The Upper McCloud River Watershed: A Basin Roadmap

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1. Introduction

The Upper McCloud River Watershed comprises an area of over 500 square miles, and contains a mix of relatively flat to more mountainous terrain. The 14,162-foot Mount Shasta volcano is the source of the headwaters of the McCloud River. Snowmelt from Mount Shasta permeates the porous volcanic soils of the mountain's southern flank, and later emerges down slope as the streams and creeks that feed into the valley to form the McCloud River. The Upper McCloud Watershed encompasses these tributary lands that stretch above the river to the north and east of the town of McCloud and Highway 89, an area also know as the McCloud Flats, as well as the area south of the river to just above the McCloud Reservoir.

The watershed provides habitat for over 200 species of animal life, 17 of which are species of special concern. The primary vegetation in the watershed is second growth mixed conifer and white fin ponderosa pine forests. Of the five fish species that live in the Upper McCloud Watershed only one is a true native – the McCloud River redband trout (Oncorhynchus mykiss ssp.), which survives mainly in fragmented streams in the upper reaches of the watershed. Anadromous fish once made their home in the McCloud as well, but they were extirpated after the construction of the Shasta Dam and McCloud Reservoir cut off the fish from their traditional spawning grounds.

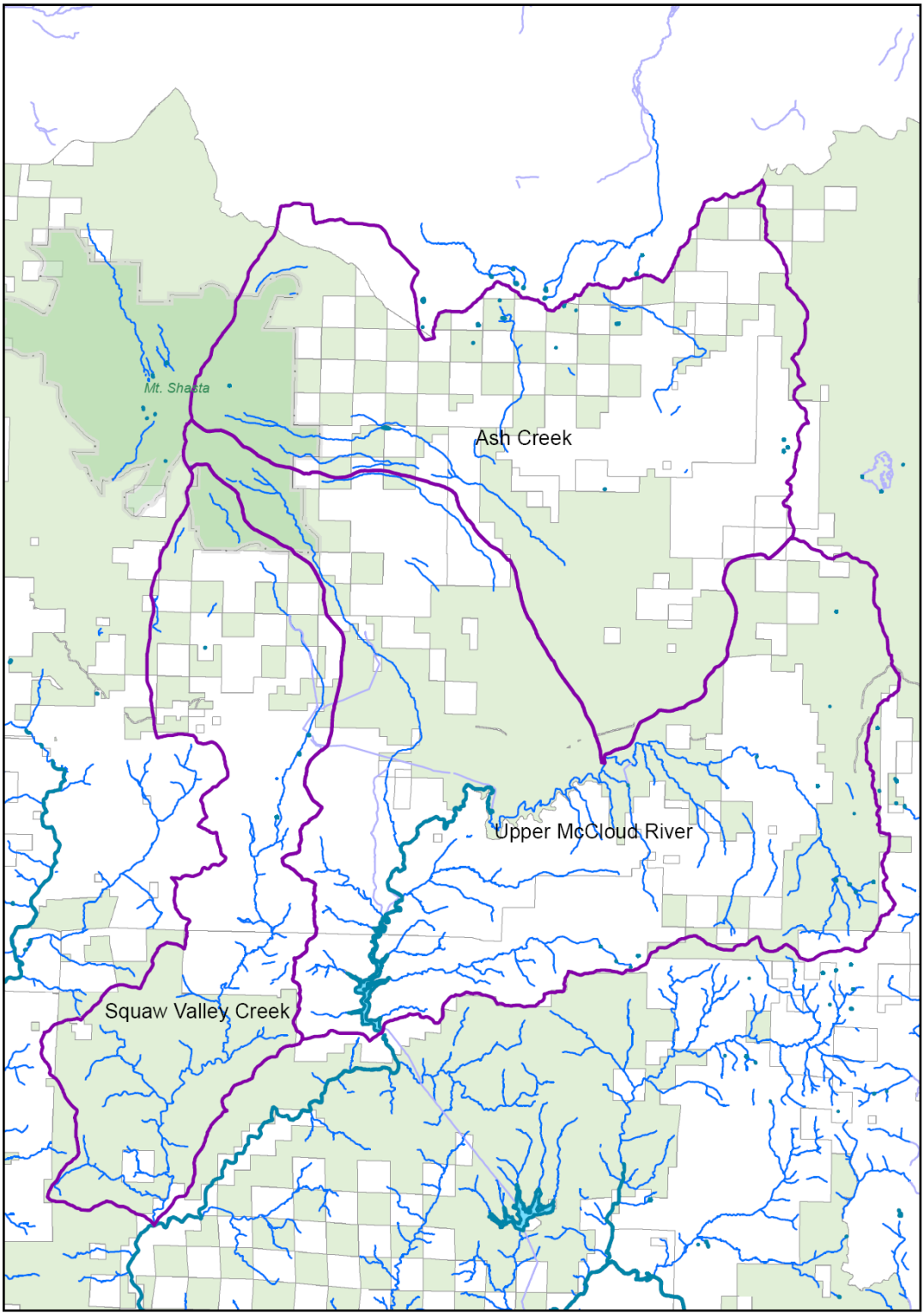
There is a mix of land ownership in the watershed, with approximately 40% of the area in private hands, and the remaining in public ownership. Timber management and harvesting is the dominant land use in the watershed, followed by recreational uses and some grazing. Natural and anthropogenic influences in the watershed include water use, dams or other diversions, timber harvesting, maintenance of road systems, droughts, floods and fire.

The Upper McCloud River Watershed has been the site of a number of investigative and restoration activities over the past decade, driven primarily by the listing of the McCloud redband trout as a candidate species under the federal Endangered Species Act (ESA). In 1998 the private and public landowners in the watershed, along with other interested government entities, signed a Redband Trout Conservation Agreement. Because of the Conservation Agreement, the redband was removed from candidate status in 2000.

A number of sub-watersheds analyses have been completed in the Upper McCloud basin, but the watershed has never been the subject of a comprehensive watershed assessment, nor of a collaborative, stakeholder-driven management plan. The following basin "roadmap" is the result of a year-long process to uncover what is known and unknown about the ecology of the Upper McCloud, and to perhaps serve as a basis for a more comprehensive assessment and management plan in the future.

2. Project Area Map

Figure 1. Map of the Upper McCloud River Watershed, including the three Hydrological Unit sub-systems: Ash Creek, Upper McCloud River, Squaw Valley Creek.



3. Project Overview

3.1 Project description

The objective of this project is to provide a basin roadmap for the Upper McCloud River Watershed, including:

- Cataloging past, ongoing, and funded future research and documentation related to the Upper McCloud River Basin (defined as the portion of the McCloud River Watershed extending from its headwaters on Mt. Shasta to the dam at the lower end of the McCloud Reservoir) including its tributaries, riparian and upland habitats, and the Squaw Valley Creek Drainage, in terms of this conceptual framework.
- Organizing catalogued research by subject area (based on the broad categories of Watershed and Ecosystem Analysis, Climate, Geology and Hydrology, Ecology and Natural Resource Science, Land Use, Resource Management and Conservation, and Cultural Resources) and geographic region of focus.
- Identifying information and data gaps and proposing measures to fill those gaps.
- Conducting interviews with private landowners and holding public outreach meetings, to capture key issues, perceived watershed strengths and weaknesses or challenges, and opportunities for improvement.
- Synthesizing the conceptual framework, existing information (both documented and from landowner/public interviews) and proposed measures for resolving gaps into a series of suggested next steps.
- Explaining the conceptual framework for this roadmap and for a future comprehensive watershed assessment for the Upper McCloud River Watershed, by specifically characterizing landscape in terms of a hierarchical organization and the dominant suite of landscape dynamics, and categorizing available landscape information in terms of its origin, era, underlying questions, and intended application.

The information assembled for this project encompasses a range of past, present, and future watershed science, land use policy, qualitative reports, and cultural surveys pertaining to the Upper McCloud River Watershed, including the Squaw Valley Creek Drainage.

The product is intended to 1) provide a high level overview and summary of available watershed information and key data gaps for funding agencies, resource managers, scientists, and other interested parties; 2) provide the foundation (informational and conceptual) for a more comprehensive assessment of the Upper McCloud Watershed and the associated development of a watershed management strategy; and,

3) recommend a series of actions that can be taken immediately towards the goal of improving and supporting watershed sustainability.

The report is organized in terms of the following broad areas of emphasis:

- **Watershed and ecosystem analysis** – Whole watershed, multi-watershed, or inter-watershed scale research or analysis of existing research.
- **Climate, geology and hydrology** – Includes all physical science evaluation focused on climate, underlying geology and soils, and surface and groundwater. (As distinguished from fluvial geomorphology and water quality focused evaluation addressing a specific ecosystem, species, or habitat related question).
- **Ecology and natural resource science –** All environmental science related to understanding, species, communities, habitats, ecosystems, and/ or natural resources (includes fluvial geomorphology and water quality).
- **Land use, resource management, and conservation** – All research and analysis focused on resource management or land use objectives (including conservation, restoration and mitigation) or based on questions derived from pursuits in these arenas.
- **Cultural resources –** Archeological, anthropological, and historical research and documentation related to Native-American and Euro-American land use, heritage, and cultural resources.

3.2 Report summary

3.2.1 Assessment Approach

This roadmap utilizes a framework for landscape assessment that employs the following key concepts and associated applications:

- ***Hierarchical organization of landscape*** – to facilitate collection and organization of existing data, identify data gaps, and prioritize measures to fill those gaps (Appendix A, Figure 1).
- ***Distinguishing between landscape information based on its origin, era, underlying questions, and intended application*** – to further organize existing data, identify data gaps, and promote effective research.
- ***Linking best available science and land management using landscape dynamics*** – to organize data, design research and monitoring, track multi-scale landscape trends, reveal opportunities to join management and stewardship, and prioritize actions.

3.2.2 Existing information

Watershed and ecosystem analysis – A comprehensive summary of the existing information on the Upper McCloud River Basin reviewed as part of this study is provided in Figure 2(a,b). Across both environmental science- and land use and management-driven research, information on the Upper McCloud is primarily contained in high level, coarse resolution landscape evaluations and land management documentation (e.g., the U.S. Forest Service McCloud Flats Ecosystem Analysis (1995), and the Shasta-Trinity Land and Forest Management Plan (1994)). In both of these research categories, the amount of information decreases as the degree of specificity increase as to what is being studied.

In addition, most of the high level documentation is the result of research on public lands managed by the U. S. Forest Service. There is very little information on the nature or management of private lands in the Upper McCloud Basin. The bulk of the Upper McCloud River basin is has been recently assessed within multiple Forest Service watershed or ecosystem analyses. The main exceptions to this (in terms of the scope of this study) are the Squaw Valley Creek Drainage and the McCloud Reservoir. There is however, a great deal of work related to the McCloud Reservoir occurring as part of an on-going application review by the Federal Energy Regulatory Commission in response to re-licensing requests for several hydroelectric projects owned by Pacific Gas and Electric in the Lower McCloud River Watershed.

Climate, geology and hydrology – Detailed information on the hydrology, geomorphology and ecology of the Upper McCloud region has been largely the result of specific land use activities. Historically, these were primarily centered around management of the forest and the fishery, although more recently, fisheries conservation (especially of endemic redband trout) and management of surface water and groundwater have emerged as land management objectives driving a great deal of research.

As a result of this trend, the fishery in the Upper McCloud represents one of the most-researched areas, from both a science and land management perspective. Still, most of the ecological information available is specific to conservation of the redband trout and its known habitat, with other biota, trophic and ecologic interactions, and physical processes in the systems that support them left largely unexplored.

Another specific area of intense research has been the Shasta Mudflow Research Natural Area (RNA). Here, the Forest Service and scientists from the University of California have performed extensive work on geomorphology, soil typing and analysis, as well as some work characterizing vegetation community structure, and to a lesser extent wildlife presence/absence. Surface water hydrologic information for the watershed is limited, and consists primarily of two U.S. Geological Survey stream flow

monitoring stations, and some channel dimension data for tributaries to the Upper McCloud collected by the Forest Service.

Groundwater research in the watershed, currently driven by the non-profit organization California Trout, in cooperation with the University of California, Davis, is also underway, and is designed to map and characterize the watershed's myriad spring water resources. This work is ongoing, however, and has not yet produced reportable results.

Ecology and natural resource science – Over the years there have been a steady trickle of graduate theses and dissertations, as well as peer-reviewed journal articles, studying the biota and ecosystems of the Upper McCloud Watershed. Though many of these have been focused on redband trout, there has also been a limited amount of research on mammals, birds, amphibians, invertebrates and mollusks. These studies have been generally focused on specific reaches of the Upper McCloud River, or specific tributaries, rather than occurring at a watershed scale.

Some watershed scale information on species observations is captured, however, within the Forest Service GIS dataset. Additional information (primarily descriptive/ qualitative) on species and ecosystems in the Upper McCloud can be found in Forest Service documentation on land use and management related to forest products harvesting, fire and fuels management, roads and transportation, and grazing allotments. Information on wildlife management (including listed species) is generally on found a high level for Forest Service lands, except where specific conservation or mitigation projects are underway, in which case more fine resolution data is available in the initial assessments and reports related to specific projects.

Land use, resource management, and conservation – Land use and resource management documentation for the Upper McCloud River Basin is significantly more extensive in its coverage than ecologic and natural resource science documentation. Landscape-level topics such as timber management, fire and fuels management, grazing allotments, and transportation and road networks are generally well-documented for a great deal of the Upper McCloud Watershed. The of the primary reasons for this is that a large percentage of the land in the Watershed is managed by the Forest Service and falls within the scope of their comprehensive management plan for the Shasta-Trinity National Forest (USFS 1994).

As with ecology and natural resource science documentation, however, resolution in land use documents is generally coarse and broad-scale, and information decreases at finer resolutions, both in terms of subject area, and specific geographic regions addressed.

Finally, documentation of land use and management on large number of privately-held lands in the Upper McCloud Watershed is extremely sparse.

The main exception to the coarse resolution of land use and management documentation is in the areas of conservation and restoration. Specifically, research efforts centered on redband trout habitat have resulted in detailed land use and management plans for several small tributaries tributary reaches in the Upper McCloud Watershed (most notably Trout Creek (USFS 2007)). Generally, largely as a function of the breadth of the Redband Trout Conservation Agreement (USFS 1998), the fishes and fishery in the Upper McCloud River and its tributaries are the one component of the ecology addressed at a very high level in the existing body of land use and management documentation.

There have also been some efforts towards organizing landscape data based on a conceptual framework that incorporates landscape dynamics, as opposed to organization around resource management objectives. The main examples of this are restoration of channel-floodplain connectivity and landscape patch dynamics, and forest management and thinning focused on eliminating disease or insect infestation and reducing the risk of fire.

Cultural resources – Cultural resources in terms of archeological sites are fairly well-researched and documented in the Upper McCloud Watershed. The Forest Service performs archeological surveys on all of the areas within the lands they manage where they have active projects or management plans. The exceptions to this are those sites in the area currently occupied by the reservoir. These have been mapped but never investigated.
Archeological sites in the Upper McCloud range from Native American settlement sites and sites of cultural significant, to early Euro-American sites, to historic road, trail, and railway locations.

3.2.3 Data gap resolutions and research opportunities

Watershed and ecosystem analysis – Currently, there is an opportunity for an ecosystem assessment encompassing the entire Upper McCloud River Basin, framed in terms of landscape dynamics, categorized and analyzed based on the origin, intent, and era of existing information and associated data gaps, framed around key issues or topics, and organized based on landscape hierarchy. Additionally, the Squaw Valley Creek Drainage and McCloud Reservoir represent the main sub-watersheds within the Upper McCloud Basin that are not encompassed in an existing watershed or ecosystem-scale assessment. These subcomponents could be addressed separately or as a higher resolution component of a larger Upper McCloud Basin assessment.

Climate, geology and hydrology - There is currently no groundwater model or aquifer characterization for the Upper McCloud Watershed. There is also a need for more detailed hydrologic data for surface water in the region, including temporal variability in discharge for major tributaries to the Upper McCloud River, multiple discharge measurements for the Upper McCloud River itself, multiple discharge measurements and temporal variability for Squaw Valley Creek, and a general hydrologic model for the McCloud Reservoir.

Ecology and natural resource science – There is a need for a watershed-scale ecologic assessment and monitoring program for the Upper McCloud River and Squaw Valley Creek Watersheds that are grounded in landscape dynamics and available research, as opposed programs that are driven by specific, isolated land use or resource management directives and projects. Most in need of investigation are food-web and ecologic interactions, community composition and population dynamics for species other than fish, and listed birds. In the case of fish, while presence, distribution and abundance is somewhat known, their role in the food-web or in multi-habitat ecologic interactions is poorly understood and warrants investigation.

Also in need of investigation are detailed species distribution and abundance patterns, species/habitat relationships, and implications of food-web dynamics and habitat distribution for all species of concern. Water quality and air quality data throughout the region is also very limited and these are areas of concern that also warrant further investigation.

Land use, resource management, and conservation – There is currently only limited documentation of past and present land use and management in the Upper McCloud River drainage, outside of that encompassed in the Shasta-Trinity Land and Forest Management Plan (USFS 1994), and almost no information available concerning private land management within the Squaw Valley Creek Drainage and the McCloud Reservoir and its tributaries.

As a result, there is an opportunity for creation and maintenance of a land use and management dataset specific to the Upper McCloud Basin. Related to this, there is also at present no collaborative land and use and resource management strategy for the Upper McCloud Watershed. There is an opportunity to leverage data assembled here, or as part of a more comprehensive Watershed Assessment for the Upper McCloud, to develop a Watershed Management Strategy that spans stakeholders and interest groups, is sensitive to landscape dynamics and climatic conditions operating at a range of temporal and spatial scales, and has as its objective collaborative watershed stewardship and increased sustainability.

In addition, there are also some new categories of on-going or proposed land uses within the watershed that pose likely significant impacts, but there is very little or no

supporting research on, or investigation of, those impacts. The two most notable examples of this are precipitation enhancement (a.k.a. "cloud seeding") projects in the Upper McCloud Basin to increase hydropower potential, and the proposed Nestle water bottling facility, with its implications for groundwater and surface water disruptions in the Squaw Valley Creek Drainage.

Cultural Resources – While a great deal of cultural resource sites in the Upper McCloud Watershed have been surveyed and mapped, only a limited number have been investigated or researched. Further, only a limited number of the sites on private lands within the Upper McCloud or Squaw Valley Creek watersheds have been mapped.

Oral history accounts from Native Americans are largely unrecorded, though they constitute perhaps the most far-reaching and continuous body of regional information. Investigation into both Native American and Euro-American presence in the region has been primarily documented from a historical and anthropological perspective. There is also an opportunity to investigate this presence from the perspective of landscape ecology and human ecology, with specific focus on the history and present state of the region, as well as an evaluation of trends in regional land use and landscape condition spanning a range of temporal and spatial scales.

3.2.4 Private landowner interviews

Large-scale private landowners in the watershed include major timber harvesting companies, ranchers, and recreational users. Key findings from interviews with the major private landowners include:

1. The watershed was generally perceived as being healthy, and its health was improving.
2. Areas of perceived weakness in the watershed were fairly limited and specific.
3. Suggestions for watershed improvements, beyond those identified by the Red Band Trout Core Group, were relatively few and fairly general.

3.2.5 Suggested next steps

The list of suggested next steps is drawn from the data gap analysis, public outreach, and private landowner feedback assembled during the project. "Next step" recommendations are organized in four categories: 1) Assessment; 2) Research and Monitoring; 3) Restoration; and, 4) Education and Outreach.

Assessment

- Conduct a comprehensive and collaborative stakeholder-driven Upper McCloud River Watershed Assessment that includes a Watershed Management Strategy.
- Complete a regional land use dataset and tracking system.

Research and monitoring

- Conduct hydrologic and water quality monitoring of the Upper McCloud and its tributaries
- Document through oral history the ecological change and land use patterns in the Upper McCloud Watershed.
- Document historic well depths and output in the Upper McCloud Watershed.
- Conduct an eco-geomorphic survey of the Squaw Valley Creek Drainage that includes characterization of habitat and biotic communities.
- Understand the annual trends in the Upper McCloud Watershed's contribution to Lake Shasta and the Shasta Reservoir.
- Investigate the impacts to stream and riparian corridors from trails and roadways in the Upper McCloud Watershed.
- Perform an ecosystem analysis and food-web investigation of ephemeral tributaries and vernal pools in the Upper McCloud Watershed.
- Complete aquifer and groundwater mapping and characterization for the Upper McCloud and Squaw Valley Creek Watersheds.

Restoration

- Map the historic springs in the Squaw Valley Creek Drainage that were capped and restore them to a natural state.

Education and outreach

- Promote conservation of stream ecosystems and water quality in the Squaw Valley Creek Drainage.
- Facilitate a forum on watershed issues.

4. Overview of Existing Information and Data Gaps

4.1 Introduction and summary

As previously noted, this report is organized around the broad categories of 1) watershed and ecosystem analysis; 2) climate, geology and hydrology; 3) ecology and natural resource science; 4) land use, resource management, and conservation; and, 5) cultural resources. However, these areas of emphasis are included only when applicable or where information is available. Additionally, detailed information in these areas exists at multiple scales ranging from whole watersheds, or forests spanning multiple watersheds, to individual springs and tributaries.

For the purpose of organization, the summaries of existing information and associated data gaps have also been grouped by scale. The individual tributary scale summary includes separate sections specifically focused on Squaw Valley Creek and the two reservoirs in the Upper McCloud River Basin (Dwinell Lake and McCloud Reservoir). The Squaw Valley Creek Drainage is also addressed as part of the section on watershed scale analysis and associated data gaps.

In addition to the three part narrative review to follow, a complete annotated list of the references used as the basis for this review and analysis is provided in available on CD-ROM, in Microsoft EXCEL format, and can be sorted by either geographic region of focus, or subject, or both, for an even more specific analysis of available information.

All of the existing information across all geographic regions and subject areas presented in this review (with the exception of cultural resources), is also graphically summarized in Figure 3(a,b) (pp. 38-39). Both the graphic summary and the annotated reference list include the Squaw Valley Creek Drainage as well as Dwinell Lake and the McCloud Reservoir.

4.2 Watersheds, sub-watersheds, flats, and uplands

Watershed and ecosystem analysis

Existing information

A large portion of the Upper McCloud Watershed falls specifically within the boundaries of the Bartle Watershed Analysis (USFS 1997) and McCloud Flats Ecosystem Analysis (USFS 1995). These analyses are broad in scope and span categories including 1) watershed characterization (e.g., physical features - soils, geology, hydrology, stream order class, and biological features - forest type, succession, species, human, grazing,

land use, and management); 2) issues and key questions; 3) current conditions (e.g., landscape vegetation patterns, plant communities, wildlife, fungi/ lichen, bryophytes, exotic weeds, caves, hardwoods, range, forest health, fire and fuels, recreations, roads, heritage resources, geology, hydrology, channel morphology); 4) reference conditions; 5) interpretations; 6) recommendations (e.g., old growth and biodiversity, old growth management, redband trout conservation, grazing, caves, grassland and aspen restoration, biodiversity monitoring needs and data gaps, road closure, forest health, consumptive and non-consumptive uses, distribution and function of riparian areas); and, 7) accompanying maps.

In addition to summaries and descriptions, based on both quantitative and qualitative data and information, the Bartle watershed analysis includes watershed scale distribution maps representing management designations, and landscape characterization relative to ecotype and forest condition.

Data gaps and associated opportunities

Currently, there is no watershed or ecosystem analysis for the Squaw Valley Creek Drainage, a primary watershed within the scope of this research project. The Squaw Valley Creek watershed is regionally significant in several respects. It is one of the most expansive sub-watersheds within the Upper McCloud, originating high on Mt. Shasta and joining the McCloud River below McCloud reservoir. Squaw Valley Creek is also the only watershed that has not experienced a significant landscape altering fire in its recent history. Additionally, the drainage is mainly privately-owned holdings consisting of very large tracts, with differing land use histories. All of these converging aspects make Squaw Valley Creek ecologically distinct from other drainages in the region and create extensive opportunities for research.

Although much of the Upper McCloud River watershed is encompassed in either the Bartle analysis or the McCloud Flats analysis, these are both over ten years old and were crafted without a design that facilitates incorporation into watershed models or active data repositories, other than the USFS GIS index. In addition, though very broad in scope, spanning physical environment, biology, land use, and management, these analyses lack detail and are often more descriptive than quantitative in their characterization of the watershed/ ecosystem.

Patch matrix dynamics are addressed at a large/ landscape level scale, but need improved resolution. Many riparian and floodplain habitats, critical to the structure and function of aquatic habitats are not addressed specifically. Neither the ephemeral tributaries which make up a huge percentage of the system's drainage network during high flow periods, nor the springs which serve as the primary source of water in the Upper McCloud system are tracked in terms of hydrology, water quality, surface water-groundwater interaction, or ecologic significance, except in a limited number of isolated

cases. At the ecologic scale, much of the wildlife information is extrapolated from research on larger areas, drawn from outdated data, or is only qualitative in nature.

Examples of key data gaps at the watershed analysis level include: specific hydrologic and water quality information for streams encompassed within watershed boundaries (both perennial and intermittent or ephemeral watercourses), specific groundwater information for the watershed, specific distribution, abundance, ecologic and trophic data for many species of concern, and for most species not considered either endangered or of concern.

Figure 2. Map of Upper McCloud region that shows the numerous perennial and ephemeral streams that form the tributaries to the main river (USFS).

Geology and hydrology

Existing information

Geologic data for sub-watersheds within the Upper McCloud Watershed consists primarily of United States Geological Service (USGS) data from the mid 1900s, paired with a 1960's document providing a general description of the Geology of the Cascade Range and the Modoc Plateau. In addition, USGS topographic maps exist for the entire McCloud region. An underlying geologic map of the McCloud watershed and surrounding region describing large-scale features and formations is also available.

As part of their Mt. Shasta spring water research project, California Trout has assembled GIS mapping of the springs in the Upper McCloud and Upper Sacramento River Watersheds. While not exhaustive, those maps do cover the major springs, their locations, and provide, discharge/ flow data, and isotope data in cases where it exists (CalTrout 2007). This research is the most recent attempt to characterize the aquifer, hydrodynamics, and surface water-groundwater interactions in the Upper McCloud Watershed.

Currently, regular hydrologic data for the Upper McCloud consists of discharge data from USGS gauging station #11367500. Other USGS gauging stations also operated in the Upper McCloud for discrete periods (e.g., Mud Creek #11367000 (1927-32), McCloud River above Panther Creek #11367700(1955-59)), but are no longer operational.

Data gaps and associated opportunities

Key hydrologic and geologic data gaps for the Upper McCloud Watershed and its sub-watersheds include hydrologic characterization of all tributaries to the Upper McCloud, and of the Upper McCloud itself. A water balance for the Upper McCloud has not been attempted, nor has any type of system scale hydrologic model been created. In addition, at a fine scale and as a component of systemic hydrology, the relative contribution of perennial versus ephemeral tributaries to network dynamics in the Upper McCloud drainage has yet to be investigated.

Ephemeral tributaries in the Upper McCloud have not been hydrologically characterized, in terms of discharge (snapshot or seasonal variability), source of water (spring vs. direct precipitation), or temporal variability in relative contribution to the Upper McCloud itself. The connectivity between geographically discrete springs, a model of the fractured aquifer, and general characterization of surface water/groundwater interactions in the Upper McCloud drainage also all have yet to be explored. The CalTrout spring water project includes some of these specific elements as part of its longer-term goals, but has not yet achieved those goals in the short term.

In addition, Pacific Gas and Electric is also known to have performed a significant amount of groundwater research in the Upper McCloud Watershed in association with its hydropower operations on the McCloud. Findings from its research, however, are not publicly available. PG&E is also performing a great deal of ongoing research as part of its re-licensing application for its McCloud-Pit Project. Detailed study plans are summarized in PG&E 2007. Research for this project is primarily focused on the Lower McCloud and McCloud Reservoir.

Ecology and natural resource science

Existing information

Though a general ecological assessment of the Upper McCloud Watershed has not been performed, a number of documents have attempted to characterize some portion of the regional ecology, albeit at a fairly coarse level. These include the Shasta-Trinity Land and Forest Management Plan, several ecosystem or sub-watershed analyses, the Environmental Impact Statement (EIS) for the Pilgrim Vegetation Management Plan, the Environmental Impact Report (EIR) for the Nestle Waters project in the town of McCloud, and the California Department of Fish and Game's McCloud Flats Deer Heard Management Plan.

Within this available body of forest- and watershed-level ecologic research, information on aquatic and riparian ecology is focused primarily on fish populations in the Upper McCloud and its tributaries. *Trout Unlimited* performed a survey of the Upper McCloud fishery in the late 1970's, and the California Department of Fish and Game (CDFG) continues to survey specific sub-drainages within the McCloud system.

Within the fish-related work, redband trout distribution, abundance, and genetic characterization have been the primary areas of focus in recent years. Previously (until their recent extirpation), bull trout distribution and abundance was another area of focus for aquatic research. Generally, the existing work on the fishery captures presence/absence data or maps species distribution and habitat use.

Forest-level data on distribution and occurrences of a range of wildlife as well as vegetation mapping, data on forest community composition, and patterns in vegetation distribution are available as part of the USFS Shasta-Trinity GIS dataset. USFS Wildlife GIS data for the Shasta-Trinity National Forest includes collected encounter data (amalgamated in 1996) for many species at a forest level. Specific information on range and habitat of sensitive bird populations including the northern spotted Owl and Northern Goshawk is also available in the USFS GIS dataset.

Some additional taxonomic general information on the northern spotted owl population, spanning the Upper McCloud drainage, is available in Gutierrez and

Barrowclough (2005). An in depth analysis of Goshawk habitat use in southern Cascades including the Upper McCloud Region is available in Austin (1993).

Detailed information on female mule deer distribution and habitat use in the Upper McCloud is presented in the study by Weist (1993), and additional information is available in the McCloud Flats Deer Heard Management Plan (CDFG 1983). Both the CDFG and the USFS also have anecdotal information on large game presence and distribution based on hunting reports.

Data gaps and associated opportunities

Watershed scale ecologic data for the Upper McCloud River Watershed is perhaps the most limited of the four data categories used in this report. There is very little information available on the food web, ecologic interactions, or community composition and dynamics for anything other than fish. Even where fish are concerned, their role in the food web or in multi- or cross-habitat ecologic interactions is unexplored and poorly understood.

Additionally there is little or no research on the ecology of the ephemeral tributaries to the upper McCloud, though the proposed redband trout barrier project will likely illuminate this to some degree (USFWS and USGS 2007). Given the significant percentage of the drainage these tributaries constitute during high flow periods, this presents a large unexplored ecological resource, and an associated opportunity for deeper understanding of the ecosystem.

Aquatic invertebrate communities, amphibian communities, and riparian and upland bird communities have not been characterized at a watershed scale in terms of presence/absence, distribution, or seasonal fluctuations and ecologies.

Bat community (residence and migratory) has also not been characterized at a watershed scale, although some information does exist in Person and Rainey (1996), and again in the USFS GIS index. Additionally, the Forest Service has recently begun bat surveys in several specific drainages of the Upper McCloud system, partially in conjunction with its Trout Creek restoration and mitigation project (USFS 2007). Findings from these studies are not yet available.

Little is known about upland mammals in the Upper McCloud watershed, with the exception of those that are hunted or are otherwise part of some game management system. USFS also maintains species lists and GIS habitat data for species of concern, though the information is not based on any active monitoring programs and does not address distribution and abundance.

Land use, resource management and conservation

Existing information

The Shasta-Trinity Land and Forest Management Plan is the most comprehensive overview of the status and management objectives for land and natural resources in the Upper McCloud basin. Specifically, the plan presents USFS land use designations, management practices, and monitoring efforts for federal lands within the Upper McCloud Watershed (USFS 1994). As a large portion of the land in the Upper McCloud Watershed is managed by the USFS, a large percentage of the basin falls directly within the plan's jurisdiction.

Specific areas of focus covered in the Plan include heritage resources, biological diversity, facilities, fire and fuels, fisheries/ water, human and community development, minerals, range, recreation, riparian areas, special areas, timber, visual quality, wild and scenic rivers, and wilderness and roadless areas. Additional areas of focus include biomass, botany, forest pests, geology, soils, water, and wildlife.

The Plan addresses these focus areas in the context of: 1) public issues; 2) management situation (past and current); 3) management direction; and, 4) monitoring and evaluation requirements. Also included as appendices (among other information) are sensitive endemic plant lists, required resource implementation plans, ten-year timber sale plans, timber data, description of silviculture treatments used in timber management, timber land suitability criteria, fire management programs, road construction, maintenance and use standards, developed recreation sites, soil quality standards, and water quality best management practices (USFS 1994).

This Plan, together with annual monitoring updates published by the USFS, also provides the most comprehensive overview of land use, landscape patterns and patch matrix characterization, and landscape dynamics for the Upper McCloud Watershed.

The Land and Forest Management Plan and associated updates also provide the primary written resource for information on timber management and fire and fuels management on public lands in the Upper McCloud basin. Updated information on landscape management, timber harvest, status of fire and fuels management, and corollary data impacting these (e.g., forest pests, specific species habitats, and single resource information) are also captured in USFS Shasta-Trinity GIS dataset.

The Wild and Scenic Rivers designation study report (JSA 1988, USFS 1994), written as a supporting document to the Shasta-Trinity Land and Forest Management Plan, also includes a generalized description of types of land use and status of physical and biological environments that is more specifically focused on the Upper and Lower McCloud River itself, rather than the forest and uplands.

A Forest Roads Analysis for the Shasta-Trinity National Forest (USFS 2002) also addresses most of the specific focus areas detailed in the Land and Forest Management Plan (USFS 1994), though specifically in terms of their intersection with road systems, transportation, associated land management, and impacts. More up-to-date information on roads within the USFS-managed lands in the Upper McCloud basin is also being developed as part of an on-going national roadless area evaluation process.

A number of other high-level resource management documents have focused, at least in part, on characterizing current land use in the Upper McCloud Watershed. Most notable of these are the PG&E re-licensing applications (2007), the Nestle Waters project EIR (2006), and the McCloud Coordinated Resource Management Plan (CRMP) (1991). The last of these is a resource management plan that was created by a group of primarily private landowners in the watershed who were working to prevent the conferring of Wild and Scenic status on the McCloud River. This plan, however, is focused primarily on the Lower McCloud, with only minimal treatment of the upper portion of the watershed.

In terms of conservation and wildlife management, both the Redband Trout Conservation Agreement (USFWS 1998), and the McCloud Flats Deer Heard Management Plan (CDFG 1983), focus specifically on conservation and management, and also address species specific goals and approaches to land use in the Upper McCloud River Basin.

All of these high level land and resource management documents detailed here are also complemented by a body of maps, GIS, and remote sensing data managed by the USFS, both as an active part of their land management and as a passive record of landscape organization, patch matrix dynamics, and use change over time.

Data gaps and associated opportunities

Though USFS-managed land makes up a large percentage of the Upper McCloud Watershed, and, therefore, fall under the previously described Land Management Plan, a detailed, comprehensive, description of land use (historical or present) specific to the Upper McCloud Basin does not exist. The other large-scale land use documents described in this section provide primarily high-level information, or, in their analysis, focus on areas larger than the Upper McCloud River watershed.

As a function of this level of resolution, landscape dynamics and single resource management issues specific to the Upper McCloud and its tributaries are frequently excluded or dealt with only generally in existing documents. Additionally, many existing documents draw heavily on information collected and made available by the USFS and often already summarized in its Land and Forest Management Plan, resulting in a great deal of redundancy within existing documentation.

In cases where documents do address the Upper McCloud specifically, the emphasis is generally on the potential impacts of proposed land uses decisions on federal or state designated species of concern. As a result, there is a need and an opportunity for a more ecosystem-based approach to qualitative and quantitative descriptions of the interactions between land use, species, their ecologies, and specific conservation efforts. And even in the cases of species of concern, there is a need for ongoing monitoring of population dynamics, distribution, and habitat use.

An additional opportunity exists for a better understanding of road system and its impacts within the watershed. While the USFS continues to map roads and transportation lines on the lands it manages, there are many new roads, trails, and OHV routes that are undocumented. Information on the roads and road systems on the private lands in the watershed is largely unavailable, although their presence can have tremendous impact on the health of the watershed.

Finally, landscape dynamics (e.g., disturbance, connectivity, succession, and diversity/ heterogeneity) are addressed in existing documentation, but primarily in the context of isolated management objectives. For example, river-floodplain connectivity is examined in the context of specific restoration efforts; fire disturbance, ecology, and succession are examined in relation to fire and fuels management and conservation; and maintenance of late successional reserves and forest landscape patch dynamics are discussed in relation to timber harvest plans.

While there is recognition of the role of landscape dynamics in shaping the physical and biological environments in the documents that exist, it is safe to say that a management framework based on landscape dynamics has not yet been widely embraced as a principal approach to understanding and managing land and forest resources, either on public or private lands.

This provides a tremendous opportunity to categorize landscape in terms of its dominant dynamics, evaluate the present and historical functionality of those dynamics, and strategize land use and resource management practices accordingly. This type of dynamics-based approach would reveal the potential for synergistic land use and natural resource management opportunities, such as targeted timber harvests that would restore patch matrix characteristics, minimize forests pests, manage fire and fuels, and restore successional states and community composition to historic levels.

This approach has the potential to dramatically reduce the cost of resource management, both in the short and long-term, while helping to maintain sustainable ecosystem structure and function. Some components of this approach are already is use in the Upper McCloud Watershed by the USFS, but there is still a great deal of potential for expansion of their application.

Cultural Resources

Existing Information

The Shasta-Trinity Land and Forest Management Plan documents policy and land use strategy surrounding the vast number of heritage sites and cultural resources in the Upper McCloud Watershed. Its approach to this, however, is one focused on the intersection of those resources with other land use practices, as opposed to providing information or documentation on the resources themselves. The USFS also performs surveys of all project sites. Generally, however, these involve only recording and mapping sites, but no investigation or excavation. Previously documented archeological resources and were also summarized by Hoertling (1989), in the archeological portion of the *McCloud River Management Plan*.

In addition to these land management- and land use policy-driven documents, there are a number of general accounts of the occupation, land use, and cultural interactions of Native American and Euro-American inhabitants of the Upper McCloud Watershed. Cranfield (1984) provides an overview of natural resource use in the McCloud Watershed with a specific focus on fisheries, timber harvest and mining.

Other general accounts range from what might be considered "grey literature" collections of old maps, published articles, and reports from regional newspapers (Stewart *unknown date*; Shiplet *unknown date*; Smith *unknown date*; Hoertling *unknown date*) to more recent historical reviews, including *The Wintu and their Neighbors: A very small world system* (Chase-Dunn 1992) and Yoshiyama and Fisher's (2001) account of the origin and development of salmon culture at the Baird Station hatchery.

Similar to the Yoshiyama and Fisher article in terms of a general historical overview, but with an even more specific focus on the intertwined histories of native culture and pacific salmon in the McCloud Watershed, are Yoshiyama's *A History of Salmon and People in the Central Valley Region of California* and Hoveman and others *Journey to Justice* (2002).

Guilford-Kardell, in a 1994 document, provides a collection of information including maps, photos and descriptions of forty-one archeological sites, features, village locations, and historic trails from locations adjacent to the Upper, Middle, and Lower McCloud River. Also included in her work are historical data drawn from period newspapers, government reports, and other historical accounts including descriptions of landscape (behavior of Mud Creek and several tributaries to the McCloud) residents, industry, and land use.

The primary large-scale ethnographic documentation available for the McCloud Watershed is found in Guiford-Kardell and Dotta's 1980 study on 293 Wintu villages in

Shasta County, and the 1984 Ethnographic Inventory for Public Law by Theodoratus Cultural Research. In addition to these two works, many native place names in the McCloud Watershed region are summarized by Bauman (1981).

Data gaps and associated opportunities

Other than what is described in *Journey to Justice* (Hoveman, et al., 2002), there is little documentation on the history of land and resource use in the McCloud Watershed prior to Euro-American settlement. A wealth of oral historical information on heritage sites and cultural history of the region, including evolving ecosystems and patterns of land use, exists in the form of the Winnemem Wintu tribe stories and oral histories, but almost none of these have been recorded or transcribed. There is a tremendous opportunity for an anthropological and historical ecological project to collect and chronicle these, with a focus on their relation to present conditions and issues.

4.3 McCloud River and Upper McCloud River

At the whole river drainage scale, a finer resolution body of documentation is available that addresses the physical nature, biological/ecological character, and land use and management dynamics of the Upper McCloud River (or in some cases, the entire McCloud River with specific relevance to the upper portion).

Geology and Hydrology

Existing information

Some groundwater reconnaissance for the Upper McCloud was performed by Jasso (1983). This research, however, was focused on assessment of the area's underlying geology based on remote sensing, and did not include measurement of reserves, pump tests, or coring samples to determine underlying geology in specific areas or at a fine degree of resolution. Additional groundwater and spring water research is taking place as part of the CalTrout Shasta Spring Water Project (CalTrout 2007). Generally, existing and ongoing groundwater research focuses on characterizing the potential yield of the basin aquifer. The CalTrout project aims to enhance this general characterization information with spring specific recharge times, and elevation of recharge.

Data gaps and associated opportunities

An overall model of the basin aquifer and its expressions in terms of springs or wells does not exist. Because of this, there is an opportunity for available information from historic well monitoring and groundwater research to be pooled, reviewed, and

evaluated (qualitatively or quantitatively), towards a basin-wide groundwater monitoring program and a strategic plan for tracking and managing groundwater use.

In terms of surface water, little flow data exists for any portion of the Upper McCloud River other than what is provided at the single USGS Upper McCloud River gauging station. There are also some records from CDFG correspondence dating to the late 1950's, and flow data from 1937-1941. A comprehensive picture of discharge, magnitude, and duration flow in the Upper McCloud River would add an important element to ecosystem and resource management. Additionally, a more comprehensive picture of the hydrology of the Upper McCloud would also help model trends in the system over time, and assess the impacts of large magnitude events, including climate change.

Ecology and natural resource science

Existing information

Existing information on ecology and natural resource science at the river drainage scale for the Upper McCloud Falls is generally related to: 1) habitat (e.g., fluvial geomorphology and riparian coverage and community structure); 2) water quality (e.g., temperature, dissolved oxygen, conductivity, suspended sediment, etc.); and, 3) biology/ecology (e.g., presence/absence and distribution of invertebrates, fish, amphibians, birds, mammals).

Galovich and Ingram (1985) describe reach-scale habitat and geomorphology for the portion of the McCloud River below Lower Falls, including characterization of riparian vegetation, its distribution, and its role in structuring specific habitat types. Willmarth (1972) describes the physical attributes of a two-mile section of the Upper McCloud, with a focus on the fishery. A number of other geomorphic or habitat analyses exist for tributaries to the Upper McCloud. These are generally associated with fisheries management or redband trout conservation.

Water quality data for the Upper McCloud River is limited to two studies (CDFG 1981 and USFS 1999). The later of these two is the most comprehensive, providing data on water quality in many locations in the Upper McCloud and its tributaries, as part of the bull trout restoration effort. Documentation and data on the overall ecosystems in the Upper McCloud River, and their associated biota, is sparse as well.
Frest and Johannes (1995) provide some information on mollusk taxa present in the Upper McCloud watershed, and Chen (1985) provides a single snapshot of invertebrate taxa present in the Upper McCloud. There were also some additional mollusk surveys performed following the 1991 Cantara railroad spill in the Upper Sacramento River, where a sampling location on the McCloud was used as a reference site.

Brode and Sturgess (1984) contains some information on amphibian species and their distribution. Sampling sites from this study, however, are spread out across the entire McCloud River drainage and are not specific to the Upper McCloud. Additionally, this study predates the current significant shifts in amphibian populations that have been occurring in California, suggesting that much of the data may no longer be accurate or applicable.

Cross (1986), in a thesis project in cooperation with The Nature Conservancy, surveyed the presence of river otters in the McCloud Watershed. While this study did include sites in the Upper McCloud, it extended only as far as Lower McCloud Falls. Additionally, the age of the study makes it valuable more as record of a reference condition than a mapping of current habitat use by the species.

The vast majority of past research and available ecological data on the Upper McCloud River Watershed has been focused around fish and the fishery. Historical data exist describing salmon run size, characterizing historical salmon runs, and describing anadromous fish presence (Dunn 1880, Campbell 1882, Wales 1939, Chipman 1939). Knight (unknown date) provides a more current overview of the existent icthyofauna, with a strong emphasis on salmonids, and particularly the conservation of redband trout and bull trout.

The most comprehensive surveys of fish presence in the Upper McCloud River are probably those encompassed in Galovich and Ingram 1985 (which focuses only on the portion of the river below Lower Falls), and CDFG 1994 (which provides a fairly comprehensive data set of electrofishing results from the Upper McCloud and its perennial tributaries.

Though intended as a management document, the Redband Trout Conservation Agreement (USFWS 1998) provides a comprehensive, although low resolution, summary of existing information on fish species composition, habitat type, riparian and upland vegetation, and channel characteristics and geomorphology in the Upper McCloud River and several of its tributaries. Also as part of the redband conservation and management effort, CalTrout, in cooperation with the CDFG and the USFS, has created a map of the McCloud and its tributaries identifying streams that support redband trout, as well as areas where additional research is required to determine whether redband are present (CalTrout *unknown date*) (Figure 4).

More general information on fish and the fishery in the Upper McCloud tends to be older. Angling reports and stocking reports are available sporadically for years prior to a conservation-based stocking reduction in 1994 (CDFG 1939, 1963, 1977, 1990, 1994). The fishery in the Upper McCloud River, and the habitat that supports it, was also described by Curtis (1959), including projections about the potential for the McCloud-Pit Hydroelectric project to impact fish species in the river.

More recently, a CalTrout commissioned report summarized existing data on the fishery, water quality, habitat, and land use in the McCloud River, both in terms of their current status, and their projected status under climate change scenarios (Tussing 2006). The purpose of this report was to evaluate of the potential for anadromous salmonid reintroduction in the McCloud (Tussing 2006). Again, however, this report focuses primarily on the Lower McCloud River.

Data gaps and associated opportunities

Given the sparse and often dated body of existing research on the ecosystems and biota of the Upper McCloud River, there is a tremendous opportunity for increased understanding and more effective resource stewardship in and across almost all categories of information.

There is no current data on water quality parameters in the Upper McCloud or its temporal/seasonal fluctuations, nor is there any standard monitoring for water quality. The only available current data on water quality is temperature monitoring, which the USFS has been conducting since the mid 1990s at one location in the Upper McCloud River and in several of its tributaries.

There is also no current comprehensive characterization of geomorphology in the Upper McCloud River at any scale (drainage, segment, or reach). Generally, descriptions of geomorphology in the region most often appear in the form of habitat typing reports or stream assessments, with a focus on the fishery that can (though it does not in all cases) limit more widespread applicability of the data. There is also information on the geomorphology connected with logging, stream impacts, and legacy effects from land use in the region, gathered in USFS surveys, but these are generally isolated analyses that could be carried out at a more comprehensive watershed-wide level.

There is also a need for a current vegetation characterization for the Upper McCloud Watershed, in terms of taxa present, functional groups, or habitat specific specie. The closest analogues to this available are species lists from land use and conservation documents spanning larger regions that are not necessarily accurate for the Upper McCloud River specifically. The USFS GIS index for the Shasta-Trinity National Forest also includes vegetation specific layers, but these also are not watershed specific, and are only at a low-resolution level for many areas within the watershed. Invertebrate populations in the Upper McCloud River also have not been characterized in terms of their taxonomic composition, distribution, abundance, or seasonal variations with the exception of some data provided by Chen 1985.

As previously stated, the fishery is the most well researched aspect of the Upper McCloud River ecosystem. However, the majority of the available data is on

presence/absence and characterization of the fishery, as well as the habitat types supporting it. There is no recent (last ten years) report, series of population estimates, or comprehensive monitoring plan for the Upper McCloud River fish populations.

Historically, the impetus for research on fish and fishery in the Upper McCloud has been related to either the unsuccessful efforts to monitor, conserve and restore the bull trout (CDFG 1975, 1977, 1982, 1989, Halbert 1983, Long 1981, Sturgess and Moyle *unknown date,* Rode 1990), or research on, taxonomic classification of, and monitoring and conservation of, redband trout (Long 1981, Knight *unknown date,* Berg 1989, USFWS 1998). Within the body of redband trout research, the bulk of it is focused on the tributaries to the Upper McCloud that house the relic populations of redband, and serve as their primary habitat, as opposed to the Upper McCloud River itself (Figure 4).

There is no available data or historical research on aquatic food-web dynamics in the Upper McCloud, nor on foraging behavior in fish species, ecological interactions, or habitat selection, other than that provided in Brode and Sturgess (1984). Given the redband conservation concerns, and the fact that amphibian populations, aquatic and riparian mammals, and birds have yet to be researched, a characterization of the food-web in the Upper McCloud in terms of the species present and their trophic dynamics offers perhaps the greatest ecological research opportunity.

Additionally, a general geomorphic description of the Upper McCloud River would also be a valuable tool for contextualizing ecosystem dynamics. Such a characterization could also work in concert with hydrologic data to help model impacts to the system from land use, large disturbance events, and both short and long-term climate shifts.

Land use, resource management and conservation

Existing information

Existing information on land use and resource management for the Upper McCloud is contained in a few large scale management documents, and most notably the Shasta-Trinity Land and Forest Management Plan (USFS 1994) and the CRMP recreational policies document (CRMP 2000). The Redband Trout Conservation Agreement (USFWS 1998) addresses land use and management in the Upper McCloud Watershed as it pertains to conservation of redband trout and protection of their habitat.

In terms of describing land use through time, Cranfield (1984) provides a comprehensive history of contemporary land use in the McCloud River Watershed, including information on fisheries management, timber harvest, and mining. Hesseldenz (*unknown date*) also addresses elements of the land use history in the McCloud in the context of developing a protection plan and approach to conservation for the drainage.

Fairly extensive information on dominant land uses exists for USFS managed lands; those uses include grazing, timber harvest, recreation, and reserve management. None of this information is specific to the Upper McCloud Watershed.

USFS lands in the Upper McCloud Watershed support four main grazing allotments: one for sheep, one for sheep and/or goats, and two for cattle. Allotment management plans are available from 1963-1988, and continue to be updated when allotments are re-allocated or experience a change in management (USFS 1963, 1966, 1967, 1975, 1982, 1986, 1988).

Timber harvest data is mapped in the USFS GIS data set, and designations for land management relative to timber harvest within the Upper McCloud watershed is detailed in the Shasta-Trinity Land and Forest Management Plan (USFS 1995).

Data gaps and associated opportunities

While many of the land use and management plans operating at the watershed or forest scale address some aspects of land use in the Upper McCloud Watershed, a comprehensive description and strategic management plan for the Upper McCloud specifically is not currently available. There is no document summarizing or spatially characterizing present and future land and natural resource use in the watershed (including past, present and future timber harvest locations, past and present mining claims, water diversions and impoundments, culverts, stream channelization, and active channel management, impervious surfaces, sewage discharge, or stream restoration past present and future). Nor does this exist for those portions of land directly adjacent to the Upper McCloud River.

The McCloud River CRMP (2000), a policy document primarily developed by landowners for the Upper McCloud River, addresses land use and natural resource management specific to the Upper McCloud River without a sensitivity to the dominant landscape dynamics, their relationship to the regional ecology, or the intersection of these with land management.

Similarly, the Redband Trout Conservation Agreement (USFWS 1998) addresses land use and management in the Upper McCloud Watershed only as it pertains to conservation of redband trout and protection of its habitat. There is no documentation summarizing any other existing conservation efforts in the Upper McCloud Watershed, the areas of emphasis of those efforts, species that may be targeted, and any measures of success, nor is there any documentation relating past and ongoing conservation efforts to past an ongoing land use practices. With this in mind, there is a clear opportunity to document land use current and historic land use and management practices in the Upper McCloud with any eye toward a better understanding of watershed landscape dynamics and the development of a comprehensive watershed management policy.

Cultural resources

Existing information

Sundahl (1997) examines the cultural prehistory of the McCloud River Watershed, based on archeological research and the excavation of multiple sites along the Upper and Lower McCloud River (from Four Mile Flat to Ah-Di-Na). Sundahl's work also provides the most extensive review to date of other archeological research and documentation on sites along the Upper McCloud River and its tributaries including, but not limited to, Upper Falls, Cattle Camp, Star City Creek, Battle Creek, Ah-Di-Na, Lower Falls, and Fowlers Campground (Sundahl 1997, Buckskin 1995, Elliott 1994, Elliott and Krieger 1990, Guilford-Kardell 1994, Guilford-Kardell and Dotta 1980, Hamusek 1993, Hoertling 1989, Legare 1997, USFS 1987, USFS 1990, USFS 1994).

Data gaps and associated opportunities

There has been not been any additional work since 1997 to summarize other archeological discoveries along the Upper McCloud River or its tributaries. While efforts are often made to control public access to information about archeological sites and investigations, cultural resource related research could be tracked in conjunction with land use in the region. Additionally, a more comprehensive research effort, aimed at enhancing additional archeological data with more anecdotal, qualitative, or oral historical accounts, joining them in single regional representation would also be extremely valuable both as a management tool and a cultural resource.

4.4 Tributaries and Reservoirs in the Upper McCloud River Watershed, and Squaw Valley Creek

4.4.1 Tributaries and Squaw Valley Creek

Geology and hydrology

Existing information

Geologic and hydrologic information and data is scarce for any of the tributaries to the Upper McCloud system. Where this data does exist, it is generally related to the Mud Creek tributary and is quite old. As mentioned earlier, Mud Creek is the only tributary to the Upper McCloud with a USGS gauging station that monitoring discharge and flows. Other data on Mud Creek is often the result of its historic debris flow or related to the Mud Creek Diversion Dam.

As a function of its being related to the potential impacts of the Mud Creek debris flow and diversion, this data includes early sediment delivery estimates for Mud Creek (1939), flow records from Elk Creek and Mud Creek (1931-32), and sediment content records for Elk Creek (1932). Included in these studies is also research proposal for a California Department of Water Resources research project related to the Mud Creek diversion. There is also a report from a 1985 solids and turbidity report for Mud Creek, based on a single sample site (Lewis 1985).

Beyond research reports, there are also two published articles centered on geology and hydrology, including a 1975 article describing historic glacial fluctuations on Mt. Shasta and relating them to the Mud Creek Debris Flow (Rhodes 1975), and an article from a similar era on the Mud Creek debris flow specifically (Hill and Egenhoff 1976). Comments from Hoopauch (1976) provide some additional information on a Mud Creek diversion from an observational survey of Mud Creek. This consists of a very brief description of what becomes of Mud Creek on the Hearst family property adjacent to the McCloud River below the Lower Falls.

Data gaps and associated opportunities

Despite sediment delivery information for Mud and Elk Creeks related to the debris flow, there is no assessment (historic or recent) of downstream impacts of Mud Creek sediment on the Upper McCloud River geomorphology. Major data gaps for the Upper McCloud River tributaries include hydrologic data (hydrograph, magnitude, and timing) for most perennial tributaries and for all ephemeral tributaries. There is also little or no water quality data for these tributaries, with the exception of those researched in conjunction with redband trout conservation (See **Ecology and Natural Resource Science** section), and those tributaries that have been monitored for temperature by the USFS (USFS 1995-2007).

It should be noted that the USFS temperature monitoring includes Squaw Valley Creek. In addition to the USFS, CalTrout worked with scientists from the University of California, Davis to installed stream gauges in 2006 on a portion of Squaw Valley Creek located on what is known as Willow Creek Ranch. These gauges have now gathered almost two years of data on annual fluctuations in discharge and temperature, though this data is not yet publicly accessible.

The Upper McCloud tributaries are a predominantly a spring-driven drainage network. There is no historic data, however, on the hydrology of specific springs, including the flow from the springs or the relative contributions of spring snowmelt and rainwater to tributaries to the Upper McCloud.

CalTrout recently began a spring water study for the Mount Shasta region that includes some springs in the Upper McCloud. The study is ongoing, but at present the scope

includes flow, temperature, conductivity, and oxygen isotopic data. Initial findings from the study are presented in CalTrout (2008). Plans for the next phase of the study include expanding the number of springs to be characterized in the Mt. Shasta region, including additional springs in the Upper McCloud, and expanding the isotopic research.

The long-term goal of the CalTrout spring water research is to characterize of spring contributions to surface flows, the residence times of springs, and the relationship between springs in terms of expressions of the fractured aquifer. From a management standpoint, the goal of the CalTrout project is to develop a spring vulnerability index, based on estimated elevation of recharge, area of recharge, and age of water (CalTrout 2007).

Ecology and natural resource science

Existing information

The bulk of research on habitat characteristics, including stream geomorphology, hydrology, temperature, and presence and structure of riparian communities, are in the form of Habitat Typing Reports assembled by CDFG. Many of these reports include photos of surveyed reaches and maps delineating surveyed area and specific research or sampling sites.

Habitat Typing Reports have been assembled for Bull Creek, Colby Meadows Creek, Cow Creek, Dry Creek, Moosehead Creek, Shady Gulch Creek, Tate Creek, Trout Creek, and Whiskey Creek ((McGraw 1995, McGraw 1995a, McGraw 1995b, McGraw 1995c, McGraw 1995d, McGraw 1995e, McGraw 1996, McGraw 1996a, USFS 1990). Habitat Typing Reports are essentially snapshots in time, capturing little temporal variability or annual variability. They are also are generally focused on characterizing the physical and biotic attributes of the system from the standpoint of fish habitat, therefore data is collected accordingly and generally are not comprehensive. Riparian communities are described only in the context of presence and complexity of cover.

In addition to Habitat Typing Reports, there are several similar but slightly more detailed assessments for tributaries with special conservation or restoration opportunities, generally related to redband trout. Stream Assessments completed within the last ten years exist for Tate Creek, Trout Creek, and Moosehead Creek. (Streamwise and USFS 2001, Streamwise and USFS 2001a, Streamwise and USFS 2001b).

These assessments, conducted for the USFS by *Streamwise*, an independent consulting firm in Mt. Shasta, are similar to the habitat typing reports, although slightly more detailed and management focused. They include data on physical characterization of

the stream, channel geomorphology and hydrology, condition of riparian and stream margin habitat, as well as restoration opportunities recommended restoration measures.

In addition to the geomorphic data encompassed within the Habitat Typing Reports and Stream Assessments, some limited data on channel width for specific tributaries to the Upper McCloud is available in USFS (2006-2007).

Some information on invertebrate and fish distribution and abundance in the smaller tributaries of the Upper McCloud River watershed is presented in a CDFG sampling report by McGraw (1996b). This report was based on a survey designed to determine the presence of redband trout in previously unsurveyed streams in the Upper McCloud drainage, and or the suitability of those streams for redband populations in terms of habitat characteristics and productivity. Tributaries sampled as part of this survey include Pilgrim Creek, Ash Creek, Cold Creek, Inconstance Creek, Brewer Creek, Gravel Creek, McKay Springs Creek and Twin Springs Creek (McGraw 1996b).

Older stream survey reports exist for a few specific tributaries, including Moosehead Creek, Dry Creek and Mud Creek (Willmarth 1972 and Coleman and Murphy 1980). The Coleman and Murphy report on Mud Creek focuses on the fishery, including a brief physical description of creek and associated fish habitat and several brief management recommendations. The report also contains copied black and white photos of the creek highlighting key geomorphic and hydrologic features, and a map of surveyed section of Mud Creek, south of Mud Creek Dam.

Along similar lines, a CDFG Mud Creek survey from a few years after the Coleman and Murphy report focused specifically on sediment loads and turbidity in relation to downstream fish habitat (CDFG 1986). Both the Coleman and Murphy report and the CDFG Mud Creek report are snapshots, representing single samplings or sample series. Information on tributaries to the Upper McCloud is also compiled in existing watershed and ecosystem analyses that encompass them. Information on Mud Creek and Ash Creek is included in the McCloud Flats Ecosystem Analysis, including summaries of known information on geology, hydrology, channel morphology, and riparian communities and aquatic biota, and descriptions of water use, water quality, and human disturbance (USFS 1995). Very general descriptions of the geology and soils, hydrology, vegetation, and aquatic and riparian wildlife of special concern for Trout Creek and Edson Creek are provided in a watershed analysis associated with a proposed vortex rock weir project (USFS 1999).

Additional information for Tate Creek is presented in the project proposal for the Tate Creek culvert array (Bachman 2004). This proposal provides general information on the watershed as well as a description of the proposed project and assumptions regarding watershed sensitivity. Watershed information in the proposals is qualitative and likely based on a Habitat Typing Report. The project constituted a significant change to the

geomorphology and habitat structure in the affected reach of Tate Creek, including the replacement of two large culverts with an array of small ones in order to disperse flow across the Tate Creek floodplain.

Most of the ecological research in the Upper McCloud tributaries centers on conservation of redband trout. Conservation-focused research includes genetic investigations into the different redband trout populations in the upper McCloud tributaries, their relationship to other redband trout in California, and their degree of hybridization (Gold 1977, Weidlein 1995, Berg 1989). Redband trout conservation status was looked at in Hoopaugh 1974 and Moyle, et al. 1995. Other tributaries to the Upper McCloud that have been looked at in the context of redband trout conservation include Tate Creek, Bull Creek, Moosehead Creek, Sheephaven Creek, Edson Creek, Swamp Creek and Trout Creek, with the Sheephaven Creek population receiving special focus. In addition, tributaries to the Upper McCloud that provide redband trout habitat have been mapped by CalTrout.

A more general snapshot of fish populations, relative abundances, and in some cases size (length) distributions in the Upper McCloud River and its tributaries is captured in CDFG (1994). Quantitative data contained in this study is based on data compiled from electrofishing surveys performed in the summer and fall of 1994. The study includes data on Swamp Creek, Trout Creek, Edson Creek, Squaw Valley Creek, Steep Hollow Creek, Tate Creek, Bull Creek, Dry Creek, and the Upper McCloud River.

Data gaps and associated opportunities

Stream assessments are generally snapshots in time (though sampling may not all have been performed at the same time), capturing limited temporal and seasonal variability and no multi-year variability. Stream assessments are limited in scope and generally focused on reach scale processes and habitat characteristics, thus lacking the landscape-level perspective on channel dynamics, migration patterns, or relationship influence on the larger network or the Upper McCloud River. The exception to this generalization is proposed restoration projects that are related to landscape-level physical processes such as river-floodplain interactions. However, these processes are generally described in terms of the potential for segment or (more often) reach scale restoration opportunities.

Many of the smaller perennial and ephemeral tributaries in the Upper McCloud River Watershed are largely unstudied, and little is known about their specific hydrology, geomorphology, or ecology other than that which can be inferred from trends in other larger neighboring systems. Further, many of the existing reports on these smaller tributaries are focused around a particular management question, and thus are limited in scope in that way.

For example, because studies on Mud Creek and Dry Creek are focused in part on viability of fish habitat (concluding that they are not suited for fish), they provide little assessment of the biotic communities that **are** supported by the creeks. Additionally, most water quality and sediment studies do not address temporal variability, or any corollary conditions, either geomorphic or ecological (Coleman and Murphy 1980, Coleman and Murphy 1980a).

The data provided in the watershed analysis as part of the proposed CDFG rock weir project is primarily a snapshot capturing little temporal variability or quantitative data on physical or ecological parameters. Additionally, though a watershed approach is used in this analysis, the main objective of the analysis is assessment of the impact of the proposed project on riparian reserves, the relationship of the project to the aquatic conservation strategy already in place.

Currently, the is not any data available on temporal variability in distribution or abundance of aquatic populations, or one time or temporal variability in habitat use, reach or segment scale distribution, or ephemeral or minor stream fish presence, abundance, and habitat use.

A proposal is currently being considered for a cooperative research effort between researchers from Humboldt State University and the USFS, USGS, CDFG and FWS to look at the potential for use of an isolation management strategy for conservation of redband trout populations in Moosehead Creek, Sheephaven Creek, and the Upper McCloud River) (FWS and USGS 2007).

Land use, resource management and conservation

Existing information

General approaches to land use and management for the tributaries to the Upper McCloud are encompassed in broad-scale forest management plans such as the Shasta-Trinity Land and Forest Management Plan (USFS 1994), McCloud Flats Ecosystem Analysis (USFS 1995), and the Bartle Watershed Analysis (USFS 1997). Current land use practice and policy regarding natural resources is also partially summarized in the Nestle Waters Draft Environmental Impact Report (EIR)/Environmental Assessment (EA) (Siskiyou County 2006). Overall, these plans outline existing policy, general approaches, and strategies for management of the landscape that encompasses the Upper McCloud Watershed.

Specific land use and management related information on the tributaries to the Upper McCloud come largely in the form of Timber Harvest Plans, project descriptions for specific construction and mitigation activities, and efforts surrounding conservation

and management of redband trout populations and (now extirpated) bull trout populations.

There is also a record of some correspondence between land management agencies concerning the description and assessment of Mud Creek with regards to the Mud Creek Diversion and its potential re-operation. This ranges from a USFS survey of Mud Creek Diversion Dam with focus on possible re-operation of the structure (1977) to correspondence from the Hearst Corporation regarding siltation of Mud Creek and the impacts of logging practices on Hearst property to water quality (PG&E 1986 and CDFG 1985).

Timber Harvest Plans provide specific information on timber harvest-related land use and land management for privately owned property. A THP was completed for a proposed timber harvest on Hearst property in the Bartle Creek drainage in 2005. Additionally, there are records from communications between Champion International and the CDFG concerning logging inspections in the Upper McCloud River watershed and tributaries to the McCloud Reservoir (with specific reference to the McCloud Reservoir, Star City Creek and Panther Creek) (Pedri 1974).

There have been several documented restoration and mitigation projects focused on tributaries to the Upper McCloud. Of these, most are associated with Trout Creek. Summaries of most of these restoration projects are included in the Shasta-Trinity Land and Forest Management Plan and associated annual monitoring updates, or specific USFS project proposals.

Available information on Trout Creek mitigation projects includes a proposal for Trout Creek improvements that would remove a debris jam to prevent meadow flooding, and development of a pool habitat and reduction of fine sediment through use of in channel bank stabilization mitigation (CDFG, USDA 1991). Detailed description of mitigation projects on Trout Creek associated with the Cayton Creek Bridge replacement and roadway realignment project include restoration of backwater pools and the floodplain around an incised and bank-eroded portion of Trout Creek. Trout Creek restoration also includes reconnection of channel and floodplain, making it one of the few tributaries to the Upper McCloud where landscape dynamics and processes other than fire management have driven land use.

Additional restoration project documentation exists for Swamp Creek (USFWS and CalTrout 2005) and Tate Creek (Bachmann 2004). In both cases projects were related to transforming existing culverts to improve aquatic habitat and increase connectivity.

Documentation around redband trout conservation and management is primarily summarized by the Redband Trout Conservation Agreement. The agreement, designed to preserve genetic integrity and long-term population viability of the Upper McCloud

River redband trout, includes: 1) area description; 2) summary of governing documents and policies; 3) description of species distribution and status; 4) list of threats to the species; 5) description of existing and proposed monitoring and conservation measures; and, 6) some information on the Redband Core Group roles and responsibilities. (Redband Core Group and USFS 2005, USFWS 1998).

There is also documentation focused on conservation and management of bull trout, now extirpated from the Upper McCloud. This includes forms and approvals for chemical treatment of Mud Creek and Huckleberry Creek preceding Bull trout reintroduction from Klamath hatchery (CDFG 1989), and results from electro-fishing surveys of the two tributaries after the chemical treatment (CDFG 1990).

More general management information with respect to the fishery in a few select streams in the Upper McCloud (as defined in this document) is available in the Lower McCloud River Wild Trout Area – Fishery Management Plan (2004-2009) (Dean, M. 2004). There is also some limited documentation on fishery management in Dwinell Lake. Available documents are principally isolated angling reports from the mid sixties (CDFG 1965, CDFG 1963).

Data gaps and associated opportunities

Timber harvest and other land use information for tributaries on private lands and, most notably, lands managed by the Hearst Corporation, is very limited.

4.4.2 Dwinell Lake and McCloud Reservoir

Ecology and natural resource science

Existing information

Quantitative physical and ecological documentation on the McCloud reservoir is mainly limited to temperature and water quality data (pH and DO) from 1966-1968, and some catch record data from the same era (CDFG 1966, CDFG 1968, CDFG 1968a). Of particular note from this era is correspondence concerning a state record bull trout caught in the reservoir (CDFG 1968). Additionally, Nauman and Olson (2004) include sampling sites on the McCloud reservoir in their investigation of distribution and abundance of terrestrial amphibians and Shasta salamanders (*Hydromantes Shastae*), specifically in the region north of Shasta Lake.

Data gaps and associated opportunities

Extensive research at McCloud Reservoir is currently underway as part of the PG&E FERC re-licensing of the McCloud-Pit Hydroelectric project (PG&E 2007). Specific areas currently being studied include aesthetic resources, cultural resources, wildlife resources, land use and recreation, water resources, fish and aquatic resources, and botanical resources. Results from these studies are not yet publicly available. Additionally, the focus of these studies is specifically on assessing the impact of dam management and operations on the McCloud reservoir and the immediate upstream reaches of certain key tributaries.

There is an opportunity for an ongoing ecological and limnological monitoring program in the McCloud Reservoir. This program could include characterizing and monitoring water quality and associated ecosystem dynamics in the reservoir, creating the potential for examination of the relationship among water quality and ecosystem dynamics in the Upper McCloud Watershed, the McCloud Reservoir, and the Lower McCloud Watershed.

Land use, resource management and conservation

Existing information

Documentation on land use and management related to the McCloud Reservoir directly generally falls into the categories of fisheries management, recreation, or water quality associated with hydropower. In terms of fisheries management, fish stocking in the McCloud Reservoir is well-documented from 1961 forward, including reports and associated correspondence (CDFG 1997, CDFG 2002). Recreation in and around the McCloud Reservoir is also well documented.

Some correspondence related to fisheries assessments and introduction of the Mysis shrimp to the Reservoir is also available (CFG 1968). General recreation policies, including trail and recreation area management plans for the Upper McCloud River and McCloud Reservoir are summarized in the recreational policies of the McCloud River CRMP (CRMP 2000). Included in this summary are relevant portions of the USFS Upper McCloud River Management plan.

In terms of water quality and its relation to hydropower production, there is information (including study proposal, interim report, and final report) from a multi-year PG&E study in the early 1980s examining the impact of prescribed flow levels for fish on water quality (PG&E 1983, PG&E 1985, PG&E 1987). In addition, there is a record of official comments from the CDFG on the content and findings of a PG&E turbidity study (CDFG 1985). Water quality in the McCloud Reservoir is also addressed

briefly in 1986 correspondence from the Hearst Corporation to PG&E regarding sedimentation from logging practices on Hearst property (PG&E 1986).

Information on logging in the McCloud Reservoir area is sparse, and addressed only in findings from an inspection of logging practices in the overall McCloud River Watershed (Pedri 1974).

Data gaps and associated opportunities

There is very little data on any land use on private lands adjacent to the McCloud Reservoir or tributary creeks to the reservoir.

Cultural Resources

Existing information

Clemmer (1963, 1964) surveyed and documented archeological sites within the boundaries of the (then proposed) McCloud Reservoir. Mapped locations of these sites are on file with the USFS.

Data gaps and associated opportunities

Little information other than location is known about archeological sites that existed before the construction of the McCloud Dam. Those sites are now submerged beneath the waters of the McCloud Reservoir.

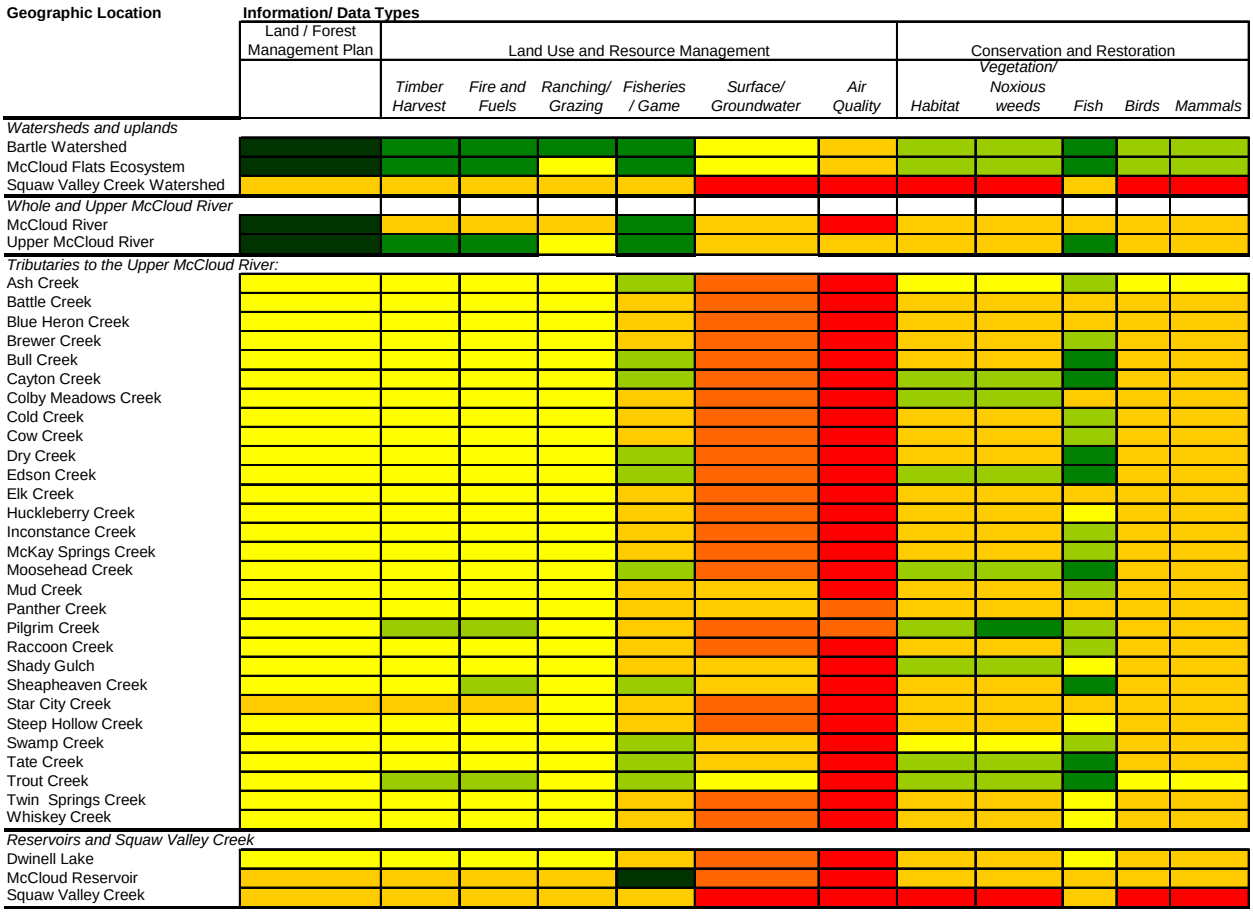
Figure 3. Matrices describing existing research in subject areas related to a) Ecology and Natural Resource Science, and b) Land Use, Resource Management and Conservation, for geographic regions within the Upper McCloud Watershed and Squaw Valley Creek Watershed. Each intersection of a subject area and a specific geographic region is assigned a color in a scale ranging from red to green, based on the nature and extent of existing information for that region in that specific subject area.

a. Ecology and Natural Resource Science

Status	Description
	Ongoing scientific monitoring capturing detailed quantitative and qualitative data, spatial and temporal variability, and with the potential for incorporation into a physical or conceptual
	Multiple scientific single monitoring efforts capturing detailed quantitative data or ongoing monitoring capturing either spatial or temporal variability.
	A single recent (last 20 years) scientific monitoring effort capturing detailed quantitative data or an ongoing monitoring effort for some portion of the system.
	Encompassed within one or multiple ongoing scientific monitoring efforts for a larger system or region capturing quantitative data and spatial or temporal variability
	Partially encompassed within one or multiple single science based assessment report for larger systems (or multiple constituent systems) capturing quantitative and qualitative data
	Multiple investigations or reports capturing qualitative data or non representative reports over 20 years in age capturing quantitative data.
	Single recent investigation or report capturing qualitative data, or connection to an assumed reference system for which there is recent quantitative information.
	No documented information

b. Land use, Resource Management and Conservation

Status	Description
	Ongoing monitoring, capturing spatial and temporal variability, with the potential for incorporation into a conceptual model, and used to inform or refine management strategy and objectives.
	Multiple individual assessments or data sets, capturing spatial or temporal variability incorporated into a larger strategy, used to inform or refine management strategy and goals.
	A single comprehensive assessment or data set capturing spatial, or temporal variability and serving as the basis for (or contributing to an existing) larger management strategy.
	Encompassed within one or multiple ongoing management and monitoring plans for a larger system or region (or multiple plans for smaller constituent systems).
	Partially encompassed within and ongoing management plan, or totally encompassed within one or multiple assessments that are outdated or not linked with a larger management plan or
	Multiple assessments capturing qualitative information; partially encompassed in other non-strategic assessments, or information over 20 years in age.
	Single recent qualitative report or assessment, or connection to an assumed reference system for which there is recent information.
	No documented information or management strategy



5. Private Land Owner Interviews

Process

In 2008, Gregory S. Weber, a public policy mediator and facilitator from Mount Shasta, conducted ten confidential interviews with representatives of large landowners in the Upper McCloud River Watershed (as defined for this assessment.) Nine of the interviews were with representatives of large private landowners. The tenth was with a representative of the Forest Service. The interviewees were:

- Steve Bachmann (USFS)
- Herb Baldwin (Sierra Pacific Industries)
- Ron Berryman (McIntosh Ranch)
- Lloyd Bradshaw (Hearst Corporation)
- Dennis Caine (Hancock Forest Management)
- Betty Couley (Couley Ranch)
- Sid Johnson (Willow Creek Ranch)
- Dave Marshall (Campbell Group)
- Maylene McCoach (Squaw Valley Ranch)
- Bill Michelon (McCloud Golf Course)

Interviewees were identified in three ways. First, the River Exchange proposed names known by it from its previous work in the watershed. Second, the interviewer contacted several people he knew who were knowledgeable about the area and asked for their recommendations. Finally, each interviewee was asked for additional names.

The interviews were all conducted in person. They lasted between 45 and 90 minutes. Each interviewee was asked three open-ended questions:

1. What are the strengths or healthy aspects of the watershed, i.e., what's working well in the system?
2. What are the weaknesses, challenges or threats facing the watershed, i.e., what's not working so well in the system?
3. What opportunities are there for collaborative efforts to address any of the challenges, threats, or things that aren't working so well, i.e., projects, programs, policies?

Interviewees were told that their remarks would not be attributed to them individually, and that they would have a chance to review a draft of the interview summary before it was released as part of the overall Upper McCloud River basin roadmap.

Summary of Interviews

This summary catalogs the main observations of the ten interviewees grouped according to question and, to some extent, topic. Although there appeared to be a fair amount of agreement among many of the interviewees on many of the points made, the interviewer made no attempt to gauge the degree of consensus for any given observation. Similarly, no attempt was made to gauge the accuracy of any of the observations made. As such, the observations presented below are best considered to represent a range of opinions – starting points for additional conversation rather than final conclusions.

Key Findings

Overall, the interviewees considered that the watershed is healthy and is generally getting healthier. Suggested areas and topics of perceived weakness were fairly specific, and suggestions for improvements, beyond those identified by the Red Band Trout Core Group, were relatively few and fairly general

General Watershed Strengths

- Overall vegetative health appears sound; anecdotal comparisons of 1944 photographs reveal more trees now in many parts of the watershed.
- Anecdotal assessments of much of area wildlife (mammals, birds) is that populations are in good shape; in the Squaw Valley Drainage bear and mountain lions sightings have increased over the last 50 years, while deer populations seem to have dropped.
- Current state and federal laws and regulations, best management practices, and oversight generally address most matters of concern from the impact of timber harvest and management activities upon fisheries, including buffers, equipment limitation zones, and meadow restoration projects.
- With specific exceptions (see below), overall water quality in the McCloud and its tributaries is believed to be good.
- Overall, the Red Band Trout Core Group partners are working well together, with a new (2008) conservation agreement about to be signed.
- There are a few looming housing development projects in the watershed that threaten large scale physical disruption of the system, or will result in a substantial increase in the number of new residents

Squaw Valley Creek Strengths

- Springs in the Squaw Valley Creek Drainage have remained reliable over the years.

- Portions of lower Squaw Valley Creek have been restored as a fish spawning area.

McCloud River Strengths

- The legacy of 1990s land exchanges that put 13 ½ miles of the McCloud River, including the Upper, Middle, and Lower Falls, in public hands, continues to pay conservation and recreational benefits.
- The McCloud Flats area remains highly productive and very resilient; intermittent streams show little channelization or other cumulative impacts from logging.
- There are conservation easements on portions of the watershed south of the river.
- Swamp Creek has had two successful fish passage projects.
- There have been successful wet meadows restoration on private lands, e.g., Angel and Huckleberry Meadows.
- Substantial work on the Trout Creek restoration project has been completed and additional work is ongoing; it remains to be seen how successful the project will be.

General Watershed Weaknesses/Threats/Challenges

- Population increases, tourism increases, and increased interest in outdoor recreation will continue to put pressure on public lands, often with spillover effects on private lands (e.g., trespass, theft, vandalism).
- Given current knowledge, any residential or commercial growth north of Highway 89 will necessarily require the use of additional surface water, increasing stresses on the river and tributary creeks. These flows are highly variable, being precipitation and snowpack sensitive.
- There are species of concern (spotted owl, western flycatcher, and redband trout) that need continued or additional attention.
- Pest infestations on public lands need better management to prevent widespread outbreaks, subsequent tree loss, and consequent fire hazards.
- Portions of the public lands have accumulated fuels, threatening catastrophic fire.
- Portions of the public lands have an accumulated road maintenance deficit that can lead to rutting and erosion.

Squaw Valley Creek Drainage Weaknesses/Threats/Challenges

- Squaw Valley Creek is faced with the uncertain impact of increased upstream diversion from the proposed Nestle water bottling project. These concerns are particularly strong regarding diversion during summer low flows, when Nestle

proposes diverting 2.8 cfs (cubic feet per second) of water, while the stream is estimated to flow at only 9 cfs. A second concern is the impact on Squaw Valley Creek of any groundwater drilling in conjunction with the proposed Nestle plant.

- The proposed Nestle plant will also have some other impacts to the watershed, particularly from the greatly increased truck traffic.
- Squaw Valley Creek water temperatures are dangerously high for fish at times during summer low flows.
- Squaw Valley Creek water quality is potentially subject to spillage from the McCloud Community Services District's sewage treatment plant, as well as from nitrate fertilizer and pesticide run-off from use by adjacent landowners.
- Some Squaw Valley Creek water rights holders feel threatened by external forces, i.e., Central Valley diverters who are using regulatory agencies to force re-evaluations of water rights in the region.
- Brush has grown out of control along many of the feeder creeks to Squaw Valley Creek. While some is probably necessary for fish cover and vegetation, too much growth blocks access and may have other negative consequences.
- Dolly Varden trout, once prevalent in the Drainage, have all but disappeared.
- Poaching has contributed to the decline of large deer populations.
- Beaver dams present some challenges to stream maintenance.
- Upper Squaw Valley Creek has some out-of-stream-course ponding.
- The Soda Springs trail project has insufficient resources to keep it maintained as an education and public access site.
- Porcupine sightings in the Drainage have decreased significantly.

McCloud River Weaknesses/Threats/Challenges

- South of the McCloud River there are more disturbances to the landscape. These include legacy impacts from past railroad activities.
- On both sides of the McCloud, control of sediment to reduce impact on redband trout is still a concern (e.g., on the south side of the river, Bull Creek and Raccoon Creek have some sediment loading issues).
- Upper Trout Creek, Upper Dry Creek, and Swamp Creek have some actual or potential gullying, braiding or bank sloughing issues.
- Sporadic, stochastic events off of Mt. Shasta can cause significant amounts of debris to fall suddenly and unexpectedly, with consequent impacts on roads and creeks.
- Increased recreational use along the river is causing increases in garbage dumping, fires, traffic accidents, soil erosion and soil compaction.
- Off- Highway Vehicle (OHV) use is increasing, and is currently largely uncontrolled on public lands.

Suggested Opportunities for Improvements

- Overall, most interviewees believe that the Red Band Trout Core Group has identified most of the principal trout-related restoration activities.

- There may be some opportunity for public and private entities to seek funding jointly in order to improve roads that cross both public and private lands.
    - One specific suggestion for lands north of the river was to drill a well for dust suppression purposes that would reduce the need to draw water directly from Trout Creek.

- Another specific suggestion was to consider some rocking, culverting, or other improvements on Moosehead Creek near Bartle.

- Springs within the Squaw Valley Creek watershed that were sealed with clay by the McCloud River Lumber Company during logging operations in the 1950s could be reopened.

- Squaw Valley Creek Drainage residents could be made more aware of the impacts of pesticide and nitrate fertilizer run off, and educated regarding alternative products or alternative application methods.

- An aquifer study could help develop non-surface water sources for the eastern portions of the watershed north of the river as development pressures increase there.

- There may be some possibilities for joint field surveys to help improve fire management planning.

- Resources for fire management on the public lands might be better spent on fire avoidance rather than fire suppression.

- Where a specific need can be demonstrated, there may be willingness on the part of some landowners to consider land exchanges or sales to put areas of heightened conservation value into public hands.

- Some residents of the watershed have ideas for additional restoration of meadows or riparian habitat on lands under multiple public/private ownership.

- Increased timber salvage opportunities might support a local forest products industry, such as biomass or ethanol.

6. Suggested Next Steps

The following list of suggested next steps is drawn from the data gap analysis, public outreach, and private landowner feedback assembled during this project and detailed in the preceding sections of this report. These steps are intended to develop watershed sustainability, ecosystem function, and collaborative multi-stakeholder stewardship, and are grouped (in no particular order or prioritization) in four categories: 1) Assessment; 2) Research and Monitoring; 3) Restoration; and, 4) Education and Outreach. While this list is not intended to be exhaustive, it is intended to capture the major issues and range of topics addressed in this report.

6.1 Assessment

- **Watershed assessment**
  While the one of the objectives of this project is to lay the groundwork for a possible comprehensive watershed assessment for the Upper McCloud (by providing a conceptual framework for such an assessment, assembling existing information, and identifying data gaps), a comprehensive assessment of the watershed is still needed. This type of assessment would build on the foundation created by this roadmap by:
    - Creating a prioritized list of key issues and topics for the watershed, representative of the watershed's physical, ecological, and stakeholder/ interest group diversity in the region.
    - Analyzing and synthesizing existing information and associated data gaps around key topics.
    - Developing a suite of topical, prioritized research questions and monitoring recommendations based on results of analysis.
    - Formulating a suggested management strategy for the watershed, based on the findings from the assessment.

- **Regional land use tracking and data set**
  There is an opportunity for creation and maintenance of a land use and management data set specific to the Upper McCloud River Watershed. This type of living analysis and associated data would serve as a tool for land use planning, natural resource management, and scientific research. A comprehensive effort would include:
    - Assembling existing available documentation relevant to past, present, and future regional land use, and summarizing it.
    - Researching patterns in private land use and cataloging and summarizing those where possible.
    - Cataloging and summarizing existing conservation and restoration efforts (both public and private) in the region.

- Collecting and summarizing existing land use policy (past and present) for the region, and key changes that have affected the state of the landscape.
- Identifying the dominant landscape dynamics and patterns of disturbance in the watershed, and charting key landscape events and trends (both environmental and anthropogenic) in relation to those.
- Mapping this total body of related topics onto the landscape in a GIS format, in such a way as to represent areas of overlap and track trends and changes over time and geographic space.

6.2 Research and monitoring

- **Monitoring of the Upper McCloud and its tributaries**
  Monitoring of hydrologic variability and water quality at multiple sites along the Upper McCloud River, in its major tributaries, and at multiple sites along Squaw Valley Creek.

- **Oral history of ecological change and land use in the Upper McCloud Watershed**
  Investigating and charting the prehistory and history of landscape change and transformation in the Upper McCloud Watershed as represented in the oral histories of the Winnemem Wintu Tribe, including:
  - Historical ecology and perspective on disturbance and landscape dynamics.
  - Resource stewardship, land use, and human communities.
  - Geographic and spatial patterns and trends.
  - Trends over time.
  - Relationship to accounts (both oral and written) from early Euro-American inhabitants of the watershed.

- **Historic well depths and output in the Upper McCloud Watershed**
  Tracking the historic and present status of groundwater resources in the Upper McCloud River Watershed and Squaw Valley Creek Drainage through well data (e.g., depth, output, number of wells).

- **Characterization of habitat and biotic communities in Squaw Valley Creek**
  An in depth study of aquatic and riparian habitat in the Squaw Valley Creek Drainage, including:
  - Geomorphic mapping.
  - Habitat typing.
  - Water quality analysis.
  - Characterization and mapping of vegetative communities.
  - Distribution, abundance and community composition of aquatic and riparian biota.

- **Trends in the contribution of the Upper McCloud River to Lake Shasta**
  Mapping varying trends in annual contribution of the Upper McCloud River Watershed to Shasta Reservoir, including:
    - Surface vs. groundwater contributions.
    - Variability in contribution relative to the Upper Sacramento and Pit River Watersheds.

- **Investigation of stream and riparian corridor impacts from previously undocumented trails and roadways in the Upper McCloud watershed**
  Research that builds on the USFS National Environmental Policy Act roads analysis to assess the potential impacts of the existing road network on the watershed, with a focus on new or previously unmapped trails and roadways.

- **Ecosystem analysis and food-web investigation of ephemeral tributaries and vernal pools in the Upper McCloud Watershed**
  Investigating the role of ephemeral tributaries and vernal pools in the food-web interactions and ecosystem function with the Upper McCloud Watershed. Some specific focus areas might include:
    - Characterizing biotic communities in ephemeral tributaries and vernal pools.
    - Investigating use of ephemeral tributaries and vernal pools as seasonal habitat for aquatic and riparian biota.
    - Investigating the role of ephemeral tributaries in the distribution, habitat selection, and trophic interactions of redband trout in the Upper McCloud Watershed.

- **Aquifer and groundwater mapping and characterization for the Upper McCloud Watershed and Squaw Valley Creek Drainage**
  Continuation and expansion of the existing regional spring water characterization project (CalTrout 2007) focused on:
    - Characterization of the aquifer and associated water resources using a combination of modeling and on-the-ground research.
    - Further investigation of elevation of recharge for the springs in the region, and further development and understanding of spring water resources through isotopic dating of spring water, and characterization of springs based on source and time of recharge.

6.3 Restoration

- **Mapping and unplugging historic springs in the Squaw Valley Creek Drainage**
  Among the landscape changes in the Squaw Valley Creek Watershed revealed during interviews with private landowners was the historic plugging of many of the

area springs. There is also historical evidence from the USFS of spring plugging and water diversion in the Upper McCloud to support grazing. Based on this, a near-term restoration project could focus on:

- Mapping the location of historic springs.
- Investigating the impacts of spring plugging.
- Uncovering previously plugged springs.
- Planting and restoration at the location of spring restoration.

6.4 Education and outreach

- **Conservation of stream ecosystems and water quality in Squaw Valley Creek**
  This effort would develop an education and outreach program targeted at private landowners in the Squaw Valley Creek Watershed around effective stewardship of the landscape and its ecosystems, including:
  - Background and discussion on the region, its ecology, and land use.
  - Sustainable approaches to irrigation, grazing, and timber harvest.
  - Fire and fuels management.
  - Climate change implications.
  - Conservation and restoration of stream water quality, habitat (in-stream, riparian, and upland), ecosystems functions, and wildlife.
  - Workshop series designed to help individual landowners 1) investigate the status of their landscape; 2) design a plan for land stewardship that joins their land use needs with conservation and restoration opportunities; and, 3) implement simple monitoring programs that will help them track the results of their efforts and be sensitive to the dynamic face of their landscape and associated needs for adaptive management.

- **Forum on watershed issues**
  This project would entail holding a series of public fora to present and discuss issues specific to the Upper McCloud Watershed. The range of discussion topics might include:
  - Climate change – current research and potential impacts on the region watershed and water based resources.
  - Proposed land use and management activities with the potential to impact the watershed and its resources (e.g., road construction and closure, timber harvest, water bottling, precipitation enhancement, etc.).
  - Past, present, and future conservation and restoration efforts and opportunities within the watershed.

- **Regional watershed assessment and planning for the Upper McCloud River**
  This effort would organize and carry out series of public education and outreach events in preparation for the development of a comprehensive watershed

assessment and associated management strategy for the Upper McCloud Watershed. Goals of these meetings would include:

- Introduce community members and stakeholders to the collaborative Assessment and Management Strategy approach to watershed stewardship.
- Identify potential watershed stakeholders interested in participating.
- Gather key issues and topics related to the watershed.

Appendix A: Conceptual Framework for Watershed Assessment

Among the challenges in landscape assessment is capturing the landscape's inherent complexity, overlapping gradients, multiple spatial and temporal scales, nested hierarchical relationships, and suite of landscape dynamics, physical processes, and ecological processes. This combination of factors is the context and driver for patch matrix relationships, species habitat relationships, ecological interactions, the status of the region's natural resources and, ultimately, land use and management.

With this complexity in mind, we have utilized an approach to landscape assessment in this project that incorporates key components from this suite of factors, and addresses them both categorically and individually, and in relation to and with one another. Specifically, we used a model based on three key concepts and associated applications in the assessment process.

1.1 Hierarchical organization of landscape

Landscape can be conceived of as organized in terms of a nested hierarchy, within which landscape level physical structures and processes (e.g., geology, hydrology, climate), govern habitat scale processes and interactions (e.g., water quality, vegetation distribution), which in turn shape ecological scale community composition, species-habitat relationships, and ecologic interactions. Adding complexity to this hierarchical model for landscape are many inherent feedback loops that are both dynamic and system dependent. Figure A.1 (below) provides a simplified diagram of this hierarchical relationship.

Application in landscape assessment: *Collection and organization of existing data, identification of data gaps, and prioritization of measures to fill those gaps.*

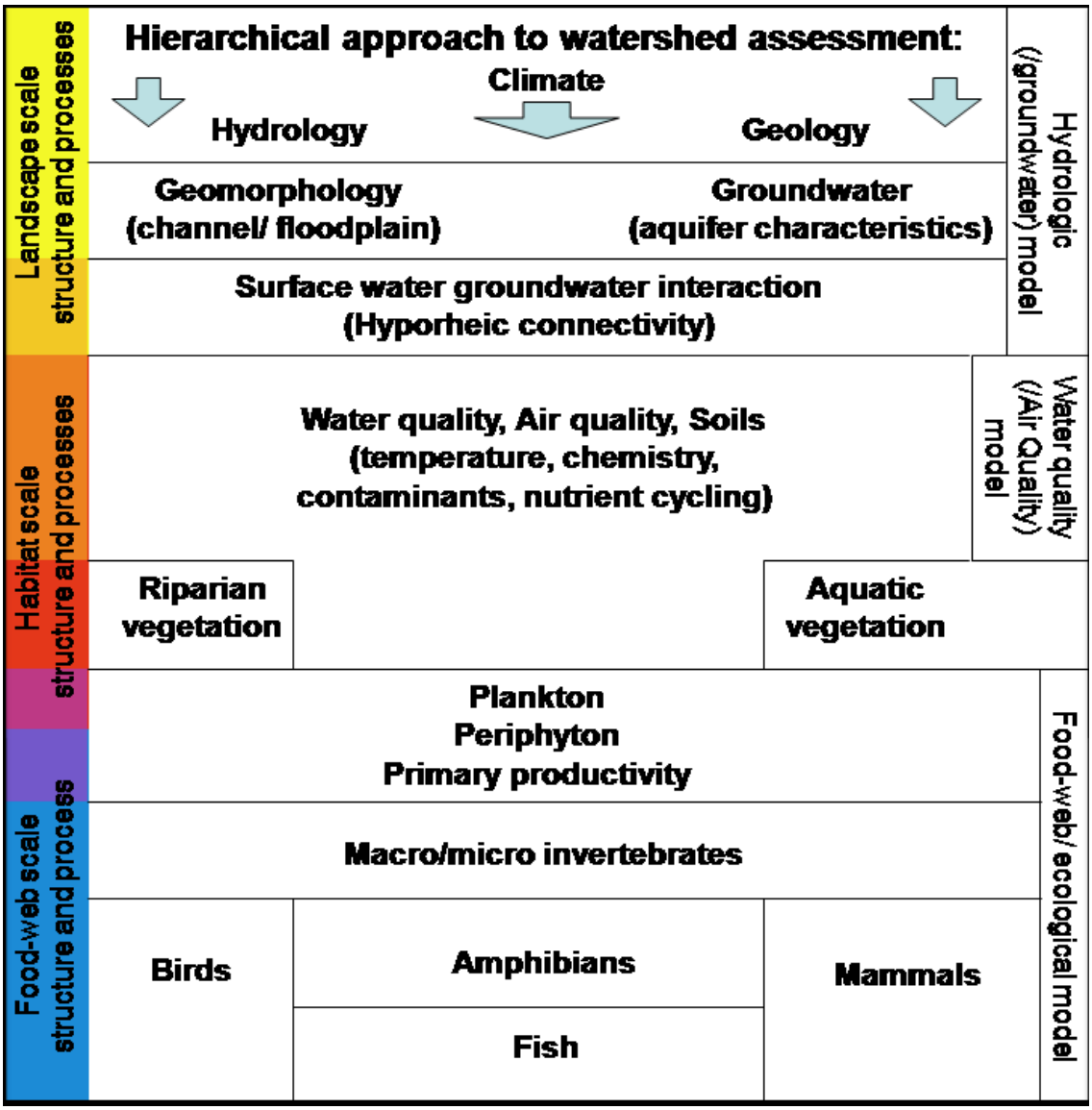
Categorizing existing data in terms of hierarchical components of landscape and geographic region of focus is useful as an organizational tool for understanding the scope and resolution of the existing knowledge base, and consequently that of the gaps in knowledge. Organizing landscape-based information in this way also facilitates an understanding of complex-system specific relationships that emerge as a function of the interactions between physical structure and process and ecosystems.

This type of hierarchical model can also be used to prioritize measures to fill data gaps in a way that minimizes resource expenditure. Since the upper levels of the hierarchy govern (to a large extent) the levels below, beginning research at the upper levels can allow for significant refinement of hypotheses related to lower levels, prior to research. For example, a detailed understanding of regional underlying geology can inform the

study of fluvial geomorphology in a drainage, which in turn can inform research on distribution of and community composition in riparian plants. This refinement process allows for more focused research questions, and reduction in research time and cost.

Figure A.1. Flow chart of hierarchical design for watershed assessment and monitoring

This chart attempts to visually represent the hierarchical approach to watershed assessment and monitoring utilized in this report (with a focus on in-stream and riparian habitats). Direction of flow is from top to bottom, where data collected during monitoring of upper tiers progressively modifies and focuses monitoring of tiers below. Multiple headings on the same tier suggest connected or parallel categories that may modify each other and have related or synergistic implications for categories on lower tiers. The vertical colored bands on the left couch the tiered categories in a conceptual hierarchy, including regions of overlap or transition. Vertical blocks on right indicate the model that data collected for a given category or tier will contribute to, with an eye towards adaptive management and further refinement of the monitoring process.



1.3 Distinguishing between landscape information based on origin, era, underlying question, and intended application

Historically, specific land use goals and objectives have driven landscape-based physical and environmental science. Tailoring research to answer specific management driven questions, however, can significantly limit the applicability of the research outside the scope of those questions. It is important that land use and management be supported by 1) a diverse and current knowledge base; 2) an understanding of historical land use and the rational and motivation behind it; 3) sound research drawn on a broad suite of questions and sensitive to a range of spatial and temporal scales (beyond those specific to particular human resource needs), and, 4) ongoing monitoring to track changes and shifts in the landscape.

Application in landscape assessment: *Collection and organization of existing data, identification of data gaps, prioritization of measures to fill data gaps, effective research design*

When collecting and analyzing existing information within the context of a watershed assessment, it is important to understand that information in the context of past present and potential future considerations for the landscape and the ecosystems and resources it supports.

Given the often limited scope and applicability of research performed in support of specific applications or management questions, we utilized an approach that 1) clearly distinguishes between research based on when it was performed, who performed it and the methodology they employed, what the intended application of the research was at the time it was performed and what the underlying research questions were; and, 2) uses land use and management strategically as a means of prioritizing research, but not as a means of determining underlying research questions, measures to fill data gaps, or research design.

As an alternative, we recommend that watershed assessment research be centered on a series of key topics with research questions weighted towards a deeper understanding of the topics themselves as opposed to their implications for specific management objectives. For example, research on a particular species of concern should prioritize understanding the species, and the habitat and ecosystems that support it, over measuring the success of specific conservation and restoration efforts targeting that species.

1.3 Linking best available science and land management using landscape dynamics

A suite of landscape dynamics both defines and arises from the interactions of (hierarchically related) landscape components, and land use and management. Key landscape dynamics include: *succession*, *connectivity*, *disturbance*, and *heterogeneity/biodiversity*. These dynamics operate across a range of temporal and spatial scales. Landscape dynamics provide a useful framework for understanding historical change to landscape, tracking current landscape status, and designing research, monitoring, and land use to all work synergistically in support of healthy ecosystem function.

Application in landscape assessment: *Data organization and evaluation, design of research questions, identifying and tracking multi-scale, spatio-temporal landscape trends, prioritizing ongoing physical and ecological monitoring of the landscape, identifying opportunities for land use and management prioritization and practice grounded in ecosystem stewardship.*

As an approach to assessment, we support the of use landscape dynamics as the base criteria for 1) assessing the status of landscape (e.g., historic trends, primary mechanisms of change, current status); 2) identifying opportunities (e.g., key research questions, ongoing monitoring needs, opportunities for synergy between land use and management objectives and ecosystem stewardship needs); 3) strategizing best management practices to meet the suite of demands on the landscape; and, 4) prioritizing action.

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***Note: This reference list is also available in a sortable EXCEL spreadsheet format on CD-ROM.*

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