3 BIOLOGICAL SETTING AND PROCESSES

3.1 INTRODUCTION

This chapter begins with a description of key physical and ecological processes that produce and maintain existing patterns of vegetation and aquatic ecosystems in the Taylor, Tallac, and Spring Creek watersheds. Key geomorphologic and hydrologic processes important in structuring the watershed's ecological systems were described in Chapter 2. This chapter connects geomorphic and hydrologic processes to observed biotic patterns. While a brief discussion of natural and anthropogenic changes that have affected the system's patterns and processes are included in this chapter, they are discussed more fully in Chapter 4.

The Taylor, Tallac, and Spring Creek watershed consists of a continuum of plant communities and aquatic ecosystems moving from the high elevations near the summit of Mount Tallac to the lower elevations at Lake Tahoe. These diverse plant communities and aquatic ecosystems in turn support a range of aquatic organisms and terrestrial wildlife. The key physical and ecological processes supporting these biological communities and the principal natural and anthropogenic disturbances affecting them is the basis upon which the opportunities for restoration have been developed (Chapter 7). While biological resources of the watershed are reviewed in general, the primary focus of this chapter is the wetland-riparian complex north of SR 89 in an area known as the Taylor Tallac Marsh (Exhibit 1-1).

3.2 METHODS

The plant community and aquatic ecosystem assessments in this chapter are based primarily on existing information provided by the U.S. Forest Service (Forest Service), supplemented by a literature review and by field reconnaissance conducted in October 2003. Terrestrial wildlife surveys were conducted separately for the Forest Service by another consultant. The results of their surveys are reproduced in Appendix F.

3.2.1 LITERATURE AND DATA REVIEW

The main data sources supplied by the Forest Service and utilized for this section include the following:

- *Physical and Biological Process Affecting Taylor and Tallac Creek Marshes, Lake Tahoe* (LTBMU 2000)
- *Fallen Leaf Management Area, Lake Tahoe Basin Management Unit Forest Plan* (USDA 1988)
- *Baldwin Beach TRPA Plan Area Statement* (TRPA Undated)
- Forest Service Lake Tahoe Basin GIS data
- *Shorezone Spawning in Lake Tahoe: The Effects of Shorezone Structures and Associated Activities on the Spawning Success of Native Minnows* (Allen and Reuter 1996)

- *Minimum Flow Needs for Taylor Creek, Lake Tahoe Basin Management Unit, with Taylor Creek Kokanee Fishery* (Haynes 1981)
- *Fish Sampling Data from Tallac and Taylor* (Muskopf 2004)
- Chapter 2. Wildlife inventory and monitoring in the Tallac Creek Watershed, Taylor Creek Watershed and Truckee Marsh: Pre-restoration *In* Wildlife Inventory and Monitoring in the Lake Tahoe Basin, California: Pre-restoration (Borgmann and Morrison 2005).

Region 5 established vegetation change/trend transects in the Taylor Tallac Marsh in 1999 and they were resurveyed by LTBMU staff in 2003. Over the long term, this data will be useful for assessing changes in vegetation following restoration.

3.2.2 RECONNAISSANCE SURVEYS

Reconnaissance surveys of the area north of Fallen Leaf Lake were conducted on October 14, 22, and 23, 2003 by EDAW biologists. Information gathered in these surveys was intended to provide a greater understanding of existing vegetation and aquatic habitat conditions, particularly for the riparian-wetland complex in the focal study area. A plant species list developed during the reconnaissance surveys is provided in Appendix E.

3.3 PLANT COMMUNITIES

The Taylor, Tallac, and Spring Creek Watershed consists of a continuum of plant communities moving from the high elevations near the summit of Mount Tallac to the lower elevations at Lake Tahoe. The complex assemblage of plant communities along this geologic and geomorphic continuum range from the sparse low growing vegetation in rocky, subalpine conditions to dense forested uplands to wet meadow and riparian areas to open water lagoonal areas and sandy barrier beach. In the upper segments of the watershed, plant communities include sub-alpine conifer, fell fields, red fir, Sierran mixed conifer, white fir, aspen, lodgepole pine, sub-alpine dwarf shrub, montane chaparral, montane riparian, and alpine meadows. The lower portions of the watershed include Sierran mixed conifer, Jeffrey pine, lodgepole pine, aspen, montane riparian, and montane meadow. The highest elevations of the two watersheds are characterized by large expanses of rock interspersed with montane lakes, scattered tree copses, and alpine meadows. This section provides an overview of key vegetation shaping processes followed by a description of each plant community and the principal processes supporting them. Plant communities that are found in the watershed, but not within the focal study area, were not assessed in detail and do not include a discussion of processes.

The plant community designations used in this chapter are based upon the CALVEG (Forest Service 1981) and the Guide to Wildlife Habitat of California (Mayer and Laudenslayer 1988) classification systems. Names of some vegetation types were modified from the CALVEG and CWHR terminology to more accurately reflect observed conditions.

Observations made during the October 2003 surveys and examination of the October 9 2003 aerial photograph were used to estimate plant community boundaries in the focal study area.

These communities were digitized onto the 2003 aerial base (Exhibit 3.3-1). The acreage of each plant community and vegetated aquatic ecosystem shown in Table 3.3-1 was estimated using Geographical Information System (GIS) software.

3.3.1 VEGETATION SHAPING PROCESSES

The vegetation map in Exhibits 3.3-1 and 3.3-2 demonstrate the diversity and complexity of the plant community mosaic present in the Taylor Tallac Marsh. This diversity is primarily the result of the interaction between climate and environmental gradients, particularly hydrology and topography, and the characteristics of individual plant species. Other important processes discussed here include fire, disease and insects, and land use.

CLIMATE

The temperature and moisture regimes of a location set the context for plant community development. Climate is the whole range of weather conditions—temperature, precipitation, sunlight, winds, and so forth—that an area experiences over an extended period of time (Cox and Moore 1985). Many factors contribute to climate including latitude, altitude, and an area's geographic position in relation to oceans and continental land masses.

Table 3.3-1
Estimated Acreages of Plant Communities and Vegetated Aquatic Ecosystems in the Focal Study Area

Plant Community	Acres
Sierran Mixed Conifer	46.6
Jeffrey Pine	55.5
Lodgepole Pine	89.0
Aspen	29.2
Alder Scrub	26.9
Willow Scrub	37.7
Wetter Meadow	111.1
Drier Meadow	15.7
Beach Ridge Meadow	11.5
Beach	15.1
Vegetated Total	438.3
Lagoon	3.8
Beaver Ponds	1.5
Aquatic Total	5.3
Asphalt	3.8
Total	447.4

Much of the research on and explanation of, stream and riparian ecosystem degradation in the arid and semi-arid western United States has focused on the effects of anthropogenic disturbance such as grazing and logging. The effects of past and present climate change have received much less attention. There is, however, a growing recognition that climatic factors are important components in understanding existing conditions and that climate is a key context in which other ecosystem disturbances and stresses play out (Millar and Woolfenden 1999, Chambers and Miller 2004).

One of the most important aspects of climate for plant growth is the relationship of seasonal temperature patterns to seasonal precipitation patterns. In all climates of the world, except those influenced by Mediterranean-type conditions, the high sun season (the season of highest temperatures) is also the season of highest precipitation. This pattern holds even in deserts, where total precipitation is very low. In Mediterranean-type climates this pattern is reversed and the highest precipitation occurs during the low sun season, or winter. This winter wet-summer dry pattern is characteristic of the climate of the Tahoe Basin. Occasional summer rain showers occur in the Basin, but the majority of the precipitation falls in the winter.

A summer dry climate stresses plants as they must cope with high temperatures at the same time that available moisture is reduced. They do so in one of a few ways: by shedding leaves or by adopting other strategies such as thickened cuticles to reduce transpiration or by avoiding the stress of summer altogether through an annual habit. Annuals pass the summer as seeds awaiting winter rain or snow. Riparian and wetland plants require high levels of water throughout the year. To persist through stressful summer conditions, they require additional summer moisture by way of streams, springs, seeps, or high ground water tables. In the arid west, the presence of extra summer moisture often results in very distinct boundaries between areas that have extra water and those that do not. The availability of extra moisture is also part of what makes riparian and wetland systems so important to wildlife.

At the Taylor Tallac Marsh, as at many riparian and wetland systems throughout the Sierra, the ultimate source of additional summer moisture is the high altitude snow pack, which slowly metes out water to streams and ground water over an extended period of time. This source of additional water is vulnerable to alteration under conditions of global climate change.

Restorationists frequently propose “pre-European impact” as the timeframe of reference for the ecosystem conditions to which they wish to restore. At Lake Tahoe and the Sierra Nevada in general, this timeframe is roughly the mid- to late 1800s. This timeframe corresponds to the end of the Little Ice Age, generally dated at 650 to 150 years before present (YBP). During the Little Ice Age conditions were generally cooler (average 1.2 degree C) and wetter throughout the Sierra. Mountain glaciers advanced to their greatest extent since the end of the Pleistocene. Marshes and wetlands expanded and lake levels increased throughout the Lahontan drainage (Tausch et al. 2004). Climatic conditions from the middle of the nineteenth century to the beginning of the twentieth were generally warmer and drier. The first half of the 20th century was again wetter, the wettest 50 year period of the last thousand years (Millar and Woolfenden 1999).

These cyclic variations in climate are increasingly recognized as regular, mechanistic drivers that are independent of anthropogenic impacts on climate. There are interannual and decadal scale cycles driven by ocean-atmosphere dynamics, century-scale variations apparently driven by sun spots and other solar variability interacting with oceanic and atmospheric circulation, and millennial scale cycles corresponding to complex regular changes in the earth's orbit (Millar 2002, Tausch et al. 2004).

The interannual to decadal-scale cycles are particularly relevant to our attempts to understand current ecological patterns and potential reference conditions for restoration at Taylor Tallac Marsh. In the early 20th century, not only was the lake being held at artificially high levels because the dam, but a higher level of rainfall was available to sustain those levels. Lake level records for Lake Tahoe over the last 100 years generally correspond to the western North American patterns of the El Nino/Southern Oscillation (two to eight year cycle) and Pacific Decadal Oscillation (20–50 year cycles). The ecological effects of these cycles have most commonly been studied in terms of their effects on fire regimes (e.g., Hessel et al. 2004), but they would obviously have similar impacts to lake-fringe wetlands such as Taylor Tallac Marsh.

ENVIRONMENTAL GRADIENTS

A walk across the Taylor Tallac Marsh, or examination of an aerial photograph, reveals obvious differences in vegetation (Exhibit 3.3-1). Mixed coniferous and Jeffrey pine forests give way to lodgepole pine and aspen along the fringe of a meadow complex, which is composed almost exclusively of herbaceous species. A thicket of alders and willows flourish along the upper reaches of the streams while a band of shrubby willows surrounds the stream's lower distributary channels. Pond lilies and submersed aquatic species grow in areas of standing water.

An environmental gradient is a change in an environmental factor across a given space or landscape. The environment of any plant species consists of a series of interacting gradients of various environmental factors. Among the factors that influence plant distribution are elevation, slope, aspect, soil or substrate characteristics, and distance to surface or ground water. While some species have broader ranges of tolerance than others do, a given species functions effectively over a more or less limited portion of each gradient. Both individual plant species and the collections of species called plant communities are distributed along environmental gradients.

Associated with an increasing elevation are increasing quantities of annual precipitation and decreasing average annual temperatures. Generalized vegetation zones are evident as one ascends the Sierra slope, grassland gives way to oak woodland and chaparral, then to mixed coniferous forests, and then to red fir forests at the highest elevations, before descending again to South Lake Tahoe.

The generally accepted hypothesis explaining plant species distribution is that individual plant species are distributed individualistically along environmental gradients (Whittaker 1970). Each species population has an optimum distribution along a set of environmental gradients. Suites of species with similar or overlapping responses to dominant environmental factors are

recognized as plant communities. The following discussion provides the basis for the majority of vegetation patterns observed within the watershed and focal study area.

Hydrology and Topography

At the Taylor Tallac Marsh, hydrologic and topographical gradients are the single most important drivers of plant species composition. The shaded relief map in Exhibit 3.3-3 illustrates the variation in topography from SR 89 to Lake Tahoe.

Most of the focal study area consists of wetland and riparian vegetation. Wetland ecosystems are transitional between terrestrial (upland) and aquatic (perennially or deeply flooded) ecosystems. Along this spectrum from dry to wet, small changes in water level can produce significant changes in wetland vegetation (Mitsch and Gosselink 1993). Cowardin et al. (1979) define a wetland as an area where the water table is at or above the land surface for long enough each year to promote the formation of hydric soils and support the growth of aquatic vegetation, much of which is emergent (i.e., with photosynthetic organs above the water surface). Most definitions of wetlands include similar elements. Hydric soils are created by anaerobic conditions induced by soil saturation and flooding. Saturation and flooding causes many physical and chemical changes in soils. Wetland hydrologic regimes can range from nearly continuous saturation (swamps) to infrequent, short-duration flooding (riparian systems). The most significant result of flooding is the isolation of the soil from atmospheric oxygen, this isolation activates several biological and chemical processes that change the system from aerobic and oxidizing to anaerobic and reducing (Faulkner and Richardson 1989).

One of the most important environmental gradients influencing the vegetation patterns at the Taylor Tallac Marsh is the degree and length of soil saturation. This is the fundamental relationship of topography and groundwater levels reflected in the diagram in Exhibit 3.3-4. Jeffrey pine and Sierran mixed conifer are found in the highest and driest locations; lodgepole pine is found along the meadow's edge and on the higher remnant beach ridges; willow scrub dominates the streamside vegetation along the lower stream segments; the herbaceous dominated meadow is found over the majority of the site; the lowest elevation portions of the meadow behind the barrier beach become lagoon when lake and ground water levels are high. Willow scrub and beach vegetation have other drivers in addition to soil water levels that influence their distribution. As soil saturation changes over time, either due to climate patterns or land use changes, vegetation community structure and composition change accordingly. While not directly observed, this process is likely responsible for changes in vegetation patterns within the focal study area.

Soils

The following description of soils found in the focal study area is based on information from the USDA Soil Conservation Service (SCS) survey (Rodgers 1974). A more recent soil survey has been conducted by the Natural Resources Conservation Service (NRCS) (formerly the SCS), but this survey was not publicly available for inclusion in this report. Detailed soils

surveys would be required to describe soils more specifically within the focal study area. A map of these soils is depicted in Exhibit 3.3-5.

Tallac gravelly coarse sandy loam, seeped, 5 to 9% slopes (TcC)

These soils occupy the highest elevations of the area north of SR 89. This map unit is formed on glacial outwash deposits and is moderately well-drained. The typical profile includes a thin layer of conifer needles followed by 42 inches of sandy loam (21 inches of gravelly coarse sandy loam and 21 inches of cobbley coarse sandy loam and gravelly sandy loam). This substrate is underlain by a weakly cemented silica layer that restricts root penetration and water percolation, causing standing water during the period of snowmelt. The surface layer does not absorb water readily and runoff is slow to medium (Rodgers 1974). In the focal study area, this soil unit supports Sierran mixed conifer forest.

Tallac gravelly coarse sandy loam, seeped, 0 to 5% slopes (TcB)

This soil series is also found on higher elevation areas north of SR 89, but generally have more gently sloping gradients than the TcC unit. These soils are as described above for TcC and support Jeffrey pine, Sierran mixed conifer, and lodgepole pine in the focal study area.

Gravelly Alluvial Land (Gr)

This soil unit is found along the upper segment of Taylor Creek and a large area east of the Tallac Creek wetter meadow. These soils have formed in areas of recent gravelly alluvium adjacent to stream channels and in meadows. In the typical profile, this soil is greater than 60 inches deep and consists of stratified gravelly sandy loam, gravelly loam, and gravelly silt loam that generally becomes very gravelly with increasing depth. In some areas the surface is covered with a shallow peat layer (1 to 6 inches). The slopes range from 0 to 5 % and vegetation cover includes grasses and sedges with scattered lodgepole pine. These soils are somewhat poorly drained to poorly drained and they are typically flooded in spring (Rodgers 1974).

This soil unit supports lodgepole pine, aspen, alder and willow scrub, and drier meadow in the focal study area.

Loamy Alluvial Land (Lo)

This soil unit occurs adjacent to Tallac Creek north of SR 89. These soils have formed in areas of recent alluvium adjacent to stream channels and in meadows, which are nearly level to gently sloping. The typical profile consists of a slightly acidic to medium acid sandy loam to silt loam surface layer that can sometimes be overlain with a shallow peat layer (1 to 6 inches). The underlying layers are stratified and include mottled sandy loam and silty clay loam. The substratum, which is encountered generally at a depth of more than 48 inches, can be gravel, lake sediment, or loamy alluvium. These soils are somewhat poorly drained to poorly drained and flooding may occur in spring during periods of runoff. In the focal study area, this soil unit supports alder and willow scrub, aspen, lodgepole pine and wet meadow.

Marsh (Mh)

Marsh soils occur along the lower segments of Taylor and Tallac Creeks. These soils are formed in poorly drained and ponded meadows. The terrain is mostly level and the typical vegetation includes reeds, sedges, and tules in the ponded areas and sedges, meadow grasses and scattered willow shrubs and lodgepole pine in the very poorly drained areas. Most of this area is under water/snow for at least 10 months of the year (Rodgers 1974). In the areas where water is not ponded for long durations, the surface is covered with about 6 to 8 inches of reddish-brown peat. The next layer consists of approximately 6 to 10 inches of black peat, which is underlain by black muck. The substratum, found between 30 to 60 inches, is gleyed sand and gravel. In the focal study area, this soil unit supports willow scrub, wet meadow, and lagoon.

Beaches (Be)

Beach soils occur along the existing lake shore and on a series of old beach ridges above it. This soil unit is composed of unconsolidated coarse granitic alluvial sand (Rogers 1974). In the focal study area, beach soils support beach, beach ridge meadow and lodgepole pine communities.

LIFE HISTORIES AND RECRUITMENT

The varied life history strategies of plant species interact with the limits imposed by environmental factors to create the species composition of plant communities (Grime 1979; Middleton 1999). Life history refers to the life cycle strategies of plants: how they reproduce, disperse, establish, and persist in an environment. As Grime (1979) has pointed out, juvenile and mature stages in the same plant population may be subject to different forms of natural selection, or because of differences in size and function, may respond differently to the same selection force. Seeds, seedlings, and adults often have different requirements. For a species to persist in a given environment, appropriate conditions must exist in each phase of the plant's life cycle.

Middleton (1999) has emphasized the importance of dynamic hydrologic conditions and disturbance in the life histories of many riparian wetland plants. Adult stages of many wetland and riparian species can tolerate flooding, but many cannot establish themselves under those conditions. Rather, they require a periodic drawdown to germinate and begin growth. This process is occurring within the watershed and focal study area. The hydrology of the nearshore wetlands is primarily driven by lake levels.

The importance of fluctuating hydrologic cycles and various forms of natural disturbance to wetland systems is emphasized in the concept of flood pulsing. Flood pulsing is the concept that the physical and biological functions of a floodplain wetland are linked to the seasonal dynamics of water moving out of a stream channel and into the floodplain (Middleton 1999). The concept is clearly applicable to the ecology of stream overbank flow in the meadow systems of the Sierra. Flood flows saturate meadow surfaces that were previously dry. The alteration of wet and dry soils has significant consequences for the decomposition of organic matter and nutrient cycling. The movement of water transfers nutrients, sediments, and organic matter from the stream to the meadow and may move nutrients, sediments, and organic matter from

the meadow to the stream. The flow of water influences the spatial flow of detritus, plants, and animals and provides for the dispersal of plant propagules (seeds, spores, vegetative pieces). The movement of water out of the stream channel and onto the floodplain also may remove vegetation to expose mineral soil and/or deposit bare mineral sediments on the floodplain. The seeds of most willow and other riparian tree species such as cottonwood require moist bare mineral soils to germinate. This disturbance provides sites for plant regeneration. This process is occurring within the watershed and focal study area. In particular, willow regeneration appears to be occurring along the streams and in the montane meadow with the exception of the first set of swales. As compared to historical photographs, willows along the sandy ridges of the near shore swale are not reproducing. More discussion of willow reproduction within this area is provided in Section 3.3.9 under Beach Ridge Meadow.

FIRE

Fire plays a major role in many plant communities in Mediterranean climates. The periodic recurrence of fire under dry summer conditions affects the persistence and evolution of species in this climate. While a more detailed discussion of the history and effects of fire in the watershed is provided in Chapter 5, this chapter briefly describes fire as an important process for many of the disturbance-dependent communities found in the Sierras. Of particular importance is how the suppression of wildfires over the last century has affected these communities.

Fires are commonly caused by lightening strikes and human activity, which includes both intentional and unintentional ignitions. Fire-adapted plants persist and flourish during these periodic disturbances by physical adaptations such as fire-induced flowering, bud protection and sprouting subsequent to fire, in-soil seed storage and fire-stimulated germination, on the plant seed storage and fire-stimulated dispersal, thick bark, evanescent branches, rapid growth, and early maturity. Many examples of these traits are exhibited in the species found with the watershed. For instance, the seeds of snowbrush may remain viable for 500 to 600 years in forest litter and will germinate after fires (Zavitkovski and Newton 1968). Some lodgepole pines have serotinous (serotiny literally means “late to open”) cones that remain sealed by resin until heat of fire opens them (Barbour et al. 1987). However, in the Sierras, the cones of lodgepole pine generally open without fire.

Fires can physically, chemically, and biologically affect soils and in turn alter the recovering community’s structure. The extent of the alteration is mainly dependent on the temperatures reached during the fire, the duration of extreme temperatures, and post-fire operations. Physical changes include loss of soil organic matter, loss of soil structure, hydrophobicity, erosion, and in extreme cases, destruction of soil clay minerals. Chemical changes include increases in pH and the loss of nutrients by volatilization, in fly ash or by leaching. Biological changes include direct mortality of soil organisms and loss of their habitat. Large wildfires may have a much greater impact on soil productivity than prescribed fire, especially during post-wildfire salvage and recovery operations (Poff 1996).

Fire used to be a major process in forests of the Sierra, as lightening ignited low-intensity surface fires that burned slowly consuming brush and litter. These recurrent fires would open

up the forest to allow for regeneration of shade intolerant species, create favorable germination sites for many species, and release seeds from serotinous cones. Periodic fire is considered to be a defining influence on ecosystem function and health of Lake Tahoe coniferous forests. Historically, frequent low-intensity fire has been the main disturbance dynamic producing the structure, function and composition of many plant communities. Fire suppression, in combination with other factors such as logging history, has significantly altered stand conditions creating dense forests of shade-tolerant species, such as white fir (*Abies concolor*), that have thick litter layers (Rizzo and Maloney 2000). In forests where fires are infrequent, the large amount of fuel loading can lead to highly destructive crown fires.

Fire is an important process to the sustainability of aspen stands. Without some type of infrequent disturbance regime, such as low intensity fire, shade tolerant conifers such as white fir begin to encroach into the aspen stands and may eventually replace them. Fires rejuvenate aspen stands by killing conifer seedlings, initiating root sprouting, and destroying diseased trees.

In some cases, fire may either reduce or intensify infestations of nonnative plant species. Following fire-related vegetation removal, open areas may be easily invaded by nonnative species that are adapted to disturbance. However, some nonnative species can be eliminated by repeated fire.

DISEASE AND INSECTS

Plant community ecology is also influenced by plant pathogens. The importance of these pathogens is supported by their ubiquitous presence throughout all ecosystems. It has been suggested that pathogens influence plant to plant interactions (Mills and Bever 1998). Recent work in natural communities indicates that pathogens play a significant role in plant demography and may even play a part in community succession. While it is not known how pathogens may maintain diversity in natural plant communities, recent research suggests that the entire soil community may contribute to the preservation of diversity in plant communities (Mills and Bever 1998). Mills and Bever (1998) found a negative feedback between plant growth and changes in the soil community composition. Once a plant has become established, it changes the surrounding soil community in a manner that decreases the growth of that particular plant species relative to other species. The researchers concluded that this negative feedback process maintains diversity within the plant community.

In addition to the more “hidden” roles these organisms have, outbreaks of disease become apparent as large swaths of dying trees move across a landscape. In most ecosystems, outbreaks of disease typically occur in cycles to which plant communities have become adapted and in most cases the pathogen affects only a few of the weaker trees in a stand. Most of the time pathogen populations are kept under control by other organisms, but occasionally a population explosion will occur and affect huge expanses of forest.

These large outbreaks over a sustained period of time may be associated with some environmental stress that weakens the ability of species to fend off pathogens. In the focal study area, insect infestations have likely played a significant role in lodgepole pine forest mortality.

These infestations were likely brought about by a combination of overstocking and an extended drought (Chapter 4). Insects may also be affecting other plant communities.

LAND USE PRACTICES

Since the time of human settlement in the basin, the land and its resources have been utilized and "managed" in ways that alter vegetation patterns. Historic and current land use practices that are of particular importance in explaining some of the vegetation patterns observed in the focal study area include logging and grazing. More information on the history and effects of grazing and other land use practices is presented in Chapter 4.

Logging

The majority of forest stands within the study area would be classified as secondary growth because of harvesting operations during the Comstock Era. Prior to the Comstock Era, the Tahoe Basin was generally characterized by the predominance of low-density coniferous forests with large, mature trees and an open understory. On the west side of the Basin, the upper montane forests were dominated by red fir (*Abies magnifica*) with a ratio of 2:1 (red fir to pine) and a tree density of more than 160 per hectare (Murphy and Knopp 2000). In the lower montane forests of the west side, the dominant species was Jeffrey pine (*Pinus jeffreyi*) with a ratio of 1.5:1 (Jeffrey pine to white fir [*Abies concolor*]), and a density of approximately 120 trees per hectare (Murphy and Knopp 2000). It is assumed that this structure was characteristic of forests in the Taylor, Tallac and Spring Creek watersheds. These pre-Comstock forests were generally multistoried and had a complex stand structure (Murphy and Knopp 2000). The younger, second growth forests typically have very dense canopies and are even-aged. The lower montane forests have shifted towards the dominance of more shade tolerant species such as white fir. Murphy and Knopp (2000) found that the relative abundance of white fir and incense cedar (*Calocedrus decurrens*), which were previously understory associates, has approximately doubled over the past 200 years, while the relative abundance of Jeffrey pine had declined by 50%. Because little light reaches the forest floor in these second growth forests, they typically lack structural diversity and understory vegetation layers are absent. Current forestry practices such as thinning and prescribed burning within the watershed are limited, and as a result many forest stands are overstocked with high fuel loads.

Grazing

While managed grazing can be beneficial to plant communities by removing thatch and promoting growth and species diversity, heavy grazing can be potentially detrimental especially in wetland and riparian areas. Some hydrophytic plants are more susceptible to damage than others are, and these more susceptible species may eventually be replaced by more resilient species, which are commonly nonnatives. Native wetland species such as Nevada rush (*Juncus nevadensis*) and primrose monkeyflower (*Mimulus primuloides*) are highly susceptible to grazing damage, while nonnative graminoids such as common timothy (*Phleum pretense*) and Kentucky bluegrass (*Poa pratensis*) persist and often increase under heavy grazing

regimes (Potter 2003, Menke et al. 1996). Grazing can also significantly reduce and possibly eliminate some sedge species (Murray 1997). Less desirable or unpalatable species eventually replace the more palatable grasses, sedges, and rushes. Grazing may also diminish the hydrologic function that supports wetland and aquatic systems. Repeated grazing can result in soil compaction, which decreases soil porosity and water storage capacity, and grazing near streams typically leads to streambank trampling, which can lead to erosion and the overwidening of a stream. The compaction of soils and removal of vegetation may initiate gully formation, which produces drier conditions by draining surface and groundwater. Evidence of overgrazing was observed in the allotment in the focal study area. More details on the effects of grazing and observations of overgrazing made during reconnaissance surveys are provided in Chapter 4.

3.3.2 RED FIR

Red fir plant communities are found along the steep lower slopes of Mount Tallac. The characteristic structure of this community is even-aged stands of red fir that cover considerable expanses (Mayer and Laudenslayer 1988). Red fir communities are readily recognizable because they are composed mostly of red fir with very few other species in any layer. Associates may include scattered lodgepole pine (*Pinus contorta* var. *murrayana*) and western white pine (*Pinus monticola*) (Forest Service 1981). The dense closed canopy and thick duff layer tends to inhibit understory vegetation development. In less dense stands or along the interface between this community and those adjacent, associated shrub species include snowbrush (*Ceanothus velutinous*), mountain whitethorn (*Ceanothus cordulatus*), pinemat manzanita (*Arctostaphylos nevadensis*), and greenleaf manzanita (*Arctostaphylos patula*) (Forest Service 1981). This community may contain small inclusions of lodgepole pine, aspen, and montane meadows (Mayer and Laudenslayer 1988). This community type occurs within the watershed, but is not found in the focal study area.

3.3.3 MONTANE CHAPARRAL

This upland community occurs in mid to high elevations, typically on steep slopes. The community is characterized by a dense, sometimes impenetrable growth of shrubs. These shrubs can attain heights that resemble trees, but in harsher environments they typically remain low-growing, or prostrate (Mayer and Laudenslayer 1988). The majority of the dominant shrubs are evergreen species, but some deciduous species are present. Because of the dense growth of shrubs, understory development is typically absent. A few conifers or oak (*Quercus* spp.) trees may occur as sparse stands or scattered individuals. Species composition varies with elevational changes, soil type, and aspect. Common species include greenleaf manzanita, pinemat manzanita, mountain whitethorn, tobacco brush (*Ceanothus velutinus*), chinquapin (*Chrysolepis sempervirons*), huckleberry oak (*Quercus vaccinifolia*), and mountain mahogany (*Cercocarpus montanus*) (Mayer and Laudenslayer 1988). This natural community type occurs within the watershed, but is not found in the focal study area.

Recent research found evidence that historically large fires were responsible for the establishment and persistence of contemporary chaparral stands (Taylor 2002). Fire affects the

structural diversity and community composition within these stands. Managing and maintaining this diversity is desirable. More details on the role of fire in this plant community are provided in Chapter 5.

3.3.4 SIERRAN MIXED CONIFER

PLANT COMMUNITY DESCRIPTION

Sierran mixed conifer is found throughout the majority of the study area above SR 89 and occupies a small portion of the focal study area (Exhibit 3.3-1). This upland community can be divided into two distinctive sub-groups, stands dominated by pine and those dominated by fir. These assemblages of mixed conifer typically form multilayered forests (Mayer and Laudenslayer 1988). While some stands are even-aged, others appear to have been subject to some type of disturbance (e.g., fire, disease epidemics, tree thinning, avalanches) resulting in variable tree heights. Mature stands tend to have two tree canopies, an overstory of mixed conifer and an understory of white fir and incense cedar (Mayer and Laudenslayer 1988). These multilayered stands can provide dense cover with little shrub and herbaceous plant development. However, a shrub layer is common in canopy openings.

The dominant tree species in the mixed conifer pine stands are Jeffrey pine or ponderosa pine and the mixed conifer fir stands are typically dominated by white fir. White fir is the most widespread species throughout most of this community type even though it does not typically dominate the upper canopy. A few red fir individuals are associates at higher elevations in this community, while sugar pine and incense cedar are scattered throughout. Shrubs commonly found in this community include deerbrush (*Ceanothus integerrimus*), greenleaf manzanita, chinquapin, tan oak (*Lithocarpus densiflorus*), pinemat manzanita, mountain whitethorn,

mountain snowberry (*Symphoricarpos rotundifolius*), gooseberry (*Ribes* spp.), and Woods' rose (*Rosa woodsii*). The herbaceous groundcover consists of grasses and forbs such as California brome (*Bromus californica*), squirreltail (*Elymus elymoides*), rockcress (*Arabis* spp.), sedges (*Carex* spp.), phacelia (*Phacelia* spp.), erigeron (*Erigeron* spp.), mountain peony (*Paeonia brownii*), rushes (*Juncus* spp.), slender ryegrass (*Elymus trachycaulus*), onion (*Allium* spp.), and Lemmon's needlegrass (*Achnatherum lemmonii*) (Mayer and Laudenslayer 1988).

PROCESSES

Sierran mixed conifer forests are found along the southern edge of the focal study area where there are higher, drier soils with a sloping topography. The soils supporting these communities in the focal study area are well-drained in the upper portion but underlain by a weakly cemented silica layer that perches groundwater throughout most of the dry summer. While many of the species common to these communities are drought tolerant, others have root systems that are in contact with the perched groundwater table.

An important process that shapes these communities is fire. Stand diversity was supported by recurrent fires, both in species composition and stand structure. Recurrent fire opens up areas of the forest for regeneration and triggers the germination of certain species. The lack of fire has produced an even-aged forest with a predominance of white fir and incense cedar and reduced numbers of Jeffrey pine and sugar pine (Rizzo and Maloney 2000). Investigations into the fire history of the basin show that during the era before Euro-American settlement, fire scars indicate a frequent return of low-intensity fires. It appears that 6 years was the longest period in between fires (WTNC 2001, Taylor 2000).

White fir was observed during reconnaissance surveys as a dominant species in both the Sierran mixed conifer and the Jeffrey pine stands in the vicinity of the marsh. The species has become ubiquitous throughout many of the Sierran forests because it tolerates shade and the lack of fire has allowed it to persist and proliferate for long periods. Whereas, previously important species, such as Jeffrey pine, persist with recurrent fires but cannot regenerate under shady conditions. Thus, there has been a shift from Jeffrey pine dominated stands with a diverse understory to dense, white fir dominated stands.

3.3.5 JEFFREY PINE

PLANT COMMUNITY DESCRIPTION

Jeffrey pine occurs both north and south of SR 89, but is significantly less prevalent than Sierran mixed conifer in the southern part of the watershed. Jeffrey pine typically persists in soils that are dry to moderately dry. On drier sites, Jeffrey pine generally forms pure stands with very open canopies. When not in pure stands, conifer associates include ponderosa pine, sugar pine, red fir, and white fir (Mayer and Laudenslayer 1988). Where this community intergrades with wetter communities, quaking aspen (*Populus tremuloides*) and lodgepole pine may be present (Mayer and Laudenslayer 1988). The shrub layer includes drought tolerant species such as greenleaf manzanita, mountain whitethorn (*Ceanothus cordulatus*), bitterbrush (*Purshia tridentata*), rabbitbrush (*Chrysothamnus* spp.), and sagebrush (*Artemisia tridentata*). This suite of species is typical of Jeffrey pine communities found east of the Sierra Nevada crest and along the southern rim of Lake Tahoe. Common herbaceous species include squirreltail, blue wildrye (*Elymus glaucus*), slender hairgrass (*Deschampsia elongata*), western needlegrass (*Achnatherum occidentale*), woolly wyethia (*Wyethia mollis*), and pennyroyal (*Mondardella odoritissima*).

In the focal study area, this upland plant community occurs mainly on the higher elevations adjacent to the access road for Baldwin Beach and intergrades with the Sierran mixed conifer community to the south. The Jeffrey pine community in this area is characterized by a very open canopy of Jeffrey pine, but also includes a few white fir and ponderosa pine. The understory is a sparsely vegetated mosaic of drought tolerant low-growing shrubs and herbaceous forbs and grasses. Dominant shrubs include sagebrush and bitterbrush and dominants in the herbaceous layer include mule's ears, blue wildrye, naked buckwheat

(*Eriogonum nudum*) and aster (*Aster* sp.). A large, very open area is apparent along the access road to Baldwin Beach (Exhibit 3.3-3). This area includes mature lodgepole pine and a few younger white fir trees, but more characteristically resembles an open sagebrush community dominated by sagebrush and bitterbrush.

PROCESSES

Many of the same processes discussed under Sierran Mixed conifer are true for Jeffrey pine. These forests are also found on the higher, drier soils in the focal study area, but typically inhabit soils that lack changes in gradient. Fire is an important factor in maintaining Jeffrey pine as the dominant tree in this community.

3.3.6 LODGEPOLE PINE

PLANT COMMUNITY DESCRIPTION

Lodgepole pine occurs on more mesic sites than Jeffrey pine. This community is characteristically open with few other species and little understory development (Mayer and Laudenslayer 1988).

In the focal study area, lodgepole pine occurs in areas that are transitional from drier more upland conifer forests and montane meadow. Lodgepole has mainly established along the fringe of the forested upland and near the lake shore on remnant beach ridges. Lodgepole pine is the dominant species in this community, but minor associates include quaking aspen, Jeffrey pine, and white fir. The majority of this plant community near the wetlands has experienced high mortality. In these stands, the dead standing trees are thin and dense. Fire scars on many of these trees provide evidence that this area experienced a burn somewhat

recently, which was subsequent to the period of high mortality. Recruitment into this area was observed and several young lodgepole have become established in these areas along with aspen, willow and gooseberry (*Ribes* sp.) (Exhibit 3.3-6). Some of the smaller, more mature lodgepole stands in the study area are still thriving. Scattered shrubs are present when the canopy is open and include species such as Western serviceberry (*Amelanchier alnifolia*) and Woods' rose. The herbaceous understory is dominated by sedges and rushes but likely includes a suite of wildflowers during the summer. Surveys conducted in the summer of 1999 found the wildflower component included swamp onion (*Allium validum*), alpine lily (*Lilium parvum*), and corn lily (LTBMU 2000).

PROCESSES

Lodgepole has the widest range of environmental tolerance of any conifer in North America (USDA 2003). It grows in areas with cold, wet winters and warm, dry summers. Lodgepole pine is found growing along the meadow and riparian fringe, in soils that may fluctuate from inundated and saturated to extremely dry. This species can tolerate high water tables and withstand short-term flooding. Snow melt in the spring supplies critical soil water which is used by the tree for rapid growth in early summer. Cones are generally not persistent on the trees, and released seeds germinate quickly after snow melt. Most seedlings are relatively poor competitors with herbaceous sod-forming meadow species. However, without recurrent fire to remove saplings, lodgepole pine is known to invade meadows.

Although it is usually killed by fire, wildfires are the key to regeneration of this species. Bare mineral soils created by fire supply the ideal conditions for seedling germination. Burned areas are typically colonized quickly by wind-dispersed seed and vigorous seedlings proliferate across the charred landscape. The large numbers of new seedlings created during this one-time event develop into an even-aged stand. Since the species is such a prolific seeder and does not self-thin, these stands are especially vulnerable to overstocking. Overstocking can result in limited growth and stagnant stands.

Mountain pine beetles play an important role in the dynamics of natural lodgepole pine stands. The beetle periodically invades stands, killing many individuals and creating large amounts of fuel. These fuels are eventually consumed by fire, creating a favorable seed bed for lodgepole regeneration. This cycle increases the probability that lodgepole will reoccupy a site at the expense of other species. The ability of lodgepole pine to regenerate at the expense of other species is because of a combination of life strategies including cone serotiny, high seed viability and germination rates, early rapid growth, and ability to survive a wide variety of microsite and soil situations (Kocher 1998).

The extensive stand of dead lodgepole pine present along the remnant beach ridges in the focal study area is even-aged and very crowded. The forests in the vicinity have experienced severe outbreaks of both Jeffrey pine bark beetle and mountain pine beetle. Highly visible levels of tree mortality because of infestations of bark beetles in the basin began in the mid-1980s. The primary reasons for the infestations appears to be physiological stress associated with many years of overstocking, reinforced by other factors such as other pathogens and drought (USDA 1988). Other species such as the Lodgepole needle-miner (*Coleotechnites*

milleri), which has caused large stands of dead, bleached pine found in the upper basins of the Tuolumne River watershed, may also be a factor. These insects often weaken the trees and allow infestation by bark beetles (Whitney 1979). Dense forest stands are more susceptible to disease outbreaks during droughts because of the large number of trees they support (Rizzo and Maloney 2000). It is likely that the combination of drought and overcrowding allowed a pathogen to infect and kill the lodgepole pine community on the remnant beach ridges. The decline of this stand is discussed in Time Series Analysis exhibits in Chapter 4.

3.3.7 ASPEN

PLANT COMMUNITY DESCRIPTION

Aspen occurs in mid to upper montane areas within the watershed where soils are moist. Snow bank areas, hillslope seeps, or areas adjacent to lakes ands streams may all favor aspen growth. Aspen stands are typically composed of clones representing one or more genetic lines (Hipkins 2004; Kitzmiller 2004; Mayer and Laudenslayer1988). This community can occur as small stands but more typically forms larger patches (Potter 2003). The structure of aspen stands can range from relatively closed canopies composed of even-aged trees to more open and uneven canopies. In open stands, herbaceous cover can be significant. This community type is usually found on relatively gentle slopes along meadow edges in valleys, but also grows on the steep inclines of hillslope seeps. The community is dominated by quaking aspen with a few scattered shrubs and an understory characterized by lush herbaceous perennials including forbs such as false hellebore (*Veratrum californicum*) and mountain sweet cicely (*Osmorhiza chilensis*) as well as grasses and sedges (Potter 2003). In wetter areas, the aspen understory is dominated by wetland species such as sedges and rushes.

In the focal study area, this community is dominated by even-aged stands of quaking aspen. This dense canopied woodland is present along both creeks and the margin of the wetter meadow and provides a transition between forested uplands and montane meadow. Larger stands are typically dense but smaller stands have a more open canopy, especially in areas where beaver activity is high. Associated subdominant trees and shrubs included willows, alders, lodgepole pine, and Jeffrey pine, but in many of the mature stands throughout the focal study area, aspen is the dominant upper canopy species. The shrub understory includes white-stemmed gooseberry (*Ribes inerme*) and creeping snowberry (*Symphoricarpos mollis*). The diverse herbaceous layer was characterized by bentgrass, Nebraska sedge (*Carex nebrascensis*), big-leaf avens (*Geum macrophyllum*), monkshood (*Acontium columbianum*), giant red Indian paintbrush (*Castilleja miniata*), and lily (*Frittilaria* sp.).

It was observed that some aspen stands on Tallac Creek were exhibiting signs of disease but did not appear unhealthy, while others along Taylor Creek did seem to be injured by pathogens. Horse grazing is permitted in one of the large aspen stands near Tallac Creek and a number of unvegetated trails meander through this stand. The groundcover in this area appears trampled. A small stand of dead aspen was encountered adjacent to the largest beaver pond on Tallac Creek. Some of the snags in this stand were resprouting, but many of the decadent trees have been felled by beaver activity (Exhibit 3.3-6). Dead lodgepole pines were apparent in this stand as well.

PROCESSES

Quaking aspen is the most widely distributed tree in North America and tolerates a wide spectrum of environmental conditions. In the study area, aspen is found in wetter areas along the meadow and riparian edges that experience infrequent flooding but have moist soils. This species can not withstand frequent or long duration flooding that is generally associated with wet meadow and riparian habitats. Aspen often intergrades with lodgepole pine along these wetter fringes.

These trees produce abundant litter that is high in nutrients such as nitrogen and phosphorus. The leaf litter decays rapidly, forming nutrient-rich humus that reduces runoff and aids in percolation and recharge of ground water as well as reduces evaporation from the soil surface. Compared to conifers, more snow accumulates under quaking aspen and snowmelt begins earlier in the spring, though the soil under quaking aspen thaws faster and infiltrates snowmelt more rapidly than soil under conifers (USDA 2003). This community is typically found on soils with very high available water capacity as compared to upland sites and most meadow soils (Potter 2003).

Quaking aspen forms variably-sized stands of clones connected by a common parent root system. Clones may be distinguished by differences in phenology, leaf size and shape, branching habit, bark character, and laboratory tests (USDA 2003). Quaking aspen stands in the Sierras are often even-aged because the stands are created following a single top-killing event. However, some may be more broadly aged as a result of sprouting in a gradually deteriorating stand (USDA 2003). In the Sierras, quaking aspen rarely regenerates from seed.

This species is shade intolerant and is dependant on disturbance events such as fire or windthrow to regenerate. Fire-killed stands are promptly revegetated by root sprouts. Adaptations to fire allow quaking aspen to be highly competitive on burned sites. Even when quaking aspen was a very small component of the pre-fire community, it often dominates a site after fire (USDA 2003). In the absence of fire, aspen stands are typically replaced by shade tolerant conifers.

The history of fire suppression has led to a decline in the health and abundance of aspen stands. This decline has been further exacerbated by grazing pressure. The young, supple sprouts are favored browse in the late, dry summer when little green vegetation is available. Livestock trampling and soil compaction under wet conditions also reduces the health and vigor of these stands. Many of these sites have loamy topsoil, which can be severely impacted by long-term loss of porosity if grazed when sites are wet (Potter 2003). A more in-depth discussion of the interaction between grazing and soils is provided in Chapter 4. It is assumed that this disturbance is occurring in the Baldwin allotment, but more detailed soil studies would be required to assess the extent of this disturbance.

Beaver are also likely playing a role in the health of some of these stands. The large beaver dams along Tallac Creek may be causing the prolonged inundation of some of the nearby aspen stands, which were previously inundated less frequently, and killing the trees. The beaver are also causing direct mortality because of consumption and pruning of trees for building dams. A more in-depth discussion of the interaction between aspen and beaver is provided in the Time Series Analysis in Chapter 4.

3.3.8 MONTANE RIPARIAN

PLANT COMMUNITY DESCRIPTION

This mesic plant community is variable in species composition and structurally diverse. Dominants include deciduous tree species such as alders (*Alnus* spp.), willows (*Salix* spp.), black cottonwood (*Populus balsamifera*), dogwood (*Cornus* spp.), and water birch (*Betula occidentalis*). The community frequently occurs as a narrow strip along perennial and intermittent streams, and it is present along the upper extents of both Taylor and Tallac Creeks in the focal study area. Under favorable conditions the upper canopy can create tall, dense woodland, but often at higher elevations the dominant species remain shrub-like. The tangled, shrub-like canopy often creates impenetrable thickets. The herbaceous understory is mainly composed of grasses and sedges that are common in wet meadows, but scattered wildflowers and other shrubs are typically present along the outer fringe where the canopy is more open (Mayer and Laudenslayer 1988). In the focal study area, this community can be sub-divided into two distinct groups: alder scrub and willow scrub. The alder scrub community is characterized by the dominance of mountain alder (*Alnus incana* ssp. *tenuifolia*).

Willow scrub occurs lower on the stream profile and intergrades with the alder scrub and montane meadow. Small areas of willow scrub also occur along the distributary channel fingers in the wetter meadows.

ALDER SCRUB

In the focal study area, alder scrub occurs on the upper extents of Taylor and Tallac Creeks on the stream's banks and floodplains. On Taylor Creek the upper canopy of this community is dominated by mountain alder but includes black cottonwood, willows, and mountain dogwood (*Cornus sericea*). On Tallac Creek, the upper canopy is dominated by alder but includes a large number of associated willow species. This community along Tallac Creek is a very dense thicket of shrub-like trees with little variation in height. The community along Taylor Creek is more varied and includes scattered, tall black cottonwood trees that add variation to the canopy structure. The thick layer of herbaceous groundcover includes willowherb (*Epilobium ciliatum*), monk's hood, fowl mannagrass, big-leaf avens, mugwort (*Artemisia douglasiana*), cow parsnip (*Heracleum lanatum*), horsetail (*Equisetum hymale*), gooseberry, and sedges. It is assumed that the differences in plant community structure are related to the differences in soil and geomorphic position in relation to hydrology along the two streams (Chapter 2). Studies would be necessary to assess detailed differences in this community on Taylor and Tallac Creeks. Based on observations, it does not appear that one is functioning better than the other, but differences in structure and composition likely indicate that they are utilized differently by wildlife.

WILLOW SCRUB

The canopy of the willow scrub can be dense to open and is dominated by Lemmon's willow (*Salix lemmonii*), Jepson's willow (*S. jepsonii*), arroyo willow (*S. lasiolepis*), and shining willow (*S. lucida*). The herbaceous understory includes several species of grasses, sedges, and rushes such as panicled bulrush (*Scirpus microcarpus*), corn lily, swamp onion (*Allium validum*), cow parsnip, western polemonium (*Polemonium occidentale*), and big-leaved avens. There are a significant number of dead willows in and adjacent to the large beaver pond on Tallac Creek.

PROCESSES

The dominant species in riparian communities are considered phreatophytes ("well plants"); that is, species restricted to habitats with permanent underground water supplies. Species such as cottonwood, willow, and alder require root contact with the capillary fringe above a water table (Barbour et al. 1987). In addition, many riparian communities are disturbance driven and persist in areas subjected to flooding and sediment deposition. Adaptations of the dominant species allow them to quickly colonize stream banks following these large disturbance events that remove large areas of vegetation and leave bare mineral soil behind. These species may resprout from living root systems or grow from newly deposited seeds.

Alder scrub establishes in floodprone areas as dense thickets in the drainage bottom and areas directly adjacent to streams at the bankfull level (Potter 2003). Stand density and structure varies according to the degree of scouring, deposition, and rearrangement of substrates during flood events. Stands with a more open structure often indicate that the area is subject to high flows (Potter 2003).

Willow stands are able to withstand flooding, but can not persist in areas inundated for long durations. It is apparent that the flooding caused by the large beaver dam complex along Tallac Creek has caused some mortality by direct consumption and prolonging inundation, a process which is also discussed in the Time Series Analysis section of Chapter 4.

Well-developed root systems of riparian trees and shrubs also stabilize recently eroded stream banks. These deciduous communities are important for shading streams and the annual flush of litter supports instream fauna (Potter 2003).

3.3.9 MONTANE MEADOW

PLANT COMMUNITY DESCRIPTION

The continuum of plant associations included in this vegetation type are characterized by a dominantly herbaceous layer, and may contain a few, scattered shrubs or trees such as willow or lodgepole pine. Small meadows occur at higher elevations in the upper watershed, and a larger expanse of this community occurs at the lower end of the watershed north of SR 89. While the overall appearance of this community is often one of uniform height and a simple structure, microscale differences can be important. Some species may reach heights of only an inch or so, while others grow to three feet or more (Mayer and Laudenslayer 1988). The microstructure of plants surrounding a small rivulet through Tallac meadow is depicted in Exhibit 3.3-7. Typically the herbaceous layer provides very dense cover, except in instances where there is standing water or recently receded ponded water, or rock outcrops. Where grazing animals are present, the meadows in the focal study area have occasional breaks in the cover because of trampling or overgrazing.

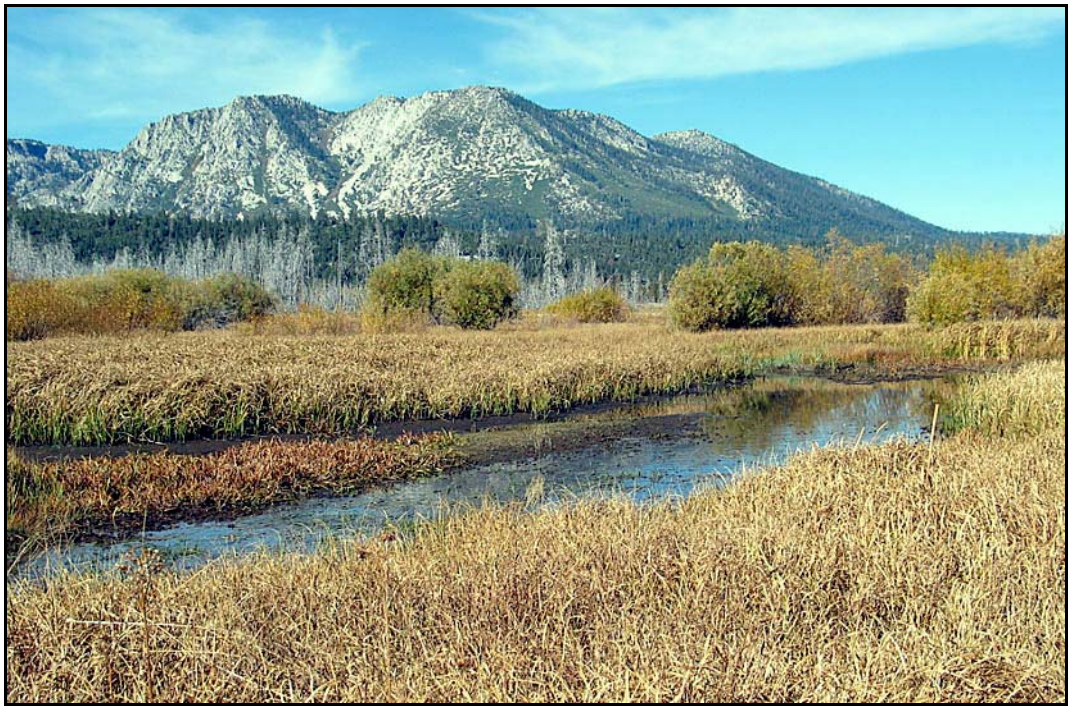
This community is characterized by a great diversity of species, with the most common genera including bentgrass (*Agrostis* spp.), sedges, rushes (*Juncus* spp.), hairgrass (*Deschampsia* spp.), and bulrush (*Scirpus* spp.) (Mayer and Laudenslayer 1988). A variety of perennial and annual wildflowers are abundant as well.

Montane meadow communities exist along a spectrum from wetter to drier conditions. In the focal study area, montane meadow can be sub-divided into three types that develop predominantly because of differing hydrological patterns: wetter meadow, drier meadow, and beach ridge meadow. These subtypes are evidenced by distinctive species compositions. At the wettest end of the spectrum, montane meadow may grade into emergent marsh. Near the lake, the same area may support montane meadow one year and open water aquatic habitat another, depending upon lake level. This oscillating pattern is discussed separately in the Lagoon section.

While the reconnaissance surveys conducted in 2003 provided a general understanding of the differences between the plant communities associated with Taylor and Tallac Creeks, no quantitative data is available to support those observations. The general impression was that the wetter meadow's species composition on Tallac Creek is less diverse and the vegetation is generally less robust. The wetter meadow on Tallac Creek ranges from sedge dominated to rush dominated while the Taylor Creek meadow includes areas dominated by hydrophytic

grasses as well. Overall, the species in the wetter meadow along Taylor Creek appeared more vigorous, and the meadow in general appeared to have a more complex arrangement of species. However, Tallac Creek supports a greater diversity of plant community types (i.e., includes drier meadow and beach ridge meadow) and a large complex of beaver ponds. Some of the observed differences may be because of grazing along Tallac Creek, but the meadow complex along Taylor Creek is generally wetter than that at Tallac Creek. Additional studies would be necessary to determine if there are significant differences between these two areas and identify potential causes.

WETTER MEADOW



Wetter meadow occurs in frequently inundated areas along Taylor and Tallac Creeks. Its landscape position is generally between higher elevation forested areas and shrub communities and the beach. An undulating series of remnant beach ridges form a number of swales that were dominated by wetter meadow in 2003, but were lagoon during wetter years. Wet meadow is dominated by a dense cover of herbaceous species and may include scattered shrubs such as willow and alder. The wetter meadow occurring adjacent to Tallac Creek appears to be less diverse and less robust in the areas that experience grazing and some small gullies have developed in a portion of this meadow type. Additional studies would be necessary to determine and assess these differences. In areas where standing water was receding, the edges and bottoms of these depressions were damaged by trampling. The drier edges of this meadow are dominated by lodgepole pine, and a few lodgepole seedlings were noted growing in the meadow along a fenceline. However, it does not appear that conifer encroachment is occurring in the meadow to any significant degree. The wetter meadow on Tallac Creek ranged from sedge dominated to rush dominated while the Taylor Creek meadow included areas dominated by grasses as well. Overall, the species in the Taylor Creek wetter meadow

appeared more vigorous. The dominant species grew to heights of four feet, while the species in the Tallac wet meadow grew only to heights of approximately two feet. Taylor Creek wetter meadow also appeared more heterogeneous with a complex arrangement of species.

Large homogenous stands of beaked sedge were observed along Taylor Creek in the deeper/longer-duration inundation portions of the wetter meadow. This plant association is characteristically supported by moving water and flows from subsurface and overland sources that typically cause conditions of permanent soil saturation. In the Tallac meadow, rushes appear to be the dominant species in the wetter communities near the mouth of the stream. However, in the vicinity of the beaver ponds, the wetlands more resemble the wetter meadows along Taylor Creek in that they include a diverse number of sedges, rushes, grasses, and forbs.

Dominant species found in the wetter meadows of Taylor Tallac Marsh included a suite of rushes and sedges including beaked sedge, slender-beak sedge (*Carex athrostachya*), lakeshore sedge (*Carex lenticularis*), inflated sedge (*Carex vesicaria*), Baltic rush, Coville's rush (*Juncus covillei*), iris-leaved rush, slender rush (*Juncus tenuis*), and Nevada rush. Dominant grasses included tufted hairgrass, mountain timothy (*Phleum alpinum*), Kentucky bluegrass (*Poa pratensis*), western bentgrass (*Agrostis exarata*), and ticklegrass (*Agrostis scabra*). Forbs included spiked checkerbloom (*Sildalcea oregona* spp. *spicata*), ranger's buttons (*Sphenosciadium capitellatum*), alkali marsh ragwort (*Senecio hydrophyllus*), long-leaf aster (*Aster acendens*), mint (*Mentha* spp.) and primrose monkeyflower. The areas of recently exposed mudflat were characterized by young willows, tufted hairgrass, toad rush (*Juncus bufonius*), narrow-leaved bur-reed (*Sparganium angustifolium*), needle spikerush, and yellow pond-lily. According to a study completed in 2000, a population of marsh skullcap (*Scuttelaria galericulata*), which is listed as a rare plant in California by the California Native Plant Society, was observed near the middle of Tallac wet meadow (LTBMU 2000).

Included in the areas mapped as wetter meadow are small areas of emergent marsh. Because of their small areal extent, these are not mapped separately. They form the wettest end of the wet-dry continuum. The classic concept of emergent marsh is tule and cattail dominated communities. These two species have very limited distribution, found only in small pockets. Cattails were observed more frequently than tule, though neither is common. When present, these two species are generally found along the downstream edges of Taylor Creek and in a small ditch-like feature in the southeastern portion of the wetter meadow surrounding Taylor Creek, which transitions from wetter meadow to lagoon in wet years.

DRIER MEADOW

A large dry meadow is present east of Tallac Creek (Exhibit 3.3-1). The dominant species in this area are primarily grasses and forbs including bentgrass, Idahoe fescue (*Festuca idahoensis*), annual hairgrass (*Deschampsia danthioides*), common timothy (*Phleum pretense*), yarrow (*Achillea millefolium*), slender cinquefoil (*Potentilla gracilis*), aster, and annual willowherb (*Epilobium brachycarpum*). Baltic rush is also a part of this drier community. This area appears to experience heavy grazing and much of the grass was eaten to the ground. The cover in the drier meadow area is not a dense as the wetter meadow, and bare areas were common.

BEACH RIDGE MEADOW

Along the current and remnant beach ridges, the dry, sandy conditions create a distinct vegetation pattern. Along the near-lake beach ridge, Baltic rush is the dominant species and typically forms a dense layer that bind unconsolidated sand. Baltic rush can withstand periodic flooding as well as prolonged periods of drought typical of this near lake environment. Baltic rush dominated areas may also include occasional silverleaf phacelia (*Phacelia hastata*) and silvery lupine (*Lupinus argenteus*). Some remnant beach ridges are sparsely vegetated by species such as Baltic rush, penstemon (*Penstemon* spp.), rabbitbrush, and include scattered lodgepole pines. Along the near shore beach ridges, adjacent to the wet swales, a few senescent willows are present. These willows are not reproducing, which may be associated with changes in the hydrology on the near-shore wet swales (Chapter 4). Some areas within the beach ridge meadow community are very open with large expanses of unvegetated sand. Repeated disturbance by human foot traffic, sewerline construction, and other maintenance activities have likely contributed to the currently sparse vegetative cover in this area.

PROCESSES

As indicated above, the species composition in montane meadow varies in a complex and dynamic fashion. The primary driver of plant association differences is generally considered to be ground water level in relation to ground surface elevation (i.e., hydrology and topography). Montane meadows in the Sierra Nevada typically occur in low landscape positions and frequently have poorly-drained soils that remain saturated throughout the growing season. Most vegetative growth occurs in spring and early summer with water derived from snow-melt. Growth is curtailed in the summer as available water decreases. The high groundwater table

that characterizes these meadows excludes the growth of most woody tree species, but lodgepole pine may persist along the drier margins.

A number of studies have demonstrated the relationship between water table patterns and the distribution of plant species in Sierra Nevada meadows (Allen-Diaz 1991; Halpern 1986; Heady and Zinke 1978). Heady and Zinke (1978) found no strong relationship between observed vegetation differences and soil texture, soil development, or pH in the Yosemite Valley meadows they studied. Rather they found drainage pattern and water table level to be the primary determinants of vegetation associations. Similarly, Halpern (1986) found that a complex moisture gradient based on water depth and movement, along with the degree of site exposure or shading, to be the most important variables for observed plant associations in the meadows of Sequoia National Park. Seasonal fluctuations of the water table were important in structuring vegetation.

Allen-Diaz (1991) conducted two years of ground water monitoring at Sagehen Creek Field Station, near Truckee, California. She identified a suite of distinctive groundwater table patterns that were correlated with plant community variation including high water table, low water table, and drawdown (i.e, sites that fluctuated between high and low water tables). Interestingly, Allen-Diaz found that the water table did not drop with increasing distance from the creek and therefore distance from the creek was not significantly related to observed groundwater pattern or vegetation pattern. She also found that sampling areas adjacent to each other along a transect did not necessarily have similar water table patterns. Seeps and springs occurred throughout the site, along with overland and underground water flows. She speculated that clay pans and other impervious layers may have caused perched water tables in some locations. The result was an intricate, complex water table pattern and associated vegetation pattern. She found, for instance, that tufted hairgrass and Nebraska sedge occurred at sites with the greatest water table fluctuation, while sites with sedges and Kentucky bluegrass had the smallest water table fluctuation.

The growth of meadow species typically follows the seasonal hydrological cycle. Spring snowmelt and rainstorms flood the meadows early in the growing season. As snowmelt decreases and average summer temperatures increase, groundwater levels begin to decline. During the later half of the summer, higher evapotranspiration rates may exceed water inputs causing a rapid drop in the water table. Some meadows may have an abundant supply of water and will remain saturated for the duration of the summer despite high evapotranspiration rates. In the late summer or fall, following a hard frost and plant senescence, evapotranspiration rates begin to drop and the water table typically starts to rise (Hagberg 2003).

Further, these spatial variations in soil moisture and depth to ground water are not static. Year-to-year fluctuations in precipitation and lake level will be reflected in surface and ground water patterns. A site in the meadow described as mesic one year may be classified as relatively dry during the following year. Some sedge and grass species are better adapted to these fluctuating moisture levels than others and therefore may persist through extreme wet/dry cycles, while others will be excluded. This process is occurring within the focal study area and

is a reason why the montane meadow is subdivided into wetter, drier, and beach ridge meadow.

At Taylor Tallac Marsh, there are important differences between the hydrologic regimes in the northern (lake-ward) portion of the wetland and the southern, with a large and dynamic area of interface and overlap between these two zones. Year-to-year variations in hydrologic patterns and their influence on vegetation are made more complex because meadow vegetation is influenced not only by stream flow and down-gradient ground water movement, but also by fluctuating lake levels. In the northern portion of the wetland groundwater level is predominantly set by lake level. The southern portions of the study area are outside this zone of strong lake level influence and are primarily driven by stream and ground water flows. Significant breaks in slope from upland to wetland, just beyond the upland forest communities, can be a significant source groundwater input. It was observed that the break in ground slope between the upland forest and the westernmost arm of Taylor Creek wetland had significant groundwater seepage in 1999 (LTBMU 2000).

As mentioned earlier, historic variations in climate conditions may also be important in creating existing patterns. Sometimes degradation apparently because of land uses practices may in fact reflect the site's climate history. Miller and Woolfenden (1999) examined the history of existing conditions of Glass Creek meadow in the eastern Sierra Nevada, southwest of Mono Lake. Previous investigators had concluded that the present-day meadow had fewer grasses and sedges, lower willow abundance, and more lodgepole pine invasion than expected. Those investigators attributed these differences to heavy impact by grazing and concluded the meadow was not functioning at its historical potential. However, pollen analysis of a sediment core extracted from the meadow showed no significant changes in meadow species composition over the last 500 years. No significant impact of the grazing era was evident in the pollen record. The authors also dated the lodgepole pine invasion of the meadow to around 30 to 45 years ago, possibly correlated with decadal-scale climate changes (i.e., drier conditions) but not with grazing history. The vegetation pattern within the focal study area is a reflection of the interaction between climate, environmental gradients (e.g., hydrology and soils), life history and recruitment, and land uses such as grazing.

At Taylor Tallac, some observable patterns may however be attributable to the site's history of grazing. Some montane meadow species are more tolerant of grazing pressures than others, and these more tolerant species are selected over time while the less tolerant species decrease in importance. Even though most sedge species are robust and well-rhizomed, many of them are not considered resistant to grazing pressure and other disturbances (Menke et al. 1996). Kentucky bluegrass, a nonnative perennial grass, is thought to proliferate with increased grazing pressure and replace native sedges and rushes. Because of the tufted nature of native bunchgrasses, they may be severely impacted by heavy grazing than turf-forming species. Some forbs such as common monkeyflower and primrose monkeyflower may be eliminated under grazing.

Grazing and other human activities, such as recreation, may also have introduced a number of nonnative species now found in Sierran meadows. Some of the common nonnative species

found in the meadow include redtop (*Agrostis stolinifera*), velvet grass (*Holcus lanatus*), common timothy, Kentucky bluegrass, bull thistle (*Cirsium vulgare*), common dandelion (*Taraxacum officinale*), salsify (*Tragopogon dubius*), English peppergrass (*Lepidium campestre*), white clover (*Trifolium repens*), sheep sorrel (*Rumex acetosella*), and curly dock (*Rumex crispus*). Most of these species are now considered somewhat naturalized such as Kentucky bluegrass and timothy. These species are now ubiquitous and have equilibrated with native species. Other species, such as bull thistle, are not as common but can be a persistent problem.

More details on the effects of grazing and other human activities on the wetland meadow are provided in Chapter 4.

3.3.10 BEAVER PONDS

ECOSYSTEM DESCRIPTION

Beaver activity in the lower watershed has created a system of ponds along all three of the major streams. The large beaver complex on Spring Creek is above SR 89, and is therefore not included in the discussion below. The other two beaver pond complexes are found in the focal study area. These shallowly ponded areas may be vegetated by aquatic or emergent vegetation and by scattered willows and alders, depending primarily on the depth and duration of flooding.

An extensive open water area has been created along Tallac Creek, clearly visible in aerial photographs of the site (Exhibit 1-3). The vegetation in these ponds is predominantly mare's tail (*Hippurus vulagaris*) and dying willows. Along Taylor Creek, a set of beaver dams is located

downstream of SR 89 in the alder scrub community but these dams have not created as large of a beaver pond complex as observed along Tallac Creek.

PROCESSES

Beaver are well known for their ability to significantly affect the landscapes they inhabit, including fostering the creation of meadows (Ives 1942; Naiman et al. 1988). Beaver modify stream morphology and hydrology by cutting wood and building dams. Impounding water behind dams changes the stream-discharge regime, decreases velocity, changes the channel gradient to a stair-step profile, expands the area of flooded soils, and increases the retention of sediment and organic matter (Naiman et al. 1988; Butler and Malanson 1995). Beaver sometimes dig canals to float cut logs to their ponds (Ives 1942). Stream channel alterations by beaver also modify the structure and dynamics of the riparian zone and may increase habitat for fish, waterfowl and other birds, amphibians, and other species (Medin and Clary 1990, 1991). The dams that beaver create allow water to percolate into the soil, creating moist habitats in the areas surrounding the dams. Habitat modifications by beaver have resulted in increased relative density of small mammal populations (Medin and Clary 1991) and increases in bird density, bird species riches, and diversity (Medin and Clary 1990), when compared to adjacent areas not influenced by beaver activity. Beavers have also been purposely used in restoration projects to improve hydrology, riparian vegetation, and wildlife habitat (Albert and Trimble 2000). Beaver dams clearly trap sediment, but, as Butler and Malanson (1995) point out, most measurements of trapped sediment in beaver ponds do not distinguish between that introduced by the incoming stream, and that created by the excavational activities of the beaver themselves. During large flow events, dams may fail and therefore could have the potential to introduce a flux of sediment and nutrients to the stream and lake.

Beaver dams along the Taylor and Tallac Creeks increase flooding in the meadow, increase ground water levels, and allow sediment deposition and uptake of nutrients by meadow plants. Along Tallac Creek, the large dam system along the upper segment of the creek has contributed to the expression of a confused distributary stream system downstream. Beaver are present along Taylor Creek as well, but do not appear to have as large of an influence in this area.

The history of beaver activity in the Taylor Tallac Marsh and their effects on adjacent plant communities over the last 60 years is discussed in the time series analysis in Chapter 4. Most scientists believe that beaver were introduced into the Sierra Nevada sometime between 1938 and 1946 (Beier and Barrett 1987; Trappe 1942). However, beaver are native to the Central Valley of California and on the Pit, Klamath, Shasta, and Trinity Rivers in northern California (Taylor 1916; Trappe 1942). Some have argued that beaver could have been found, though perhaps in low numbers, in other high elevation areas (e.g., Lassen Volcanic National Park). A report by the Cooperative Park Resources Study Unit concluded that beaver are not native to the Warner Valley in Lassen Volcanic National Park, though why they had not expanded their range into higher elevation areas was a mystery (Beier 1998). Tappe (1942) cited evidence that beaver were present in the upper Carson River watershed in the late 1800s. Tappe (1942) also describes a “planted colony of 4 beavers” on the headwaters of the Upper Truckee River. The

Forest Service transplanted these beaver from the Rogue River in Oregon to this site on the Upper Truckee River in 1938.

3.3.11 LAGOONS

ECOSYSTEM DESCRIPTION

Periodically, an open water lagoonal ecosystem is created by high lake levels, high groundwater levels, the pooling of surface water behind the barrier beach or a combination of these (Exhibit 3.3-1). Today, the presence and size of the lagoon depends largely on lake level. In 2003, the extent of this community was small (Exhibit 3.3-1). However, during wetter years, e.g., 2000, the area occupied by lagoon was more extensive (Exhibit 3.3-2). Theoretical inundation areas at various lake stands are presented in Chapter 2.

When water levels are shallow, the lagoon supports yellow pond-lily (*Nuphar luteum*) and other floating and submerged aquatic species such as aquatic buttercup (*Ranunculus* spp.) and pondweed (*Potomogon* spp.). When water levels are deeper, aquatic vegetation can not establish and the area is unvegetated. As water recedes, the lagoon becomes mudflats colonized by species common to the wetter meadow such as young willows, tufted hairgrass, toad rush, narrow-leaved bur-reed, and needle spikerush.

The nonnative Eurasian watermilfoil (*Myriophyllum spicatum*) has been reported from the mouth of Taylor Creek (LRWQCB 2002; Walter 2000). This invasive pest plant can build large populations, replacing native species and impacting aquatic ecology. The species prefers the calm water conditions typical of the lagoonal areas.

PROCESSES

As lake levels fluctuate from year to year, areas behind the barrier beach oscillate between lagoon and meadow. During wet years, low-lying swales are inundated and develop a floating and submerged aquatic vegetation community. During drier years, the water recedes and these former lagoon areas begin to support species common to the montane meadow. When first exposed, most of these areas are mud flats and devoid of vegetation. In a few months, however, plants begin to sprout and grow including grasses such as tufted hairgrass and ticklegrass as well as willow seedlings. When high lake levels return and a deep, open water lagoon returns the majority of vegetation will be killed, but their seeds may persist in the seedbank.

This sequence is represented in Exhibits 3.3-8 and 3.3-9. Near the mouth of Tallac Creek the lagoon is shallow, but wet enough to support pond lilies and submerged aquatic species. The lagoon near the mouth of Taylor Creek lacks floating aquatics (Exhibit 3.3-8). A swale behind the beach that supported lagoon over the summer becomes dry by fall and transitions to mudflat (Exhibit 3.3-9). Note the tufted hairgrass germinating along the drier edge. If dry for a significant period, the depressions in the lower marsh area that support lagoon in wet years will fill in with a mix of grasses, rushes, forbs, and shrub seedlings (Exhibit 3.3-9). Lake levels and drought cycles regulate the fluctuation between lagoon and montane meadow in the focal study area. This fluctuation between habitat types affects wildlife utilization of this area. Detailed studies would be necessary to determine other consequences of these fluctuations between habitat types.

Rejmankova et al. (1999) surveyed the vegetation of Pope Marsh from 1988 to 1996, a period encompassing a long drought (1988 to 1994) as well as the transition to higher lake stands at the end of the drought. In 1988, they identified four plant associations corresponding to water level. Baltic rush was dominant at high elevation, sandy sites; beaked sedge dominated somewhat lower but still relatively dry sites in the marsh; tule (*Scirpus acutus*) occupied the transitional area between shallow and deep water; and yellow pond-lily occupied the deepest water areas.

The authors' original hypothesis was that changing water levels would lead to plant species migration; that is, as water levels dropped, beaked sedge would move into the tule zone, and tule would move into the pond lily zone. Under increased water levels the direction of the migration would reverse. However, this was not observed. Rather, as the drought progressed, the growth of tule and yellow pond-lily were suppressed, but tule did not invade the pond lily zone. Over the long-term of the drought, yellow-pond lily and tule almost completely disappeared. After re-flooding, the yellow pond lily returned quickly, but tule did not. The dominance of Baltic rush and beaked sedge in their respective zones was largely unchanged and neither migrated into other zones (Rejmankova et al.1999). The authors suggest that a dense litter layer and light competition from pond lily leaves were among the factors inhibiting tule regeneration. Additional studies would be necessary to identify the precise habitat requirements of tule at the site, and the factors that inhibit its broader growth. In general, tule seems marginally adapted to growing conditions in the Basin. It was especially stressed by the

late-1980s-early 1990s drought. Experimental tule transplantation could be used to help determine requirements for tule persistence and growth. Tule plugs could be gathered from existing patches and transplanted to areas that either have the existing habitat requirements or areas that are created to incorporate these habitat requirements.

3.3.12 BEACH

PLANT COMMUNITY DESCRIPTION

The beach community occupies a narrow linear band adjacent to Lake Tahoe. Beach is defined here as the area of sandy substrate subject to wave action and exposed between high and low lake levels. The area above the elevation of maximum lake level and largely stabilized by vegetation is described in Section 3.3.9 under 'Beach Ridge Meadow'. The beach zone is characterized by expanses of unvegetated sand. Generally sparse vegetation occurs as linear rows corresponding to past lake levels. The beach plant community is typically dominated by herbaceous species, but a few trees and shrubs may occur as well. Common species include lupine (*Lupinus* spp.), roundfruit yellow cress (*Rorippa sphaerocarpa*), Tahoe yellow cress (*R. subumbellata*), and pussy paws (*Calliptridium umbellatum*). Willows and a few dead pines occur on the top of the barrier beach near the mouth of Tallac Creek and Baltic rush is common along the beach ridge near Taylor Creek. In between the two creeks, the beach ridge is dominated by scattered willow shrubs and some herbaceous undergrowth.

This community provides habitat for Tahoe yellow cress, a Tahoe Basin endemic that is state listed as Endangered. These populations are protected by enclosures that restrict access and prevent trampling. Some Tahoe yellow cress was observed growing beyond the protected area in the enclosures. In addition, the large sand bar controlling the outlet of Taylor Creek

appears to be migrating southwards, which is deflecting the outlet's left bank onto a raised beach ridge and causing accelerated erosion of an area that is Tahoe yellow cress habitat.

PROCESSES

Beaches along Lake Tahoe are formed as sand is carried down from streams and then reworked and deposited back onto the land by wave action. Beaches vary in size depending upon lake level and therefore the area offered for plant establishment can be extensive or limited. Plants found in these habitats have a number of adaptations that allow them to persist in the harsh conditions. These plants are often succulent with small leaves and deep root systems that can tap into the groundwater table. They also typically produce floating fruits. The regeneration of Tahoe yellow cress is closely tied to the fluctuations in lake level that open up large expanses of beach for colonization.

3.4 AQUATIC ECOSYSTEMS

This section provides baseline information on aquatic ecosystems in the Taylor, Tallac, and Spring watershed. The section is divided into two main subsections: 1) fisheries and 2) aquatic invertebrates. Each subsection provides a general overview followed by a more in-depth assessment of conditions and processes in the study area including an analysis of factors affecting species abundance and distribution.

3.4.1 FISHERIES

FISH OF THE TAHOE BASIN

A total of seven native fish species occur in the lakes and streams of the Tahoe Basin (Table 3.4-1) (Murphy and Knopp 2000). All of these species also have been documented to occur or have the potential to occur in the study area watershed (Murphy and Knopp 2000, Muskopf unpublished data). The general abundance of the native fish community has declined considerably since the arrival of Euro-Americans to the Lake Tahoe Basin. It is believed that several factors have contributed to the decline or extinction of native fish and the degradation of fish habitat in the Tahoe Basin. Extensive logging, water diversions, intense grazing, commercial harvest, road building, and the introduction of nonnative fish and other aquatic organisms are believed to have cumulatively contributed to the change in the Tahoe Basin's fisheries composition and degradation of fish habitat (SNEP 1996, Murphy and Knopp 2000). Since the Comstock Era (circa 1860), 20 additional species of nonnative fish have been introduced into Lake Tahoe's aquatic communities (Table 3.4-1) (Murphy and Knopp 2000). The variety of fish introduced into the Tahoe Basin is the result of numerous attempts by state agencies and anglers to establish sustainable commercial and recreational fisheries. The introduction of nonnative fish has greatly influenced the native fish community. Summarized species accounts are provided for all native and selected important nonnative fish species that occur, have the potential to occur, or potentially significantly affect fish communities in the study area watershed.

Table 3.4-1 Fish Species in the Tahoe Basin	
Common Name	Scientific Name
Native Fish Species	
Lahontan cutthroat trout	*Oncorhynchus clarki henshawi*
Mountain whitefish	*Prosopium williamsoni*
Tahoe sucker	*Catostomus tahoensis*
Paiute sculpin	*Cottus beldingi*
Lahontan speckled dace	*Rhinichthyes osculus robustus*
Lahontan redside	*Richardsonius egregious*
Tui chub	*Gila bicolor*
Nonnative Fish Species	
Lake trout	*Salvelinus namaycush*
Rainbow trout	*Oncorhynchus mykiss*
German brown trout	*Salmo trutta*
Brook trout	*Salvelinus fontinalis*
Kokanee salmon	*Oncohynchus nerka*
Golden trout	*Salmo aquabonita*
Chinook salmon[1]	*Oncorhynchus tshwaytscha*
Atlantic salmon[1]	*Salmo salar*
Arctic grayling[1]	*Thymallus arcticus*
Lake whitefish	*Coregonus clupeaformis*
Largemouth bass	*Micropterus salmoides*
Smallmouth Bass	*Micropterus dolomieu*
Bluegill	*Lepomis macrochirus*
Brown bullhead catfish	*Ictalurus nebulosus*
Black crappie	*Pomoxis nigromaculatus*
White crappie	*Pomoxis annularis*
Golden shiner	*Notemigonus crysoleucas*
Goldfish	*Carassius auratus*
Carp	*Cyprinus carpio*
Mosquito fish	*Gambusia affinis*
Source: Moyle 2002, Dill and Cordone 1997, Schlesinger and Romsos 2000 [1] Not currently present, extirpated since introduction.	

Native Fish Species

The Lahontan cutthroat trout (*Oncorhynchus clarki henshawi*) is the only native salmonid to lakes and streams in the Lahontan Basin. Of all of the native fish species, Lahontan cutthroat trout were especially revered by Native Americans because they provided ample food for their people. In the late 1800s and early 1900s the Lahontan cutthroat trout supported a commercial fishery in the Tahoe Basin that supplied markets as far away as San Francisco. The fishery was in decline during the 1920s and finally collapsed in the early 1930s (Cordone and Frantz 1966). By 1939, the Lahontan cutthroat trout was extirpated from the Tahoe Basin. The failure of this fishery and its extirpation were the result of over-harvesting, habitat degradation, and the introduction of nonnative fishes (Moyle 2002). Numerous attempts have

been made to reintroduce this native trout into the Tahoe Basin. Between 1956 and 1964, Lahontan cutthroat trout (from Independence Lake strain reared in Heenan Lake in Alpine County, California) were planted annually in Taylor Creek and in headwater streams of the Upper Truckee River (Cordone and Frantz 1966). In 1970, the Lahontan cutthroat trout was listed as Federally Endangered, but was reclassified as Federally Threatened in 1975 to facilitate its management and allow angling (Benke 1992).

Numerous efforts are under way to restore Lahontan cutthroat trout populations in streams and small lakes. Reintroduction efforts in the Tahoe Basin have been hampered by the presence of nonnative trout (see below) which compete with, predate upon, and/or hybridize with Lahontan cutthroat trout (Rischbieter 1990a and Moyle 2002). Consequently, these projects often involve efforts to eradicate nonnative trout above natural or human made barriers prior to reintroduction. Lahontan cutthroat trout were planted into headwater streams in the Upper Truckee River watershed in 1990, following attempts to eradicate brook trout from the watershed using rotenone (fish toxicant) in 1988 and 1990. Additionally, significant numbers of Lahontan cutthroat trout were stocked into lakes in the Upper Truckee River watershed between 1996 and 2001. In 2001, the California Department of Fish and Game (DFG) curtailed planting all trout, including Lahontan cutthroats, in backcountry lakes and streams in the Sierra Nevada above 5,000 feet elevation because of concerns over their impact on native amphibians, particularly, the mountain yellow-legged frog (*Rana muscosa*) (Knutson, pers. comm., 2005; Lehr, pers. comm., 2005).

Fallen Leaf Lake has been stocked with Lahontan cutthroat trout from 2002 through 2004 as part of a collaborative interagency adaptive management effort undertaken to foster the greater Lahontan cutthroat trout restoration effort (Allen et al. 2004). With funding from the US Fish and Wildlife Service and support from the California Department of Fish and Game (DFG), Forest Service, California Trout Unlimited, and the Fallen Leaf Lake Homeowners Association; the University of California- Davis, Tahoe Research Group, and University of Wisconsin- Madison, began a food web study designed to evaluate the factors inhibiting successful Lahontan cutthroat trout recovery in a lacustrine (lake) environment. Early results of the study are showing promise for establishing Lahontan cutthroat trout in Fallen Leaf Lake through stocking adult fish (Allen et al. 2004).

The mountain whitefish (*Prosopium williamsoni*) are native to lakes and streams of western North America including the Tahoe Basin. Adults are typically 10 to 16 inches in length and spawn in the fall or early winter. Lake dwelling individuals may spawn in the shallow littoral zone in lakes or among gravel, cobble and boulders in riffles of tributary streams. Mountain whitefish spend much of their time near the bottom of streams and feed mainly on aquatic insect larvae. These fish were an important food fish for Native Americans (Moyle 2002). Their current distribution throughout the Tahoe Basin is poorly documented and generally believed to be less abundant and less widely distributed relative to historic levels. The reasons for decline are unclear; however, construction of dams and predation on whitefish fry by alien trout species are believed to be possible causes (Moyle 2002). Whitefish are observed every spring in Tahoe City Marina and have been sampled in Fallen Leaf Lake (Allen, pers. comm., 2005). Forest Service reports

that Taylor Creek was the last know tributary to have a whitefish population (Muskopf, pers. comm., 2005).

The Tahoe sucker (*Catostomus tahoensis*) is native to lakes and streams in the Lahontan Basin. In the Tahoe Basin, suckers can spawn in the Lake or tributary streams such as Taylor and Tallac creeks. In streams, spawning generally occurs in runs or areas of small gravel in pools. Juveniles prefer pools and deep runs with abundant cover (Moyle 2002).

The Paiute sculpin (*Cottus beldingi*) is the only sculpin native to the Lahontan Basin, including the Truckee, Carson, Walker, Quinn, and Humbolt River watersheds. This species inhabits streams with slight to moderate current and is found in riffle areas among rubble or large gravel. It also occurs in lakes. In Lake Tahoe, Paiute sculpins spawn in the spring. Eggs are laid in clusters on the undersides of rocks and are guarded by the male. Their food consists of a variety of aquatic invertebrates. This sculpin is an important prey item for some species of trout (Moyle 2002).

The speckled dace (*Rhinichthyes osculus*) is the most widely distributed fish in western North America. Lahontan speckled dace (*R. o. robustus*) occurs throughout streams and lakes in the Lahontan Basin and is the only sub-species native to the Tahoe Basin. Speckled dace may spawn either in shallow waters of the littoral zone in lakes or among gravel areas in riffles in tributary streams. In streams, fry concentrate in warm shallows, particularly between large rocks or among emergent vegetation. Adults prefer large substrates with interstitial spaces, shallow rocky riffles and runs, and submerged vegetation or tree roots (Moyle 2002).

The Lahontan redside (*Richardsonius egregious*) is native to streams and lakes in the Lahontan Basin, including Truckee, Walker, and Carson River watersheds. Spawning occurs in the littoral zone (<1 m deep) in lakes, or among gravel and cobble substrate in tributary streams. In small streams, adults associate with high velocity water along the stream margin or in backwater areas (Moyle 2002).

The tui chub (*Gila bicolor*) is native to streams and lakes in the Lahontan Basin, located in northeastern California and west-central Nevada. Two subspecies of tui chub are reported to occur in the Tahoe Basin: the Lahontan lake tui chub (*G.b. pectinifer*) and the Lahontan stream tui chub (*G.b. obesa*). The pectinifer form is a pelagic fish that feeds on zooplankton in the open waters of Lake Tahoe. The obesa form is a benthic fish that feeds on bottom invertebrates in Lake Tahoe and tributary streams. The two forms are difficult to distinguish between because of slight variations in morphology and are often more reflected in the different habitat preferences. Spawning generally occurs over sandy bottom or in the mouths of tributaries. Larvae of both forms will eventually move out of the nursery areas and into their respective habitats (Moyle 2002).

Nonnative Fish Species

Lake trout (*Salvelinus namaycush*) from the Great Lakes were introduced into Lake Tahoe in 1886 by the Nevada Fish Commission to establish a sport fishery (Moyle 2002). The California

Fish Commission planted 217,800 fish between 1895 and 1899. By the 1920s and 1930s, lake trout had become the top predator and primary sport fish in Lake Tahoe. Lake trout were also planted in Fallen Leaf Lake around the same time they were planted in Lake Tahoe and are currently part of the recreational fishery. Competition, predation, and diseases from introduced lake trout were presumably important factors in the extirpation of Lahontan cutthroat trout in Lake Tahoe (Moyle 2002).

Rainbow trout (*Oncorhynchus mykiss*) were first introduced into Lake Tahoe in the late 1800s. Between 1960 and 1964, three wild strains of rainbow trout (Pyramid Lake, Nevada; Williams Lake, Idaho; Kamloops Lake, British Columbia) were introduced to determine which strain exhibited the highest potential for developing into a premium sport fishery. Although none of the plants were considered successful, the Kamloops strain showed the most potential (Cordone and Frantz 1968). However, the cost of developing a trout fishery using the Kamloops strain was too expensive and the program was discontinued. Currently, large numbers of domestic hatchery-raised rainbow trout are planted annually into Lake Tahoe. Rainbow trout have been recently observed in Taylor and Tallac creeks (Muskopf unpublished data). Rainbow trout have the potential to affect Lahontan cutthroat trout through competition, predation, and hybridization.

Brown trout (*Salmo trutta*) were introduced into eastern North America from Europe and from there into California in 1893 (Dill and Cordone 1997). It is likely that this fish was introduced into the Tahoe Basin shortly after its first planting in other parts of California. Brown trout are fall spawners and have the potential to affect cutthroat trout through predation and competition. Brown trout currently inhabit Taylor Creek (Muskopf unpublished data).

Brook Trout (*Salvelinus fontinalis*) are native to eastern North America and were first brought to California in 1871 and maintained in hatcheries operated by the California Acclimatization Society (Dill and Cordone 1997). They were soon planted in numerous streams and lakes throughout California. The timing of the first introduction of brook trout into the Tahoe Basin is undocumented. DFG stocking records indicate that brook trout were planted in 1950 and 1952 and a small number were planted in 1969. Large numbers of brook trout were planted directly into Lake Tahoe from 1953 through 1958 (Cordone and Frantz 1968). Brook trout introductions can fundamentally change alpine lake and stream ecosystems. Brook trout have eliminated yellow-legged frogs, other amphibians, and large invertebrates through predation. Brook trout have also been documented to contribute to elimination of native cutthroat trout through competitive interactions (Moyle 2002). Brook trout are known to inhabit Tallac Creek (Muskopf unpublished data).

Kokanee salmon (*Oncohynchus nerka*) were introduced into Lake Tahoe in 1944 when kokanee at the Tahoe Hatchery (near Tahoe City) were released into a small stream that drains into the lake (Fraser and Pollitt 1951). Between 1949 and 1955, kokanee fry were stocked annually by the DFG and the Nevada Fish and Game Commission into numerous tributaries of Lake Tahoe to establish a sport fishery (Cordone et al. 1971). This stocking program produced spawning runs during the 1950s. However, nearly all of these runs declined following cessation of the program in 1954, and currently only Taylor Creek supports a fall run.

Spawning occurs between late September and late November, although most takes place in early October (Beauchamp et al. 1994). Sustainability of the Taylor Creek run is principally the result of good quality spawning gravel, and artificially enhanced fall flows made possible by releases from Fallen Leaf Lake (discussed in additional detail below). Spawning runs have ranged in size from a low of 474 in 1952 to a high of 25–30,000 fish in 1964. Spawning fish generally live 2-4 days in Taylor Creek, which is fairly typical for these species (Beauchamp et al. 1994). Kokonee impact on native fishes, such as tui chubs and Lahontan cutthroat trout, is not known but is probably negative (Moyle 2002). More so, the management of flow releases for this species may be causing negative impacts on native fishes in this watershed.

More recently, several warm-water fishes (bluegill [*Lepomis macrochirus*], largemouth bass [*Micropterus salmoides*], smallmouth bass [*Micropterus dolomieu*], and brown bullhead catfish [*Ictalurus nebulosus*]) have appeared in Lake Tahoe and some tributary streams including Taylor and Tallac creeks (Moyle 2002, Muskopf unpublished data). Their impact on other fishes and invertebrates occupying the lower reaches of Taylor and Tallac creeks is unknown at this time; however, these introductions likely have an adverse effect on native fishes (and possibly amphibians and invertebrates) that use the lower gradient cool- and warm-water habitats in the focal study area.

FISHERIES IN THE STUDY AREA

Fisheries Survey Results

A recent fish survey (snorkel survey) of Taylor and Tallac Creeks was conducted in 2004 (Muskopf unpublished data). Fish sampling locations in Taylor and Tallac Creeks are illustrated in Exhibit 3.4-1. A summary of the sampling results is provided below (Table 3.4-2). Analysis of potential factors affecting abundance and distribution of fish species is also provided.

Table 3.4-2
Summary of 2004 Fish Sampling In Taylor and Tallac Creeks

Species Sampled	Tallac Creek (# observed)	Taylor Creek (# observed)
Lahontan Cutthroat Trout[1]	0	0
Brook Trout	701	0
Brown Trout	0	379
Rainbow Trout	1	669
Brown Bullhead Catfish	6	37
Largemouth Bass	6	4
Bluegill	3	5
Lahontan Redside	0	236
Lahontan Speckled Dace	801	3,176
Tui Chub[2]	4	0
Tahoe Sucker	0	18
Unkown species	0	1

Source: Muskopf unpublished data
[1] Not observed
[2] Subspecies not determined

Fish assemblages in the two creeks varied significantly despite their proximity in the same watershed. The difference in fish assemblage between the two creeks is likely attributed to the difference in flow and stream habitat characteristics described below. The primary similarity between the two creeks was relative abundance, which was dominated by speckled dace (65% of all fish sampled) in both creeks.

A total of 1,522 fish (seven different) species were sampled in Tallac Creek. Brook trout were the second most abundant fish documented with only one other salmonid (rainbow trout) being observed. Most of the brook trout (70%) were identified as young of the year (YOY). Bluegill, largemouth bass, and catfish were all documented in relatively low numbers. Four tui chubs were also sampled.

Distribution of the different species was fairly distinct and appears to be governed by habitat requirements and morphological characteristics. Bluegill, largemouth bass, and catfish were all found at the lower-most sampling location, Tallac-1 (lagoon habitat) (Exhibit 3.4-1). The four tui chubs were also sampled at the Tallac-1 location. The brook trout were the only species documented in upper sampling locations.

The fish assemblage in Taylor Creek was documented to be much larger. A total of 4,525 fish (eight species) were sampled. Rainbow trout followed by brown trout were documented as the second and third most abundant fish, respectively. Lahontan redside were also observed in relatively high numbers. The three warm-water nonnatives (bluegill, largemouth bass, and catfish) were sampled with the catfish documented at significantly higher numbers compared to the other two species. A total of 18 Tahoe suckers were also noted.

Fish species distribution in Taylor Creek was much more evenly divided throughout the area sampled with no clear longitudinal trends. The only exception was catfish and largemouth bass which, like Tallac, were only found in the lower-most sampling location in the creek (lagoon habitat).

FACTORS AFFECTING ABUNDANCE AND DISTRIBUTION OF FISH SPECIES

Fish and aquatic invertebrate communities in aquatic ecosystems are determined by several factors. The size and composition of a community is governed by habitat type, quantity, and quality; historical events of geomorphic change and evolution, natural invasion, geographic isolation and breakdown, and human introductions. The number and kinds of species can be attributed to several ecological mechanisms: dispersal, physiological tolerances, biological interactions among species, and environmental disturbances. Typically biological interactions (e.g., predation and competition) are important community structuring agents in physically stable and complex aquatic systems, whereas the ability to disperse and colonize may be more important in aquatic environments subject to harsh recurrent disturbances (Schlosser 1987). Species distribution across varying habitat types is typically attributed to specific habitat requirements and morphological characteristics.

Aquatic habitats in the focal study area include streams, springs and seeps, beaver ponds, lagoons and the Lake Tahoe shorezone. A description of each aquatic habitat and the ecological processes that affect abundance and distribution of fish species is provided for each.

Streams

Primary streams in the project area include Taylor, Tallac, and Spring Creeks. Primary ecological processes that affect abundance and distribution of fish species in stream ecosystems include streamflow patterns, geomorphic conditions and physical habitat, and fish community interactions.

Streamflow patterns in particular play a significant role in determining the characteristics of all other factors. Streamflow patterns are important in driving geomorphic processes that in turn create, maintain, and/or change aquatic habitats. Pool, riffle, and run habitat types and substrate composition are directly influenced by fluvial geomorphic processes and associated streamflow patterns. Streamflow patterns also dictate the abundance and types of organisms present in a system. Both the flow needs for sustaining fisheries and other aquatic life, and the amount, timing and variability of flow are important in relation to the overall ecosystem function. Salmonids such as the Lahontan cutthroat trout require sufficient flows (and temperature) to queue spawning and to provide spawning habitat. Eggs require sufficient flows during the incubation period to prevent egg exposure to freezing or desiccation, and to provide necessary water quality and temperature conditions. Rearing juveniles and adults both require flows necessary to maintain suitable water temperatures and dissolved oxygen concentrations.

Physical attributes and processes of the streams in the project study area were analyzed in the geomorphic assessment (Chapter 2). A general overview of stream habitat types and attributes for Tallac and Taylor creeks were derived from the generalized assessment of channel conditions.

Tallac Creek

The general streamflow patterns in Tallac and Spring creeks are typical of Tahoe Basin tributaries and are influenced by winter snow storms and snow pack accumulation followed by spring warming and runoff. Occasionally the winter snow pack is greatly reduced by warm storms in mid-winter that rapidly melt the snow pack and cause flooding.

The upper watershed of Tallac Creek was noted to be very steep and dominated by debris flows and channel erosion and deposition. Habitat in this reach of the creek appears to be steep boulder step-pools that may act as fish passage barriers under different flows. Downstream of Highway 89, the channel grade flattens out and is dominated by a series of beaver dams that are trapping sediment. The braided channels present in this area are likely the result of all of theses processes (debris flows, change in channel grade, and beaver dams trapping sediment) potentially combined with historical grazing and agricultural management activities (see Chapter 2).

The fish assemblage in Tallac Creek is typical of many Tahoe Basin tributary streams and is likely the product of natural flow regimes, geomorphic instability (see Chapter 2) of the drainage, and species (native and nonnative) presence in the vicinity.

The native and nonnative fishes of Tallac Creek as well as other Tahoe Basin streams are morphologically diverse and this characteristic dictates the their distribution across habitat types. Headwaters with fast, shallow water usually contain only trout. Most commonly brook trout are found in high gradient streams and are replaced by brown and rainbow trout at lower elevations. In addition to typically being present in high elevation streams, brook trout are extremely prolific and better adapted to redistribute and survive in less stable aquatic environments that are subject to reoccurring disturbances.

In general the first species other than trout to occur heading downstream is sculpin. As gradients decrease and pools and runs become more common, Tahoe sucker and speckled dace become more abundant followed by Lahontan redside in deeper pools. Tui chub are also found inhabiting this type of stream habitat, although, typically associated with larger stream systems (Moyle 2002).

Taylor Creek

Streamflow patterns in Taylor Creek below Fallen Leaf Lake are regulated by releases from Fallen Leaf Lake Dam. Strict operating guidelines for managing lake levels were established in a Memorandum of Understanding (MOU) between the Forest Service and Fallen Leaf Lake Protection Association, 1972 (MOU) and Amendments (1987). Minimum instream flows are managed under a separate MOU between the Forest Service and DFG. Instream flows are managed for the following different prioritized beneficial uses (Hanes 1981):

1. Maintenance of the kokanee salmon fishery. Instream flows are required from October through March to provide for spawning habitat, egg incubation, fry development and migration into Lake Tahoe.

2. Maintenance of bald eagle habitat. The bald eagle rely on the Taylor Creek kokanee fishery as a food source during and after the spawning run. Continuance of the kokanee fishery will provide needed habitat for the endangered species.

3. Maintenance of aquatic ecosystems.

4. Operation of the Forest Service Stream Profile Chamber. The chamber, located in the Forest Service visitor center adjacent to Taylor Creek, consists of a man-made diversion channel and pond. It provides exhibits and an underwater-level view of aquatic ecosystems and the kokanee spawning run. Water is needed from Taylor Creek to provide aerated water at temperatures similar to that in the creek itself.

5. Maintenance of brown and rainbow trout fisheries. Flow is needed to provide for spawning habitat, egg incubation, and fry and fingerling habitat.

6. Recreation and aesthetics. Property adjacent to Taylor Creek is entirely in the public domain under the management of the Forest Service. Numerous Forest Service recreational facilities in the area give rise to heavy use of the Taylor Creek stream environment zone for such uses as sightseeing, hiking, biking, picnicking, nature study, cross country skiing, and fishing.

Attempting to provide for the multiple beneficial uses has led to many past problems with management of the Fallen Leaf Lake. Two of the uses, flood control and management of flows for the kokanee fishery appear to be incompatible. Lowering flows in the fall to provide storage for flood control results in less water availability for kokanee egg incubation. Conversely, conserving flows for maintenance of the fishery results in increased risk associated with reduced flood storage capacity to attenuate flood flows. Fluctuating management direction and the lack of knowledge as to water resources of the adjoining basin have led to less than optimum management of the water resources (Hanes 1981). In addition, management of instream flows to benefit the fall spawning kokanee may be detrimental to spring spawners such as Lahontan cutthroat trout. However, the relatively high numbers of rainbow trout, also a spring spawner, sampled in Taylor Creek (see Table 3.4-2 above) contradict this theory.

Taylor Creek was noted to be more stable upstream of the focal study area and below Fallen Leaf Lake and appeared to be functioning well with an abundance of high quality step-pool aquatic habitat. Downstream of Highway 89, Taylor Creek is also influenced by beaver dams that create associated ponds. Beaver pond habitats and associated ecological processes are discussed further below.

The species, distribution, and numbers documented in Taylor Creek are qualities indicative of the much steadier, managed nature of this creek. Managed flow releases from Fallen Leaf Lake Dam combined with more stable geomorphic conditions (Chapter 2) may allow for higher numbers of fish to be evenly distributed throughout the more established and less dynamic habitats of Taylor Creek.

The limited data on fish populations present in Taylor and Tallac Creeks makes it difficult to draw specific conclusions on the possible effects of management activities and the precise reasons for presence and/or absence of a given species. Generally, the species abundance and distribution observed in Tallac and Taylor creeks is expected given the existing conditions. Habitat alterations, introductions of nonnative species, and habitat niche use are all factors that can generally be attributed to the fish assemblage in the study area.

Stream habitat quality in the study area watershed appears to be generally good and supports a relatively diverse assemblage of native and nonnative fish species. The primary habitat alteration is one related to flow and results from the artificial flow releases from Fallen Leaf Lake into Taylor Creek. While there is little doubt that the fall spawning kokonee population in Taylor Creek benefits from the management of flow releases from Fallen Leaf Lake, it is not clear how the managed releases are affecting other species that are present in the creek. Reintroduction and recovery of Lahontan cutthroat trout in Taylor Creek would likely require a change in this management (Allen, pers. comm., 2005).

Introduction of nonnative fish species can have varying effects on native fish species in the study area. Introduction of warm-water predator species, such as largemouth bass, have been documented to significantly impact native fisheries through predation. Introduction of other nonnatives such as catfish and bluegill can clearly have negative effects through habitat disruption and competition mechanisms. All of these types of effects are typically prevalent in lentic environments and thus the consequence of these species in the study area streams may be less pronounced. With the exception of the lagoon and beaver pond habitats (see below), the study area creeks consist of relatively swift, cold-water pool and riffle habitats. These habitats are not favorable for the species noted above and thus their direct effect throughout the stream ecosystem is likely to be minor. Indirect effects resulting from these species utilizing the lower beaver pond and lagoon habitat niches, however, could be much more important and would require additional study in order to fully understand the larger implication of these interactions.

The effects resulting from the introduction of cold-water nonnative fish such as rainbow, brown and brook trout are more direct. As stated above, a primary cause of Lahontan cutthroat trout decline is due to interactions (predation, competition, and hybridization) with alien trout (Moyle 2002). Rainbow, brown and brook trout have similar habitat requirements to native Lahontan cutthroat trout and therefore are well suited to the aquatic environment of the study area streams. The similar habitat requirements for both native and nonnative species presents challenges in evaluating and implementing management strategies geared to encourage restoration of native Lahontan cutthroats and discourage presence of nonnatives.

Springs and Seeps

The ecology and biodiversity of springs and seeps in the greater Taylor, Tallac, and Spring watershed ecosystem have not been documented, however, it can be assumed that their function is important to aquatic and terrestrial habitats in the study area. Spring Creek takes its name from the springs that provide its source, and their generally perennial nature forms an important contribution to Tallac Creek's baseflow. In the focal study area, springs and seeps are found, at least temporarily, along the break in slope where the remnant moraine meets the lower elevations of the meadow and probably also contribute to groundwater conditions supporting aspen in these locations.

The ecology of small springs and seeps in general has not been well studied, but there has been an increase in interest in recent years. In 2002, the Desert Research Institute organized a symposium on spring-fed wetlands (DRI 2001) and in the same year springs and seeps were the focus of a special session at the Ecological Society of America meetings (ESA 2002). Many small springs in the Sierra and the Great Basin harbor endemic species of invertebrates (Erman 1996, 2001). In the focal study area, springs and seeps are also likely important components of habitat for native amphibians. Management activities in the focal study area that may result in effects to groundwater quality and levels could have an impact on springs and seeps; however, the incidence and/or extent of this cause and affect relationship is unclear.

These groundwater connections are primary sources of hydrology supporting perennial streams and are vital to maintaining riparian ecosystems. Fish populations rely on springs and seeps to provide cold baseline flows to creeks, especially during dry summer months. Aquatic invertebrates also are believed to rely on springs and seeps to provide habitat quantity and quality, and input of primary production. Wetland communities associated with natural springs typically have a high amount of organic accumulation and support a wide variety of species locally and downstream.

Beaver Ponds

A general description of beaver pond locations and their ecological characteristics and processes in the project study area is provided in Section 3.4.10.

Ecologists commonly call beaver "ecosystem engineers" because these animals physically alter habitats by cutting down trees, building dams, digging canals and building lodges. In doing so, beaver change the distribution and abundance of many other animals and plants, mostly by indirect interactions. Before the beaver dam is built, streams are typically dominated by lotic (fast-water) conditions. After the beaver dam is built and an impoundment (pond) of water forms behind it, lentic (slow-water) conditions replace the lotic conditions. These significant changes in the physical environment can greatly affect the related biological and chemical processes that govern the ecosystem dynamics.

Positive and negative fish responses to beaver pond development in streams can vary widely depending specific circumstances. Pool-like habitats and backwaters associated with beaver ponds offer deep water and low-velocity conditions that are the winter habitat choice for many stream fishes. The use of beaver ponds for overwintering has been noted for several salmonids including cutthroat trout, brook trout, rainbow trout, and salmon (Chisholm et al. 1987, Jakober 1995, Cunjak unpublished data, and Nickelson et al. 1992). The deeper water in the ponds, and in the adjacent flooded backwaters, provides the requisite space where fish can aggregate and swim, even beneath a complete ice cover. Conversely, beaver dams can pose an impediment to fish migration and therefore block upstream habitat that may be crucial for spawning success of certain species. Forage availability (see Section 3.4.2 below) and associated predator-prey dynamics can shift as a result of beaver ponds. At least two species of trout (brown trout and brook trout) have been documented to live primarily on pond invertebrates in beaver ponds. Rainbow trout living in beaver ponds, however, have been documented to still rely on stream invertebrates for food (Gard 1961 cited in Cunjak 1996). In a stream with several beaver ponds, rainbow trout may be at a disadvantage when competing with brown trout and brook trout.

Two sample sites along Tallac Creek, Tal-12 (mainstem Tallac) and Tal-44 (Spring Creek beaver ponds) were noted as beaver ponds. Only brook trout were observed at the two sites. A total of 43 fish were observed in Tal-44 with 29 of these individuals recorded as YOY fish. Twelve of the remaining fish were documented as juveniles and 4 as adults. Two fish were observed at the Tal-44 site which is located higher in the drainage. Both of these fish were identified to be YOY. These results are fairly expected as brook trout are typical inhabitants of

beaver pond habitat in mountain streams. Specific effects of beaver pond habitat on native Lahontan cutthroat trout are unknown; however, the presence of competing brook trout in the watershed and specifically in this habitat type can be assumed to be detrimental.

While the survey data does not suggest it, beaver ponds may also be favorable to the success of introduced nonnative warm-water species in the study area such as bluegill, catfish, and largemouth bass. Beaver ponds may provide velocity refugia for these nonnative species which, without beaver ponds present, may be washed out of the creek during high flows. Increased temperatures associated with the standing water in beaver ponds may also give these fish an advantage. These factors may provide a specialized habitat niche for introduced species in the study area watershed.

Lagoons

A general description of lagoon locations and their ecological characteristics and processes in the project study area is provided in Section 3.4.11. Understanding specific fish use of the lagoons in the study area is limited to a single sample for each creek.

The lagoon ecosystem is the most lake-ward portion of the stream and includes the stream mouth and intermittently inundated portions of the beach and shorezone. The mouth of both Taylor and Tallac Creeks close periodically when barrier beaches are formed. Breaching of the mouth typically occurs naturally in Tallac Creek during spring runoff events. The mouth of Taylor closes less frequently then Tallac due to littoral processes, but does periodically close during periods of lower flows. When the mouth does close, it is artificially breached in the fall by LTBMU personnel to accommodate kokanee salmon runs. Due to limited data, the effect of these processes on fish and aquatic invertebrates in the focal study area is not well understood.

Lagoon habitat may provide intermittently available suitable rearing habitat for Lahontan redside, Lahontan speckled dace, and Tahoe sucker as well as nonnative warm-water species. Young Lahontan stream tui chub are also likely to associate with the seasonally available lagoons. In streams, they prefer calm water with well-developed beds of aquatic plants growing in sand or fine substrate. In streams, young Lahontan redside prefer quiet water along edges or in backwater, and often with floating debris on the surface. Young Lahontan speckled dace are known to use shallow-calm swampy coves with an accumulation of floating debris (Moyle 2002).

Tay-1 and Tal-1 sampling sites were both noted as lagoons for the associated Taylor and Tallac Creeks. A total of 670 fish were observed in Tay-1 and 60 fish in Tal-1 (see Table 3.4-2 above). Of the 670 fish in Tay-1, 625 were speckled dace, 37 were catfish, 4 were rainbow trout, and 4 were largemouth bass. Of the 60 fish observed at the Tal-1 site, 40 were speckled dace, 6 largemouth bass, 6 catfish, 4 tui chub, 3 bluegill, and 1 rainbow trout. These results are all expected considering the presence of these species in the watershed and general vicinity. Bluegill, largemouth bass, and catfish are aggressive warm-water species that are likely outcompeting and predating upon native species, such as tui chub.

Lake Tahoe

The ecosystem of Lake Tahoe as it relates to the focal study area is limited to the shallow water habitats of the shorezone. This area of the lake generally receives the greatest concentration of human activity, including intense recreation, commercial interests, and private development. However, the shorezone in the focal study area is not used nearly as intensively as other areas around the lake. The shorezone is critical to Lake Tahoe's ecology as it provides shallow water habitat that is important for reproduction and juvenile life stages for many fish species, especially native minnows. The quality of this type of habitat is largely dependent upon substrate type, availability, and disturbance levels.

The size and location of shallow water habitats of Lake Tahoe is based on water levels and varies year to year and seasonally depending on precipitation, runoff, and storms. Fluctuations in the Lake water levels can result in changes in water depths and inundation of the shorezone which in turn can significantly change habitat quality and quantity available to the fish and aquatic invertebrate (see Section 3.4.2 below) species inhabiting the shallow water areas.

The fish assemblage of the shallow water habitat of Lake Tahoe generally includes several species that live in water less than 10 meters deep in rocky bottomed areas. The assemblage is primarily comprised of six species: speckled dace, Lahontan redside, Paiute sculpin, Tahoe sucker, rainbow trout, and brown trout. Dace and scuplin live primarily among the rocks, seeking shelter during the day and actively feeding at night. Redsides are more surface oriented and swim in large schools. Tahoe suckers typically are more exposed, utilizing sandy substrates along with rocky cover. Rainbow trout and brown trout in the Lake primarily utilize the shallow habitat in the evenings and at night to feed on suckers and redsides (Moyle 2002).

In addition to the species identified above, YOY of most other fishes can be found in the shallow water habitat and different times. Large aggradations of YOY fishes are especially likely to be found along marshy shores, where the emergent plants provide a measure of cover and protection (Moyle 2002).

In 1996, TRPA commissioned a study on shorezone spawning that included Baldwin Beach as a survey site (Allen and Reuter 1996). No species were observed spawning at the site and the substrate was characterized as sand.

Kokanee salmon utilize midwater pelagic portions of the Lake during most of their adult life stage and enter into Taylor Creek to spawn during the fall. Kokanee have also been observed shore spawning on gravel substrates in the vicinity of Taylor Creek (Cordone et al. 1971).

3.4.2 AQUATIC INVERTEBRATES

Aquatic invertebrates are common and important inhabitants of aquatic environments in the Taylor, Tallac, and Spring watershed. This section provides a general description of taxa and functional groups, position and basic functions in aquatic ecosystems, and their role as an

indicator of stream degradation. Information on aquatic invertebrate populations specific to the project study area is also provided.

Insects are the main types typically present and commonly include mayflies (Ephemeroptera), stoneflies (Plecoptera), caddisflies (Trichoptera), and true flies (Diptera). Non-insect invertebrates include snails, leeches, worms, and scuds (Herbst 2001). Several nonnative aquatic invertebrates were introduced into the Tahoe Basin by the DFG to supplement forage for fish (Rischbieter 1990b). Signal crayfish (*Pacifasticus klamathensis*) from the Klamath River were introduced in 1916 (Riegel 1959). Opossum shrimp (*Mysis relicta*) were introduced in 1963 and 1964 to provide food for juvenile lake trout (Linn and Frantz 1965). These shrimp are suspected to have caused significant changes to the Lake ecosystem including declines in native invertebrates (Goldman et al. 1979).

Interactions among aquatic invertebrates and their food resources vary among functional groups. Five functional groups are frequently identified based on feeding behavior: scrapers, shredders, collectors, filterers, and predators.

- Scrapers are animals adapted to graze or scrape materials (periphyton, or attached algae, and its associated microbiota) from mineral and organic substrates;
- Shredders are organisms that comminute primarily large pieces of decomposing vascular plant tissue (>1 mm diameter) along with the associated microflora and fauna, feed directly on living vascular macrophytes, or gouge decomposing wood;
- Collectors are animals that feed primarily on fine particulate organic matter (FPOM; e1 mm diameter) deposited in streams;
- Filterers are animals with specialized anatomical structures (e.g. setae, mouth brushes, fans, etc) or silk and silk-like secretions that act as sieves to remove particulate matter from suspension; and
- Predators are organisms that feed primarily on animal tissue by either engulfing their prey or piercing prey and sucking body contents.

Aquatic invertebrates are essential to the proper ecological function of all types of aquatic systems. Many aquatic invertebrates exploit the physical characteristics of aquatic ecosystems to obtain their foods. As consumers at intermediate trophic levels, aquatic invertebrates are influenced by both bottom-up and top-down forces in streams and serve as the conduits by which these effects are propagated. Aquatic invertebrates can have an important influence on nutrient cycles, primary productivity, decomposition, and translocation of materials. Aquatic invertebrates constitute an important source of food for numerous fish, and unless outside energy subsidies are greater than in-stream food resources for fish, effective fisheries management must account for fish-invertebrate linkages and invertebrate linkages with resources and habitats.

FACTORS AFFECTING ABUNDANCE AND DISTRIBUTION

Primary factors affecting the abundance and distribution of aquatic invertebrates include aquatic ecosystem health and integrity and habitat type. Both of these factors are discussed below.

Aquatic Ecosystems and Bioassessment

Aquatic invertebrates serve as valuable indicators of stream degradation. Each aquatic invertebrate species has a different tolerance level to degradation. Some species have narrow and specific habitat requirements and are therefore restricted to certain habitat conditions, while others can survive in a wide variety of habitat conditions (Erman 1996). It is possible to use different invertebrate species and assemblages as indicators of water quality and habitat conditions (Herbst 2001).

Aquatic invertebrates have been shown to be sensitive and informative indicators of stream ecosystem health and water quality and have been used for many decades to monitor impacts on aquatic and terrestrial habitats (bioassessment). The principal behind bioassessment is to determine the biological integrity of an impacted site by comparing its biotic community to that of a known unimpacted or reference site. Aquatic invertebrates are becoming a critical component of bioassessment because they are more diverse and ubiquitous and abundant than fish and because these organisms are in contact with both the water and bottom substrate in streams. Aquatic invertebrate studies have contributed to an understanding and assessment of stream ecosystem health as related to land-use activities. A survey of aquatic invertebrates in the study area watershed has been conducted; however, these data are not currently available for analysis. Once available, these data could be analyzed using biological metrics that are commonly used in bioassessment procedures. Biological metrics used in bioassessment procedures include taxa richness measures, species composition measures, tolerance/intolerance measures, and functional feeding groups (Table 3.4-3).

Aquatic Habitats

Streams

Inventory data of aquatic invertebrates in the focal study area streams is limited. A survey of aquatic invertebrates was conducted by the Forest Service in 2004, however, these data are not currently available. A report from a historic survey in the study area is provided below.

Murphy (1963) collected samples of mud, sand and gravel substrate during the month of August from Taylor Creek. Diptera larvae dominated gravel, sand, and mud bottom samples. Murphy (1963) also reported the presence of Hydrcarina (mites), which were found primarily in gravel, Anisoptera (dragonfly nymphs), and Trichoptera larvae. Trichoptera larvae were extremely abundant during the beginning of August, but became much scarcer at the end of the month. Nemertinean, annelid, and nematode worms were also reported in small numbers.

Table 3.4-3 Biological Metric Used in Bioassessment Procedures		
Biological Metrics	Description	Response to Impairment
Richness Measures		
Taxa Richness	Total number of individual taxa	decrease
EPT Taxa	Number of taxa in the Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) insect orders	decrease
Ephemeroptera Taxa	Number of mayfly taxa (genus or species)	decrease
Plecoptera Taxa	Number of stonefly taxa (genus or species)	decrease
Trichoptera Taxa	Number of caddisfly taxa (genus or species)	decrease
Composition Measures		
EPT Index	Percent composition of mayfly, stonefly and caddisfly larvae	decrease
Sensitive EPT Index	Percent composition of mayfly, stonefly and caddisfly larvae with Tolerance Values of 0 through 3	decrease
Shannon Diversity Index	General measure of sample diversity that incorporates richness and evenness (Shannon and Weaver 1963)	decrease
Tolerance/Intolerance Measures		
Tolerance Value	Value between 0 and 10 weighted for abundance of individuals designated as pollution tolerant (higher values) and intolerant (lower values)	increase
Percent Intolerant Organisms	Percent of organisms in sample that are highly intolerant to impairment as indicated by a tolerance value of 0, 1 or 2	decrease
Percent Tolerant Organisms	Percent of organisms in sample that are highly tolerant to impairment as indicated by a tolerance value of 8, 9 or 10	increase
Percent Hydrosychidae	Percent of organisms in the caddisfly family Hydropsychidae	increase
Percent Baetidae	Percent of organisms in the mayfly family Baetidae	increase
Percent Dominant Taxa	Percent composition of the single most abundant taxon	increase
Functional Feeding Groups		
Percent Collectors	Percent of macrobenthos that collect or gather fine particulate matter	increase
Percent Filterers	Percent of macrobenthos that filter fine particulate matter	increase
Percent Scrapers	Percent of macrobenthos that graze upon periphyton	variable
Percent Predators	Percent of macrobenthos that feed on other organisms	variable
Percent Shredders	Percent of macrobenthos that shreds coarse particulate matter	decrease
Source: California Stream Bioassessment Procedure		

While this historic survey provides some information on aquatic invertebrates in the study area, the dated and limited nature of the data does not allow for conclusions to be drawn on the current assemblage or health of the system. The survey was conducted in 1963 and

therefore does not reflect the changing existing conditions in the study area. The survey also does not identify the invertebrates down to the genus and species levels which are the standard taxonomic efforts necessary to place tolerance values to most invertebrates. While orders such as Trichoptera are generally intolerant, genus and species taxonomic resolution are required to determine specific tolerance values for individuals.

Beaver Ponds

Beaver activity dramatically influences the aquatic invertebrate communities in streams. Before beaver dams are built, streams are typically dominated by lotic invertebrates, such as stoneflies, mayflies, and caddisflies. After beaver dams are built and an impoundment (pond) of water forms behind it, lentic invertebrates replace the lotic invertebrates. Examples of lentic invertebrates that may increase after beaver dam a stream include leeches, dragonflies, mussels, and worms. By building dams and creating impoundments, beaver can increase the absolute abundance of collectors and predators, while decreasing the relative abundance of shredders and scrapers (McDowell and Naiman 1986).

Lagoons

Generally, aquatic invertebrate assemblages similar to those typically occurring in beaver ponds and to a lesser extent, the Lake Tahoe shorezone (see below), are likely to inhabit the lagoons in the study area. Similarities between the aquatic habitats include standing water and relatively finer substrates (e.g., sand and silt).

Lake Tahoe

Aquatic invertebrates in the shallow water shorezone area of Lake Tahoe include small snails, and blackfly, midge, and caddisfly larvae that live in sediments and on the surface of rocks. All of these aquatic invertebrates provide an important source of food for the fish species noted above (Moyle 2002).

3.5 TERRESTRIAL WILDLIFE

An inventory and monitoring assessment of five potential restoration sites in the Lake Tahoe Basin was conducted by the Forest Service, including Taylor Creek and Tallac Creek watersheds, in an effort to provide baseline conditions and assist the development of desired conditions. This inventory and monitoring assessment is included as Appendix F. Appendix F includes the executive summary for all five potential restoration sites, an introduction to the pre-restoration wildlife inventory and monitoring, and the chapter that discusses wildlife inventory and monitoring for the Taylor Creek and Tallac Creek watersheds.

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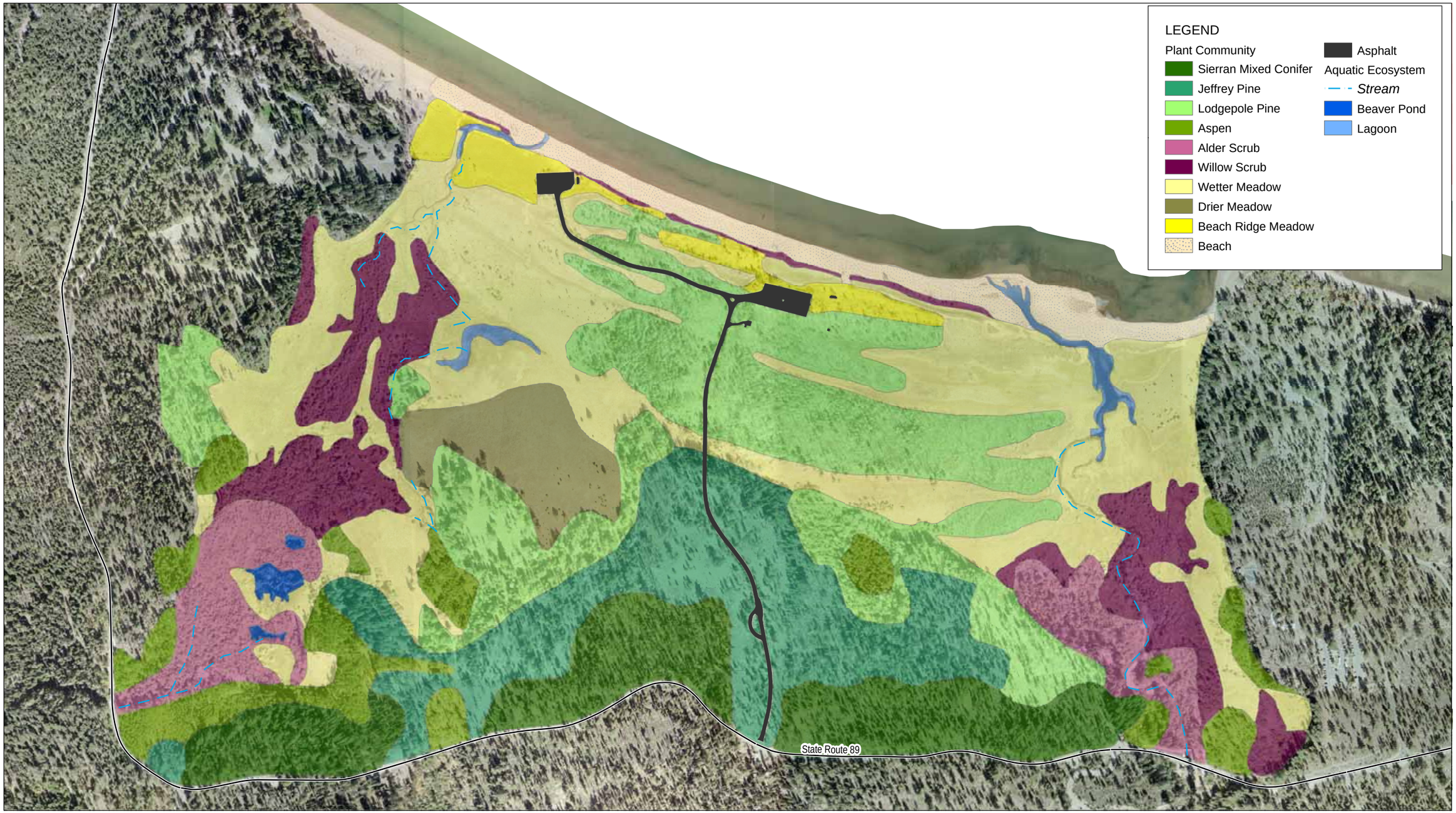
PERSONAL COMMUNICATIONS

Allen, Brandt. University of California, Davis, Tahoe Research Group. January 21, 2005 – telephone conversation with Chris Fitzer of EDAW regarding fish distribution and management throughout the Tahoe Basin.

Knutson, Chuck. Fish Hatchery Program Manager. California Department of Fish and Game, Rancho Cordova, CA. March 10, 2005 – telephone conversation with Chris Fitzer of EDAW regarding trout stocking in the Tahoe Basin.

Muskopf, Sarah. Aquatic Biologist. Lake Tahoe Basin Management Unit. January 12, 2005 – edits on administrative draft.

Lehr, Stafford. Associate Fish Biologist. California Department of Fish and Game, Rancho Cordova, CA. March 22, 2005 – telephone conversation with Chris Fitzer of EDAW regarding trout stocking in the Tahoe Basin.



Sources: North American Mapping Company 10/9/04, EDAW 2004

Plant Communities and Aquatic Ecosystems

EXHIBIT 3.3-1

Taylor, Tallac, and Spring Creek Watershed EAR

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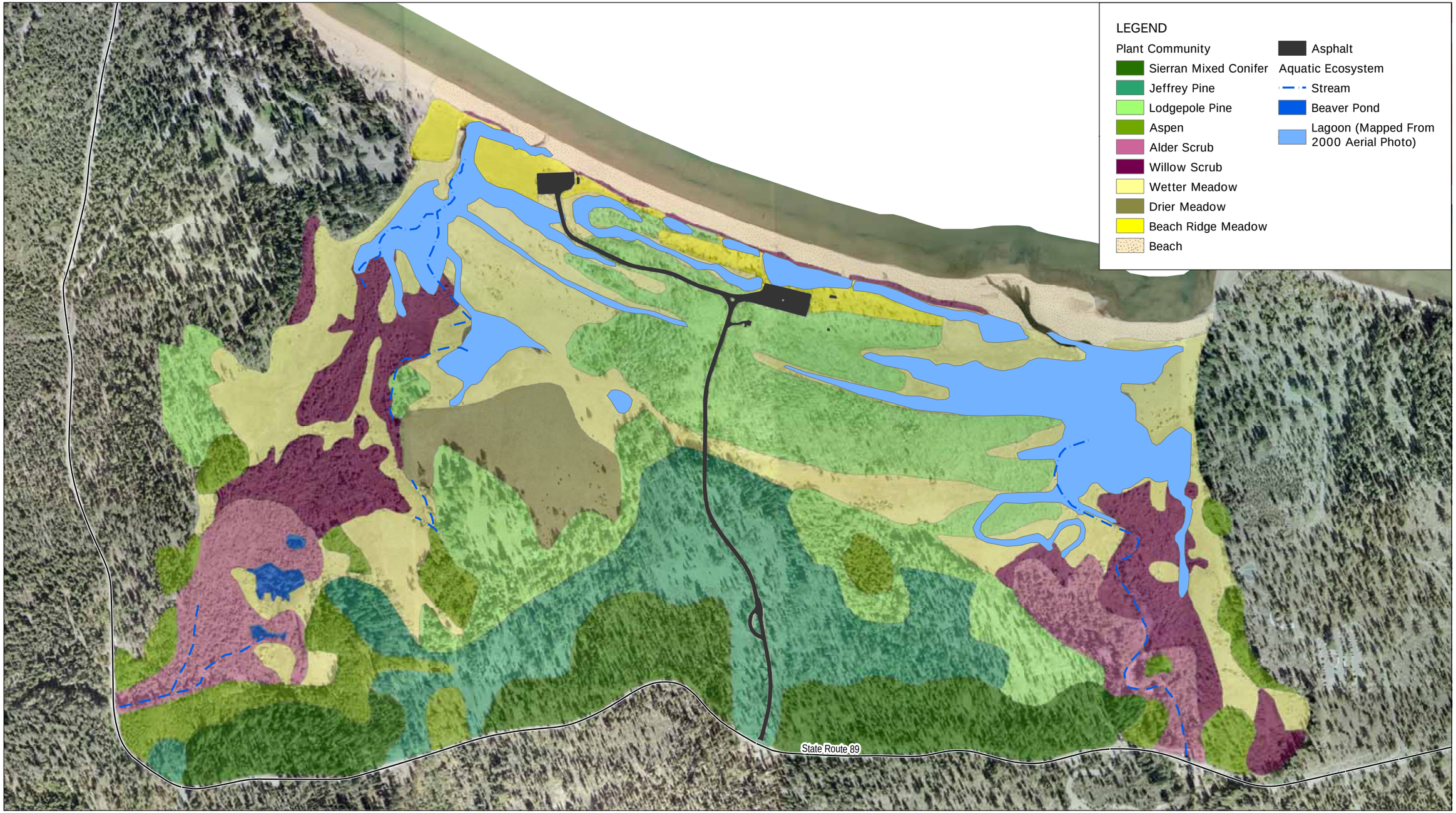
NORTH

EDAW



Sources: North American Mapping Company 10/9/03, EDAW 2004

Plant Communities and Aquatic Ecosystems with Lagoon from 2000

EXHIBIT 3.3-2

Taylor, Tallac, and Spring Creek Watershed EAR

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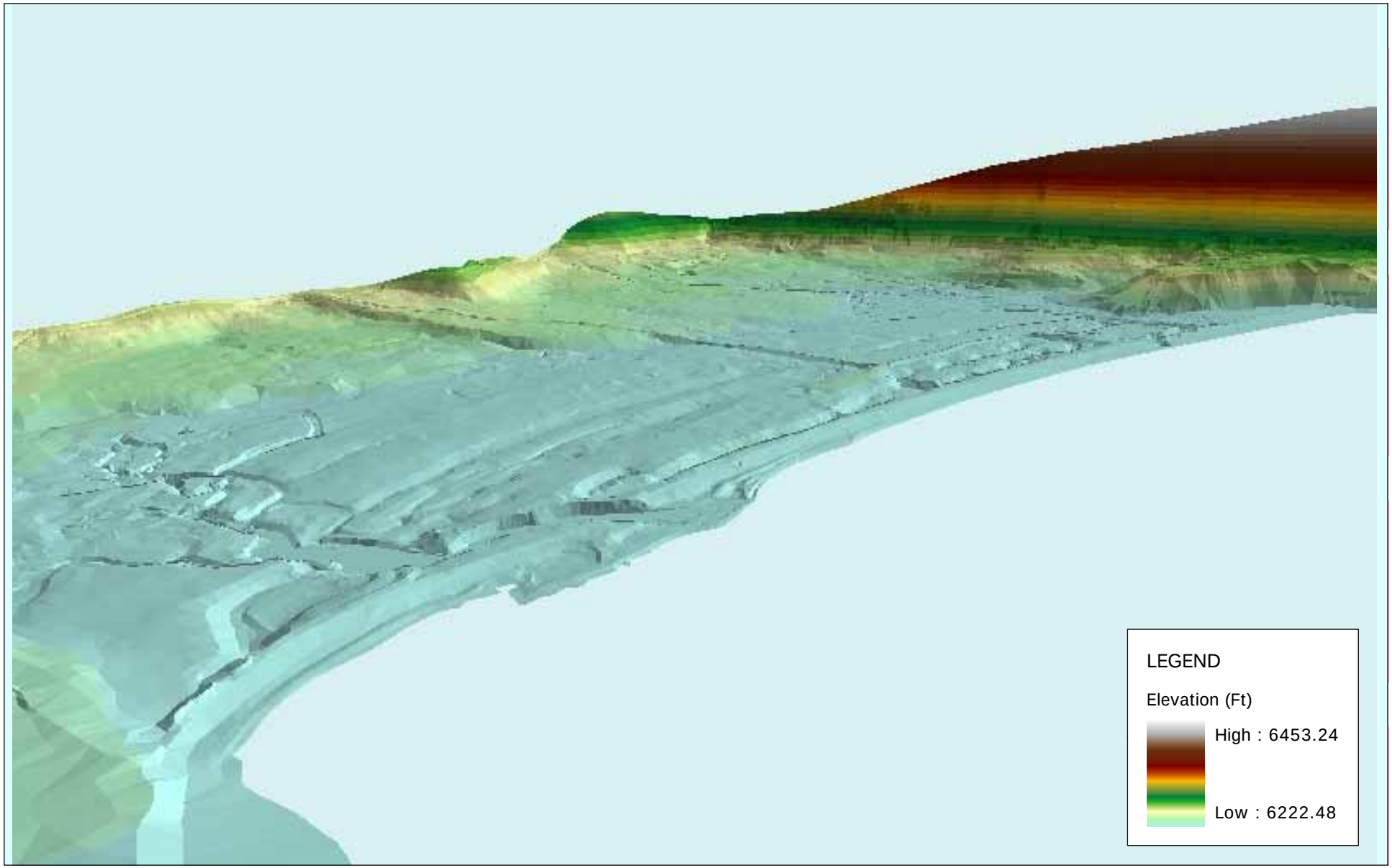

Source: PWA 2004

Elevation Surface Model for Taylor and Tallac Marsh

EXHIBIT 3.3-3

Taylor, Tallac, and Spring Creek Watershed EAR

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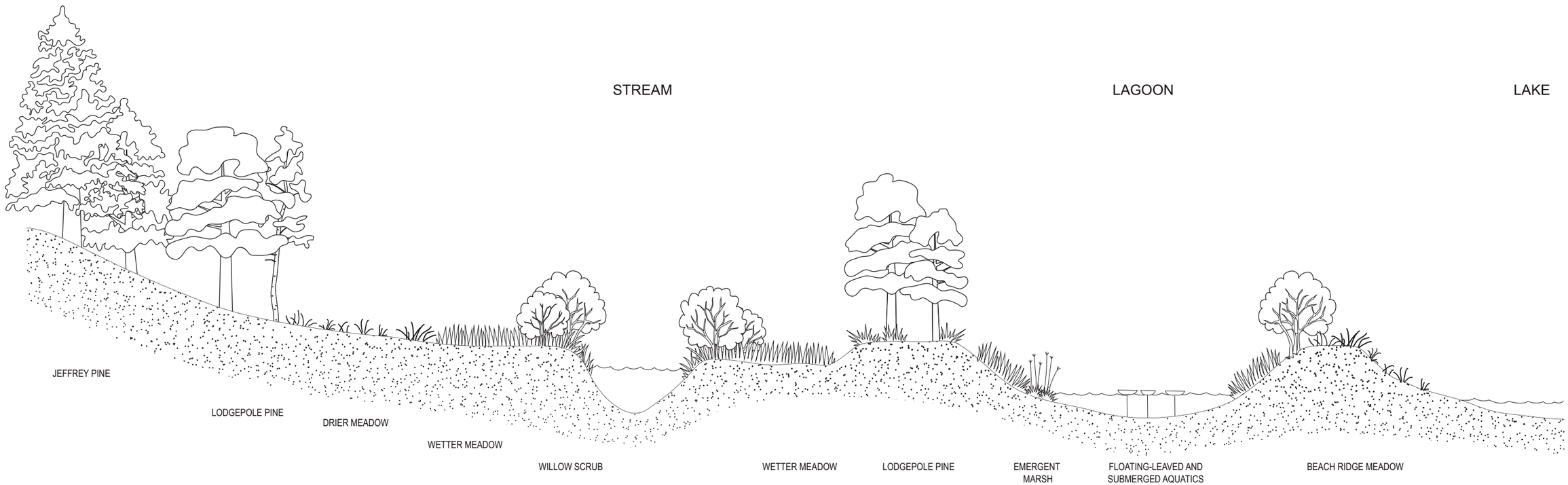

Plant communities are distributed in relation to ground-surface elevation and water levels.

Source: EDAW 2004

Plant Distribution Along an Environmental Gradient

EXHIBIT 3.3-4

Taylor, Tallac, and Spring Creek Watershed EAR
U.S. Forest Service
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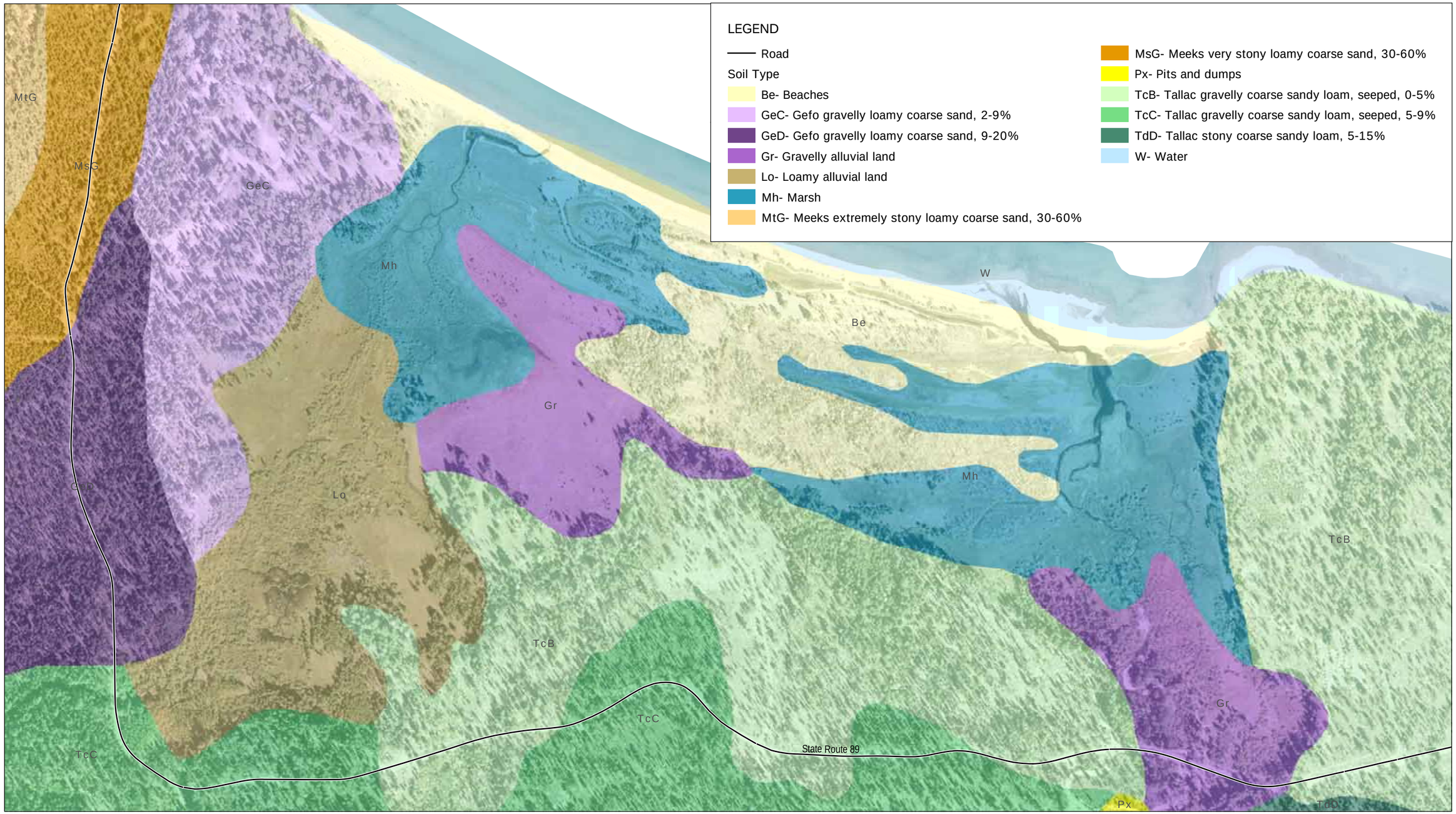

Sources: Natural Resources Conservation Service 1999, EDAW 2004

Soils

EXHIBIT 3.3-5

Taylor, Tallac, and Spring Creek Watershed EAR

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EDAW

Regeneration within lodgepole pine stand (note fire scars)

Felled aspen in foreground. Note young aspen sprouts within dead in background stand.

Source: EDAW 2004

Lodgepole Pine and Aspen Regeneration

EXHIBIT 3.3-6

Taylor, Tallac, and Spring Creek Watershed EAR
U.S. Forest Service
P 3T058.01 04/04

EDAW

Source: EDAW 2004

Microstructure in a Montane Meadow

EXHIBIT 3.3-7

Taylor, Tallac, and Spring Creek Watershed EAR
U.S. Forest Service
P 3T058.01 04/04

EDAW

Lagoon near mouth of Tallac Creek vegetated with pond lilies and pondweed.

Lagoon near mouth of Taylor Creek lacks floating aquatic vegetation.

Source: EDAW 2004

Lagoon on Taylor and Tallac Creek

EXHIBIT 3.3-8

Taylor, Tallac, and Spring Creek Watershed EAR
U.S. Forest Service
P 3T058.01 04/04

EDAW

Lagoon transitioning to mudflat.

Montane meadow community that will transition to lagoon under wetter conditions.

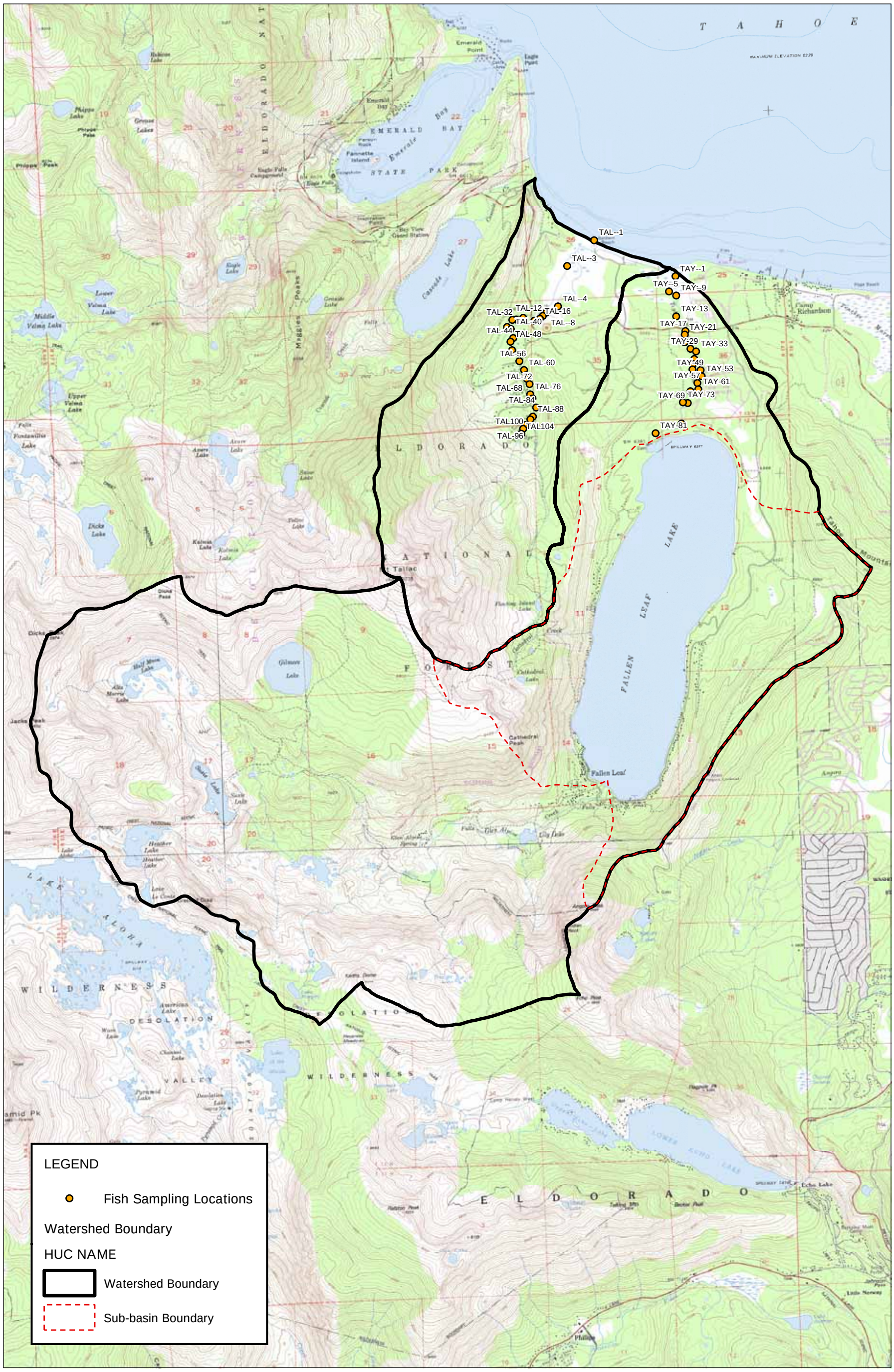
Source: EDAW 2004

Succession of Lagoon to Meadow

EXHIBIT 3.3-9

Taylor, Tallac, and Spring Creek Watershed EAR
U.S. Forest Service
P 3T058.01 04/04

EDAW



Source: USFS 2004

Fish Sampling Locations

EXHIBIT 3.4-1

Taylor, Tallac, and Spring Creek Watershed EAR

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FEET

NORTH

EDAW