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ANNOTATED BIBLIOGRAPHY OF HISTORICAL CONDITIONS IN STREAMS AND RIVERS OF THE WESTERN UNITED STATES

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Abstract

Resource managers are often challenged by the lack of adequate benchmarks, or reference conditions, for assessing the biological condition of streams. Increasing human alteration of landscapes reduces the availability of minimally-disturbed stream sites that can be used to represent a reference condition in regional assessments. Historical data offer an alternative point of reference for gauging the relative deviation of current conditions from an established minimally-disturbed condition and can thereby contribute to better-informed management decisions within the context of present-day land uses and range of attainable conditions. This collection of over 150 annotated references represents a significant portion of the literature that reports historical conditions and changes due to human impacts that have occurred since European settlement relevant to fish, aquatic insects, amphibians, and physical habitat. Its intent is to provide sources of information for those involved in historical reconstructions of stream conditions. Key references providing the most comprehensive syntheses at basin or regional scales in the western United States were selected for the bibliography. Bibliographic subsections are tailored toward EPA's Environmental Monitoring and Assessment Program (EMAP), although the information should be useful in a wide range of environmental assessments and restorations that address basin- or regional-scale stream conditions.

Notice

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PREFACE

This collection of annotated references represents a significant portion of the literature that reports historical conditions and changes due to human impacts that have occurred since European settlement relevant to fish, aquatic insects, amphibians, and physical habitat (including riparian vegetation). The geographic scope of the literature includes 12 western states comprising the assessment area for the Environmental Monitoring and Assessment Program's Western Pilot Study (EMAP-West), encompassing EPA Regions 8-10.

This project grew out of the need for benchmarks, summaries, and ancillary information about minimally disturbed conditions that could enhance EMAP-West assessments of current stream condition. However, the information should apply to a variety of environmental assessments and restorations that are conducted at a basin or regional scale. It is particularly relevant in regions that have undergone extensive land-use alterations and where existing least-disturbed reference sites may set unrealistically low reference benchmarks, resulting in inadequate protection of the resource. Historical data can provide a model of regional ecosystem bio-integrity that can be used to assess the relative deviation of present day stream condition from a pre-settlement, or minimally disturbed, condition. The data are not intended for re-creating historical conditions and landscapes but, rather, they offer a point of reference for making better-informed management decisions within the context of present-day land uses and range of attainable conditions.

Content and Format

The bibliography includes primary literature sources (e.g., results of historical fish surveys conducted in the 19th century), as well as more current literature syntheses that report changes from the historical condition (e.g., estimated declines in fish populations) and the causes of the changes. References report conditions and changes over broad regions or river basins. Publications reporting results of small-scale or site-specific studies (e.g., stream segments in a single drainage) are not included. Instead of including every reference identified for a specific topic (e.g., salmon losses in the Columbia River basin), we attempted to select key publications that provided the broadest and most thorough syntheses of historical data or changes from the historical condition. Cited publications include historical documents, journal articles, books and book chapters, reports, web sites, and gray literature. Gray literature was considered valuable since it comprises numerous syntheses of changes in historical ranges and populations, which was precisely the topic of interest for this project. As in any use of gray literature, therefore, it should be applied accordingly.

When possible, bibliographic entries report a minimally disturbed condition, defined as pre-settlement or early settlement (i.e., 19th century). Since much of the earliest documentation of stream conditions was not made until the 20th century, later publications are also included in the bibliography. This is particularly true for the macroinvertebrate literature, much of which did not appear until the mid-1900s. In addition, literature that contrasts a perceived minimally disturbed condition with a changed condition is also included. For example, dam construction in the Colorado River basin beginning in the 1930s drastically changed native fish habitat and populations, which were considered relatively unchanged prior to that time. To a limited extent, literature that contrasts before/after conditions in a more recent time period are also included, for example, large-scale studies of fish assemblages and stream habitat in logged vs. unlogged watersheds within relatively undisturbed forests.

References focus on stream habitats, although a broader landscape perspective is often found in the literature for the Plains aggregated ecoregion because of the intermittent nature of most streams and a closer association between stream and non-stream habitats in that region. Also, early (pre-settlement) stream surveys in the Plains ecoregion are rare or non-existent, so historical stream conditions may have to be inferred from characteristics of the broader landscape.

The annotated portion of each reference contains five summary fields: *abstract* (when available), *geographic location* (see below for descriptors), *value of the reference*, *results relevant to EMAP,* and *keywords*. The '*value of the reference*' field describes the general topic of the publication and why it is considered useful for EMAP applications. It also may include the type of publication (e.g., historical survey results vs. current synthesis), the format in which information is presented, the degree of data synthesis already done, and the prominence of the work in the literature. The '*results relevant to EMAP*' field briefly summarizes the major points or findings of the publication relevant to EMAP topics of interest. Its purpose is to help the user determine whether the publication is worth acquiring and reading in further detail. The '*geographic location*' field includes state, river basin, EPA ecoregion level III, EPA administrative region, and EPA aggregate ecoregion (mountains, xeric, plains). The *'keywords'* field specifies the affected attribute (physical habitat, fish, macroinvertebrates, etc.) and the human impacts that caused the change to historical condition.

References are listed alphabetically. Within each citation, a number of search variables are included in the geographic location and keyword fields to allow a user to more easily find references for specific geographic areas, human disturbances, and impacted biota using the "Find" function in the edit menu. The following lists show, in italics, potential search variables in each category.

- Geographic Location

  State: *Arizona, California, Colorado, Idaho, Montana, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington, Wyoming*

  EPA administrative region: *region 'x'* (e.g., region 8)

  EPA level III ecoregion: *Eco'xx'* (e.g., eco20)

  EMAP aggregate ecoregion: *mountains, plains, xeric*

  River basin: *'xxxxxx' basin* (major basins such as the Columbia River basin, Colorado River basin, or river tributaries within major basins, e.g., Snake River basin, Gila River basin)

- Keywords

  Human disturbances—activities that have brought about changes in streams or biota:
  - *grazing*
  - *agriculture*
  - *mining*
  - *roads*
  - *dams*
  - *fishing* (commercial or sport)
  - *nonnative species*
  - *recreation*
  - *urban*
  - *water diversion*
  - *channelization*

groundwater pumping
general (referring to any human impact; non-specific)

Impacted Attribute:
fish
macroinvertebrates
amphibians
riparian vegetation
phab (physical habitat)

Application

Information in the publications cited in this bibliography can be applied in a variety of basin- or regional-scale assessments and restorations. Two examples of using the bibliography in the context of EMAP stream assessments are illustrated here.

Riparian Vegetation in the Missouri River Basin

Historical documentation indicates that, with the exception of badlands, riparian habitats in the Northwestern Great Plains (Ecoregion 43; Missouri River basin) were composed largely of forest and shrub habitats prior to settlement (Warren 1856, Evermann and Cox 1896, Johnson 1992, Rumble et al. 1998). Descriptions in these references note extensive forests dominated by cottonwood and willow; “extensive native woodlands”; canyons filled with deciduous trees including cottonwood, willow, ash, oak, and wild plum; heavily-forested floodplains; “abundance of wood”; “swarms of beaver”; “excellent timber of ash, oak, elm, and box-elder”. At least-disturbed reference sites in Ecoregion 43 today, however, EMAP physical habitat measurements show that riparian canopy averages only 4% of the riparian cover. Total riparian woody cover (the sum of woody cover in each of three vegetation layers, with highest potential value of 300% due to overlapping layers) averages just 41%, less than half of today’s total riparian cover including herbaceous species. This comparison suggests that canopy cover at least-disturbed sites is much less than what would be expected based on historical documentation, and that woody vegetation as a proportion of the total is likely under-represented.

Fish Assemblage Biotic Integrity in the South Platte River basin.

Another useful application of historical information is in the development of multimetric indices of biotic integrity (IBIs), which translate biological indicator abundance data into a numeric score to evaluate stream condition. In a highly altered region, historical information can be used to set expectations for the number of species that would have been found in minimally disturbed ecosystems of the region (Hughes *et al.* 1998). For example, EMAP field crews sampled 23 native species of fish at 19 sites on the upper South Platte River in the foothills of the Rocky Mountains of Colorado. In a paper that reviewed historical collections on the South Platte River, Probst and Carlson (1986) determined that three fish species had been extirpated from the South Platte basin and several others were now rare. Seven of these historically recorded species were not collected during the EMAP-West survey. If we were to construct an IBI for the South Platte basin, we might increase the total number of species from 23 to 30 to more closely represent a state of biointegrity. Since total number of species is the denominator in species proportionate metrics (for example, % tolerant species or % native vagile species), all such metrics would be scored somewhat lower than metrics based on present day field data alone, and the lower IBI score would more accurately reflect the departure of sites in developed regions from a minimally disturbed condition.

ANNOTATED BIBLIOGRAPHY

Author: Abruzzi, W., others
Year: 2002
Title: Riparian Area Loss and Degradation
Reference Type: Electronic Source
Access Year: 2005
Access Date: July 25

Value of reference: Web site addresses reduction in riparian areas, the causes, and associations between losses and fish distribution. It proposes a link between native fish presence and intact riparian areas. The focus of numerous other publications is on the devastating effects of river regulation and introduced species on the Colorado River native fishery; this overview proposes that the presence of healthy riparian areas seems related to the survival of some of the only remaining populations of native fish.

Results relevant to EMAP: Overall, a 90% loss of pre-settlement riparian ecosystems has occurred in Arizona and New Mexico, beginning in the early 19th century with the near extirpation of the beaver.

As a result of various human-related impacts, water tables are lowered, surface sediments are desiccated, channels are less complex and more static, erosion increases, suitable habitat for establishment of riparian vegetation such as cottonwood and willow is limited, and plant community structure changes.

The few remaining fish stocks native to smaller riparian systems on the Plateau survive only in those areas with intact riparian habitats, often in remote upper-elevation watersheds.

Geographic location: Colorado Plateau, xeric, Arizona, New Mexico, eco20, eco21, eco22, eco23, EPA Region 9

Keywords: phab, fish, riparian vegetation, beaver, dams, agriculture, channelization, grazing, logging, nonnative species, roads, urban

URL: http://www.cpluhna.nau.edu/Biota/riparian_degradation.htm

Author: Adams, S. B.; Frissell C.A.; Rieman, B.E.
Year: 2001
Title: Geography of invasions in mountain streams: consequences of headwater lake fish introductions
Reference Type: Journal Article
Journal: Ecosystems
Volume: 2001
Pages: 296-307

Value of reference: This paper reviews the potential consequences of fish introductions into headwater streams and lakes in the western United States, and the nature of the impacts upon downstream aquatic ecosystems. A review of the literature is provided describing the consequences of nonnative fish species invasions in higher elevation mountainous regions.

The authors suggest that knowledge of the differential effectiveness of barriers can be used in conjunction with stocking history to interpret where stocking activities may have had impacts upon native ichthyofauna, macroinvertebrates, and amphibians. This information can be of value for interpreting the quality of vertebrate faunal metrics, particularly for stream reference sites.

Results relevant to EMAP: Headwater streams historically provided refuges for native fish, amphibians and aquatic macroinvertebrates. Approximately 95% of all high-mountain lakes in the western United States lie above Pleistocene-age barriers to fish dispersal (Bahls 1992). Where native fish species existed, stream dispersal barriers have prevented influences of downstream communities which have been impacted by intentional and unintentional fish introductions. Downstream dispersal of fish is more effective than upstream dispersal, consequently upstream or isolated drainages represent refugia for both native fish and non-fish fauna such as amphibians and invertebrates.

Intentional and accidental introduction of fish species such as brook trout (*Salvalinus fontinalis*) have occurred at upper elevations throughout the west since the late 1800s. Such introductions have impacted native fauna through a wide range of mechanisms, and have often led to displacement. Brook trout (*S. fontinalis*), for example, have been implicated in the displacement of both native bull trout (*Salvalinus confluentus*) and cutthroat trout (*Oncorhynchus clarki*).

Geographic location: Region 8, Region 9, Idaho, Montana, Rocky Mountains, MOUNTAINS, MT-NROCK, SF Salmon River, eco15, eco16, Northern Rockies, Idaho Batholith

Keywords: fish; invasion; dispersal; landscape; demography; conservation; nonnative species; salmonids; lake; stream; Columbia River basin; Idaho, Montana

Abstract: The introduction of fish into high-elevation lakes can provide a geographic and demographic boost to their invasion of stream networks, thereby further endangering the native stream fauna. Increasingly remaining populations of native salmonids are concentrated in fragmented headwater refugia that are protected by physical or biological barriers from introduced fishes that originate in the pervasive source populations established at lower elevations. Although fish introduced near mainstem rivers frequently encounter obstacles to upstream dispersal, such as steep slopes or falls, we found brook trout (*Salvelinus fontinalis*) dispersed downstream through channel slopes of 80% and 18-m-high falls. Thus, headwater lake stocking provides source populations that may be capable of invading most downstream habitats, including headwater refugia of native fishes. The extent of additional area invasible

from lakes, beyond that invasible from downstream, depends on the geography of the stream network, particularly the density and distribution of headwater lakes and their location relative to barriers inhibiting upstream dispersal. In the thermal and trophic environments downstream of lakes, fish commonly grow faster and thus mature earlier and have higher fecundity-at-age than their counterparts in other high-elevation streams. The resulting higher rates of population growth facilitate invasion. Larger body sizes also potentially aid the fish in overcoming barriers to invasion. Trout introductions to high-elevation headwater lakes thus pose disproportionately large risks to native fishes -- even when the place of introduction may appear to be spatially disassociated from populations of the native species. Mapping the potential invasible area can help to establish priorities in stocking and eradication efforts.

Notes: Bahls, P. 1992. The status of fish populations and management of high mountain lakes in the western United States. Northwest Science 66:183-93

Author: Arizona Game and Fish Department
Year: 1994
Title: Gila Chub (*Gila intermedia*), unpublished abstract
Reference Type: Electronic Source
Producer: Heritage Data Management System, Arizona Game and Fish Department
Access Year: 2005
Access Date: October 6
Last Update Date: December 4, 2002

Value of reference: This is a short synopsis of this species, which includes a short description of its historical and current distribution. It is useful for defining the historical range of the species and estimating the proportion of it that is no longer occupied.

Results relevant to EMAP: Historically the Gila chub was found in headwater streams of the Gila River in Arizona, New Mexico and likely in Sonora, Mexico. It is currently considered extirpated from New Mexico and from 3 waterways in AZ: Cave Creek, Fish Creek, and Monkey Spring. This report lists a number of creeks in Arizona where it is still found. The Gila chub was commonly found in association with Gila topminnow, desert and Sonora sucker and longfin and speckled dace.

Populations have slowly been disappearing but are expected to fluctuate with habitat changes due to climatic events. Threats to this species include aquifer pumping, stream diversion, reduced flows, habitat alteration, competition by nonnative crayfishes and competition and predation by nonnative fishes

Geographic location: Arizona, EPA Region 9, eco22, eco23, xeric, Gila River basin

Keywords: fish, water diversion, groundwater pumping, impoundment, nonnative species, habitat degradation

URL: http://www.gf.state.az.us/w_c/edits/documents/Gilainte.fo_001.pdf

Author: Beechie, T.; Beamer, E.; Wasserman, L.
Year: 1994
Title: Estimating coho salmon rearing habitat and smolt production losses in a large river basin, and implications for habitat restoration
Reference Type: Journal Article
Journal: North American Journal of Fisheries Management
Volume: 14
Pages: 797-811

Value of reference: An extremely valuable reference that uses the historical record to estimate the loss of summer and winter coho salmon rearing habitats and the associated loss of coho smolt production for the entire Skagit River basin. In addition, the amount of lost habitat was apportioned to particular land use impacts, an analysis that is not often seen.

Results relevant to EMAP: See abstract for loss of coho smolt production.

Early hydromodifications on the Skagit River, such as diking, dredging, and damming, caused comparatively larger losses of physical habitat areas than more recent modifications, which are more incremental impacts from multiple activities such as timber harvest, flood protection, and residential and urban development.

Prior to settlement the river wandered freely over its floodplain creating new side channels, oxbows, sloughs, and wetlands. In the lower river valley over 25% of the floodplain and delta area consisted of beaver ponds, sloughs, and wetlands.(The authors were not able to estimate lost beaver pond area.) Diking and reclaiming the land for agriculture began in the early 1860's. The lower elevation uplands were logged in the early 20th Century; reports as early as 1921 reported habitat degradation and loss due to logging and hydroelectric dams.

The largest estimated losses in habitat area and smolt production have occurred in the side-channel and distributary sloughs. Over 115 km - nearly 700,000 m^2 - of Skagit River side channel and distributary sloughs have been eliminated in the past century.

Geographic location: mountains, eco2, eco77, Skagit River basin, Puget Sound, EPA Region 10

Keywords: salmonids, rivers, fish habitat, fish losses, coho salmon, agriculture, urban, channelization, dredging, logging, phab

Abstract: To develop a habitat restoration strategy for the 8270 km^2 Skagit River basin, we estimated changes in smolt production of coho salmon (*Oncorhynchus kisutch*) since European settlement began in the basin, based on changes in summer and winter rearing habitat areas. We assessed changes in coho salmon smolt production by habitat type and by cause of habitat alteration. We estimated that the coho salmon smolt production capacity of summer habitats in the Skagit River basin has been reduced from 1.28 million smolts to 0.98 million smolts (--24%) and that the production capacity of winter habitats has been reduced from 1.77 million to 1.17 million smolts (--34%). The largest proportion of summer non-main-stem habitat losses has occurred in side-channel sloughs (41%), followed by losses in small tributaries (31%) and distributary sloughs (29%). The largest loss of winter habitats has occurred in side-channel sloughs (52%), followed by losses in distributary sloughs (37%) and small tributaries (11%). By type of impact, hydromodification (diking, ditching, dredging) associated with agricultural and urban lands accounts for 73% of summer habitat losses and 91% of winter habitat losses. [33]

Blocking culverts on [37 km of] small tributaries account for 13% of the decrease in summer habitat and 6% of the decrease in winter habitat. Forestry activities account for 9% of summer habitat losses and 3% of winter habitat losses. Limitations of the analysis and implications for developing a habitat restoration strategy are discussed.

Author: Behnke, R.J.
Year: 1992
Title: Native Trout of Western North America
Reference Type: Book
City: Bethesda, MD
Publisher: American Fisheries Society, Monograph 6
Number of Pages: 275

Value of reference: Book presents baseline information about historical presence by basin of native trout (given for most species in the *Distribution* subsection). Information can be further used to assist in reconstructing historical trout occurrence and distribution in basins throughout the West.

This reference is frequently cited and used. For example, the Interior Columbia Basin Ecosystem Management Project (ICBEMP) used it to help define the historical ranges of fish species in the Interior Columbia Basin (see Lee et al. 1997, in this bibliography). Availability of historical information is inconsistent among species, and it takes some piecing together of text to isolate portions that are relevant to pre-settlement distributions. Nevertheless, this work seems to be a significant synopsis of trout species in the West.

Results relevant to EMAP: This book gives species-by-species distributions, original native ranges (in some cases, but presented with different details) and status of western trout species. Summaries also include trout occurrence in lakes. Text is somewhat laborious for EMAP purposes, but presents good information about historical presence by basin and whether native or exotic (i.e., many trout species have been introduced into streams where they did not occur historically). This information would be valuable if there was an interest or need to know the historic occurrences of trout species in river basins of the West in order to determine whether trout of a particular basin have been introduced or are native or to assist in reconstructing pre-settlement fish communities. Bulk of book is text, but also includes a few maps and illustrations.

Geographic location: westwide distributions of multiple species of trout

Keywords: fish, trout, historical distribution, status, xeric, mountain, westwide

Author: Bilby, R. E.; Ward, J. W.
Year: 1991
Title: Characteristics and function of large woody debris in streams draining old-growth, clear-cut, and second-growth forests in southwestern Washington
Reference Type: Journal Article
Journal: Canadian Journal of Fisheries and Aquatic Sciences
Volume: 48
Pages: 2499-2508

Value of reference: This article compares woody debris at present day minimally disturbed sites with that at logged sites. By examining the characteristics of large woody debris in streams bordered by forests of different age classes, the authors document the ways in which large woody debris volume changes following timber removal from the riparian area. They also record the influence of large woody debris on stream channel morphology. A companion article to Bisson et al. 1987 which relates old growth large woody debris distribution to salmon biomass.

Results relevant to EMAP: Plunge pools formed by large woody debris were significantly more common at old-growth sites than at second-growth sites for all stream-size classes and at clear-cut sites in streams < 7 m wide. The frequency of large woody debris associated pools decreased with increasing stream size for all three stand age classes, but was significantly greater at old growth sites than at the other two stand age classes. Average pool surface area was significantly greater in streams > 10 m wide at old growth sites.

Geographic location: Pacific Northwest, Willapa Hills, southwest Washington, western Cascades, eco1, eco4, EPA Region 10, mountains

Keywords: phab, large woody debris, sediments, logging, fish, pools, salmonids

Abstract: Amount of large woody debris (LWD) surveyed in 70 stream reaches flowing through old-growth, clear-cut, and second-growth forests decreased with increasing stream size for all stand types but was greatest at old-growth sites. Average piece volume was larger at old-growth sites than at other stand types in streams > 10 m wide, but no differences were seen in smaller streams. Scour pools accounted for 90% of the wood-associated pools at second-growth and clear-cut sites but only 50% at old-growth sites, which contained more pools than other stand types, particularly for larger streams. Pool size was similar for all stand types in smaller streams, but averaged 10 m^2 in streams > 10 m wide at old-growth sites and 4 m^2 for other stand types. Sediment and fine organic matter retained by woody debris decreased with increasing stream size for all stand types, but old-growth sites contained greater amounts of both materials than other stand types. The frequency of pool formation, the type of pool formed, and sediment accumulation were influenced by the amount of fine debris associated with LWD. Changes in LWD amount, characteristics, and function occurred very rapidly following removal of streamside vegetation.

Notes: This reference is a companion article to Bisson et al. 1987 which relates old growth large woody debris distribution to salmon biomass.

Author: Birken, A.S.; Cooper, D.J.
Year: 2006
Title: Processes of *Tamarix* invasion and floodplain development along the lower Green River, Utah
Reference Type: Journal Article
Journal: Ecological Applications
Volume: 16
Issue: 3
Pages: 1103-1120

Value of reference: The study attempted to determine the cause and role of the invasion of *Tamarix* with the intent of 1) providing insights into when, how, and why recent fluvial adjustments may have occurred and 2) assessing the influence of exotic plant invasions in altering geomorphic and ecological processes, which have implications for river restoration efforts. It is notable for its finding that *Tamarix* invasion did not start because of river regulation.

The paper gives background on how *Tamarix* has changed southwestern riparian areas and altered hydrogeomorphological processes. It is also an example of how historical information can be used to address current resource management issues.

Results relevant to EMAP: Throughout the Southwest, floodplain vegetation was historically dominated by Fremont cottonwood (*Populus deltoides*), but *Populus* has declined during the 20th century, while *Tamarix* has invaded and now dominates most floodplain ecosystems, displacing native vegetation and reducing diversity. The invasion of *Tamarix* has altered the hydraulic characteristics of floodplain surfaces, causing many rivers in the southwest to accrete and narrow. The invasion coincided with reduced flows and sediment transport in the mid-20th century caused by climate fluctuation, so it is difficult to determine whether *Tamarix* drove the fluvial adjustments or whether it benefited from climate-or dam-induced reductions in peak flows and sediment transport.

An increase in *Tamarix* establishment is more likely when peak flow is substantially lower in the year following recruitment. *Tamarix* began invading long before river regulation. Other factors, such as multiple years of low flows and changing precipitation patterns in the 1930s, allowed it to invade a previously unoccupied niche with little competition from native vegetation. By 1951, *Tamarix* had already occupied nearly all the floodplain area it presently occupies. It decreased flow velocities and stabilized floodplain landforms long before construction of Flaming Gorge Dam; the species established and proliferated in unregulated river conditions. The return of larger floods in the 1950s did not result in the erosion of landforms that *Tamarix* then occupied because of its dense growth and anchoring ability.

Geographic location: Utah, Green River basin, EPA region 8, eco20, xeric

Keywords: phab, riparian vegetation, climate fluctuation, invasion, channel narrowing, exotic plants, floodplain development, river regulation, *Populus deltoides, Tamarix ramosissima.*

Abstract: Significant ecological, hydrologic, and geomorphic changes have occurred during the 20th century along many large floodplain rivers in the American Southwest. Native Populus forests have declined, while the exotic Eurasian shrub, *Tamarix*, has proliferated and now dominates most floodplain ecosystems. Photographs from late 19th and early 20th centuries illustrate wide river channels with largely bare in-channel landforms and shrubby higher channel margin floodplains. However, by the mid-20th century, floodplains supporting dense *Tamarix* stands had expanded, and river channels had narrowed. Along the lower Green River in eastern Utah, the causal mechanism of channel and floodplain changes remains ambiguous due to the confounding effects of climatically driven reductions in flood magnitude, river regulation by Flaming Gorge Dam, and *Tamarix* invasion. This study addressed whether *Tamarix* establishment and spread followed climate- or dam-induced reductions in annual peak flows or whether *Tamarix* was potentially a driver of floodplain changes. We aged 235 *Tamarix* and 57 *Populus* individuals, determined the hydrologic and geomorphic processes that controlled recruitment, identified the spatial relationships of germination sites within floodplain stratigraphic transects, and mapped woody riparian vegetation cohorts along three segments of the lower Green River. The oldest *Tamarix* established along several sampling reaches in 1938, and 1.50-2.25 m of alluvium has accreted above their germination surfaces. Nearly 90% of the *Tamarix* and *Populus* samples established during flood years that exceeded the 2.5-year recurrence interval. Recruitment was most common when large floods were followed by years with smaller peak flows. The majority of *Tamarix* establishment and Green River channel narrowing occurred long before river regulation by Flaming Gorge Dam. *Tamarix* initially colonized bare instream sand deposits (e.g., islands and bars), and most channel and floodplain changes followed the establishment of *Tamarix*. Our results suggest that *Tamarix* recruitment was triggered by large annual floods that were followed by years with lower peak flows, not by periods of low flow alone. *Tamarix* appears to have actively invaded floodplains, while *Populus* colonization has been limited. Thus, *Tamarix* invasion may have greatly influenced floodplain development and riparian vegetation composition along the lower Green River since the early 20th century.

Author: Bisson, P. A.; Bilby, R. E.; Bryant, M. D.; Dolloff, C. A.; Grette, G. B.; House, R. A.; Murphy, M. L.; Koski, K. V.; Sedell, J. R.
Year: 1987
Title: Large woody debris in forested streams in the Pacific Northwest: Past, present, and future
Reference Type: Book Section
Editor: Salo, E. O.; Cundy, T. W.
Book Title: Streamside Management: Forestry and Fishery Interactions
City: Seattle, Washington
Publisher: University of Washington
Pages: 143-190

Value of reference: The reference includes a very complete examination of the functions of large woody debris, its frequency in old growth forests, the history of its decline as a result of logging practices over the last 150 years, and how its presence or absence affects salmon densities. Companion article to Bilby and Ward 1991 that discusses how large woody debris shapes stream channel morphology.

Results relevant to EMAP: "The combination of debris removal for fish passage in headwater areas of watersheds, historical splash damming, and removal of snags and logjams from large rivers has led to situations where whole drainage systems no longer possess the debris load present in pristine, undisturbed river basins."

Graph, p. 156 shows increasing densities of coho salmon with increasing volumes of large organic debris.

Table, p. 160 showing biomass of large woody debris (kg/m^2) in streams flowing through regional examples of unmanaged old-growth forests in the Pacific Northwest

Geographic location: Pacific Northwest, Washington, Oregon, Alaska, British Columbia, eco1, eco4, mountains, EPA Region 10

Keywords: phab, large woody debris, sediments, temperature, dissolved oxygen, logging, fish, pools, salmonids

Abstract: This paper reviews the form, function, and management of woody debris in streams, and reaches three major conclusions: (1) Large woody debris enhances the quality of fish habitat in all sizes of streams. (2) Removal of most trees in the riparian zone during logging, combined with thorough stream cleaning and short-rotation timber harvest, has altered the sources, delivery mechanisms, and redistribution of debris in drainage systems, leading to changes in fish population abundance and species composition. (3) There is an urgent need for controlled field experiments and long-term studies that focus on the protection of existing large woody debris in stream channels and the recruitment of new debris from the surrounding forest.

Woody debris has long been considered a potential source of logjams that could block river navigation, water-based log transport, and the upstream passage of salmon and trout on their way to spawning grounds, but is now understood to play an important role in the creation and maintenance of fish habitat throughout entire rivers. Although wood itself eventually enters the food web of the stream ecosystem as it gradually decays, the major importance of debris lies in its structural characteristics and the way these features influence channel hydraulics. Physical processes associated with debris in streams include the formation of pools and other important rearing areas, control of sediment and organic matter storage, and modification of water quality.

Biological properties of debris-created structures can include blockages to fish migration, provision of cover from predators and from high stream flow, and maintenance of organic matter processing sites within the benthic community. The locations and principal roles of woody debris change throughout the river system. In steep headwater streams where logs span the channel, debris creates a stepped longitudinal profile that governs the storage and release of sediment and detritus, a function that facilitates the biological processing of organic inputs from the surrounding forest. When the stream channel becomes too wide for spanning by large logs, debris is deposited along the channel margins, where it often forms the most productive fish habitat in main stem rivers. In all but the smallest streams there is some degree of clumping, although the size and spacing of debris clumps generally increase in a downstream direction. Debris related fish habitat can be found anywhere in small forested streams. In large rivers it is primarily associated with debris accumulations along the margins and secondary channel systems of the floodplain, although it also occurs behind and under very large pieces (intact boles and root wads) along main stem gravel bars.

Changes in tree species composition, abundance, and input rates to streams resulting from forest management practices have differed according to location in the watershed, and many physical and biological processes have been altered by these changes in the river system's debris load. Several questions have not been fully explored, particularly with regard to the long-term consequences of streamside management for debris recruitment. Yet the majority of studies of streams in second-growth forests have demonstrated that the input of large, potentially stable debris from second growth stands in which nearly all large merchantable trees had been harvested was significantly reduced relative to debris inputs from old growth stands. Other studies have shown that loss of large debris has led to a shift in stream habitat composition that favored underyearling steelhead (*Salmo gairdneri*) and cutthroat trout (*S. clarki*) at the expense of the older trout age classes as well as both underyearling and yearling coho salmon (*Oncorhynchus kisutch*). Loss of debris has also reduced overwinter survival of all species. In order to develop procedures that will protect existing instream debris, as well as provide a continues supply of the proper quantity and quality of large woody debris for the future, it will be necessary to test scientifically a variety of management options over a wide range of stream sizes. Many management procedures have been proposed, including techniques for removing slash from stream channels after logging, determining the configuration of buffer strips, selective harvesting within the streamside management zone, and deliberately adding debris to streams for habitat enhancement. Evaluation of these proposals will require a great deal of time and effort, as well as the cooperation of many resource management organizations. However, long term research is essential in view of the complexity of debris management issues.

Notes: This reference is a companion article to Bilby and Ward 1991 that discusses how large woody debris shapes stream channel morphology.

Author: Blinn, D.W.; Cole, G.A.
Year: 1991
Title: Algal and invertebrate biota in the Colorado River: Comparison of pre-and post-dam conditions
Reference Type: Book Section
Editor: Committee on Glen Canyon Environmental Studies
Book Title: Colorado River Ecology and Dam Management.
City: Washington, D.C.
Publisher: National Academy Press
Pages: 102-122

Value of reference: This is one of very few summary documents about algal and invertebrate biota in a basin and is thus worth noting even though the historical information it contains is from the mid-1900s (pre-dam) and the focus is on the mainstem lower Colorado River. It presents a broad overview of changes in the biota of the Colorado River between Glen Canyon Dam and Lake Mead, including some documentation for backwater and tributary conditions, as a result of the closure of Glen Canyon Dam in 1963. It also gives several examples of invertebrate introductions in the Colorado River basin. The authors present material in a general summary format (i.e., no data are presented) that synthesizes an extensive body of literature and includes a useful bibliography.

Results relevant to EMAP: The average suspended sediment load in the lower Colorado River before impoundment was 3.5 times higher than after the construction of Glen Canyon Dam. Substrata available for attachment were more numerous. Flowers (1959) reported 53 taxa of riverine algae including 28 chlorophytes and 20 diatom taxa in tributaries of the canyon. The authors note the lack of pre-impoundment data for macroinvertebrates in the main stem but cite several studies pertaining to species in tributaries or springs, dating back to 1911 (see Notes section). The difficulty in reconstructing historical invertebrate communities is due to both the lack of historical data and the changes in native communities as a result of numerous introductions of invertebrates from other parts of the continent.

Cell densities for diatom species in the Colorado River after impoundment were over 1600-fold lower than prior to the impoundment of the river. (Williams 1964).

The authors mention numerous invertebrate introductions, beginning in the late 1800s.

The species diversity of macroinvertebrates in the Colorado River is much lower than in the tributaries, despite numerous introductions. General community change in algal and macroinvertebrate communities as a result of dams is also discussed.

Geographic location: Arizona, Colorado River basin, eco22, xeric, EPA region 9

Keywords: macroinvertebrates, algae, phab, dams, invertebrate introductions, nonnative species

Abstract: Few reports exist on the physicochemical conditions of the pre-impounded Colorado River that relate to the growth and development of algal and aquatic invertebrate communities. Post-impoundment studies indicate that Cladophora glomerata is the dominant attached filamentous green algal species. Two hundred-thirty-five diatom taxa from the Colorado River and tributaries and from springs in the Glen and Grand Canyon systems have been reported. Ephemeropterans, snails, leeches, species from at least 10 insect families, and crayfish were

intentionally introduced into the Colorado River after the Glen Canyon dam was closed. Zooplankters show a richness of faunas in backwaters along the borders of the river channel and at the mouths of tributaries. The macroinvertebrates occurring in the Colorado River consist of only a few species. The amphipod *Gammarus lacustris* constitutes an important food for most of the fishes of the Colorado River. Exotic and unusual species such as *Craspedacusta sowerbyi, Branchiura sowerbyi*, and the parasite *Lernaea cyprinacea* have also been reported in the Colorado River. Damming of the river has caused stranding of some plant and animal communities during periods of low flow. Some species have shown adaptations to fluctuating flow regimens caused by dams. Regulated flow can increase the standing crops of both attached algae and aquatic macrophytes, as well as aquatic mosses. Creation of reservoirs may cause enrichment of some nutrients that affect algal growth. The most common effect of impounded rivers on the macroinvertebrate community is reduced species diversity accompanied by high density and biomass. Modifications in thermal conditions also contribute to the compositional changes in macroinvertebrates below reservoirs. Research priorities recommended are: seasonal studies of *Cladophora glomerata*, studies on optimal flow rates for *Cladophora glomerata* population growth, food web studies in tail waters of Glen Canyon Dam, phenological studies of invertebrates in the Colorado River ecosystem, and model development to study the effects of physicochemical parameters on plant and animal communities in regulated rivers. (See also W93-02624) (Geiger-PTT)

Notes: See Musser, 1959 (in this bibliography) for a list of macroinvertebrate species found in Glen Canyon in 1958 (before dam closure).

Flowers, S. 1959. Algae collected in Glen Canyon. Pages 203-205 IN C.E. Dibble (ed.), Ecological Studies of the Flora and Fauna in Glen Canyon, Appendix D. University of Utah Anthropology Papers, Salt lake City. 226 p.

Author: Bogan, M.A.; Allen, C.D.; Muldavin, E.H.; Platania, S.P.; Stuart, J.N.; Farley, G.H.; Mehlop, P.; Belnap, J.
Year: 1998
Title: Southwest
Reference Type: Electronic Source
Producer: United States Geological Survey, Biological Resources Division
Access Year: 2005
Access Date: June 15

Value of reference: Synthesis article addresses changes in fish occurrence and distribution in a very large river basin (Colorado) as a whole and also mentions changes in specific tributaries. General historical ranges and declines or extinctions are given for four significant native fish species: Colorado squawfish, bonytail, razorback sucker, and humpback chub. Web site brings together a number of important references, including some from gray literature.

Results relevant to EMAP: The percentage of the native fish fauna in the Colorado River basin that are threatened is 85% in AZ, 72% in CA, 30% in NM, and 42% in UT.

The Colorado squawfish is now reduced to about 1/3 its original range, with natural populations extinct in the lower basin; Humpback chubs, once found in most large-river habitats of the CO River, now exists in only five canyon reaches in the upper basin; Bonytails, once one of the most abundant fishes in the basin, is now considered functionally extinct; Razorback suckers were once so numerous that they were commercially fished in southern AZ in the early 1900s, but now inhabit only 1208 river km in the upper basin.

These conditions have been brought about by dams, impoundments, loss of physical habitat, habitat degradation, chemical pollution, overfishing, altered water flow regime, groundwater pumping, and introduction of at least 72 nonnative species.

Geographic location: southwest, xeric, mountains, Colorado, Utah, New Mexico, Arizona, Colorado River basin, eco 20, eco22, eco23, eco81, eco14, xeric, EPA Region 8, EPA Region 9

Keywords: fish, dams, nonnative species, fishing, habitat degradation, pollution, groundwater pumping

URL: http://biology.usgs.gov/s+t/SNT/index.htm

Author: Bradford, D.F.; Graber, D.M.; Tabatabai, F.
Year: 1994
Title: Population declines of the native frog, *Rana muscosa*, in Sequoia and Kings Canyon National Parks, California
Reference Type: Journal Article
Journal: The Southwestern Naturalist
Volume: 39
Issue: 4
Pages: 323-327

Value of reference: This article reports the dramatic decline of the mountain yellow-legged frog since 1955 from relatively undisturbed areas of the Sierra Nevada. Few accurate historical records are available prior to 1955; the "historical" period was thus defined as 1955-1979. Areas both within and outside Kings Canyon and Sequoia National Parks were compared on the basis of historical and current (1988-91) presence of the species. Historical geographic range is shown in Figure 1 (Zweifel 1955).

Results relevant to EMAP: In the current survey, *Rana muscosa* remained at 11 of 21 historical sites within the parks but at only 3 out of 24 historical sites outside the parks. The authors conclude that the species has disappeared from about half of its historical localities in the two parks during the past three decades, and has been extirpated in some drainages. The magnitude of decline seems greater outside the parks. The causes for the declines are not clear. Several possible factors contributing the decline are discussed; the authors appear to favor the hypothesis that the cause is due to habitat fragmentation and isolation of populations by nonnative fishes (Bradford et al. 1993). The degree of isolation differs by about tenfold compared to the period prior to fish introduction.

Geographic location: Sierra Nevada, Kings Canyon National Park, Sequoia National Park, San Joaquin River, Kings River, Kaweah River, Kern River, EPA region 9, eco5, California, mountains

Keywords: amphibians, declining populations, isolation, habitat fragmentation, headwater streams, high elevation

Abstract: *Rana muscosa* (mountain yellow-legged frog) is one of a number of amphibians around the world that reportedly have declined in numbers in recent years in seemingly well-protected environments. In Sequoia and Kings Canyon National Parks, California, two study areas comprising the headwaters of seven creek systems were surveyed for *R. muscosa* and *Pseudacris regilla* (Pacific chorus frog) in 1978-79 and again in 1989. *R. muscosa* was found at 27 sites greater than 200 m apart in 1978-79, but at only one site in 1989, and the population at this site disappeared by 1991. In contrast, *P. regilla* was found at 15 to 17 sites both times. A comparison of 21 historical (1955-1979) and recent (1989-90) records scattered throughout the parks showed that *R. muscosa* remained at only 11 of these sites in 1989-90. A similar comparison of 24 historical and recent records elsewhere in the Sierra Nevada showed that *R. muscosa* remained at only three sites. We conclude that *R. muscosa* has disappeared from about half of the historical localities in Sequoia and Kings Canyon National Parks during the past three decades, and has been extirpated in some drainages. The magnitude of decline appears to be even more pronounced outside the parks. The causes for these declines are not clear.

Notes: Zweifel, R.G. 1955. Ecology, distribution, and systematics of frogs of the *Rana boylei*

group. University of California Publ. Zool. 54:207-292.

Bradford, D.F. et al. 1993. Isolation of remaining populations of the native frog, *Rana muscosa*, by introduced fishes in Sequoia and Kings Canyon National Parks, California. Conservation Biology 7:882-888.

Author: Bradford, D.F.; Jaeger, J.R.; Jennings, R.D.
Year: 2004
Title: Population status and distribution of a decimated amphibian, the relict leopard frog (*Rana onca*)
Reference Type: Journal Article
Journal: The Southwestern Naturalist
Volume: 49
Issue: 2
Pages: 218-228

Value of reference: Previous publications describing this species' historical range (Jaeger et al. 2001; Jennings 1988, Jennings and Hayes 1994) are questioned because of taxonomic uncertainties regarding various leopard frog populations within the region. This article synthesizes past (pre-1970) and recent information and reports the latest understanding of distribution, size, structure, and dynamics of extant and recently extinct *R. onca* populations. The authors also specifically define a minimum historical distribution of *R. onca* in light of recent taxonomic clarification and describe observations of habitat changes that seem to be causally associated with recent population extinctions.

Results relevant to EMAP: The historical range was identified by examining museum specimens, using morphological characters to distinguish between *R. onca* and *R. pipiens.* Since not all areas of the basins were sampled in the past, the study establishes a *minimum* historical distribution.

R. onca occurred in springs, streams, and wetlands within the Virgin River drainage downstream from the vicinity of Hurricane and Gunlock, Utah; along the Muddy River, Nevada; and along the Colorado River from its confluence with the Virgin River downstream to Black Canyon below Lake Mead in Nevada and Arizona. All historical localities are within a few km of these rivers, and many localities are at the river (Figure 1). The five populations currently remaining are small and isolated and concentrated in two areas: near the Overton Arm of Lake Mead and in Black Canyon along the Colorado River below Lake Mead, Nevada. All remaining populations inhabit spring systems with unaltered hydrology.

Possible causes of disappearance from the majority of its historical range include habitat alteration due to agriculture, impoundments, water diversions, and introduction of nonnative species such as bullfrogs, various fishes, and red swamp crayfish.

Geographic location: Arizona, Nevada, Colorado River basin, Virgin River basin, Black Canyon, Lake Mead, EPA Region 9, eco14, eco22, eco20, xeric

Keywords: amphibians, agriculture, nonnative species, water diversion
Abstract: The relict leopard frog (Rana onca) was once thought to be extinct, but has recently been shown to comprise a valid taxon with extant populations. We delineate the minimum historical range of the species based on records from 24 localities, report the extinction of 2 of 7 populations extant in the 1990s, and estimate total population size. The 5 remaining populations occurred in 2 areas: near the Overton Arm of Lake Mead and in Black Canyon along the Colorado River below Lake Mead, Nevada. These 2 areas are only 3.6 and 5.1 km long, respectively. The 5 extant populations inhabited spring systems with largely unaltered hydrology and no introduced American bullfrogs (*Rana catesbeiana*) or game fishes. In a mark-recapture study conducted in the
Overton Arm area, the estimated number of adult frogs averaged 36 over 555 m of stream

habitat, and estimated annual survivorship of adults averaged 0.27. A single mark-recapture estimate for the size of the largest population within Black Canyon, at a site approximately 450 m in length, was 637 adult frogs. An estimate for the total number of frogs at all sites, based on mark-recapture data, visual encounter surveys, and extent of habitat, was approximately 1,100 adults (range 693–1,833). The 2 recent population extinctions occurred concomitantly with encroachment of emergent
vegetation into pools. We speculate that this occurred as a result of natural processes in one case, and anthropogenic processes in the other.

Notes: Jaeger, J.R. et al. 2001. Rediscovering *Rana onca:* evidence for phylogenetically distinct leopard frogs from the border region of Nevada, Utah, and Arizona. Copeia 2001:339-354.

Jennings, M.R. 1988. Rana onca Cope, relict leopard frog. Catalogue of American Amphibians and Reptiles 417:1-2.

Jennings and Hayes. 1994. Decline of native ranid frogs in the Desert Southwest. Pages 183-211 IN Brown, P.R. and J.W. Wright, eds. Herpetology of the North American deserts. Southwestern Herpetologists Society, Special Publication Number 5.

Author: Bradford, D. F.; Tabatabai, F.; Graber, D.M.
Year: 1993
Title: Isolation of remaining populations of the native frog, Rana muscosa, by introduced fishes in Sequoia and Kings Canyon National Parks
Reference Type: Journal Article
Journal: Conservation Biology
Volume: 7
Issue: 4
Pages: 882-888

Value of reference: This paper documents the decline of yellow-legged frogs (*Rana muscosa*) from a minimally-disturbed area within the Sierra Nevada during the past century. The decline is attributed to intentional fish introductions stocking of lakes and streams. This reference provides an example of how fish introductions can influence vertebrate assemblages, vertebrate metrics, and derived diversity indices.

Results relevant to EMAP: The authors propose that the introduction of fish into previously fishless streams and lakes has resulted in increased isolation of populations of yellow-legged frogs (*Rana muscosa*). This isolation, they suggest, has made subpopulations more vulnerable to extinction through natural causes associated with fluctuations in the physical environment, and subsequent re-colonization through streams more difficult.

Much of the water within Sequoia and Kings Canyon National Parks were historically fishless due to the steep gradients of connecting streams, with the exception of certain streams and possibly lakes containing golden trout (*Oncorhynchus aguabonita*), and some rainbow trout (*O. mykiss*). During the past century four species of trout and char, including golden trout, rainbow trout, brook trout (*Salvalinus fontinalis*) and brown trout (*Salmo trutta*) have been systematically introduced above fish barriers throughout the region.

To assess the level of "connectivity" between sample sites, the number of potential dispersal links between present and former fishless stream networks were evaluated. Contemporary yellow-legged frog-bearing sites are much more isolated (approximately 10-fold) from one another than prior to beginning of fish introductions early in the twentieth century. This loss of connectivity is suggested as one cause of the decline of the species, attributed to natural extinction due to stochastic processes, in combination with decreased probability of re-colonization.

Geographic location: California, Sierra Nevada, mountains, eco5, EPA Region 10

Keywords: amphibians; nonnative species; predation; habitat fragmentation

Abstract: *Rana muscosa* (mountain yellow-legged frog) was eliminated by introduced fishes early in this century in many of the lakes and streams in Sequoia and Kings Canyon National Parks, California. In waters not inhabited by fish, however, *R. muscosa* has disappeared from many sites within the past 30 years, and it appears to have gone extinct in some drainage systems. Fragmentation of populations may have caused or contributed to these recent extinctions, because *R. muscosa* populations are significantly more isolated from one another by fish at present than in pre-stocking conditions. A total of 312 lake-sites in 95 drainage basins were surveyed for amphibians and fish in 1989-90. For the 109 sites containing *R. muscosa*, we delineated networks of sites connected to one another via fishless streams, and we compared these present fishless networks ("present networks") to those expected for the same sites

assuming that fish had not been introduced to the parks ("former networks"). Most present networks consist of only one site (mean 1.4), whereas the former networks average 5.2 sites. This difference represents approximately a 10-fold difference in connectivity of populations, which is defined as the mean number of potential links (fishless streams) per network. Connectivity averages only 0.43 in present networks, in contrast to 4.15 in former ones.

Author: Brothers, T. S.
Year: 1984
Title: Historical vegetation change in the Owens River riparian woodland
Reference Type: Book Section
Editor: Warner, R. E.; Hendrix, K. M.
Book Title: California riparian systems: Ecology, conservation, and productive management
City: Berkeley, California
Publisher: University of California Press
Pages: 75-84

Value of reference: The article attempts to reconstruct the pre-settlement riparian vegetation of the Owens River valley and compare it to present day riparian vegetation. Though there is very little information available from early explorers' journals, available references to original vegetation are compared with the subsequent land use and water management history to make inferences about changes in riparian vegetation since settlement.

Results relevant to EMAP: The author pieces together evidence of riparian vegetation from the Walker, Fremont, von Schmidt, and Brewer expeditions that passed through the Owens Valley between 1834 and 1864. Fremont mentions willow and cottonwood, but the others mention only a few small cottonwoods and no other timber. The author lists species recorded in the present day sample and discusses which species may have increased since pre-settlement times (narrowleaf willow and rabbitbrush tend to increase with grazing pressure).

The diversion of Owens River water to Los Angeles may have affected regeneration of willows and cottonwoods that are dependent on periodic flooding to reproduce. Below the diversion aqueduct on the Owens River, the riverbed is dry and vegetated with the alien saltcedar, Russian olive, and herbaceous weeds.

Geographic location: California, EPA Region 9, Owens River, xeric, eco13, central basin and range

Keywords: phab, riparian vegetation, water diversion

Abstract: This study evaluates human-caused vegetation change in the riparian woodland of Owens River (Inyo Co., California). the greatest change has occurred below the intake of the Los Angeles aqueduct, where drying of the channel has eliminated most native riparian cover and allowed invasion by saltcedar (*Tamarix ramosissima*) and Russian olive (*Elaeagnus angustifolia*). Fire, water management, and other factors may have reduced tree cover above the aqueduct intake and encouraged proliferation of weedy native shrubs. The present scarcity of tree seedlings suggests that one or more of these factors continues to inhibit tree regeneration.

Author: Brown, L.A.; Moyle, P. B.
Year: 2005
Title: Native fishes of the Sacramento-San Joaquin drainage, California: A history of decline
Reference Type: Book Section
Editor: Rinne, J. N.; Hughes, R. M.; Calamusso, B.
Book Title: Historical changes in large river fish assemblages of the Americas
City: Bethesda, Maryland
Publisher: American Fisheries Society Symposium 45
Pages: 75-98

Value of reference: This paper is a companion to other papers on the Sacramento-San Joaquin rivers in this collection (Skinner 1962 (salmon catch data), Katibah 1984 (riparian forest), Scott and Marquiss 1984 (sediment)) that covers the decline of a broad variety of fishes, both commercial and non-commercial, and how they have been affected by a range of human disturbances.

Results relevant to EMAP: The fish assemblages of the Sacramento and San Joaquin rivers and tributary streams are separated into elevational regions for the discussion of their historical distribution and present day status: mountains over 1000 m, fishless; mountains 450-1000 m, rainbow trout assemblage (5 species); foothills 30-450 m, pikeminnow/hardhead/sucker assemblage (up to 11 species); valley <30 m, deep bodied fish assemblage (10 species).

The valley fish assemblage, that once occupied low elevation rivers, oxbows, and sloughs, only exists as remnant populations. The thicktail chub is globally extinct; the bull trout and coho salmon have been extirpated; the Sacramento perch was once common, but now exists mostly as transplanted populations in reservoirs; the splittail is commonly found in Native American middens in the Tulare basin where it is now scarce.

The huge increases in sediments after mining in the mid-1800's may have facilitated the invasion by alien striped bass and American shad that are more likely to thrive in systems with high loads of fine sediment. The rise of agriculture and the loss of wetland habitats led to the extinction and decline of the valley fishes. Flow regime is a key factor in the reproductive success of native and alien fishes. The streams and rivers of the Sacramento system have a relatively higher representation of native species than the San Joaquin likely because there is less flow alteration on the Sacramento and no canal systems in agricultural areas. In the San Joaquin drainage the native species are restricted to the areas just below the reservoirs. Those above the reservoirs are threatened by alien species moving upstream from the lakes.

Geographic location: EPA Region 9, Sacramento River, San Joaquin River, Central Valley, eco6, eco7, xeric

Keywords: fish, nonnative species, mining, sediment, agriculture, altered water flow regime, dams

Abstract: In this paper, we review information regarding the status of the native fishes of the combined Sacramento River and San Joaquin River drainages (hereinafter the "Sacramento-San Joaquin drainage") and the factors associated with their declines. The Sacramento-San Joaquin drainage is the center of fish evolution in California, giving rise to 17 endemic species of a total native fish fauna of 28 species. Rapid changes in land use and water use beginning with the Gold Rush in the 1850's and continuing to the present have resulted in the extinction, extirpation, and reduction in range and abundance of the native fishes. Multiple factors are

associated with the declines of native fishes, including habitat alteration and loss, water storage and diversion, flow alteration, water quality, and invasions of alien species. Although native fishes can be quite tolerant of stressful physical conditions, in some rivers of the drainage the physical habitat has been altered to the extent that it is now more suited for alien species. This interaction of environmental changes and invasions of alien species makes it difficult to predict the benefits of restoration efforts to native fishes. Possible effects of climate change on California's aquatic habitats add additional complexity to restoration of native fishes. Unless protection and restoration of native fishes is explicitly considered in future water management decisions, declines are likely to continue.

Author: Brown, L. R.; Moyle, P. B.; Yoshiyama, R. M.
Year: 1994
Title: Historical decline and current status of coho salmon in California
Reference Type: Journal Article
Journal: North American Journal of Fisheries Management
Volume: 14
Issue: 2
Pages: 237-261

Value of reference: The article gives an overview of the vulnerable status of coho salmon in California. Historical information on coho salmon is limited; here it is given in terms of historical and current presence/absence records in individual streams.

Results relevant to EMAP: Unfortunately, much of the "historic" information in this article is from the 1930's, 50's, and 70's as abundance figures from gill net or sport fish catches. Examples: Klamath River, lower river 1919 - 11,162 in gill net fishery; 1955 - 1145 in sport catch. Klamath River; 301 km from mouth - Coho termed abundant in 1923. By 1956, none counted. Table of historic and recent abundance data for adult coho salmon in some California Rivers, p. 244.

There are 582 California streams known to have supported coho salmon at some time. Information on the recent presence or absence of coho salmon was available for only 248 of those streams. Of these 248 streams, 54% still contained coho salmon and 46% did not. By 1956, it was estimated that over 1600 km of streams in California had been lost as important fish habitat.

Juvenile coho salmon require deep, cold pool habitats for high survival. Their wide distribution over many small coastal streams and their relatively short life span (3 years) make California coho salmon more vulnerable to severe declines during drought years. Inadequate protection of watersheds from the effects of logging, grazing, and urbanization has resulted in increased water temperatures, the loss of pools through sedimentation, and the removal of large woody debris needed for cover and pool formation.

Geographic location: xeric, California, Central Valley, Klamath River, Smith River, Redwood Creek, Eel River, eco6, eco7, EPA Region 9

Keywords: fish, coho salmon, dams, logging, genetic integrity, roads, grazing, urbanization

Abstract: The southernmost populations of coho salmon (*Oncorhynchus kisutch*) occur in California where native coho stocks have declined or disappeared from all streams in which they were historically recorded. Coho salmon previously occurred in as many as 582 streams, from the Smith River near the Oregon border to the San Lorenzo River on the central coast. Information on the recent presence or absence of coho salmon was available for only 248 (43%) of those streams. Of these 248 streams, 54% still contained coho salmon and 46% did not. The farther south a stream is located, the more likely it is to have lost its coho salmon population. We estimate that the total number of adult coho salmon entering California streams in 1987-1991 averaged around 31,000 fish per year, with hatchery populations making up 57% of this total. Thus, about 13,000 non-hatchery coho salmon have been spawning in California streams each year since 1987, an estimate that includes naturalized stocks containing about 9,000 fish of recent hatchery ancestry. There are now probably less than 5,000 native coho salmon (with no known hatchery ancestry) spawning in California each year, many of them in populations of

less than 100 individuals. Coho populations today are probably less than 6% of what they were in the 1940's, and there has been at least a 70% decline since the 1960's. There is every reason to believe that California coho populations, including hatchery stocks, will continue to decline. The reasons for the decline of coho salmon in California include: stream alterations brought about by poor land use practices (especially those related to logging and urbanization) and by the effects of periodic floods and drought, the breakdown of genetic integrity of native stocks, introduced diseases, over-harvest, and climatic change. We believe that coho salmon in California qualify for listing as a threatened species under state law, and certain populations may qualify for listing as threatened or endangered under federal law.

Author: Burroughs, Raymond Darwin
Year: 1961
Title: The natural history of the Lewis and Clark Expedition
Reference Type: Book
City: East Lansing, Michigan
Publisher: Michigan State University Press
Number of Pages: 340

Value of reference: This book summarizes the journals from the Lewis and Clark Expedition and groups the information into chapters by species observed. The chapters include: Introduction, bears and raccoons, weasel family, wild dogs and cats, rodents and rabbits, deer-elk and antelope, bison, mountain goats and bighorn sheep, diving and wading birds, ducks - geese and swans, birds of prey, marsh and shore birds, gulls and terns, pigeons - parroquets - goatsuckers and hummingbirds, woodpeckers, passerine birds, fishes, reptiles and amphibians.

Results relevant to EMAP: The information listed in the journals helps reconstruct habitats and landscape elements at the time of observation. The presence of certain mammals, birds, fish, and plant species can paint a picture of what the riparian and landscape habitat was like when first encountered by early explorers. A summary of the many fish, mammals, and other natural history data collected on the expedition is included in the chapters of this book.

The chapters require some sifting through to extract small pieces of anecdotal information or to reconstruct stream related attributes, however; the information is quite valuable and may be the only source of pre-settlement conditions of the plains. This is a good broad reference and inventory that includes specific information about pre-settlement conditions along the route of the expedition.

Geographic location: Great Plains, plains, mountains, Lewis & Clark expedition route, Kansas, Missouri, Nebraska, Iowa, North Dakota, South Dakota, Montana, Idaho, Oregon, Missouri River Basin, EPA region 7, EPA region 8, eco47, eco42, eco43, eco46,

Keywords: Lewis & Clark expedition, pre-settlement, mammals, phab, fish, natural history

Author: Bury, R. B.; Corn, P. S.
Year: 1988
Title: Responses of aquatic and streamside amphibians to timber harvest: A review
Reference Type: Book Section
Editor: Raedeke, K. J.
Book Title: Streamside management: Riparian wildlife and forestry interactions
City: Seattle, Washington
Publisher: College of Forest Resources, University of Washington
Volume: 59
Pages: 165-181

Value of reference: This study compared density estimates of four salamander species in uncut vs. cut riparian reaches on 43 streams in the Coast Range of Oregon. It is one of a limited number of papers examining the effects of logging on amphibians. Mature and old growth reference reaches are used in the absence of historical information on amphibians and their habitats.

Results relevant to EMAP: "There were marked differences in the occurrence, density, and biomass of amphibians between control streams and streams in logged sites. All four species (tailed frogs, Pacific giant salamanders, Olympic salamanders, and Dunn's salamanders) occurred significantly more often in the control streams than in the streams in logged stands" (bar graph, Figure 2, p. 172). The species differed in their sensitivity to temperatures and their ability to withstand some level of logging activity.

Control streams had a higher percentage of cobbles and boulders in the substrate, while logged streams had significantly more sediment. Sediments can be attributed to logging in this case because there were no road crossings upstream from the sample reach in any of the streams in logged stands.

Geographic location: mountains, Pacific Northwest, Oregon, Coast Range, eco1, EPA Region 10

Keywords: amphibians, tailed frog, Olympic salamander, Pacific giant salamander, Dunn's salamander, logging, temperature, sediments, phab

Abstract: Stream dwelling amphibians, which can be the dominant vertebrates of small streams and forests of the Pacific Northwest, are prototypic riparian organisms. Larvae of several species are totally aquatic, while adults use the terrestrial streamside (riparian) habitat to varying degrees. Impacts of timber harvest vary among species, physical habitats, and regions of the Pacific Northwest. Populations of giant salamanders (*Dicamptodon*) increase following clear cutting in the Oregon Cascades, while in the Oregon Coast Range, the long term effects of logging were negative and severe for all species. Timber harvest is less disruptive in high gradient streams and in streams where there is uncut timber remaining upstream. Buffer strips adjacent to headwater and small streams can provide shad and reduce ecological requirements of amphibians in headwaters, assess the effects of logging on amphibians in different regions and under varying climatic regimes, and determine what sizes of buffer strips or uncut patches are most effective and cost-efficient for protecting stream amphibians.

Author: Carlson, C.A.; Muth, R.T.
Year: 1989
Title: The Colorado River: Lifeline of the American Southwest
Reference Type: Journal Article
Journal: Canadian Special Publication of Fisheries and Aquatic Sciences
Volume: 106
Pages: 220-239

Value of reference: Important synthesis paper that summarizes many of the historical and current published and gray literature on status of CO river and its biota. This key reference presents an excellent summary of conditions prior to 1935 (date of Hoover Dam closure), including historic distributions of 54 species of fish in different sections of the basin (see Table 2), specific historic locations where fish were found (also in Table 2), and historic riparian community composition. Historical conditions are contrasted with current conditions, and causes for the changes are presented.

Results relevant to EMAP: River regulation has lowered mainstream water temperatures 10-15 degrees C, resulting in cooler summer and warmer winter water temperatures below dams (Stanford and Ward 1986a); lower summer temperatures have adversely affected native fishes. By 1957, salinity (about 250 mg/L) at Lee Ferry had doubled (reports of 600, 825, and 750 mg/L have been reported in various locations); paper also describes historical aquatic conditions for oxygen levels, algae, nutrient levels, and zoobenthos.

Seventeen of the 54 native fish are either threatened, endangered, or extinct, and most have experienced drastic abundance and range reductions due to impacts including dams and impoundments, poisoning with rotenone, introduction of exotic species, and stocking of various invertebrates carried out in the mid 1900s.

At least 2023 ha of cottonwood communities existed along 322 km of potentially suitable habitat on the lower river in the 1600s; due to water management, grazing, competition with tamarisk, and phreatophyte removal, only about 1130 ha of these communities remain, and less than 202 ha can be considered pure cottonwood communities.

Geographic location: Colorado River Basin, Wyoming, Utah, Colorado, Arizona, New Mexico, Nevada, California, xeric, eco13, eco81, eco23, eco79, eco22, eco20, eco21, eco19, eco18, EPA Region 8, EPA Region 9.

Keywords: dams, water diversion, nonnative species, grazing, water temperature, sediments, fish, macroinvertebrates, riparian vegetation

Abstract: In less than a century, the wild Colorado River has been drastically and irreversibly transformed into a tamed, man-made system of regulated segments. The pristine Colorado, characterized by widely fluctuating flows and physico-chemical extremes, supported unique assemblages of indigenous flora and fauna. Closure of Hoover Dam in 1935 marked the end of the free-flowing river. The system has since become one of the most altered and intensively controlled in the United States; many mainstem and tributary dams, water diversions, and channelized river sections now exist in the basin. Despite having one of the most arid drainages in the world, the river supplies more water for consumptive use than any river in the United States. Its biota is dominated by non-native organisms, and about one third of its native fishes are threatened, endangered, or extinct. This paper treats the Colorado River holistically as an ecosystem and summarizes current knowledge on its ecology and management. Little

has been published on productivity and fisheries of the mainstream river.

Author: Chapman, D.W.
Year: 1986
Title: Salmon and steelhead abundance in the Columbia River in the nineteenth century
Reference Type: Journal Article
Journal: Transactions of the American Fisheries Society
Volume: 115
Pages: 662-670

Value of reference: This reference synthesizes harvest data, early fish literature, and optimum exploitation rates to reconstruct peak-period run estimates for salmon (4 species) and steelhead in the Columbia River basin in the late 1800s. The estimation procedure is based on 5 consecutive years of greatest total harvest and therefore overestimates the average year but better approximates what the basin was capable of supporting, i.e., potential historical production.

Results relevant to EMAP: Peak-period runs for the entire Columbia River system estimated from optimum harvest rates were 2,623,000 sockeye, 4,338,000 chinook (Table 3 breaks down into summer, fall, and spring runs), 618,000 coho, 554,000 steelhead, and 748,000 chum--8,881,000 adults altogether. These are based on optimum exploitation rates (rate at maximum sustained yield) from the literature of 0.77 for coho, 0.73 for sockeye, 0.68 for spring and summer chinook, 0.88 for fall chinook, 0.69 for steelhead, and 0.48 for chum. On the basis of the more probable harvest rates that produced overfishing (0.80-0.88), total run size was about 7,505,000 adults, a single best estimate of total predevelopment runs. This estimate falls within the low range of previous run estimates (cited in this publication), which were partly speculative and varied drastically.

Overfishing and environmental degradation caused numbers to rapidly decrease after catches peaked in the late 1800s. Mining, grazing, irrigation, dams, water diversions, and logging contributed habitat degradation.

Losses can be estimated by subtracting current run sizes from predevelopment estimates of 7.5-8.8 X 10^6. This publication is dated, but it gives the 1977-1981 run data, with corrections for ocean harvest, as 2.5 X 10^6.

Geographic location: Columbia River basin, Oregon, Washington, Idaho, eco10, eco4, eco1, eco11, eco12, eco 15, eco16. eco3, eco9, EPA Region 10, xeric, mountains

Keywords: fish, salmon, mining, grazing, irrigation, dams, water diversions, logging

Abstract: I estimated peak runs of Pacific salmon *Oncorhynchus* sp. and steelhead *Salmo gairdneri* in the Columbia River during the 40 years centered on 1900 on the basis of peak-period commercial catches and probable optimum exploitation rates. Peak-period catches were estimated from mean catch weights during the five consecutive years of greatest total harvest, and from mean weights of fish reported in the early literature. These catches were 1,700,000 summer chinook salmon *Oncorhynchus tshawytscha*(1881-1885), 382,000 steelhead (1892-1896), 1,100,000 fall chinook salmon (1915-1919), 400,000 spring chinook salmon (approximately), 476,000 coho salmon *O. kisutch* (1894-1898), 1,915,000 sockeye salmon *O. nerka* (1883-1887), and 359,000 chum salmon *O. keta* (1915-1991). Optimum harvest rates for maximum sustained yield from non-hatchery stocks were obtained from literature: 0.77 for coho, 0.73 for sockeye, 0.68 for spring and summer chinook, 0.88 for fall chinook, 0.69 for steelhead, and 0.48 for chum. Peak-period runs estimated from optimum harvest rates were 2,623,000

sockeye, 4,338,000 chinook, 618,000 coho, 554,000 steelhead, and 748,000 chum--8,881,000 adults altogether. On the basis of the more probable harvest rates that produced over-fishing (-.80-0.88), total run size was about 7,505,000 adults, a single best estimate of total pre-development runs. I discuss aboriginal catch in relation to the theory that decimation of Indian populations after 1800 permitted salmon and steelhead stocks to expand. Using the shape of stock-recruitment functions and appropriate commercial harvest rates, I support the alternative hypothesis that salmon stocks actually decreased in the early 1800s with decreased Indian harvest, then increased after 1850 as commercial fisheries developed, and finally decreased in response to overfishing. Environmental degradation exacerbated the latter decrease.

Author: Close, D. A.; Fitzpatrick, M.; Li, H.; Parker, B.; Hatch, D.; James, G.
Year: 1995
Title: Status report of the Pacific Lamprey (*Lampetra tridentata*) in the Columbia River Basin
Reference Type: Report
City: Portland, Oregon
Institution: U. S. Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife
Pages: 40
Report Number: BPA Report DOE/BP-39067-1

Value of reference: This document provides a good synthesis of what is known of Pacific lamprey population changes in the Columbia River and Snake River Basins during the last century and suggests causes leading to dramatic declines in recent years.

Results relevant to EMAP: Historically, Pacific lamprey were fairly common in the Columbia and Snake River drainages and occurred wherever salmon occurred. During the early part of the twentieth century, adult lamprey were used as food during artificial propagation of young salmon. Twenty seven tons were reported harvested for this purpose in 1913. A commercial market developed for this species, and 816 tons (approximately 10-20% of the total run) were reported harvested in the Willamette River drainage alone between 1943 and 1949. Dramatic declines in recent years are attributed to (1) problems for both adult and juvenile passage through dams; (2) loss of spawning and rearing habitat; (3) declines in marine prey species resulting from commercial fishing; and (4) chemical poisoning of streams to remove non-game species.

Geographic location: EPA Region 10, mountains, xeric, Oregon, Washington, Columbia River basin, Snake River basin, Idaho, eco1, eco3, eco4, eco10, eco11, eco12, eco15, eco16, eco17

Keywords: fish, Pacific lamprey (*Lampetra tridentata*), fishing, dams

URL: http://www.efw.pba.gov/cgi-bin/efw/FW/publications.cgi

Author: Collins, B.D.; Montgomery, D.R.; Hass, A.D.
Year: 2002
Title: Historical changes in the distribution and functions of large wood in Puget Lowland rivers
Reference Type: Journal Article
Journal: Canadian Journal of Fish and Aquatic Sciences
Volume: 59
Pages: 66-76

Value of reference: The useful part of this reference, with respect to pre-settlement conditions, is the reconstruction of wood abundance, size, and log jamming using archival sources. The reference also demonstrates the use of historical information to evaluate the suitability of reference sites, and the integrated use of both historical information and current least-disturbed sites to re-create pre-settlement conditions. The link between wood and fish habitat value is mentioned on page 75, where two studies are referenced as support for large wood and wood jams in fish habitat sustainability.

Results relevant to EMAP: Early accounts document transport by rivers of vast amounts of wood, for example a Skagit river jam was described as 9 m deep, consisting of 5-8 tiers of logs, ranging from 3-8 feet in diameter and existed for at least a century, as its surface supported live trees 0.6-1.2 m in diameter (Interstate Publishing Company 1906); individual jams of this size could have stored several hundred thousand pieces of wood.

Current numbers of snags are estimated at 0.2-0.4 pieces per km, which is 2 orders of magnitude less than possible snag recruitment rates suggested by data from 1881-1909. Annual maximum diameters between 1889 and 1909 were 3.6 to 5.3 m, based on snagboat records.

A comparison of pool data from the Snohomish and Stillaguamish rivers with data from the Nisqually suggests that the transition from a freely migrating or avulsing river with mature floodplain forest to a leveed river with little riparian recruitment has reduced the number of pools by two to three times. Field studies in the Skagit River indicate that wood (particularly wood jams) significantly increases the fish habitat value of riverbanks.

Geographic location: Puget Lowland, Washington, eco1, eco2, eco77, mountains, Nisqually River, Skykomish River, Snoqualmie River, EPA Region 10

Keywords: phab, fish, large wood, wood jams, pools

Abstract: We examined changes in wood abundance and functions in Puget Lowland rivers from the last ~150 years of land use by comparing field data from an 11-km-long protected reach of the Nisqually River with field data from the Snohomish and Stillaguamish rivers and with archival data from several Puget Lowland rivers. Current wood abundance is one to two orders of magnitude less than before European settlement in the Snohomish and Stillaguamish basins. Most importantly, wood jams are now rare because of a lack of very large wood that can function as key pieces and low rates of wood recruitment. These changes in wood abundance and size appear to have fundamentally changed the morphology, dynamics, and habitat abundance and characteristics of lowland rivers across scales from channel unit to valley bottom. Based on our field studies, rivers had substantially more and deeper pools historically. Archival data and field studies indicate that wood jams were integral to creating and maintaining a dynamic, anastomosing river pattern with numerous floodplain channels and abundant edge habitat and routed floodwaters and sediment onto floodplains. Establishing the

condition of the riverine landscape before European settlement sets a reference against which to evaluate contemporary conditions and develop restoration objectives.

Author: Collins, B.D.; Sheikh, A.J.
Year: 2002
Title: Mapping historical conditions in the Snoqualmie River valley (RM 0 - RM 40)
Reference Type: Report
City: Seattle, WA
Institution: King County Department of Natural Resources and Department of Earth and Space Sciences, University of Washington
Pages: 30

Value of reference: This study used a combination of maps and field notes from the General Land Office (GLO) cadastral survey 1871-1873 and aerial photographs from 1936. These data were then put in a GIS database and used to establish a baseline of "historic condition" by mapping the channel, wetland, forest, and oxbow ponds in the Snoqualmie River valley prior to Euro-American settlement, or about 1870. To evaluate subsequent change, conditions were also mapped from 1936 and 2000 aerial photos.

The availability of pre-settlement accounts and inventories of an area varies by region, so the implementation of a combination of resources to establish a baseline may be the only way to try to determine what the conditions were like before Euro-American settlement. This report is a good example of this type of method and is a useful tool to identify changes in stream habitat since settlement.

Results relevant to EMAP: This study provides a good baseline of historic condition and documents the changes to the system since settlement.

Much of the forest present prior to Euro-American settlement had been cleared, and much of the wetland cleared and drained by 1936. Riparian vegetation remained along river channels and oxbows in some areas in 1936

Since ~1870, only a few additional oxbows have been created, because the river migration rate is generally low; most oxbows that now exist were created prior to the earliest mapping in ~1870. Valley wetlands, on the other hand, are substantially diminished in area, in 2000 being less than one-fifth (19%) the pre-settlement wetland area. Forest cover in 2000 is about one-sixth (16%) its mapped pre-settlement extent. The small rate of change to the river itself contrasts with the extensive historical changes to wetlands and forests, which have been greatly diminished.

Geographic location: Washington, Snoqualmie River Valley, EPA region 10, eco77, mountains

Keywords: phab, riparian wetlands, forest cover, oxbow, river valley, historical change, pre-settlement, Euro-American settlement

URL: http://dnr.metrokc.gov/wlr/waterres/streams/snoqhist.htm

Author: Confluence Consulting Inc.
Year: 2004
Title: Powder River biological survey and implications for coalbed methane development
Reference Type: Report
City: Bozeman, MT
Institution: Confluence Consulting, Inc
Pages: 179

Value of reference: Land use practices in the Great Plains dramatically affect stream health and watershed habitat. This report outlines the changes to the greater watershed looking at pre-settlement and current conditions. The study includes: physiochemical water quality measurements; count summaries and listings for, macroinvertebrates, periphyton, fish, reptiles, amphibians, and birds; and overall habitat health summaries.

In addition, "this study provides a limited opportunity to evaluate the effects of coalbed methane (CBM) development already occurring in the Powder River basin in Wyoming. Site selection provided comparisons of biological, physical, and chemical condition above and below CBM development along the Powder River. These results allow inference on the effects of current CBM development on the biological, physical, and chemical integrity of waters in the Powder River basin."

Results relevant to EMAP: This report contains extensive sampling and survey information on the Powder River Basin. The detailed species listings and water quality information highlight the habitat diversity still present within this system. This system has remained relatively undisturbed and data from the early 1960's could be used to estimate pre-settlement conditions.

The Powder River also has importance in terms of Wyoming's natural heritage. In an evaluation of Wyoming's fish fauna since the 1960s, Patton et al (1998) identified several declining native species, including flathead chub, plains minnow, river carpsucker, and channel catfish. The Powder River drainage " due to its relatively pristine conditions, remains one of the few places in Wyoming where these species are abundant."

One of the few Great Plains prairie rivers lacking a main stem dam, the Powder River represents one of the last ecosystems of its kind (Hubert 1993). Moreover, it represents our last chance to conserve a community of fish and invertebrates that was once widespread. This community probably occurred throughout the northern Great Plains but dams and other water developments have changed the ecology of these rivers. As a result, this community is now relegated to the Powder River and short segments of the Yellowstone and Milk rivers in Montana.

This report is a good source that illustrates a relatively undisturbed watershed (very close to historic condition) along with the changes and impacts the system is currently facing.

Geographic location: Wyoming, Montana, Powder River Basin, Powder River, Clear Creek, Piney Creek, eco43, EPA region 8

Keywords: Coalbed methane, stream flow, Great Plains streams, disturbance, salinity, soil waterlogging, EIS, phab, native species, biological survey

URL:
http://www.powderriverbasin.org/cbm/confluence_study/CCI%20Powder%20River%20Biological

%20Survey%2010%20March%202004.pdf

Author: Cross, Frank B.; Moss, Randle E.
Year: 1987
Title: Historic changes in fish communities and aquatic habitats in Plains stream of Kansas
Reference Type: Book Section
Editor: Matthews, W.J.; Heins, D.C.
Book Title: Community and evolutionary ecology of North American stream fishes.
City: Norman, Oklahoma
Publisher: University of Oklahoma Press
Pages: 155-165

Value of reference: Article reviews early accounts and collections (mid to late 1800's) to try to establish pre-settlement conditions of plains streams in Kansas. Using this information as a baseline the article summarizes the changes in habitat and fish assemblages over time and current conditions. This reference also documents the drastic changes in water use and flows due to land uses, such as irrigation, cropland agriculture, and impoundments. A good overview of the changes and disturbances in plains riverine habitats since settlement.

Although study area is outside of current EMAP region, the plains streams in Kansas are similar to ones found in the plains ecoregions within the EMAP area (e.g., eastern Colorado) and inferences may be drawn from this study. It is an important, frequently-cited article addressing historical fish communities in the Plains and is included here because of its prominence in the literature.

Results relevant to EMAP: Modified flow regimes have greatly altered the composition of the riverine community in the past decades. Species most highly adapted, morphologically and behaviorally, to plains rivers have been decimated, whereas fishes less specifically adapted to fluctuating, turbid rivers have increased.

Changes documented in this article are predominately related to changes in water use and flows; most of the habitat changes are within the last two to three decades.

Chapter is a good overview of change to historical stream conditions due to water use impacts. Includes an extensive bibliography.

Geographic location: Kansas, plains, Arkansas river, Smokey hill river, Solomon river, Kansas river, Missouri River, eco25, High Plains, eco27, Central Irregular Plains, eco 47, Western Corn Belt Plains, EPA region 7

Keywords: phab, fish, nonnative species, turbidity, fish communities, modified flow, historic condition, plains rivers, impoundments, agriculture, irrigation

Abstract: Most fishes native to Plains streams have wide distributions in eastern North America. Species richness declines from east to west as aridity increases; taxonomic diversity also decreases, with a few minnow and fewer killifishes becoming increasingly dominant westward. Subordinate to that trend, the fauna contains distinguishable communities characteristic of (1) large streams with erratically variable flow, sandy substrate, and high levels of turbidity and dissolved solids, (2) prairie ponds, marshes, and small streams that are clear and relatively stable, sustained by high water tables, and (3) residual pools of highly intermittent streams.

The first community is most distinctive, including several endemic species with sensory and

reproductive adaptations to extreme turbidity and widely fluctuating discharge. The second community includes relic populations of species whose occurrence in the Great Plains is traceable to glacial climates. The third community consists of four or five exceedingly widespread, nearly ubiquitous species. Historically the small-stream community in Kansas was extirpated or reduced in complexity soon after settlement of the western plains in the last quarter of the nineteenth century. Dominant species of the turbid-river community persisted longer, but many declined precipitously in 1950-80 coincident with receding water tables in the west and regulated flows in the east (following impoundment of nearly all rivers in the region). The endemic riverine fauna was largely replaced by sight-feeding planktivores and piscivores adapted to lentic habitats and clear, moderate flow. Several plains species that were common 30 year ago are now seriously threatened.

Author: Cross, Frank B.; Moss, Randle E.; Collins, Joseph T.
Year: 1985
Title: Assessment of dewatering impacts on stream fisheries in the Arkansas and Cimarron Rivers
Reference Type: Report
City: Lawrence, KS
Institution: Kansas Fish and Game Commission and Museum of Natural History, University of Kansas
Pages: 161

Value of reference: Report summarizes status of fishes in Arkansas River basin in Kansas. The summary utilizes reports from 1853 to 1983 to establish baseline information on fish communities and stream flow and discharge for the basin. The report includes hydrologic data and fish habitat information (historic and present). It is a good summary of what historic conditions may have been like (based on the historic accounts available) and how the region has changed post-settlement.

The results of this project are arranged under the following headings: 1) Hydrologic records; 2) Fish faunas and habitat notes at sites (or stream reaches) for which an historic record is available; 3) Accounts of species of primary concern; 4) Accounts of other species captured in 1979-83; 5) Summary: and 6) Appendix - field notes on collections made in 1983.

Although study area is outside of current EMAP region; the plains streams in Kansas are similar to ones found in the plains ecoregions within the EMAP area and inferences may be drawn from this study. This study highlights similar conditions and issues found in other plains streams farther west.

Results relevant to EMAP: The objectives of the study were to locate populations of several species characteristic of the western Plains segment of the Arkansas River basin; to assess the extent to which these fishes are threatened, by comparison of current and historical distributional records; and to examine the relationship between changes in stream flows and changes in the status of each species.

The first impact of changes on native fishes was extirpation or reduction in range of species characteristic of small spring-fed streams and marshes. For example, the blacknose shiner and the Topeka shiner have been extirpated, probably early in this century, before 1950. The blacknose shiner was listed as abundant (1891), but has not been found anywhere in Kansas since 1900. The second major impact on the native fish fauna of the region was the decline or disappearance of several species characteristic of shallow, sandy river channels. Fishes affected adversely are the Flathead chub, Speckled chub, Arkansas river shiner, Emerald shiner, River shiner, Plains minnow, and Plains killifish. The lower numbers and distributional change is indicative of altered flow conditions.

Altered flows in the larger rivers have not affected all native fishes in the same way. For example Red shiners have increased, probably as a result of reduced fluctuation and turbidity, increased lentic habitat, and reduced competition from native species that have declined.

The riverine species that have declined most precipitously are those whose native ranges were confined to prairie streams. Species that have sustained or increased their abundance all range eastward into trans-Mississippi, forested watersheds. The composite effects of habitat alteration in streams of this region have "caught in a crunch" those species best adapted to highly unstable Plains rivers. The climatic and edaphic conditions which caused highly variable flows, unstable streambeds, high turbidity and salinity, and rapidly fluctuating stream temperatures were negated by "dewatering" of the western part of the basin. "Plains river" habitats are no longer attenuated down stream, due to loss of the western drainage, coupled with extensive impoundment of the eastern streams.

Geographic location: Kansas, Arkansas River basin, Cimarron River, eco25, High Plains, eco27, Central Irregular Plains, plains, EPA region 7

Keywords: fish, native species, fish communities, historic condition, plains rivers, dewatering, discharge records, impoundments

Author: Dodds, Walter K.; Gido, Keith; Whiles, Matt R.; Fritz, Ken M.; Matthews, William J.
Year: 2004
Title: Life on the Edge: The ecology of Great Plains prairie streams
Reference Type: Journal Article
Journal: BioScience
Volume: 54
Issue: 3
Pages: 205-215

Value of reference: This article presents a good overview of the ecology of plains streams. Humans have modified most prairie rivers and streams with dams, channelization, pollution, water abstraction, vast increases of impermeable surfaces in urbanized areas, and other watershed modifications. These alterations have had a substantial negative impact on a diverse fish fauna; loss of abundance, smaller or fragmented habitat range, and extirpation. They disrupt the connectivity of river systems, alter flooding regimes, increase or decrease sediment loads, decrease connection with riparian flood zones, and alter the food webs of the Great Plains rivers.

Understanding the ecosystem function of small streams in the Great Plains region is essential, because those streams represent a key interface between terrestrial habitats and downstream areas, and substantial in-stream nutrient processing may control downstream water quality. Physical and biological factors that influence the ecosystem function of native prairie streams, including even small headwater reaches, must be studied to help assess current water quality issues on both local and continental scales.

This reference has some limited historical information; primarily it is a good overview of the ecology and unique characteristics found in plains streams. It also highlights many of the disturbance issues that have occurred since settlement of the region in the mid to late 1800's.

Results relevant to EMAP: Great Plains stream fishes are highly adapted to harsh conditions and can migrate to areas of permanent water, reproduce quickly, or withstand poor water quality in isolated pools. Nevertheless, water withdrawals in a number of semiarid regions including the Great Plains, have exacerbated stream drying and eliminated many spring refugia, while impoundments have restricted the movement of fishes and further fragmented population. These alterations to plains streams have had profound effects on the otherwise tolerant fish communities. Streams in prairies are even more endangered, because many of the remaining fragments of prairie are not large enough to encompass a significant, functional watershed.

The most heavily affected guild of fishes consists of the large-river minnows. These fish have historically defined Great Plains river vertebrate communities. This article summarizes the ecology of the Great Plains streams and documents the changes in habitat extent, abundance, and assemblages in some fish communities due to land use practices.

Geographic location: South Dakota, Wyoming, Nebraska, Platte River, Loup River, Little Missouri River, White River, Upper Missouri River, Big Sheyenne River, eco43, eco44, eco42, eco47, eco46, plains, EPA region 7, EPA region 8

Keywords: disturbance, drying, flood, prairie, Great plains, streams, phab, fish, fragmentation

Abstract: Great Plains streams are highly endangered and can serve as model systems for studying disturbance ecology and related issues of resistance and resilience in temperate

freshwaters. These streams exist in a precarious balance between flood and drying. In general, microbial activity recovers in days to weeks after drying or flooding, and invertebrate and fish species are quick to follow. In lower forested reaches, floods may be more intense but drying less common. Upstream reaches of prairie streams are characterized by frequent drying, little canopy cover, and limited leaf input. Life history and adaptations alter the ways in which stream organisms respond to these linear patterns. Human modification has altered these patterns, leading to large-scale loss of native grassland streams. The future for Great Plains streams is bleak, given the land-use changes and water-use patterns in the region and the large areas required to preserve intact, ecologically functional watersheds.

URL: http://www.bioone.org/bioone/?request=get-abstract&issn=0006-3568&volume=054&issue=3&page=0205

Author: Dose, J.J.; Roper, B.B.
Year: 1995
Title: Long-term changes in low-flow channel widths within the South Umpqua Watershed, Oregon
Reference Type: Journal Article
Journal: Water Resources Bulletin
Volume: 30
Issue: 4
Pages: 993-1000

Value of reference: Logging and associated road-building activities have been a major form of disturbance in the Western Forested Mountains, reducing large wood availability in stream channels. This paper documents evidence that this loss of wood from streams has resulted in consistent changes in physical habitat (large woody debris, low flow wetted width) between 1937 and ~1990. The authors suggest that the condition of anadromous salmonid stocks is linked, at least in part, to the logging disturbance histories of the basins upon which the fish depend.

A major value of this reference is that it records changes in physical habitat conditions at the same locations more than 50 years following logging, a primary form of anthropogenic disturbance in the Coast and Cascade Ranges of the Pacific Northwest.

Results relevant to EMAP: Most of the catchments in which timber harvest and road construction had occurred in the upper South Umpqua River experienced widening of low-flow wetted stream widths, perhaps attributable to a reduction in large woody debris in active channels. Streams that had not been historically logged generally had more wood within the active stream channel than those in which logging had occurred. Stream width was similarly associated with both percent harvest ($r^2 = 0.44$), and road density ($r^2 = 0.45$).

Three of four anadromous salmonid stocks in the South Umpqua River basin are considered at-risk for extinction, including chinook salmon (*Oncorhynchus tschawytscha*), coho salmon (*Oncorhynchus kisutch*), and searun cutthroat trout (*Oncorhynchus clarki*). The population of winter-run steelhead remained healthy at the time of the publication.

These declines are attributed, in part, to impacts associated with timber harvest. The at-risk populations are found primarily in catchments impacted by silvicultural activities, while he healthier steelhead population utilizes upstream portions of the basin protected from road building and timber harvest.

Geographic location: Region 10, South Umpqua River Basin, Oregon, Western Forested Mountains, mountains, eco1, eco4, eco78, Coast Range, Cascades, Klamath Mountains

Keywords: phab; aquatic ecosystems; forest hydrology; habitat alteration; channel width; watershed management; logging; roads; salmonids; chinook salmon (*Oncorhynchus tschawytscha*); coho salmon (*Oncorhynchus kisutch*); steelhead trout (*Oncorhynchus mykiss*); searun cutthroat trout (*Oncorhynchus clarki*); large woody debris

Abstract: Recent stream survey data (1989-1993) from 31 stream segments within the South Umpqua Watershed Oregon were compared to 1937 stream survey data collected from these same stream segments. Concurrent low-flow wetted stream widths of 22 of the 31 surveyed segments were significantly narrower. In only 1 of 8 tributaries to the South Umpqua River

which originated from the lands designated as timber emphasis were significantly wider than in 1937. The observed change in stream width was linearly related to timber harvest ($r^2 = 0.44$), road density ($r^2 = 0.45$), and the amount of large organic debris remaining in the active stream channel ($r^2 = 0.43$). These findings suggest that timber harvest and road construction may have resulted in changes in channel characteristics. These channel changes may also be a factor in the observed decline of three of the four populations of anadromous salmonids within the basin.

Notes: For the historic site sample descriptions, see: Roth, A.R. 1937. A survey of the waters of the South Umpqua Ranger District, Umpqua National Forest. U.S.D.A. Forest Service, Portland, Oregon. (Also available from the Umpqua National Forest, Roseburg, Oregon, 97470.)

Author: Drost, C. A.; Fellers, G.M.
Year: 1996
Title: Collapse of a regional frog fauna in the Yosemite area of the California Sierra Nevada, USA
Reference Type: Journal Article
Journal: Conservation Biology
Volume: 10
Issue: 2
Pages: 414-425

Value of reference: The primary value of this study is that it represents a careful resurvey of the margins of streams, in addition to lakes and ponds, and documentation of change of seven species of amphibians at sites in the Sierra Nevada that were originally surveyed in 1915. The original survey was conducted prior to the majority of fish introductions or other types of anthropogenic disturbances. This study is of particular value because of the level of historical detail, and the range of taxa examined, and the implications related to changes in aquatic vertebrate indices through time.

Results relevant to EMAP: Severe declines in most species of sampled amphibians were observed between the 1915 and 1992 surveys. The broad scale decline of an entire frog fauna over a diverse region is unprecedented. Intensive stocking of fish into the area began following the 1915 survey. Large lake populations of amphibians had historically provided opportunities for amphibian recolonization of small, isolated habitats which are most susceptible to the effects of natural drought cycles.

The authors hypothesize that large lakes function as reservoirs for amphibian populations, while perennial streams function as corridors metapopulation dispersal. They suggest that major reductions of amphibian populations in large lakes following fish introduction may have reduced the probability of recolonization of other habitat types, including perennial streams as well as more isolated habitats following natural localized extinctions.

The authors provide evidence that the introduction of nonnative fish alone, however, is insufficient to explain the general trends in amphibian declines. Toads, for example, have also declined, yet tend to breed in ephemeral waters lacking fish, and produce toxins that fish tend to avoid. Other, unidentified causes of the observed declines remain to be identified. The results have implications regarding interpretation of vertebrate metrics from reference sites in this ecoregion.

Geographic location: EPA Region 9, California, Sierra Nevada, eco5, mountains

Keywords: amphibians; frogs; toads; introduced fish; nonnative species; amphibian decline; mountain yellow-legged frog; *Rana muscosa*; foothill yellow-legged frog; *Rana boylii*; red-legged frog; *Rana aurora*; Yosemite toad; *Bufo canorus*; western toad; *Bufo boreas*; Great Basin spadefoot; *Scaphiopus intermontanus*; Pacific treefrog; *Hyla regilla*

Abstract: There has been much concern about widespread declines among amphibians, but efforts to mine the extent and magnitude of these declines have been hampered by the scarcity of comparative inventory data. We surveyed a transect of the Sierra Nevada mountains in western North America that was carefully studied in the early 1900s. Our comparisons show that at least five of the seven frog and toad species in the area have suffered serious declines. One species has disappeared from the area entirely and a second species, formerly the most

abundant amphibian in the area, has dwindled to a few small remnant populations. These declines have occurred in a relatively undisturbed, protected area and show some of the same patterns noted in other reports of amphibian declines. Introduced predatory fish, possibly interacting with drought-induced loss of refuge habitats, have contributed to the decline of some species. However, the overall cause of these dramatic losses remains unknown.

Author: Duff, D. A.
Year: 1988
Title: Bonneville cutthroat trout: Current status and management
Reference Type: Book Section
Editor: Gresswell, R. E.
Book Title: Status and management of interior stocks of cutthroat trout.
City: Bethesda, Maryland
Publisher: American Fisheries Society
Volume: Symposium 4
Pages: 121-127

Value of reference: The book chapter outlines the historical distribution of the Bonneville cutthroat trout, its presumed extinction, and the rediscovery of 39 pure strains in headwater streams of the Bonneville Basin.

Results relevant to EMAP: The article discusses the historic importance of the Bonneville cutthroat trout to Native American and early settlers' diets and an early commercial fishery. The fish was once widespread in all available habitats surrounding the Bonneville Basin. The paper includes a list of pure populations by state and state plans for managing the species, as well as a map of present day occurrences in the 4 state area.
Fish numbers have been affected by dewatering of streams through irrigation, competition with nonnative species, and fishing pressure. Trout numbers began their decline after construction of early irrigation projects when large numbers of fish became trapped in irrigation ditches.

Geographic location: eco13, Utah, Wyoming, Nevada, Idaho, EPA Region 8, xeric, Bonneville Basin

Keywords: fish, cutthroat trout, distribution, nonnative species, water diversion, habitat degradation

Abstract: Only one trout subspecies, the Bonneville cutthroat trout, *Salmo clarki utah*, is endemic to the Bonneville Basin, the largest endorheic basin in the Great Basin of western North America. The subspecies was historically abundant throughout all suitable habitat of a vast area of Utah, Wyoming, Nevada, and Idaho until about 8,000 years ago, when the desiccation of ancient Lake Bonneville occurred. During this century, the subspecies suffered a catastrophic decline from introductions of nonnative trouts and habitat alteration. Today, only 41 populations, primarily limited to small headwater streams, are known to be genetically pure. Habitat conditions existing in waters containing the Bonneville cutthroat trout are marginal, and the streams are generally small with depleted flows. Yet, in many of these streams, Bonneville cutthroat trout still survive. Introductions of nonnative trout have been largely unsuccessful in these marginal streams, but they have led to the demise of the native cutthroat trout. The Bonneville cutthroat trout has promising possibilities for enhancing wild trout fishery management programs within the Great Basin states. As a result of the subspecies' limited distribution and present threats to its survival, protection of the few remaining populations is being considered. This paper summarizes the current status and management direction for this subspecies.

Notes: Hickman, T. J. 1978. Systematic study of the native trout of the Bonneville Basin. MS Thesis. Colorado State University, Fort Collins, Colorado, is a paper cited in Duff (1988) that discusses the taxonomy of the Bonneville cutthroat trout, the search for pure populations, and the reasons for the species' decline in more detail.

Author: Eberle, Mark E.; Hargett, Eric G.; Wenke, Thomas L.; Mankdrak, Nicholas E.
Year: 2002
Title: Changes in fish assemblages, Solomon River basin, Kansas: habitat alterations, extirpations, and introductions
Reference Type: Journal Article
Journal: Transactions of the Kansas Academy of Science
Volume: 105
Issue: 3-4
Pages: 178-192

Value of reference: This paper summarizes changes in fish communities from likely early fish assemblages to current assemblages. The study area is outside of the EMAP-West study area, but is very similar to surrounding plains ecoregions with respect to landscape characteristics, land uses, human impacts, and numerous fish species. Therefore, some aspects from this paper can be applied to plains regions in EMAP-West, particularly those in Colorado.

Results relevant to EMAP: The authors reviewed historic literature related to fish accounts to establish likely native fish assemblages. Using this baseline the study attempts to establish what changes in fish assemblages have occurred in the Solomon River basin. Within the whole basin, 32% of the native species of fishes have been extirpated, and 51% of the present assemblage was comprised of nonnative species. Extant native species in the basin are more tolerant of a wide range of conditions.

Segments of the historical headwater sections of the rivers and tributary streams had clear, cool water maintained by springs and groundwater seepage. Conversion of grassland to cropland increased turbidity in small streams, and most of the fish species extirpations occurred in these streams.

Stream widths in the two tributary forks were 18-30 m in the 1860s, but were reduced to 2-20 m by the 1990s, and substrates contained more fine sediments in the 1990s. Lower stream flows have resulted from decreases in surface runoff and base flow.

Changes in fish populations are due to extirpations, range contractions, introductions, and range expansions associated with alteration in physicochemical attributes of the streams as a consequence of agricultural developments and the construction of impoundments.

Geographic location: Kansas, Solomon River basin, eco27, plains, Central Irregular Plains, EPA region 7

Keywords: fish, habitat alterations, turbidity, stream discharge, extirpations, introduction, nonnative species, impoundment, agriculture, eco27

Abstract: We sampled fishes four times each year at 12 sites on the Solomon, North Fork Solomon, and South Fork Solomon rivers in north-central Kansas during 1996 and 1997. Kirwin and Webster reservoirs are located on the North Fork Solomon River and South Fork Solomon River, respectively, and Waconda Reservoir inundates the confluence of these two rivers at the head of the Solomon River. Multivariate analyses identified two fish assemblages that were related to stream discharge. One fish assemblage was associated with stream segments that had lower discharges, such as those located upstream from Kirwin and Webster reservoirs. This assemblage was characterized by equal numbers of extirpations of native species and introductions of nonnative species. The other fish assemblage was associated with the

reservoirs and stream segments that had higher discharges. This assemblage was characterized by a large number of species that were introduced or had immigrated into these areas. For the basin as a whole, 32% of the native species of fishes have been extirpated, and 51% of the present assemblage was comprised of nonnative species. Most of the extirpations and introductions are associated with habitat changes caused by agricultural development and the construction of impoundments. The relatively large component of the fish assemblage comprised of nonnative species reflects the trend toward homogenization of fish assemblages throughout the United States.

Author: Eby, L. A.; Fagan, W. F.; Minckley, W. L.
Year: 2003
Title: Variability and dynamics of a desert stream community
Reference Type: Journal Article
Journal: Ecological Applications
Volume: 13
Issue: 6
Pages: 1566-1579

Value of reference: Minimally disturbed reference streams in desert regions are rare. Aravaipa Creek, a tributary to the San Pedro River in Arizona, retains its historic complement of native fish species, and it is often studied to develop expectations for other desert streams.

Results relevant to EMAP: Seven native fish species inhabit Aravaipa Creek, including 2 federally listed species and five candidate species. The mid- and upper reaches retained the full complement of fish species over the last 30 years, though there was variation in the proportional abundances of the dominant fish species (longfin dace, Gila spikedace, and desert sucker). The lower reaches of Aravaipa Creek did show a decline in species richness, likely due to the invasion of eight exotic species. Two species, spikedace and loach minnow, have disappeared from the lower reaches of Aravaipa Creek; both are susceptible to replacement by the nonnative red shiner

The authors conclude that one of the major factors central to maintaining a full complement of native fish species in desert streams is flow variability. Flash floods and high spring runoff favor native fish that are adapted to such conditions and discourage the establishment and domination of exotic (nonnative) species.

Geographic location: Aravaipa Creek, Sonoran Desert, Region 9, Arizona, San Pedro River, eco23, eco81, xeric

Keywords: Aravaipa Creek, community composition, conservation, desert stream, exotics, fish, flow variability, measures of community change, Sonoran Desert, hydrologic variability, flash floods, runoff, nonnative species

Abstract: Communities can be highly variable over a few years, but remain fairly constant over the long term. Evaluating measures and examining the variability associated with long term change is useful because it increases our understanding of and our ability to predict responses to disturbances. We used long term fish community data from Aravaipa Creek, Arizona, USA, a Sonoran Desert stream, to determine whether there had been long term changes in the community composition, what measures best describe these shifts, and what environmental factors are correlated with the changes. Aravaipa Creek is an intrinsically variable system and one of the few remaining desert streams to support its complete historical assemblage of native fishes. Multivariate analyses illustrated important changes in composition of the native fish community that were not described by traditional measures of persistence and stability. In the early 1980's, changes in community composition were correlated with alterations in base flow, while more recent changes are likely associated with the presence of exotic species. Changes in stream morphology, hydrology, and climate have decreased flow variability, thereby increasing the likelihood of exotic establishment, and may have increased the downstream connection between Aravaipa Creek and the San Pedro River thus increasing the likelihood of repeated invasions by nonnative species. These results support previous research in intrinsically variable desert systems, which conclude that retention of high flow variability is

important to conservation of the native fish community. In addition, although connectivity in aquatic lotic systems is important, isolation from large river systems teeming with exotics may be important in preserving these remnant native fish assemblages.

URL: www.esajournals.org/esaonline/?request=get-toc&issn=1051-0761&volume=013&issue=06

Author: Echelle, A.A.; Luttrell, G.R.; Larson, R.D.; Zale, A.V.; Fisher, W.L.; Leslie, D.M., Jr.
Year: 1995
Title: The Great Plains: decline of native prairie fishes
Reference Type: Report
City: Washington, DC.
Institution: U.S. Department of the Interior, National Biological Service
Pages: 530

Value of reference: This reports specifically on declines of the Arkansas River shiner and the Arkansas River speckled chub, both of which once occurred in the upper Arkansas River in Colorado, as well as other states that are outside the EMAP-West region. The text reports both as historically inhabiting Colorado, although the historical range maps (Figures 1 and 2) do not show historical collections in Colorado. The authors may have used anecdotal information to define historical ranges even if the species were not formally sampled historically in some portions of the basin; however, they do not cite these ancillary sources, if used. The reference is one of very few that represent a modern synthesis of historical fish distributions in the Plains.

Results relevant to EMAP: The Arkansas River shiner was historically widespread in the Arkansas River basin. It has been extirpated from about 75% of the river reaches in its range, as assessed before 1985, and is now considered extirpated in Colorado. It experienced great decline between 1983 and 1985.

The speckled chub occurred throughout the Arkansas River basin, including Colorado. By the early 1990s, the chub had declined notably, and it is believed to be extirpated from Colorado and reduced by about 75% of its total historic range.

Low stream flow during the breeding season, a period historically associated with peak flows, has affected successful reproduction and recruitment. Intensive agriculture has resulted in demand for irrigation water and creation of numerous reservoirs, resulting in degraded habitat Impoundments fragment the landscape, limiting access to suitable habitat and isolating populations.

Geographic location: Colorado, Arkansas River basin, eco26, eco25, plains, EPA region 8

Keywords: fish, habitat fragmentation, altered water flow regime, agriculture, dams

URL: http://biology.usgs.gov/s+t/pdf/Plains.pdf

Author: Erman, N.A.
Year: 1996
Title: Sierra Nevada Ecosystem Project: Final Report to Congress, vol. II, Assessments and scientific basis for management options. Status of Aquatic Invertebrates.
Reference Type: Report
City: Davis, CA
Institution: University of California, Centers for Water and Wildland Resources
Pages: 987-1008
Report Number: Report No. 39

Value of reference: An important paper based upon a systematic review of standard library databases, including taxonomic studies, impact studies, geographic surveys of specific taxonomic groups, and behavioral studies, unpublished, non-refereed reports, and experts on specific taxonomic groups. Museum collection information was not examined.

This resource thoroughly reviews the types of anthropogenic disturbances (mining, logging, damming, diversions, roads, grazing) and associated stressors which have impacted Sierra Nevada streams during the last 200 - 300 years. The author discusses changes in physical habitat, macroinvertebrates, and elaborates on problems associated with reconstructing historic macroinvertebrate distributions in the face of limited reference collections and revisions of taxonomic relationships. This document can be of use for guiding best professional judgment regarding probable changes in macroinvertebrate assemblages and derived metrics following anthropogenic disturbances characteristic to the region.

Results relevant to EMAP: Prior to the immigration of Europeans and Asians 200-300 years ago, the Sierra Nevada systems contained macroinvertebrate taxa characteristic of continuously flowing waters. Major changes in the region have occurred in flow regimes as a result of dams (see Fig. 35.1), sediment budgets, substrate characteristics, stream temperature, and channel morphology. Over the last 200 years, many rock-bottomed perennial streams have been filled with sediment due to hydraulic gold mining activities to the point where surface flow no longer exists (Mount 1995). Dispersal barriers have been destroyed, major changes have occurred to riparian vegetation, streams have been intentionally poisoned with rotenone and actinomycine, and unintentionally contaminated with heavy metals, herbicides, and pesticides. Nonnative organisms have been both intentionally and unintentionally introduced.

As a result of these changes, the author uses deductive reasoning to conclude that there has probably been a reduction in macroinvertebrate richness, macroinvertebrate species diversity, and relative abundance of certain species in streams. In reservoirs, portions of streams that once contained fauna characteristic of free-flowing water, such as Plecoptera for example, are now dominated by taxa characteristic of habitats where sediments accumulate, such as burrowing Chironomidae larvae, other midges, and oligochaetes.

Habitat destruction such as alteration of natural hydrology and accumulation of excess sediment is of special concern due to the high degree of endemism in the region. Twenty five percent of known Plecoptera species, 19% of Trichoptera, 9% of Blephariceridae midges, 25% of Deuterophlebeiidae midges, 20% of molluscs, and 10% of fairy and brine shrimp (*Anostraca*) are endemic. The author stresses, however, that a systematic survey of aquatic macroinvertebrates has yet to be conducted in the Sierra Nevada. While some groups have been reasonably well surveyed, such as Plecoptera and Trichoptera, others require more attention, such as Diptera and Ephemeroptera.

Geographic location: EPA Region 9, California, Sierra Nevada, mountains, Eco5

Keywords: macroinvertebrates; fish; pre-European; change; Sierra Nevada; California; dams; water diversion; roads; mining; grazing; sediments; intentional invertebrate introductions; opossum shrimp; *Mysis relicta*, signal crayfish; *Pacificasticus leniusculus*; rotenone; antimycin

Abstract: The aquatic invertebrate fauna of the Sierra Nevada is diverse and extensive, with many endemic species throughout the range. Aquatic systems differ widely in the Sierra because of such natural factors as elevation, climate patterns, geology, substrate type, water source, water volume, slope, exposure, and riparian vegetation. These differences are reflected in the aquatic invertebrate fauna. Small, isolated aquatic habitats such as springs, seeps, peatlands, and small permanent and temporary streams have a high probability of containing rare or endemic invertebrates. Aquatic invertebrates are a major source of food for birds, mammals, amphibians, reptiles, fish, and other invertebrates in both aquatic and terrestrial habitats. Changes in a food source of such importance as aquatic invertebrates can have repercussions in many parts of the food web. The life cycles of aquatic invertebrates are intricately connected to land as well as water, and the majority of aquatic invertebrates spend part of their life cycle in terrestrial habitats. Aquatic invertebrates are affected by human-caused activities on land as well as activities in the water. Land and water uses and impacts are reflected in species assemblages in streams and lakes. Changes in aquatic invertebrate assemblages have been used for many decades to monitor impacts on land and in water. However, the level of detail of most monitoring is not sufficient to track species losses in aquatic invertebrates. Aquatic invertebrates have not been inventoried or well-studied at the species level in most of the Sierra. Aquatic invertebrates are rarely considered or evaluated in environmental impact assessments in the Sierra. Major changes have occurred in aquatic and terrestrial habitats in the Sierra of the last 200 years: we must logically assume that corresponding changes have occurred in aquatic invertebrate assemblages.

Notes: Mount, J.F. 1995. California rivers and streams: The conflict between fluvial process and land use. Berkeley and Los Angeles: University of California Press.

URL: http://ceres.ca.gov/snep/pubs

Author: Evermann, B.W.
Year: 1891
Title: A Reconnaissance of the Streams and Lakes of Western Montana and Northwestern Wyoming
Reference Type: Journal Article
Journal: Bulletin of the United States Fish Commission
Volume: 11
Pages: 3-60

Value of reference: This is a primary data source that reports the physical and natural-history features of the streams and lakes of the region, including size, depth, current, stream obstructions, source of water, water temperature, water clarity, composition of bottom and banks, human impacts, fish species, abundance, size, condition, and distribution, and invertebrates (crustaceans, insects, mollusks) that could be fish prey. The authors had a particular focus on geographical distribution of fishes and attempted to trace the limits in the range of species. All waters examined are given, which include locations on the Clarke Fork and Snake River of the Columbia basin and the Yellowstone River, Madison, River, Gallatin River, Jefferson River, and Prickly Pear Creek of the Missouri River basin.

The first part of the report is a series of description of the streams visited, including physical habitat, and lists of fish, invertebrates, and frogs present. The second part is an annotated list of each fish species, including all the locations where it was found and the number of each that were collected. This section also contains species descriptions and taxonomic notes. The third part is an annotated list of reptiles and batrachians collected.

This information is valuable for constructing the historical distribution of indigenous fish species in the region and to assign the presence of invertebrates and amphibians to particular streams. It may also be useful for comparing historical physical habitat attributes with current conditions.

Results relevant to EMAP: The total collection of indigenous fish obtained on this expedition was only 16. The author was confident that it represented the fish fauna of the region fairly well. The species included genera in the following families: Catostomidae, Cyprinidae, Salmonidae, Cottidae, and Gadidae. Four introduced Salmonids were also noted. Reports of amphibians and reptiles were incidental, i.e., no time was devoted to searching for them. Nevertheless, over 2 pages of the report are devoted to reporting results of findings of (primarily) amphibians in the genus *Rana*.

The report should be consulted for details of fish species occurrences and physical habitat descriptions of the streams visited.

Geographic location: Montana, Wyoming, Columbia River basin, Missouri River basin, Clarke Fork River, Snake River, Yellowstone River, Madison River, Gallatin River, Jefferson River, Prickly Pear Creek, EPA region 8, mountains, eco17

Keywords: fish, amphibians, phab, macroinvertebrates, historical data, historical distribution, primary source

Author: Evermann, B.W.
Year: 1896
Title: A report upon salmon investigations in the headwaters of the Columbia River, in the state of Idaho, in 1895 together with notes upon the fishes observed in that state in 1894 and 1895
Reference Type: Report
City: Washington, D.C.
Institution: Government Printing Office

Value of reference: This report covers 2 areas in central Idaho: 1) the headwaters of the Salmon River and 2) several inlets and outlet streams in the Redfish Lakes region on the west side of the Salmon River Valley at the east base of the Sawtooth Mountains. The first part of the report describes physical habitat (riparian vegetation, width, depth, sediment type, woody debris, water temperature) and presence of salmon and other fish species, as well as extent of spawning habitat in the inlet and outlets streams and in Salmon River headwater tributaries.

The second part is a detailed report on each species of fish observed, including information about relative abundance and distribution and specific tributary streams where each species was seen or collected. Known distribution and abundance of each species in other portions of the Snake or Columbia basins is also mentioned for some of the species. The focus of the report is salmon, particularly the sockeye; therefore these species receive more treatment in the text. The report is an important synopsis of historical fish distribution in an area that is not often reported in the historical literature (see other citation in Notes section below). It also documents the distribution of chinook and sockeye salmon and gives other detailed descriptions, such as length and weight of individuals collected.

Results relevant to EMAP: The report covers 21 species of fish from the central region of Idaho, including lamprey, sturgeon, suckers, chubs, shiners, dace, whitefish, salmon, steelhead, bull trout, and sculpins. Details about distribution, relative abundance, and stream physical habitat descriptions occur throughout; the report should therefore be consulted for specific information.

Geographic location: Idaho, eco16, EPA region 10, mountains, Salmon River basin

Keywords: fish, phab, historical data, primary source, baseline information

Notes: A related document focusing on salmon in the same region:

Evermann, B.W. 1896. A preliminary report upon salmon investigations in Idaho in 1894. Bulletin of the U.S/ Fish Commission 1896:253-284.

Author: Evermann, B.W.; Cox, U.O.
Year: 1896
Title: Report upon the Fishes of the Missouri River Basin
Reference Type: Report
City: Washington, D.C.
Institution: U.S. Commission of Fish and Fisheries

Value of reference: This primary source is an excellent synthesis of the fishes known to the Missouri River basin in the late 1800s. The report is presented in four sections, beginning with results of fish examinations done in various streams the authors visited in South Dakota, Nebraska, and Wyoming in 1892-1893. Results include physical habitat descriptions of streams visited and a notations of fish in each location. Following that report is an annotated bibliography (in chronological order) of the ichthyology of the entire Missouri River basin, including all known faunal lists at the time. Complete citations of these works is given for further consultation, if desired. Each entry lists the locations examined, a list of the fish species found and their locations. Next is an annotated list of the fishes based on sources listed in the bibliography, including all the locations in the basin where each species had been documented prior to 1896. This section can be cross-referenced, by source, with the annotated bibliography in the preceding section. Finally, the table on pages 426-428 summarizes the occurrence of 143 fish species by state in the Missouri River basin. In addition to these 143 species, a list of 74 nominal species is given on pages 424-425; of these, 52 had been recognized at the time of this report.

This is an important historical synthesis and would be useful for reconstructing historical ranges and fish communities before major fish introductions and interbasin transfers had occurred. It may also be useful for comparing historical and current physical habitat attributes of streams and river tributaries.

Results relevant to EMAP: Lists of fish species, by sub-basin and state, and physical habitat descriptions (for sites visited in South Dakota, Nebraska, and Wyoming in the late 1800s) can be found in detail in this report. The results synthesize what had been published on species occurrences in the basin, beginning with the explorations of Lewis and Clark in 1803-06. The report should be consulted for details.

The total number of species and subspecies of fishes known from the Missouri Basin in 1896 was 143. These were distributed among 24 families and 68 genera (see table, pages 426-428), and among 9 states. The majority of species occurred in non-EMAP states in the lower basin and in the eastern portion of the basin; only 55 species were known from North Dakota, Montana, Wyoming, and Colorado, and 10 of those were endemic. The authors present a section on the unique community of 15 species found in the isolated Black Hills region. They also acknowledge introduced species--notably carp, rainbow trout VonBehr trout (brown trout), and Eastern brook trout. They note that there may be others that have been introduced by state fish agencies, but do not provide any further detail about nonnative species (possibly there were not many to report).

Geographic location: Missouri River basin, Montana, North Dakota, South Dakota, Wyoming, Colorado, eco17, eco18, eco26, eco21, eco42, eco43, eco46, eco25, plains, mountains, xeric, EPA region 8

Keywords: fish, phab, historical data, Missouri River basin, historical occurrence, primary source

Notes: This report is Appendix 5 from the Report of the U.S. Commissioner of Fish and Fisheries for 1894, pages 325-429. It was extracted and published as a stand-alone report.

Author: Evermann, B.W.; Rutter, C.
Year: 1894
Title: The Fishes of the Colorado Basin
Reference Type: Journal Article
Journal: Bulletin of the United States Fish Commission
Volume: 9
Pages: 473-486

Value of reference: This is a frequently-cited, early, primary data source that presents a comprehensive synthesis of the earliest documentations of fishes in the Colorado River basin, based on publications dating from 1848 to1891. An annotated bibliography (18 citations) of the ichthyology of the Colorado Basin is included to provide the background material the authors use to construct, in chronological order, the different places in the Colorado Basin where each species was recorded during the period of 1849-91. Since fish documentation was not based on surveys or a systematic census, the data indicate only presence (not absence); the historical accounts also differ in their geographic scopes. The paper lists, by species, locations where present, as reported in the literature (all of which is referenced in the annotated bibliography). Most of the historical collections on which this work was based were made in river tributaries of the Colorado River.

Results relevant to EMAP: Thirty-two native fish species, representing 5 families and 18 genera, were recognized for the Colorado Basin by 1891 (list by family and genus, with number of species in each genus is given in this publication). The Cyprinidae, by far, contained the greatest number of species, comprising almost 60% of the species, followed by Catostomidae with 25% of the species. Approximately 78% of the species of fishes known in 1891 from the CO Basin were endemic.

The approximate locations where each species was documented on each tributary are given in tabular format for each species separately. These lists are cross-referenced with the citations in the annotated bibliography. The text contains scattered notes about relative abundance (e.g., common, abundant...) for some of the species.

Geographic location: Colorado River basin, EPA Region 8, EPA Region 9, xeric, mountains, eco21, eco22, eco23, eco20, eco18, eco81, Colorado, Wyoming, Utah, Arizona, New Mexico

Keywords: fish, historical data, geographic distribution

Author: Fausch, Kurt D.; Bestgen, Kevin R.
Year: 1997
Title: Ecology of fishes indigenous to the Central and Southwestern Great Plains
Reference Type: Book Section
Editor: Knopf, Fritz L.; Samson, Fred B.
Book Title: Ecology and Conservation of Great Plains Vertebrates.
City: New York, NY
Publisher: Springer
Pages: 131-166
Series Title: Ecological Studies 125

Value of reference: Journals from early scientific expeditions, such as John C. Fremont's two trips up the Platte River system in 1842 and 1843 are assumed to be accurate representations of undisturbed Plains ecosystems. However this information is sparse and does not include detailed accounts of fish assemblages of the time. Little is known about the indigenous fishes of the Great Plains, especially considering the extensive modification of aquatic environments that began about 1860. Distributions of some species were likely altered by transfers among waters, whereas others were probably locally extirpated before any specimens were collected.

This chapter attempts to draw together information about the distribution and ecology of fishes indigenous to the central and southern Great Plains, a region encompassed largely by upstream reaches of the Platte, Kansas, Arkansas, Canadian, and Pecos rivers; includes pre-settlement and post-settlement information.

Chapter includes descriptions of the physical characteristics of Plains streams and what is known of the original fish fauna and its characteristics, reproductive ecology of Plains fishes, and factors influencing variability of populations and assemblages. Summary is a synthesis of ecological mechanisms with broad implications for conservation of plains fishes of the region.

Results relevant to EMAP: Describes the ecology of the region; based on historic data and current information about the biota, streams, and physical characteristics of the streams and landscape.

Chapter highlights what is known about the distribution of fish fauna and factors influencing variability of populations and assemblages.

This provides a synthesis of the changes in fish distribution, assemblages, and habitat that have occurred since settlement due to factors like; impoundments, water diversions; introductions, etc.

Geographic location: Colorado, Platte River, Kansas River, Arkansas River, Canadian River, Pecos River, eco 25, High Plains, eco27 Central Irregular Plains, plains, EPA region 8

Keywords:
Great plains, plains, phab, fish, native species, pre-settlement, water diversion, impoundments,

Abstract: The Great Plains of western North America are a harsh environment for fishes. Due to the increasing aridity and general lack of permanent water one finds traveling westward across the Plains, even trained biologists rarely consider fishes or their habitats when transversing the region. The same was true of early explorers. For example, none of the four scientific expeditions that ascended the Platte River in the first half of the 1800s described

Plains fishes, whereas flora and other fauna were collected and described extensively (e.g. Fremont expedition , 1843-1843; Jackson and Spence 1970). Indeed, no collections of fish from the Plains region of the South Platte River Basin in Colorado were preserved until 1873 (Cope and Yarrow 1875).

It is therefore not surprising that relatively little is known about the indigenous fishes of the Great Plains, especially considering the extensive modification of aquatic environments that began about 1860 (Eschener et al. 1983). Distributions of some species were likely altered by transfers among waters, whereas others were probably locally extirpated before any specimens were curated (cf. Jordon 1891). Moreover, little is known about the basic life history of many fishes that range widely throughout the Plains, and even less is understood about the ecology of other biota in Plains streams and riparian zones (Matthews 1988, Zale et al. 1989, Brown and Mathews 1995). This information is urgently needed, due to the continued acceleration of human degradation and loss of species populations from these aquatic ecosystems (Cross and Moss 1987).

Our goal in this chapter is to draw together information about the distribution and ecology of fishes indigenous to the central and southern Great Plains, a physiographic region encompassed largely by upstream reaches of the Platte, Kansas, Arkansas, Canadian, and Pecos rivers (Cross et al. 1986) (Fig 6.1). We emphasize the Platte and Arkansas rivers in eastern Colorado and the Pecos River in New Mexico, because we have firsthand knowledge and experience in these basins. However, we incorporate literature from other Plains rivers and from similar rivers in the adjacent Central Lowlands to the east, where appropriate.

Because one can interpret little about the ecology of organisms without understanding the physical template to which they are adapted (cf. Southwood 1988), we begin by describing the physical characteristics of Plains streams. We then discuss what is known of the original fish fauna and its characteristics, reproductive ecology of Plains fishes, and factors influencing variability of populations and assemblages. We end by attempting a synthesis of ecological mechanisms with broad implications for conservation of plains fishes of the region and by summarizing needs for further research.

Author: Fisher, R. N.; Shaffer, H. B.
Year: 1996
Title: The decline of amphibians in California's Great Central Valley
Reference Type: Journal Article
Journal: Conservation Biology
Volume: 10
Issue: 5
Pages: 1387-1397

Value of reference: This is one of a very few historical trend analyses of amphibians in the western United States.

Results relevant to EMAP: Historical distribution data were compiled for six native species of amphibians based on museum specimens (see Notes below) for the Sacramento Valley, San Joaquin Valley, and the Coast Range near San Francisco. These data were compared with field data collected between 1986 and 1994 at 315 ponds distributed across the same geographic area to document species declines. Six amphibian species were historically widespread in this habitat and a single aquatic breeding site would generally contain between two and five species.

Results record a statistically significant decline in the number of species currently found in most counties compared with that found historically. Declines varied from 1 out of 28 counties lost for Pacific treefrog (*P. regilla*) to 24 out of 28 counties lost for California red-legged frog (*R. aurora*). Graphs and distribution maps are given for 5 species (four natives plus introduced bullfrog) showing historical records compared to recent detections. Table 1 shows that there is a significant inverse relationship between introduced exotics and native amphibians. For three species, historical localities were significantly lower in elevation than are current viable populations. Most of low elevation sites sampled were unoccupied by native species, compared with their historical pattern of distribution, implying they have been lost from these areas.

Causes of decline are attributed to exotic and introduced species predation and competition, pond alteration or loss.

Geographic location: xeric, Central Valley, California, coast range, San Joaquin valley, Sacramento valley, eco6, eco7, EPA Region 9

Keywords: amphibians, historical data, museum records, California newt, California tiger salamander, Pacific treefrog, western spadefoot toad, western toad, California red-legged frog, bullfrog, nonnative species, habitat degradation, habitat loss

Abstract: Declines in amphibian populations are rarely reported on the community or ecosystem level. We combined broad-scale field sampling with historical analysis of museum records to quantify amphibian declines in California's Great Central Valley. Overall, amphibians showed an unambiguous pattern of decline, although the intensity of decline varied both geographically and taxonomically. The greatest geographical decline was detected in the counties of the Sacramento and San Joaquin valleys. Two species, *Rana aurora* and *Bufo boreas*, were identified as the most affected by decline, whereas *Pseudacris regilla* was the least affected. The Coast Range counties had little or no detectable decline. We provide new evidence implicating introduced predators as a primary threat. Introduced predators occur at lower elevations than native species, and our data indicate that for some native species there has been significant restriction to higher elevation sites from a formerly broader distribution. Our historical approach provides a strategy for identifying declining amphibian communities that

complements more detailed, long-term monitoring programs and provides an assessment of the pattern of change that is a necessary prerequisite for the development of field experiments that test hypothesized mechanisms of change.

Notes: See Schaffer et al. 1998 in this bibliography for general discussion of the use of museum specimens for reconstructing historical aquatic communities.

Author: Frissell, C.A.
Year: 1993
Title: Topology of extinction and endangerment of native fishes in the Pacific Northwest and California (U.S.A.)
Reference Type: Journal Article
Journal: Conservation Biology
Volume: 7
Issue: 2
Pages: 342-354

Value of reference: Existing information is synthesized into a synoptic map of WA, OR, ID, and CA with isopleths showing patches representing numbers of native fish species extinct, endangered, or threatened. Also included is Table 1, listing basins in CA, OR, and WA, the number of native fish taxa in each, and the proportions that are extinct, endangered, threatened, or of special concern. The mapping procedure can identify regions and ecosystems at high risk, which can be targeted for more intensive monitoring.

Results relevant to EMAP: The native ichthyofauna that has become extinct, endangered, or threatened (EET) is highest in CA (mean 48%), lower but still high in OR (mean 33%) and lowest in WA (mean 13.5%); the proportion of native fauna that is EET declines as native species richness in the basin increases.

The spatial patterns of EET are influenced more by the many basin-specific population groups of seven widely distributed species of anadromous salmonids than by the more than 60 locally endemic species and subspecies of suckers, minnow, pupfishes, and other fishes.

The simultaneous decline of numerous taxa in basins with and without dams or diversions suggests that cumulative damage to aquatic habitats caused by logging, grazing, urbanization, and other land uses plays a major role in ichthyofaunal impoverishment.

Geographic location: mountains, xeric, eco1, eco3, eco7, eco6, eco78, west coast, California, Oregon, Washington, EPA Region 9, EPA Region 10

Keywords: fish, status, extinction, mapping, dams, logging, grazing, urban

Abstract: Recent studies have provided a broad data base on extinction and endangerment of species, subspecies, and distinct populations of inland fishes in western North America. Development of a synoptic, regional-scale image of extinction and risk of extinction is complicated by the small size and linear distribution of fluvial aquatic habitats and by interspecific variation in areal extent of populations. I developed a regional map of extinction-risk isopleths based on the number of extinct and persistently declining species in drainage basins of the Pacific Northwest and CA. This topological synthesis is useful for delineating and monitoring areas of historic and ongoing loss of aquatic biodiversity, and for relating losses to patterns of land use and habitat modification, climate, hydrology, and geomorphology. From an ecological perspective, endangerment of numerous indigenous populations of seven widely distributed species of anadromous salmonids in this region is as important as the more local, diffuse effects of declines in more than 60 endemic, non-anadromous species and subspecies. The simultaneous decline of numerous taxa in basins not afflicted with dams or diversions suggests that cumulative damage to aquatic habitats caused by logging, grazing, urbanization, and other land uses plays a major role in ichthyofaunal impoverishment.

Author: Fulton, L.A.
Year: 1968
Title: Spawning areas and abundance of chinook salmon (*Oncorhynchus tshawytscha*) in the Columbia River Basin--past and present
Reference Type: Report
City: Washington, D.C.
Institution: U.S. Department of Interior. Fish and Wildlife Service, Bureau of Commercial Fisheries
Report Number: Special Scientific Report--Fisheries No. 571

Value of reference: This article shows status and trends based on run estimates for a middle period of time (1930s to 1960s), as well as the commercial catch trend for the Columbia River, 1865-1962 (see Figure 1) as an indicator of chinook salmon population changes through time. Since much degradation had already occurred by the 30s, the 1930s numbers of salmonids are probably lower than pre-settlement, but estimates still represents a period when chinook salmon were much more numerous and widely distributed than today. The losses of spawning areas since the 30s indicate changes in distribution, reduction in range, habitat destruction, physical barriers, and impacts on reproduction. Locations of spawning areas and their status (past and present) are given in a tabular format for multiple tributaries of the Columbia River basin.

Results relevant to EMAP: Commercial catch trends for Columbia River 1865-1962 were fluctuating but stable from the late 1800s through 1920, but then fell to about 1/3 the previous numbers. This decline was attributed to advancing civilization in the PNW--irrigation, logging, mining, dam construction, and other activities reduced the size and capacity of spawning areas; for most species, many spawning areas had been completely lost by 1968.

Spring and summer runs of chinook in the Columbia River 1939-55 (excludes catches by sport fishery in the ocean and lower Columbia River, landings by the offshore troll fishery, and escapement to tributary streams entering the Col River below Bonneville Dam with the exception of the Willamette River run) had an increasing trend. Runs of fall chinook in the Columbia R. and escapement to areas above Bonneville Dam (excludes same as above), 1938-66, showed a fairly steep declining trend.

Geographic location: Columbia River basin, mountains, xeric, eco1, eco3, eco4, eco2, eco10, eco11, eco15, eco16, eco12, eco17, eco9, Washington, Oregon, Idaho, EPA Region 10

Keywords: fish, Chinook salmon, water diversion, logging, mining, dams

Abstract: Chinook salmon, the most abundant species of salmon in the Columbia Basin, formerly spawned in nearly all tributaries of the Columbia River and in many areas of the main river. Over the past 60 years, the construction of dams has inundated, impeded, or blocked access to spawning areas. Despite these heavy losses, large areas of spawning grounds in the middle and lower portions of the drainage are still available to chinook salmon. Stream improvements by State and Federal fishery agencies have rehabilitated some areas and have brought others into production for the first time. Important spawning areas are listed and charted in this report according to their past use (before 1965) and present use (1966). Estimates of recent spawning populations in major tributaries and in segments of the main stem are also given. Former and present levels of abundance are listed according to three major runs--spring, summer, and fall.

Notes: This reference is a companion to Fulton 1970, which provides synopses for steelhead trout, coho, chum, and sockeye salmon

Author: Fulton, L.A.
Year: 1970
Title: Spawning areas and abundance of steelhead trout and coho, sockeye, and chum salmon in the Columbia River Basin--past and present
Reference Type: Report
City: Washington, D.C.
Institution: U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service
Report Number: Special Scientific Report--Fisheries No. 618

Value of reference: Conditions in the mid to late 1800s are scattered throughout this document, much in the form of commercial catch or production records, which are used as surrogates of relative population sizes. Also shown are status and trends for 1930s to 1960s, using run counts. Spawning areas and their status (past/present) are given per creek or river in a tabular format.

Results relevant to EMAP: The Columbia river run and commercial catch estimates have fluctuated greatly with time, but the general trends have been substantial declines for all four species since the turn of the century. Coho had a slight rebound in the early 60s; chum were practically extinct at the end of the 1960s. Tabular detail in the paper shows how the changes in spawning ranges contributed to the declines in each tributary in the Columbia River drainage, by species, for 1938-66 (fish runs) and 1890/1900 --1966 (commercial catch).

Declining catches and loss of spawning areas are attributed to logging, highway construction, agricultural cultivation, placer mining, and dumping of wastes. Report lists parts of subwatersheds where these fish species once spawned and where they no longer occurred in 1969.

Geographic location: Columbia River basin, mountains, xeric, Oregon, Washington, EPA Region 10, eco10, eco4, eco11, eco 15, eco16. eco3, eco9

Keywords: fish, salmonids, logging, roads, agriculture, mining, pollution, dams, water diversion

Abstract: Past spawning areas (those removed from use before 1969) and present ones (those in use in 1969) are described for steelhead, trout, *Salmo gairdneri*; coho salmon, *Oncorhynchus kisutch*; sockeye salmon, *O. nerka*; and chum salmon, *O. keta*. The different species characteristically spawn in the following areas: 1) steelhead trout--in streams of all sizes (widely dispersed throughout the watershed, 2) coho salmon--in small streams (mostly in the lower tributaries) and in a few areas in the middle watershed, 3) sockeye salmon--in lakes and tributaries of lakes (in the middle portion of the watershed), and 4) chum salmon--in lower portions of tributaries that enter the Columbia River below The Dalles dam. All four species have lost many spawning areas because of water-use developments and changes in the watershed resulting from logging, highway construction, agricultural cultivation, placer mining, and dumping of wastes. Serious depletion of the runs of all four species is evident from the available data (the commercial catches before 1938 and since 1938 augmented by information on escapement and sport catch). The future prospects are fair for steelhead trout, good for coho salmon, and poor for sockeye and chum salmon.

Notes: This reference is a companion to Fulton 1968, which provides similar synopses for Chinook Salmon

Author: Gerstung, E.R.
Year: 1988
Title: Status, life history, and management of the Lahontan cutthroat trout
Reference Type: Journal Article
Journal: American Fisheries Society Symposium
Volume: 4
Pages: 93-106

Value of reference: This is the most complete summary found of the decline of the Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) and its causes. It thoroughly describes the historic distribution and decline separately for 5 sub-basins: Truckee River, Carson River, Walker River, Humboldt River, and Smoke Creek/Black Rock sub-basins. Populations that have been established outside their native waters of the Lahontan Basin, as a result of stocking hatchery-reared fish, are also covered.

Although possibly not of as much use to EMAP, this publication also summarizes the life history of Lahontan cutthroat trout, including migration, breeding, habitat preferences, feeding, and growth. In full, it is an excellent synopsis of the species and its historical and current status (as of 1988).

Results relevant to EMAP: At the time of early settlement of the region, Lahontan cutthroat trout reportedly existed in waters throughout the basin, including most cooler perennial streams downstream from impassable falls, totaling at least 6,100 km of stream habitat (as well as in 11 lakes). A map is included (Figure 1) that shows the probable historic and present distribution of the trout in the 5 sub-basins of the region. Also shown are the locations of introgressed populations. Following European settlement, the species was extirpated from much of the native range. Currently (1982) self-sustaining populations are found in a total of only 490 stream miles, which represents only 7% of the historic range in stream habitats.

Historical distributions are described in detail for each of the sub-basins and contrasted with the subspecies' current distribution; reasons for decline are given for each as well. Table 1 gives the probable historic and present (1982) habitat extent (stream km) for each of the sub-basins. From this, one could calculate the percent of probable historic stream km occupied presently.

There is dispute among authors over whether the Humboldt River sub-basin populations are the same subspecies as those in other sub-basins, but they are covered here as if they are the same. The Humboldt populations differ taxonomically and also seem better adapted for life in a fluvial system than in a lacustrine one.

Reasons for severe decline of this subspecies include over-fishing, competition and interbreeding with nonnative trout, construction of dams, water diversions, and general habitat degradation.

Geographic location: Nevada, California, Lahontan basin, eco80, eco13, eco5, EPA Region 9, xeric, mountains

Keywords: fish, fishing, nonnative species, dams, water diversion, habitat degradation

Abstract: The Lahontan cutthroat trout *Salmo clarki henshawi* is believed to have occupied at least 6,100 km of stream habitat and 135,000 ha of lake habitat in its historic range. Some lake populations such as those in Lake Tahoe, California-Nevada and in Pyramid and Walker lakes

in Nevada were large enough to support thriving commercial fisheries. Pure self-sustaining stocks of Lahontan cutthroat are now limited to headwater streams within the Humboldt River drainage, to Summit and Independence lakes, and to several small tributaries of the Truckee, Carson, and Walker rivers. A small number of additional populations have been established outside the Lahontan Basin in both California and Nevada by transplants and hatchery production in each of these states. Self-sustaining Lahontan cutthroat trout populations are known to occur in 100 locations, representing about 7% of the historic stream habitat and 0.4% of the historic lake habitat. Competition from and hybridization with introduced nonnative trout, the construction of dams and diversions on important spawning streams, and water quality deterioration are largely responsible for the decline of Lahontan cutthroat trout. Restoration efforts in California and Nevada will involve, eliminating nonnative trout from selected streams, restocking with endemic stocks where possible, and improving and protecting habitat. Hatchery-reared stocks will continue to be utilized in various lake and reservoir recreational fishing programs, including those existing in Pyramid and Walker lakes.

Notes: Dunham et al. (1997) (citation below) discuss the effects of habitat fragmentation and loss of connectivity throughout the range of this trout as being a major obstacle in its survival as a subspecies.

Dunham, J.B., G.L. Vinyard, and B.E. Rieman. 1997. Habitat fragmentation and extinction risk of Lahontan cutthroat trout. North American Journal of Fisheries Management 17:1126-1133.

Author: Gilbert, C.H.; Evermann, B.W.
Year: 1894
Title: A report upon investigations in the Columbia River basin, with descriptions of four new species of fishes
Reference Type: Journal Article
Journal: Bulletin of the United States Fish Commission
Volume: 1
Pages: 169-207

Value of reference: This is a detailed primary literature source reporting fish specimens collected as part of a survey begun in 1892 to locate a hatchery site in the Columbia basin. It contains a list of the river tributaries and streams examined and a report on each, including brief descriptions of physical habitat (substrate, riparian vegetation, water temperature, channel width, depth, nature of banks, pools, and current), general abundance of fish, and a short list of the dominant fish species. Following stream descriptions is a list of fish species, the locations where they were collected, and the numbers collected. Results are useful for determining historical presence and distribution. Report contains scattered anecdotal notes on what was known about distribution and abundance based on surveys or other work prior to 1892.

The information about fish presence and relative abundance would be useful for reconstructing historical ranges and fish assemblages in river tributaries. Some reconstruction of taxonomy based on type specimens and location from the historical text would be necessary for interpreting results and making comparisons with present-day taxonomy. A variety of physical habitat information can also be extracted from this source for use in reconstructing historical physical conditions for specific streams in the Columbia basin.

Results relevant to EMAP: A variety of baseline data can be extracted from this document, including fish species presence, relative abundance, and dominance in various tributary basins, as well as physical habitat features of streams.

The specimens collected include lamprey, sturgeon, suckers, minnows, chub, squawfish, dace, salmon, steelhead, trout, and sculpin; mention also of carp, which at that time had been recently introduced.

Geographic location: Columbia River basin, Oregon, Washington, Idaho, EPA Region 10, mountains, xeric, eco10, eco11, eco12, eco16, eco15, eco9, eco4, eco3, eco1

Keywords: fish, phab, historical data, fish presence, fish abundance

Author: Gilbert, C.H.; Scofield, N.B.
Year: 1895
Title: Notes on a collection of fishes from the Colorado basin in Arizona
Reference Type: Journal Article
Journal: Proceedings of the U.S. National Museum
Volume: 20
Issue: 1131
Pages: 487-499

Value of reference: This account details the occurrence in the Colorado River basin of 19 fish species in the late 1800s. It also makes corrections to a previous collection and archival account by Evermann and Rutter (1894, this bibliography).

Results relevant to EMAP: The primary objective of the research expedition was to investigate the alleged occurrence of shad in the Lower Colorado. In the process, the authors made reports and descriptions of other fish they found and their locations in the lower basin. Therefore, this was not a complete or systematic survey of the river basin, but it can be used for developing a list of species and general locations where species were present in the late 19th century.

The number of specimens (or relative number, e.g., "numerous specimens"), collection locations, and sometimes the relative abundance at the location are given at the beginning of each species account for each of 19 species. Locations are specified very generally, e.g., "in the Salt River at Tempe, AZ"; "Chino, AZ, in a tributary of the Rio Verde". The great majority of text is descriptions of fish and not of much use to EMAP. It is a good supplement to the 1894 account of Colorado Fishes by Evermann and Rutter (in this bibliography) for describing historical fish community composition and species distributions.

Geographic location: Colorado River Basin, Arizona, eco81, eco23, eco22, eco14,eco20, EPA Region 9, xeric

Keywords: fish, historical data

Notes: This reference is a supplement to Evermann and Rutter (1894)--in this bibliography

Author: Gilbert, E.W.; Litt, B.
Year: 1966
Title: The exploration of Western America 1800 - 1850
Reference Type: Book
City: New York
Publisher: Cooper Square Publishers, Inc.
Number of Pages: 233
Original Publication: 1933
Reprint Edition: 1966

Value of reference: These early explorations of the west are the first observations of the region by European-Americans. Observation of the landscape and plants and animals of the area help establish what pre-settlement conditions were like. This book contains documentation of several explorations ranging from 1800 to 1850 and provides good descriptions of the physical habitat, geology, flora and fauna of the region..

Results relevant to EMAP: The book contains chapters on the Physical geography, climate, natural drainage, natural vegetation, and animals of the region. In addition to overall descriptions of the landscape, many of the expeditions include information about the characteristics of the streams and rivers. This mainly consists of physical characteristics including: flow, sinuosity, riparian vegetation, and some fish information. This baseline is helpful in establishing pre-settlement condition of the streams before navigation and irrigation modifications had been made.

The chapters require some sifting through to extract pieces of anecdotal information or to reconstruct stream related attributes, however; the information is quite valuable and may be the only source of pre-settlement conditions of the region. This is a good broad reference and inventory that includes specific information about pre-settlement conditions.

Geographic location: Western United States, North Dakota, South Dakota, Nebraska, Kansas, Missouri, Colorado, Wyoming, Oregon, Washington, Utah, EPA Region 7, EPA Region 8, EPA Region 9, eco47, eco27, eco25, eco44, eco42, eco46, eco17, eco18, eco21, eco17, eco80, eco16, eco15, eco3, eco4, eco10, eco11

Keywords: exploration, phab, resource inventories, pre-settlement condition, historic condition, historical geography, geology, expeditions

Author: Gregory, S.C; Deacon, J.E.
Year: 1994
Title: Human induced changes to native fishes in the Virgin River drainage
Reference Type: Book Section
Editor: Marston, R.A.
Book Title: Effects of Human Induced Changes on Hydrologic Systems.
City: Middleburg, VA
Publisher: American Water Resources Association
Pages: 435-444
Series Title: Technical Publication Series No. 94-3

Value of reference: Article addresses the native fish of the Virgin River, the impacts that have caused their declines beginning in the 1930s, and the reduction of these species from different parts of the drainage. It is a good and thorough synopsis, including graphics of the trends in native and nonnative species abundances, and describing the trends in species distribution in different sections of the drainage as a result of multiple impacts.

Results relevant to EMAP: Despite early settlement of the Virgin River, (1850s-90s), the six native fish species of the Virgin River remained relatively unaffected until large scale habitat changes occurred, beginning in 1935 with the Hoover Dam, which eliminated the native fish community in the lower 25 miles of the river.

Tributary populations were depleted in the 1960s and 1970s due to reservoir construction and dewatering (diversions) and poisoning of fish, followed by introduction of trout and cattle grazing, while middle mainstream fishes were most affected during 1980s by municipal and agricultural water management that altered both variability and volume of flow and by the upstream invasion by the introduced red shiner.

Today, the Virgin chub and woundfin are federally endangered, and the Virgin spinedace is a candidate for threatened status--all three are endemic to the Virgin River. Water diversions and dewatering is the greatest threat to native fish, followed by dams and other flow alterations; more recently, population pressures and municipal water development projects have put demands on the river.

Geographic location: xeric, eco20, eco22, eco14, Nevada, Utah, Arizona, Virgin River basin, EPA Region 8, EPA Region 9

Keywords: fish, historical data, dams, nonnative species, grazing, water diversion, fish poisoning, endangered species, Federal Reserved Water Rights

Abstract: The Virgin River originates in southwestern Utah and joins the Colorado River in southern Nevada where it flows into the Overton Arm of Lake Mead. Analysis of a considerable database on native fishes collected over the past 17 years, supplemented by historical records, reveals reductions in both distribution and abundance of the native fish community. Following construction of Hoover Dam, Lake Mead flooded the lower 25 miles of the Virgin River, eliminating the native fish community in the 1930s. Reservoir construction, development of trout fisheries, and cattle grazing, depleted native fish communities in tributary streams during the 1960s and 1970s. The middle mainstream fish fauna was most severely affected during the 1980s following upstream invasion by the introduced red shiner and construction of a 45,000 acre-foot off-stream reservoir. The native fish community of the Virgin River Drainage maintains relatively natural abundance today only in Zion National Park and for a short distance

downstream, and in a segment of the Santa Clara River above Gunlock Reservoir. Water development plans for the future threaten the fish community in those areas. Federal Reserved Water Rights, management of endangered species, sport fish management, irrigation rights, and pressure to provide water for urban growth place conflicting demands on the Virgin River and highlight ethical dilemmas of a human population faced with adjusting to a world with limits.

Author: Gresh, T.; Lichatowich, J.; Schoonmaker, P.
Year: 2000
Title: An estimation of historic and current levels of salmon production in the Northeast Pacific ecosystem
Reference Type: Journal Article
Journal: Fisheries
Volume: 25
Issue: 1
Pages: 15-21

Value of reference: This work reviews estimates of historic salmonid run sizes in western North America, based upon historic cannery records and previously published estimates of historical abundance dating back to 1866. It also provides an estimate of the amount of marine-derived nitrogen and phosphorous that were delivered to regional streams annually in the form of salmon carcasses, which, the authors argue, were important for the survival of juvenile salmonids in nutrient-poor streams. It provides a review of what is known about the influence of marine-derived carbon (MDC) upon algal growth, macroinvertebrate abundance, growth and survival of juvenile coho salmon (*Oncorhynchus kisutch*). This paper may be helpful in reconstructing 'reference conditions' in stream systems that were historically dependent upon marine-derived nutrients.

Results relevant to EMAP: Marine-derived nitrogen, phosphorous, and carbon, which play an important role in algal growth, macroinvertebrate abundance, and juvenile salmonid growth and abundance in western streams, have dropped to 6 - 7% of historic (1880s) levels, associated with the decline of historic salmon (*Oncorhynchus* spp.) runs. Regionally, the Pacific salmon biomass return has dropped from an estimated 156 - 254 million kilograms to 12 - 13 million kilograms. Anthropogenic disturbances such as extirpation of beaver, logging, irrigation, grazing, pollution, dams, sport and commercial fishing have contributed to the decline of salmonids, and possibly a spiraling ecosystem failure in streams of Washington, Oregon, and California.

Geographic location: Region 10, Region 9, Washington, Oregon, California, Sacramento River, Columbia River, Fraser River, Coastal Oregon Rivers, Klamath River, Coastal Washington Rivers, eco1, eco2, eco3, eco4, eco78, eco6, eco7, eco9, eco10, eco11, eco77, Coast Range, Puget Lowland, North Cascades, Willamette Valley, Cascades, Klamath Mountains, Southern and Central California Chaparral and Oak Woodland, Central California Valley, Eastern Cascades Slopes and Foothills, Columbia Plateau, Blue Mountains, mountains

Keywords: fish, phab, salmon populations; coho; *Oncorhynchus kisutch*; fishing; logging; agriculture; grazing, pollution; dams; nutrient deficit; nitrogen; phosphorous

Abstract: We used historical cannery records and current escapement and harvest records to estimate historical and current salmon escapement to western North American river systems, in order to determine the biomass and marine-derived nitrogen and phosphorous levels delivered by adult salmon, and deficits corresponding to the diminished returns of adult salmon over the past century. We have estimated the historic biomass of salmon returning to the Pacific Northwest (Washington, Oregon, Idaho, and California) to be 160-226 million kg. The numbers indicate that just 6-7% of the marine-derived nitrogen and phosphorous once delivered to the rivers of the Pacific Northwest is currently reaching those streams. This nutrient deficit may be one indication of ecosystem failure that has contributed to the downward spiral of salmonid abundance and diversity in general, further diminishing the possibility of salmon population

recovery to self-sustaining levels.

Author: Haden, G. A.; Shannon, J. P.; Wilson, K. P.; Blinn, D. W.
Year: 2003
Title: Benthic community structure of the Green and Colorado rivers through Canyonlands National Park, Utah, USA
Reference Type: Journal Article
Journal: Southwestern Naturalist
Volume: 48
Issue: 1
Pages: 23-35

Value of reference: The authors suggest a model of the pre-settlement benthic flora and fauna of the Colorado River system by examining the invertebrate communities in the free flowing sections of the Green and Colorado Rivers in Canyonlands National Park. These river reaches are the farthest downstream of large impoundments and they retain similar hydrographs to pre-dam condition.

Results relevant to EMAP: This study provides the first description of the abundance, standing mass, taxa, feeding guilds, and primary carbon sources for benthic macroinvertebrates at six remote sites on the Green and Colorado rivers and provides an example of how the pre-dam Colorado River system might have functioned. The authors hypothesized that the aquatic community adjusted to flooding and high suspended sediment and that macroinvertebrate standing mass was relatively stable even with seasonal community composition changes.
They found that macroinvertebrate food resources were limited to allochthonous sources due to high suspended sediment concentrations; however, there was an invertebrate assemblage that processed this form of carbon and provided food for higher trophic levels.
Hard substrates were limited, but the complexity of riverine habitats, such as side channels, backwaters, and wetlands, and the presence of wood might have augmented the standing mass and species richness of the invertebrate assemblage.

Geographic location: Region 8, Utah, Green River, Colorado River, eco20, xeric, Canyonlands National Park

Keywords: macroinvertebrates, phab, dams, sediment, hydrologic variability, historic reference

Abstract: We sampled the aquatic benthos at 6 remote sites on the Colorado and Green rivers through Canyonlands National Park, Utah, USA. This study provides the first published description of benthic standing mass, invertebrate community composition, and primary carbon source for this portion of the Colorado River system. High suspended sediment concentrations prohibited growth of primary producers. The primary carbon source for benthic invertebrates was terrestrial organic matter. The invertebrate community was composed of 49 taxa, mostly mayflies, caddisflies, and Diptera, which were dominated by filterer/collector species. A smaller portion of the community was made up of predatory stoneflies and odonates. Standing mass of invertebrates on cobble substrates within a given site was stable over the multiyear sample period (1993 through 1996) and was comparable with other southwestern streams (overall mean = 0.41 g/m^2 ash-free dry mass). Invertebrate standing mass at each site was controlled by the availability of primary carbon. Primary carbon availability was controlled by supply to the site and retention within the site. Both aspects might be influenced by anthropogenic alteration of the river basin and discharge patterns upstream of the study site.

Author: Hamilton, J.B.; Curtis, G.L.; Snedaker, S.M.; White, D.K.
Year: 2005
Title: Distribution of anadromous fishes in the upper Klamath River watershed prior to hydropower dams--a synthesis of the historical evidence
Reference Type: Journal Article
Journal: Fisheries
Volume: 30
Issue: 4
Pages: 10-20

Value of reference: This publication uses a variety of historical information to reconstruct the distribution of anadromous fish above the Iron Gate Dam, which now restricts fish passage to the upper Klamath River basin. It is significant in its use of multiple sources as lines of evidence of fish species' historical presence at multiple sites throughout the upper basin. Detailed historical documentation about presence and distribution in the upper basin is provided for: Chinook salmon (spring and fall runs), steelhead, coho salmon, anadromous Pacific lamprey, sockeye salmon, green sturgeon, eulachon, cutthroat trout, chum salmon, and pink salmon

Results relevant to EMAP: Prior to dam construction on the Klamath system, anadromous fish migrated beyond the current site of Iron Gate dam (closed in 1962). This dam, at river km 307, is the current limit of upstream passage.

Numerous sources of information (many dating to the 19th century) are presented regarding the occurrence of Chinook salmon, steelhead, coho salmon, and Pacific lamprey above the current location of Iron Gate Dam. A map (Figure 1) plots the cited incidents of each species in the upper basin, with cross-references to the literature documentation used as evidence (listed in Table 1).

Chum salmon, pink salmon, eulachon, and cutthroat trout were limited historically to the lower Klamath River, well below current location of Iron Gate Dam.

Geographic location: Klamath River basin, Oregon, California, eco78, eco4, eco9, EPA Region 10, mountains

Keywords: fish, dams, anadromous fish distribution, historical documentation, historical photographs, fish passage

Abstract: Knowledge of the historical distribution of anadromous fish is important to guide management decisions regarding the Klamath River including ongoing restoration and regional recovery of coho salmon (*Oncorhynchus kisutch*). Using various sources, we determined the historical distribution of anadromous fish above Iron Gate Dam.
Evidence for the largest, most utilized species, Chinook salmon (*Oncorhynchus tshawytscha*), was available from multiple sources and clearly showed that this species historically migrated upstream into tributaries of Upper Klamath Lake. Available information indicates that the distribution of steelhead (*Oncorhynchus mykiss*) extended to the Klamath Upper Basin as well. Coho salmon and anadromous lamprey (*Lampetra tridentata*) likely were distributed upstream at least to the vicinity of Spencer Creek. A
population of anadromous sockeye salmon (*Oncorhynchus nerka*) may have occurred historically above Iron Gate Dam. Green sturgeon (*Acipenser medirostris*), chum salmon (*Oncorhynchus keta*), pink salmon (*Oncorhynchus gorbuscha*), coastal cutthroat trout (*Oncorhynchus clarki clarki*), and eulachon (*Thaleichthys pacificus*) were restricted to the

Klamath River well below Iron Gate Dam. This synthesis of available sources regarding the historical extent of these species' upstream distribution provides key information necessary to guide management and habitat restoration efforts.

URL: http://www.fisheries.org/html/fisheries/F3004/F3004p10-20Hamilton.pdf

Author: Hasse, Adelaide R.
Year: 1899 (digital version: 2003)
Title: Reports of Explorations Printed in the Documents of the United States Government: a Contribution Toward a Bibliography
Reference Type: Electronic Source
Producer: U.S. Government Printing Office
Access Year: 2005
Access Date: August 25, 2005
Last Update Date: Aug. 25, 2005

Value of reference: A great source of surveys, reports, and exploration made during the mid to late 1800's by the US government. This listing is a comprehensive source of any type of resource inventory, observation, report, etc. made throughout the US and could be a valuable look at the "historic conditions" of these areas.

This is a digitized edition of Reports of Explorations Printed in the Documents of the United States Government taken from a 1st edition (1899) copy held by the University of Minnesota libraries:

Reports of Explorations Printed in the Documents of the United States Government: a Contribution Toward a Bibliography. Compiled by Adelaide R. Hasse. (Washington, D.C.: U.S. Government Printing Office, 1899. (GP 3.5:2 1899)). Transcription and encoding by Jennifer Claybourne Torkelson, 2000. XML Source Encoding. Navigation elements added by Amy West, Government Publications Library, 2003.

Results relevant to EMAP: A good source to locate available pre-settlement literature and references. This web site includes listings of many early exploration accounts and observations, which may be the only sources for pre-settlement conditions in some areas of the Western United States. Stream conditions and species inventories may be limited; however, some baseline information can be gleaned from some of these references.

Geographic location: western United States

Keywords: Explorations, phab, resource inventories, pre-settlement condition, historical data, historical condition, geography, geology, expeditions

URL: http://govpubs.lib.umn.edu/digdoc/hasse.phtml

Author: Hassemer, P. F.; Kiefer, S. W.; Petrosky, C. E.
Year: 1997
Title: Idaho's salmon: Can we count every one?
Reference Type: Book Section
Editor: D. J. Stouder; P. A. Bisson; R. J. Naiman
Book Title: Pacific Salmon and their Ecosystems: Status and Future Options.
City: New York, NY
Publisher: Chapman and Hall
Pages: 113-125

Value of reference: The article's main focus is present day salmonid status and monitoring, but there is a section on habitat loss over the last 100 years.

Results relevant to EMAP: Dam construction has been the major factor resulting in loss of access to salmon spawning and rearing habitat in Idaho. About 62% of Idaho's historical spawning and rearing habitat for spring/summer chinook and steelhead remains available, but only 17% of the historical habitat remains available for Snake River fall chinook salmon due to the construction of the 3 dam Hell's Canyon complex in the 1960's.

The 62% that is still accessible to spring and summer chinook and steelhead represents approx. 6055 river km out of 9741 km estimated to exist in predevelopment times. Similarly, 172 km of suitable habitat is available to fall chinook out of and estimated 989 river km (17% of predevelopment km).

Approximately 30% of Idaho's stream kilometers inhabited by salmon and steelhead are located within designated wilderness areas or waterways classified as wild and scenic rivers.

Geographic location: Idaho, Salmon River, Snake River, Clearwater River, mountains, Columbia River, eco15, Northern Rockies, EPA Region 10

Keywords: fish, habitat loss, phab, dams, chinook salmon, spawning habitat

Abstract: Since the late 1950's, Idaho Dept. of Fish and Game (IDFG) biologists have collected standardized information about the status of salmon (*Oncorhynchus* spp.) in Idaho to assist fisheries management. Currently, IDFG uses indices of production such as redd and parr counts for streams, and adult salmon counts at dams and weirs, to assess the recent history of our salmon runs. We depict Idaho anadromous salmon trends using indices for sockeye, spring, summer, and fall chinook salmon, and steelhead. Counts of redds in index areas provide the best historical indicator of trends and status of spring and summer chinook salmon. Numbers of redds have declined sharply through the last 33 years. All of the naturally reproducing Snake River anadromous salmonid populations, excluding chinook salmon in the Clearwater River drainage and Snake River steelhead, have been listed as endangered pursuant to the federal Endangered Species Act. Hydroelectric development of the mainstem Snake and Columbia rivers is widely recognized as the major factor causing the decline of these populations.

Aggregated trend information is useful, but alone does not provide information needed for future management. We must augment historical information with knowledge about brood-year performance of multiple populations. We are using our indexed production information for life cycle modeling to assess productivity, a key to assessing recovery actions. Increased monitoring and analyses of indicator populations will better describe salmon status and trends to meet management needs for the future.

Author: Hatch, M. H.
Year: 1949
Title: A century of entomology in the Pacific Northwest
Reference Type: Book
City: Seattle
Publisher: University of Washington Press
Number of Pages: 43

Value of reference: This short reference provides the best historical overview of who collected what types of macroinvertebrates, where, and when in the Pacific Northwest. The author divides entomological activities into four periods, including (1) the period of itinerate collectors, (2) the period of resident collectors, (3) the period of established laboratories from 1890-1930, and the 'present' (4) 1930 - 1949. The work contains a taxonomic index by order to guide readers to references to specific historic materials.

This is baseline information, and, although sparse in coverage, it should help to define the limitations of historical reconstructions of aquatic macroinvertebrate assemblages in this region. It also lists important literature for macroinvertebrates in the region by order. [Note: *Many of the collections mentioned in this reference have subsequently been assembled in the entomological museum collection housed at Oregon State University*]

Results relevant to EMAP: Macroinvertebrates were first collected in the Pacific Northwest in the mid 1830's, but most collection activities were focused upon certain terrestrial orders (Coleoptera, Lepidoptera) or those of importance to humans at that time, such as horticultural pests, rather than aquatic macroinvertebrates. References to aquatic orders discussed in this reference include Coleoptera, Diptera, Hemiptera, Neuroptera, Odonata, and Plecoptera.

Geographic location: Oregon, Washington, Idaho, Region 10, Mountains, Xeric, Eco1, Eco2, Eco3, Eco4, Eco9, Eco78, Eco77, Eco10, Eco11, Eco12, Eco15, Eco16, Eco17, Eco80

Keywords: Macroinvertebrates; historical data; taxonomy; Coleoptera; Diptera; Hemiptera; Neuroptera; Odonata; Plecoptera; Pacific Northwest

Author: Hatch, M. H.
Year: 1953
Title: The beetles of the Pacific Northwest
Reference Type: Book
City: Seattle, WA
Publisher: University of Washington
Volume: 16
Number of Pages: 340

Value of reference: There are few works which synthesize early information on aquatic macroinvertebrates other than taxonomic keys. Keys such as this one provide a brief overview of the history of the collection and study of specific groups within the western United States, bringing together links to hundreds to thousands of individual published taxonomic records. This key contains records of Coleoptera collected in the Pacific Northwest as early as 1834. It provides the starting point for identifying who collected aquatic Coleoptera, where, when, and who described the taxa, dating back to the 1850s. The key provides information on generalized occurrence information by state, and qualitative abundance. This may be useful for beginning to reconstruct expected macroinvertebrate faunal composition and diversity metrics.

Results relevant to EMAP: Coleoptera were among the first insect orders collected in the western United States. By the end of the 1870s, 500-600 species of Coleoptera were known from the Pacific Northwest, most of which were terrestrial. Descriptions of the families Amphizoidae and Dytiscidae, which inhabit stream margins date to the early 1850s (LeConte 1852).

Geographic location: EPA Region 9, EPA Region 10, mountains, xeric, Oregon, Washington, Idaho, California

Keywords: macroinvertebrates; historical data; Coleoptera; Amphizoidae; Dytiscidae

Notes: LeConte, John L. 1852. Descriptions of some new species of Coleoptera from California. Ann. Lyc. Nat. Hist. N. Y. V:125-216.

Author: Henshall, J.A.
Year: 1906
Title: A list of the fishes of Montana with notes on the game fishes
Reference Type: Report
City: Missoula, MT
Institution: University of Montana
Pages: 13
Report Number: Bulletin of the University of Montana, No. 34-11

Value of reference: This is a compilation from multiple sources of the 36 native fish known in Montana in 1906. It is arranged by family and species and gives the names of rivers and streams or general portion of the state where each species had been documented up to that time. Several species were identified from descriptions of Lewis and Clark; but most species were collected on U.S. government railroad surveys and, more recently, by the U.S. Bureau of Fisheries. The list is followed by the list of species that had been introduced in Montana at that time. The final section, notes on game fish, is not as relevant to EMAP as the initial list. The location information can be used to reconstruct historical ranges of species and species composition of major tributaries

Results relevant to EMAP: As of 1906, 36 species of fishes had been recorded as native in Montana, and numerous introductions had occurred. The locations for each species listed here might not be the complete list of where they actually occurred; however, this list can provide information on general historical distribution of the fish species (primarily in the Missouri River basin of Montana) and might be useful cross-referenced with Evermann and Cox 1896 (in this bibliography)

Geographic location: Missouri River basin, Montana, EPA region 8, eco17, eco42, eco43, mountains, plains

Keywords: fish, historical data, geographic distribution, primary source, baseline information

Author: Holden, P. B.; Deacon, J. E.; Golden, M. E.
Year: 2005
Title: Historical changes in fishes of the Virgin-Moapa River system: Continuing decline of a unique native fauna
Reference Type: Book Section
Editor: J.N. Rinne; R.M. Hughes; Calamusso, B.
Book Title: Historical Changes in Large River Fish Assemblages of the Americas.
City: Bethesda, Maryland
Publisher: American Fisheries Society
Pages: 99-114

Value of reference: The chapter gathers what is known about the historical distribution of native fishes in the Virgin-Moapa Rivers and their tributaries, and compares that with more recent trends from the 1970's to the present. The river valleys were populated with settlers in the 1850's but were little studied until the 1930's (Hubbs and Miller) and 1970's (Cross).

Results relevant to EMAP: The authors describe the native fish species and their typical habitats in both the mainstem and the tributary streams of the Virgin and Moapa Rivers. They present very limited evidence of fish collections from early surveys (1870's) and attribute the shrinking habitat left for native fish to irrigation diversions, drowning of the lower rivers by Lake Mead, and competition from warm water exotics and introduced trout.

Of the 9 native fish species and subspecies in the Virgin-Moapa River system 5 are endemic, which is indicative of the unique habitats in these rivers. Map (p. 100) showing refugia for native fishes in 1970 compared with 2002. Table (p. 104) of native and nonnative species in the Virgin-Moapa Rivers, listing extirpated species (desert sucker, woundfin) and endangered species (Moapa dace, Virgin River chub).

Geographic location: EPA Region 9, EPA Region 8, Utah, Nevada, Arizona, Virgin River, Moapa River, eco19, eco13, eco14, xeric, mountains

Keywords: fish, nonnative species, water diversions, agriculture, dams, urban

Abstract: The Virgin-Moapa River system supports nine native fish species or subspecies, of which five are endemic. Woundfin (*Plagopterus argentissimus*) and Virgin River chub (*Gila seminuda*) are endemic to the main-stem Virgin River, whereas cooler and clearer tributaries are home to the Virgin spinedace (*Lepidomeda mollispinis*). Moapa dace (*Moapa coriacea*) and Moapa White River springfish (*Crenichthys baileyi moapae*) are found in thermal springs that form the Moapa River, and Moapa speckled dace (*Rhinichthys osculus moapae*) is generally found below the springs in cooler waters. The agricultural heritage of the Virgin-Moapa River system resulted in numerous diversions that increased as municipal demands rose in recent years. In the early 1900's, trout were introduced into some of the cooler tributary streams, adversely affecting Virgin spinedace and other native species. The creation of Lake Mead in 1935 inundated the lower 80 km of the Virgin River and the lower 8 km of the Moapa River. Shortly thereafter, nonnative fishes invaded upstream from Lake Mead, and these species have continued to proliferate. Growing communities continue to compete for Virgin River water. These anthropogenic changes have reduced distribution and abundance of the native Virgin-Moapa River system fish fauna. The woundfin, Virgin River chub, and Moapa dace are listed as endangered, and the Virgin spinedace has been proposed for listing. In this paper we document how the abundance of these species has declined since the Endangered Species Act of 1973. Currently, there is no strong main stem refugium for the Virgin River native fishes, tributary

refugia continue to be shortened, and the Moapa River native fishes continue to be jeopardized. Recovery efforts for the listed and other native fishes, especially in the Virgin River, have monitored the declines, but have not implemented recovery actions effective in reversing them.

Author: Hoppe, G. N.
Year: 1938
Title: Plecoptera of Washington
Reference Type: Journal Article
Journal: University of Washington Publications in Biology
Volume: 4
Issue: 2
Pages: 139-174

Value of reference: This valuable reference provides a well documented example of the paucity of knowledge of aquatic macroinvertebrates prior to the period of systematic surveys conducted between the 1920s - 30s, long after settlement of the region. Although this represents only one order, it reflects the level of familiarity with western macroinvertebrate fauna prior to the 1930s. The author also describes the general distribution, and the location of specific recorded samples dating back to 1895, although most of the early descriptions date from the early 1920s to 30s.

Results relevant to EMAP: The diversity of aquatic macroinvertebrates is poorly represented in early literature. Prior to 1930, for example, only 30 species of Plecoptera had been recorded and described from Washington State. Following a series of surveys between 1930 and 1937, an additional 41 species were collected and recorded, representing 137% increase in recorded Plecoptera diversity for that state. This clearly illustrates the challenges facing those interested in reconstructing changes in macroinvertebrate assemblage characteristics from pre-settlement or early settlement conditions and suggests that a later time frame, although confounded by human alteration that occurred after European settlement, may be a more realistic benchmark for historically reconstructing macroinvertebrate distribution.

Geographic location: Region10, Washington, mountains, xeric, eco1, eco2, eco3, eco4, eco9, eco10, eco15, eco77

Keywords: macroinvertebrates; Plecoptera; Washington; change detection

Notes: Hatch, M. H. 1949. A century of entomology in the Pacific Northwest. University of Washington Press. 43 pp. (in this bibliography)

Author: Jewett, Jr., S. G.
Year: 1959
Title: The Stoneflies (*Plecoptera*) of the Pacific Northwest
Reference Type: Book
City: Corvallis, OR
Publisher: Oregon State College Press
Number of Pages: 95

Value of reference: The primary value of this document is that it makes reference to the original description and relevant taxonomic references. The author provides basic geographic range information in addition to relative abundance and seasonal occurrence of adults, although it is difficult to determine both time frame and geographic localities for which this abundance information is relevant. Unfortunately, papers devoted to distributional records that lack taxonomic treatment were not included in the preparation of this resource. This may be useful for beginning to reconstruct expected macroinvertebrate faunal composition and diversity metrics.

Results relevant to EMAP: Of the approximately 400 species of Plecoptera identified in the United States, 146 were reported in Washington, Oregon, Idaho, and British Columbia by 1959.

Geographic location: EPA Region 10, Washington, Oregon, Idaho, mountains, xeric, Eco1, Eco2, Eco3, Eco4, Eco78, Eco77, Eco9, Eco10, Eco11, Eco80, Eco15, Eco16, Eco12, Eco17

Keywords: macroinvertebrates; stoneflies; Plecoptera; Oregon; Washington; Idaho; Pacific Northwest

Author: Jewett, S.G., Jr.
Year: 1960
Title: The Stoneflies (Plecoptera) of California
Reference Type: Journal Article
Journal: Bulletin of the California Insect Survey
Volume: 6
Issue: 6
Pages: 125-177

Value of reference: This very useful resource contains county-level records of 101 species of Plecoptera in California. It also provides an overview of the Plecoptera literature relevant to the state ca. 1960. Most of the citations date from the 1930s -1950s. The primary value of this document is that it synthesizes collection information on each species, including location, date, often elevation, and occasionally stream size. Some information on relative abundance by locality is also provided, although it is difficult to determine the time frame for which this information is relevant. This may be useful for beginning to reconstruct expected macroinvertebrate faunal composition and diversity metrics.

Results relevant to EMAP: Of the 6 families and 350 species of Plecoptera described in the United States, all 6 families and 101 species have been recorded in California. The California stonefly fauna is very similar to that throughout the western cordilleran region. More than 70 percent of the species are also found in Oregon, and approximately 60 percent in Washington. None of the holarctic species of Plecoptera have been collected in California. The author reports that many species have limited range, and distinct regional differences in stonefly faunal assemblages are apparent.

Geographic location: California, EPA Region 9, mountains, xeric, Eco1, Eco4, Eco5, Eco6, Eco7, Eco8, Eco9, Eco13, Eco14, Eco80, Eco81

Keywords: macroinvertebrates; Plecoptera

Author: Johnsgard, Paul A.
Year: 2003
Title: Lewis and Clark on the Great Plains: A Natural History
Reference Type: Book
City: Lincoln, Nebraska
Publisher: University of Nebraska Press

Value of reference: This book chronicles the Lewis & Clark expedition and summarizes the extensive natural history information collected over the Great Plains. In addition the web page access to the book includes links to other journals and texts associated with the expedition.

Results relevant to EMAP: A summary of the many plants, mammals, fish, and other natural history data collected on the expedition. The book includes geographical information that uses present day locations to correlate where the original observations occurred. This is a very good broad reference that also includes very specific information about pre-settlement conditions in the Great Plains.

Geographic location: Kansas, Missouri, Nebraska, Iowa, North Dakota, South Dakota, Montana, Missouri River Basin, EPA region 7, EPA region 8, eco47, eco42, eco43, eco46,

Keywords: Lewis & Clark expedition, pre-settlement, mammals, phab, birds, fish, natural history

Abstract: Lewis and Clark on the Great Plains is an easy-to-use reference on the wildlife that Meriwether Lewis and William Clark encountered during their 1804-6 Corps of Discovery expedition. Over one hundred animals and plants that were first carefully described and in some cases discovered by Lewis and Clark are identified here. More than an expedition reference guide, Lewis and Clark on the Great Plains also examines the lasting importance of the expedition's discoveries, the significance of the Plains plants and animals to local Native Americans, and the current status of Plains wildlife. Lavishly illustrated with Paul A. Johnsgard's drawings of mammals, birds, fish, reptiles, and plants, the book also includes a guide to the Lewis and Clark sites of botanical and zoological interest and more than seventy sites where readers can follow in the footsteps of two of America's greatest pioneering naturalists. Visit the Journals of the Lewis and Clark Expedition Online Project, based on Gary E. Moulton's celebrated edition of the Lewis and Clark Journals. Initially offering almost two hundred pages from volume 4, the site will eventually feature the full text of the Journals--almost five thousand pages. Also view a gallery of images and hear acclaimed poet William Kloefkorn reading selected passages. With full-text searchability and ease of navigation, the Journals of the Lewis and Clark Expedition Online Project is a useful tool for students and scholars and an engaging website for the general public. Sponsored by the University of Nebraska Press, the Center for Great Plains Studies, and the University of Nebraska E-Text Center.lewisandclarkjournals.unl.edu

URL:
http://libtextcenter.unl.edu/examples/servlet/transform/tamino/Library/lewisandclarkjournals?&_xmlsrc=http://libtextcenter.unl.edu/lewisandclark/files/xml/lc.johnsgard.01.xml&_xslsrc=http://libtextcenter.unl.edu/lewisandclark/LCstyles.xsl#ch1

Author: Johnson, W.C.
Year: 1992
Title: Dams and riparian forests: case study from the upper Missouri River
Reference Type: Journal Article
Journal: Rivers
Volume: 3
Issue: 4
Pages: 229-242

Value of reference: This article reports the effects of altered flow and meander rate on floodplain forest composition along the Missouri River in central North Dakota as a result of the closing of the Garrison Dam in 1953. Several historical time periods, dating back to the late 1800s, were used to reconstruct changes due to construction of the dam. Over time, river dynamics have changed due to hydrological alteration, which has changed forest cover composition and succession.

Erosion and deposition over time are estimated. General Land Office Survey notes and maps were used to determine the proportional composition of riparian forest successional categories at the time of settlement. Pre-settlement data for meander and forest successional rates are used to create a model to predict future forest compositional shifts.

Results relevant to EMAP: Mean annual flows have changed slightly in the 25 post-dam years, as compared with the early 1900s, while peak flows have changed dramatically (see Figure 3). The seasonal timing of peak and minimum flows has been reversed. Flooding now occurs only on very low terraces. The mean annual flood has been reduced by about 70%, while the maximum annual flood has reduced 81%. Historically, the Missouri River was a rapidly meandering stream. Post-dam erosion rates were 25% of pre-dam rates, while deposition rates were only 1% of pre-dam rates. The result was a reduction in new alluvium for formation of bars for colonization by cottonwood and willow.

On the upper Missouri River, pioneering young forests occupied only 6% of the total forest area in 1979, down from 47% prior to settlement. In contrast, transitional forests occupied 48% of the area in 1979, as compared with 21% pre-settlement (see Table 5). Over 90% of pre-settlement forests had cottonwood as a significant member of the forest overstory. By 1938, approximately 38% of the floodplain forest had been cleared. In 1979, forest vegetation comprised about 44% of the area.

Model simulations showed that the pre-settlement dominance of the floodplain by cottonwood and willow cannot be maintained under current low meander rates. The prediction is a rapid increase in proportion of equilibrium forests as pioneer forests age and are not replaced. River regulation and agriculture are given as the primary impacts bringing about this change.

Geographic location: North Dakota, EPA region 8, eco43, eco42, Missouri River basin, plains

Keywords: phab, dams, agriculture, meander rates, deposition, erosion, riparian forest composition, forest succession

Abstract: This research examined the effects of altered flow and meandering rate of the Missouri River in central North Dakota on the compositional dynamics of floodplain forests. This was accomplished by estimating the rates of river erosion and deposition during pre-dam and post-dam periods from historical maps and aerial photographs. Future changes in forest

composition were simulated using a simple mathematical model based on measured rates of forest succession and river meandering for pre- and post-dam periods. Simulations indicated a future decline in the areal extent of pioneer forests (cottonwood, willow) due to river regulation. Later successional species (primarily green ash) will dominate the future forests. Experimentation is needed in order to regenerate pioneer forests to maintain current levels of species diversity on the floodplain. (DBO)

Notes: A general overview and comparison of the effects of river regulation on meandering (e.g., Missouri River) vs. braided (e.g., Platte River) channels in areas of differing water usage is given by Johnson, 1998, who synthesizes results from this publication (Johnson 1992) and Johnson 1994 (also in this bibliography), as well as other publications.

Johnson, W.C. 1998. Adjustment of riparian vegetation to river regulation in the Great Plains, USA. Wetlands 18(4):608-618.

Another relevant and cited article:

Bragg, T.B. and A.K. Tatschl. 1977. Changes in flood-plain vegetation and land use along the Missouri River from 1826 to 1972. Environmental Management 1(4):343-348.

Author: Johnson, W.C.
Year: 1994
Title: Woodland expansion in the Platte River, Nebraska: patterns and causes
Reference Type: Journal Article
Journal: Ecological Monographs
Volume: 64
Issue: 1
Pages: 45-84

Value of reference: This article uses historical sources (GLO notes, time-series photographs) to reconstruct pre-settlement vegetation along the Platte River and its tributaries, including areas in Colorado, Wyoming, and similar Ecoregion 25 in western Nebraska. The causes of riparian vegetation changes are discussed. The results are notable because, rather than loss of woodland, there has been an increase in woodland, despite regulation of the river. This is in marked contrast to historic changes on the Missouri River in South Dakota (see Rumble et al. 1998 in this bibliography) and in many other places in the West where river regulation has led to a decline in cottonwood and willow recruitment.

Results relevant to EMAP: Prior to settlement, scattered trees occurred on river banks and on islands in central Nebraska, but farther upstream on the South Platte River in Colorado, woodland was scarce and few trees were present; thus, riparian woodland decreased in a westward direction. Cottonwood, American elm, and willow were the dominant trees; minor species were box elder, ash, and oak in central Nebraska and pine and cedar in western Nebraska. The river was described as a very shallow stream that could be crossed at any point in most seasons and filled with islands of all sizes covered with grass, bushes, and small trees.

Woodland began to expand into the North Platte River about 1900, occurring earliest in upstream reaches. By the late 1930s, much of the pre-settlement active channel in the North and South Platte rivers had transformed to woodland, resulting in a reduction of channel area. This process occurred in a west to east direction from the Colorado and Wyoming tributaries into central Nebraska. Woodland expansion rates since the 1930s have been highly variable, and the river has become more homogenous from east to west with respect to the mix of channel and woodland cover. The system appears to have reached a new equilibrium between flow and forest successional stage. The author postulates that the balance between woodland extent and active channel area was quite dynamic historically, changing during climatic cycles and sensitive to small but persistent changes in flow.

Irrigation and impoundments, beginning on a large scale in the early 1900s, may have set this process into motion. The effect of consistently-reduced flows, in combination with tree life histories, climatic factors, and hydrogeomorphology, provided conditions more amenable to establishment and recruitment of trees. The factors that restricted tree growth in the pre-settlement period were high June flows (which would have restricted seedling recruitment) and ice on sand bars (which would have reduced survivorship of tree seedlings). Water developments curtailed both of these factors, and woodland expansion was the result. The system is now reaching a new equilibrium, and the process of forest expansion is actually reversing itself to some extent; for example, some of the forests that have expanded into the upper tributaries have already declined substantially in recent years.

Geographic location: Wyoming, Colorado, eco25, EPA region 8, Platte River basin, plains

Keywords: phab, dams, agriculture, demography, geomorphology, hydrology, management,

Populus, primary succession, remote sensing, riparian woodland, *Salix*, sandbar colonization

Abstract: This research was conducted to identify the factors that have permitted *Populus-Salix* woodland to expand into the formerly active channels of the Platte River and its two major tributaries, the South and North Platte rivers. The research included: pre-settlement vegetation reconstruction based on the General Land Office survey notes, a statistical comparison between historic rates of woodland expansion from aerial photographs and environmental variables, and a field study of seedling demography to isolate the factors controlling recruitment and survival in the modern river. Woodland expansion began in the South and North Platte rivers around 1900 and spread downstream into the Platte River. By the late 1930s, vegetation had occupied most of the former channel area of the South and North Platte rivers and was expanding into Platte River channels. Rates of channel loss in the Platte River have been as great as 10%/yr during droughts. By 1986, channel-to-woodland proportions were relatively uniform throughout the Platte River system. Statistical models indicated that sandbar succession to woodland was regulated by three environmental factors: June flows, summer drought, and ice. June flow regulated seedling recruitment and initial survival because it coincided with the main *Populus-Salix* seed germination period. Historic reductions in flow at this time for irrigation and to fill reservoirs exposed much of the riverbed and elevated recruitment and seedling survivorship. Late-summer seedling survival was regulated by factors that affect seedling water balance, including river stage, seedling elevation in the riverbed, and rainfall. Winter conditions exerted the largest effect on seedling survivorship. Dominant factors were air temperature, stream flow, and seedling elevation in the riverbed. Lowest survivorship occurred during cold, icy winters with relatively high flow and when most seedlings were growing on low sandbars. The dominant historic trend, of losses in channel area and gains in woodland area, has ceased in recent years. No significant declines in channel area have occurred since 1969; in several reaches channel area has significantly increased since 1969. Comparatively small changes in channel and woodland proportions are expected in the future as long as water use and climate do not change markedly. The steady state has developed because flows have come into balance with active channel area, thereby reducing recruitment and increasing the mortality of tree seedlings. Because of the importance of wide, unvegetated channels to certain avifauna, it may be desirable to manage future flows to ensure no further reduction in channel widths, even if narrowing is only temporary. Dominance by *Populus* and *Salix* on new sandbars can be explained by life history characteristics. These include large and dependable seed crops that are effectively dispersed by wind and water to optimal germination sites; rapid germination; rapid root and height growth to withstand flooding, drought, and sedimentation; tolerance of low soil fertility; and the ability of *Salix* to reproduce vegetatively. Pioneer vegetation and geomorphic processes (principally sedimentation) facilitate succession on floodplains by modifying the highly variable riverbed environment suitable for early successional species into relatively stable surfaces favorable for recruitment of later successional species. Much of the extensive *Populus-Salix* woodlands that now occupy the Platte River will be replaced by later successional tree and shrub species with lower associated faunal diversity. Maintenance of the current biotic diversity may require artificial regeneration, as is taking place along other river systems in western North America. The response of the Platte River to altered flow differed from that of other rivers. This divergent response despite similar disturbances points out the complex interrelationships among plants and hydrogeomorphic processes operating on floodplains and the difficulties associated with understanding, generalizing, and predicting the effects of human modification of stream flow on natural ecosystems.

Notes: A general overview and comparison of the effects of river regulation on meandering (e.g., Missouri River) vs. braided (e.g., Platte River) channels in areas of differing water usage is given by Johnson, 1998, who synthesizes results from this publication (Johnson 1994) and

Johnson 1992 (also in this bibliography), as well as other publications.

Johnson, W.C. 1998. Adjustment of riparian vegetation to river regulation in the Great Plains, USA. Wetlands 18(4):608-618.

For further supporting documentation of physical changes in the Platte River system, see Knopf, F.L. 1986. Changing landscapes and the cosmopolitism of the eastern Colorado avifauna. Wildlife Society Bulletin 14:132-142.

Author: Jordan, D.S.
Year: 1878
Title: Report on the collection of fishes made by Dr. Elliott Coues U.S.A. in Dakota and Montana during the seasons of 1873 and 1874.
Reference Type: Journal Article
Journal: Bulletin of the U.S. Geologic and Geographic Survey of the Territories
Volume: 5
Pages: 777-799

Value of reference: This report is an inventory of the fish species collected during 1873 and 1874 in northern Montana and North Dakota and surrounding areas into Canada. Its focus is on taxonomy. It adds Dr. Coues findings to existing museum records. It includes descriptions, relative abundance of specimens collected, and (rarely) location observed. The report is broken down by family and then species.

Results relevant to EMAP: This is one of the few baseline inventories to be found for the northern plains. Any information found in this inventory is helpful in establishing the pre-settlement species and "historic range" for the fishes of the Great Plains.

Geographic location: Montana, North Dakota, EPA Region 8, eco43, eco42, Missouri River basin, Red River, Milk River, Mouse River, Saint Mary's River, Plains

Keywords: fish, historical data, plains

Author: Jordan, D.S.
Year: 1889
Title: A Reconnaissance of the Streams and Lakes of the Yellowstone National Park, Wyoming, in the Interest of the United States Fish Commission
Reference Type: Journal Article
Journal: U.S. Fish Commission Bulletin
Volume: 9
Pages: 41-63

Value of reference: This is a primary source that contains much detail about the fish species and physical habitat of streams at the headwaters of the Missouri and Columbia basins. Since this area had been little explored and not yet settled at the time of this report, this is good baseline information for constructing pre-settlement, high-elevation stream conditions and fish communities. Although its focus is in Yellowstone National Park, it covers streams that originate outside the park, spanning 2 major basins on either side of the continental divide.

The report is aimed at identifying waters where trout could be introduced. Its focus is therefore on current trout distribution; nevertheless, it contains much baseline information about the streams and fish community at the headwaters of the Missouri and Columbia River basins, a region influenced by geothermal activity.

Results relevant to EMAP: The author lists 10 fish species that were found and the locations where specimens were collected in and surrounding the Park, as well as those species that had been introduced prior to this exploration. Following that are notes, by species, of the fish found, including locations and relative abundance, with notes on physical barriers to some of the streams. There is also discussion of a common parasitic worm on the suckers and trout of the warmer waters.

The last section is a description of all the creeks and rivers in the Park, categorized by 3 major drainages: Yellowstone basin, Missouri River drainage, and Columbia River drainage. This section includes notes on fish species and abundance, stream physical habitat, vegetation, invertebrate abundance, stream width and depth, water temperature, waterfalls as physical barriers to fish movement, water permanence, and known fish introductions. Some of the information is second-hand. This section is summarized with a list of the streams in the Park suitable for trout and those where trout were not found (primarily due to barriers). The article should be consulted for specific details.

Geographic location: Wyoming, eco17, EPA region 8, Columbia River basin, Missouri River basin, mountains

Keywords: fish, macroinvertebrates, phab, historical data, geographic distribution, primary source, baseline information

Author: Jordan, D.S.
Year: 1891
Title: Report of explorations in Colorado and Utah during the summer of 1889, with an account of the fishes found in each of the river basins examined
Reference Type: Journal Article
Journal: U.S. Fish Commission Bulletin
Volume: 89
Pages: 1-40

Value of reference: Reference is a useful primary historical reference of the presence and relative abundance of fish in main stem and tributaries of 6 major river basins encompassing areas of Colorado and Utah on both sides of the continental divide in 1889. It reports early stream conditions and is valuable as a reference, since it represents a condition that is relatively close to pre-settlement and largely before major extinctions or changes in fish communities (although some fish species were already experiencing mortalities due to early impacts).

Results relevant to EMAP: Reference systematically describes the historical condition in basins of Colorado and Utah. River and tributaries were examined in the following basins: Platte River, Arkansas River, Rio Grande, Colorado River, Salt Lake Basin, Sevier Lake Basin. The physical character (e.g., water clarity, substrate, flow, width, depth, general fish community) of each stream is briefly described, and a summary is given, by species, of fish distribution in the various tributaries and relative abundance in the late 1800s. Abundance is described as scarce, not common, common, very common, abundant, very abundant, etc.

Geographic location: eco19, eco20, eco21, eco26, eco25, eco26, Colorado, Utah, xeric, mountains, plains, Platte River basin, Arkansas River basin, Rio Grande River basin, Colorado River basin, Salt Lake Basin, Sevier Lake Basin, EPA Region 8, EPA Region 9

Keywords: fish, phab, fish distribution, fish abundance, historical data, primary source, baseline data

Author: Katibah, E. F.
Year: 1984
Title: A brief history of riparian forests in the Central Valley of California
Reference Type: Book Section
Editor: Warner, R. E.; Hendrix, K. M.
Book Title: California Riparian Systems: Ecology, Conservation, and Productive Management.
City: Berkeley, California
Publisher: University of California Press
Pages: 23-29

Value of reference: A comprehensive treatment of pre-settlement hydrology, riparian vegetation, and patterns of degradation of Central Valley riparian forests over the last 150 years.

Results relevant to EMAP: The chapter gives a description and map of surface hydrology of the Central Valley circa 1850 (page 24) recording flow and flood regimes. There are also descriptions of the pattern of natural riparian forest growth on natural levees, the riparian species found there, and the history of decline of riparian forests.

Estimates of extent of riparian forest circa 1848 from literature:
Sacramento Valley - 324,000 ha (800,000 ac)
San Joaquin Valley - 57,000 ha (140,600 ac)
Tulare sub-basin (Kings, Kaweah, Tule, Kern rivers) - 20,000 ha (50,000 ac)
Tributary streams, sloughs, marshes - 40,500 ha (100,000 ac)
Author's revised estimate of the total 1848 riparian forest coverage in the Central Valley - 373,000 ha (921,000 ac)

Estimates of present day riparian forest from a mapping project begun in 1979 - 41,300 ha (102,000 ac) remaining in the Central Valley. 19,800 ha (49,000 ac) were in a disturbed or degraded condition. 21,500 ha (53,000 ac) were identified then as mature riparian forest, no condition specified.

Geographic location: California, xeric, San Joaquin River, Sacramento River, eco6, eco7, EPA Region 9

Keywords: phab, riparian vegetation, historical, EPA Region 9, pre-settlement, agriculture, water diversion, channelization, dams

Abstract: Riparian forests once occupied substantially greater areas in the Central Valley of California than they do today. This paper explores the hydrologic influences which allowed the original riparian forests to establish themselves, the extent and the reasons for the decline of the pre-settlement forests, as well as an estimate of the extent of today's remaining forests.

Author: Knapp, R.A.
Year: 1996
Title: Non-native trout in natural lakes of the Sierra Nevada: an analysis of their distribution and impacts on native aquatic biota.
Reference Type: Report
City: Davis, CA
Institution: University of California, Centers for Water and Wildland Resources

Value of reference: Although the focus of this article is on fish introductions in lakes, the effects of these introductions on biota in associated streams is also addressed. Native trout, amphibians, and invertebrates occurring in watersheds of formerly fishless lakes have been impacted by trout introductions in this region when introduced fish move into stream habitats and compete with native biota that are not adapted to compete.

This reference presents a map of the region above 1800 m that was formerly fishless.

Results relevant to EMAP: Historically, trout were absent above approximately 1800 m in the Sierra Nevada. Trout introductions to streams and lakes began in the mid-1800s and all watersheds currently contain as many as 5 nonnative trout species. Although stocking has been terminated in the National Parks of the region, data from Yosemite NP suggest that trout are likely to occur in at least 60% of all streams. The effects of introductions on naturally fishless ecosystems can have severe impacts on native trout in perimeter streams, amphibians, and macroinvertebrates; this paper provides some support for this, although limited quantitative examples. Native trout are impacted by introductions due to hybridization/introgression and resource competition.

Historically, the mountain yellow-legged frog was widespread throughout the Sierra Nevada at elevations above 1500 m, and found in all major watersheds, whereas it is now present in fewer than 15% of the sites where it was found in 1915. The decline is attributed to predation by nonnative trout.

Geographic location: California, eco7, EPA region 9, mountains, Sierra Nevada, nonnative species, predation, competition, fishless streams

Keywords: fish, nonnative species, alpine habitats, biodiversity, cold water fisheries, lakes, streams, recreation, watersheds, wilderness, food chains, amphibians, aquatic invertebrates, introduced species, plankton, Sierra bioregion, conservation biology, endangered species, federal lands, geographic information systems, land management, park management, restoration.

Abstract: The objective of this study was to describe the current distribution of introduced trout in the Sierra Nevada relative to the historic fish distribution, and to review the impacts of introduced trout on native aquatic biota. Historically, trout were absent above approximately 1800 m in the Sierra Nevada. In the mid-1800's, however, widespread trout introductions were begun to move fish into formerly fishless lakes and streams to enhance recreational fishing. Trout stocking is now conducted by the California Department of Fish and Game, and the current program is intended to supplement and maintain existing populations of non-native trout. As a result of past and current trout stocking, the proportion of trout-containing lakes in the Sierra Nevada has increased from less than 1% of all lakes larger than 1 ha (N=4000+) to approximately 63% of all such lakes. National forests have a much higher proportion of lakes containing non-native trout than national parks, with trout in at least 85% of the lakes larger than

1 ha. Only 7% are known to be fishless. In Sequoia, Kings Canyon, and Yosemite National Parks, the proportion of lakes with fish has increased from less than 1% to approximately 35-50% of such lakes. The greater number of fishless lakes in the national parks than national forests is due in part to the termination of fish stocking in park lakes in the 1970's. Recent surveys in Sequoia, Kings Canyon, and Yosemite National Parks show that trout have disappeared from 29-44% of previously stocked lakes. Although data on the distribution of non-native trout in Sierran streams is generally lacking, data from Yosemite National Park suggests that trout are likely to occur in at least 60% of all streams. Given the current ubiquity of trout in the formerly fishless portion of the Sierra Nevada, their impacts on native aquatic biota are likely widespread.

Introduced trout are affecting the distribution of a wide range of native aquatic species in the Sierra Nevada, including native fishes, amphibians, zooplankton, and benthic macroinvertebrates. The introduction of non-native trout has caused widespread declines of native trout species such as golden trout as a result of hybridization, competition, and predation. The decline of at least one amphibian species, the mountain yellow-legged frog, has been attributed largely to predation by introduced trout. Predation by introduced trout has also caused dramatic changes in zooplankton and benthic invertebrate species composition in lakes, shifting the dominant species in these communities from large-bodied to small-bodied forms.

The majority of lakes stocked by the California Department of Fish and Game lie within designated wilderness areas, areas managed for their natural values. Given that trout stocking serves to maintain an artificial fishery that has substantial impacts on native aquatic biota, and that continuation of this fishery is strongly supported by portions of the public, the ongoing stocking of trout poses inherent management conflicts. Resolution of these conflicts will require additional research on the ecological and sociological consequences of alternatives to the current trout stocking program that provide a better balance between the needs of aquatic ecosystems and those of recreational interests.

Author: Knapp, R. A.; Matthews, K.R.
Year: 2000
Title: Non-native fish introductions and the decline of the mountain yellow-legged frog from within protected areas
Reference Type: Journal Article
Journal: Conservation Biology
Volume: 14
Issue: 2
Pages: 428-438

Value of reference: Although the focus of this paper is on the impact of introduced trout on yellow-legged frogs, the greater value of this study may be that it represents a very large space-for-time investigation of the impact that introduced fish species can have upon native biota. This study investigates patterns of amphibian distribution across multiple spatial scales to better investigate alternate explanations for observed amphibian declines. This reference provides strong support for the interpretation that fish introductions have influenced aquatic vertebrate assemblages, and derived indices.

Results relevant to EMAP: After factoring out the influence of habitat conditions, there was a negative correlation between trout and yellow-legged frogs at the landscape scale; at the watershed-scale, the presence of introduced trout accounted for approximately 60% of the variance in the distribution of yellow-legged frogs; and at the scale of the individual water body ($n = 1728$), the effect of trout on frog presence or absence was very significant ($p < 0.0001$). Although the species has disappeared from sites lacking trout, there is some evidence to indicate that these areas may represent marginal habitat containing non-equilibrium metapopulations. The authors surmise that the decline of the yellow-legged frog in the Sierra Nevada began shortly after fish introductions in the 1850s.

Geographic location: California; Sierra Nevada; mountains; eco5; EPA Region 9

Keywords: amphibians; introduced fish; nonnative species; predation; yellow-legged frog; *Rana muscosa*

Abstract: One of the most puzzling aspects of the worldwide decline of amphibians is their disappearance from within protected areas. Because these areas are ostensibly undisturbed, habitat alterations are generally perceived as unlikely causes. The introduction of non-native fishes into protected areas, however, is a common practice throughout the world and may exert an influence on amphibian distributions. We quantified the role of introduced fishes (several species of trout) in the decline of the mountain yellow-legged frog (*Rana muscosa*) in California's Sierra Nevada through surveys of >1700 sites in two adjacent and historically fishless protected areas that differed primarily in the distribution of introduced fish. Negative effects of fishes on the distribution of frogs were evident at three spatial scales. At the landscape scale, comparisons between the two protected areas indicated that fish distribution was strongly negatively correlated with the distribution of frogs. At the watershed scale, the percentage of total water-body surface area occupied by fishes was a highly significant predictor of the percentage of total water-body surface area occupied by frogs. At the scale of individual water-bodies, frogs were three times more likely to be found and six times more abundant in fishless than in fish-containing water-bodies, after habitat effects were accounted for. The strong effect of introduced fishes on mountain yellow-legged frogs appears to result from the unique life history of this amphibian which frequently restricts larvae to deeper water bodies, the same habitats into which fishes have most frequently been introduced. Because fish populations in at

least some Sierra Nevada lakes can be removed with minimal effort, our results suggest that the decline of the mountain yellow-legged frog might be relatively easy to reverse.

Author: Lavier, D.C.
Year: 1976
Title: Distribution of salmon and steelhead in the Columbia River Basin, 1850-1976: a summary of data from maps prepared for the Columbia Fisheries Project, Pacific Northwest Regional Commission
Reference Type: Report
City: Olympia, WA
Institution: Washington Department of Game

Value of reference: This is a series of tabular synopses of river miles available to and in use by steelhead, spring, summer, and fall chinook, coho, chum, and sockeye salmon in 8 different river sections of the Columbia, Snake, Yakima, and Willamette Rivers in 1850 vs. 1975. The tributaries included in each river section are listed with each table.

Since this is a summary from maps, the original mapped areas of use by each species are presumably available from the Columbia River Fisheries Project, but the maps are not part of this particular summary. There is also no text, explanation of methods, or interpretation, although the tabular results are straightforward and can be very useful for quantitative comparisons of pre-settlement and 1970s conditions. For more detail and clarification, this tabular summary may need to be supplemented with background information or reporting from the Washington Department of Game or the Columbia River Fisheries Project..

Results relevant to EMAP: A wide range of information can be extracted from these tables including: river length (miles), miles accessible to fish, miles blocked to fish, and miles in use by several species of salmonids in 1850 and 1975. River miles accessible to fish can be compared to accessibility prior to major impacts (1850). For example, sockeye salmon used 320 miles of the Yakima drainage in 1850, but did not use any of the river miles in 1975. In comparison to 1850, an additional 136 miles of the basin were blocked to fish in 1975. Between 1850 and 1975, steelhead use decreased by 143 miles (22%), spring chinook use by 232 miles (40%), and coho use by 61 miles (19%) in the Yakima River basin. All river miles can easily be converted to proportions or percentages of a basin. The summary does not address causes of decline, but increases in blockage to fish since 1850 were likely associated with dams.

Geographic location: Washington, Oregon, Idaho, EPA region 10, eco3, eco4, eco9, eco10, eco11, eco12, eco15, eco16 eco80, Columbia River basin, mountains, xeric

Keywords: fish, blockage to fish, fish use, map summaries

Author: Lee, D.; Sedell, J.; Rieman, B.; Thurow, R.; Williams, J.; others
Year: 1997
Title: A broad-scale assessment of aquatic species and habitats [Chapter 4]
Reference Type: Report
City: Portland, OR
Institution: USDA Forest Service, Pacific Northwest Research Station
Report Number: General Technical Report PNW-GTR-405

Value of reference: This long and detailed chapter represents a very large synthesis of current data, knowledge (including professional judgment), historical information, and predictive modeling. Current status is given in relation to historical range, reconstructed from 1) actual samples and 2) predicted occurrences based on landscape features (i.e., potential range), using classification tree analysis. The report synthesizes an immense literature and, along with professional judgment and predictive modeling, reconstructs and maps the historical ranges of 46 fish species in the Columbia Basin and compares them with current ranges; habitat requirements and key factors influencing status are also discussed for each. A separate section presents historical changes in pool habitats.

Results relevant to EMAP: Approximately 50% of the native fish taxa in the assessment area has exhibited significant declines from historical levels. Presently, 45 of the 88 native fish taxa (51%) in the assessment area are identified as threatened, endangered, sensitive, or of special concern by state or Federal agencies or by the American Fisheries Society. Overall changes in composition, distribution, and status of fishes are dramatic and extensive; a wide range of human impacts on these populations are given in discussions of each species.

Example status conclusion: "Bull trout are known or predicted to occur in 45% of watersheds in the historical range and to be absent in 55%. We found bull trout less widely distributed within the potential historical range than other non-anadromous salmonids...Watersheds believed or predicted to be strong spawning and initial rearing areas represented only 6% of the historical range..."

In managed streams, roads and accompanying human activities including timber harvest, highway construction, grazing, agricultural practices, and loss of riparian vegetation have combined to create major decreases in pool habitats, which appear to have been the greatest in the low-gradient, biologically productive areas of river basins most disturbed by humans.

Geographic location: eco 10, eco11, eco15, eco16, eco80, eco12, mountains, xeric, Oregon, Washington, Idaho, Interior Columbia Basin, EPA Region 10

Keywords: fish, human impacts, historical range

Notes: A 9-page Executive Summary of this chapter is in Volume I, Chapter 1 of this series.

The portion of this reference discussing pool habitats is largely from McIntosh 1995. In addition, see McIntosh 1994 in this bibliography.

McIntosh, B.A. 1995. Historical changes in stream habitats in the Columbia River Basin. Corvallis, OR: Oregon State University. Ph.D. dissertation.

Author: Leidy, R.A.; Becker, G.; Harvey, B.N.
Year: 2005
Title: Historical status of coho salmon in streams of the urbanized San Francisco estuary, California
Reference Type: Journal Article
Journal: California Fish and Game
Volume: 94
Issue: 4
Pages: 1-36

Value of reference: The article represents an in-depth investigation and synthesis of historical literature, museum specimens, agency files, and long-term data records to reconstruct the relative probability of the past presence of coho salmon in 65 watersheds around San Francisco estuary. Probability of presence was based on a combination of documented historical presence of the species and the likelihood of occurrence of essential habitat requirements historically.

The information in this document is useful for reconstructing the historical range of the species and its presence in specific estuary watersheds of the region.

Results relevant to EMAP: Coho salmon were last documented from an estuary stream in the early to mid-1980s. Coho salmon populations have experienced declines throughout California attributable primarily to human activities, including water diversions, creation of migration barriers, streambed alteration for flood control, impaired water quality, removal of riparian vegetation, disruption of natural hydrological processes, and reduced instream habitat complexity.

At least 4 of 65 estuary watersheds (6%) historically supported coho salmon. A minimum of an additional 11 watersheds (17%) may also have supported coho salmon. These 15 watersheds and supporting evidence for the occurrence of coho salmon are summarized in Table 1. Habitat characteristics of the 15 watersheds are shown in Table 2.

Although broadly distributed, the environmental characteristics of streams known historically to contain coho salmon shared several characteristics: cool summer water temperatures, suitable spawning and juvenile rearing habitat, distinct surface water connections to the estuarine and marine environments, as well as stream flows during the months of February through May suitable for smolt out-migration.

Estuary coho salmon typically were members of three-to-six species assemblages of native fishes, including Pacific lamprey, steelhead, California roach, juvenile Sacramento sucker, threespine stickleback, riffle sculpin, prickly sculpin, and/or tidewater goby.

Geographic location: California, eco6, EPA Region 9, local watersheds of the San Francisco Bay Estuary, xeric

Keywords: fish, urban, water diversion, dams

Author: Lichatowich, J. A.
Year: 1997
Title: Evaluating salmon management institutions: The importance of performance measures, temporal scales, and production cycles
Reference Type: Book Section
Editor: D.J. Stouder; P. A. Bisson; Naiman, R. J.
Book Title: Pacific Salmon and their Ecosystems.
City: New York, New York
Publisher: Chapman and Hall
Pages: 69-87

Value of reference: The article makes an argument for historical reconstruction to set meaningful goals for restoration of salmon runs and to evaluate the success of management strategies to date.

Results relevant to EMAP: Lichatowich uses salmon productivity graphs to show what happens when managers work on short temporal scales without considering the historic baseline. A short time frame, particularly during favorable climatic conditions, may make managers overly optimistic in their predictions of increased productivity when the real result is the preservation of the status quo or a continual adjustment of the baseline downward to extinction. An ecosystem's history determines the system's present state and helps establish the range of possibilities for future development trajectories. Developing baselines from historical reconstruction of salmon abundance and habitats is a critical step in salmon restoration.

By considering only the currently available habitat, Oregon and Washington have compressed the habitat baseline. There is no historical component. Past habitat loss is not taken into account in either definition. The implication is that we are satisfied with the status quo, the current condition of salmon habitat. This has led to stocks being listed as healthy that have exhibited dramatic declines. For example, the Tillamook Bay chum salmon is listed as a healthy stock even though the annual run declined from an average of 92,000 fish in the late 1940's and early 50's to an average of 17,000 fish in recent years.

If each generation is allowed to reset the temporal scale of the baselines used to evaluate management performance, the result will be no evaluation or accountability, a misinformed public, and a spiral of decline for which the outcome will be the inevitable extinction of Pacific salmon in much of their range.

Geographic location: mountains, xeric, Columbia River, coastal rivers, eco10, eco1, eco4, eco3, Oregon, Washington, EPA Region 10

Keywords: historic fish abundance, historical reconstruction, baseline, chinook salmon, coho salmon, temporal scale, institutional learning, management expectations

Abstract: Management of renewable resources from an ecosystem perspective will require institutional changes. Management institutions will have to enhance their ability to learn, use what they learn, and promote more effective evaluation of performance. Development of appropriate management baselines is an important prerequisite to institutional learning and evaluation. Three important components of management baselines are biological performance measures, temporal scale of institutional evaluation, and natural environmental fluctuations in the ecosystems that produce Pacific salmon. Performance measures should broaden the

traditional focus on harvest and economics to include measures of the condition of important ecological processes. Temporal scale will have to include the entire history of management institutions. Compressing the temporal scale and shifting baselines forward will create inevitable extinction of the resource. Natural cycles in production require flexibility in management programs and the development of realistic expectations.

Author: Liknes, G. A.; Graham, P. J.
Year: 1988
Title: Westslope cutthroat trout in Montana: Life history, status and management
Reference Type: Book Section
Editor: Gresswell, R. E.
Book Title: Status and management of interior stocks of cutthroat trout.
City: Bethesda, Maryland
Publisher: American Fisheries Society
Pages: 53-60

Value of reference: The authors compare the historic and present range of the westslope cutthroat trout, identify the locations of pure populations, and list the important factors responsible for the decline of the subspecies.

Results relevant to EMAP: The historic range of the westslope cutthroat trout in Montana both east and west of the Continental Divide is estimated at 25,547 stream kilometers. The present distribution is at 6993 stream km or 27.4% of the historic range (includes hybridized trout). Genetically pure populations are present in 72 streams (nine river drainages) representing 2.5% of their historic range.

Westslope cutthroat trout are sensitive to riparian disturbance, and they are often replaced by the alien brook trout following disturbances such as logging, grazing, or mining.

As with other cutthroat trout populations (Lahontan and Bonneville, see references Duff (1988)and Gerstung (1988)), the authors believe that the major factor in the trout's decline is hybridization with rainbow trout, golden trout, and Yellowstone cutthroat trout.

Geographic location: Region 8, Montana, mountains, Flathead River, eco17, eco41

Keywords: fish, westslope cutthroat trout, historic distribution, habitat degradation, nonnative species

Abstract: The historic range of westslope cutthroat trout *Salmo clarki lewisi* included western Montana, central and northern Idaho, a small portion of Wyoming, and portions of three Canadian provinces. The distribution and abundance of westslope cutthroat trout have drastically declined from its historic range during the last 100 years. Although previous studies in Montana identified strongholds of populations, the status of westslope cutthroat trout over its complete range is uncertain. Three life history forms are found within this range: 1) lacustrine-adfluvial stocks, 2) fluvial-adfluvial populations, and 3) fluvial fish. Migratory adults travel long distances during periods of high stream flow and spawn when water temperatures are near 10 degrees C. Most migratory adults quickly leave the spawning grounds following the spawning act. Sexual maturity is attained at age 3 or older. In some drainages, repeat spawning occurs predominantly in alternate years. Westslope cutthroat trout are opportunistic in their food habits, but are not highly piscivorous; they tend to specialize as invertebrate feeders. The decline of westslope cutthroat trout has been attributed to overexploitation, genetic introgression, competition from or replacement by nonnative species, and habitat degradation. Westslope cutthroat trout occupy only 27.4% of their original range in Montana, and genetically pure populations are present in only about 2.5% of their historic range. As a whole, westslope cutthroat trout populations in Idaho and British Columbia, Canada, have fared better than in Montana. Management programs designed to protect the westslope cutthroat trout have helped to maintain or increase existing populations, and even to create new populations.

Author: Lytle, D. A.
Year: 2003
Title: Reconstructing long term flood regimes with rainfall data: Effects of flood timing on caddisfly populations
Reference Type: Journal Article
Journal: The Southwestern Naturalist
Volume: 48
Issue: 1
Pages: 36-42

Value of reference: This article is one of several that demonstrate how natural flow regimes (e.g., flash floods, spring runoff) historically affected desert stream biota. The author integrates short term flood data with long term rainfall data to infer patterns of the influence of flooding on caddisfly populations. This approach is particularly useful for a biological indicator for which there is little or no historical data.

Results relevant to EMAP: There is a large interannual variation in caddisfly population sizes due to the stochastic nature of flash floods.
"Mortality of aquatic insects from flash floods exceeds 90% for most taxa, and some species are locally extirpated by floods, so recolonization of flooded streams from adjacent, non-flooded drainages might also be important for maintaining species diversity."

"The timing of individual floods relative to the long term average strongly affected caddisfly populations; early and timely floods had little affect on population size in the next year, but late floods significantly reduced population size in the next year."

Geographic location: Region 9, eco79, Arizona, Chiricahua Mountains, xeric

Keywords: desert streams, hydrographic variability, flash floods, macroinvertebrates, phab, precipitation, flood frequency, caddisfly, recruitment,

Abstract: Flash floods are a defining feature of desert streams, but flow records are not always available to characterize long term flood dynamics. In this study, rainfall data spanning 100 years were used as a proxy to quantify long term flood regimes for southeastern Arizona (USA) streams. The frequency and seasonal timing of severe floods (>50% substrate movement) were highly variable at short temporal scales (days to several years), but clear patterns emerged in the long term (several years to a century). To explore the ecological effects of flood timing, populations of the caddisfly *Phylloicus aeneus* were monitored in 2 streams over 3 years. The timing of individual floods relative to the long term average strongly affected *P. aeneus* populations: early and timely floods had little effect on population size in the next year, but late floods significantly reduced population size in the next year. Thus, flood timing might play a role in regulating populations of desert stream organisms.

Author: MacCoy, D.; Blew, D.
Year: 2005
Title: Impacts of land-use changes and hydrologic modification on the lower Boise River, Idaho, USA
Reference Type: Book Section
Editor: L.R. Brown; R.H. Gray; R.M. Hughes; M. Meador
Book Title: Effects of Urbanization on Stream Ecosystems.
City: Bethesda, MD
Publisher: American Fisheries Society
Volume: 47
Pages: 133-156

Value of reference: This research uses cadastral survey notes from the late 1800s to recreate the historical lower Boise River and assess changes in the structure and function. Historical hydrogeomorphology and riparian conditions were reconstructed: average bankfull width, channel forms, parafluvial surfaces, sloughs, and riparian vegetation. The changes in these features since the 1800s, as a result of human alteration, are described.

Results relevant to EMAP: Today, the average bankfull width is about one-quarter to one-half the historical width, and parafluvial surfaces are stabilized by trees and shrubs. Historically, an extensive network of sloughs was present, with numerous surface connections between sloughs and the main channel. Between 1868 and 1939, many sloughs were filled or converted to agricultural drains or canals. Today, many river channels are incised.

River bottom substrate was historically dominated by cobble and gravel, and the banks were subject to frequent inundation and scouring; cottonwood stands were extensive, in some places reaching 900 m in width. In contrast, current flows do not produce adequate shear stress to mobilize bed material, resulting in sandy bottoms and embeddedness over 50% in many places; alien species dominate in most sections of river. Table 2 compares physical features (average bank-full width, channel forms, parafluvial surfaces, sloughs, and vegetation) of the historic (1867-1868) versus current (1994-2002) in four reaches of the lower Boise River,

Modifications due to urbanization and agriculture have stabilized the river and reduced parafluvial surfaces and bankfull widths. Three large dams in the upper basin have altered flow regime and sediment supply to the river. Increased abundance of tolerant and alien species has lowered the quality of natural aquatic assemblages. Alien hardwoods have replaced native cottonwood stands, and alien herbaceous species are present along most of the lower river.

Geographic location: Idaho, Boise River basin, eco12, EPA region 10, xeric

Keywords: phab, hydrogeomorphology, riparian vegetation, cadastral surveys, urban, agriculture, dams

Abstract: In less than two centuries, the lower Boise River below Lucky Peak Dam in southwestern Idaho has been transformed from a meandering, braided, gravel-bed river that supported large runs of salmon to a channelized, regulated, urban river that also provides irrigation water to more than 1300 km^2 of land. The construction of three large dams in the upper basin dramatically altered the flow regime and sediment supply to the lower river. Flows are no longer sufficient to mobilize bed sediments and have allowed cottonwood trees and alien hardwoods to stabilize parafluvial surfaces, thereby narrowing sections of the river channel. Cadastral survey notes of 1867 and 1868 were used to recreate features associated with the

lower Boise River Valley and identify characteristics of the river channel prior to dam construction and urbanization. Gravel and sand bars, historically present throughout the river, which are necessary to maintain biodiversity and productivity, are currently scarce. Sloughs were a dominant feature on the floodplain of the late 1800s, but today have been converted to irrigation canals, drains, or residential and commercial land uses. Flow alterations, water quality degradation, and habitat loss due to urbanization near the lower Boise River have resulted in macroinvertebrate and fish assemblages dominated by tolerant and alien species.

Author: Martin, B. A.; Saiki, M.K.
Year: 1998
Title: Effects of ambient water quality on the endangered Lost River Sucker in Upper Klamath Lake, Oregon
Reference Type: Journal Article
Journal: Transactions of the American Fisheries Society
Volume: 128
Pages: 953-961

Value of reference: This paper reviews historic literature documenting the dramatic changes in fish abundance and community characteristics in the upper Klamath River Basin, resulting from the cumulative effects of overharvest, mining, grazing, agriculture, impoundments, and water diversions. It also identifies the primary causal factors associated with recent fish mortality in the basin.

Results relevant to EMAP: The Lost River sucker (*Deltistes luxatus)* was the most important food fish in the Klamath Lake region for the Klamath and Modoc Indians prior to the turn of the twentieth century (Gilbert 1898), and heavily used by white settlers for food and livestock feed (Cope 1879). It has subsequently been pushed to the edge of extinction by human impacts associated with damming of rivers, draining of marshes, water diversions, competition with or predation by exotic species, loss and isolation of habitat, and impacts on water quality by logging, agriculture, and grazing. In this study, hypoxia, associated with a dissolved oxygen deficit, was identified as the primary factor currently influencing juvenile Lost River sucker mortality.

Geographic location: Upper Klamath River Basin, Oregon, California, eco78, Klamath Mountains, Region 10, mountains

Keywords: fish; water quality; Lost River sucker; *Deltistes luxatus;* Shortnose sucker; *Chasmistes brevirostris*; Klamath largescale sucker; *Catostomus snyderi*; mortality; dissolved oxygen; population decline; logging; grazing; agriculture; dams, water diversion, nonnative species

Abstract: Populations of the Lost River sucker *Deltistes luxatus* have declined so precipitously in the Upper Klamath Basin of Oregon and California that this fish was recently listed for federal protection as an endangered species. Although Upper Klamath Lake is a major refuge for this species, fish in the lake occasionally experience mass mortalities during summer and early fall. This field study was implemented to determine if fish mortalities resulted from degraded water quality conditions associated with seasonal blooms of phytoplankton, especially *Aphanizomenon flos-aqua*. Our results indicated that fish mortality did not always increase as water temperature, pH, and un-ionized ammonia concentration increased in Upper Klamath Lake. Little or no mortality occurred when these water quality variables attained their maximum values. On the other hand, an inverse relation existed between fish mortality and dissolved oxygen concentration. High mortality (>90%) occurred whenever dissolved oxygen concentrations decreased to 1.05 mg/L, whereas mortality was low (<10%) when dissolved oxygen concentrations equaled or exceeded 1.58 mg/L. Stepwise logistic regression also indicated that the minimum concentration of dissolved oxygen measured was the single most important determinant of fish mortality.

Notes: Gilbert, C. H. 1898. The fishes of the Klamath basin. U.S. Fish Commission Bulletin 17:1-13.

Cope, E. D. 1879. The fishes of Klamath Lake, Oregon. American Naturalist 13:784-785.

Author: McAllister, K.R.; Leonard, W.P.; Hays, D.W.; Friesz, R.C.
Year: 1999
Title: Washington state status report for the northern leopard frog
Reference Type: Report
City: Olympia, WA
Institution: Washington Department of Fish and Wildlife
Pages: 36

Value of reference: Report contains known historical records and distribution of the species, dating back to 1881. Reduction in distribution is assessed and reason for decline are discussed.

Results relevant to EMAP: Museum specimens indicate that northern leopard frogs were found historically in 8 counties in eastern Washington (see Table 1). They were considered abundant in the Walla Walla basin in 1960. The Snake River and its associated flood plain wetlands may have provided an aquatic corridor to historically abundant leopard frog populations in Idaho and Montana. In addition to the Walla Walla River populations, the link may have been responsible for colonization along the Columbia River downstream to Fort Dalles, Oregon. The species seems to have occurred in few locations, but in large numbers.

Geographic location: Washington, EPA Region 10, mountains, xeric, Columbia River basin, eco10, eco77, eco15

URL: http://wdfw.wa.gov/wlm/diversty/soc/status/leopfrog/nlepfrog.pdf

Author: McDowell, P. F.
Year of Conference: 2000
Title: Human impacts and river channel adjustment, northeastern Oregon: Implications for restoration
Reference Type: Conference Proceedings
Editor: P.J. Wigington; R.L. Beschta
Conference Name: Riparian Ecology and Management in Multi-Land Use Watersheds
Publisher: American Water Resources Association, Middleburg, VA
Pages: 257-261

Value of reference: Though the title implies that the article is about the future rather than the past, the paper contains an example of reconstructing past river channel configuration. McDowell reconstructs channel changes for a 30 km section of the Middle Fork John Day River in eastern Oregon using 1881 land survey records, and aerial photos from 1939 and 1989.

Results relevant to EMAP: The paper outlines human impacts contributing to declining salmon numbers in the John Day basin over the last 125 years, but it also provides a quantitative measure of sinuosity taken from aerial photographs in 1939 (prior to major changes in the segment) and 1989. Sinuosity decreased on all seven study channel segments. Not unexpectedly, there has been more direct human modification of the channel and riparian zone in wide valley (unconstrained) segments than in narrow valley (constrained) segments.

1881 survey notes show dense willow thickets, or riparian communities of willow, cottonwood, and alder, in many places along the Middle Fork that today have little or no woody riparian vegetation (and no large woody debris). 1881 notes show that anabranching reaches with two or three active channels were present in 3 study segments.

The only major human caused change between 1881 and 1939 was a km of channel cut off by the construction of the railroad. Between 1939 and 1989 sinuosity was reduced in every segment with wide valley segments experiencing the largest reductions in sinuosity. Other segments have dredged artificial channels and bank stabilizing structures that harden the banks and eliminate the possibility of future lateral migration of the channel. The segments with the most structures today had unconfined sinuous channels in 1881 and 1939.

Geographic location: John Day River, eco11, Blue Mountains, mountains, Northern Rockies, EPA Region 10, Oregon

Keywords: phab, fluvial geomorphology, human impacts, channel adjustment, riparian restoration, bank stabilization, sinuosity, historical, mining, channelization

Abstract: Historical data were used to reconstruct channel change in the Middle Fork John Day River, a tributary of the Columbia River. Human impacts on the channel from the 1800s to present include: beaver trapping, early alluvial gold mining, dredge mining, livestock grazing, haying and irrigation, railroad building, road building, and placing of bank stabilization structures. 1881 land survey records, 1939 aerial photos, 1989 aerial photos, and a detailed 1996 channel habitat inventory were used to identify the extent and location of channel change, and to compare direct human modification of the channel with channel self-adjustment by fluvial processes. Channel change and human impacts have been expressed differently in wide valley segments, which are inherently sinuous with abundant pools, compared to narrow valley segments, which are inherently less sinuous. The major effects of human activities include loss of sinuosity, loss of riparian woody vegetation, probably loss of large woody debris and pools,

and reduced potential for adjustment because of bank stabilization structures. Wide valley segments have more potential for fish habitat, but also have been the most affected by human impacts. Implications for restoration are discussed.

Notes: Also see Welcher, K.E. 1993. Channel restoration plan and geomorphology of the Middle Fork John Day Preserve. Report prepared for The Nature Conservancy, Portland, OR (unpublished). 88 p. + appendices.

Author: McFarling, L.
Year: 1955
Title: Exploring the Northern Plains
Reference Type: Book
City: Caldwell, Idaho
Publisher: The Caxton Printers, Ltd.
Number of Pages: 441

Value of reference: The early explorations into the northern Great Plains contain descriptive information of the landscape, geology, vegetation, and general river conditions within the region. There is also mention of the wildlife present. These accounts help establish what was present prior to and during settlement of the region.

Results relevant to EMAP: Descriptions of the Platte River, James River, White River, Missouri River, Niobrara River, and Ponca Creek (among others within the Missouri River basin) include physical characteristics, geology, flora, and large fauna. These early expeditions contain valuable baseline information of what landscape and riverine conditions were like prior to settlement of the region. The information is presented as descriptive text, maps, and explorer narratives including explanatory footnotes.

The chapters require some sifting through to extract small pieces of anecdotal information or to reconstruct stream related attributes, however; the information present is quite valuable and may be the only source of pre-settlement conditions of the plains and plains streams. This is a good broad reference and inventory that includes specific information about pre-settlement conditions in the plains.

Geographic location: Nebraska, Wyoming, South Dakota, Montana, North Dakota, Niobrara River, Ponca Creek, Missouri River, James River, White River, eco43, eco42, eco17, plains, EPA region 7, EPA region 8

Keywords: explorations, phab, resource inventories, pre-settlement condition, historic condition, geography, geology, expeditions

Author: McIntosh, Bruce A.; Sedell, James R.; Smith, Jeanette E.; Wissmar, Robert C.; Clarke, Sharon E.; Reeves, Gordon H.; Brown, Lisa A.
Year: 1994
Title: Management History of Eastside Ecosystems: Changes in Fish Habitat Over 50 Years, 1935 to 1992. Volume III: Assessment
Reference Type: Report
City: Portland, OR
Institution: USDA Forest Service, Pacific Northwest Research Station
Pages: 55
Report Number: General Technical Report PNW-GTR-321

Value of reference: The most useful data from this publication (and reliable, in terms of its relevance to a true pre-settlement condition) are the historical run estimates given for coho, chinook, and steelhead in the Upper Grand Ronde, Yakima River, Metthow River, and Wenatchee River basins. For comparison, the present day (late 1980s) runs are given, but not consistently. In addition to historical runs, this publication reports changes in pool habitats between the 1930s and 1990s (see Notes section below for suggested citations). In some areas, the 1930s condition was quite degraded already.

Results relevant to EMAP: *Grand Ronde Basin* historically had large runs of spring chinook and summer steelhead (see Northwest Power Planning Council 1990), which have been reduced to a small fraction of their predevelopment numbers (spring chinook are listed as threatened) due to dams, habitat degradation (from numerous human impacts), and over exploitation of mixed-stock fisheries.

Yakima River Basin historic salmon runs were estimated at 790,000 adults before the 1870s (break down by species and run is included--also see Northwest Power Planning Council 1989). By 1900, >90% of runs were thought to be depleted as a result of dams, irrigation canals, log drives, local overfishing; present runs are estimated at only 7018.

Wenatchee Basin historical runs (1850s): chinook=41,300; coho=3900; sockeye=228,100; steelhead=7300. Numbers for 1967-87 were higher but distributed much differently: coho=0, Chinook=204,800; sockeye=93,700, steelhead=8200 (from Mullan et al. 1992).

Methow Basin historical runs (1850s): chinook=24,200, coho=36,000, steelhead=3600. 1967-1987: chinook=86,100, coho=0; steelhead=5000 (see Mullan et al. 1992). Coho were near extinction by 1941, while the other species increased by the 1980s; decline of coho was due to impassable dams, unscreened irrigation diversions, overharvest, and the indiscriminate use of coho eggs for early hatchery programs.

Geographic location: mountains, xeric, Washington, Oregon, eco11, eco10, eco77, Grande Ronde River basin, Yakima River basin, Wenatchee River basin, Methow River basin, EPA Region 10

Keywords: fish, anadromous, fish habitat, historical changes, land-use practices, pools, stream-flow, fish, mountains, arid, general human impacts

Abstract: From 1934 to 1942, the Bureau of Fisheries surveyed over 8000 km of streams in the Columbia River basin to determine the condition of fish habitat. To evaluate changes in stream habitat over time, a portion of the historically surveyed streams in the Grande Ronde, Methow, Wenatchee, and Yakima River basins were

resurveyed from 1990 to 1992. Streams were chosen where the primary impacts were natural disturbance (unmanaged), such as wilderness and roadless areas, and where human impacts (managed) were the major disturbances. In addition, historical changes in land-use, stream-flow, and climate regimes were also analyzed. Many of these streams had been degraded from land-use activities (riparian timber harvest, splash dams, stream channelization, livestock grazing, and mining) prior to the historical survey. While the general trend throughout the Columbia River basin has been towards a loss in fish habitat on managed lands and stable or improving conditions on unmanaged lands, the data for these four river basins suggest there is a regional pattern to this change. Based on this information, along with data on the status of anadromous fish runs in these basins, fish habitat has shown some improvement from past abuses in eastern Washington, while continuing to decline in eastern Oregon. This appears to be the result of different land-use histories in the two regions. The river basins of eastern Washington apparently had a period of recovery after World War I from past land-use practices, as the impacts of development decreased. In contrast, river basins of eastern Oregon have been affected continuously by land-use practices over the entire development period (1850-present). From this information, it is clear that land-use practices have degraded fish habitat throughout eastern Washington and Oregon. Strategies to protect, restore, and maintain anadromous and resident fish populations and their habitat, must be based on a watershed approach that protects the remaining habitat and restores historical habitats.

Notes: Mullan, J.W. et al. 1992. Production and habitat of salmonids in mid-Columbia River tributary streams. Leavenworth, WA: U.S. Department of Interior, Fish and Wildlife Service. Monograph I. 489 pp.

Northwest Power Planning Council. 1989. Yakima River sub-basin salmon and steelhead plan: draft report. Portland, OR, 212 p.

Northwest Power Planning Council. 1990. Grande Ronde River sub-basin salmon and steelhead production plan: draft report. Portland, OR. 129 p.

Additional information on changes in fish habitat (namely pools) since the 1930s in basins of the Columbia River basin can be found in:

McIntosh, B.A., J.R. Sedell, R.F. Thurow, S.E. Clarke, and G.L. Chandler. 2000. Historical changes in pool habitats in the Columbia River Basin. Ecological Applications 10(5):1478-1496.

McIntosh, B.A., J.R. Sedell, J.E. Smith, R.C. Wissmar, S.E. Clarke, G.H. Reeves, and L.A. Brown. 1994. Historical changes in fish habitat for select river basins of Eastern Oregon and Washington. Northwest Science 68 (Special Issue):36-53.

Author: Meengs, C.C.; Lackey, R.T.
Year: 2005
Title: Estimating the size of historical Oregon salmon runs
Reference Type: Journal Article
Journal: Reviews in Fisheries Science
Volume: 13
Pages: 51-66

Value of reference: This research estimates pre-settlement salmon (coho, chinook) runs for the west coast of Oregon using 2 methods: 1) converting estimated aboriginal population levels into numbers of salmon; and 2) extrapolating cannery pack into numbers of salmon. It is unique in that its focus is on the streams and rivers that drain to the Pacific Ocean on Oregon's West Coast, *excluding* the Columbia River basin.

The authors calculate estimates of coho and chinook salmon populations for the Oregon coastal rivers in 1850, before major European influence or impacts had altered salmon habitat, and the data are thus notable as pre-settlement conditions. The authors compare these estimates with today's estimates to obtain estimates of population losses. Based on spawning habitat loss, *potential* populations are also estimated.

Past publications and methods of estimating salmon populations in a similar manner are reviewed and provide good additional data and references. Some of the past estimates are also used in the calculations of this publication (e.g., Craig and Hacker 1940, estimates of aboriginal consumption and proportion of a run that was harvested).

Results relevant to EMAP: Total pre-settlement salmon runs along the Oregon coast were estimated to be 1.75-5.36 million fish. Salmon runs may have been larger in the 1850s than any other time in post-glacial history because of the rapid decline in the aboriginal population and the resulting decline in harvest just prior to major European impacts such as gold mining, farming, and logging.

The pre-1850 estimates were1.5-2.5 million fish in the coho run and 290,000-517,000 in the chinook run. During "poor" ocean years, the current run size for coho is 3-6% of the historical run size, whereas in "good" ocean years it is 11-19% of the historical run size. Overall, on the Oregon coast, coho runs have been reduced by 80-95% since the 1850s. Current population estimates are far below *potential* salmon numbers, which were calculated based on available habitat remaining. The authors conclude that, since spawning habitat has declined, ocean conditions are the dominant factor affecting fluctuations in run size.

Reasons given for decline include deteriorating ocean conditions, competition with nonnative fish, predation, pollution, and past or current fishing levels. Mining, logging, and agriculture beginning in the 1800s have also impacted salmon populations.

Geographic location: Oregon, Coastal Oregon rivers and streams, EPA Region 10, eco1, mountains

Keywords: fish, mining, logging, agriculture, habitat degradation, nonnative species, urban, fishing

Abstract: Increasing the abundance of salmon in Oregon's rivers and streams is a high priority public policy objective. Salmon runs have been reduced from pre-development conditions

(typically defined as prior to 1850), but it is unclear by how much. Considerable public and private resources have been devoted to restoring salmon runs, but it is uncertain what the current recovery potential is because much of the freshwater and estuarine habitat for salmon has been altered and there is no expectation that it will be returned to a pre-development condition. The goals of all salmon recovery efforts are based on assumptions about the size of the runs prior to significant habitat alteration, coupled with an estimate of the amount and quality of freshwater and estuarine habitat currently available. We estimated the historical aggregate salmon run size in rivers along the Oregon coast (excluding the Columbia River) using two methods: (1)
Converting estimated aboriginal population levels into numbers of salmon; (2) Extrapolating cannery pack into numbers of salmon. Annual aboriginal harvest of all salmon species is estimated to have been approximately 10 million pounds per year (4,500,000 kg) or 1.75-5.36 million salmon, a harvest level similar to that occurring during the height of commercial fishing on Oregon's coastal rivers in the late 1800s and early 1900s. Extrapolating cannery pack data, the estimated size of the late 1800s aggregate runs of coho salmon (*Oncorhynchus kisutch*) was 1.5-2.5 million. The estimated size of aggregate runs of chinook salmon (*Oncorhynchus tshawytscha*) runs was 290,000-517,000. Compared to our estimates of mid-1800s coho salmon levels, early 2000 runs (during favorable ocean conditions), were 11-19% of the historical level.
During poor ocean conditions (1990s), current coho salmon runs were 3-6% of the historical size.

Notes: Craig, J.A. and R.L. Hacker. 1940. The history and development of the fisheries of the Columbia River. Bulletin of the Bureau of Fisheries 49:133-216.

URL: http://www.epa.gov/wed/pages/staff/lackey/recntpub.htm

Author: Miller, A.I.; Counihan, T.D.; Parsley, M.J.; Beckman, L.G.
Year: 1995
Title: Columbia River Basin White Sturgeon
Reference Type: Electronic Source
Producer: U.S. Department of Interior, National Biological Service
Access Year: 2005
Access Date: May 18

Value of reference: This web site addresses a particular species (white sturgeon) in a large basin (Columbia River) and graphically shows the population status in sections of that basin in rough comparison with historical population levels. This might not have a wide application within EMAP-West, since the sturgeon is a large river fish, and EMAP focuses on smaller streams.

Results relevant to EMAP: Historically, white sturgeon inhabited the Columbia River from the mouth upstream into Canada, the Snake River upstream to Shoshone Falls, and the Kootenai River upstream to Kootenai Falls; they also used the extreme lower reaches of other tributaries, but not extensively.

A commercial fishery that began in the 1880s peaked in 1892 when 2.5 million kg (5.5 million lb) were harvested (Craig and Hacker 1940). By 1899 the population had been severely depleted due to overfishing; more recent causes for populations declines include dam-building (which affects spawning habitat), and continued over-harvest.

The Figure included on this web site shows portions of the Columbia River Basin in the U.S. where white sturgeon are currently abundant (lower Columbia River only), abundant but below historical levels (portion of Columbia River above Bonneville Dam, upper Columbia near Canadian border, between Lower Granite Dam and Hells Canyon Dam, and portion of upper Snake River), sparse, endangered, extirpated, and unknown.

Geographic location: eco1, eco3, eco4, eco10, eco11, eco15, eco12, Columbia River Basin, xeric, mountains, Washington, Oregon, Idaho, EPA Region 10

Keywords: fish, dams, fishing

URL: http://biology.usgs.gov/s+t/noframe/e065.htm

Author: Miller, R.R.; Williams, J.D.; Williams, J.E.
Year: 1989
Title: Extinctions of North American fishes during the past century
Reference Type: Journal Article
Journal: Fisheries
Volume: 14
Issue: 6
Pages: 22-38

Value of reference: Information about extinct species can be used to reconstruct a more complete species list to describe historical fish diversity. This article profiles 40 species or subspecies of North American fish that have become extinct. The list includes 14 species or subspecies from states within the EMAP-West 12-state region, plus 3 species in that region that inhabited only lakes.

The article discusses human impacts that are thought to have caused extinction, and summarizes these, by species, in Table 2. It also lists erroneously reported extinctions of fishes from North America and their current (1989) status, e.g., endangered, threatened...)(Appendix).

Results relevant to EMAP: The following 14 species, originally found in streams of the EMAP-West region, have gone extinct as of 1989: *Oncorhynchus clarki* ssp*., Gila bicolor isolata, Gila crassicauda, Lepidomeda altivelis, Pogonichthys ciscoides, Rhinichthys deaconi, R. osculus reliquus, Chasmistes l. liorus, C. muriei, Cyprinodon nevadensis calidae, C.* sp*., Empetrichthys latos concavus, E. l. pahrump, E. merriami.* Species were lost from Colorado, Wyoming, Utah, Nevada, Oregon, California, and Arizona

Most of these were originally known from a very small locale or number of streams or springs and may have had very specific geographic ranges and/or habitat requirements. Some had been known for only a short time and were presumably in decline for many years prior to being described, and therefore the original geographic ranges will never be fully known for most of these species or subspecies

Reasons for extinction include physical habitat alteration, introduction of species, chemical alteration or pollution, hybridization, and overharvest.

Geographic location: westwide, Colorado, Wyoming, Utah, Nevada, Oregon, California, Arizona, EPA region 8, EPA region 9, EPA region 10, mountains, plains, xeric

Keywords: fish, habitat degradation, nonnative species, pollution, fishing

Abstract: Extinctions of 3 genera, 27 species, and 13 subspecies of fishes from North America are documented during the past 100 years. Extinctions are recorded from all areas except northern Canada and Alaska. Regions suffering the greatest loss are the Great Lakes, Great Basin, Rio Grande, Valley of Mexico, and Parras Valley in Mexico. More than one factor contributed to the decline and extinction of 82% of the fishes. Physical habitat alteration was the most frequently cited causal factor (73%). Detrimental effects of introduced species also were cited in 68% of the extinctions. Chemical habitat alteration (including pollution) and hybridization each were cited in 38% of the extinctions, and over-harvesting adversely affected 15% of the fishes. This unfortunate and unprecedented rate of loss of the fishery resource is expected to increase as more of the native fauna of North America becomes endangered or threatened.

Author: Minckley, W.L.; Deacon, J.E.
Year: 1968
Title: Southwestern fishes and the enigma of "endangered species"
Reference Type: Journal Article
Journal: Science
Volume: 159
Pages: 1424-1432

Value of reference: This paper is about extinction primarily, but in this context it gives examples of declining species and fauna and the changes in distribution that have occurred in the Gila basin. Paper describes historical ranges for a number of native fish of the Gila basin, the changes in distribution that had occurred as of 1968, and the causes of the declines in native fish. The historical and current distributions of several selected species are depicted in maps and juxtaposed with range maps for exotic species. Conditions in the Gila drainage are presented as an example of what was postulated to be happening in the Colorado River basin overall (in 1968).

Results relevant to EMAP: As an example of the changes in a whole fish fauna, data for occurrence or probable occurrence are given for 34 species in the Salt River tributary of the Gila basin from 1900 to 1960 (natives and exotics listed separately), showing the decline of natives (all but 2) and the appearance and increase in 20 exotics beginning in 1920 (see Table 1).

Two other examples: 1) the Gila spinedace once occurred throughout the upper Gila River basin but more recently it has drastically declined, apparently replaced by the introduced red shiner (see historical maps Figure 2); 2) the Gila topminnow lived in off-channel habitats from a high-elevation in western New Mexico to the area near Dome AZ and throughout the Gila drainage; once considered very common, they were considered rare in 1968 (see historical distribution map Figure 3).

Historical distributions of larger river (mainstem) species--squawfish, humpback suckers, and woundfish--are also described.

Declines have been the result of habitat destruction--including water diversions, impoundments, erosion and downcutting, agriculture, and pollution--and competition with introduced fish species. These impacts are discussed in more detail by Molles 1980 with respect to their present and likely future influences in the upper Colorado River basin.

Geographic location: Gila River basin, Arizona, eco81, eco79, eco23, xeric, EPA Region 9

Keywords: fish, nonnative species, dams, water diversion, erosion, agriculture

Notes: Molles, M. 1980. The impacts of habitat alterations and introduced species on the native fishes of the upper Colorado River basin. Pages 163-81 IN Spofford, W.O., Jr., A.L. Parten, A.V. Kneese (eds.), Energy development in the southwest. Research paper 18. Resources for the future, Washington, D.C.

Author: Minckley, W.L.; Marsh, P.C.; Brooks, J.E.; Johnson, J.E.; Jensen, B.L.
Year: 1991
Title: Management toward recovery of the razorback sucker
Reference Type: Book Section
Editor: W.L. Minckley; Deacon, J.E.
Book Title: Battle Against Extinction: Native Fish Management in the American West
City: Tucson, AZ
Publisher: The University of Arizona Press
Pages: 303-357

Value of reference: The first portion of this chapter summarizes what is known about the historical distribution of the razorback sucker in the Colorado River basin and chronicles the species' decline. It is extensively researched, using both peer-reviewed and published literature as well as personal contacts. The historical summary is largely a literature review, which includes many historical survey references and an overview of historical abundance in various portions of the river basin (see subsection 'Abundance in Aboriginal and Early Historical Times', on page 307). Other relevant sections summarize survey records from the 1900s, which provide evidence of declining populations, and reasons for decline.

Results relevant to EMAP: Although it is estimated that the species began declining before 1912, much of the concern regarding the species status is more recent, beginning in the 1930s after closure of the Hoover Dam.

Possible reasons for declining populations include dewatering, dams, water diversions, lower water temperatures, competition with non-native fishes, predation, and hybridization

Historical records of presence and abundance are cited throughout the text. Figure 17-2 shows a map of present and historic distribution of the sucker in the Colorado River basin.

Geographic location: Colorado River basin, xeric, mountains, eco20, eco18, eco22, eco14, eco23, eco81, EPA Region 8, EPA Region 9, Colorado, Wyoming, Arizona, California, Utah,

Keywords: historical distribution, fish, razorback sucker, dams, water diversion, nonnative species

Author: Minckley, W.L.; Rinne, J.N.
Year: 1985
Title: Large Woody debris in hot-desert streams: an historical review
Reference Type: Journal Article
Journal: Desert Plants
Volume: 7
Issue: 3
Pages: 142-153

Value of reference: This work provides a good historical review of desert riparian communities in the mid 1800s. Many selected quotations from early literature help to illustrate riparian conditions. The fate of large wood in desert systems and the changes in human impacts between the late 1800s and late 1900s are addressed. The influence of wood and organic particulates on macroinvertebrates is also treated to link the physical and biological aspects of desert streams.

Results relevant to EMAP: Historically, large wood contributed to heterogeneity of the desert stream ecosystem. Lithographs, photographs, and written historical documentation provide evidence of dense riparian gallery forests, marshlands, densely-vegetated floodplains, and accumulations of large, woody debris along Sonoran Desert streams, much of which originated in the upper basin. Conditions along smaller tributaries included large stands of riparian trees (including cottonwood, mesquite, willow), and thus presumably substantial amounts of downed timber. Based on historical accounts, the authors conclude that substantial amounts of vegetative debris, including fine particulates, were available to streams of the Sonoran Desert. Extensive literature citations are given for historical documentation.

A large percentage of southwestern riparian communities, especially at low elevations, have now been replaced by introduced saltcedar (*Tamarix chinensis*). Riparian communities have been further destroyed by woodcutting, agricultural development, urbanization, and desiccation from stream incision, impoundment, channelization, and over-grazing. In central AZ, cleared and irrigated agriculture land increased from less than 200 hectares in 1862 to many thousands of hectares in 1982., while the population of Phoenix grew from 100 to over a million. Dams now trap most particulate materials.

Geographic location: xeric, Arizona, California, EPA Region 9, Sonoran Desert, lower Colorado River basin, eco14, eco81, eco23, eco22, eco20

Keywords: phab, large wood, riparian vegetation, particulate organic matter, Sonoran Desert, historical documentation, agriculture, urban, grazing, impoundment

Abstract: Large-particulate organic debris is denied to present-day desert streams because of interception by impoundments and as a results of decimation of formerly extensive riparian vegetation. Historical records indicate a substantial, but sporadic, input of coarse debris, which was reduced to finer particles through molar action in canyon-bound reaches of desert rivers. Historical changes, functions of large debris in the system, and probable future conditions are reviewed.

Author: Minshall, G. W.; Jensen, S. E.; Platts, W. S.
Year: 1989
Title: The ecology of stream and riparian habitats of the Great Basin region: A community profile
Reference Type: Report
Institution: U.S. Fish and Wildlife Service
Pages: 142
Report Number: Biological Report 85(7.24)

Value of reference: The reference provides a good overview of the fish of the Great Basin with an emphasis on the post-Pleistocene distribution of cutthroat trout and a timeline of fish introductions. It also has a section on the history of livestock grazing in the Great Basin.

Results relevant to EMAP: Introduction of exotic fish into Bonneville basin waters began in the late 1880's. Table 22 p. 86, lists fish presently established in the Great Basin with native species noted. In the Carson River system, nonnative trout introduced in the 1880's displaced the native cutthroat trout within a few decades, except where the natives had been stocked above impassable falls. The west face of the Ruby Mountains and East Humboldt Range in Elko County show the most significant impact of past trout stocking practices. Native cutthroat trout have been replaced by other salmonids, principally the eastern brook trout.

Lahontan cutthroat trout have been eliminated from 95% of their native habitat as a result of human activity. p. 92. In the Humboldt River drainage Lahontan cutthroat trout still live in the headwaters, but occur in only about 12% of their former range. Lahontan cutthroat trout of the Humboldt River drainage fared better than the trout in the Truckee-Walker drainages because they were better adapted to stream life with its flood/drought cycle. The trout in the Humboldt drainage also have not experienced as much displacement or hybridization with other stocked trout species.

Geographic location: xeric, Nevada, Utah, Bonneville Basin, Lahontan Basin, eco13, eco80, Truckee River, Humboldt River basin, Carson River, EPA Region 9, EPA Region 8

Keywords: fish, cutthroat trout, nonnative species, riparian vegetation, grazing

Author: Mongillo, P.E.
Year: 1993
Title: The distribution and status of bull trout/Dolly Varden in Washington state June 1992
Reference Type: Report
City: Olympia, WA
Institution: Washington Department of Wildlife Fisheries Management Division
Report Number: Report No. 93-22

Value of reference: A rough estimate of past distribution of bull trout/Dolly Varden is presented, based on personal knowledge of the individuals interviewed and on historic creel records. Extrapolation and assumptions were made, based on limited location information from historical sources; therefore historical absence might only mean that no historical documentation was found for certain drainages or streams. The report is more of a current status of 77 populations of the species, but changes since pre-settlement are also embedded; Figure 1 gives the current knowledge on present and past distribution of bull trout/Dolly Varden.

Results relevant to EMAP: Most of the Columbia River was previously utilized by bull trout/Dolly Varden, whereas only sections of the river associated with larger tributary populations commonly contain bull trout/Dolly Varden today (see Figure 1); the species was likely never abundant in the mainstem River and never seems to have been present in the Cowlitz River drainage of southwest WA or the Quileute system below Solduc Falls on the coast.

The Okanogan, Lake Chelan, and Lower Yakima River populations have been lost, while other populations or groups of populations have become fragmented or isolated, for example in the streams in the Blue Mountains of southeast WA, the upper Yakima River in central WA, the Lewis River in southwest WA, and the Cedar River near Seattle.

Easy public access, poaching and presence of nonnative fish species (brook trout, brown trout, rainbow trout) are adversely impacting approximately the same number of populations; interbreeding between small resident populations of bull and brook trout will likely lead to elimination of bull trout. A number of human impacts harming the species are discussed; forest management is affecting the greatest number of populations, and grazing the least.

Geographic location: Washington, eco77, eco15, eco10, eco1, eco2, eco4, Pacific Northwest, EPA Region 10, mountains, xeric

Keywords: fish, nonnative species, logging, roads, fishing

Abstract: Bull trout (*Salvelinus confluentus*), and Dolly Varden (*Salvelinus malma*), are generally present in all parts of Washington State except the area east of the Columbia River and north of the Snake River in eastern Washington (Columbia Basin) and the extreme southwest portion of the state. Distribution losses from historical levels have been confined mainly to eastern Washington. In addition to a reduced distribution from historical levels, several populations in both eastern and western Washington have become fragmented because lower river reaches are no longer utilized. A total of three populations have become extinct. It is estimated that a minimum of 77 distinct bull trout/Dolly Varden populations remain in Washington. Nine are at high risk of extinction, six are at moderate risk, 13 are at low risk and six are believed to be at no immediate risk. The remaining 43 populations do not have sufficient data on them to assign a level of risk. Additionally, the habitat and non-habitat factors affecting each population are identified and summarized.

Author: Moyle, P.B.; Nichols, R.D.
Year: 1974
Title: Decline of the native fish fauna of the Sierra Nevada foothills, central California
Reference Type: Journal Article
Journal: American Midland Naturalist
Volume: 92
Issue: 1
Pages: 72-83

Value of reference: Historical data from three historical surveys were synthesized and compared to the 1970 survey. The results, shown in Table 2, show how the fish assemblage changed over time in reference to the construction of Friant Dam (1942) and with respect to the proportions of native and introduced species. Distribution maps, showing pre-1900 and 1970 locations are presented for the most abundant species. General changes in numbers and distribution are discussed briefly for each species.

The study was confined to streams between 90 and 1100 m elevation with a mean elevation of 401 m.

Results relevant to EMAP: The San Joaquin foothill fish fauna has change dramatically in many areas as native fishes are replaced by introduces species. Table 2 illustrates the changes that have occurred since 1989, as documented in 4 surveys, published in 1898, 1934, 1941, and 1970 (present study). The 1898 survey indicates that the areas originally had a fish fauna transitional between those of the Valley floor and the foothills.

The San Joaquin River systems experienced modification due to dam construction and the introduction of numerous fish species. By 1970, the river below Friant Dam (closed in 1942) was dominated by introduced species. Healthy populations of native fishes occurred only in a restricted region of relatively undisturbed foothill streams.

Geographic location: xeric, eco7, California, EPA region 9, San Joaquin River basin

Keywords: fish, nonnative species, dams, habitat fragmentation

Abstract: A survey was made of the fishes occurring in streams of the Sierra Nevada foothills above the San Joaquin Valley, California. Twenty-four species were collected, 12 native, 12 introduced. The present distributions of these fishes were compared to their pre-1900 distributions, as inferred from old records. Overall, the ranges of introduced species and rainbow trout have expanded while the ranges of native species, especially California roach, hardhead, Sacramento squawfish and Sacramento sucker, have contracted. Healthy populations of native fishes were found only in a rather narrow middle elevation band of comparatively undisturbed sections of foothill streams. The native fish populations in different foothill stream systems are now isolated from each other and are, thus, in danger of local extinction as foothill development proceeds. The study indicates that populations of native stream fishes, even if they do not contain endangered species, should be protected, to make sure that severe natural conditions, when combined with human alterations to the streams, do not destroy unique assemblages of fishes.

Author: Moyle, P.B.; Williams, J.E.
Year: 1990
Title: Biodiversity loss in the temperate zone: decline of the native fish fauna of California
Reference Type: Journal Article
Journal: Conservation Biology
Volume: 4
Issue: 3
Pages: 275-284

Value of reference: This article synthesizes information and reports on the status of 113 native fish taxa in California, in a manner similar to that of Nehlsen et al. 1991 (this bibliography). It does not present historical information specifically, but uses historical information and knowledge of declining populations, based on past status, and assigns a status ranking of 1-6 for each of several ratings of natural and artificial factors influencing the species distribution. Causes of decline are also summarized briefly.

Results relevant to EMAP: Of 113 native fish taxa in California, 6% are extinct, 57% are in various stages of decline, and 36% appear to be stable. Much of the decline has been recent, rapid, and unexpected. Fish taxa at particular risk are most likely to be endemic, restricted in range, part of a small fish assemblage, or found in isolated springs, warm water stream, or big rivers. Entire regional faunas are threatened with extinction or with being confined to isolated fragments of habitat.

Cause for decline is attributed mainly to water diversions and introduced species, acting in concert. Habitat alterations associated with agricultural practices, grazing, and channelization are other contributors.

Geographic location: California, eco1, eco78, eco4, eco9, eco5, eco7, eco6, eco8, eco14, eco81, EPA Region 9, Mountains, Xeric. Non-specific to river basin, although some summaries used ichthyological provinces.

Keywords: fish, status, water diversion, nonnative species, agriculture, grazing, channelization

Author: Moyle, P.B.; Yoshiyama, R.M.; Knapp, R.A.
Year: 1996
Title: Status of Fish and Fisheries
Reference Type: Report
City: Davis, CA
Institution: University of California, Centers for Water and Wildland Resources
Pages: 953-973

Value of reference: This is a good synthesis of changes in native fish populations in the Sierra Nevada range. Historical (pre-European) distributions (largely affected by elevation) are discussed briefly for each of four major basins and summarized in general in Figure 1. Current status and short species accounts of 40 native fish species are presented. Factors contributing to declines and the importance of their impact on native fishes of the region are summarized in Table 4. A special section is included for Chinook salmon, although a more thorough treatment of this species can be found in Yoshiyama et al. 1998, in this bibliography.

Fish introductions in this region are treated in detail, since they are a major factor in the decline of native species. The effect of trout introductions on native biota--native trout, amphibians, and invertebrates--is included, although few specific details are presented.

Results relevant to EMAP: Since 1850, anadromous fishes have been excluded from most west side rivers; most resident native fishes have declined and aquatic communities have become fragmented; 30 species of nonnative fishes have been introduced or have invaded most waters, including historically fishless, high-elevation areas; and fisheries now focus on nonnative fish, rather than natives. Chinook salmon have lost 62% of the stream length originally available to them for spawning in the Central Valley (Table 3).

Historically, all four of the major basins in the region were fishless at high elevation. Chinook salmon, steelhead trout, and Pacific lamprey were abundant in the Sacramento-San Joaquin drainage. The Lahontan drainage supported 10 native fish species and all were widespread and abundant. Known historical elevation limits are given for a number of species.

Of the 40 fishes native to the Sierra Nevada, 15% have been listed as threatened or endangered, 30% are listed as species of special concern by Moyle et al. 1996, 10% are in severe decline in this region, and 45% seem to be stable or expanding. Chinook salmon, steelhead, and 5 native trout have mostly disappeared from the region. The mountain yellow-legged frog is found at fewer than 15% of the high-elevation sites at which it was present in 1915 (Drost and Fellers 1994).

The biggest declines in native fish abundance occurred between 1850 and 1950 as a result of hydraulic mining, construction of dams and diversions, and introductions of nonnative fish. Other factors include road building/urbanization, channelization, grazing, logging, and pollution.

Geographic location: California, eco5, eco6, eco7, Sierra Nevada, EPA region 9, mountains, xeric, Sacramento-San Joaquin basin, Owens basin, Lahontan basin, Eagle Lake basin

Keywords: fish, status, distribution, nonnative species, dams, urban, water diversion, logging, grazing, channelization, pollution

Notes: Moyle et al. 1996. Fish species of special concern in California. California Department of Fish and Game, Sacramento, CA.

Drost and Fellers 1994. Decline of frog species in the Yosemite section of the Sierra Nevada. U.S. Department of the Interior Technical Report NPS/WRUC/NRTR-94-02. Government Printing Office, Washington, D.C.

Author: Mueller, G.; Marsh, P.
Year: 1995
Title: Bonytail and Razorback Sucker in the Colorado River Basin
Reference Type: Electronic Source
Producer: U.S. Department of Interior, National Biological Service
Access Year: 2005
Access Date: June 21

Value of reference: This is a summary paper printed by the National Biological Service on a web site. It is a comprehensive summary of the decline of razorback suckers and bonytails in the CO River basin. It reports the extent of their historical ranges, the tributaries where they were once common to abundant, and the major causes of their declines.

Results relevant to EMAP: Both species were common historically; today, no measurable recruitment is evident for either species, and old individuals are reaching the end of their lifespan.

Bonytails were historically common in mainstem CO, Green, Gunnison, Yampa, Gila, and Salt rivers before construction of large dams. They now exist only in Lake Mohave, which comprises <2% of their former range (see Figure 3).
Razorback suckers were historically common to abundant in the CO mainstem and portions of the Green San Juan, Animas, Duchesne, Gila, Salt, and Verde rivers, but today are very rare and found in <25% of the former range (see Figure 3).

Declines have been caused by physical and biological changes to habitat cause by large dams, reservoirs, and diversion canals, direct competition with introduced fish species, and predation on young fish by non-native fishes. Promotion of recreational fisheries, introduction of sport fish more adapted to colder water, and poisoning compromised the native fish.

Geographic location: Colorado River Basin, eco18, eco19, eco20, eco21, eco13, eco22, eco23, eco81, eco14, Wyoming, Utah, Colorado, Arizona, Nevada, xeric, mountains, EPA Region 8, EPA Region 9

Keywords: fish, endangered species, dams, channelization, water diversion, nonnative species

Notes: A related, but less current publication documenting historical range and the 1970s distribution in the Colorado R. system is:
McAda, C.W. and R.S. Wydoski. 1980. The Razorback Sucker, *Xyrauchen texanus*, in the Upper Colorado River Basin, 1974-76. U.S. Department of Interior, Fish and Wildlife Service, Technical Paper 99. Washington, D.C.

URL: http://biology.usgs.gov/s+t/noframe/r166.htm

Author: Mueller, G.; Marsh, P.
Year: 2002
Title: Lost, A Desert River and Its Native Fishes: A Historical Perspective of the Lower Colorado River
Reference Type: Report
City: Fort Collins, CO
Institution: Geological Survey Fort Collins Science Center
Pages: 80
Report Number: Information and Technology Report USGS/BRD/ITR--2002-0010

Value of reference: This detailed report documents the history, exploration, settlement, and historical fish community of the lower Colorado River basin, as well as the story of water development of the basin and the changes in physical habitat and the native fish community that followed. Information includes descriptions of channel characteristics, sediment loads, backwater habitats, vegetation, river dynamics, and flooding patterns typical of the undisturbed river. Changes occurring during the settlement and development period are chronicled in detail. The changes in physical properties of the water, channel configuration, riparian habitat, and aquatic biota as a result of human impacts are discussed at length. This discussion includes the survival strategies and life histories of all native fish of the lower river. Table 5 gives the relative historical abundance and current federal/state status of these species. Numerous historical accounts and photographs are included.

Results relevant to EMAP: Prior to 1880, only 9 freshwater species were found in the lower CO river, representing 4 families and two marine species in the lower river (in 1880, this would have been in Mexico and not relevant to EMAP). Most fish were found in off-channel habitats where there were fewer suspended sediments and effects of flooding were less severe. Fish kills were common due to a hostile and unpredictable river environment. Fish communities periodically disappeared from the broader floodplains and extended portions of tributaries. Populations that numbered in the millions could be reduced to only a few dozen fish in a single season.

In contrast to other reports, the authors claim that the majority of natives were lost long before the Hoover Dam was built in 1935, but the larger water developments after 1935 likely guaranteed their demise. Irrigated agriculture led to stranding of fish in fields. Commercial fishing, loss of habitat, migration barriers (dam construction, diversions, dewatering), and introduction of carp, bullhead, and channel catfish occurred before 1935.

Profiles of past abundance and distribution in the basin and estimates of what remains are described for each of the native species (beginning on page 62, summarized in Table 5).

Geographic location: Arizona, California, Utah, Colorado, eco81, eco23, eco22, eco20, lower Colorado River basin, Region 8, Region 9, xeric

Keywords: human impacts, historic documentation, lower basin, native fish, agriculture, fishing, dams, water diversion, channelization, nonnative species, historical photographs, fish, phab

Abstract: The Colorado River had one of the most unique fish communities in the world. Seventy-five percent of those species were found nowhere else in the world. Settlement of the lower basin brought dramatic change to both the river and its native fish. Those changes began more than 120 years ago as settlers began stocking nonnative fishes. By 1930, nonnative fish had spread throughout the lower basin and replaced native communities. All resemblance of

historic river conditions faded with the construction of Hoover Dam in 1935 and other large water development projects. Today, few remember what the Colorado River was really like. Seven of the nine mainstream fishes are now Federally-protected as endangered. Federal and state agencies are attempting to recover these fish. However, progress has been frustrated due to the severity of human impact. This report represents testimony, old descriptions, and photographs describing the changes that have taken place in hopes that it will provide managers, biologists, and the interested public a better appreciation of the environment that shaped these unique fish.

URL: http://www.stormingmedia.us/23/2322/A232214.html

Author: Mueller, G.A.; Marsh, P.C.; Minckley, W.L.
Year of Conference: 2005
Title: A legacy of change: the lower Colorado River, Arizona-California-Nevada, USA, and Sonora-Baja California Norte, Mexico
Reference Type: Conference Proceedings
Editor: Rinne, J.N.; Hughes, R.M.; Calumusso, B.
Conference Name: Historical Changes in Large River Fish Assemblages of the Americas
Conference Location: Phoenix, AZ
Publisher: American Fisheries Society
Volume: 45
Pages: 139-156

Value of reference: This chapter is a concise synopsis of what has happened to the Colorado River and its native fish community. The section on 'Native Fish Assemblage' describes the historical fish community and provides citations of numerous original historical documents and reports.

A section on 'Physical Description' includes a few riparian descriptions.

Factors causing the decline of native fish are discussed.

Results relevant to EMAP: Historically, the lower CO river had only 9 native fish species, which are today extirpated, federally endangered, or being reintroduced through stocking. Eighty alien species have been introduced to the lower basin, and 20 of these have become common. Predation by nonnative species and physical habitat degradation were the primary causes of the decline of native fauna.

Table 1 summarizes historical abundance and current status of the native fish species.

Geographic location: Colorado River basin, Colorado, Utah, Wyoming, Arizona, EPA Region 8, EPA Region 9, eco18, eco19, eco20, eco21, eco22, eco23, xeric, mountains

Keywords: fish, nonnative species, habitat degradation, historical abundance, status

Author: Murphy, Peter J.; Randle, Timothy J.; Fotherby, Lisa M.; Daraio, Joseph A.
Year: 2004
Title: The Platte River Channel: History and Restoration
Reference Type: Electronic Source
Producer: U.S. Department of the Interior; Bureau of Reclamation Technical Service Center
Access Year: 2005
Access Date: July 26, 2005

Value of reference: Good summary of the human impacts and physical changes that have occurred to the Platte River valley since settlement (mid -late 1800's). Changes in geomorphology, flow and sediment transfer of the river are the main focus of the study. Includes an extensive bibliography.

Results relevant to EMAP: The emphasis of this study is a historic review and analysis of the geomorphology of the central Platte River. This analysis is based primarily on existing historic field data, historic mapping, aerial photos, written narrative, historic photos, recorded information on Platte River Basin development, and some recent field data collection associated with this study. Historic and recent field data include measurements of river discharge, climate indicators, bed-material size gradations, average un-vegetated channel widths or active channel widths, and stage-discharge relationships.

Initial anthropogenic influences on the central Platte River in the 1800s are primarily raised sediment inputs from land use beginning in the 1840s, and flow depletions in the last decades of the century. The beaver trapping industry eradicated almost all beaver in the area by the mid 1800s. The impact of this harvest may have contributed small increases in sediment load in the Rocky Mountain tributaries, through the gradual elimination of sediment-trapping beaver dams. Extensive gold mining and timber harvesting in the South Platte tributaries and some activity in the North Platte tributaries, may have increased sediment loads to the central Platte River.

Reaches of the present channel have an un-vegetated or active channel width that is 50 to 90 percent narrower than the channel that existed in the 1860s and in the period 1898 to 1902. The central Platte River has generally experienced channel narrowing throughout its length with greater reductions in un-vegetated or active channel width in the upper reaches.

Geographic location: plains, Platte River Valley, Nebraska, Wyoming, Colorado, eco25, eco27, eco43, EPA region 7, EPA region 8

Keywords: Platte River, phab, channel width, channel stability, pre-settlement, geomorphology, beaver trapping, mining, logging, sediments

URL: http://www.platteriver.org/library/index.htm

Author: Murray, T.B.
Year: 1964
Title: Chinook and steelhead historic spawning grounds, Shoshone Falls to Salmon River, Snake River drainage
Reference Type: Report
City: Boise, ID
Institution: Idaho Power Company

Value of reference: The author uses multiple sources and personal observation to piece together what the distribution and range of steelhead and chinook salmon in the unobstructed, pre-settlement middle Snake River (mouth of Salmon-Imnaha Rivers to Shoshone Falls) would have been. Estimates of the river miles available as spawning habitat for these species before major human impacts and dam building are given for each tributary, extending as far as the Jarbidge and Santa Rosa mountain ranges in northern Nevada. Other pre-settlement conditions are mentioned throughout, such as vegetation, historical conditions in each basin that would have favored spawning and rearing of fingerling salmonids, human impacts that changed migration potential in the Snake River drainage, and Native American fisheries.

The document gives a broad view of the fish population potential of the Snake River in pre-settlement times. It summarizes pre-settlement spawning conditions in each tributary in the basin for spring chinook, steelhead, and fall chinook. Information is presented in a draft format of text only. The information is not referenced, and some statements are based on second-hand knowledge.

Results relevant to EMAP: Prior to obstructed migration, the middle Snake River was a prime producer of fingerling salmonids. Pre-settlement conditions favorable for spawning and rearing, including the space available (in river miles) are summarized for the following Snake River tributaries: Boise, Owyhee, Payette, Malheur, Weiser, Burnt, Powder, and Wildhorse Rivers and Pine Creek.

On page 32 is a summary of the river miles historically available for spawning and rearing in each sub-basin, totaling 2060 river miles. By 1955, the availability and use of this production potential had been reduced by 90% due to over-fishing, habitat alterations and blockage to fish passage caused by dams, agriculture, logging, pollution, water diversions, and climate changes. In 1955, remnant runs were spotty, and river habitat occupied by steelhead or chinook salmon totaled barely 200 miles on portions of Weiser and Wildhorse Rivers and Pine and Eagle Creeks.

Geographic location: Idaho, Nevada, Snake River basin, eco80, eco12, EPA region 10, xeric

Author: Musser, G.G.
Year: 1959
Title: Ecological Studies of the Flora and Fauna in Glen Canyon, Appendix E: Annotated check list of aquatic insects of Glen Canyon
Reference Type: Report
City: Salt Lake City, UT
Institution: University of Utah
Pages: 207-221
Report Number: Anthropology Papers No. 40

Value of reference: Since historical macroinvertebrate data are very limited, this article is sufficiently notable to include here, even though it was published in the mid 1900s. It is considered the best comparable data for aquatic insects that exists for the geographic region. Although the data are reported for an area now under water, their historical presence in the region is notable for reconstruction of insect distribution and community composition before dam construction.

Results relevant to EMAP: In a 1958 survey of the Glen Canyon (before impoundment), 2315 individual aquatic insects were collected, including more than 91 species in 73 genera, 41 families, and eight orders. The bulk of the collection was from tributaries, while only 247 were taken from the river.

This listing provides 1-8 lines of text description for each species collected regarding presence, relative abundance, other locations where present, habitat preferences, and other anecdotal information.

Geographic location: Arizona, Colorado River basin, eco22, xeric, EPA region 9

Keywords: macroinvertebrates, baseline data, species list

Author: Muth, R. T.; Crist, L.. W.; LaGory, K. E.; Hayse, J. W.; Bestgen, K. R.; Ryan, T. P.; Lyons, J. P.; Valdez, R. A.
Year: 2000
Title: Flow and temperature recommendations for endangered fishes in the Green River downstream of Flaming Gorge Dam
Reference Type: Report
Publisher: Upper Colorado Endangered Fish Recovery Program
Report Number: Rpt. No. FG-53

Value of reference: This is a comprehensive reference (344 pp.) for the changed conditions on the Green River downstream of the Flaming Gorge dam, how they affect the native warmwater fish populations (particularly the 3 major endangered species, humpback chub, Colorado pikeminnow, and the razorback sucker), and suggested mitigations of the adverse effects to ensure the continued existence of these fish species.

Results relevant to EMAP: The historic abundance and habitat needs of each of the species of interest is covered in a separate chapter. For example, critical habitat designated for Colorado pikeminnow makes up only about 29% of the species' original range and occurs exclusively in the upper Colorado River basin, and 600 to 650 adult Colorado pikeminnow occur today in the Colorado River upstream of the Green River confluence.

Geographic location: Region 8, Utah, Green River, xeric, eco20

Keywords: fish, dams, water diversion, habitat degradation, nonnative species, flow variability, sediment, temperature

URL: http://www.ead.anl.gov/pub/doc/flaminggorgeflowrecs.pdf

Author: Nehlsen, W.; Williams, J.E.; Lichatowich, J.A.
Year: 1991
Title: Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington
Reference Type: Journal Article
Journal: Fisheries
Volume: 16
Issue: 2
Pages: 4-21

Value of reference: This is a landmark report of the status of salmon and steelhead on the West Coast of the U.S. It is extremely comprehensive and often cited. It lists the population status of 7 species (comprising 214 stocks), and the reasons for declines in individual bays and tributaries throughout the region; it also mentions changes from historical conditions.

Few actual historical data are given; historical references reported are from varying years, depending upon what is available, and the year is usually not specified. For many of these species, the declines that have occurred even since the mid-1900s is so substantial, being closely associated with hydropower development which intensified at that time, that the most significant changes from an "historical" benchmark are captured in the period of the late 1900s. The data reported are therefore significant and noteworthy.

Results relevant to EMAP: Since 1850s, development activities such as hydropower, fishing, logging, mining, agriculture, and urban growth have caused extensive losses in salmon and steelhead populations and habitats.

A few examples of the numerous summary statements provided in this document: the Klamath River population of spring and summer chinook has undergone a 95% reduction from historical population levels, due to dams, irrigation diversions, mining, timber harvest, and floods; many native coho stocks on the southern Oregon coast have declined from historical levels of about 2000 spawners to fewer than 100 and are now dominated by hatchery programs; in the Columbia River basin, historically large chum stocks in the lower river have declined to about 0.5% of their historic level; at least 106 major populations of salmon and steelhead on the West Coast have been extirpated, and over 200 stocks have become extinct in the Columbia River basin, including 95 streams where chinook have disappeared, 83 for steelhead, 17 for coho, and 12 for sockeye (Oregon Trout, Personal communication by Nehlsen et al.) (see Table 2); natural production in the Columbia River basin is now about 4-7% of pre-development levels, which likely represents a significant loss of genetic diversity.

With the loss of so many populations prior to our knowledge of stock structure, the historic richness of the salmon and steelhead resource of the West Coast will never be known; it is clear that what has survived is a small proportion of what once existed.

Geographic location: mountains, xeric, eco1, eco3, eco10, eco11, eco15, eco16, eco17, eco12, eco6, eco78, eco7, eco9, Pacific Northwest, Oregon, Washington, Idaho, California, Columbia River basin, Coast Range, West Coast, EPA Region 9, EPA Region 10

Keywords: fish, salmon, status, habitat loss, agriculture, logging, dams, urban, nonnative species, fishing

Abstract: The American Fisheries Society herein provides a list of depleted Pacific salmon,

steelhead, and sea-run cutthroat stocks from California, Oregon, Idaho, and Washington, to accompany the list of rare inland fishes reported by Williams et al. (1989). The list includes 214 native naturally-spawning stocks: 101 at high risk of extinction, 58 at moderate risk of extinction, 54 of special concern, and one classified as threatened under the Endangered Species Act of 1973 and as endangered by the state of California. The decline in native salmon, steelhead, and sea-run cutthroat populations has resulted from habitat loss and damage, and inadequate passage and flows caused by hydropower, agriculture, logging, and other developments; overfishing, primarily of weaker stocks in mixed-stock fisheries; and negative interactions with other fishes, including nonnative hatchery salmon and steelhead. While some attempts at remedying these threats have been made, they have not been enough to prevent the broad decline of stocks along the West Coast. A new paradigm that advanced habitat restoration and ecosystem function rather than hatchery production is needed for many of these stocks to survive and prosper into the next century.

Notes: Williams, J.E. and others. 1989. Fishes of North America endangered, threatened, or of special concern: 1989. Fisheries (Bethesda) 14(6):2-20.

Author: Nesler, T.P.; VanBuren, R.; Stafford, J.A.; Jones, M.
Year: 1997
Title: Inventory and status of South Platte River native fishes in Colorado
Reference Type: Report
City: Fort Collins, CO
Institution: Colorado Division of Wildlife, Aquatic Wildlife Section

Value of reference: This report focuses primarily on current surveys of fish, but it also addresses the available historical information, utilizing Propst and Carlson 1986 (in this bibliography) as a basis for reporting and is thus a good companion article to that paper (although not a significant source of historical information on its own). The added useful information provided by this source is the mapped locations of historical vs. current collections in the basin (Figures 3-11). Although notable, the historical distributions cannot realistically be compared to modern distribution data because of a much lower sampling effort in the past. The article provides the list of native species, extirpated species, and species that are now considered common and at low risk of imperilment. It also provides a brief literature summary of the historical river (page 80).

Results relevant to EMAP: The river channel of the South Platte is only 15% of its historical dimensions due to agricultural use and water diversions. Historically it was wide, shallow, braided, and sparsely vegetated. After spring runoff, the river was intermittent, often running underground. Today, irrigation return flows have created a perennial stream and raised water table.

The historical composition of fish fauna and changes through time as a result of human impacts have not been well-documented. This article reviews the historical literature, but the lack of detail in historical survey literature prevents a meaningful comparison for most species.

The article's focus is on the 1992-94 survey results, but the species list, historical summary, and maps are useful and will complement the historical information presented by Propst and Carlson 1986--in this bibliography.

Geographic location: Colorado, South Platte River basin, eco25, plains, EPA region 8

Keywords: fish, phab, agriculture, dams, water diversion

Notes: Propst and Carlson. 1986. The distribution and status of warm water fishes in the Platte River drainage, Colorado. Southwestern Naturalist 31:149-67.

Author: Northwest Power Planning Council
Year: 1986
Title: Compilation of Information on Salmon and Steelhead Losses in the Columbia River Basin
Reference Type: Report
City: Portland, OR
Institution: Columbia River Basin Fish and Wildlife Program

Value of reference: This is a valuable document of over 200 pages that uses several different methods for estimating historical run sizes and losses of salmon and steelhead since pre-settlement. It was developed with extensive public review and comment and is frequently cited for the Pacific Northwest region. Numerous tables of historical data.

It presents comprehensive information on historical and current run sizes of salmon and steelhead in the Columbia River basin. Data on historic fish runs have been gathered from every available source ranging from actual recorded fish counts over time to the accounts of Indian tribal elders and historical records from early settlers. Sources include historical, anthropological, and archaeological data. Descriptions of current runs are based on adult fish counts, redd (spawning nest) counts, and harvest records.

Results relevant to EMAP: Salmon and steelhead runs in the Columbia River basin ranged from about 10 to 16 million fish prior to a number of development activities by white settlers in the 1800s, whereas the current run size averages about 2.5 million fish, representing a loss of at least 75%.

At one time, salmon and steelhead inhabited the entire Columbia River basin up to the Arrow Lakes in Canada and below Shoshone Falls on the Snake River. Since the mid-nineteenth century, the estimated salmon and steelhead habitat in the entire basin has declined from about 13,000 miles of stream to only 9,000 miles, a 31% loss.

The greatest losses of fish runs and habitat have occurred in the upper Columbia and upper Snake river areas, where much of the habitat has been permanently damaged by the federally-operated Chief Joseph and Grand Coulee dams in the mid-Columbia River area and development in the Snake River Basin.

The document examines the impact on fish runs of a variety of development activities including hydropower, fishing, irrigation, logging, mining, grazing, and agriculture. The major impacts caused by hydropower are blockage of fish habitat, alteration of fish habitat, and obstacles to juvenile fish passing downstream and to adult fish returning upstream to spawn.

Geographic location: Columbia River Basin, Oregon, Washington, Idaho, EPA Region 10, eco11, eco10, eco16, eco4, eco1, eco3, eco9, mountains, xeric

Keywords: fish, salmon, steelhead, hydropower, dams, fishing, agriculture, logging, mining, grazing

Author: Olden, J.D.; Poff, N.L.; Bestgen, K.R.
Year: 2006
Title: Life-history strategies predict fish invasions and extirpations in the Colorado River Basin
Reference Type: Journal Article
Journal: Ecological Monographs
Volume: 76
Pages: 25-40

Value of reference: Much of this paper is theoretical and provides a basis for assessing risk to native species from both biotic and abiotic drivers. It thereby illustrates the use of historical data to predict future risk of extinction. Of more direct use to EMAP is its summary of percent changes in native and nonnative fish species in the lower Colorado River basin before and after 1980. This information constitutes Appendix D, which is on-line in the Ecological Archives M076-002-A4 (http://esapubs.org/archive/mono/M076/002/appendix-D.htm).

The authors use historical data from the SONFISHES data base (developed by W.L. Minckley and others), which contains over 38,000 occurrence records for freshwater fishes from over 150 years of research. Records include incidence, identity, and collection information for the complete holdings of major regional museum collections, numerous smaller holdings, and records from peer-reviewed and gray literature, and they are geo-referenced to within 1 km of their collection site in a GIS. This historical data base would likely be of value for other EMAP applications and data analyses (e.g., use of a different threshold year to define "historical"; or excluding records from Mexico) and is available on-line at http://desertfishes.org//na/gis/index.html.

In this application, the historical period was defined as 1843-1980, and the modern period was 1981 to 1999. The 1980 threshold corresponds with a major shift in sampling goals (see Fagan et al. 2005)

Results relevant to EMAP: Table D1 of the on-line Appendix D lists 23 native fish species and 47 nonnative species of the lower Colorado River basin (including both U.S. and Mexican reaches between Glen Canyon Dam and the Gulf of California) and the distributional changes for each between the pre- and post-1980 threshold. Percent declines are given for native species, while the spread (km/yr) is given for each nonnative species. Declines range from 100% to -14% (negative declines being an increase); nonnative species spread ranges from 0.0 to 54.6 km/yr.

Geographic location: Colorado River basin, Colorado, Utah, Arizona, EPA Region 8, EPA Region 9, xeric, mountains, eco21, eco20, eco22, eco23, eco81, eco14

Keywords: fish, SONFISHES data base, nonnative species, prediction, extinction risk, historical occurrence data, species distribution, ranges, endangered fishes, functional niche, dams, river regulation

Notes: For a related application, see Fagan et al. 2005 in this bibliography (different 2005 publication than the one listed below).

Two additional examples of the use of the SONFISHES data base to predict current risk of extinction and need for management and listing at different spatial scales can be found in:

Fagan, W.L., C. Aumann, C.M. Kennedy, and P.J. Unmack. 2005. Rarity, fragmentation, and

the scale dependence of extinction risk in desert fishes. Ecology 86(1):34-41.

Olden, J.K., and N.L. Poff. 2005. Long-term trends of native and non-native fish faunas in the American Southwest. Animal Biodiversity and Conservation 28(1):75-89.

Author: Osmundson, D. B.; Burnham, K. P.
Year: 1998
Title: Status and trends of the endangered Colorado squawfish in the upper Colorado River
Reference Type: Journal Article
Journal: Transactions of the American Fisheries Society
Volume: 127
Issue: 6
Pages: 957-970

Value of reference: The article examines the factors that contribute to the episodic recruitment of young pikeminnow in the upper Colorado river. Though the link to historic abundance of pikeminnow is not presented in a quantitative fashion, the paper does relate what would have been historic hydrography and phab quality to successful pikeminnow reproduction.

Results relevant to EMAP: Colorado pikeminnow were once very abundant in the upper Colorado River basin including the Green, Yampa, White, and Uncompahgre tributaries. Today pikeminnow numbers are much reduced. Adult survival rates are fairly high (up to .87), indicating that adult survival is not a major constraint on population increase, but successful pikeminnow reproduction is rare.

The results of this study show that high recruitment years follow extra high spring flows; historically, before dams and irrigation diversions, high spring flows were a common, almost yearly, phenomenon. High flows assist pikeminnow reproduction by flushing fine sediments from cobble bars and reducing the numbers of nonnative minnows.

Geographic location: Region 8, upper Colorado River basin, Colorado River, Green River, Yampa River, Utah, Colorado, eco20, xeric

Keywords: Colorado squawfish, Colorado pikeminnow, upper Colorado River, endangered species, extirpation, recruitment, runoff, phab, fish, nonnative fish, hydrologic variability, sediment

Abstract: Status of the Colorado River population of the endangered Colorado squawfish *Ptychocheilus lucius* (recently renamed the Colorado pikeminnow) was investigated by 1) estimating adult numbers, 2) evaluating frequency of reproduction and recruitment, 3) identifying trends via changes in size structure over time, and 4) examining historical accounts for clues to former abundance. Adults and subadults were systematically captured from 278 km of river during 1991-1994. Larvae and age 0 fish were systematically sampled in two reaches during 1986-1994. Estimated number of adults in the upper 98 km averaged 253 individuals; estimated annual adult survival rate was 0.86. In the lower 181 km, estimates of subadults and adults combined averaged 344 individuals. A sizable pulse of subadults 300-400 mm long found in the lower reach in 1991 were from three year classes, 1985-1987. By 1992, these were distributed throughout the river. Although catch rates of larger adults did not increase significantly in the upper reach during 1991-1994, catch rates of fish less than 550 mm long increased fivefold. Size frequency analysis of lower reach fish indicated the 1985-1987 cohorts were the largest produced since before 1977, and no similarly strong year classes were produced subsequently. Estimated years of origin of these recruiting fish coincided with years of higher than average catch rates of larvae and age 0 fish in the upper reach and catch rates in subsequent years were comparatively low. Very few individuals less than 450 mm long were found in the upper reach during the past 15 years, suggesting that recruitment there is from colonization from the lower reach. In contrast, significant numbers of fish less than 400 mm in total length occurred in

the upper reach during the mid-1970's. Abundance appears much lower than suggested in historical accounts. Low adult numbers and sporadic pulses of recruitment may make this population vulnerable to extirpation. Though adult survival rate is probably fairly constant, recruitment is highly variable and may represent the most important demographic factor to population persistence.

Author: Patton, Timothy M.; Rahel, Frank J.; Hubert, Wayne A.
Year: 1997
Title: Using Historical Data to Assess Changes in Wyoming's Fish Fauna
Reference Type: Journal Article
Journal: Conservation Biology
Volume: 12
Issue: 5
Pages: 1120-1128

Value of reference: The article details methodology for comparing historic (1960) fish survey data with recent (1990) fish survey data; even data with different sampling protocols. Comparisons of recent and historic data for the purpose of assessing species trends are frequently problematic due to differences in sampling designs, methodologies, and efficiencies. Nevertheless, historic data can be a valuable source of information for trend assessments.

The article defines historic as "fish survey data from 1960". This would not be considered "pre-settlement"; however, few data exist on fish populations in this region that date back beyond the early part of the 20th century. A comparison of these different data sets is a place to start and a helpful benchmark to monitor change.

Results relevant to EMAP: Findings include a general decline in species at the smaller spatial scale (reach, stream, etc), with less evidence of decline overall at the drainage scale. "Although this suggested that a drainage scale examination may be too coarse to detect changes in distribution, changes at this scale may be the most important: species extirpated at such a large scale represent the most serious declines and loss of evolutionary potential, and species expanding into new drainages likely represent artificial introductions."

Among the declining native species, two habitat guilds are apparent. Species in the first guild (flathead chubs, plains minnows, silvery minnows, river carpsuckers, and channel catfish) are adapted to turbid rivers with silt and sand substrates historically common on the Great Plains. Reservoirs and diversion dams have stabilized flows and reduced silt loads and likely have led to declines among species in this guild. Species in the second guild (common shiners, finescale dace, horneyhead chubs, lake chubs, and mountain suckers) tend to occupy small to medium-sized streams with cool, clear water, and many require gravel substrates for spawning. Land management and irrigation practices have increased turbidity and siltation in many of these streams.

Geographic location: Wyoming, Missouri River Drainage, eco17, eco18, eco25, eco43, plains, mountains, xeric, EPA region 8

Keywords: historic fish survey, phab, fish, land management, irrigation practices, turbidity, reservoirs, diversion dams, plains, mountains, declining species

Abstract: If conservation efforts are to be implemented before a species becomes imperiled, population declines must be identified before that species becomes extremely rare. Historic survey data are more useful than recent data for detecting such declines. We compared 1960's and 1990's fish survey data from 10 drainages in Wyoming (USA) in an effort to identify declining species, but these comparisons were problematic because of differences in sampling designs, methodologies, and efficiencies. We restricted our comparisons to locations common to both surveys and to presence and absence data; we adjusted our data to account for the more efficient sampling protocol of the 1990's survey; and we examined data at four nested

spatial scales: site, stream, sub-drainage, and drainage. based on data not adjusted for gear bias, 12 our to 31 (39%) native species were collected in fewer locations during the 1990's survey even though we used more efficient sampling gear. Based on data adjusted for gear bias, the same 12 plus 4 additional native species (52%) showed declines. Fewer species appeared to have changing distributions at the drainage scale than at the smaller scales, but extirpations at the drainage scale represent the most serious declines. Despite the problems of comparing historic and recent surveys, we were able to make minimum estimates of species declines. Adjustment of data to account for gear bias allowed us to identify declines beyond a minimum estimate.

Author: Pearson, W.D.; Kramer, R.H.; Franklin, D.R.
Year: 1968
Title: Macroinvertebrates in the Green River below Flaming Gorge Dam, 1964-65 and 1967
Reference Type: Journal Article
Journal: Proceedings of the Utah Academy of Science, Arts, and Letters
Volume: 45
Pages: 148-167

Value of reference: This article reports conditions primarily in the mid-1900s, but since early macroinvertebrate data are generally scarce, it represents some of the only baseline data available for the basin. The Flaming Gorge Dam was closed in 1962. The authors summarize pre-1962 macroinvertebrate presence data from 5 sources (Table 3). These data are then compared to data collected after closure of the dam.

The article serves 2 functions: 1) it provides baseline macroinvertebrate data from the early 1960s for the Green River above Ouray, Utah; and 2) it allows a comparison of pre- and post-impoundment invertebrate communities for assessing the effects of the dam and changes in water physical attributes on the invertebrate community. Most invertebrate data are reported by genus or family. Table 3 reports presence data by taxon for pre- and post-impoundment periods. Table 4 gives abundance data (mean number per square meter) on rubble-gravel substrates at the first collection site downstream from the dam, 1965 and 1967 (post-impoundment).

Results relevant to EMAP: Seasonal variations in flow were reduced after closure of the dam; summer, fall, and winter flows increased, and spring flow decreased (data in Table 1). Winter temperatures increased, while summer temperatures decreased, compared to pre-impoundment years. Mean monthly pre-impoundment temperatures ranged from 0.5 to 21.0 degrees C at Greendale, while mean monthly post-impoundment temperatures ranged from 2.0 to 12.5 degrees C. At greater distances downstream from the dam, the river physical condition seemed to transition back to its pre-impoundment state.

Nine invertebrate forms reported from the area prior to the dam were not collected in the post-impoundment study, while 10 groups not previously reported in the area were collected after impoundment. The latter group were not considered recent invaders, but were assumed to have been missed in previous sampling efforts. The community at the sampling location directly below the dam had a much lower species richness compared to pre-dam conditions. Species composition was not noticeably altered below the confluence of the Yampa River. Invertebrate communities between the dam and the confluence of Vermillion Creek were altered, likely as a response to lower summer water temperatures, which caused the near disappearance of one species of *Baetis* from the first 9.5 km below the dam.

Mean number of individuals on rubble-gravel substrates ranged from 11 (several species) to 40,124 (*Baetis* sp.) per m^2. Other abundance data are given in Table 4.

Geographic location: Utah, Colorado Green River basin, EPA region 8, eco20, xeric

Keywords: macroinvertebrates, phab, dams, historical data, baseline data

Notes: For additional information about invertebrates above Flaming Gorge, see Binns, N.A. 1965. Effects of rotenone treatment on the fauna of the Green River, WY. Unpublished Master's Thesis, Oregon State University, Corvallis, OR. 258 p.

Author: Peters, E. J.; Schainost, S.
Year: 2005
Title: Historical changes in fish distribution and abundance in the Platte River in Nebraska
Reference Type: Book Section
Editor: Rinne, J. N.; Hughes, R. M.; Calamusso, B.
Book Title: Historical changes in large river fish assemblages of the Americas.
City: Bethesda, Maryland
Publisher: American Fisheries Society
Pages: 239-245

Value of reference: The historical changes stated in the title are inferred rather than clearly stated due to a general lack of historical information and a presentation that only indirectly addresses the historical changes in fish assemblages. Though the mainstem of the Platte is mainly in Nebraska, there is some discussion in the article of the forks of the Platte, North and South. The chapter was included even though the mainstem of the Platte is outside the EMAP sampling region because there are few sources available about the fish assemblages of the plains.

Results relevant to EMAP: Little is known of the fishes from the Platte River basin prior to the time when diversions and damming had already altered flows. The earliest published fish collections are those of Meek (1895) and Evermann and Cox (1896). Collection records in Nebraska prior to 1945 documented 47 species from the Platte River of which one, the common carp, was an introduced species. Today Platte River fish species number 100, most of them introduced. In Table 1, p. 243, the authors show changes in ranks of percent frequency of occurrence for fish species reported in collections from the Platte River before 1945 (pre- large scale fish introductions) and after 1985.

Two groups of fish species are declining for opposite reasons. Headwater or tributary species that favor clear warm water and clean gravel substrate (10 species listed), such as brook stickleback, central stoneroller, and johnny darter, are declining due to a shortage of habitat, and are listed as species of concern in the plains states. The other declining group contains species typical of large, turbid rivers, such as shovelnose sturgeon, flathead chub, and sauger. Goldeye and sauger, for example, have been extirpated from the North and South Platte and occur in small numbers in the lower Platte in Nebraska. The lower Platte River retains the wide, shifting sand bar habitats and high turbidity characteristic of the pre-settlement river.

North Platte River - Reservoirs and diversion canals were completed in the mid-1940's. The river has been reduced from multiple channels to a single channel and sections are dewatered. South Platte River - River flow in Colorado is augmented from interbasin transfers of Colorado River water. However, virtually all flow is diverted in Colorado and returned to the river as sewage treatment water return flows downstream of the metropolitan areas along the front range.

Geographic location: EPA Region 7, EPA Region 8, Nebraska, Colorado, Wyoming, Platte River, North Platte River, South Platte River, eco25, eco21, high plains, southern Rockies

Keywords: fish, dams, water diversion, agriculture, pollution, nonnative species

Abstract: From its headwaters in the Rocky Mountains, the Platte River drains 230,362 km^2 in Colorado, Wyoming, and Nebraska. The Platte River is formed by the confluence of the North Platte and South Platte near the city of North Platte, Nebraska, and receives additional flow

from the Loup and Elkhorn rivers that drain the Sand Hills region of Nebraska. Water diversions for mining and irrigation began in the 1840's in Colorado and Wyoming, and irrigation diversions in Nebraska began in the 1850's. Construction of dams for control of river flows commenced on the North Platte River in Wyoming in 1904. Additional dams and diversions in the North Platte, South Platte, and Platte rivers have extensively modified natural flow patterns and caused interruption of flows. Pollution from mining, industrial, municipal, and agricultural sources, and introductions of 24 nonnative species have also taken their toll. Fishes of the basin were little studied before changes in land use, pollution, and introduction of exotic species began. The current fish fauna totals approximately 100 species from 20 families. Native species richness declines westward, but some species find refugia in western headwaters streams. Declines in 26 native species have led to their being listed as species of concern by one or more basin states.

Author: Pilsbry, H.A.; Ferriss, J.H.
Year: 1911
Title: Mullusca of the southwestern states, V: the Grand Canyon and northern Arizona
Reference Type: Journal Article
Journal: Proceedings of the Academy of Natural Sciences of Philadelphia
Volume: 63
Pages: 174-199

Value of reference: The article provides baseline information on the snails of the Grand Canyon and the northern Arizona plateau, an area that had previously not been explored for snails. It lists the species collected, organized by family, listing all collection stations and the exact collection spot. Much of the document is taxonomic description of the species, but the presence and distribution in the region would be the most valuable information for EMAP.

Collections were done by searching through sediment layers to find species that would likely be seeking refuge from the arid climate. Since snails are not active most of the year, they might be easier to miss in an EMAP sampling visit. Therefore this information is valuable as the most complete listing of species found historically in the area.

Results relevant to EMAP: The annotated list of species found in the area begins on page 178 and is organized by species and locality where collected. This baseline information can be used for reconstruction of species richness or presence for this area. It is difficult to discern from descriptions whether all collections sites are on a stream, but most seem to be associated with a spring or seep, if not a tributary stream; many locations were high in the canyon.

Geographic location: Arizona, Colorado River basin, EPA region 9, eco22, xeric

Keywords: macroinvertebrates, snails, baseline data, historical data

Author: Platts, W. S.; Gebhardt, K. A.; Jackson, W. L.
Year of Conference: 1985
Title: The effects of large storm events on basin-range riparian stream habitats
Reference Type: Conference Proceedings
Editor: Johnson, R. R.; Zieball, C. D.; Patton, D. R.; Ffolliott, P. F.; Hamre, R. H.
Conference Name: Riparian ecosystems and their management: Reconciling conflicting uses
Conference Location: Tucson, Arizona
Publisher: U.S. Forest Service General Technical Report RM-120
Pages: 30-34

Value of reference: The value of this reference is to document that woody debris was an important component of stream channel structure even in aspen-dominated Northern Great Basin riparian ecosystems.

Results relevant to EMAP: In the Jarbidge Mountains of northeastern Nevada, where there is a concentration of EMAP sites, riparian zones historically were shaded by large aspen. Decomposing aspen logs in streams provide evidence of this. However, due to heavy grazing pressure (cattle eating young tree sprouts), the last generation of aspen has not been replaced. The disappearance of wood in the channel allows floods to scour the alluvium and cause accelerated erosion and incision of the stream channel.

Cutthroat trout were able to survive the floods in these streams. The authors conclude that drought conditions may have more effect on cutthroat numbers than high water events. Where streamside vegetation was abundant, flood impacts to fish populations were minimal.

Geographic location: Nevada, mountains, xeric, eco80, Great Basin, basin and range, Jarbidge Mountains, EPA Region 9

Keywords: fish, cutthroat trout, grazing, sediments, erosion, woody debris, riparian vegetation, phab

Author: Propst, D.L.
Year: 1999
Title: Threatened and endangered fishes of New Mexico.
Reference Type: Report
City: Santa Fe, NM
Institution: New Mexico Department of Game and Fish
Report Number: Tech. Rpt. No. 1

Value of reference: Although New Mexico is not in the EMAP-West region, several major drainages flow out of the state into Arizona and Colorado, and the corresponding fish species occur in those neighboring states. The report focuses on the distribution of fish in New Mexico, but makes numerous statements about species' total historical ranges and relative abundance in portions of the basins outside of New Mexico. In the second part of the report, 23 species are profiled separately (although not all species were historically distributed in AZ or CO). For each profile, sections on listing status, distribution and current population status include known historical and current distribution throughout the species' ranges in all states and basins where they occurred, as well as factors contributing to their decline. This report would be valuable for reconstructing historic ranges and comparing them with the current, reduced ranges.

The report includes an extensive bibliography, representing syntheses of numerous publications for each species' profile. "Historical" does not necessarily equate to pre-settlement, but it encompasses all of the known records of a species in its former distribution.

Results relevant to EMAP: Typical results are illustrated here, using Gila chub (the first species profile in the report) as an example:

The Gila chub is a species of special concern in Arizona. Historically, it occurred in suitable and rather specialized habitat throughout much of the Gila River drainage in southwestern New Mexico and central and southeastern Arizona. Its preference historically was for cienéga habitats. In Arizona, Gila chub persist in small headwater streams (many are springs or cienégas) tributary to the San Pedro, Santa Clara, San Francisco, Gila, Verde, and Agua Fria rivers. Although Gila chub still occur in a moderate number of localities within its historic range in Arizona, its numbers are low at many locations, and populations are considered unstable.

A variety of factors probably contributed to the decline of Gila chub, but loss of cienéga habitats by dewatering and channelization were probably the most detrimental. Introduction of nonnative piscivores also contributed to elimination of the chub from portions of its historic range.

Geographic location: Arizona, Colorado, eco23, eco26, eco20, eco21, eco22, EPA region 9, EPA region 8, Arkansas River basin, Colorado River basin, Gila River basin, xeric, mountains, plains

Keywords: fish, altered water flow regime, channelization, nonnative species, historical ranges

Author: Propst, D.L.; Carlson, C.A.
Year: 1986
Title: The distribution and status of warmwater fishes in the Platte River drainage, Colorado
Reference Type: Journal Article
Journal: The Southwestern Naturalist
Volume: 31
Issue: 2
Pages: 149-167

Value of reference: Fish data of the late 1970s are compared with historical data to assess changes in community composition in the South Platte drainage. There have been few publications over time reporting on the warmwater ichthyofauna of the South Platte River and none for the North Platte, and most previous studies have been geographically restricted. Therefore, this article is of value for gathering and reporting compositional changes in the historical community. Historical data included all past reports of a species, dating as far back as 1891.

Annotated species accounts from present-day sampling are given in various levels of detail, including citations for studies in which a species was previously sampled, where the species is currently found or not found, presence/absence or relative abundance compared to historical reports, whether the species is exotic, and reasons for decline.

The species assemblage is grouped into 4 categories: rare, common, uncommon, and nonnative. Each category is discussed, and reasons for decline or low numbers are given. Species in each category are addressed singly or as a group, and generalizations are made regarding their status as compared to historical abundance.

Results relevant to EMAP: The native species composition of the Platte River in Colorado has never been diverse. Thirty-one fish species were historically present in the South Platte The lake chub, hornyhead chub, and blacknose shiner have been extirpated. Another three species were not collected in the present study, and it is not apparent whether they are still present.

Current distribution and abundance is a factor of historical distribution and status, and habitat alterations due to human impacts. Extensive alterations in the basin are due to water diversions, dams, impoundments, ground water pumping, channelization, and pollution.

Table 2 lists all fish species grouped by abundance category, excluding three reported historically but not collected and three known to be extirpated, and including nine non-native species. Rare species (8 of 31 historical species) have been restricted historically and more recently have experienced habitat reduction as a result of human impacts. Uncommon species (6 of 31 historical species) were considerably more widespread and common historically than they are presently; common species (11 of 31 historical species) have maintained their populations largely because of wide environmental tolerances, but they have been affected by habitat degradation or pollution in stressed reaches.

Geographic location: Colorado, South Platte River basin, eco25, EPA region 8, plains

Keywords: fish, water diversion, dams, ground water pumping, channelization, pollution, warmwater fishes

Abstract: In a 2.5 year (1978-1980) study of the lotic warmwater fish communities of the Platte River Basin, Colorado, 25 native and 9 non-native species were collected. Three natives (*Nocomis biguttatus, Couesius plumbeus, and Notropis heterolepis*) have been extirpated. *Salmo clarki stomins* was not collected, nor were the provisional natives, *Stizostedion vitreum* and *Carpoides cyprinus*. Eleven native species were rare in the basin. The rarity of each was strongly correlated with their limited historic distributions, rather special habitat requirements, and intolerance of environmental stresses. Six native species were historically more common and widespread, but habitat deterioration associated with European settlement has caused their decline. The remaining native species (8) were common and widely distributed. The common carp (*Cyprinus carpio*) was the only common non-native fish. Lack of suitable habitat is believed responsible for the rarity of other non-native species.

Notes: See also Nesler et al. 1997 (in this bibliography) as a companion article which provides maps of plotted collection locations from "historical" surveys in the South Platte drainage. Nesler, T.P., R. VanBuren, J.A. Stafford, and M. Jones. 1997. Inventory and status of South Platte River native fishes in Colorado. Colorado Division of Wildlife, Aquatic Wildlife Section, Fort Collins, CO.

Author: Rahel, F.J.; Thel, L.A.
Year: 2004
Title: Flathead Chub (*Platygobio gracilis*): a technical conservation assessment
Reference Type: Electronic Source
Producer: USDA Forest Service, Rocky Mountain Region.
Access Year: 2006
Access Date: June 14

Value of reference: This is primarily a management document, but it contains information on what is known of the historical distribution of the flathead chub. It also reports on current listing and population status, habitat requirements, and threats to the species. Although a significant portion of the chub's range is in Montana, this report does not address it because it is outside of the Forest Service region 2 management jurisdiction.

Results relevant to EMAP: In Colorado, flathead chubs historically occurred in the Arkansas River up to Salida, but specimens have not been collected recently upstream of a large diversion on the Arkansas River near Florence, Colorado. It is considered a species of special concern in Colorado and as threatened in Kansas where it historically occurred in the large rivers draining from Colorado. With only one exception, it has not been sampled in Kansas since 1994. In South Dakota, flathead chubs were common and characterized as the dominant minnow species in the western tributary rivers and larger streams of the Missouri River. To the north and east of the Missouri River, flathead chubs occurred only in the lower portions of larger tributaries. Currently flathead chubs continue to be considered common in the rivers and larger streams of western South Dakota. Recent surveys found flathead chubs to be common in the Moreau River, the Cheyenne River, and the Belle Fourche River. In Wyoming, flathead chubs were historically present in the North Platte and Little Missouri rivers but are now known to occur only in very low numbers in the North Platte River and are likely much reduced in numbers in the Little Missouri River. Currently, they are widely distributed in the rivers of the northeast part of the state, including the Big Horn, Tongue, Powder, Little Powder, Belle Fourche, and Cheyenne river systems.

Loss of turbid conditions, adequate in-channel flow, and habitat connectivity associated with water impoundment are major threats to this species. The species remains widespread throughout much of its historical range, but it is unknown if remaining populations are stable or if the species is continuing to decline. Competition with nonnative species also has a negative effect on populations of the flathead chub.

Geographic location: South Dakota, Wyoming, Colorado, Missouri River basin, Arkansas River basin, EPA Region 8, eco43, eco42, eco25, eco26, plains, Missouri River basin, Arkansas River basin, Platte River basin

Keywords: fish, altered water flow regime, dams, nonnative species

URL: http://www.fs.fed.us/r2/projects/scp/assessments/flatheadchub.pdf

Author: Rees, D.E.; Carr, R.J.; Miller, W.J.
Year: 2005
Title: Plains minnow (*Hybognathus placitus*): a technical conservation assessment
Reference Type: Electronic Source
Producer: USDA Forest Service, Rocky Mountain Region
Access Year: 2006
Access Date: June 12

Value of reference: This report expands on Cross and Moss 1987 (also in this bibliography) with respect to a single species in the plains. The authors cite Cross and Moss frequently, but their summary covers the broader region outside of Kansas, including states in EPA Region 8. They note the absence of distributional data for plains minnow prior to settlement, and state that it impossible to know the entire historical distribution of the species. However, trends since the mid-20th century and human impacts in the region are discussed. The status and decline of plains minnow is summarized for the major basins draining the east side of the Rocky Mountains.

Results relevant to EMAP: The plains minnow was historically distributed in suitable habitat throughout the Arkansas River, Platte River, Kansas River, and Missouri River basins, including the following states in the EMAP-West region: North and South Dakota, Montana, Wyoming, and Colorado (they have been introduced into Utah). It maintains stable populations locally, but its range has been restricted in South Dakota and Montana, while both its range and abundance are in decline in Montana, Wyoming, North Dakota, and Colorado.

It was once the most common fish of the Arkansas River system, but its abundance and distribution have decreased substantially, and it now constitutes less than 1% of the overall fish population in that basin; it has possibly been extirpated from some drainages in Colorado. Changes in the Missouri River have led to a less severe decline of the species there, and tributary populations in eastern Wyoming are currently stable. The potential for further declines in distribution and abundance is high across the species' range.

An altered flow regime, groundwater pumping, and impoundments have reduced water quality and altered the natural flood regime necessary to induce spawning. A loss of shifting channels and gravel bars has resulted from water diversions, impoundments, land uses that alter flow regimes, and groundwater mining, leading to degraded habitat and loss of natural disturbances to which the plains minnow is adapted. The larger impact of these pressures has been the fragmentation of metapopulations. Competition with and predation by nonnative fish species is an important potential impact, but it is not fully understood at present.

Geographic location: North Dakota, South Dakota, Montana, Wyoming, Colorado, EPA Region 8, eco43, eco25, eco26, eco42, plains, Missouri River basin, Arkansas River basin, Platte River basin

Keywords: fish, nonnative species, habitat degradation, habitat fragmentation, altered water flow regime, groundwater pumping, water diversion

URL: http://www.fs.fed.us/r2/projects/scp/assessments/plainsminnow.pdf

Author: Rinne, J. N.
Year of Conference: 2004
Title: Forest and fishes: Effects of flows and foreigners on southwestern native fishes
Reference Type: Conference Proceedings
Editor: Scrimgeour, G. J.; Eisler, G.; McCulloch, B.; Silins, U.; Monita, M.
Conference Name: Forest Land-Fish Conference II: Ecosystem stewardship through collaboration
Conference Location: Edmonton, Alberta
Pages: 119-124

Value of reference: The author reviews the historic and present day occurrence of the fishes of Arizona as well as the chronology of alterations to the natural hydrology of the state.

Results relevant to EMAP: 75% of the riverine habitats in Arizona have been either lost or altered between 1911 and 1970. Diversions on the Gila River constructed in 1928 dried the Gila River to its confluence with the Salt River. Other major tributaries to the Gila, such as the San Pedro, San Simon and Santa Cruz Rivers have been dried due to groundwater pumping.

Six species of fish are now on the endangered or threatened list in Arizona. The Gila topminnow was very common during early settlement times. Now it persists in fewer than a dozen isolated springs in southern Arizona. The razorback sucker was once so abundant that it was pitchforked from canals and used as fertilizer. The Colorado pikeminnow (formerly squawfish) and bonytail chub persist today only as a result of restoration programs.

The paper includes tables that illustrate how flood flows favor native fishes and drought periods (e.g., 1994-2003) result in increases in nonnative species.

Geographic location: eco81, eco79, eco22, eco23, eco14, Arizona, Region 9, xeric, mountains, Gila River, San Pedro River, Salt River

Keywords: fish, Colorado pikeminnow (squawfish), dams, habitat degradation, nonnative species, hydrologic variability, water diversions

Abstract: Habitat alteration in physical (stream channel characteristics), chemical (nutrients, temperature), or biological (introduced species) form can have dramatic effects on native southwestern USA fishes. Southwestern flow regimes, their alterations, and introduction of alien species have had a dramatic, negative impact on native southwestern fishes. The cumulative and interactive impacts may result in various responses by native fish assemblages. Managers should not expect the same result when one or more factors are in operation that may affect an aquatic ecosystem in the southwestern USA. Ultimately, consideration of temporal-spatial influences, natural factors, interactions of factors, and sound monitoring or research activities will determine which factors most influence southwestern fish assemblages in respective situations.

Notes: A related paper that includes a description of the historic hydrologic variability (i.e., rivers turbid during spring runoff, clear during base flow, and intermittent in lower reaches during drought), and a map of the hydrology of Arizona showing 20th Century changes:
Rinne, J. N., and J. A. Stefferud. 1999. Single versus multiple species management: Native fishes in Arizona. Forest Ecology and Management 114:357-365.

Author: Rinne, J. N.; Simms, J. R.; Blasius, H.
Year: 2005
Title: Changes in hydrology and fish fauna in the Gila River, Arizona-New Mexico epitaph for a native fish fauna?
Reference Type: Book Section
Editor: Rinne, J. N.; Hughes, R. M.; Calamusso, B.
Book Title: Historical changes in large river fish assemblages of the Americas.
City: Bethesda, Maryland
Publisher: American Fisheries Society
Pages: 127-137

Value of reference: This book chapter summarizes earlier articles and gathers results from the gray literature about the Gila River and its tributaries concerning historic hydrology and native fish species and their present day status.

Results relevant to EMAP: Historically, the Gila River between Florence and Phoenix, Arizona was about a kilometer wide, scattered with beaver ponds, shaded by cottonwood gallery forest, and "teeming with fishes." The Gila was described as a large, essentially permanent stream of clear to sea green water with a well-defined channel flanked by numerous cottonwoods and a dense growth of willows and cane. In 1848 Emory described the river as "wide and rich" and alive with geese and ducks. By 1920 this same area was described by Ross (1923) as "desolate wastes of sand and silt."

Twenty fish species were native to the Gila River basin (listed in Table 1 on p. 130). Four of these species (Monkey Spring chub, Santa Cruz pupfish, Colorado pikeminnow, razorback sucker) have been extirpated, 8 species are endangered (includes pikeminnow and razorback sucker), two species are threatened, and two species are state listed species of concern. The pikeminnow and razorback sucker once ran in spawning schools up the Gila and Salt rivers. Razorback suckers were once removed from canals in the Phoenix valley with pitchforks because they were so numerous they blocked the water flow. The last pikeminnow was taken in the Gila basin in 1950. The razorback sucker has been reintroduced, but is not self sustaining. Gila trout persist naturally in a few headwater streams in New Mexico. Nonnative fish (40 species) dominate the Gila River today, particularly in the lower reaches where there are no native fish present.

Geographic location: Arizona, Gila River, EPA Region 9, eco23, eco79, eco81, xeric

Keywords: dams, water diversion, nonnative species, historical, hydrology, fish, xeric

Abstract: The Gila River originates in southwestern New Mexico and courses its way for over 700 km to the west before emptying into the main-stem Colorado River near Yuma, Arizona. Historically, this river was a major watercourse across the Sonora Desert of Arizona. At present, main-stem dams and numerous diversions have markedly altered the historic hydrology of the river. Seventeen native species once occupied the main stem of this large southwest desert river. More than twice that number (40) of nonnative fish species have been introduced into the waters of the Gila over the past century. Currently, less than half of the native fauna is present in the main stem and then primarily in the upper three reaches of the river. The majority of the species (70%) are federally listed as threatened, endangered, or sensitive. The combination of hydrological alteration and accompanying introductions of nonnative, principally sport fishes has basically extirpated the native fauna in all but the uppermost reaches of the Gila River main stem.

Author: Robison, R.S.
Year: 1957
Title: The Yakima River--historical and present Indian fishery
Reference Type: Report
City: Seattle, WA
Institution: Washington Department of Fisheries
Pages: 13

Value of reference: Report provides rough estimates of pre-settlement salmonid abundance and catches by Native Americans in the Yakima River basin. The earliest estimates are for the period prior to 1848, which is significant because the Yakima Valley was developed very early for agriculture, and this represents probably the best estimate of a true pre-settlement salmon population. These estimates provide baseline data for numbers of salmonids that the basin was capable of supporting before major impacts destroyed or prevented access to spawning habitat.

Results relevant to EMAP: The dominant native fish species of the Yakima River were chinook salmon, sockeye salmon, coho salmon, steelhead trout, cutthroat trout, dolly varden trout, whitefish, squawfish and suckers. Salmon ran up to Keechellus Lake in the headwaters of the Yakima River in the Cascade Mountains. Based on the estimated number of pre-settlement Indian families and average consumption per family, the author estimates that the total Yakima River catch was 160,000 salmon annually prior to settlement. He further states that the actual run to the river and its tributaries could easily have been 3 times the catch or 480-500 thousand salmon.

From 1847 to 1875, harvest by Native Americans apparently dropped from 160,000 to 20,000 salmon annually. From 1875-1906, runs were still declining, but greater fishing effort kept the catches at 20,000 annually. The catch dropped to a low of 1000 by 1930

Streambed assessments in the 1950s led to the conclusion that available habitat in the basin could support at least 500,000 spawning salmon each year. The construction of irrigation diversion dams, beginning in 1850, created migration barriers, and diversion ditches led salmon into orchards where they died. Other early impacts were log drives, mining, and over-fishing. (Note: The report does not address impacts occurring downstream in the Columbia River, which could have impacted runs if their timing coincided.)

Geographic location: Yakima River basin, Washington, EPA region 10, mountains, xeric, eco10

Keywords: fish, water diversion, dams, mining, logging, fishing

Author: Roemhild, G.
Year: 1982
Title: The Trichoptera of Montana and ecological notes
Reference Type: Journal Article
Journal: Northwest Science
Volume: 56
Issue: 1
Pages: 8-13

Value of reference: The diversity of aquatic macroinvertebrates is poorly represented in early literature. Although this synthesis report of Trichoptera distribution in Montana was made more than a century after settlement, it can be used to gauge the level of knowledge of the diversity of this order prior to 1980. Following five years of surveys, the author collected 78 species reported from Montana for the first time (54% increase in recorded diversity). The author also identifies portions of the region where more work was needed to adequately describe the Trichoptera fauna, including the southwestern, southeastern, and northeastern portions of the state. While this is a recent work, it helps to characterize some of the challenges of using anecdotal historical macroinvertebrate data for reconstructing reference conditions. References such as this help to highlight the limits of what can be gleaned regarding macroinvertebrate diversity and geographic distributions from historic literature prior to systematic collection activities.

Results relevant to EMAP: Between 1970 and 1980, the number of recorded species of Trichoptera from Montana increased from 100 (Newell 1970) to 222 (122% increase in recorded species diversity), resulting from a series of systematic surveys. This reference provides useful baseline data for Trichoptera distribution in Montana up to that date, since the notes concerning ecological preferences and distribution are drawn from a number of previous publications. The author collected 204 of 222 species (92%) known to exist in Montana during the late 1970s and 1980, including 78 species that had not previously been reported. During the same general timeframe, others collected specimens of many of the remaining 18 species known to exist in the state, but not collected by the author. Geographic distribution, altitudinal distribution, habitat affinity, water temperature preference, and relative abundance information are provided that may be helpful for reconstructing potential historical distributions for each species.

Geographic location: Region8, Region10, Plains, Mountains, Montana, North Dakota, Idaho, Oregon, Eco15, Eco16, Eco17, Eco18, Eco41, Eco42, Eco43

Keywords: macroinvertebrates; Trichoptera; historical data

Abstract: The known Montana Trichoptera is comprised of 14 families, 69 genera, and 222 species. Seventy-eight species are reported from Montana for the first time. One hundred sixty-seven species (77 % of the total) are known to occur on both sides of the continental divide, 22 species (10 %) occur on the east side only, and 29 species (13 %) occur only west of the divide.

Notes: Newell, R. L. 1970. Checklist of some aquatic insects from Montana. Proc. Mont. Acad. Sci. 30:45-56.

Author: Rucks, M.J.
Year: 1984
Title: Composition and trend of riparian vegetation on five perennial streams in southeastern Arizona
Reference Type: Book Section
Editor: Warner, R.E.; Hendrix, K.M.
Book Title: California Riparian Systems: Ecology, Conservation, and Productive Management.
City: Berkeley, California
Publisher: University of California Press
Pages: 97-107

Value of reference: Though the sample size is small, the more highly disturbed streams are compared to a reference stream where grazing had been excluded since 1973. There is no historical data used in the study, and there is an assumption that the broadleaf community was once more prevalent along Arizona streams. It is also unclear whether the streams/rivers are similar in size and discharge. They were selected because they all occur on BLM lands. The value of this article is in the observation that riparian vegetation on Arizona streams that is subject to prolonged disturbance evolves away from a broadleaf community toward a so-called riparian scrub community.

Results relevant to EMAP: The reference stream where grazing had been excluded was the only one of the five streams to have a good representation of broadleaf tree seedlings (Fremont cottonwood, Arizona sycamore, Arizona walnut, velvet ash) in the 1-3 inch size class. Other sample sites may have had mature broadleaf species represented, but the seedling size class in each case was absent or heavily browsed by cattle.

The author recorded the % of broadleaf trees in the seedling size class and the % of seedlings browsed by cattle. For example, at Bonita Creek, 1.5% of willows were in the seedling size-class, and 67% of these were browsed.

The author concludes by saying that three of the five streams show a trend toward replacement of the broadleaf riparian community by riparian scrub (such as saltcedar, burro brush, and mesquite).

Geographic location: Arizona, xeric, EPA Region 9, eco79, eco23, Aravaipa Creek, Gila River, San Francisco River

Keywords: riparian vegetation, phab, grazing

Abstract: Composition and trend of 78 km (49 mi) of riparian vegetation on five watercourses was determined. Aravaipa Creek has been excluded from cattle since 1973 and was the only study area with a dominant broadleaf riparian community and a trend towards maintaining this community.

Author: Rumble, M.M.; Sieg, C.H.; Uresk, D.W.; Javersak, J.
Year: 1998
Title: Native woodlands and birds of South Dakota: past and present
Reference Type: Report
City: Fort Collins, CO
Institution: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station
Pages: 11
Report Number: Research Paper No. 8

Value of reference: The authors use historical and present bird community and General Land Office Surveys, historical photos, and early journal excerpts to reconstruct the general character of pre-settlement riparian areas along the Missouri River and its tributaries in South Dakota. The intent was to test the hypothesis that woodlands were expanding and the bird community was changing as a result, a process which had been hypothesized for the Platte River in eastern Colorado (Knopf 1986). This paper does not attempt to determine change in the amount of woodlands between pre-settlement and the present; it simply reported an historical condition based on several pieces of evidence. It includes a section describing woodlands along the Missouri River and larger tributary streams in pre-settlement times.

Results relevant to EMAP: Extensive native woodlands occurred in the valleys of the Missouri River and its tributaries in central and western South Dakota in the 1870s and 1880s. Canyons were filled with deciduous trees, including cottonwood, green ash, willow, oak, and wild plum. In many places the under story was very thick. Many large pieces of driftwood were left by torrents and floods that scoured the floodplain and exposed roots. Early 20th century photographs of mature trees indicate that trees were established well before settlement.

Geographic location: South Dakota, Missouri River basin, eco43, EPA region 8, plains

Keywords: phab, historical data, GLO notes, historical photographs

Notes: Knopf, F.L. 1986. Changing landscapes and the cosmopolitism of the eastern Colorado avifauna. Wildlife Society Bulletin 14:132-142.

Author: Samson, Fred B.; Knopf, Fritz L.; Ostlie, Wayne R.
Year: 1998
Title: Status and Trends of the Nation's Biological Resources: Regional Trends of Biological Resources--Grasslands
Reference Type: Electronic Source
Producer: Northern Prairie Wildlife Research Center Online
Access Year: 2005
Access Date: July 2005
Last Update Date: January 21, 2000

Value of reference: This chapter highlights the status and trends of the main bodies of North American grasslands; the tall-grass prairie, the mixed-grass prairie, and the short-grass prairie. It features the animals and plants dependent on native grassland and attempt to provide insight into the relationship between remaining native grassland and biological resources by reviewing available, current information and by describing threats.

Great Plains stream ecology is closely connected to the land use practices now common to the region. This source outlines the changes in grassland habitats and how in turn these changes affect streams. Impoundments and irrigation practices have altered the sediment content and stream flow. This in turn has contributed to changes in fish populations. Decades of intensive agricultural development and modified flow regimes are held responsible for declines in the fishes endemic to the small streams and turbid rivers of the Great Plains (Cross and Moss 1987--in this bibliography).

Results relevant to EMAP: A good overview of prairie ecosystems in North America. This is a comprehensive source that documents changes to the prairie ecosystem since settlement and the development of agriculture. The article describes the flora, fauna, soil characteristics, and overall ecology of the various regions (short grass to tall grass prairies) of the Great Plains.

Chapters include; prairie past and present (prairie grasses, land resources and management, prairie insects and animals), prairie integrity and legacies, resource and research needs, and literature cited.

This reference is a good all-around source that catalogs the ecosystem structure, the biotic community, and the changes that have occurred since agricultural development. This source also contains an extensive bibliography.

Geographic location: Great Plains, plains, EPA region 6, EPA region 7, EPA region 8, Kansas, Nebraska, Oklahoma, Texas, New Mexico, Colorado, North Dakota, South Dakota, Wyoming, Montana, eco25, High Plains, eco26, Southwestern Tablelands. eco27, Central Great Plains, eco44, Nebraska Sand Hills, eco43, Northwestern Great Plains

Keywords: phab, fish, native species, turbidity, fish communities, altered water flow regime, grasslands, prairie insects, prairie animals, historic condition, plains rivers, impoundments, agriculture

URL: http://www.npwrc.usgs.gov/resource/2000/grlands/grlands.htm

Author: Say, T.
Year: 1825
Title: Descriptions of new hemipterous insects collected in the expedition to the Rocky Mountains, performed by order of Mr. Calhoun, Secretary of War, under command of major Long
Reference Type: Journal Article
Journal: Journal of the Academy of Natural Sciences Philadelphia
Volume: 4
Issue: 2
Pages: 307-345

Value of reference: This reference provides an example of the qualitative characteristics of the earliest macroinvertebrate collection literature in western North America. Although Say was a zoologist, and the descriptions of collected Hemiptera specimens are provided in detail, important collection information is lacking. Dates and specific collection locations are usually not provided, although they may be recorded on museum specimens. Distribution information is very generalized, such as "inhabits North America", "inhabits Missouri", "inhabits Arkansas near Rocky Mountains".

Results relevant to EMAP: The earliest macroinvertebrate collection data in western North America provides some anecdotal information regarding species encountered during expeditions. The collection was made in a very non-systematic fashion; information on collection date was not recorded (although this information may be available in the museum records) , and location information is very coarse. In this case, only a few of the specimens collected are aquatic. The relevance of this reference to EMAP is that it establishes coarse baseline data and elucidates the limitations of what can and cannot be reconstructed of aquatic macroinvertebrate communities prior to European settlement.

Geographic location: EPA Region7, EPA Region8, Mountains, Plains, Rocky Mountains

Keywords: macroinvertebrates; Hemiptera; baseline conditions

Author: Schalk, R.F.
Year: 1986
Title: Estimating salmon and steelhead usage in the Columbia basin before 1850: the anthropological perspective.
Reference Type: Journal Article
Journal: Northwest Environmental Journal
Volume: 2
Issue: 2
Pages: 1-30

Value of reference: Evidence of salmonid declines were reported as early as 1882; thus many "historical" population data do not reflect an approximate pre-settlement condition. In this article, salmon runs are estimated for a very early time period, producing probably the best supported approximations of pre-settlement salmon runs for the Columbia basin (also see Meengs and Lackey 2005--in this bibliography--who used similar approaches for calculating historical *coastal* runs). Estimates are based on native American fish catches, consumption, population data, and catch efficiency. The catch estimate adjusts earlier estimates by Hewes (1973) and Craig and Hacker (1940)--both cited below--by accounting for variation in consumption rates among tribes, inclusion of a migration calorie loss factor, and an inedible waste loss factor. Catches are converted into total run size by dividing by an catch efficiency rate.

This reference illustrates the use of anthropological data for determining the former importance of salmon and steelhead to the Indian tribes of the Columbia basin, estimating the magnitude of the aboriginal salmon and steelhead catch in the early 19th century, and translating to total fish. It provides a baseline historical datum for gauging the magnitude of total losses and for broad application in managing and sustaining current populations.

Results relevant to EMAP: The annual salmonid catch by Indians in the early 19th century was estimated to be 41,754,800 pounds, which is almost twice as large as previous estimates, but which is considered a minimal catch, capable of sustaining human populations, even in years of low salmon production.

This translates into a total run size range estimate of 9 to 12.6 million fish per year, which compares well with the low end of the estimate by the Northwest Power Planning Council (NWPPC 1986, in this bibliography), yet is consistent with the conclusion that it is a minimum estimate, not including fish catches for uses other than human consumption, e.g., dog food, fuel.

Geographic location: Oregon, Washington, Idaho, EPA region 10, eco3, eco4, eco11, eco10, eco9, 3co15, eco12, eco16, mountains, xeric, Columbia River basin

Keywords: fish, salmon, steelhead, pre-settlement population estimate, anthropological data, native American fish catch

Notes: Craig, J.A. and R.L. Hacker. 1940. The history and development of the fisheries of the Columbia River. Bulletin of the Bureau of Fisheries 49:133-216.

Hewes, G.W. 1973. Indian fisheries productivity in pre-contact times in the Pacific salmon area. Northwest Anthropological Research Notes 7(2):133-155.

Author: Scheurer, Julie A.; Bestgen, Kevin R.; Fausch, Kurt D.
Year: 2003
Title: Resolving Taxonomy and Historic Distribution for Conservation of Rare Great Plains Fishes: Hybognathus (Teleostei: Cyprinidae) in Eastern Colorado Basins
Reference Type: Journal Article
Journal: Copeia
Volume: 3
Issue: 1
Pages: 1-12

Value of reference: This article highlights the difficulty in establishing historic fish distribution and numbers. "Few early collections exist and most of these were made after habitats were already altered, some native species were extirpated and nonnative species ere introduced." For example, fish collections are known from only 12 locations before 1900 in the Great Plains portion of eastern Colorado (Fausch and Bestgen, 1997), yet diversion of water for irrigation was well developed by the 1860's. As a result, the historic distributions of fishes described only in early reports are not fully known. A second main problem is that identification of some taxa is difficult, resulting in inaccurate field surveys.

The goal of the research was to develop a technique to distinguish *H. hankinsoni* from *H. placitus* in western Great Plains watersheds where they are sympatric. The model is then used to accurately identify all available museum specimens of *Hybognathis,* this allowed for clarification of historic distributions of *H. hankinsoni* and *H. placitus*.

This study helps document the importance of museum collections and the correct species identification for the determination historic conditions and establish changes in distribution and habitat over time.

Results relevant to EMAP: The different morphologies of *H. hankinsoni* and *H. placitus* are consistent with adaptations for their preferred habitats. *H. hankinsoni* prefers small, clear streams with low velocity. In contrast, *H. placitus* prefer medium to large plains streams with more turbid environments.

Correct identification of these two species helped establish what the historic stream environment was like in the area of collection. In addition, better identification of museum specimens provides a more accurate conclusion about historic distributions and range of species within the stream system. Based on the finding of this study, the current distribution for these two species is believed to be contracting from the western edge of their former range. Article also contains an extensive bibliography.

Geographic location: Colorado, eco25, Great Plains, plains, EPA region 8, Platte River, Republican River, Smoky Hill River

Keywords: native fish, historical distribution, fish, early collections, taxonomy

Abstract: Similar morphology and confused historical taxonomy of *Hybognathus hankinsoni* (brassy minnow) and *Hybognathus placitus* (plains minnow) have made determination of their historic distributions and conservation status unclear in eastern Colorado basins. We developed logistic regression models from morphometric measurements to predict species identity of *Hybognathus* collections from Colorado and adjacent counties (n = 1154 specimens in 134 lots). A model based on orbit diameter, standard length, and eye position correctly predicted 98% of

the specimens examined and 100% of the museum lots. *Hybognathus hankinsoni* have larger eyes centered on a horizontal line through the tip of the snout, whereas *H. placitus* have smaller eyes centered above the tip of the snout. The two species were historically sympatric in the Platte, Republican, and Smoky Hill River basins, whereas *H. placitus* was allopatric in the Arkansas River basin. The taxonomic characters defined here will allow accurate identification of future collections to determine the status of these native fishes.

URL: http://www.bioone.org/bioone/?request=get-abstract&issn=0045-8511&volume=003&issue=1&page=0001

Author: Scott, L. B.; Marquiss, S. K.
Year: 1984
Title: An historical overview of the Sacramento River
Reference Type: Book Section
Editor: Warner, R. E.; Hendrix, K. M.
Book Title: California Riparian Systems: Energy, Conservation, and Productive Management.
City: Berkeley, California
Publisher: University of California Press
Pages: 51-67

Value of reference: This article contains a useful description of the early (1850's) effects of hydraulic mining.

This paper summarizes an analysis of two aspects of the history of the Sacramento River: the fluvial process; and man's development of the floodplain over the last 130 years. The analysis was made to trace the origins of problems - seepage, loss of riparian vegetation, and limited public access - occurring in the riparian zone, and to establish a perspective from which to study these problems. Significant historical aspects of these problems must be considered in a comprehensive study of the river.

Results relevant to EMAP: Thirty five years of hydraulic mining created an estimated equivalent of 100 years of sediment delivered from the Sacramento Basin into San Francisco Bay--three times the average delivery under natural conditions. It is estimated that the elevations of the Sacramento, Feather, Yuba, Bear, and American Rivers rose as much as 6 m (20 ft). The higher streambeds led to a series of floods in the 1860's and 70's and finally an act of the legislature banning hydraulic mining. The floods literally buried farms under many feet of mud and debris.

Graph on p. 55 of changes in bed elevation of the Sacramento and Yuba rivers from 1850 to 1950.

Geographic location: California, Central Valley, Sacramento River, eco7, eco6, EPA Region 9, xeric, mountains

Keywords: riparian vegetation, phab, xeric, mountains, sediment, water diversions, dams, mining, agriculture

Author: Sedell, J. R.; Froggatt, J.L.
Year: 1984
Title: Importance of streamside forests to large rivers: The isolation of the Willamette River, Oregon, U.S.A., from its floodplain by snagging and streamside forest removal
Reference Type: Journal Article
Journal: Verh. Internat. Verein. Limnol.
Volume: 22
Pages: 1828-1834

Value of reference: The authors provide a well documented example of changes in morphological characteristics, general physical habitat, and riparian conditions within the 10th largest river in the continental U.S., dramatically altered by agricultural activities and snagging over the last 150 years. The links to locations of original source material for reconstructing river channel characteristics and riparian forests at the time of settlement (1850's) may be of use for tracking down historical material for other watersheds and regions.

Human disturbance types and associated changes in stream and riparian conditions are clearly documented, with quantitative estimates made that can be compared against current conditions.

Although the authors discuss the implications of the habitat changes in terms of possible generalized changes in aquatic macroinvertebrate and fish community characteristics, the primary value of the paper lies in its detailed documentation of changes in physical habitat and riparian conditions.

Results relevant to EMAP: Channel complexity and riparian gallery forest composition changed dramatically since settlement began in earnest in the 1850's (see Fig. 2). Between 1870 and 1950, more than 65,000 snags and streamside trees were removed from 114 km of river to aid navigation. Channel simplification began when channels and sloughs were closed off with wing dams by 1872.

By 1983, surface water volume, coarse and fine organic inputs had decreased to 25 percent of their historic levels in the upper portion of the watershed. Gallery forests, which had extended 1.5 - 3.5 km on either side of the river, were reduced to narrow, discontinuous ribbon, immediately adjacent to the main channels and primary tributaries.

Conversion to agriculture was the primary factor responsible for loss of riparian woodlands. Secondary and tertiary channels, which functioned as 3rd- or 4th-order streams in 1854 had all but disappeared by 1946, when the river was confined primarily to a single channel. The authors speculate that the functional feeding groups of invertebrate and fish communities would have been more like lower order streams in these lost channels. Most of the channel changes occurred prior to the construction of dams for flood control.

Geographic location: EPA Region10; Oregon; Willamette Valley; Mountains; Willamette River Basin, eco3, mountains

Keywords: phab; fish; macroinvertebrates; snag removal; agriculture; dams; habitat loss; change detection

Author: Sedell, J.R.; Luchessa, K.J.
Year of Conference: 1981
Title: Using the historical record as an aid to salmonid habitat enhancement
Reference Type: Conference Proceedings
Editor: Armantrout, N.B.
Conference Name: Symposium on Acquisition and Utilization of Aquatic Habitat Inventory Information
Conference Location: Portland, Oregon
Publisher: American Fisheries Society, Bethesda, Maryland (1982)
Pages: 210-223

Value of reference: This paper discusses historical conditions in numerous basins of Washington and Oregon and is therefore more of a general observation of prevailing conditions in multiple basins, as compared to the historical condition. It presents an historical perspective that the authors suggest can help provide a needed rationale for rehabilitation of wild salmonid stocks, including creation of new habitat, restoring damaged habitat, and protecting good habitat.

The basic premise is that historical information can assist in our understanding of how far many river systems deviate from a pre-settlement condition (i.e., optimum habitat requirements for salmonids), specifically with respect to habitat complexity created by large wood and debris dams.

Results relevant to EMAP: Historically, streams in lowlands of the Willamette Valley and Puget Sound consisted of a network of sloughs, islands, beaver ponds, and drift dams with no main channel. Using historical documentation, the authors found that debris dams in many basins of western Oregon and Washington were once very common, often damming 20% or more of a stream's length. In many lowlands, a high degree of interaction of the stream with its flood plain was common. For example, over a quarter of the area of the Skagit River lowlands were beaver marsh, sloughs, and wet grass meadows.

Large volumes of wood influenced both low and high gradient channels; many rivers were completely blocked by drift jams for 100-1500 m in the mid 1800s. The historical record shows that even in big rivers, large wood contributed to in-channel structure. Salmon were once abundant under these conditions. For example, using published material for the Siuslaw River, estimated runs in the 1890s would have been about 27,500 chinook and 218,750 coho salmon. However, the habitat is no longer present to support those run sizes, even though they are being set as goals.

Channelization and clearing of large wood and debris to facilitate river transport began in the mid 1800s and continued into the 20th century to create easier access to spawning areas. Management alternatives to debris clearing in high-gradient reaches is discussed and supported by the historical record and current literature findings.

Geographic location: Washington, Oregon, EPA region 10, eco1, eco2, eco3, numerous basins, mountains

Keywords: phab, large wood, debris dams, anadromous fish, logging, channelization, habitat degradation

Abstract: Historically, wild anadromous fish stocks evolved with stream systems that were obstructed by fallen trees, beaver dams, and vegetation growing in and beside the channels. River systems as large as 7th order had large numbers of fallen trees in their channels and often were obstructed by drift jams that were up to 1500 m long. The main river channels contained abundant gravels and fine sediments. Habitat complexity was great because of scour around boulders and fallen trees, and the presence of numerous and extensive stable side channels and sloughs. These pristine streams interacted intensively with their flood plains. Historical records document over 100 years of "diligent" stream and river cleanup. Primary activities included removal of boulders, large woody debris, and other obstructions from channels. We believe that historical documentation of the ways unmanaged streams interacted with the streamside forest allows us to know how far we have deviated from the optimum habitat requirements for various salmonids. Until we understand the structure of undisturbed habitats that wild stocks develop within, and the sequence of changes that have occurred in those habitats, our present protection and enhancement efforts will lack both a rational context and effective direction.

Author: Sedell, J. R.; Reeves, G. H.; Hauer, F. R.; Stanford, J. A.; Hawkins, C. P.
Year: 1990
Title: Role of refugia in recovery from disturbances: Modern fragmented and disconnected river systems
Reference Type: Journal Article
Journal: Environmental Management
Volume: 14
Pages: 711-724

Value of reference: The reference does not describe reference condition per se (except for a short description of changes on the Willamette River (see Results below), but it does give a useful table of attributes of refugia at various spatial scales. These attributes are the same as those natural features composing a reference stream reach, segment, or watershed. The authors see this classification system as being applicable to both the conservation of existing minimally disturbed systems as well as the recognition of isolated natural features within disturbed systems.

Results relevant to EMAP: The authors compile a list of stream refugia attributes at various spatial scales (channel unit, reach, segment, watershed).

Between 1854 and 1967 the Willamette River, Oregon, became increasingly isolated from its floodplain as a result of channelization and agricultural modification of riparian forests. In 1854, the riparian forest was in contact with >250 km of river edge on oxbow lakes and cutoff sloughs. By 1967 the length of river edge had been systematically decreased to 64 km, a reduction of 74%. Much of the change in riparian forest interaction was completed by 1910 owing to snag removal and river navigation improvements (revetments).

The implication of these changes are that the ability of alluvial reaches to provide refugia, retain sediments and organic materials and to determine the quantity of organic inputs has been greatly reduced.

Geographic location: Willamette River, Oregon, EPA Region 10, eco3, mountains

Keywords: phab, riparian vegetation, river ecosystems, refugia, groundwater, reference condition, human disturbance

Abstract: Habitats or environmental factors that convey spatial and temporal resistance to biotic communities that have been impacted by biophysical disturbances may be called refugia. Most refugia in rivers are characterized by extensive coupling of the main channel with adjacent streamside forests, floodplain features, and groundwater. These habitats operate at different spatial scales, from localized particles to channel units such as pools and riffles, to reaches and longer sections, and at the basin level. A spatial hierarchy of different physical components of a drainage network is proposed to provide a context for different refugia. Examples of refugia operating at different spatial scales, such as pools, large woody debris, floodplains, below dams, and catchment basins are discussed. We hope that the geomorphic context proposed for examining refugia habitats will assist in the conservation of pristine areas and attributes of river systems and also allow a better understanding of rehabilitation needs in rivers that have been extensively altered.

Author: Shaffer, H. Bradley; Fisher, Robert N.; Davidson, Carlos
Year: 1998
Title: The role of natural history collections in documenting species declines.
Reference Type: Journal Article
Journal: Trends in Ecology and Evolution
Volume: 13
Issue: 1
Pages: 27-30

Value of reference: This article summarizes ways in which museum collections and related data repositories have been used as a source of historical information in documenting changes in the presence or absence of species. Although museum data often represent an imperfect match to current sampling programs, they can still provide the critical information necessary to identify declines, and should comprise one of the standard databases in conservation biology.

Results relevant to EMAP: Museum and other historic locality archives offer a rich source of material for the analysis of species declines; however, assessments of changes in abundance over time are very problematic, and should be interpreted with great caution.

Judiciously using museum collections as a source of historical data, changes in the presence/absence of individual species and communities can successfully be evaluated across a wide range of plant and animal taxa in habitats ranging from single-species temperate habitats to complex tropical systems.

This article is a helpful tool and includes a good bibliography.

Geographic location: Article not specific to one geographic area, however the article does list several studies from California (e.g., Fisher, R.N and Shaffer, H.B., 1996, The decline of amphibians in California's great central valley, Conservation Biology 10, 1387-1397, in this bibliography) as examples of studies using museum specimens or other archival records as historical data to document species decline.

Keywords: historic condition, phab, museum collections, fish, amphibians, species decline

Abstract: Efforts to document the decline of extant populations require a historical record of previous occurrences. Natural history museums contain such information for most regions of the world. at least at a coarse spatial scale. Museum collections have been successfully used to analyze declines in a wide range of plants and animals, at spatial scales ranging from single localities to large biotic and political regions. Natural history museum collections, when properly analyzed, can be an invaluable tool in documenting changes in biodiversity during the past century.

Author: Sheldon, A.L.
Year: 1979
Title: Stonefly (Plecoptera) records from the basin ranges of Nevada and Utah
Reference Type: Journal Article
Journal: The Great Basin Naturalist
Volume: 39
Issue: 3
Pages: 289-292

Value of reference: Since macroinvertebrate information is limited, this record of the distribution of Plecoptera in streams on Nevada's mountain ranges in the 1979 may have value to EMAP if combined with other papers such as Stewart et al. (1974) on distribution and past dispersal of southwestern U.S. Plecoptera.

Distributional records are given for 40 stonefly species on 15 isolated mountain ranges mostly in Nevada (1 included in Utah).

Stewart, K.W., R.W. Baumann, and B.P. Stark. 1974. The distribution and past dispersal of southwestern United States Plecoptera. Transactions of the American Entomological Society 99:507-546.

Results relevant to EMAP: This list of Plecoptera species sampled in 1979 may be compared with species sampled 25 yrs later for EMAP.

Stonefly (Plecoptera) species are listed by family with a record of mountain range and county where collected.

Geographic location: EPA Region 9, central basin and range, Nevada, Utah, eco13, xeric

Keywords: macroinvertebrates, animal taxonomy and geography, entomology, stonefly, Plecoptera

Author: Shepard, B.B.; Sanborn, B.; Ulmer, L.; Lee, D.C.
Year: 1997
Title: Status and risk of extinction for westslope cutthroat trout in the upper Missouri River basin, Montana
Reference Type: Journal Article
Journal: North American Journal of Fisheries Management
Volume: 17
Pages: 1158-1172

Value of reference: Although this article focuses on calculating probabilities and risk of extinction of westslope cutthroat trout in multiple basins in Montana, it does contain some historical information about distribution in the upper Missouri River, including Figure 1: map showing sub-basins in Montana believed to have supported westslope cutthroat trout at the time of European settlement (Behnke 1992, this bibliography). The authors examined evidence from the historical record to estimate the length of streams and rivers once occupied by the trout. 144 sub-basins on federal lands were assessed and rated according to the estimated extinction risk for westslope cutthroat as: very high, high, and moderate.

Results relevant to EMAP: There is some disagreement in the historical record as to the historical range of the trout. For this analyses, the authors assumed that it originally occupied the entire Missouri River drainage down to, and including, the Musselshell River and the upper Milk River basin, but not the upper Sun River basin

The abundance and distribution of westslope cutthroat trout have declined substantially throughout their historical range. Trout that are at least 90% genetically pure (based on allozyme electrophoresis) now occupy less than 5% of the original 93,000 km of stream habitat they historically occupied in the upper Missouri River basin in Montana. Remaining populations are restricted to isolated headwater habitats, many of which are impacted. Factors suggested as contributing to decline were grazing, mining, fishing, genetic introgression, and competition with nonnative species.

Each current population of the trout occupied relatively small habitat fragments in headwaters (<35 km of continuous stream length), and each was isolated either physically or biologically. Most (71%) of the 144 populations assessed had a very high predicted risk of extinction; 19% had a high risk, and 10% had a moderate risk. The conclusion was that westslope cutthroat trout populations inhabiting federal lands within the upper Missouri basin are at serious risk of extinction under current conditions.

Geographic location: Montana, upper Missouri River basin, eco43, eco42, eco17, EPA region 8, mountains

Keywords: fish, westslope cutthroat trout, habitat fragmentation, nonnative species, grazing, mining, fishing, genetic introgression

Abstract: Westslope cutthroat trout *Oncorhynchus clarki lewisi* now occupy less than 5% of the subspecies' historical range within the upper Missouri River drainage in Montana. We assessed the risk of extinction for 144 known populations inhabiting streams within federally managed lands in the upper Missouri River basin using a Bayesian viability assessment procedure that estimates probability of persistence based on subjective evaluation of population survival and reproductive rates as influenced by environmental conditions. We first customized this model using estimates of demographic parameters from the literature and field data. Each population

was classified into one of three risk groups based on their Bayesian probability of persistence over 100 years (p100). Most (71%) of the 144 populations had a very high predicted risk of extinction (p100 ≤ 50%), 19% exhibited a high risk (50% < p100 ≤80%), and 10% had a moderate risk (80 < p100 ≤ 95%). Higher average predictions of plop were consistently associated with populations inhabiting watersheds with lower levels of management activities. Analysis of variance and a matrix of information divergence measures indicated that livestock grazing, mineral development, angling, and the presence of nonnative fish had the greatest association with both estimated population parameters and persistence probabilities. Of 26 major sub-basins within the upper Missouri River drainage, 16 support at least one known westslope cutthroat trout population on federal lands, and 14 of these 16 support at least one population with an estimated p100 value of 0.5 or greater. Results of our analysis have led to action by citizens of Montana, prompting state and federal managers to develop a conservation and restoration program for this subspecies in the upper Missouri River basin.

Author: Silkensen, G.
Year: 1993
Title: South Platte River observations: Historical clues to the evolution of a river's ecology
Reference Type: Book Section
Editor: Woodring, R. C.
Book Title: Defining ecological and sociological integrity for the South Platte River basin.
City: Fort Collins, Colorado
Publisher: Colorado Water Resources Research Institute
Pages: 41-53
Series Title: Information Series No. 72

Value of reference: The author compiles multiple views of the pre-settlement South Platte River written by the first explorers to the region.

Results relevant to EMAP: In the mid-19th Century large stretches of the South Platte River valley in northeastern Colorado were treeless, and described by phrases such as "a miserable country" of "alkali soils" and "unvaried sterility". The earliest observations of the South Platte reveal a river which could be a raging torrent one year, and a dry sand bed the next. P. 42.

Today the hydrography is evened out by diversion of water from the upper Colorado River; an average total of nearly 400,000 acre-feet/year of water is imported into the South Platte basin. This is approximately 30% of the South Platte's annual native runoff. Nearly 95% of this water originates in the Colorado River basin. The North Platte basin supplies most of the balance. P. 51

Short descriptions of observations made during expeditions in 1820 and 1842, addressing variability in amount of riparian vegetation on tributaries and relative to the Rocky Mountains, as well as two descriptions of the confluence of the North and South Platte (pages 43 and 44), are included.

Geographic location: Colorado, EPA Region 8, xeric, eco25, eco26, South Platte River

Keywords: riparian vegetation, phab, hydrology, runoff, agriculture

Abstract: The South Platte River begins high in the Colorado Rockies, emerging from the foothills of the front range southwest of Denver. From here the river flows in a general northeasterly direction across Colorado's high plains before leaving the state and entering Nebraska. During the 19th Century, that portion of the river which traverses the high plains was explored by both Stephen H. Long and Charles C. Fremont. The river also became one of the primary routes (the Denver Road) to the Colorado gold fields during the 1859 Pikes Peak gold rush, and later for pioneers, settlers, and the railroads. Eventually the river's water was stored and used to irrigate crops in the South Platte valley. Throughout Colorado history, the river has been both praised and cursed. Early descriptions have ranged from "treeless", " sandy", "barren", to " a beautiful river in whom the thirsty finds a true friend." Many 19th Century explorers, gold-seeking fifty-niners, pioneers, and farmers encountered the South Platte River and described it in detail. These descriptions, albeit unintentionally, often provide clues to the ecological nature of the South Platte River as it began to evolve during the last half of the 19th Century.

Author: Skinner, J. E.
Year: 1962
Title: An historical review of the fish and wildlife resources of the San Francisco Bay area
Reference Type: Report
City: Sacramento, CA
Institution: The Resources Agency of California and California Department of Fish and Game
Pages: 57-71
Report Number: Water Projects Branch Report No.1

Value of reference: The reference provides a view of the extent of the fishing effort on the Sacramento-San Joaquin River system during the years of commercial fishing and salmon canneries. Although the river system was considered degraded in the late 1800s, the salmon catch data provide a good benchmark for assessing salmon losses since then.

Results relevant to EMAP: A table in Appendix C-2 and a bar graph show the salmon catch data for the gillnet fishery on the lower Sacramento-San Joaquin River for the years 1864-1957. The numbers do not include the portion of the catch consumed locally or that were caught above the city of Sacramento. The gillnet catch peaked at over 10,000,000 pounds in 1880 and 1910; and it exceeded 1,000,000 pounds every year until 1910, after which the catch amounts became more variable.

The Wakeman report in 1870 surveyed the fisheries of the tributaries of San Francisco Bay and described the disturbed condition of streams due to the logging operations, saw mills, and flour mills located on them. The inference from his description is that the coastal streams had once been very productive of silver salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdnerii*), but at the time of the 1870 survey they were already degraded.

Map IV Fold out map in back of book. Historical salmon migration routes and probable distribution.
Appendix F comprises two tables: a "List of selected freshwater fishes of the San Francisco Bay area" and "Some initial introductions of freshwater food and game fishes now occurring in the San Francisco Bay area". The majority of the introductions occurred in the late 1800's, beginning in 1872 with eastern brook trout (*Salvelinus fontinalis*). Of the anadromous fishes, silver salmon were limited to coastal streams until 1956 when they were introduced into the Sacramento River system.

Geographic location: California, San Francisco Bay basin, Sacramento River, San Joaquin River, eco6, eco7, Central Valley, EPA Region 9, xeric

Keywords: fish, chinook salmon, silver salmon, fishing, urban, logging, dams, nonnative species

Author: Stalnaker, C.B.; Holden, P.B.
Year: 1973
Title: Changes in native fish distribution in the Green River system, Utah-Colorado
Reference Type: Journal Article
Journal: Proceedings of the Utah Academy of Science, Arts, and Letters
Volume: 50
Pages: 25-32

Value of reference: This article provides descriptive summaries of the historical distribution and relative abundance of seven indigenous species common to the main tributaries of the upper Colorado basin and reports fish distribution following impoundment by the Flaming Gorge dam. It cites publications dating from the 1890s to the early 1960s (pre-impoundment), documenting declines before closure of the dam. It then reports changes in abundance and distribution in the mid-1960s following closure of the dam and in 1973. It thus provides several historical points of reference for tracking the changes in populations of these 7 species (Colorado squawfish, roundtail chub, bonytail chub, humpback chub, humpback sucker, bluehead sucker, flannelmouth sucker).

Results relevant to EMAP: Minckley and Deacon (1968; in this bibliography) document the decrease in native fishes in the lower Colorado River basin. Subsequently, the upper Colorado River basin was the last available habitat for the large river endemic fishes. All species were historically reported to be common to abundant in the upper Colorado basin except the humpback chub. Prior to closure of the dam, declines were already being reported for some of these species, but the roundtail chub, bonytail chub, bluehead sucker, and flannelmouth sucker still seemed to be doing well at least in some portions of their range.

After closure of the Flaming Gorge dam, stream physical habitat in the first 65 miles downstream (above the mouth of the Yampa River) changed drastically. None of the 7 native species investigated were still reproducing, and all species except the flannelmouth sucker, bluehead sucker, and roundtail chub were eliminated from that area. Growth rates of the bonytail chub, roundtail chub, and Colorado squawfish had decreased greatly. Introduced rainbow and brown trout had replaced the large native fishes in that stretch of river. The humpback chub, Colorado squawfish, bonytail chub, and humpback sucker were considered rare and possibly endangered at the time of publication (1973).

Geographic location: Utah, Colorado, Green River basin, EPA region 8, xeric, eco18, eco20, eco21

Keywords: fish, nonnative species, dams, habitat fragmentation

Author: Starnes, W.C.
Year: 1995
Title: Colorado River Basin Fishes
Reference Type: Electronic Source
Producer: U.S. Department of Interior, National Biological Service
Access Year: 2005
Access Date: May 18

Value of reference: Web site summarizes the changes in fish species richness between the 1800s and present, including the increase in nonnative species. Tributaries and sections of the river are listed along with the species richness in the 1800s and the changes in richness that occurred throughout the 20th century, notably the introduction of numerous species, creating higher species richness (sometimes more than double the historical levels) but lower native species diversity (Table 2). Gives list of native fish taxa of the river basin, including status of jeopardized species (Table 1). Summary also discusses the use of baseline data describing unaltered native fauna and determining, to the extent possible, the true extent of diversity of native fish.

Results relevant to EMAP: Historically, the lower basin (downstream of the Arizona/Utah border) had the greatest diversity of taxa (44), while the upper basin contained 14 species; the number of native species has drastically declined since the 1800s in every portion of the basin, while the number of introduced species has increased, and in many cases, far surpassed the native richness (Table 2).

Presently, 40 of the 49 native species are considered either possibly or actually jeopardized or are extinct (see Table 1 for status by species). Impacts to fish include impoundments, irrigation diversions, diking, channelization, pollutants, habitat destruction, grazing, dewatering, and competition with nonnative species (at least 72 nonnative fish taxa have been introduced to the CO River system); genetic integrity is compromised by hybridization between native and nonnative species.

The situation complicates the use of biodiversity as an indicator of ecological integrity of the ecosystem.

Geographic location: Colorado River basin, xeric, eco20, eco22, eco14, eco81 eco23, Colorado, Utah, Arizona, EPA Region 8, EPA Region 9

Keywords: fish, dams, agriculture, water diversion, diking, channelization, pollutants, habitat destruction, grazing, dewatering, nonnative species, species diversity

URL: http://biology.usgs.gov/s+t/noframe/e063.htm

Author: Steedman, R. J.; Whillans, T. H.; Behm, A. P.; Bray, K. E.; Cullis, K. I.; Holland, M. M.; Stoddart, S. J.; White, R. J.
Year: 1996
Title: Use of historical information for conservation and restoration of Great Lakes aquatic habitat
Reference Type: Journal Article
Journal: Canadian Journal of Fisheries and Aquatic Sciences
Volume: 53
Issue: Suppl. 1
Pages: 415-423

Value of reference: Though the specific information applies to the Great Lakes, the conceptual background and application of the approach to management is universal. The section "Why is it important to consider historical information?" is among the most thorough presentations of the utility of historical information encountered.

Results relevant to EMAP: Why is it important to consider historical information?
(Section headings)
1. Those who ignore history are doomed to repeat the worst of it.
2. Historical information is frequently required during the specification of targets for ecosystem restoration.
3. Historical information can be used to modify values and beliefs as they relate to habitat.
4. By its very nature, information about natural ecosystem processes needs to be interpreted in a context that is long term and retrospective.
5. Humans are not very good at perceiving slow processes or rare events without the help of scientists or historians.
6. In culture, religion, and science, humans have often preferred to seek out and preserve stability in the natural world and to filter human perceptions through models grounded on stability or steady-state dynamics.
7. Human perceptions and expectations are influenced by the highly modified and simplified state of most contemporary landscapes.
8. The present is the history of the future.

Geographic location: Not applicable

Keywords: historic fish abundance, historical information, retrospective analysis, aquatic habitat management

Abstract: We provide a rationale and methodological overview for historical (retrospective) study of Great Lakes aquatic habitats and biota. Historical information has significant potential to direct aquatic habitat management in the Great Lakes, particularly in setting restoration goals. Although the use of historical information has been opportunistic (it is limited by the preservation of information in specific forms) and generally of low resolution(it is generally semiquantitative at best), the products of these analyses have been compelling (they have changed attitudes and expectations of people) and surprising (many of the conclusions of historical analysis were not predictable from other sources).

Author: Suckley, G.
Year: 1860
Title: Report upon the fishes collected on the survey
Reference Type: Book Section
Editor: U.S. War Department
Book Title: Reports of Explorations and Surveys to ascertain the most practicable and economical route for a railroad from the Mississippi River to the Pacific Ocean, made under the direction of the Secretary of War, in 1853-4.
City: Washington, D.C.
Publisher: Government Printing Office
Volume: 12
Pages: 307-368

Value of reference: This is an original early source that describes the massive numbers of various species of salmon in river basins of the Pacific Northwest in the mid-19th century. It offers first-hand descriptions and drawings of the species encountered. Notes on abundance, general distribution, and migration distances to inland rivers and streams are spread throughout the document. It is somewhat laborious to sift through to glean pertinent information, but it is worthwhile in its documentation of true pre-settlement conditions. Taxonomy may be difficult to pair with modern names, but should be possible for a fish biologist with the descriptions and drawings included in the document. Most is descriptive information, but it provides a good perspective, which could be very useful as a supplement to later, more quantitative summaries in reconstructing historical conditions.

Results relevant to EMAP: A range of descriptive information can be extracted from this document, including fish distribution, general abundance, species present, distance ascended upriver to spawn, habits, descriptions, early Native American fishing and usage, and other natural history anecdotes. A variety of baseline information can be extracted that may not be reported in later documentation. The reference should be consulted for details. The information is relevant for any historical reconstruction of pre-settlement conditions.

Geographic location: Pacific Northwest, Oregon, Washington, Columbia River basin, Puget Sound, EPA Region 10, eco1, eco2, eco3, eco4, eco9, eco10, eco11, mountains, xeric

Keywords: fish, historical data, primary source, baseline information

URL: http://www.cprr.org/Museum/Pacific_RR_Surveys/

Author: Swift, C. C.; Haglund, T. R.; Ruiz, M.; Fisher, R. N.
Year: 1993
Title: The status and distribution of the freshwater fishes of southern California
Reference Type: Journal Article
Journal: Bulletin of the Southern California Academy of Sciences
Volume: 92
Issue: 3
Pages: 101-167

Value of reference: This is one of the few references encountered that cover the fishes of southern California. The article describes native and exotic species, their ranges, and changes in their status (qualitative) between early settlement times and the present.

Results relevant to EMAP: In southern California 38 native freshwater fish taxa have been extirpated or severely reduced in number since European settlement.
Coastal areas were once well watered with an extensive stream system, springs, and marshes. After settlement, channel modifications and lowering of the water table altered stream habitats toward more desert-like conditions. The lowland areas are so highly modified today (e.g., concrete-lined channels) that they are practically uninhabitable for resident species and those that migrate between the headwater areas and the coast. 40% of the freshwater fishes of the Los Angeles basin were extirpated after the second World War following the completion of a large flood control project.
The article includes detailed distribution maps for selected species that separate records into pre-1970 and post-1970.

Geographic location: xeric, eco6, eco8, southern California, Los Angeles basin, Region 6

Keywords: fish, distribution, habitat degradation, water diversion, channelization, dams, nonnative species, urban, pollution

Abstract: The fresh and low salinity waters of southern California include the Owens, Mohave, Colorado, and coastal drainages south of Monterey Bay to the Mexican border. The youthful topography presents a strong dichotomy between steep rocky streams abruptly meeting relatively flat deserts or coastal plains. Little or no intermediate, foothill habitat exists. Thirty-eight native freshwater and 23 estuarine fishes have been recorded from this area. In addition, at least 100 species have been introduced, with widely varying success. Since the late 1940's and 1950's the native fishes of the Owens, Colorado, and Mohave drainages have been in jeopardy or extirpated in California. At the same time, the lowland fishes in coastal drainages still remain in a few isolated areas, but are so reduced that special protection is needed. Only one estuarine species, *Eucyclogobius newberryi*, is threatened. Some tropical estuarine species of extreme southern California were last collected 50 to 80 years ago, and are very rare or extirpated here. If the remaining elements of the fish fauna are to survive, immediate action is needed to preserve the remaining habitat and to restore areas within the native range.

Author: Tabor, V.M.
Year: 1998
Title: Endangered and threatened wildlife and plants: Final rule to list the Topeka shiner as endangered
Reference Type: Report
City: Manhattan, KS
Institution: U.S. Department of Interior, Fish and Wildlife Service
Report Number: Federal Register: 69008-69021, 50 CRF Part 17

Value of reference: This document provides justification and background for listing the Topeka shiner as an endangered species. It provides a summary of the species' historical distribution in 6 states, including one--South Dakota--in the EMAP-West region. The reasons for decline of the species are summarized in detail.

Results relevant to EMAP: The Topeka shiner was historically widespread and abundant throughout low order tributary streams in portions of 6 states of the central prairie region. Stream basins within the range historically occupied by Topeka shiners within the EMAP-West region include the Big Sioux, Vermillion, and James basins in South Dakota. The species occupied open pools in small streams with cool, clear water. Many such streams reportedly existed throughout the species' geographic range.

The number of known occurrences of Topeka shiner populations has been reduced by approximately 80%, with 50% of this decline occurring within the last 25 years. It now inhabits less than 10% of its original geographic range. The species now primarily exists as isolated and fragmented populations. Some recent capture sites in each of the historical basins in South Dakota, including a few new localities, are given in the document. The species has been extirpated in many of its historical river basins, primarily in Kansas, Missouri, Iowa, and Nebraska.

Intensive agricultural development and grazing, leading to increased sedimentation and eutrophication, has the greatest impact on the Topeka shiner. Other impacts include the maintenance of altered waterways, dewatering of streams, tributary impoundment, and channelization.

Geographic location: South Dakota, EPA region 8, eco34, eco42, eco46, plains, Big Sioux basin, Vermillion basin, James basin

Keywords: fish, endangered status, agriculture, grazing, water diversion, dams, channelization, habitat degradation

Author: Taft, Oriane W.; Haig, Susan M.
Year: 2003
Title: Historical wetlands in Oregon's Willamette Valley: implications for restoration of winter waterbird habitat
Reference Type: Journal Article
Journal: Wetlands
Volume: 23
Issue: 1
Pages: 51-64

Value of reference: This reference is a good synthesis of the pre-settlement condition and extent of the Willamette River, associated wetlands, oxbows, marshes, etc. and how land use practices have extensively altered the habitat to bring it to its current condition. The study used a combination of primary sources: expedition journals, explore/naturalist logs, missionary writings, early settler-farmer diaries, promotionists' reports, and government documents; Secondary sources include habitat maps, geomorphology studies, anthropological research, and prior work on the historical Willamette River and its floodplain to compile a view of the "pre-settlement" habitat of the Willamette Valley.

Results relevant to EMAP: This report investigated the historical Willamette Valley at the time of Euro-American settlement (ca. 1840) and attempts to determine the pre-settlement spatial extent of the river and wetlands in the valley.

This is a good source for establishment of pre-settlement habitat condition of the Willamette Valley and the river/ wetlands structure. It also helps document habitat change after agricultural development in the valley.

Paper presents a good historical overview and changes to the Willamette River system due to land use practices and development; includes an extensive bibliography.

Geographic location: Oregon, Willamette River, Willamette Valley, Pacific Northwest, EPA region 10, eco3

Keywords: phab, agricultural landscape, fire, historical wetlands, Kalapuya, land use, shorebirds, pre-settlement condition, wading birds, waterfowl, wetland loss, wetland prairie

Abstract: Before agricultural expansion in the 19th century, river valleys of North America supported expanses of wetland habitat. In restoring these landscapes, it is important to understand their historical condition and biological function. Synthesizing historical primary accounts (from explorers, travelers, settlers, and farmers) with contemporary knowledge of these wetland systems, we developed a profile of the wetlands and their use by non-breeding waterbirds (e.g., waterfowl, wading birds, and shorebirds) within the Willamette Valley, Oregon, ca. 1840. We found evidence for three types of wetlands used by non-breeding waterbirds in fall, winter, and spring: emergent wetlands, riverine wetlands, and wetland prairie. The most extensive wetland type was wetland prairie, which functioned as fall/winter habitat for waterbirds, but only while native Kalapuyans managed the region with fire. Since the mid-1800s, four species, in particular, have decreased their use of the Willamette Valley: trumpeter swan (*Cygnus buccinator*), snow goose (*Chen caerulescens*), sandhill crane (*Grus canadensis*), and long-billed curlew (*Numenius americanus*). Information suggests that ca. 1840, waterbirds and their habitats were more abundant in the Willamette Valley than today. Restoration of the Willamette Valley landscape is warranted, and today's agricultural wetlands-former wetland

prairie-hold highest restoration potential.

URL: http://www.bioone.org/bioone/?request=get-abstract&issn=0277-5212&volume=023&issue=1&page=0051

Author: Tait, C. K.; Li, J. L.; Lamberti, G. A.; Pearsons, T. N.; Li, H. W.
Year: 1994
Title: Relationships between riparian cover and the community structure of high desert streams
Reference Type: Journal Article
Journal: Journal of the North American Benthological Society
Volume: 13
Issue: 1
Pages: 45-56

Value of reference: Tait *et al.* recreate studies done in western Oregon and Washington in the semiarid Blue Mountains of eastern Oregon to examine how the absence of riparian canopy affects fish and macroinvertebrate communities. Though the mention of pre-settlement conditions is brief, the assumption is that there was once much more riparian vegetation present along Blue Mountain streams, that agriculture and grazing have greatly reduced the amount of vegetation and shading along those streams, and that stream communities have been dramatically altered as a result.

Results relevant to EMAP: The hypothesis of the study is that extensive destruction of riparian stream cover by human activity has affected the structure of Blue Mountain streams by increasing incident radiation and altering water temperature regimes. Canopy removal in coolwater streams often has been associated with increased salmonid abundance or biomass in western Washington and Oregon. In this study, densities of steelhead trout (*Oncorhynchus mykiss*) and sculpin (*Cottus* sp.) decreased significantly with greater incident radiation and higher stream temperatures.

Sites with considerable upstream vegetative cover, maintained cooler summer temperatures than unshaded reaches or canopied sites with limited extent of upstream riparian vegetation. Water temperatures in open reaches at study sites often exceeded 30 degrees C, well beyond the normal range of tolerance for salmonids and cottids. Study sites with high light levels were dominated by the large caddisfly larvae *Dicosmoecus*, that feeds on thick beds of filamentous algae. This armored caddisfly escapes predation by the warmwater fish populating the open study reaches and sequesters a significant portion of the energy entering the stream that would otherwise be transferred to predators.

"Warm water species of fish, such as redside shiners, bridgelip suckers, northern squawfish, and chiselmouth chub, were positively related to solar input ($r = 0.82$, $p = 0.025$), but unrelated to temperature ($r = 0.63$, $p = 0.13$)." These warmwater species would normally not enter tributaries of the size sampled in this study. "In contrast, cool-adapted rainbow trout and Paiute sculpin showed a strong negative correlation ($r = -0.97$, $p = 0.0004$) with temperature and a negative but insignificant correlation ($r = -0.47$, $p = 0.29$) with incident light."

Geographic location: xeric, mountains, eastern Oregon, John Day River basin, eco11, EPA Region 10

Keywords: riparian vegetation, macroinvertebrates, periphyton, fish, salmonids, sculpins, cyprinids, open canopy, stream ecology, benthic community structure, trophic interactions, agriculture, grazing

Abstract: Many studies on cool, forested streams have shown that removal of riparian canopy leads to higher incident radiation, blooms in algal and macroinvertebrate populations, and concomitant increases in salmonid abundance. In warm, high-elevation desert streams,

however, an open canopy may not increase salmonid density. Our seven study reaches on 3rd order tributaries of the John Day River in eastern Oregon included riparian areas ranging from denuded, heavily grazed stream banks to intact conifer forest. Average summer solar inputs to these sites varied from 165 to 2230 megajoules/sq m, and stream temperatures were influenced by the density and extent of canopy. Densities of steelhead trout (*Oncorhynchus mykiss*) and sculpin (*Cottus* spp.) decreased significantly with greater incident radiation and higher stream temperatures, although many warmwater cyprinids increased in abundance in unshaded sites. Periphyton standing crop (g ash-free dry mass/m^2) closely tracked solar inputs and was, in turn, strongly positively correlated with biomasses of total invertebrates and of grazers. Collector, shredder, and predator biomasses, and numerical abundances of all invertebrate groups, did not change with canopy density. The abundances of chironomids and baetids were unrelated to increases in light or algal resources, in contrast to studies in Cascades and Coast Range streams where irruptions of these taxa occurred in canopy openings. In our streams the large-bodied caddisfly *Dicosmoecus* accounted for the higher total invertebrate biomass observed in exposed sites. These insects composed 55-96% of the total biomass in open reaches, but only 0-1.4% in the three most shaded sites. Increases in total invertebrate biomass with increasing light levels or periphyton were not observed when *Dicosmoecus* were removed from the analysis. *Dicosmoecus* are consumed infrequently by juvenile trout or other small fish species common in John Day tributaries; consequently, extensive openings in the canopy appear to produce few advantages to upper trophic levels in these streams.

Author: Thurow, R.F.; Lee, D.C.; Rieman, B.E.
Year: 1997
Title: Distribution and status of seven native salmonids in the interior Columbia River basin and portions of the Klamath River and Great Basins
Reference Type: Journal Article
Journal: North American Journal of Fisheries Management
Volume: 17
Issue: 4
Pages: 1094-1110

Value of reference: This paper presents individual and composite distributions and status of seven native salmonids: bull trout, westslope cutthroat trout, Yellowstone cutthroat trout, redband trout, steelhead, ocean type chinook salmon and stream type chinook salmon. It describes their potential historical range, loss of historical range, and factors that have influenced current distribution and status. This is a detailed summary of seven salmonids, which are addressed similarly but in less detail in a broader summary by Lee and others 1997 (this bibliography).

Results relevant to EMAP: Results are summarized for each species and for the area as a whole with respect to all species combined. Tabular (Table 1) and mapped results of historical and current distributions and predicted strong populations (Figures 2-7).

Known or predicted occurrence as a percentage of subwatersheds in the historical range: Bull trout--6%; Yellowstone cutthroat trout--66%; westslope cutthroat trout--85%; redband trout--64% (combined occupancy by sympatric and allopatric forms); steelhead--46%; chinook salmon stream type--28%; chinook salmon ocean type--29%.

Although some of the taxa remain in most of their potential range, declines in abundance, reductions in distribution, and fragmentation into smaller patches are apparent for all species examined. Four of seven taxa are present in less than 50% of their historical range. Less than 38% of subwatersheds supported two or more taxa. Less than 0.01% supported strong populations of three salmonids and only 3% supported two.

A literature review of the human impacts that have contributed to declines (provided in the discussion) addresses introduction of nonnative species, habitat degradation, habitat fragmentation and inaccessibility caused by dams, overfishing, and genetic dilution in hatchery programs.

Geographic location: Oregon, Washington, Idaho, EPA region 10, Columbia River basin, Klamath River basin, eco80, eco9, eco11, eco10, eco15, eco16, eco12, mountains, xeric

Keywords: fish, salmonids, habitat degradation, nonnative species, dams, fishing, hatchery programs

Abstract: We summarized presence, absence, current status, and potential historical distribution of seven native salmonid taxa - bull trout *Salvelinus confluentus*, Yellowstone cutthroat trout *Oncorhynchus clarki bouvieri,* westslope cutthroat trout *O. c. lewisi*, redband trout and steelhead *O. mykiss gairdneri*, stream type (age-1 migrant) chinook salmon *O. tshawytscha*, and ocean type (age-0 migrant) chinook salmon - in the interior Columbia River basin and portions of the Klamath River and Great basins. Potential historical range was defined as the likely distribution in the study area prior to European settlement. Data were compiled

from existing sources and surveys completed by more than 150 biologists. Within the potential range of potamodromous salmonids, status was unknown in 38-69% of the area, and the distribution of anadromous salmonids was unknown in 12-15%. We developed models to quantitatively explore relationships among fish status and distribution, the biophysical environment, and land management, and used the models to predict the presence of taxa in unsampled areas. The composition, distribution, and status of fishes within the study area is very different than it was historically. Although several of the salmonid taxa are distributed throughout most of their potential range, declines in abundance and distribution and fragmentation into smaller patches are apparent for all forms. None of the salmonid taxa have known or predicted strong populations in more than 22% of their potential ranges, with the exception of Yellowstone cutthroat trout. Both forms of chinook salmon are absent from more than 70% and steelhead from more than 50% of their potential ranges, and all are approaching extirpation in portions of their remaining ranges. If current distributions of the taxa are useful indicators, many aquatic systems are remnants of what were larger and more complex, diverse, and connected systems. Because much of the ecosystem has been altered, areas supporting strong populations or multiple species will be critical for conservation management. Moreover, restoration of a broader matrix of productive habitats also will be necessary to allow fuller expression of phenotypic and genotypic diversity in native salmonids.

Notes: Lee and others 1997 (this bibliography) present an extensive assessment of changes in status of 46 fish species in the interior Columbia basin and portions of Klamath and Great basins.

Rieman and others 1997 describe bull trout in more detail:
Rieman, B.E., D.C. Lee, and R.F. Thurow. 1997. Distribution, status, and likely future trends of bull trout within the Columbia River and Klamath River basins. North American Journal of Fisheries Management 17:1111-1125.

Author: U.S. Department of Agriculture, Forest Service.
Year: 1996
Title: Status of the interior Columbia basin: summary of scientific findings
Reference Type: Report
City: Portland, OR
Institution: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station and U.S. Department of the Interior, Bureau of Land Management
Pages: 144
Report Number: Gen. Tech. Rpt. PNW-GTR-385

Value of reference: Though the results of the assessment are general and presented for the entire region, there are several useful maps and tables that summarize historical and present day distributions of key salmonids in the Columbia Basin.

Results relevant to EMAP: A Basin-wide analysis of riparian vegetation found a widespread decline in shrublands in the riparian zones. In the overstory, cottonwood and aspen have also declined significantly in the last 100 years.

Map of historic salmonid distribution in the Columbia Basin for six species of salmon and map of current key salmonid presence.

Table of Historical and Occupied Range and Habitat Status for key salmonids within the Basin assessment area.

Geographic location: Columbia Basin, eco10, eco15, eco16, eco12, eco11, eco80, Oregon, Idaho, Washington, northern Great Basin, Blue Mountains, Columbia Plateau, EPA Region 10, mountains, xeric

Keywords: fish, ecosystem assessment, ecosystem management, ecosystem integrity, risk analysis, salmonids, historical, riparian vegetation

Abstract: The Status of the Interior Columbia Basin is a summary of the scientific findings from the Interior Columbia Basin Ecosystem Management Project. The Interior Columbia Basin includes some 145 million acres within the northwestern United States. Over 75 million acres of this area are managed by the Forest Service or the Bureau of Land Management. A framework for ecosystem management is described that assumes the broad purpose is to maintain the integrity of ecosystems over time and space. An integrated scientific assessment links landscape, aquatic, terrestrial, social, and economic characterizations to describe the biophysical and social systems. Ecosystem conditions within the Basin have changed substantially within the last 100 years. The status of ecosystems is described in terms of current conditions and trends under three broadly defined management options. The scientific information brought forward will be used in decision making, and may potentially amend Forest Service and Bureau of Land Management plans within the Basin. The information highlighted here represents an integrated view of biophysical and socioeconomic elements at a scale never before attempted. The risks and opportunities are characterized in the broad context of the Basin for managers and the public to use as a foundation for discussion about future management.

URL: http://www.fs.fed.us/pnw/pubs/summary/gtr_385a.pdf

Author: U.S. Department of Interior
Year: 1994
Title: Endangered and Threatened Wildlife and Plants: Designation of Critical Habitat for the Threatened Spikedace (*Meda fulgida*)
Reference Type: Report
Publisher: Federal Register
Volume: 59
Issue: 45
Pages: 10906-10915

Value of reference: This is a policy document, but it briefly summarizes the historical and present range, habitat needs, and status of the spikedace as background for designating critical habitat.

Results relevant to EMAP: The spikedace is found in moderate to large perennial streams where it inhabits shallow riffles with sand, gravel, and rubble substrates and moderate to swift currents. Recurrent flooding is important to maintain habitat and the species' competitive edge over nonnative fish species.

The spikedace was first collect in 1851 from the San Pedro river in Arizona. Historically it was common throughout much of the Verde, Agua Fria, Salt, San Pedro, San Francisco, and Gila (upstream from Phoenix) River systems in both main stem and moderate gradient perennial tributaries up to 1900 m elevation.

Due to habitat destruction and competition and predation by nonnative fish, its range and abundance have been severely reduced, and it is now restricted to only 9% of its historic range of 2600 km of stream.

Geographic location: Arizona, xeric, mountains, eco22, eco23, eco79, eco81, EPA region 9, Verde River, San Pedro River, Gila River, Salt River, San Francisco River, Agua Fria

Keywords: fish, nonnative species, habitat degradation, flooding, flow alteration

Author: U.S. Department of Interior
Year: 1994
Title: Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for the Threatened Loach Minnow (*Tiaroga cobitis*)
Reference Type: Report
Publisher: Federal Register
Volume: 59
Issue: 45
Pages: 10898-10906

Value of reference: This is a policy document, but it briefly summarizes the historical and present range, habitat needs, and status of the loach minnow as background for designating critical habitat.

Results relevant to EMAP: The loach minnow was first collected in 1851 from the San Pedro River in Arizona. Historically, it was locally common throughout much of the Verde, Salt, San Pedro, San Francisco, and Gila (upstream from Phoenix) River systems in suitable habitat in both main stem and tributaries up to 2200 m elevation. The historical range was estimated as 2600 km of river.

This species needs recurrent flooding to maintain a substrate free of embedded sediments and to maintain conditions that allow it to better compete with nonnative fish species. Due to flow alterations, habitat destruction, and competition and predation by nonnative fish species, its range and abundance have been severely reduced, and it is now restricted to only 17% of its historic range. It is included o the State lists of threatened and endangered species in Arizona and New Mexico.

Geographic location: Arizona, San Pedro River, Blue River, White River, Verde River, Gila River, EPA region 9, eco22, eco23, eco79, eco81, xeric, mountains

Keywords: fish, nonnative species, habitat degradation, flooding, flow alteration

Author: U.S. Geological Survey
Year: 2004
Title: Pre-settlement wildlife and habitat of Montana: An overview (Pre-settlement Habitat and Wildlife literature)
Reference Type: Electronic Source
Producer: U.S. Geological Survey; Northern Prairie Wildlife Research Center
Access Year: 2005
Access Date: June 24

Value of reference: A bibliography of books, papers, and documents pertaining to pre-settlement habitat and wildlife of Montana and adjacent lands. References cover the Great Plains and include information on the following: Natural history, exploration, history of settlement, ecology, species inventories, expedition accounts, etc.

Results relevant to EMAP: A good source to locate available pre-settlement literature and references. This web site includes listings of many early exploration accounts and observations, which may be the only source for pre-settlement conditions of the Great Plains. Stream conditions and species inventories may be limited, however some baseline information can be gleaned from some of these references.

Geographic location: Montana, North Dakota, South Dakota, Wyoming, Colorado, Iowa, Great plains, mountains, plains, eco25, eco21, eco43, eco17, eco42, eco41, eco15, eco44, eco27, EPA region 7, EPA region 8

Keywords: phab, pre-settlement, literature survey, early expeditions, species inventories, fish, ecology, historic condition

URL: http://www.npwrc.usgs.gov/resource/literatr/presettl/books.htm

Author: Valdez, R.A.; Muth, R.T.
Year of Conference: 2005
Title: Ecology and conservation of native fishes in the upper Colorado River basin
Reference Type: Conference Proceedings
Editor: Rinne, J.N.; Hughes, R.M.; Calamusso, B.
Conference Name: Historical Changes in Large River Fish Assemblages of the Americas
Conference Location: Bethesda, MD
Publisher: American Fisheries Society
Volume: 45
Pages: 157-204

Value of reference: Although the focus of this chapter is on current status and ecology of the fishes (see Table 1), the section 'Current Status and Ecology' includes summaries of the historical status and distribution for the following species: Colorado Pikeminnow, Humpback Chub, Bonytail, Razorback Sucker, Roundtail Chub, Flannelmouth Sucker, Bluehead Sucker, Mountain Sucker, and Colorado River Cutthroat Trout.

The relative abundance in different parts of a river and its tributaries is described in text format, with references to many of the original historical ichthyological reports, some of which are cited in this bibliography.

A section on 'threats to native fishes' is also included, describing the primary causes of decline of the native fish species.

Results relevant to EMAP: Historical distribution and abundance is described for a number of species, for example: "The Colorado pikeminnow...was once widespread and abundant in warm main-stem rivers and tributaries...Wild populations of Colorado pikeminnow are presently found only in the upper basin in about 25% of historic range basin-wide"; "Razorback sucker was historically common to abundant in most warm regions of the Colorado River system during the 19th and 20th centuries....the species now exists naturally in only a few locations"; "Roundtail chub in the upper basin remains as 15 populations in about 55% of its historic habitat...[it] was once common in 5 tributary rivers where it is now nearly eliminated."

Threats to native fishes are discussed: flow regulation and diversion, degraded water quality. nonnative fish, and physical habitat destruction, alteration, and fragmentation.

Geographic location: Colorado River basin, Colorado, Wyoming, Utah, EPA region 8, xeric, mountains, eco20, eco22, eco23, eco21, eco18, eco19

Keywords: fish, historical status and distribution, water diversion, dams, nonnative fish, habitat degradation and fragmentation

Author: Van Steeter, M. M.; Pitlick, J.
Year: 1998
Title: Geomorphology and endangered fish habitats of the upper Colorado River. 1. Historic changes in stream flow, sediment load, and channel morphology
Reference Type: Journal Article
Journal: Water Resources Research
Volume: 34
Issue: 2
Pages: 287-302

Value of reference: The authors examine the changes in channel morphology and sediment load of a segment of the upper Colorado River near Grand Junction, Colorado between 1900 and 1995 and relate it to the habitat requirements of a native fish, the Colorado squawfish.

Results relevant to EMAP: Flow records were divided into a predevelopment period (1900-1949) and compared to a post-development period (1950-1995) since most of the reservoirs were built upstream after 1950. Dams, irrigation withdrawals, and interbasin transfers have significantly altered the natural flow regimes of the upper Colorado and Gunnison rivers. Peak discharges in reaches used by endangered native fishes are 29-40% lower than they were in the past. Reservoirs affect the way runoff is distributed throughout the year; yearly average discharge is similar to that in the past, but the spring peak flows are much reduced.

Sediment loads are similar to those in the past; however, since high flows are less common, the rivers have lost their capacity to carry the sediment. In the last 40 years or so, there is a tendency for sediment to build up in the channel, causing it to become narrower and less complex.

The rivers' declining ability to carry sediment affects native fish because the substrate is not regularly cleaned of silt and sand by peak flows. This has limited the reproductive success of the Colorado squawfish. The silting of the channel also favors nonnative (competitive) fish such as the channel catfish. There has also been significant habitat loss for native fish as backwaters, bars, and islands have been reduced. Analysis of aerial photographs indicates that between 1937 and 1993 the main channel of the Colorado River has narrowed by an average of 20 m and about 1/4 of the area formed by side channels and backwaters has been lost.

Geographic location: eco20, Region 8, Colorado, upper Colorado River, Gunnison River, xeric

Keywords: fish, Colorado squawfish, sediment, dams, habitat degradation, nonnative species, phab, channel geomorphology, historic change, hydrologic variability, peak discharge

Abstract: The hydrologic, geomorphic, and ecologic effects of reservoir operation are thought to be key factors in the decline of native fishes in the upper Colorado River basin. The present paper examines the extent to which changes in stream flow and sediment loads have affected alluvial reaches of the Colorado River near Grand Junction, Colorado. The analysis shows that since 1950, annual peak discharges of the Colorado River and its major tributary, the Gunnison River, have decreased by 29-38%. The total volume of runoff delivered to the study area has not changed significantly over the period of record, but the annual hydrograph has been modified greatly by reductions in peak flows and augmentation of base flows. Annual suspended sediment loads of the Colorado River and Gunnison River have likewise decreased. This was particularly apparent during the period from 1964 to 1978, when annual sediment loads were 40-65% less than the long-term average. Analysis of aerial photographs indicates

that between 1937 and 1993 the main channel of the Colorado River has narrowed by an average of 20 m and about 1/4 of the area formed by side channels and backwaters has been lost.

Author: Varley, J. D.; Gresswell, R. E.
Year: 1988
Title: Ecology, status, and management of the Yellowstone cutthroat trout
Reference Type: Book Section
Editor: Gresswell, R. E.
Book Title: Status and management of interior stocks of cutthroat trout.
City: Bethesda, Maryland
Publisher: American Fisheries Society
Pages: 13-24

Value of reference: The authors compare historical and present Yellowstone cutthroat trout distribution and discuss the factors implicated in its decline.

Results relevant to EMAP: Yellowstone cutthroat trout once inhabited about 24,000 km of stream in Montana, Wyoming, Idaho, and a corner of Utah. Today they exist in an estimated 2400 km of stream in and around Yellowstone and Grand Teton National Parks.

The Yellowstone cutthroat trout presently occurs mainly in headwater streams, but historically, the fish had a greater elevational distribution. Its historic elevational range extended from 275 m to 3200 m. The fish were common in large rivers such as the Snake River above Shoshone Falls and the main stem Yellowstone River at Miles City, Montana.

Yellowstone cutthroat declines are attributed mainly to stream dewatering, grazing-related riparian vegetation loss, and the introduction of nonnative species.

Geographic location: Region 8, Montana, Wyoming, Idaho, Utah, Yellowstone River basin, Snake River basin, mountains, eco17, eco43, eco12

Keywords: fish, cutthroat trout, distribution, grazing, riparian vegetation, habitat degradation, nonnative species, water diversion

Abstract: The Yellowstone cutthroat trout *Salmo clarki bouvieri* is the most abundant and widely dispersed subspecies of inland cutthroat trout. The historic range of the subspecies included the Yellowstone River drainage in Montana and Wyoming and portions of the Snake River drainage in Wyoming, Idaho, Nevada, Utah, and perhaps Washington. Introductions of nonnative fishes, environmental degradation, and human exploitation have severely reduced this range. The subspecies is estimated to presently exist in a genetically pure form in about 85% of the historic lake habitat but only in about 10% of the estimated original stream range. Additionally, Yellowstone cutthroat trout populations have been established outside the historic range in at least seven western states and two Canadian provinces. High landing rates and angler success, coupled with the fish's relatively large mean length, make the Yellowstone cutthroat trout a valuable recreational resource; however, vulnerability to angling has often led to overharvest of wild stocks. Current management of the Yellowstone subspecies includes wild trout programs for native and introduced populations and maintenance stocking from hatchery brood stocks. Genetic integrity, habitat management, and special angling regulations are important elements that influence the success of these programs. The status of the Yellowstone cutthroat trout is encouraging, but future management must emphasize protection of the full range of genetic diversity.

Author: Warren, G.K.
Year: 1856
Title: Explorations in the Dacota Country, in the year 1855
Reference Type: Report
City: Washington, D.C.
Institution: U.S. Senate
Report Number: Executive Document No. 76, 34th Congress, 1st Session.

Value of reference: This primary source provides physical descriptions of several river basins in the plains, including the Missouri, Little Missouri, Platte, Rapid, White, Big Shyenne, Big Sioux, Vermillion, and James. Appendix A gives accounts of the explorations of these areas in journal format, including additional habitat descriptions of stream widths, bank height, sediment composition, and riparian vegetation. Appendix B provides detailed descriptions of a smaller area under consideration for a military reserve in the vicinity of eastern Wyoming and western South Dakota. Appendix E is a geological summary, but also provides descriptions of riparian vegetation along rivers and streams, including the dominant trees, shrubs, and herbaceous riparian plants of the region, and a portion about travel through the badlands. This is a good source for early descriptions of riparian areas and landscapes of the plains region.

Results relevant to EMAP: Accounts describe the region encompassing southeast Wyoming, southern South Dakota, and northern Nebraska, including numerous descriptions of riparian habitats and stream physical characteristics throughout the exploration route. The majority of accounts mention the presence of grasses and woody plants such as cottonwood, willow, ash, oak, elm, boxelder, and wild plum. In places along streams where only grass was found, the accounts often include a mention of nearby wooded areas, upstream or downstream. Stream sediment type, width, depth, bank height, presence of fish (occasional mention) are also included in descriptions.

In several locations of the exploration route, the author notes that trees (primarily cottonwood)were once more plentiful (based on signs of trees being cut), but they had been cut down for use by the "Indians".

Geographic location: Wyoming, South Dakota, plains, EPA Region 8, Missouri River basin, Little Missouri River basin, Platte River basin, Rapid River basin, White River basin, Big Shyenne River basin, Big Sioux River basin, Vermillion River basin, and James River basin, eco43, eco17, eco42, eco46

Keywords: phab, riparian vegetation, primary source, historical accounts, explorations

Author: West, Elliott; Ruark, Greg
Year: 2004
Title: A long, long time ago ... Historical evidence of riparian forests in the Great Plains and how that knowledge can aid with restoration and management
Reference Type: Journal Article
Journal: Journal of Soil and Water Conservation
Volume: 59
Issue: 5
Pages: 105-110

Value of reference: This article presents a differing point of view regarding the historical presence of large woody riparian areas along larger Great Plains streams and waterways. The author suggests that early historic accounts of the streams suggest that the original vegetation included large wooded riparian zones and that current thought (streams without woody vegetation) is based on post-settlement accounts which were after the woody vegetation had been removed by the increased demand on the resource due to the push for settlement and westward expansion.

This article points out the importance of finding pre-settlement accounts and surveys when determining "natural" conditions. The author points out that much of the current historical baseline used to determine "normal conditions" is based on accounts that date back to the early 20th century. In those reports trees were largely absent or thinly represented along water courses. No one should conclude from these records, that the absence of timber was natural. Rather the lack of trees was the consequence of some of the most rapid changes that the region has ever known.

Results relevant to EMAP: Many of the larger streams of the Great Plains had a more extensive riparian woodland than had been commonly assumed. Riparian vegetation experienced substantial change during the mid to late 1800's due to human impacts. By 1900 most of the trees and other woody vegetation along the rivers and streams in the Great Plains had been cut and removed by Indians, gold seekers, soldiers, railroad crews and settlers. These riparian zones were once heavily forested with wide bands of trees but are now occupied primarily by herbaceous plants or cropland.

Looking at historical accounts from the pre- or early 1800's point to a more abundant woody riparian cover. This article highlights the importance of true pre-settlement reports and descriptions to determine "historic or reference condition", particularly in the Plains, which was altered early and dramatically.

Geographic location: Great Plains, Nebraska, Kansas, Colorado, Wyoming, eco25, eco27, eco43, plains, Platte River, North and South Platte rivers, Arkansas River, Solomon River, Republican River, EPA Region 7, EPA Region 8

Keywords: phab, riparian zone, trees, human impact

Author: Wissmar, R. C.; Smith, J. E.; McIntosh, B. A.; Li, H. W.; Reeves, G. H.; Sedell, J. R.
Year: 1994
Title: A history of resource use and disturbance in riverine basins of eastern Oregon and Washington (early 1800's-1990's)
Reference Type: Journal Article
Journal: Northwest Science
Volume: 68
Issue: Special Issue
Pages: 1-35

Value of reference: A comprehensive look at the settlement and cumulative disturbance history of six river basins in eastern Oregon and Washington (the Okanogan, Methow, Yakima, Little Naches, John Day River, and Grand Ronde Rivers) and how 150 years of human use has affected fish populations and instream and riparian habitats. This paper is a companion to McIntosh et al. 1994 (in this bibliography), but it delves into the chronology of historical resource use in greater detail.

Results relevant to EMAP: Wissmar et al. also discuss impacts to fish populations that are not as evident as those that are commonly reported, such as the effects of early diversions, ditching, and dredging for mining operations, changes to the pattern of snow accumulation and an earlier snowmelt caused by clear cutting, and fish response to high temperatures from a loss of shading in eastern Oregon streams.

Earlier peak flows in the Upper Grande Ronde River may influence the survival of salmon smolts because fish outmigration is timed largely to peak flows. Early peak flows could force smolts to outmigrate too early and lower fish survival. The hydrograph of the John Day basin has changed significantly due partly to vegetative changes, with base flows increasing in all managed watersheds and remaining the same in wilderness areas. Prior to settlement, the John Day River basin supported substantial runs of spring and fall chinook salmon and steelhead and resident fish such as bull trout (*Salvelinus confluentus*). Currently salmon runs are suppressed, with fall chinook being nearly extinct (escapements < 100 fish), while spring chinook runs range from 2000 - 5000 and steelhead from 15,000 - 40,000 fish.

Turbidity in some parts of the basin, such as Cottonwood Creek, a tributary to the North Fork, is notoriously high after storm events. The resulting siltation of stream beds decreases aquatic insect production and degrades spawning gravels. Lack of thermal cover also affects fish food availability. Exposed reaches with high solar radiation produce algae which changes the types of invertebrate prey base. Severe increases in water temperatures both summer and winter are critical limiting factors for salmonids over many portions of the John Day River basin.

Geographic location: eco10, eco11, Columbia Plateau, Blue Mountains, North Cascades, Eastern Cascades Slopes and Foothills, eco77, eco9, Oregon, Washington, mountains, xeric, EPA Region 10

Keywords: historical, fish, salmonids, human disturbance, temperature, sediments, logging, mining, grazing, dams, roads, water diversions

Abstract: A historical review of human activities influencing streams and riparian ecosystems in eastern Washington and Oregon shows that cumulative effects of resource uses and management over the past two centuries are altering the health of many river basins. Past practices such as livestock grazing and forest harvest near riparian areas and streams became

collectively significant over long time periods and are continuing today. Case histories for the Okanogan and Methow River basins (north central Washington), the Naches River (eastern Cascade Mountains), and the Grande Ronde and John Day River basins (eastern and north central Oregon) provide chronologies of events that shaped the present-day landscapes and socio-economic conditions of the region. Historic cumulative effects on stream and riparian ecosystems include livestock grazing and mining from the 1860's until about 1910. Timber harvest, roads, fire management, dams, irrigation, and fisheries increased in importance during the 20th Century. Management histories show minimal actions for reducing damage to stream and riparian ecosystems. Managers commonly perpetuate the notion that streams and riparian areas are difficult to manage because little is known about how these ecosystems function. Many agencies strive to develop procedures for treating the symptoms of degraded ecosystems while giving little consideration to the causes. Other agencies and public groups concerned with conflicting issues like water allocations and minimum instream flows for fish usually disagree with plans for resolving these issues. The continuous dissent by these parties only adds to the plight of fish as available water and habitats continue to decline. Alternatively, new basin-wide management strategies of federal and environmental organizations offer hope for improving the ecosystem biodiversity and population levels of fish and wildlife. Priorities include the protection, restoration, and monitoring of habitats and networks that connect stream and riparian ecosystems in degraded and intact watersheds. Intact watersheds (e.g., roadless and wilderness areas) function as critical habitats and refuge areas for fish and wildlife of adjoining ecosystems.

Editor: Yarrow, H. C.; Henshaw, H. W.; Cope, E. D.
Year: 1875
Title: Reports upon the zoological collections obtained from portions of Nevada, Utah, California, Colorado, New Mexico, and Arizona during the years 1871, 1872, 1873, and 1874
Reference Type: Edited Book
Series Title: Geographical and geological explorations and surveys west of the 100th meridian in charge of first lieutenant George M. Wheeler
City: Washington, D. C.
Publisher: Government Printing Office
Volume: 5
Number of Volumes: 6
Number of Pages: 1021

Value of reference: This tome describes biota (fish) collected on a series of survey explorations made between 1871 and 1874 in 6 western states. The landscape descriptions in the mammals and birds chapters give glimpses of riparian vegetation. The chapter on fish (retained as hard copy) is valuable because it describes non-commercial cyprinids and suckers (including some line drawings).

Results relevant to EMAP: The descriptions of riparian growth along streams flowing through foothills and low mountains (at elevations as low as 2700 ft.) in arid regions (San Luis Valley, Colorado; Gila River, Arizona, smaller streams in Arizona) are notable in their continual mention of tall cottonwoods and heavy brush, so thick at times to "render progress at all times difficult, and occasionally well nigh impossible."

Streams issuing from the base of the mountain normally disappeared in the "thirsty sands of the plains below", but even on the dry flats, the luxuriant vegetation which enclosed the banks did not disappear until the stream sank beneath the sand.

The chapter on fish collected during the surveys lists species encountered and location, descriptions of individual fish with some body measurements, some general indications of abundance, and occasional anecdotes of fishing for subsistence or market.

Geographic location: Nevada, Utah, California, Colorado, New Mexico, Arizona, mountains, xeric, eco19, eco13, eco21, eco23, Provo River, San Pedro River, Gila River, EPA Region 8, EPA Region 9

Keywords: fish, riparian vegetation, phab, historical survey

Author: Yoshiyama, R.M.; Fisher, R.W.; Moyle, P.B.
Year: 1998
Title: Historical abundance and decline of chinook salmon in the central valley region of California
Reference Type: Journal Article
Journal: North American Journal of Fisheries Management
Volume: 18
Pages: 487-521

Value of reference: This research reconstructs historical chinook salmon estimates (numbers and pounds) in two major drainages--San Joaquin and Sacramento Rivers, and discusses declines that may have begun as early as the 1850s, the factors causing those declines, and the general changes in ranges of the four major chinook runs over the last 70 years. It brings together many historical and current references and thus is a very thorough synthesis article that covers the history and status of Chinook salmon in the Central Valley. Paper also discusses the differential impacts on the 4 runs (spring, winter, fall, late-fall).

Results relevant to EMAP: The Central Valley system contained a productive chinook resource before the 20th century; historical chinook runs for the Central Valley were estimated between 1 and 2 million spawners per year in the late 1800s, which was reduced by approximately 50-90% by the late 1900s (see Table 5).

Harvest records estimate takings in 1856 at 450,000 fish (nearly 4000 per day); at an average weight of about fifteen pounds each, this amounts to 6,750,000 pounds (includes spring, summer, and winter run catches). Catches during 1875-1910 were often 5-10 million pounds annually, averaging at least 7,180,000 lb and exceeding 10 million pounds in 1880, 1883, 1909, and 1910 (see Table 2).

A decrease in the abundance of salmon in the Sacramento River was noticed as early as 1851 beginning with widespread mining. Factors causing declines over time are overfishing, destruction of habitat by hydraulic mining, dredge mining, railroad construction, logging, construction of dams, water diversions, and establishment of hatchery programs.

Geographic location: eco6, eco7, California, Central Valley, xeric, San Joaquin River, Sacramento River, EPA Region 9

Keywords: fish, historical fish catch, historical fishery, fishing, mining, dams, water diversion, hatchery egg collecting

Abstract: The Central Valley drainage of California formerly produced immense numbers of chinook salmon *Oncorhynchus tshawytscha.* Four seasonal runs occur in this system--fall, late-fall, winter, and spring runs. Differences in life history timing and spatial distribution enabled the four runs to use the drainage to the fullest possible extent and once made it one of the richest regions in the world for chinook salmon production. Native American fishers within the central valley drainage harvested chinook salmon at estimated levels that reached 8.5 million pounds or more annually. Native harvests, therefore, were roughly comparable to the peak commercial harvests taken later by Euro-American fishers, but whether or not native fishing depressed the productive capacities of the salmon populations to any substantial degree is not known. The commercial chinook salmon fishery in CA started about 1850 in the San Francisco Bay and Sacramento-San Juaquin Delta region, where it formed the nucleus of the first major fishery conducted by Euro-American immigrants in the state. This fishery was one of the important

early industries that supported the Euro-American settlement of the Central Valley region. The salmon fishery remained centered there until the early 1900s, when ocean salmon fishing began to expand and eventually came to dominate the fishery. Annual catches by the early Sacramento-San Juaquin in-river fishery commonly reached 4-10 million pounds and generally were higher than the total statewide catches made during the most recent several decades. The historical abundances of Central Valley chinook salmon before large-scale commercial exploitation and depletion of the runs cannot be determined with certainty. However, on the basis of early commercial catch records, the maximal production levels of the central valley chinook salmon stocks in aggregate may be conservatively estimated to have reached approximately 1-2 million spawners annually. Although substantial investment has been made by the state of California in managing the chinook salmon resource since the early years of the commercial fishery, chinook salmon have declined over the decades to small fractions of their previous numbers. The decline of the central valley chinook salmon resource was caused by several factors: overfishing, blockage and degradation of streams by mining activities, and reduction of salmon habitat and stream flows by dams and water diversions. Differences between the four chinook salmon runs in life history timing and habitat requirements partly account for their different population histories; the winter run is now threatened with extinction, the spring run recently has approached a similarly imperiled state, and the late-fall run has been at moderately low population levels for the past two decades. Only the fall run, in aggregate, can be regarded as secure, but it too has undergone substantial reductions in abundance. Fall-run spawner numbers were especially low in the San Juaquin River basin in recent years, and in Sacramento River basin streams their numbers have been heavily influenced by production of hatchery fish.

Author: Young, M.K.
Year: 2003
Title: Yellowstone Cutthroat Trout
Reference Type: Electronic Source
Producer: American Fisheries Society, Montana Chapter
Access Year: 2005
Access Date: May 18
Last Update Date: April 18, 2005

Value of reference: Summary addresses a subspecies of cutthroat trout, historically wide-ranging and found in numerous basins in several states. The focus here is on the fish species of Montana, but historical accounts are given for the species entire range in the West. Estimates of percent range reductions are given by state, although these are complicated because the species is stocked and is actually now found in more waters than it was historically. Concerns about the genetic homogenization of various subspecies of cutthroat trout and among populations within the Yellowstone cutthroat trout subspecies due to introductions are discussed.

Results relevant to EMAP: Historically, Yellowstone cutthroat trout were believed to have occupied much of the Yellowstone River basin, including portions of the Clarks Fork of the Yellowstone River, Bighorn River, and Tongue River basins in Montana and Wyoming, and parts of the Snake River basin in Wyoming, Idaho, Utah, and Nevada (Behnke 1992 (in this bibliography)—Figure 1 shows the potential historical range in Montana).

They have undergone substantial declines in distribution and abundance throughout their range. Populations in Utah and Nevada are limited to 102 basins; in Idaho, the trout occupied 43% of the historical range, in Wyoming 42% and in Montana, 32% (although more recent estimates suggest that only 10% of the historically occupied fluvial habitat in Montana still contains genetically pure populations).

The greatest threat is competition with nonnative fish--brown trout, brook trout, lake trout--while a related concern is the widespread stocking of non-indigenous populations of YC-trout throughout the historical range, which tends to genetically homogenize populations; habitat issues are of lesser importance, but examples of the detrimental effects of habitat degradation, loss, and fragmentation on Yellowstone cutthroat trout are numerous--dewatering for irrigation, dams, reservoirs, channelization, grazing, logging, mining, road-building.

Geographic location: Montana, mountains, eco 15, eco17, eco42, eco43, EPA Region 8, Yellowstone River basin, Bighorn River basin, Tongue River basin, Snake River basin

Keywords: fish, historical distribution, agriculture, logging, dams, channelization, mining, roads, nonnative species, fishing

Notes: Other species of concern in Montana are listed on the website and can be accessed electronically via the link provided in this entry. However, few present historical estimates or ranges.

URL: http://www.fisheries.org/AFSmontana/SSCpages/yellowstone_cutthroat_trout.htm