreation
  A. Objective: to reduce impacts of recreational activities on the native biota
  B. Potential methods
    1. Restrict take of wild fish by anglers
    2. Reduce recreational use of riparian and aquatic areas (trails, roads, etc.)
    3. Reduce or eliminate in-stream activities (gold dredging, rafting, etc.) that disturb anadromous or spawning fish or breeding amphibians
    4. Identify sensitive areas (spring systems, etc.) and protect them from human entry

IX. Significant Natural Areas
  A. Objective: to protect unique or sensitive habitats within the watersheds that are limited in area (e.g., large springs)
  B. Potential methods
    1. Inventory watersheds to locate SNAs
    2. Acquire title or conservation easements (or equivalent) if private land or special protective designations if public land
    3. Provide individualized protective measures (e.g., signing, fencing, road removal)
    4. Develop educational/extension programs to provide landowners with tools to provide voluntary protection of SNAs on private land

[a]This list is not comprehensive and is meant to suggest activities and actions that would be appropriate for the maintenance and/or enhancement of aquatic biodiversity in selected watersheds.

TABLE 57.5

Management objectives and potential methods for partially achieving the objectives for ADMA watersheds by focusing on management activities on public lands or on regulations within the normal purview of public agencies.[a]

I. Monitoring and management
  A. Objective: to have continuous and responsible management and monitoring of ADMA watersheds
  B. Potential methods
    1. Hire professional stream keepers to monitor and lead management efforts in streams on public lands
    2. Encourage development of watershed associations made up of landowners and other interested parties to guide watershed management
    3. Develop watershed management plans for public lands that encourage adaptive management and protect biodiversity while permitting other uses
    4. Provide educational/extension programs to assist landowners in developing management strategies for private lands

II. Flows
  A. Objective: to maintain natural flow regime and natural passage for fish movements
  B. Potential methods
    1. Allow no new dams to be constructed on public lands; retire old dams wherever possible
    2. Allow no increase in diversions on public lands
    3. Protect headwater areas to reduce “flashiness” of runoff
    4. Remove or modify artificial barriers to fish movement

III. Riparian areas
  A. Objectives
    1. To maintain and enhance structure of in-stream, lake, and wetland habitat
    2. To maintain natural temperature regimes in streams
    3. To provide continuous habitat for riparian-dependent native plants and animals
    4. To maintain large riparian trees
    5. To maintain native riparian vegetation
  B. Potential methods
    1. Follow riparian prescriptions in table 57.4 for federal and state land
    2. Develop incentives for improved riparian management on private lands
    3. Restrict number and size of in-stream dredge mining operations; enforce laws to keep mining activity out of riparian areas

IV. Pollution
  A. Objective: to reduce pollution from toxic materials and sediments from local sources to levels within the presumed range of natural variation
  B. Potential methods
    1. Manage portions of watersheds on federal and state lands to reduce sediment runoff (e.g., require proper road construction, eliminate “bad” roads, minimize grazing and logging practices that increase erosion, provide better management of ski areas)
    2. Develop incentives for reducing sediment and non-point-source pollution on private lands
    3. Eliminate or reduce toxic drainage from abandoned mines
    4. Allow only tertiary treated sewage, if any, from municipal plants to be dumped into streams

V. Land use
  A. Objective: to minimize or reduce human-caused disturbance of existing terrestrial systems in the watersheds, in order to reduce human impacts on aquatic systems
  B. Potential methods
    1. Develop incentives to keep human population levels at reduced levels compared to neighboring non-ADMA watersheds
    2. Institute fire management strategies that minimize the potential for large-scale, devastating fires
    3. Create educational/extension programs to enable private landowners to maximize income and benefits from land while minimizing the impact on aquatic systems

VI. Exotic species
  A. Objective: to reduce the influence of non-native species on aquatic and riparian ecosystems
  B. Potential methods

TABLE 57.5 (continued)

    1. Eliminate planting of fish in high-elevation lakes more than 4 km (2.5 mi) from a road or trailhead
    2. Allow systematic eradication of trout from selected stream and lake systems on public lands that were originally fishless
    3. Develop techniques for bullfrog eradication
    4. Manage streams and riparian areas to favor native organisms on public lands
    5. Reintroduce native fishes and frogs into areas on public lands from which they were extirpated
    6. Develop programs to encourage use of native fishes and other native organisms on private lands, including their use in stock ponds

VII. Salmon restoration
  A. Objective: to increase spawning areas for chinook salmon in order to increase populations and improve habitats for all stages in lowland rivers
  B. Potential methods
    1. Restore salmon to selected areas from which they were extirpated, such as the North Fork American River (over Nimbus and Folsom Dams)
    2. Actively improve spawning gravels, riparian areas, holding pools, and other habitats in degraded sections of rivers

VIII. Recreation
  A. Objective: to reduce impacts of recreational activities on the native biota
  B. Potential methods
    1. Reduce or eliminate in-stream activities (gold dredging, rafting, etc.) that disturb anadromous or spawning fish or breeding amphibians on waters flowing through public lands
    2. Identify sensitive areas (spring systems, etc.) on public land and protect them from human entry
    3. Develop educational programs and incentives to reduce the impact of recreation on aquatic systems on private land

IX. Significant Natural Areas
  A. Objective: to protect unique or sensitive habitats within the watersheds that are limited in area (e.g., large springs)
  B. Potential methods
    1. Inventory watersheds on public lands to locate SNAs
    2. Provide individualized protective measures (e.g., signing, fencing, road removal) for SNAs on public land
    3. Develop educational/extension programs to provide landowners with tools to provide voluntary protection of SNAs on private land

[a]This list is not comprehensive and is meant to suggest activities and actions that would be appropriate for the maintenance and/or enhancement of aquatic biodiversity in selected watersheds.

Regardless of the management details, the development of a system of ADMA watersheds that at least maintains aquatic biodiversity at current levels within the selected watersheds depends on a number of assumptions:

- It will be public policy to maintain self-sustaining populations of all aquatic and riparian-dependent species presently inhabiting the Sierra Nevada. This means that extinctions of species or of taxonomically distinct populations cannot occur and that there must be representatives of all aquatic and riparian habitat types under protective management.
- A major and continuing role of all watersheds is to supply high-quality water to the people of California either to consume or to leave in-stream for ecosystem purposes.

- The watersheds of the Sierra Nevada will continue to have increasing use by humans, and streams, lakes, and riparian areas will continue to be a focus of human activities, despite their high sensitivity to disturbance. Therefore, protection of aquatic biodiversity will require more restrictive regulation of human use in at least some watersheds.
- The aquatic and riparian systems in many areas have been severely and perhaps irreversibly altered. There is an ongoing trend toward continued degradation of the native biota, and it is highly desirable to halt and/or reverse this trend.
- Watershed management strategies must be individualized for each watershed. The major factors affecting biodiversity are often quite different at low elevations than at high elevations, as well as among different regions of the Sierra Nevada. However, until watershed-specific management strategies are developed, it is highly desirable to use broad-scale prescriptions for land and water use that err on the side of protection of habitats and biota. Such prescriptions can become more flexible (adaptive) once the condition of each watershed has been analyzed and areas and waters especially sensitive to human disturbance have been identified.
- A systematic inventory and monitoring program for the biota will be established, not only to keep track of trends in the aquatic organisms and habitats, but to identify SNAs for the protection of endemic invertebrates and other poorly known organisms.

It is obvious that for an ADMA system to work, the first goal of management for each ADMA watershed or SNA must be to protect its biotic integrity. This does not mean that each ADMA watershed should be locked away from human use, but rather that human use should be as gentle as possible. Roads, for example, should be minimized and constructed in such a way that little erosion occurs and contact with aquatic and riparian areas is minimal. Diversions of water within the watershed should be minimal so that the natural flow regime is not altered and so that reservoirs and other disruptive habitats are not created. Recreation should be limited to activities that do not significantly alter the landscape or biota (limited use by off-road vehicles, restricted camping in riparian zones, etc.). In contrast, SNAs will presumably need a much higher degree of protection, especially ones not included within an ADMA watershed.

A system of ADMA watersheds is not meant to signal that all other watersheds can be treated without respect for the natural biota and processes. Ultimately, a system of ADMA watersheds will work only if the drainages connecting them and the watersheds around each ADMA watershed are not highly degraded. A system of properly managed watersheds could demonstrate the considerable economic and social benefits of good watershed management. Such a system could also help avoid many of the problems created by the loss of biodiversity and ecosystem services while not seriously interfering with the ability of Sierran streams to provide continuing economic benefits to the people of California.

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