Chapter 6

Ecology

Plant Communities and Distributions

Due to differences in topographic features, solar exposure, soil moisture, slope, and elevation, the Butte Creek Watershed supports a diverse flora and a mosaic of plant communities. These plant communities generally follow gradients (i.e. elevation, precipitation) and are discussed as following an elevation gradient from the sink to the headwaters.

Valley Communities

There are several distinct communities in the valley sections of Butte Creek as well as many ecotones, or zones of overlap. A general discussion of the region will be followed by specific descriptions of plant communities.

Agricultural Lands

Agricultural lands occur in the lower portion of Butte Creek and the Butte Sink. Agricultural crops include English walnuts, almonds, sunflowers, beans, prunes, rice, and peaches. The reader is referred to the chapter on land use for a more detailed account of agricultural land use.

Wetlands

The Butte Creek Watershed supports a variety of natural wetlands including freshwater marsh, slough, vernal pool, montane wet meadow, and seep. Human created wetlands stemming from irrigation ditches, canals, and reservoirs also occur. Discussion is limited to the natural and major wetland communities that occur within the watershed. Distribution of wetlands differ based upon the wetland type. Freshwater marshes and vernal pools are located in the valley or basin area of the watershed. Wet montane meadows occur in forests in the upper canyon. Riparian forests are found throughout the watershed where an ephemeral or perennial water course flows.

Freshwater Marsh

The freshwater marsh community has been severely reduced from its natural range. The decrease of the community's range is in part due to the recent increased aridity of the California climate. However, this natural process has been dwarfed by the draining of the freshwater marsh for replacement by agriculture lands, by the removal of water for irrigation, and by the diversion or retention of water by dams (Ornduff, 1974).

In the Butte Creek Watershed, freshwater marshes may be found where there is standing or slow-moving shallow water. These areas include the banks of lakes, rivers, creeks, sloughs, and ponds. The most substantial areas are found in the Butte Sink, including Gray Lodge and Sanborn Slough. Three layers of plants can be found in or along the marshes or sloughs: free floating (*Lemna* spp., duckweed), emergent (*Typha* spp., cattail), and partially to fully submerged (*Potamogeton pectinatus,* fennel-leaved pondweed).

Three genera are well represented: cattails (*Typha latifolia* and *T. domingensis*), sedges (*Carex amplifolia* and *C. praegracilis*), and rushes (*Juncus balticus* var *mexicanus and J. oxymeris*). Hard-stemmed tule (*Scirpus acutus*) is often associated with the cattails, sedges, and rushes. Cane (*Phragmites australlis*), and blue vervain (*Verbena hasta*) also are present in small amounts.

Vernal Pools

Vernal pools form associations in a variety of communities including valley grassland, blue oak woodland, and montane forest. Due to their location within these communities, the distribution of vernal pools has suffered the same fate as the communities in which they are found, namely conversion to agriculture and urbanization (Holland and Griggs, 1976).

Vernal pools are shallow depressions with impervious soils that fill with winter rain creating seasonal bodies of water. As the pools dry during spring, many native annual species complete their life cycle presenting a spectacular wildflower display and seed set. Flood inundation due to winter rains and summer desiccation due to scorching summer temperatures makes this a harsh environment. It has been suggested that the high percentage of native, annual, and endemic species located in vernal pools is due to the severe and fluctuating seasonal conditions (Zedler, 1990).

There are different kinds of vernal pools in the Butte Creek Watershed including mudflow at Parrot Ranch (Jokerst, 1990), basalt flow on Table Mountain (Jokerst, 1983), and alluvial hardpan in the Richvale pools. The Richvale pools comprise the largest known aggregation of vernal pools and are the most well documented pools in the watershed (Sanders, 1981, Schlising and Sanders, 1982, Schlising and Sanders, 1983). Each of the 120 pools is unique varying in size, depth, and species composition.

Two state listed vernal pool species found in the watershed are the rare orcuttgrass (*Orcuttia pilosa*) and the endangered Green's tuctoria (*Tuctoria greenei*). Fremont's gold fields (*Lasthenia fremontii*), Fremont's tidytips (*Layia fremontii*), Douglas' microseris (*Microseris douglasii*), white meadowfoam (*Limnanthes alba*), popcorn-flowers (*Plagiobothrys* spp.), *Downingia* spp., and *Navarretia* spp. are common associates.

Riparian Communities

Riparian forests can be found at all elevations throughout the watershed wherever perennial or ephemeral watercourse flow. There are several types of riparian communities within the Butte Creek Watershed: gravel and sand bars, willow scrub, cottonwood forest, white alder forest, and valley oak woodland. The forests are capable of mixing with and forming next to one another. The distribution of each of these series has been reduced by anthropomorphic disturbances of flood control, agriculture, and urbanization. The various types are listed.

Gravel and Sand Bars

Gravel and or sand bars form as a result of the inherent flood dynamics of a riparian system. Flood waters scour the banks gathering debris and sediment from one site and depositing them at another site. It is in these disturbed sites where early succession may begin. Native early succession or pioneering species whose seedlings may be found growing on sand and gravel bars include Fremont's cottonwood (*Populus fremontii*), a variety of willow (*Salix*) species, and many native herbs. However, these newly created openings provide a opportunity for a variety of non-native species to become established as well.

Willow Riparian Scrub

Willow scrub may form dense thickets generally along sandy creek banks in the watershed. The composition of willow species may differ throughout the watershed due to elevation differences. A representative sample of willow scrub is located in the Canyon Unit of the Butte Creek Canyon Ecological Reserve (Oswald, 1990). Willows may also form an understory in areas dominated by tree species, as is the case at the site of the Forks of Butte Hydroelectric Project (Larson and Associates, 1985). Here, arroyo willow (*Salix lasiolepis*) and other willow species form an understory in a white alder forest. Sandbar willow (*S. exigua*) and Gooding's black willow (*S. gooddingii*) are more commonly found on the valley floor where as red, yellow, and arroyo willows (*S. laevigata*, *S. lucida* ssp. *lasiandra*, and *S. lasiolepis*) can reach into the coniferous forest (Oswald, 1994).

Cottonwood Riparian Forest

The cottonwood riparian forest occurs as remnant populations on the valley floor to elevations of 3700 ft. where alluvial soils occur in low-gradient areas (Oswald, 1994). The Butte Creek Canyon Ecological Reserve supports this native plant community (Oswald, 1990). Additional species that grow in conjunction with cottonwood and its perennial water source include: box elder (*Acer negundo*), Oregon ash (*Fraxinus latifolia*), western sycamore (*Platanus racemosa*). Button willow *(Cephalanthus occidentalis*) and a variety of willows may comprise the understory. Since cottonwoods are found at sites where slopes are gradual and plains are broad, the cottonwood forest can be correspondingly broad (Ornduff, 1974).

White Alder Riparian Forest

The white alder (*Alnus rhombifolia*) riparian forest is found mainly along swiftly flowing and well aerated sections of waterways, and may be found from the valley floor into the reaches of the coniferous forest to an elevation of 4000 ft. (Oswald, 1994). The white alder forms a beneficial symbiotic relationship with nitrogen fixing bacteria. This relationship results in nutritionally "conditioned" soil for the associate plant species. A representative forest is present near the Forks of Butte Hydroelectric Project (Larson and Associates, 1985). Associates include: bigleaf maple (*Acer macrophyllum*), western sycamore (*Platanus racemosa*), and miner dogwood (*Cornus sessilis*).

Valley Oak Riparian Forest/Woodland

Valley oaks (*Quercus lobata*) generally do not occur immediately along the banks of rivers and streams. Instead, they stand atop terraces overlooking the floodplain as they do along Honey Run Road (Greystone, 1993) or they stand on the alluvial aggregation setback from the main watercourse. Additional valley oak forests can be seen in the Virgin Valley Unit of the Butte Creek Canyon Ecological Reserve (Oswald, 1990).

Associates of the valley oak riparian forest include: common elderberry (*Sambucus mexicana*), California wild grape (*Vitis californica*), poison oak (*Toxicodendron diversilobum*), and western sycamore.

The valley oak may extend its range out of the riparian forest and into the surrounding grassland or woodland communities, thus integrating with grassland or woodland species and creating a valley oak woodland. In woodlands where blue oak is present, valley oaks may hybridize with the blue oak. Associate species of the woodland are those species discussed below in the woodland section.

Grassland (Valley and Annual Non-native Grasslands)

Historically, valley grassland occupied large expanses of the central valley floor which includes the lower portion of the Butte Creek watershed. However due to the conversion of this deep and rich soiled grassland to agriculture, this plant community occupies only a small remnant of its former distribution (Ornduff, 1974).

Grasslands can be found at lower elevations in the watershed (Sink and Lower Creek), and they abut the eastern side of agricultural lands and the western side of the Sutter Buttes. Extant occurrences of the valley grassland community, in particular the native perennial bunchgrasses, may occur in the Butte Creek Watershed. It is most probable that bunchgrasses will occur in undisturbed areas and/or in association with non-native annual grasses.

Not only has the distribution of the valley grassland changed, but the composition of species in the remnant occurrences has also changed. Originally, many perennial bunchgrasses, such as purple needlegrass (*Nassella pulchra*), three-awns (*Aristida* spp.), bluegrasses (*Poa* spp.), wild ryes (*Elymus* spp.), and melic grasses (*Melica* spp.) comprised the composition of the valley grassland. Due to human encroachment (agriculture, grazing, urbanization) many exotic and invasive annual grasses occur: brome grasses (*Bromus* spp.), wild oats (*Avena* spp.), medusa head (*Taeniatherum captu-medusae*) or fescue (*Festuca* spp.). Therefore, the native valley grassland has been converted to human constructs as well as to a feral or ruderal annual grassland.

Two sites for which there is a detailed account of species are the Aguas Frias Bridge at Butte Creek 17 miles west of Chico and the Butte Creek Ecological Reserve 2 miles southeast of Chico. The Reserve lists a sizable amount of exotic species and no native bunchgrasses. In fact, the flora surveyed on the preserve is composed of 44.6% non-native species, a percentage much greater than that of Butte County collectively (22%) (Oswald, 1990).

Two listed CNPS species are found on the preserve: California black walnut (*Juglans hindsii*--1B listing) and shield-bracted monkey flower (*Mimulus glaucescens*--4 listing). California hibiscus (*Hibiscus lasiocarpus*), a listed sensitive species, occurs in sloughs and ditches a few miles northwest of the Aguas Frias Bridge. Narrow-leaved goosefoot (*Chenopodium desiccatum*) has not been previously found or listed in Butte County, but is reported in the management plan, and autumnal water starwart (*Callitriche hermaphroditica*) is found at only one other location in Butte County (Oswald, 1990).

Foothill and Montane Communities

Blue Oak Woodland

If an ascending easterly transect is drawn from the sink to higher elevations, the next plant community encountered is the blue oak woodland. The grassland gently transitions into this community which begins at an elevation as low as 300 feet (Ornduff, 1974) and may continue until 1600 feet (Oswald, 1994). Many of the grassland species form the majority of the ground cover in this community. However, the salient feature of the blue oak woodland is the tree species, blue oak (*Quercus douglasii)* and gray pine (*Pinus sabiniana*), which speckle the hillsides.

Although reduced from its historic distribution, considerable stands of blue oak woodland remain and are found in the Butte Creek Watershed. Although the species composition of the dominant vegetation has not changed, the ability of the blue oak to successfully reproduce mature stands is questionable (Griffen, 1971), therefore, the species character and abundance of the blue oak woodland may change as well. Several factors may play a role preventing acorns to mature: grazing and trampling by livestock, competition with exotic species especially annual grasses, and an increase of acorn harboring animals due to the decrease of their predators. In effect, this may change the future composition of the woodland by eliminating the blue oak because certain critical life stages of the plant are hindered.

Associated species include redbud (*Cercis occidentalis*), California buckeye (*Aesculus californicas*), various forbs, and the aforementioned native and non-native species discussed in the grassland community section. When adjacent to riparian habitat, valley oaks (*Quercus lobata*) may occur as an associate. Black oak (*Quercus kelloggi*) may be associated with the woodland in moister and higher-walled sites (Oswald, 1994). Chaparral species (see below) may form associates in more xeric or drier sites. A sample of this community can be seen in the lower foothills along Honey Run Road.

Foothill Chaparral

Foothill chaparral occurs in scattered sites adjacent to the foothill woodland and is found at an elevation between 400 to 5000 feet. It occurs on ridges and upper slopes where it is restricted to poor, shallow, and/or serpentine soils (Sawyer and Keeler-Wolf, 1995). The foothill chaparral community generally lacks trees and herbs, and is characterized by evergreen and sclerophyllous (hard-leaved) shrubs that may grow to 10 feet in height (Ornduff, 1974). Other identifying features of chaparral plants are small leaves, which have a low surface to volume ratio, and leaves that have a thick and waxy cuticle. These leaf features help the plants survive in a harsh environment where soils are low in important nutrients and low in water holding capacity.

Chaparral is a fire adapted community where fire plays two major roles. First, fire is important in replenishing plants dependent on periodic fires to establish germination. Second, fire recycles nutrients (i.e. rain leeching nutrients from charred wood) in this nutrient limited environment.

Associated species include: whiteleaf, common, and greenleaf manzanitas *(Arctostaphylos viscida*, *A. manzanita*, and *A. patula* respectively), chamise (*Adenostoma fasciculatum*), wedgeleaf ceanothus or buckbrush (*Ceanothus cuneatus*), tobacco brush (*C. velutinus*), mountain whitethorn (*C. cordulatus*) ocean spray (*Holodiscus discolor*) scrub oak (*Quercus berberdifolia*), and Fremont's silk tassel (*Garrya fremontii*)(Sawyer and Keeler-Wolfe, 1995). Community representatives are found near the sites of the DeSabla, Centerville, and Forks of Butte hydroelectric projects.

Montane Chaparral

Similar to the foothill chaparral community, the montane chaparral community also occurs on shallow and/or serpentine soils located along ridges and upper slopes, is fire adapted, and has members of the same genera present. However, the elevation where montane chaparral occurs is greater (2000 to 9000 feet), and therefore generally interrupts the montane forest community. The Butte Creek House Ecological Reserve is located near sites that support montane chaparral (Oswald, 1990).

Species composition between the chaparral communities differ. Species found in the montane chaparral include: greenleaf and pinemat manzanitas (*Arctostaphylos patula* and *A. nevadensis* respectively), bitter cherry (*Prunus emarginata*), and bush chinquapin (*Chrysolepis sempervirens*). Many of these species can overlap their distribution into the surrounding communities.

Montane Forest

Ponderosa Pine - Mixed Conifer Series

The landscape of the mixed ponderosa pine forest which occurs on well drained soils of all aspects has taken on a different appearance. Historically, this forest was less densely populated by ponderosa pines, but these pines had enormous girths. The landscape resembled a park-like setting where trees grew spaciously apart from one another, and the understory growth was negligible. However, due to the practices of fire suppression, logging, and/or grazing, the ponderosa pine forest has taken on a different appearance and identity. Present day appearance differs because dominant pine trees have much lesser girth and grow more densely together. In addition, a well developed and layered understory is prominent in this series (Zack, 1997). An identity change may occur because white fir, whose elevation range (3800 to 7400 feet) in part overlaps with that of the ponderosa pine (800 to 5800 feet), may become an invasive and dominant species under the aforementioned practices. This series is found at the DeSabla Centerville Hydroelectric System site (Larson and Associates, 1985) (see Issues and Concerns chapter, # 3).

Ponderosa pine can either be the sole, dominant, or a codominant species. Associated species include: douglas *fir (Pseudotsuga menziesii*), incense cedar (*Calocedrus decurrens*), and sugar pine (*Pinus lambertiana*) in the upper canopy; black oak (*Quercus kelloggii*) and canyon live oak (*Quercus chrysolepis*) in the lower canopy;

and *Ceanothus spp*. forms a shrub layer. When an herbaceous layer is present one may find Bolander's bedstraw (*Galium bolanderi*) and California brome (*Bromus carinatus*) (Sawyer and Keeler-Wolf, 1995).

Ponderosa Pine - Douglas Fir Mixed Series

In areas where granitic, schistic, or ultramafic derived soils occur, the ponderosa pine may form codominance with the douglas fir (Sawyer and Keeler-Wolf, 1995). Associate canopy species are the same as in the previously described series, therefore, differentiation between the series may be difficult.

Mixed Fir Series

The red and white fir mixed series of the montane forest boarder the upper distribution of the ponderosa pine mixed series, have a sympatic elevation distribution with one another, but differ in substrate preference (Sawyer and Keeler-Wolf, 1995). The dominant species of each series and its associates may integrate with the neighboring series, therefore, making discrete zonation unintelligible. For example, white fir (*Abies concolor*) may become an associate species in the red fir series, and jeffrey pine, sugar pine, and lodgepole pine (*Pinus jeffreyi, P. lambertiana,* and *P. contorta* ssp. *murrayana* respectively) overlap distribution into all three series.

The white fir mixed series may have a greater present day distribution due to its invasion into the ponderosa pine forest under current logging, grazing, and fire suppression practices (see Issues and Concerns chapter, # 3).

Coniferous Forest (Non-Mixed)

Ascending in elevation and out of the montane forest, large stands of single species dominance are encountered. The Butte Creek Watershed has three species that compose these dominant stands.

White Fir Series

This series is similar to the mixed fir series except that white fir (*Abies concolor*) is the sole or dominant tree. The stand occurs on upland slopes that have well drained soils and the range can extend up to an elevation of 7400 ft. (Sawyer and Keeler-Wolf, 1995).

Layers of the canopy may range from continuous to sparse. Associated species in each layer may include: jeffrey and ponderosa pines, sierran/bush chinquipin *(Chrysolepis sempervirens*), and pacific dogwood (*Cornus nuttallii*). Understory shrubs and herbs may include: mahala carpet (*Ceanothus prostratus*), Hooker's fairybells (*Disporum hookeri*), kellogia (*Kellogia galiodes* in dry sites), and pallid mountain monardella (*Monardella odoratissima*) (Oswald, 1994).

Red Fir Series

The red fir (*Abies magnifica*) may dominate at elevations around 6000 to 7400 feet where deep and moist soils occur (Oswald, 1994). A characteristic stand is found on northeast facing slopes near the Butte Creek House Ecological Reserve (BCHER, 1993). Associates include jeffrey and sugar pines, white fir, sierran/bush chinquipin in the canopy, and creeping snowberry (*Symphoricarpos mollis*) and bracken fern *(Pteridium aquilinum*) as ground cover.

Lodgepole Pine Series

Lodgepole pine can occur over a large elevation range and often occurs as an associate in the montane forest series. However, at higher elevations in the Butte Creek watershed, lodgepole pine can become the dominant or sole species in a stand. Lodgepole pine commonly grows on the edges of meadows, streams, and lakes (Oswald, 1994). A representative area of lodgepole pine occurs near the meadow in the Butte Creek House Ecological Reserve. According to Sawyer and Keeler-Wolf (1995), it can also grow in well drained soils on all slopes at sub-alpine elevation.

Associated species in more mesic or wetter sites include quaking aspen (*Populus tremuloides*) and red fir. In drier sites western white pine (*Pinus monticola*) and jeffrey pine may occur.

Wet Montane Meadow (wetland)

This herbaceous plant community occurs at higher elevations in the watershed. A wet meadow occurs near the headwaters of Butte Creek and is surrounded by a ridge system which extends to 7000 feet. The meadow contains riparian elements and is surrounded by coniferous forest (Butte Creek Ecological Reserve, 1993). The Butte Creek House meadow supports two species of special concern, Plumas County Penstemon *(Penstemon neotericus*) and Great Basin Brome (*Bromus polyanthus*). In addition, there are many species associated with this meadow that are of interest because they are know only from the reserve and are markedly lacking in other areas of the county with similar habitat (CDFG, 1993; Oswald, 1994). The species of interest are meadow arnica (*Arnica chamissonis*), dwarf thistle (*Cirsium foliosum* [CDFG, 1993]); *C. scariosum* [Oswald, 1994]), western hawksbeard (*Crepis occidentalis*), mountain butterweed or alpine meadow ragwort (*Senecio cymbalarioides*), vernal water starwort (*Callitriche verna*), Nuttall's monolepis (*Monolepis nuttalliana*), and short-flowered monkey flower *(Mimulus breviflorus*). Many other monkey flowers are also found along the meadow: Common or seep, Brewer's, musk, and primrose (*M. guttatus*, *M. breweri*, M. *moschatus*, *and M. primuloides* respectively). Additional meadows occur in the watershed. Notably a series of wet meadows stipples the upper watershed from Butte meadows to Jonesville (Oswald, 1994).

Sensitive Botanical Resources

Special Status Plant Categories

A plant is considered a special status species when it is protected by the California State and/or Federal Endangered Species Acts. The scientific community along with government agencies play a role in promoting the status of rare species by providing data and information which has the plant considered or qualified for a protected status.

Special Status Plant Categories include:

- Plants that are listed or are proposed for listing as either threatened or endangered under the Federal Endangered Species Act (50 CFR 17.12). Species proposed for listing can be found in various notices in the Federal Register.
- Plants that are listed or proposed for listing by California either as threatened or endangered under the California Endangered Species Act (14 CCR 670.5).
- Plants that meet the definition of rare or endangered in the California Environmental Quality Act (CEQA) guidelines (Section 15380).
- Plants that are in the California Native Plant Society's *Inventory of rare and endangered vascular plants of California* (Skinner and Pavlik, 1994) as either rare, threatened, and endangered (lists 1B and 2), plants where additional information is needed to determine their status (list 3), or plants of limited distribution (list 4).
- Plants protected under the California Native Plant Protection Act (California Fish and Game Code, Section 1900).

Special-Status Species in the Butte Creek Watershed

A review of literature, the *Natural Diversity Data Base*, *and CNPS's Inventory of Rare and Endangered Plants* was conducted to determine known or suspected occurrences of rare, endangered, and threatened species in the watershed. CNPS's inventory was reviewed to ascertain special-status species (federal, state, or CNPS listed) present in Butte county. The search resulted in a finding of 36 known or potentially occurring species (see Appendix J). The status of the species listed and a key to the abbreviations used is included in Appendix J.

Appendix J lists species' habitat in Butte County (Oswald, 1994), as well as, the county distribution of the species within the state of California (Skinner and Pavlik, 1994). Additional states where the species occur are also listed in Appendix J. Site specific information was gathered from Oswald (1994) and the Natural Diversity Data Base (1996). Quadrant codes listed for the special-status plants in the CNPS's Inventory are also noted. A listing of a plant in a quadrant which the watershed occupies does not necessarily mean the plant is in the watershed since the watershed may not fall entirely in certain quadrants. It does however indicate that a suitable environment for the species is either in or near the watershed.

The watershed spans 27 quadrangles, and special-status plants occur in 24 of the quadrangles. The quadrangles with the greatest numbers of special-status plants are Hamlin Canyon (576B), Paradise East (592D), and Cohasset (592B) with 7, 6, and 5 plants respectively.

Of the 36 special-status species, 21 occur at specific documented sites within the watershed. Some species, such as *Atriplex minuscula*, occur at a single site location, while other species, *Hibiscus lasiocarpus*, occur more commonly throughout the watershed. An additional 13 species are listed as occurring in the quadrangles that cover the watershed. Only two of the species listed, *Navarretia heteranda* and *N. subuligera*, do not fall within site specific locations or within the watershed quadrants. However, a suitable environment for these two species exists in the watershed, therefore, they do have the potential to occur within the watershed.

The freshwater marsh and vernal pool communities support a fair number of special-status species. In particular, 4 species, *Atriplex cordulata*, *A. depressa*, *A. miniscula*, and *Eleocharis parvula* are found in freshwater marshes at Gray Lodge. Five species *Chamaesyce hooveri*, *Limnanthes floccosa*, *Orcuttia pilosa*, *Navarettia heteranda*, and *Tuctoria greenei* may be found in vernal pools.

Invasive Exotic Plants

Invasive exotic plants (weeds) are those that have been introduced by humans to a site which is generally disturbed and where the plant does not occur natively (Baker, 1985). These introduced invasive plants are often able to proliferate profusely in a new environment because the controls that keep them limited in their native environment are lacking.

Invasive exotics have the ability to change community structure (species composition) as well as community function, i.e. nutrient cycling (Vitousek, 1986). In fact, some invasive species are capable of supplanting an array of species, thus creating a monospecific stand and decreasing biodiversity. If these monospecific stands do not replace the functional role of the displaced species (i.e. food source, nesting habitat, shade), habitat will be lost as well.

Areas that are most susceptible to invasion are those that are disturbed due to either natural or anthropomorphic disturbances (Orians, 1986). These disturbances create ecologically open habitats where invasive species can easily gather a foothold (Mooney et al., 1986). The habitat in the Butte Creek watershed which is most susceptible to invasive species is the riparian community. The invaluable riparian habitat has high habitat value for fisheries (erosion control, water temperature moderator, basis of food chain) and wildlife (nesting sites, breeding sites, prey refuge, etc.). However, this habitat is dually hindered by disturbance. The community experiences natural disturbance annually when winter high waters scour the banks, knocking down trees and removing vegetation. The second source of disturbance is anthropomorphic (construction, urbanization) and not limited to a specific time of year.

Considering the substantial impact invasive exotic species can have on native communities, the issue of invasive species control is not one to be taken lightly. Many federal (EPA, BLM, USDOT), state (CalTrans, Dept. of Food and Agriculture.), and local (regional parks, municipal water districts) agencies have active weed eradication protocols or programs. A list of noxious weeds recognized by the California Department of Food and Agriculture was combined with a weed list produced by the California Exotic Pest Plant Council (CalEPPC, 1997). Several of those weeds occur in the Butte Creek watershed and include: tree of heaven

(*Ailanthus altissima*), giant reed (*Arundo donax*), black mustard (*Brassica nigra*), whitetop (*Cardaria pubescens*) yellow star thistle (*Centaurea solstitialis*), Canadian thistle (*Cirsium arvense*), bull thistle (*C. vulgare*), field bindweed (*Convolvulus arvensis*), edible fig (*Ficus carica*), black locust (*Robinia pseudoacacia*), himalayaberry (*Rubus discolor*), johnson grass (*Sorghum halepense*), and medusahead (*Taeniatherum caput-medusae*). Appendix K lists weeds, noxious or otherwise, that are known to occur in the Butte Creek Watershed.

Management Concerns

Many of the communities discussed in this report are affected by invasive species. In fact, a survey of management plans revealed that control of exotic species is a high management priority. Exotic species management often takes priority because it is coupled with other management practices or goals important in a given community. For example, grazing, especially in grasslands, is a management concern, and the timing and duration of a grazing episode may influence (increase or decrease) the amount of exotic species. Therefore, exotic species removal is problematic due to the inherent tenacity of the plant and the combined effects which may occur based on other management practices.

In contrast to exotic species removal, rare and endangered species need to be managed to ensure their conservation. Nowhere is this more apparent than in the vernal pool community. Vernal pools support a variety of plants whose fates are questionable. Concern for vernal pool species generally occurs when creating or restoring the pools for mitigation. Often newly created pool success is rated by physical characteristics: hydrology, species richness, vegetation cover, or target species. Rarely is the new pool measured to determine if the pool fulfills its functional or ecological roles: food chain support, raptor foraging site, amphibian breeding site, and endemic habitat (Ferren Jr. and Gevirtz, 1990). Monitoring must be long-term in order to ascertain that the pool is self-sustaining for all the roles it plays.

Riparian ecosystems provide the greatest opportunity to protect large areas of valuable habitat for many threatened and endangered species. CALFED has identified the Shaded Riverine Aquatic (SRA) as a primary habitat for the restoration of the Bay-Delta ecosystem and that of the tributaries. The benefits of riparian vegetation and management as a buffer system is critical to this restoration.

Benefits of Riparian Vegetation

Riparian vegetation provides a number of important ecosystem functions. It can support terrestrial and aquatic habitat. It can help to buffer the destructive potential of floodwaters. It can also help to control nonpoint source pollution.

Native plant species along a stream often provide diversity to the environment, promoting habitat for terrestrial wildlife. The extent of this benefit is dependent on the type of vegetation, the width of the band of vegetation parallel to the stream and the degree to which it forms a corridor with contiguous habitat areas. Riparian vegetation has been shown to be critical for the quality of the aquatic ecosystem as well. The shading of streams by vegetation reduces water temperature fluctuations that occur from solar warming (Beschta and Taylor, 1988; Brazier and Brown, 1973). Organic material falling from streamside vegetation, particularly from native plant species, is an important source of food for aquatic organisms (Meehan et al., 1987; Newbold et al., 1980).

Apart from providing food material (see Fisheries chapter), large woody debris has a particularly important role in protecting the aquatic environment. It provides habitat for a diversity of macroinvertebrates at densities much higher than on the stream bottom (Benke et al., 1984; Rhodes and Hubert, 1991; Sweeney, 1992). It acts to increase channel roughness, diversifying the stream environment, and supporting the development of debris jams, riffles, and pools. These structures provide fish habitat and slow down the movement of the organic matter that provides the food sources for resident aquatic populations. Gregory et al. (1987) pointed out that organic matter cannot serve as a nutritional resource for aquatic biota until it is retained within the stream channel. The presence of large woody debris in streams also reduces the bank erosion and channel straightening from the scouring of unimpeded stream flow (Oliver and Hinckley, 1987) and the destruction of aquatic habitat from the scouring effect that can occur during storm events (Dolloff et al., 1994).

However, to effectively enhance stability of the aquatic environment, woody debris must be of substantial size. Debris of large diameter is slower to decompose. In wide channels, where short pieces of material may be floated away, stability is improved by woody debris that is sufficiently long so that much of its weight is supported by ground outside the channel and so that the debris can lodge against standing trees (Swanson et al., 1984).

Removal of timber along streams has a long-term influence on the stream. Levels of allochthonous organic inputs are reduced for one or two decades, or longer at high elevations. However the quality of organic inputs may be changed for as long as 100 years after harvest of mature trees. Studies have shown that streamside trees do not provide substantial recruitment of large woody debris until they are 50-80 years old. Removal of timber along streams also may shift the composition of woody inputs from relatively decay resistant coniferous material to more rapidly decomposed deciduous material (Gregory et al., 1987). Even selective cutting of old growth along streams can significantly degrade the aquatic ecosystem by reducing inputs of large woody debris (Bisson et al., 1987).

The benefit of nonpoint-source pollution control is due to several effects of riparian vegetation. It can provide a physical barrier to the contamination of surface waters by pesticide sprays. It also provides a physical barrier to the movement of surface water, sediment, and sediment-borne chemicals running off upland fields. The vegetation can take up potential pollutants such as nitrogen and phosphorus through its roots and sequester them in the standing biomass. It also provides an abundance of organic matter in its litter that provides a substrate for microbial transformations.

Management of Riparian Buffer Systems

Compared to no riparian vegetation at all, even a narrow buffer of vegetation between surface water and intensive upland uses can have a positive effect on controlling water quality. Guidelines are available for the effective restoration and management of riparian areas. The U.S. Dept. of Agriculture-Forest Service with assistance from several other agencies produced a booklet specifying a three-zone buffer system representing increasing levels of management away from the stream (Welsch, 1991).

Zone 1 is permanent, undisturbed woody vegetation immediately adjacent to the stream bank that helps protect the aquatic ecosystem. Zone 2 is recommended as a managed forest strip that can be harvested periodically to provide income opportunities and maintain rapid rates of vegetation growth. Zone 3 is a strip of herbaceous vegetation that helps to spread out water flow from the upland area, and it can provide a useful area next to a field for maneuvering equipment and avoiding interference from the trees in Zone 2.

Riparian vegetation does not function in isolation from the upland area above it. For the reduction of pollutants reaching the stream, it is best to do as much as possible to reduce pollutants within the field. High levels of pollutants reaching riparian vegetation in concentrated flow may overwhelm the ability of a buffer to mitigate the pollution load.

Although farmers often begrudge taking land out of production, riparian buffer systems can provide alternative income opportunities. The growth of vegetation can allow for the sale of hunting rights and pulpwood in the short term and timber in the long term.

Land Use and Opportunities for Water Quality Enhancement in the Lower Watershed

The most intensive residential areas in the watershed are around Paradise, Butte Creek Canyon, south Chico, and Durham (see Map Appendix; Land Use). Much of this area is unsewered. Educational programs regarding the value of riparian vegetation should be promoted. People should be encouraged to maintain wide forested buffer areas near the creeks so as to minimize the influx of surface and subsurface pollutants and to protect stream habitat.

A large area on the east side of the watershed is rangeland. While well-managed rangeland is certainly not incompatible with healthy streams, overgrazing and excessive occupation of streamside areas by animals can seriously degrade stream quality. By causing soil compaction and loss of vegetation cover, overgrazing can aggravate erosion and subsequently increase sedimentation into streams. While riparian vegetation is important for protecting stream bank stability, the trampling caused by unrestricted access to the stream by grazing animals can destroy the stream banks, increasing erosion and impeding the emergence of riparian vegetation.

South of Chico and around Durham is a large area of orchards, largely sprinkler irrigated. Irrigation water is used conservatively, with apparently little surface or subsurface water loss. However, there is very little riparian vegetation in this area, and the orchards are mostly kept clean cultivated between the fruit and nut trees. During the winter rainy season, the presence of cover crops between orchard rows and riparian vegetation along the stream channels would greatly reduce pollution into the creek.

West and south of Durham, rice production dominates land use through much of the lower watershed (see Map Appendix; Land Use). Direct return flow of irrigation water into drainage channels circumvents some potential that riparian vegetation would have for mitigating contamination by water-borne chemicals. However, the practice of maintaining water in the fields for a period of time after the application of pesticides helps to reduce potential pollutants before the water leaves the fields (see discussion on "Pesticides" in Water Quality). What nitrates are not taken up by the rice plants, are probably rapidly denitrified in the process.

Farmers are understandably reluctant to try alternatives that would interfere with production practices. Weeds, consumption of the crops by blackbirds, and tunneling by rodents are problems that could be aggravated by allowance for increased vegetation around fields. It would seem that the growth of hedgerows on the berms (checks) between rice fields would offer an opportunity for enhancing the ecological diversity of the area for wildlife habitat. Where roads separate fields, the berms are wide enough so shrubs could be planted along the sides with less possibility for undermining by rodents.

Tailwater ponds and sloughs also offer logical possibilities for enhancing habitat and for cleaning pollutants from the water. Trees, shrubs, and marsh would allow pollutants to be sequestered in standing vegetation or to be degraded by microorganisms in the organic debris. Support for farmers to attempt this kind of habitat enhancement might be provided by mitigation opportunities. Observations of areas in the basin where wildlife habitat has been promoted have indicated an increase in raptor populations which help control rodent populations. More study is needed for methods of effectively maintaining non-crop vegetation without increasing pest problems.

The California Department of Fish and Game acquisition of the Howard Slough Unit has allowed the creation of over 4200 acres of wildlife refuge. Much of this area will be kept permanently or seasonally flooded with water draining from about 6000 to 7000 acres of rice fields. About 80 percent of this water is from the Western Canal Water District. This is a large scale example of a kind of vegetated filter strip that may serve to enhance water quality.

The concept of a large-scale vegetated filter strip is perhaps also a useful way of considering the kind of function provided by the marshlands in the Butte Sink at the south end of the watershed. Acting as a huge filter for much of the water from the upper reaches of the watershed, they may provide an important function in controlling the water quality of Butte Creek before it enters the Sacramento River.

Wildlife In The Butte Creek Watershed

The information gathered from the literature and consultations with agency personnel and experts have been used in this report to describe the historical and existing conditions of wildlife habitat and wildlife occurrences in the Butte Creek Watershed.

The condition of the wildlife populations in the Butte Creek Watershed can only be as good as the conditions of the associated habitat. To obtain a baseline for wildlife populations, wildlife values of the past are first reported. Because the watershed has diverse habitats the watershed has been divided into four sections: Butte Meadows Basin, Canyon Section, Valley Section, and Butte Basin. Each section discusses the importance of the plant communities to the wildlife populations found there. For the most part, only listed species or species of special concern are discussed. For more in depth listing of species, individual species distribution, and threats - see the table entitled "Special Status Wildlife Known or With the Potential to Occur in the Butte Creek Watershed, Butte County, California" in Appendix L.

Wildlife Values of Past Riparian and Fresh-Water Marsh Habitats

Prior felling of riparian trees in the valley section beginning in the 1860's (Thompson, 1961), has jeopardized or completely wiped out heron rookeries and riparian forest. Grazing, farming practices, levees, and diversion dams have significantly reduced the fresh-water marshlands and vernal pools which previously supported native wildlife, many of which are now extirpated, endangered, threatened or species of special concern (Holtgrieve et al., 1996).

Historical riparian forests along lower Butte Creek provided habitat for a variety of migratory and resident birds and mammals. Wider bands of historical riparian forest supported the Bald Eagle, Cooper's Hawk, Least Bell's vireo, Common yellow-throat, Long-eared owl, Purple martin, Swainson's Hawk, Warbling vireo, Western yellow-billed cuckoos, Willow flycatchers, Yellow-breasted chat, and Yellow warbler. These species formerly nested along Butte Creek and it's tributaries but now only the Swainson's hawk, Western yellow-billed cuckoo, and Yellow-breasted chat nest in scattered, isolated locations in the Lower Butte Creek watershed (CDFG, 1965).

Historical marshes in the lower Butte Creek watershed and the Butte Basin provided a rich habitat for a variety of migratory and resident birds, amphibians, and mammals. Hundreds of thousands of acres of historical freshwater marsh supported the Black tern, California black rail, Fulvous whistling duck, Great Blue heron, Great egret, Short-eared owl, Tricolored blackbird, Western least bittern, Western snowy plover, and Yellow rail. These species formerly nested in the fresh-water marshes of the Valley Section and Butte Basin but now only the Black tern, California black rail, Great Blue heron, Great egret, Tricolored blackbird nest in scattered, isolated locations in the valley and Butte Basin (CDFG, 1965).

The Llano Seco Rancho contains the largest Blue Heron Rookery for which data is known. The rookery was discovered in June 1937. A thousand nests were situated in the tops of tall cottonwood trees. At that time 400 pairs of Great Egrets, 200 pairs of Great Blue Herons, 150 pairs of Double-crested Cormorants, and 80 pairs of Black-crowned Night Herons was tallied. The herony at Llano Seco Rancho was impacted by logging operations in 1975. West of Gridley a Great Blue heron and Great egret rookery that held 600 nests was completely destroyed in the early 1950's due to tree removal (Sands, 1980). New growth riparian habitat on Rancho Llano Seco that was dominated by Elderberry and Poison Oak was logged in the early 1970's and burned in 1984; thereby, threatening the known habitat of the Tricolored Blackbird.

Wildlife Values of Past Butte Creek Canyon and Butte Meadow Basin Habitats

Prior to hydraulic mining in the early part of this century (last dredging for gold reported to be 1930), Butte Creek was in a natural state which included large stands of riparian forests that provided valuable wildlife habitat. Historical coniferous mixed forest of the Butte Meadow Basin provided habitat for a variety of migratory and resident birds, mammals, amphibians and reptiles. Increased human population in the canyon, increased recreational use of the upper watershed, timber harvest plans, and clearcutting have reduced or disturbed the habitat of the resident species.

The quiet streams and associated marshes, pools and ponds of the upper watershed provided habitat for the California red-legged frog, Cascades frog, Foothill yellow-legged frog, Mountain yellow-legged frog, and the Mountain beaver. Since the turn of the century the montane meadows of upper Butte Creek have been grazed by sheep and cattle. The livestock caused destructive impacts on riparian vegetation and amphibious habitat (Animal Species of Special Concern CDFG). The amphibious species formerly laid their eggs in the clear streams, pools, ponds and marshes of the upper watershed but the populations are now very small or localized in areas where they are now heavily invaded by exotic frogs and fishes.

Historical old-growth coniferous forest of the Butte Meadow basin provided nesting trees, snags, tree cavities and forest canopy closure for the California spotted owl, Great gray owl, Northern goshawk, Yellow warbler, and the Pacific fisher. The avian species formerly nested in the mature coniferous forest but now only the California spotted owl, Northern goshawk and the Yellow warbler nest in scattered and isolated locations of oak-conifer and mixed conifer forest. The Pacific fisher was virtually eliminated through trapping before 1940. It's elimination created a natural unbalance of porcupines as the Pacific fisher is the only predator that hunts porcupines (Mathews, 1998).

Current Status of Special Status Wildlife Populations

Butte Meadows Basin

The mixed conifer forest of the Butte Meadows basin supports over three hundred animal species. The upper tributaries of Colby, Willow, Jones and Bolt Creek connect with Butte Creek in the Butte Meadows Basin. These tributaries, with their associated meadows, wet swales, and seasonal ponds, provide critical breeding habitat for amphibians such as the California red-legged frog (*Rana aurora draytonii*), Cascades frog (*Rana cascadae*), Foothill yellow-legged frog (*Rana boylei*), and Mountain yellow-legged frog (*Rana muscosa*). Cattle grazing still occurs in the wet montane meadow areas of the Butte Meadow Basin. Some areas, where a creek flows through the meadows, have been fenced off from cattle to create a riparian buffer zone between the creek and meadows. As these riparian strips become naturally vegetated they will provide protective cover for wildlife attracted to the available surface water.

Avian species of special status known to occur in the mixed conifer forest of the upper Butte Creek Watershed include California spotted owl (*Strix occidentalis occidentalis*), Cooper's Hawk (*Accipter cooperi*), Great Gray Owl (*Strix nebulosa*), Merlin (*Falco columbarius*), Northern goshawk (*Accipiter gentilis*), Osprey (*Pandion haliaetus*), Purple martin (*Proque subis*), Sharp-shinned hawk (*Accipiter striatus*), Vaux's swift (*Chaetura vauxi*), and Yellow Warbler (*Dendroica petechia*). For more information see Appendix L.

The abundance of water in the upper Butte Creek Watershed enhances the value of the Douglas fir mixed conifer forest for wildlife. The composite mosaic of streams, Douglas fir mixed conifer forest, Ponderosa pine mixed conifer series, chaparral, meadow and oak woodland in the upper watershed enhances the wildlife habitat through its wide variety of habitats and ecotones.

The wildlife value of the mixed conifer forest varies with the degree of canopy cover, density, and the diversity of understory plant species present. The highest wildlife diversity and abundance occurs where the vegetation is highly stratified; the stratification offers a greater variety of niches for wildlife species. The intergrade between Douglas fir mixed conifer forest or pine mixed conifer with scrub communities creates a mosaic that is highly stratified and of high value to wildlife.

Significant habitat features include the presence of cavity bearing trees. Mature forests bear natural cavities that are vital resources for cavity-nesting birds and small animals. Mature forests typically contain snags which are valuable resources for woodpeckers as they prefer dead trees and limbs for excavation of roost and nest sites. Woodpeckers carve out a new domicile each year making their former homes available to secondary cavity-nesting species such as chickadees and wrens.

Great horned owls and Western screech owls nest in mixed conifer forest and prey on rodents that are active at night. Species of special status that are diurnal raptors in this habitat include the Golden Eagle (*Aquila chrysaetos*), Cooper's Hawk (*Accipiter cooperii*), Northern Goshawk (*Accipiter gentilis*), and Sharp-shinned Hawk (*Accipiter straitus*). These raptors feed primarily on small mammals or other birds, while golden eagles may take larger prey. The Snowshoe hare (*Lepus americanus tahoensis*), is a crucial staple in winter diet of several predators, including the Sierra red fox (*Vulpes mulpes necator*), great horned owls, bobcats and Pacific fishers (*Martes pennanti pacifica*).

Another significant feature of the mixed conifer forest is the abundance of fallen woody debris. The woody debris adds structural complexity to the forest habitat, and is important as cover, nesting, roosting, and foraging substrate for wildlife. Downed wood helps moderate arid conditions and creates micro-climates suitable for amphibians and reptiles. The downed woody debris provides suitable breeding and cover sites for several amphibious species such as the Ensatina Salamander (*Ensatina eschscholtzi*). Aquatic breeding species such as the Sierra newt (*Taricha torosa sierrae*), typically spend their terrestrial existence in rodent burrows but may also take refuge under woody debris in adjacent forests. A high diversity of reptiles is due to the abundant prey and cover by understory vegetation and fallen woody debris. Representative species that prefer the moist, wooded drainage bottoms include garter snakes, Common Kingsnakes (*Lampropeltis getulus*), and Ringneck Snakes (*Diadophis punctatus*).

Representative mammal species that utilize both the Douglas fir mixed conifer forest or Ponderosa pine mixed conifer forest habitats include the Virginia Opossum (*Didelphis virginiana*), Deer Mouse (*Peromyscus maniculatus*), Western Gray Squirrel *(Sciurus griscus*), Bobcat (*Lynx rufus*), Gray Fox (*Urocyon cinereoargenteus*), Striped Skunk (*Mephitis mephitis*), Mountain Lion (*Felis concolor*), Black Bear (*Ursus americanus*), and many bat species.

White fir forest provides excellent habitat for snag and cavity dwelling species. It also provides foraging habitat for insect-gleaning birds such as Western Tanager (*Piranga ludonciana*), Chestnut-backed Chickadee (*Parus rufescens*), Mountain Chickadee (*Parus gambeli*), Golden-crowned Kinglet (*Regulus satrapa*), and Yellow warbler (*Dendroica petechia)*, a State species of special concern.

Red fir forest habitats are significant to many species of special concern including; Northern Goshawk (*Accipiter gentilis*), Great Gray Owl (*Strix nebulosa*), Sierra Nevada Red Fox (*Vulpes v. necator*), and Marten (*Martes americana*). The Red fir habitat is also associated as habitat for the Wolverine (*Gulo luscus*).

Wildlife species in Butte Meadows Basin suffer stress from logging practices, pesticide use, road construction, livestock grazing and off-road vehicles -- particularly in meadows, riparian areas, streams and lakes (CDFG, 1993). Predation by, and competition with, the exotic bull frog threatens the Cascades frog, California red-legged frog, the Foothill yellow-legged frog and the Mountain yellow-legged frog. Human recreation in the area also causes stress as some species, such as the Western pond turtles are sensitive to human presence (CDFG, 1993). Avian species are threatened by direct and indirect human disturbances at nest sites. Forested nesting areas of the Great gray owl have been destroyed by logging. Meadow foraging areas for this State endangered species have been lost to, or damaged by, reservoirs, grazing, roads, and buildings. Numerous avian species, such as the Merlin, Northern goshawk and Northern harrier, are still being impacted by DDT, along with other threats including: exposure to toxic substances, hunting (sometimes illegal), trapping, fishing and collision (CDFG, 1993).

Canyon Section

The canyon section of the Butte Creek Watershed is a mix of Early Successional Riparian Gravel and Sand Bars, Mixed Riparian Forest, Cottonwood Riparian Forest, White Alder Riparian Forest, Riparian Scrub, Blue

Oak-Foothill Pine Woodlands, Valley Oak Woodland, Willow Scrub and Mixed Conifer Forest communities. These communities provide a complex mosaic of habitat and ecotones.

Riparian communities offer some of the highest level of wildlife species diversity and abundance in California. The factors that contribute to the high wildlife value include the abundance of plant growth, the presence of surface water, and the variety of niches provided by the high structural complexity of the habitat. Riparian habitat is used by wildlife for food, water, nesting, thermal cover, escape cover, migration, and dispersal corridors.

Mature Valley Oak mixed with cottonwood occurs in the lower canyon adjacent to or overlapping with the riparian corridor. This habitat is particularly valuable to wildlife due to the close proximity of water and the dense undergrowth of willow, wild grape, blackberry and elderberry. The dense understory is habitat for such species as the Ash-throated Flycatcher (*Myiarchus cinerascens*), swallows, Bushtits (*Psaltriparus minimus*), Osprey (*Pandion haliaetus*), American Goldfinch (*Carduelis tristis*), and Black Phoebe (*Sayornis nigricans*).

Streamside pools and low-flow shallows provide breeding habitat for Sierra Newts (*Taricha torosa sierrae*), and Pacific Treefrogs *(Hyla regilla)*. Other amphibian species such as the California Slender Salamander (*Batrachoseps attenuatus*), utilize moist, terrestrial habitats underneath fallen logs and woodland debris for breeding and refuge. Common reptile species that utilize aquatic habitat for foraging or escape cover include the Western Aquatic Garter Snake (*Thamnophis counchi*), Western Terrestrial Garter Snake (*Thamnophis elegans*), and Western Skink (*Eumeces skiltonianus*).

The deciduous trees found along the riparian corridor attract insects in abundance which create areas especially suitable for neo-tropical migrants who feed on numerous insects to replenish their migratory fat reserves. Examples of neo-tropical migrants include such species as Wilson's Warbler (*Wilsonia pusilla*), Warbling Vireo (*Vireo gilvus*), and American Redstart (*Setophaga ruticilla).* Residents that are more abundant in riparian habitats than in adjacent forests include the Winter Wren (*Troglodytes troglodytes*), Song Sparrow (*Melospiza melodia*), and Swainson's Thrush (*Catharus ustulatus*). The nearshore areas of the creek are utilized by American Dipper (*Cinclus mexicanus*), Belted Kingfisher (*Ceryle alcyon*), herons and other waterfowl. Red-shouldered Hawks (*Buteo lineatus*), utilize riparian trees for nesting while swifts, swallows and flycatchers can be found hawking their insect prey over water.

Mammals such as skunks, raccoons, opossums, Ringtail (*Bassariscus astutus*), Longtail Weasel (*Mustela frenata*), Gray Fox (*Urocyon cinereoargenteus*), Mountain Lion (*Felis concolor*), and Bobcat (*Lynx rufus*) are likely to drink from the creeks and forage on insects, amphibians and rodents. The riparian habitat provides movement corridors and water sources for Colombian Black-tailed Deer (*Odocoileus hemionus columbianus*), and birds. Bats that are associated with riparian forests include California Myotis (*Myotis californicus*), Fringed Myotis (*Myotis thysanodes*), and Long-eared Myotis (*Myotis evotis*).

Successional riparian river rock beds are dry rock beds in the river channel, deposited by the meandering effect at high water flows. During the summer months these areas frequently contain calm, shallow, backwater pools as the water levels drop and water becomes restricted to the main channel flow. Western Spadefoot Toads (*Scaphiopus hammondi*), and their tadpoles utilize these back water pools. The warmer water temperature associated with calm, shallow water and the presence of algal growth create areas that are good for Pacific tree frog reproduction. Herons, skunks and raccoons forage for stranded fish, tree frogs and tree frog tadpoles in these areas.

Rock bars with sandy patches exposed are often colonized by willows, mulefat, sticky monkey flowers and other flowering plants. Hummingbirds forage from sticky monkey flowers until the next high water event. The hot micro-climate of the rocks combined with deposits of woody debris from the river provides basking habitat for heat seeking reptiles such as Northern Alligator Lizard (*Gerrhonotus coeruleus*), Common Garter Snake (*Thamnophis sirtalis*), and Northwestern Pond Turtles (*Clemmys m. marmorata*).

The Blue Oak-Foothill Pine Woodlands of the Butte Creek Watershed lack an understory of mix of age class which is typical of oak habitats statewide and is thought to be a result of management practices such as flood and fire suppression, and overgrazing which suppress oaks from regenerating (Pavlik, et al., 1991). Oak woodlands are critical habitats for the conservation of many mammal and bird species. Significant habitat features include acorn production and the presence of cavity-bearing trees. As a seasonal food, acorns are important for survival of numerous species of wildlife in the fall and winter. The mammals and birds that are dependent on acorns as a seasonal food source include deer, woodpeckers, Black Bears (*Ursus americanus*), Western Gray Squirrels *(Sciurus griscus*), Wild Turkeys (*Meleagris gallopayo*), Northern Flickers (*Colaptes auratus*), Scrub Jays (*Aphelocoma coerulecscens*), Band-tailed Doves (*Columba fasciata*), and California Quails (*Callipepla californica*). Scrub jays, Western gray squirrels and California Ground Squirrels (*Citellus beechevi*), bury acorns which are more likely to germinate because they root better and are less likely to be eaten by other species.

Cavity-nesting birds and small mammals depend on the natural cavities associated with mature oak trees. Mature oak trees often have broken limbs that contain some degree of decay which birds and mammals can then excavate for nest and roost sites. These cavities receive high levels of use by woodpeckers and secondary cavity-nesting birds such as owls, Tree Swallow (*Tachvcineta bicolor*), Violet-green Swallow (*Tachvcineta thalassins),* and Purple Martin (*Progne subis*), a state and federal species of special concern.

The insects associated with oaks are preyed upon by several avian species such as Bushtits, Kinglets (*Regulus* spp.) and warblers. California Towhee (*Piplio crissalis*), and sparrows forage for insects on the ground under the oaks.

Wildlife species in the Canyon section suffer stress from human presence, harassment and disturbance which have caused loss of habitat by the human population expansion into nesting and feeding areas. Illegal shooting and reproductive failures due to food chain contamination by pesticides also cause the loss of wildlife in this section. The most sensitive species in this section are the Northwestern Pond Turtles, American Peregrine Falcon, American White Pelican and the Greater Sandhill Crane (CDFG, 1965).

Valley Section

In the valley section of the Butte Creek Watershed there are only a few fragmented sections of remaining mixed and Valley Oak riparian forest. Southeast of Chico where Butte Creek crosses Highway 99 is the “Virgin Valley Riparian Area” used by California State University, Chico for educational purposes (NDDB, 1995). The mature forest extends up Butte Creek on the mine tailings. Another small fragment of great Valley Oak riparian forest is located approximately three miles south of Durham. This forest is a long, disturbed corridor that is suffering from continued clearing and agricultural conversion threats. South of Biggs is a Valley Oak dominant riparian forest fragment where Swainson’s hawk (*Buteo swainsoni*) are known to nest. Another great valley mixed riparian forest fragment is on Butte Creek west of Richvale and is used for a gun club (NDDB, 1995).

Valley riparian forests support a high diversity of breeding birds; 67 species are known to nest in the forests of the Sacramento Valley. This high diversity seems to depend on foliage volume and foliage height profile. Most birds (84%) nest above ground in woody vegetation with a high percentage (41%) utilizing tree holes or cavities. Hole-nesting species show superior success as compared to open-nesting species both in hatching eggs and fledging young. This is due to the greater security tree holes provide from nest predators, such as squirrels, raccoons and jays. Tree holes are in short supply limiting the density of cavity-nesting birds. The erection of nest boxes and other artificial nesting facilities can increase the riparian forest bird population by 25-fold.

Riparian forests provide nesting and breeding sites for nine species of water birds which forage in surrounding marsh and riverine habitats. The Osprey (*Pandion haliaetus*), is a fish-eating raptor that builds its bulky stick nests in trees near the rivers where they hunt. Two species of waterfowl, Wood Duck and Common Merganser, raise their young in tree-cavities. Riparian forests are of particular importance for the colonial nesting rookeries of the Great Blue Heron (*Ardea herodias*), Great egret (*Casmerodisus albus*), Snowy Egret (*Egretta thula*), Black-crowned Night Heron (*Nycticorax nycticorax*), and Double-crested Cormorant *(Phalacrocorax auritus).*

The State and Federal endangered and threatened species occurring in the valley riparian section of the Butte Creek Watershed are Valley elderberry longhorn beetle (*Desmoecerus californicus dimorphus*), Conservancy fairy shrimp (*Branchinecta conservatio)*, Vernal pool fairy shrimp (*Branchinecta lynchie*), Vernal pool tadpole shrimp (*Lepidurus packardi)*, Greater Sandhill Crane (*Gus canaensis tabida*), Swainson's Hawk (*Buteo swainsoni*), Western yellow-billed cuckoo (*Coccyzus americanus occidentalis*), and Willow Flycatcher (*Empidonax traillii*). Only one community of Valley elderberry shrubs, which provide habitat to support valley elderberry longhorn beetles, has been located along Comanche Creek. Species of special concern occurring in the riparian forest fragments of Butte Creek Watershed include the Long-eared owl (*Asio otus*), and Yellow-breasted chat (*Icteria virens*).

The stress on wildlife in this section is the loss of vernal pools and temporary ponds, loss of riparian areas, loss of marshes, loss of woodlands, loss of grasslands, bank disturbance, toxic pesticides, water quality deterioration, illegal killing, and collisions (CDFG, 1994). The loss of riparian area has caused the decrease in the Valley Elderberry longhorn beetle. The status of the Giant Garter snake was caused by the loss of habitat from filling of sloughs and drainage of marshes. This State and Federal threatened snake is also impacted by water quality deterioration, destroyed food sources, snakes collectors, and illegal killing. The State threatened status of the Swainson's Hawk was caused by loss of grassland (foraging) and woodland (nesting) habitats primarily to agricultural and urban land use conversion. Pesticides and rodenticides are additional problems.

Butte Basin

The Central Valley of California is one of the most important waterfowl wintering areas in the Pacific flyway and the Butte Sink is one of the most significant wetlands of the Central Valley. The Butte Sink is very large (about 11,000 acres), and provides a variety of wildlife communities in its riparian forest corridors, and seasonally and permanently flooded wetlands. Since 1914 rice growers have drained water from their fields into the Butte Sink. In 1922 (Kerhoulas), an agreement was made to provide for the perpetual flowage of drainwater from the Western Canal to 7,700 acres of duck clubs, returning the land to marsh habitat and making the land unfarmable. Wildlife species found in the basin include waterfowl guilds, shorebird guilds, and riparian wildlife guilds. Generally, the wildlife populations in the Butte Basin are healthy.

Seasonally flooded wetlands are prevalent through the lower portions of the basin and are extremely important habitat areas for waterfowl, shorebird, an wading bird guilds. The riparian and riverine aquatic habitat is important for aquatic and terrestrial species. Healthy riparian vegetation provides a migration corridor that connects the mainstem Sacramento River with the habitats of the upper Butte Creek Watershed. This corridor is used by terrestrial species, such as birds and mammals.

The freshwater marshes of the Butte Basin are of great value to terrestrial wildlife as the surface water provides water for drinking. The freshwater marshes are excellent breeding areas for the Black tern (*Chlidonias niger*), Marsh wrens (*Cistothorus palustris*), Red-winged Blackbird (*Agelaius phoeniceus*), Western Pond Turtle (*Clemmys marmorata*), and Sierra Newt (*Taricha torosa sierrae*). The freshwater marshes also provide foraging habitat for the Belted Kingfisher (*Ceryle alcyon*), Black-crowned Night Heron (*Nycticorax nycticorax*), Great blue heron (*Ardea herodias*), Great egret (*Casmerodisus albus*), Green-backed Heron (*Butorides striatus*), and the Northern harrier (*Cicus cyaneus*). Federal and State listed species found in the freshwater marshes of Butte Sink include the Giant garter snake (*Thamnophis counchi gigas*), Aleutian Canada Goose (*Branta canadenis leucopareia*), California black rail (*Laterallus jamicenis coturniculus*), and Greater Sandhill Crane (*Grus canaensis tabida*). The Fulvuous whistling duck (*Dendrocygna bicolor*), was once common in the Butte Sink but is now apparently extirpated, the Harlequin duck (*Histrionicus histrionicus*) is most likely no longer breeding in the Sink and is only a rare winter resident, and though the Tricolored blackbird (*Agelatus tricolor*) occurs here, no nesting sites have been observed. Species of special concern still occurring in the Butte Sink marshes are the Western least bittern (*Ixobrychus exilis hesperis*), White-faced ibis (*Plegadis chihi*), and Yellow rail (*Coturnicops noveboracensis*).

Vernal pools in the Butte Sink are habitats for several species of special concern and are of high wildlife value for waterfowl, shore birds, mammals, predatory birds, reptiles and amphibians. The Western spadefoot toad

(*Scaphiopus hammondii*) breeds in the vernal pools, and the only known occurrence of the California tiger salamander (*Ambystoma californiense*) was observed in a vernal pool at Graylodge. The vernal pools are used for watering holes for numerous mammals and as foraging, and nesting areas for various birds. Small rodent populations particularly rely on the presence of vernal pools for seasonal water such as the Deer mouse, Blacktailed hare, and Valley pocket gopher. Migratory waterfowl and shorebirds feed on the invertebrate and amphibian species of the vernal pools.

The riparian forests are valuable because they support a high density and diversity of wildlife species and because they are a diminishing resource. These areas provide potential habitat for Federal and State listed species such as the Western yellow-billed cuckoo (*Coccyzus americanus occidentalis*), and Willow flycatcher (*Empidonax traillii*); and species of special concern such as the Yellow-breasted chat (*Icteria virens*). The above species along with the Red-shouldered hawk, and Blue Grosbeak (*Guiraca caerulea*) breed in no other forest habitat.

The preservation of dead trees and snags is an important consideration for the management of riparian forest habitat for bird populations. Most of the tree-hole nesting sites in riparian forests are excavated by woodpeckers such as the Downey Woodpecker (*Picoides pubescens*), in the soft wood of dead, decaying trees and snags. Since woodpeckers carve out a new domicile each year, their former homes are available to other cavity-nesting species.

By late summer, the riparian forests provide the only lush, insect-rich forest habitat in the lowland as the long dry period has seared the surroundings to golden brown. The importance of riparian forests to southward (fall) migrants cannot be underestimated.

Stressors to the habitats and species in the Basin include insufficient flow in the lower portions of most of the streams, and inadequate riparian vegetation. Diversions for flooding State and Federal Refuges, and private duck clubs, cause the insufficient flow of the lower portions of the streams. While the wildlife refuges and hunting clubs dependent on Butte Creek water provide some of the most valuable wildlife and waterfowl habitat in the Sacramento Valley, the timing of water needs sometimes conflicts among duck clubs, agriculture and anadromous fisheries (CALFED, 1997).

The California Tiger Salamander suffers from loss of vernal pools and other seasonal water sources that are required for viable breeding. The status of the Giant garter snake was largely caused by the filling of sloughs and drainage of marshes; they are also affected by destroyed food sources and snake collectors. The loss of inland wetlands by filling and drainage, along with stream channelization, continues to threaten the California Black rail (Flores and Edelman, 1995). Pressures of hunting, DDT, and other toxics cause problems for the Fulvous whistling duck, Great Blue Heron, Great Egret and the Greater Sandhill Crane. The status of the Western Yellow-billed cuckoo was apparently caused by DDT contamination and pesticide use (Gaines and Layman, 1984). This neotropical bird also suffers stress from the loss and degradation of riparian habitat that is vital to reproduction.

Threats by Exotic Species

<u>Brown-headed Cowbirds</u> (*Molothrus ater*), arrived to the valley ~1900, and with the spread of irrigated agriculture they arrived in flocks (Gaines and Layman, 1984). The spread of agriculture has allowed the cowbirds to penetrate into new regions where they have access to host populations that have had little or no ancestral experience through which to develop effective defenses against them. In the breeding season, cowbirds invade riparian forest habitat, where they burden other species with the task of incubating their eggs and raising their young. Since cowbirds reproduce ferociously, not having to feed their young, a single female can lay as many as 50 eggs in a breeding season. The decline of Willow Flycatcher (*Empidonax traillii*), Bell's Vireo (*Vireo bellii*), Warbling Vireo (*Vireo gilvus*), Yellow Warbler (*Dendroica petechia*) and Common Yellowthroat (*Geothlypis trichas*), in the Butte Creek Watershed has been partially attributed to cowbird parasitism. Once a female cowbird lays her eggs in the nests of vireos, warblers, or other susceptible hosts, she takes no further interest in her progeny. The hosts hatch her eggs and raise her young at the expense of

some of their own brood. Some researchers point out that cowbirds are not the primary threat to endangered songbirds--humans are (Dunaief, 1995). The least Bell's vireo, for example, has lost 95 percent of its habitat to farms and other human uses. Restoring habitat, most researchers agree, is the only long-term solution to the songbirds' woes. It would help them directly, by giving them breeding space, and indirectly, by taking that space from cowbirds.

Bullfrogs (*Rana catesbeiana*) are an exotic species that exerts differential effects on native amphibians including Foothill yellow-legged frog (*Rana boylii*), Mountain yellow-legged frog (*Rana muscosa*), Red-legged frog (*Rana aurora draytonii*), Cascades frog (*Rana cascadae*), Pacific Treefrog (*Hyla regilla*), and Sierra Newt (*Taricha torosa sierrae*). Bullfrogs prey on adult frogs, tadpoles and eggmasses of the above species in the Butte Meadows Basin and Canyon sections. The competition from large overwintering bullfrog larvae significantly decrease survivorship and growth of native tadpoles. Studies have shown that bullfrog tadpoles have the potential to cause a 48% reduction in survivorship of Foothill yellow-legged frog, and a 24% decline in mass at metamorphosis. The bullfrog has smaller effects on Pacific treefrogs; a 16% reduction in metamorph size and no significant effect on survivorship.

Threatened and Endangered Species

Valley Elderberry Longhorn Beetle (*Desmoecerus californicus dimorpus*). The Valley elderberry longhorn beetle is a Federally threatened species. This beetle is a pithbore on elderberry shrub (*Sambucus* spp.) in riparian habitats. Recent information has demonstrated that the beetle are found only in elderberry stems 1 inch or greater in diameter (CDFG, 1994). Valley elderberry shrubs are sporadically located along riparian habitats in the Valley section and elsewhere.

Conservancy Fairy Shrimp (*Branchinecta conservatio*). The Conservancy Fairy Shrimp was listed as an Federally endangered species along with several other crustaceans in September 1994. Several possible causes of extinction include urban development, agricultural land conversions, and the isolation of individual populations among a small number of vernal pools. Vernal pool habitat was once much more extensive throughout California's Central Valley, probably allowing a much broader distribution of the species. Vernal pools, temporary ponds formed by seasonal rainfall upon small watersheds, provide the sole habitat for the fairy shrimp. A water impermeable layer just below the surface of the ground assures the collection of water during the winter, while the drying effects of Spring cause a complete drydown of the pool by evapotranspiration. The fairy shrimp survives the hot, dry summer by depositing drought resistant "resting eggs" or cysts in the pond soil. The crustaceans represent a food resource for water birds, and birds may possibly disperse the shrimp's cysts on their bodies over their migratory route; the cysts may also be transported within the avian digestive tract. Population densities within individual ephemeral pools may be quite high. Fairy shrimp do not inhabit lakes which may have predatory fish and offer no seasonal dry downs for their reproductive cycle. Occurrence of the Conservancy fairy shrimp has been observed at the lower end of Comanche Creek (Valley section), in a freshwater emergent marsh in a low-lying depression within the streambed caused by the backup of water to due a beaver dam.

Vernal Pool Fairy Shrimp (*Branchinecta lynchie*). The Vernal Pool Fairy Shrimp is a Federally threatened species. In California these crustaceans inhabit ephemeral wetlands, such as vernal pools, mountain meadows, and desert playas with wet/dry cycles. The shrimps hatch and mature during the aquatic phase and deposit dormant cysts that remain in the soil through the dry phase. In some habitats, due to the variable nature of local rainfall patterns, pools at times fill only partially and dry quickly before the shrimp are able to mature and reproduce. Species in such unpredictable environments produce cysts that do not all hatch when first hydrated; a portion remain dormant and hatch in later pool fillings. Occurrence of the Vernal pool fairy shrimp was observed in a freshwater emergent marsh in the Spring of 1996 on Comanche Creek west of Hwy. 99, Valley section.

Vernal Pool Tadpole Shrimp (*Lepidurus packardi*). The Vernal Pool Tadpole Shrimp is a Federally endangered species. This shrimp exclusively inhabits vernal ponds in Northern California, and is present 4 out of 5 months that the ponds are flooded. They are often found in shallow depressions in open, treeless range land that is frequented by livestock and migrating water fowl. The margins of ponds may vary from cobbly hardpan to soft clay mud, with some areas receiving strong wave actions from prevailing winds. Tadpole shrimp are often present in the greatest abundance along wave disturbed shores. They are basically detritivores and their preference may be attributed to the accumulation of pond detritus at those locations. Occurrence in the Butte Creek Watershed was observed in a freshwater emergent marsh in Comanche Creek, west of Hwy. 99, Valley section.

California Red-legged Frog (*Rana aurora draytonii*). The California red-legged frog is a Federally threatened species and a State species of special concern. This species is found in quiet pools along streams, in marshes, and ponds. Red-legged frogs are closely tied to aquatic environments and favor intermittent streams which include some areas with intact emergent or shoreline vegetation, and a lack of non-exotic bullfrogs and non-native fishes. They are generally found on streams having a small drainage area and low gradient. The breeding season for this frog spans from January to April when females deposit 1,000-4,000 eggs on submerged vegetation at or near the surface. Introduced predators are a primary threat to this species. It has also been found that this species is showing declines in populations due to UVB sensitivity, especially on the eggs, which are potentially the most UVB-sensitive stage (Hays et al., 1996). The red-legged frog is a year-round resident of Butte Creek House Ecological Reserve located in the Butte Meadows Basin.

Cascades Frog (*Rana cascadae*). The Cascades frog is a State endangered species that is a year round resident of upper Butte Creek. They are mountain frogs that are closely restricted to water, and frequent small streams, potholes in meadows, ponds and lakes. They are found in the water or among grass, ferns and other low herbaceous growth. They are a rather slow moving frog that will often allow close approach. When frightened they will usually attempt to escape via swimming rather than seeking refuge at the bottom of the stream, pond or lake. The U.S. Forest Service has constructed riparian fencing to protect the Cascades frog on Colby Creek. This population of Cascades frog is the southernmost population in the Cascades. The Rough-skinned newt (*Taricha granulosa*) is a predator of the Cascades frog tadpole.

The Cascades frog is also declining due to UVB radiation. A lab study was made with Cascade frogs where tadpoles were raised to maturity and were supplemented with modest levels of UV light or light filtered to remove UVB wavelengths. Observations revealed severe effects of both UVA and UVB light on tadpoles and metamorphs; this included developmental abnormalities and high mortalities.

Foothill Yellow-legged Frog (*Rana boylei*) The Foothill yellow-legged frog is a Federal threatened species and a State species of special concern. It is found in or near rocky streams in a variety of habitats, including valley foothill hardwood, valley-foothill riparian, coastal scrub, mixed conifer, mixed chaparral, and wet meadows. This species is very closely tied to its aquatic habitat and is rarely found far from perennial or intermittent streams. Foothill yellow-legged frogs are typically found in shallow water of partly shaded streams. Adults seek moving but usually not swiftly flowing water. Pools are used on intermittent streams during the dry season. Breeding takes place from mid-March to early June. The female attaches grape-like clusters of eggs to gravel or rocks in moving water near stream margins. The Foothill yellow-legged frog has been observed at the Butte Creek House Ecological Preserve. The Butte Meadows Basin is a unique area where both the Mountain yellow-legged frog and the Foothill yellow-legged frog can be found.

Giant Garter Snake (*Thamnophis counchi gigas*). The Giant Garter Snake is a Federal and State threatened species. They are aquatic in habit, historically they were found in colonies in tule patches. They are extremely alert and timid. They inhabit irrigation canals that are usually about 15 feet wide, with nearly vertical banks and a current of slightly turbid water several feet deep. The wariness of these snakes is probably correlated with their open habitat. Water is usually shallow in this habitat; rocks and logs are absent both under water and along shores; trees and bushes are absent along the edge of the water, and the snakes are not screened from view from above. Under these conditions they are in constant danger from herons, marsh hawks, and other predatory birds which might drop down upon them or seek them out in the shallow water. The Giant garter snake has been observed in the northern portion of Butte Sink, Little Dry Creek, Upper Butte Basin Wildlife Area, Butte Creek at McPherrin Dam, and at the Rancho Llano Seco.

Aleutian Canada Goose (*Branta canadensis leucopareia*). The Aleutian Canada Goose is a Federally threatened species that was once listed as endangered. A stunning and unexpected recovery in populations of

Canada geese began 30 years ago when there were just a few thousand of them in all of North America. Today, there are more than 1.5 million of Aleutian Canada Geese. These geese hatch anywhere from five to eight young a year. In some areas, state and wildlife officials are trying to reduce numbers by addling (shaking to prevent hatching), eggs, moving goslings to game preserves, or killing adult birds. While resident geese flourish, some migratory populations are shrinking dramatically (Waytiuk, 1996). One Atlantic group of migratory birds now has just 29,000 breeding pairs which is a 27 percent drop from the year before and a dramatic tumble of 75 percent from 1988 numbers. The resident birds do not mix with migratory flocks that stop over twice each year on their way north or south. The two populations, genetically identical, refuse to interbreed. It has something to do with the pair-bonding as Canada geese mostly mate for life, and they choose from their own area. Currently migratory populations are protected from hunters, but the U.S. Fish and Wildlife Service has resorted to issuing kill permits on resident flocks. The Aleutian Canada Goose migrates to the Butte Sink in October and usually migrates south in December.

<u>American Peregrine Falcon</u> (*Falco peregrinus anatum*). The American Peregrine Falcon is a Federal and State endangered species. Peregrine falcons are infrequently found from annual grassland up through high elevation coniferous forest of the Coast Range. They typically require cliffs for nesting and perching, and prefer nearby lakes or rivers. The most common hunting method of Peregrine falcons is a low surprise attack initiated from a high perch; Peregrines can make up to three kills per day. During courtship the males are physically dominated by the females in landed interactions. The males bring prey to make contact easier with their mate. Until fledging size, the possibility of a male reaching the young depends on the female's control; males transfer food to the females in order to give food to the young. During the 1960s and early 1970s populations of Peregrine falcons drastically declined but indications from studies in Baja to Canada suggest that the local populations are recovering (Castellanos, et al., 1997). In Canada the natural productivity was high at 1.0-2.9 young per territorial pair. The high natural productivity and large releases of captive-raised young should continue the recovery of the Peregrine falcon. The American peregrine falcon is infrequently seen throughout the Butte Creek Watershed but is of regular occurrence from September to October.

<u>Bank Swallow</u> (*Riparia riparia*). The Bank swallow is a State threatened species. This swallow prefers to breed in colonies in earthen banks. The extent of protected, earthen banks and potential bank swallow habitat along Lower Butte Creek and its tributaries is not known, but suitable nesting sites for this species could be present. Protecting banks from disturbance could benefit this species.

<u>California Black Rail</u> (*Laterallus jamicenis coturniculus*). The California Black Rail is a State threatened species and an endangered species in Arizona. The use of habitat is not sufficiently well known for effective management. Studies have observed that California black rails select areas close to upland vegetation during the postbreeding season, possibly because broods cannot use areas with water greater than 6 cm deep. Habitat structure is more effective than plant composition in predicting use of habitat. California black rails may not use areas within wetlands where deep water occurs necessitating the minimization of fluctuations in water level in wetlands managed for the rail. Habitat should include not only vegetational cover, but also water depths within wetlands, access to upland vegetation, and overhead coverage by emergent vegetation. A few adults have been observed north of Sutter Buttes and northeast of Sanborn Slough at Butte Creek.

<u>Greater Sandhill Crane</u> (*Grus canaensis tabida*). The Greater Sandhill Crane is a State threatened species. This crane migrates to California wintering areas in October and November. Habitat improvement increases crane nesting success but brood survival can generally decline and recruitment will be low if the habitat is not managed for predator control. The mean clutch size for cranes in California is 1.91 which is generally similar to the mean clutch size in other states. Since 1986, recruitment has declined ranging from 3.4 to 6.5%. Presently, populations are stable or slightly decreasing. Even though other mortality factors are prevalent in Oregon and California, the most important population limitation appears to be low annual recruitment. With high predation on eggs by Common Ravens, raccoons, and coyotes, and losses of young to coyotes, few young fledge. Due to the longevity and deferred breeding age of adult Greater Sandhill Cranes, a decline in breeding pairs may not occur for a number of years. With the attrition of older breeders, pairs can drop abruptly, many years after declining recruitment is first recorded (Littlefield, 1995). This indicates that caution is warranted when an increased mortality factor is introduced into Sandhill crane populations, as it may take a number of years before higher mortality results in a decrease in breeding adults. Greater Sandhill Cranes usually arrive to

the Butte Sink Basin September 10-20. While at the Wild Duck Goose Club a Sandhill crane was observed in the marsh on September 29, 1997.

Great Gray Owl (*Strix nebulosa*). The Great Gray Owl is a State endangered species. The Great Gray owl have likely been stable over the past 10-100+ years, though local populations fluctuate in response to food supply and/or nest-site availability. Breeding Great Gray Owls require pre-existing nest structures in forest stands that are adjacent to open foraging habitat, preferably with hunting perches. Current forestry practices have the potential to affect about 75% of the Great Gray Owls' breeding range. Intensive timber management typically removes large diameter and deformed nest trees, leaning trees used by juveniles for roosting before they can fly, and stands with dense canopy closure used by juveniles and adults for cover and protection. Specific recommended guidelines include restriction of harvest unit size, but within a mosaic of multi-sized units, retention of forest stands with 300 m of known or potential nest trees/sites, provision of hunting perches in cut-over areas, ensuring irregularly shaped harvest units, and maintenance of forested travel corridors between cut-over areas (Duncan, 1997). Great Gray Owls can breed on home ranges up to 800 km apart in successive years. There have been isolated observations of the Great Gray owl in the Butte Meadows and Stirling City regions.

Swainson's Hawk (*Buteo swainsoni*). The Swainson's Hawk is a State threatened species. This hawk prefers a nest in the crown of tall oaks and riparian trees, and forages in nearby grassland and agricultural lands. Swainson's Hawk nest sites have been observed along Butte Creek south of Durham. Ongoing enhancement of riparian habitats in the watershed could benefit Swainson's Hawk.

A study was made of the Swainson's Hawk in Butte Valley from 1984-94. This study monitored the annual occupancy, reproductive performance, and natal dispersal of 567 Swainson's hawks banded as nestlings. The mean annual nest success was 65%, and the annual fledging rate was 1.53 young per nest attempt. The dispersal distances from natal site to subsequent breeding site ranged from 0-18.1 km with a mean of 8.2 km. Another study was conducted along the Sacramento River in 1992 where four adult Swainson's hawks were radiotagged. The mean home range was found to be greater than 4,000 ha and core areas of intensive use by nesting Swainson's hawks ranged from 25.9-82.2 ha. Individual hawks foraged as far as 2.5 km from the nest. A third study mapped 162 observations of Swainson's hawk in five years of surveys. This study found that Swainson's hawks in the Sacramento Valley preferred riparian habitat, grassland, alfalfa stands of greater than two years, and annual field crops. In the Butte Creek Watershed the Swainson's hawk is found throughout the lower watershed west of Hwy. 99.

Western Snowy Plover (*Charadrius alexadrinus nivosus*). The Western Snowy Plover is a State endangered species. Snowy plovers have biparental incubation duties, but only males care for broods. Most females depart immediately after nests hatch. Female site fidelity seems to be affected by the nesting success in the previous year. Females have been known to avoid areas with high densities of nests which may be an anti-predator strategy. Most nest failures are apparently caused by mammalian predators. The Western snowy plover is rare in the Butte Creek Watershed and may not occur annually.

Western Yellow-billed Cuckoo (*Coccyzus americanus occidentalis*) The Western Yellow-billed cuckoo is a U.S. Forest Service Sensitive species and a State endangered species. Riparian forests are the habitat which host this endangered species. They are restricted to broad expanses of cottonwood-willow forest. The wide removal of this essential habitat has caused the decline of this sinuous bird (Gaines and Layman, 1984). Western yellow-billed cuckoos historically nested on Butte Creek along the Butte Glenn County border, Little Butte Creek marsh and Butte Sink. The habitat at Little Butte Creek Marsh is predominately tule-bulrush marsh, with islands of riparian habitat which was in very good condition at a sighting in 1980. There are currently sparse breeding populations in the riparian areas of Butte Creek along the Butte and Glenn County borders, in the Little Butte Creek Marsh, and Butte Sink.

Willow Flycatcher (*Empidonax trailii*). The Willow flycatcher is State endangered species. This flycatcher was considered to be a very common summer resident in the riparian willow habitat of central California, especially along the valley rivers in 1890. Breeding Willow flycatchers have vanished from almost all of their former riparian forest haunts in the valleys of California. Willow flycatchers prefer riparian willow habitat where they can replenish their fat stores, with an average body mass gain of 1.6%/day, as they migrate between their breeding and wintering grounds. The Willow flycatcher is a Spring (April-May), and Fall (August-September), migratory transient of the Butte Creek Watershed. Because of the loss of riparian habitat in the valley the Willow flycatcher now only nests in the upland areas of the watershed (Sands, 1980).

Wolverine (*Gulo gulo luscus*). The Wolverine is a State threatened species that was denied Federal threatened status in April 1995 due to the animals rarity and mysterious nature; Fish and Wildlife claimed that there was not enough information to warrant listing. The fierce and much-feared wolverine once roamed most of North America, but has been driven back to remote areas of the Pacific Northwest and Canada, and very little is known of its location, diet or habits. Habitat destruction and trapping have reduced North America's most touted predator. A few survivors have retreated to make a last stand in remote mountains and far-northern strongholds, but biologists are not even sure where they are; extensive searches have turned up mostly inconclusive flashes of fur and blurred snowprints deep in the woods. Their ranges may be the truest maps of our few remaining wild places.

Wolverines are not little wolves, in fact they are a larger cousin of otters, weasel and skunks. They seem most at home in snowy, hostile places--deep conifer forests, tundra, above-treeline mountain tops, and Arctic ice floes. They are thinly spread and probably slow to reproduce. Wolverines are expert swimmers, diggers, and tree climbers that roam when other animals flee south, or go into hibernation. They are the ultimate scavenger, and they depend on wolves, bears and the rare human hunter to do their kill for them where they can sneak in for leftovers. They kill porcupines and hares and have been observed in the summer eating mushrooms, berries, bird eggs, and wasp larvae.

The last specimen of a California wolverine was taken in 1925, near Yosemite National Park, yet hikers keep reporting wolverine-like creature and tracks in the high Sierra Nevada. Some of the sightings are credible, and since 1991 California scientists and volunteers have used bait and motion-sensing cameras in an attempt to prove the animals presence but have so far not been successful. The wolverine has a range as big as 770 square miles. They give birth in the winter where there is deep isolation and persistent snow. They seem to exist only in areas with remote, undisturbed sites for denning and wide corridors for dispersal. When wild places are disturbed, wolverines are the first to be extinguished. The wolverine may be the best indicator that an ecosystem is intact or not. Once gone, wolverines do not seem to come back from adjoining refuges, whether because of slow reproduction and dispersal or some other, unknown factor. There have been unsubstantiated sightings of the Wolverine in the Humbug Summit-Philbrook area.

Management Concerns

The Butte Creek Watershed contains populations of seven species listed as endangered, 12 species listed as threatened, and 50 species of special concern or those under federal protection. To protect these fragile populations, and to stop the further listing of other species, the protection of intact natural resources is vital, and restoration of degraded resources is necessary.

In the Butte Meadows Basin the Cascades frog (SE), California red-legged frog (FT), Foothill yellow-legged frog (FT), and the Mountain yellow-legged frog all need further protection. The Great gray owl (FS, SE), requires the preservation of meadows for foraging which have been lost or damaged by logging, grazing and roads. This owl requires old growth, coniferous forest that border meadows; a large meadow system for foraging, and old growth forest for nesting. There are other species in this Basin who have basically the same requirements. The California spotted owl (FS, SC), requires late successional forest, including snags that are near water. The Northern goshawk (FS, SC), prefers to nest near water on a north slope of late successional forest and require a mix of different forest age classes and forest structures for foraging and nesting. The Sierra red fox (FS, T), requires Red fir and Lodgepole pine forests that are associated with montane meadows.

In the Canyon section greater protection is needed for the American peregrine falcon (FE, SE) who suffer stress from human presence, harassment and disturbance in nesting and feeding areas as they lay their eggs on bare ground or cliffs. This endangered falcon also suffers from reproductive failures due to food chain contamination by pesticides.

In the Valley section, the lower end of Comanche Creek (west of Hwy. 99, where Comanche Creek crosses the south end of the industrial zone of Chico), is in need of protection. At this site is a fresh water emergent marsh that is important habitat for the Giant Garter snake (FT, ST), Northwestern pond turtle and the Western spadefoot toad. The protection of this site (acquisition or conservation easement) is significant as the status of the Giant Garter snake was caused by the loss of habitat from filling of sloughs and drainage of marshes. In the same area along Comanche Creek are found Valley elderberry shrubs that provide critical habitat for the Valley elderberry longhorn beetle. This riparian habitat also needs protection. This is of importance as the loss of riparian areas (>90%) and Valley elderberry habitat has caused the decrease in the Valley Elderberry longhorn beetle. The Swainson's Hawk (ST), has been observed several times, in the ten year period between 1984 and 1994, on Butte Creek, NE of Durnel Road and about four miles south of Durham. The nest tree is presumed to be a Fremont cottonwood on private land on the south levee of Butte Creek. A Tricolored blackbird (FSC) colony has been observed along Seven-Mile Lane, north Nelson West Road, NE of Butte City. In 1985 about 5000 pairs were observed over several acres of cattails and tules. This is important marsh habitat that should be protected.

In the Butte Basin hunting and human harassment is a significant local problem for the Greater Sandhill Crane (ST) (CDFG, 1993). As more than half of the California population of this crane occur in Butte County, during the fall and early winter, it is significant that crane associated habitat (roost in shallowly flooded marshes, forage in grain fields) be preserved. The habitat within the watershed for the Greater Sandhill Crane is principally west of Hwy. 99 near Durham, to Rancho Llano Seco, and the Nelson area down to Butte Sink. The Western Yellow-billed cuckoo (SE), population has been declining drastically, therefore; it is critical that cuckoo habitat is protected. Within the watershed only one observance (NDDB, 1995), occurred, July 1977, in Butte Sink, east and west of Butte Creek. This neotropical bird also requires riparian habitat reproduction. A continuous riparian corridor (1/4 to 1 mile wide), along Butte Creek is vital in the preservation of this bird and other species, such as the Yellow-breasted chat.

Fisheries And Aquatic Resources

A Brief Historic Perspective

"Historically many small creeks and sloughs were braided throughout the Sacramento Valley floor. Some creeks ended in lower depressed "sinks" (Butte Sink) and did not join the main network of the Sacramento River except during floods. Sedimentation and scouring associated with frequent flooding created mosaics of natural levees, abandoned channels, sinks, lowland swamps, and hummooks over the otherwise relatively flat flood plains. The extent of these flood plains varied from a few hundred meters to several kilometers wide. Riparian forests were formerly present adjacent to rivers and creeks. Sloughs, oxbows, and meander scars were interspersed within riparian forests (Lapham et al., 1909; Keller, 1997; Thompson, 1961; and Katibah, 1984; and Scott and Marquis, 1984; in Heitmeyer et al., 1988).

Clark (1929) stated that there was only a fall-run in Butte Creek, "as the water is very low and warm in the summer." At that time (1928) so much water was being diverted from the stream during most of the summer and fall that the fall-run was stated by Clark to have been "almost destroyed." However, it appears that Clark did not fully recognize that the flow conditions he observed in the summer and fall, while detrimental to the fall-run or to any salmon that might be present in the lower creek, did not preclude the existence of the spring-run.

According to Hanson et al. (1940), Butte Creek reportedly was "a very fine salmon stream in the past" but was no longer suitable for salmon due to extensive mining and hydroelectric development that had occurred in the watershed.

Fry (1961) noted that Butte Creek had a spring-run but "almost no fall-run", setting it apart from most small streams in the north Sacramento Valley which had mainly fall-runs. The many removable dams on the creek blocked or reduced flows late into the fall, and fall-run fish could not surmount them. He reported that the spring-run ranged from <500 to 3,000 fish during the period 1953-1959.

Hallock and Van Woert conducted a study of Butte Creek Diversions for salmon losses. They concluded "that screens are necessary to protect them (adult salmon)" (Hallock and Van Woert, 1959) (see Issues and Concerns chapter, #2).

As late as 1960, the spring-run numbered > 6,700 in Butte Creek, with smaller numbers of fall and late-fall fish (Mahoney, 1962). More recent annual estimates of spring run numbers range from < 10 in 1979 (Reavis, 1981) to > 7,500 in 1995 (Pers. com., Kathy Hill, 1997).

Prior to 1965, Butte Creek supported an average of about 2,500 spring-run Chinook salmon (Flint and Meyer, 1977); however, through 1991, an average of only 349 (14% of 2500) spring-run Chinook salmon have spawned in the creek (Brown, 1993).

Flint and Meyer (1977) also spoke of a late-fall-run which "migrates up Butte Creek in January-February and spawns immediately after arriving at the spawning beds." Flint and Meyer (1977) noted that "the unimpaired reach of Butte Creek above (the Butte Head dam) produced about 2,500 trout per mile." But that the population was "drastically less" in the reach from Butte Head Dam to Forks of Butte. This was due to diversion at Butte Head Dam which, after spring-run off reduced Butte Creek to a series of warm, barely connected pools. Trout production fell off there to about 50 per mile (Flint and Meyer, 1977).

PG&E employees at one time reported salmonids past the site (the Centerville Head Dam) to areas upstream. It is not known if they were salmon or steelhead.

Hydraulic Mining Impacts

The belt of hydraulic mining traversed most of the Sierra Nevada west side drainages to the Sacramento and upper San Joaquin valleys. Between 1850 and 1885, hydraulic mining washed tons of silt, sand, and gravel into the Sacramento River and its tributaries. The mining debris, composed of clay, sand, gravel, and cobbles, washed downstream during high flows (Reynolds et. al., 1993).

The unrestricted use of hydraulic mining in the river drainages along the eastern edge of the Central Valley was extremely damaging to the stability of stream systems and habitat for anadromous fish. Riparian areas were destroyed and sediment and fines washed directly into the creek.

The State Supreme Court in 1884 upheld a suit against the hydraulic mining interest filed on behalf of agricultural interest. That decision was the beginning of the end for hydraulic mining, but extensive damage had already occurred. On Butte Creek, hundreds of acres of stream and floodplain gravel had been hydraulically mined, each area gone over at least once and in some cases 3 times (Colman, 1972). A USGS map from 1951 shows hydraulic tailings in Butte Creek covering 488 acres, probably much less than what originally was evident.

Historic Wetlands

"Each watercourse on the flat Sacramento Valley floor... flowed on an elevated platform, built up by silt the streams deposited in their own beds. As floodwaters periodically overtopped the stream banks and spread out over the Valley floor, natural levees were built up, ... from these more elevated locations paralleling the watercourses, floodwaters flowed down to pond in wide shallow basins lying between the streams. The ponds in these basins created a vast inland sea... which slowly drained into the river channels. In their lowest elevations where the water ponded longest these basins contained immense swamps of tules" (Kelley, 1989)

The extent of wetlands in the Sacramento Valley is not entirely known, but probably exceeded 1,482,000 acres (Heitmeter et al., 1988). Seventy-five percent of these were riparian forests and flooded tule marshes

(Heitmeter et al., 1988). Along the Sacramento and San Joaquin Rivers permanently flooded marshes consisted primarily of cattails, bullrushes and pondweeds. These marshes, ponds and stream channels were generally bordered by stands of riparian woodlands in various successional stages (Reynolds et al., 1993) Most recently, there are an estimated 291,000 acres of seasonal or permanent wetlands in the Central Valley. In addition to this acreage, post harvest flooding of 79,000 acres of rice, corn, and wheat fields provides additional habitat for waterfowl and migratory water birds (Heitmeyer et al., 1988). Additional acreage of seasonally flooded rice fields have been added since 1988. These fields provide an energy source for waterfowl and other animals in the waste grain (344-388 kg/hectare) (Miller and Wylie, 1996). Permanent wetlands with uplands provide moist soil seeds, invertebrates, forage, tubers, and nesting and brood rearing habitats as well (Heitmeter et al., 1988).

Based on gill-net catch data for the Sacramento-San Joaquin rivers, it has been estimated that the peak Chinook salmon runs in the Sacramento River system may have been as large as 800,000 to 1 million fish, with an average run size of about 600,000 fish prior to 1915. By 1960, salmon habitat in the Sacramento-San Joaquin river watersheds had been substantially reduced. The streams had either been dammed, blocking migration, or they had been so severely degraded that they were barely usable by salmon. Speaking of Butte Creek, Clark (1929) stated "the creek was formerly one of the best salmon streams, but because of irrigation dams and low water the run has been almost destroyed."

Stream Habitat Conditions

Riparian Habitat and Large Woody Debris

"The stream and its living creatures are directly and inexorably linked to the adjacent riparian zone, and in reality should all be thought of as part of a larger interacting system or environment that includes both an aquatic instream portion and an adjacent terrestrial riparian portion" (Reynolds et al., 1993).

Riparian vegetation moderates temperature in Butte Creek, shade or lack of it can increase temperature by 11.7º - 18º Farenheit (Reynolds et al., 1993). Vegetation protects stream banks from erosion by reducing velocities and binding soil particles. It increases deposition of silt during floods, enables willows and cottonwoods to reproduce, provides substrate material for aquatic insects, and provides escape and resting cover for fish species (Reynolds et al., 1993).

Riparian areas and forests supply large woody debris such as tree trunks with their rootwads attached or tree branches greater than eight inches in diameter. This wood supplies partially processed food and becomes continually smaller as it travels down Butte Creek's stream system. Woody food is mostly litter, such as leaves, needles, cones, twigs, bark, and wood and provides energy to stream organisms. Large trunks of old trees require special regard because they enter streams infrequently (barring drought kill). Trunks and rootwads are somewhat slow moving and physically shape smaller streams. Large wood is biologically processed and broken down in place, unless it is flushed downstream in a rare debris torrent, such as occurred in some headwater streams in the January 1997 flood event.

Debris moves fastest through the stream system during flood events (such as the 1986 and 1997 storms) and is not completely processed at any one spot. This is true to the extent that the stream has enough in-stream obstacles to slow the water and act as areas of deposition, sieving the incompletely processed organic debris out of the current. Small headwater streams feed organic debris to larger streams and larger streams feed still larger ones in Butte Creek's Watershed.

In small streams that flow through older forests, a large proportion of the basic food for invertebrates is derived from leaves and wood. Wood is 50 to 70 percent of the total organic debris available to microbes and invertebrates in small streams, including very fine particles derived almost exclusively from the massive trunks of trees (Maser and Sedell, 1994).

The greatest forest influence is in first-order streams, but the greatest diversity of both debris inputs from riparian areas and habitats is found in the third to fifth-order segments of Butte Creek, and the segments of Butte Creek with flood plains. The quantity (pieces/mile) and quality of large woody debris in Butte Creek is unknown. Stream surveys can determine quantity and quality. Numerical comparisions can then be made with similar stream types in more pristine areas.

Habitat Value of Pools

Deep pools offer fish a better chance of escaping terrestrial predators. They also allow coexisting species of fish and/or fish of the same species but of different ages to live in layers within the pool. (see Figure 6.1). Pools created by wood dams are often characterized by deep, slow-moving water, low light intensity, and complex cover afforded by root masses deeply undercut banks, and large sunken wood. They have the highest use by juvenile Coho and Chinook near the water's surface, brown trout along the bottom, and steelhead trout more than a year old at the upstream head of the pool.

Good rearing habitat for salmonids consists of pools and riffles (in a 50/50 ratio), adequate cover, and food (mostly macroinvertebrates), water temperatures between 40ºF and 60ºF during the summer, dissolved oxygen at saturation (Reiser and Bjornn, 1979). Butte Creek's pool/riffle ratio is probably much less than 50/50 thus limiting rearing area.

The greater the amount of wood in a stream, the greater the number of pools. Around 80 percent of the pools in some small streams are created by large wood (Sedell, 1988). A lack of pools in Butte Creek can be due in part to a lack of large woody debris. A habitat study is needed to confirm or deny this.

In first through third order streams, single pieces of large wood or accumulations of wood often create a stair-stepped, longitudinal profile (step pools). Such pools consist of debris dams with an upstream depositional area, the woody dam itself, a waterfall and a large plunge pool scoured by falling water. Logs can tie up significant sediment. Above one step pool on a 2nd order tributary of Little Chico Creek a 3 foot diameter log backs up approximately eight feet of sediment.

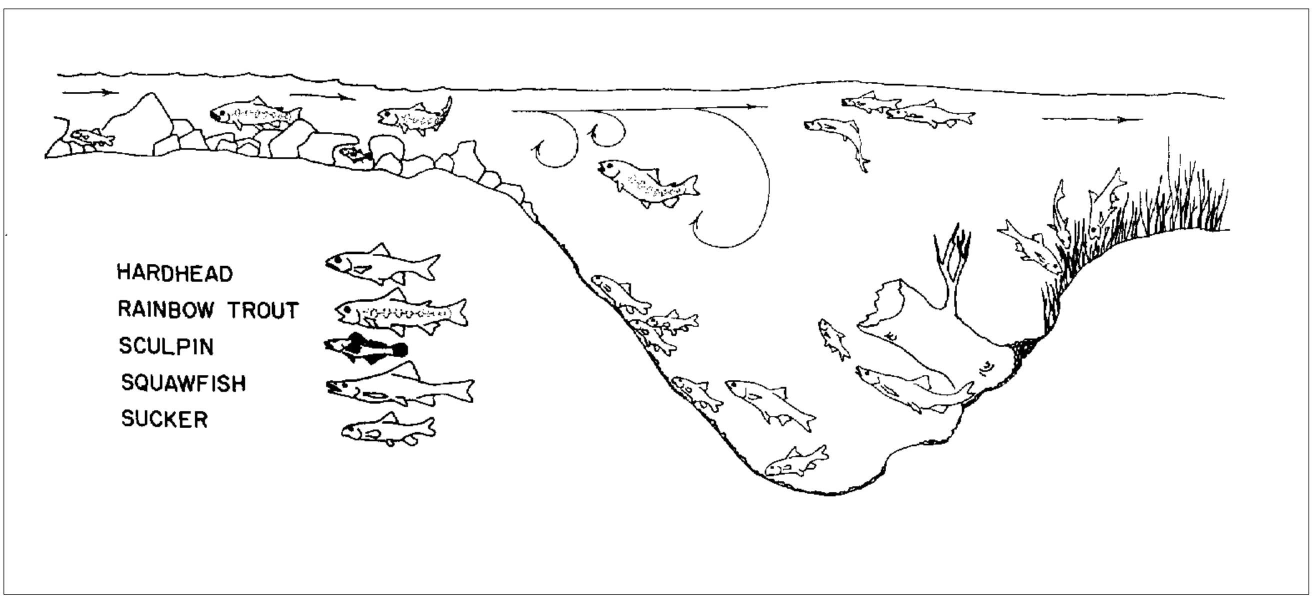

Figure 6.1

How fish species locate themselves in a typical pool.
(From Moyle, 1976)

Pools are inhabited by mayflies, whose nymphal stage feeds on algae, leaves that fall into the water and sink, and fungal mycelia. Also in the pool are immature dragonflies, stoneflies, caddisflies, and wood-eating craneflies. All species prefer pools during the normal winter flow, but the preference level is determined by the quality of a pool. Pool quality is often determined by the abundance of wood. The more wood, the more fish use a pool. During winter floods, the pool-riffle sequence of a stream's stepped profile becomes a continuous, high-velocity torrent in which there is often little protection for trout and salmon from the moving sediments or swift, turbulent waters (see Figure 6.2).

Fishes of Butte Creek

For a complete listing of fish species found in Butte Creek see Table 6.1. For a summary description of fish species found in Butte Creek refer to Appendix M.

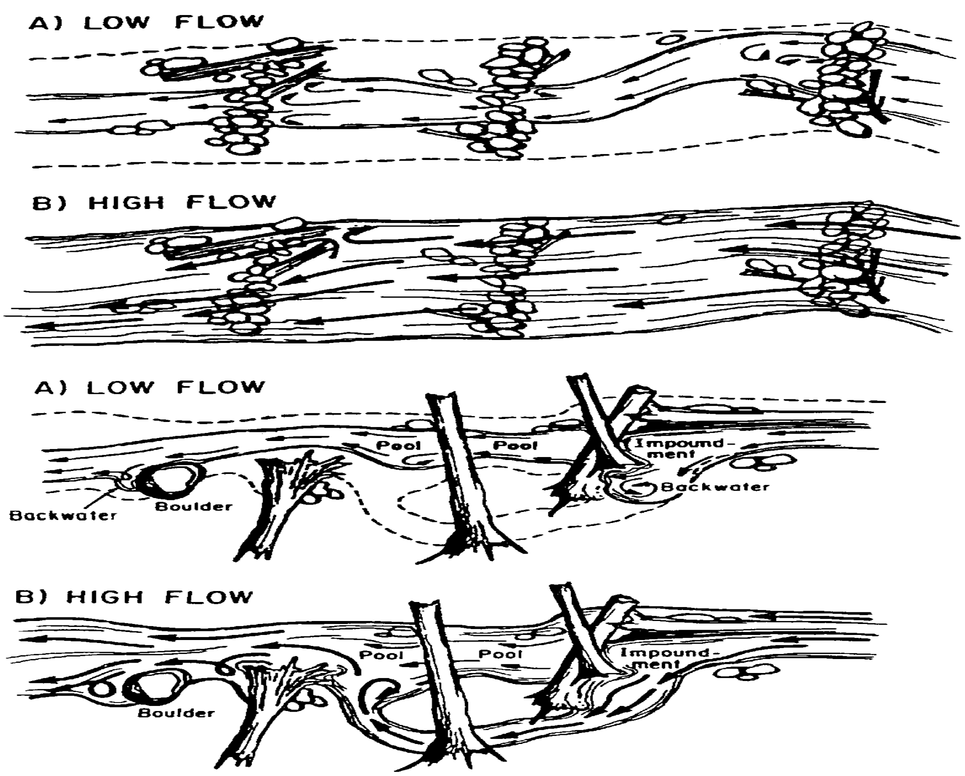

Figure 6.2

During floods, quiet water refuges are provided almost exclusively by anchored wood and standing vegetation in a stream's floodplain.

Table 6.1
The Fishes Of Butte Creek

Common Name	Scientific Name
Pacific lamprey	*Lampetra tridentata*
Pacific brook lamprey	*Lampetra pacifica*
Chinook salmon	*Oncorhynchus tshawytscha*
Rainbow trout	*Oncorhynchus mykiss*
Steelhead rainbow trout	*Oncorhynchus mykiss*
Brown trout	*Salmo trutta*
Brook trout	*Salvelinus fontinalis*
Hitch	*Lavinia exilicauda*
California roach	*Hesperoleucus symmetricus*
Hardhead	*Mylopharodon conocephalus*
Sacramento squawfish	*Ptychocheilus grandis*
Speckled dace	*Rhinichthys osculus*
Golden shiner	*Notemigonus crysoleucas*
Goldfish	*Carassius auratus*
Carp	*Cyprinus carpio*
Sacramento sucker	*Catostomus occidentalis*
Black bullhead	*Ictalurus melas*
Brown bullhead	*Ictalurus nebulosus*
Channel catfish	*Ictalurus punctatus*
Mosquitofish	*Gambusia affinis*
Threespine stickleback	Gasterosteus aculeatus
Bluegill	*Lepomis macrochirus*
Redear sunfish	*Lepomis microlophus*
Green sunfish	*Lepomis cyanellus*
White crappie	*Pomoxis annularis*
Black crappie	*Pomoxis nigromaculatus*
Largemouth bass	*Micropterus salmoides*
Smallmouth bass	*Micropterus dolomicui*
Spotted bass	*Micropterus punctulatus*
Bigscale logperch	*Percina marcolepida*
Tule perch	*Hystcrocarpus traski*
Prickly sculpin	*Cottus asper*
Riffle sculpin	*Cottus gulosus*

(Moyle, 1976, Brown, 1992b). For descriptions of species see Appendix M.

Wood creates and maintains a physically diverse habitat by (1) anchoring the position of pools along a channel, (2) creating backwaters along a stream's margin, (3) forming secondary channels in valley floors filled with sediments deposited by the stream, and (4) varying channel depth. Thus, fallen trees create new stream habitats (Sedell, 1998).

Aquatic Insects-Fish Food

Butte Creek and it's tributaries contain diverse communities of fish, invertebrates, plankton, amphibians, hydrophytes (water lovers), and vertebrates. The abundance and structure of biological communities found in stream systems are a reflection of past and present conditions and interactions. Butte Creek's floodplain and its aquatic system are intimately connected. Solar energy converted by terrestrial plants through photosynthesis, enters the stream by two paths. Primary Path: direct input of leaf litter and other plant material (especially important in headwater reaches). Secondary Path: Organic material enters the stream by excretion by organisms that consume plant material and deposit of terrestrial organisms into streams. Aquatic organisms and plants are also consumed by terrestrial organisms and vice versa.

The aquatic insect feeding group composition varies from the headwaters to medium sized streams and large rivers due to changes in nutrient availability and utilization. This stream continuum includes the available food resources for the animals inhabiting it, ranging from invertebrates, to fish, birds, and mammals. A critical role is played by streamside vegetation in the control of water temperature, stabilization of water temperature and stream banks, and food production (Reynolds et al., 1993).

Productivity in Butte Creek is determined by the amount of energy and nutrients entering it from the terrestrial system, as well as the amount of energy produced within the stream. The nutrient flow in the stream is highly variable and dependent on the biological and physical qualities, and seasons of Butte Creek. For example, in the fall there are more leaves in the creek for processing by aquatic insects; in the summer there is more sunlight available for algae and diatoms and in the spring there is a greater movement of nutrients through the system due to increased water flows. Changes in annual rainfall, temperatures, etc., also lead to variations in nutrient flow.

A critical factor is the degree to which Butte Creek has access to its flood plain/riparian areas where fines drop out and organic matter can be picked up and deposited. Flood plain interactions are also useful for absorbing stream energy, indeed the complexity of a number of Butte Creek's ecosystem niches are dependent on flood plain access.

Salmon Life Histories

Spring-run Chinook salmon

Spring-run Chinook salmon (*Oncorhynchus tshawytscha*) have an unusual life history pattern in that they migrate into Butte Creek during March - June (CDFG, 1993). They over-summer primarily in pools from the confluence of Little Butte Creek to the Centerville Head Dam, and begin spawning late September to early October. Unlike spring-runs in Deer and Mill Creeks, spring-run in Butte Creek presently spawn in the lower part of the creek at relatively low elevation (less than 1,130 ft) where they are hindered by the "Quartz Bowl", a natural barrier, and blocked by the Centerville Head Dam. Cramer and Demko (1997) state that "the warmer temperatures of Butte Creek during fall and winter at the elevation where spawning occurs would favor survival of a later spawning stock". It is apparent that Butte Creek's spawning and rearing waters are somewhat warmer than Deer or Mill Creek.

Although the spring-run in Butte Creek migrates and spawns at similar times as spring-run in other streams, it seems to be somewhat different in that the fry emerge in December, most of these fry migrate out immediately while others migrate out in the spring (Reynolds et al., 1993). The remaining fraction remains in the stream until the following fall (1 year after they had been spawned) (SNEP, Vol.3). This is in contrast to the pattern seen where spring-run fish spawn as well in colder, higher elevation reaches (i.e., Mill and Deer Creeks). There fry remain in the streams to migrate out starting in January, and as late as March. At higher elevations, under most conditions, fry remain to migrate out in February of the following year as juveniles. Recent evidence also shows that under some conditions Mill and Deer Creek spring-run migrate as fry (Pers. com., Ward, CDFG, 1998).

Studies conducted during 1993-96 provide substantial information on timing and stage of development of salmon out migrants. Rotary screw traps were used to capture spring-run fish near Chico and in lower Butte Creek within Sutter Bypass during the September to June timeframe. Starting in 1995, juveniles have been tagged using coded wire tags to provide information on downstream migration and adult returns (Baracco, 1997).

Spawning takes place during the last week in September to mid-October based on twelve years of record (Hill, 1997). The majority of fish spawn upstream from the Parrott-Phelan Diversion located a few miles west of Chico. Peak spawning density occurs from the upper limit of migration, below Centerville Head Dam and the Quartz Bowl pool (elevation 1,130 ft. at Quartz Bowl) downstream to the Covered Bridge (elevation 400 ft), a distance of about 10 miles. In Butte Creek, there is some spatial and time overlap in spawning of fall and spring-run salmon in some years (Hill, 1997; Cramer and Demko, 1997).

Generally, adequate migration flow exists to the Western Canal Dam; however, during some years there are several areas above Western Canal where the majority of water is diverted, thus causing passage problems. With the new M&T Agreement an additional 40 cfs will be left in the creek so passage problems are reduced (pers.com., Ward, 1998).

Based upon results of the 1993-96 studies, it appears juveniles emigrate from Upper Butte Creek predominantly as fry from mid-December through March. A lesser number of smolts emigrates March - June and yearlings emigrate the following October through January (Baracco, 1996). Substantial numbers of both Butte Creek and non-Butte Creek juveniles were found to use the Sutter Bypass for emigration. Data from juveniles tagged in Butte Creek canyon (at Parrott-Phelan Dam) shows that they can reach the Bypass in less than two weeks. Juveniles grew rapidly. In 1996, tagged fish were recaptured in the Delta as early as April 2, with one recaptured at Chipps Island as late as June 3 (Baracco, 1996).

Spring-Run Chinook Salmon Population

Butte Creek supported a maximum of 6,700 spring-run Chinook salmon up to 1960 (see Table 6.2). As late as the 1960's, a run of over 4,000 adults was reported. Currently, the spring-run numbers has reported fewer than 200 adults. This represents over a 95 percent decline in the past 30 years. CDFG population estimates and PG&E fish surveys indicate that few adult spring-run salmon reach upper Butte Creek, where excellent flow, temperature, and habitat conditions are available. Between 1983 and 1985, DFG attempted to restore the spring-run by planting surplus fry from the Feather River Hatchery. In 1988, 1,300 adult spring-run salmon returned to Butte Creek to spawn, most probably a result of the hatchery release. Estimated spawning success was estimated at about 50 - 60% in Butte Creek in 1989 (Campbell and Moyle, 1992). CDFG calculated a mean run size of 500 fish (1980-1989). Butte Creek recently had the highest return of spawners ever observed at 7,500 in 1995 (Cramer and Demko, 1997).

Table 6.2
Estimates of spawning spring-run Chinook salmon in Butte Creek, 1956-1997.

Year	Number	Year	Number
1956	3,000	1977	100**
1957	2,192	1978	128
1958	1,100	1979	10
1959	500	1980	226
1960	6,700	1981	250
1961	3,100	1982	534
1962	1,750	1983	50
1963	6,100	1984	23
1964	600	1985	254
1965	1,000	1986	1,371
1966	80	1987	14
1967	180	1988	1,300
1968	280	1989	1,300
1969	830	1990	100
1970	285	1991	100
1971	470	1992	730
1972	150	1993	650
1973	300	1994	474
1974	150	1995	7,500
1975	650	1996	1,413
1976	46	1997	635

** 388 spawning adults from Red Bluff Diversion Dam were released (Hoopaugh,1979)
(Information from: Fry, Gerstung and Ward, CDFG)

Fall-Run Chinook Salmon

Adult fall-run chinook salmon enter lower Butte Creek from late September into early October, and often into November. Several barriers exist which impede the adult migration until high flows occur. Spawning generally occurs from October through December. Some spawn in late October but most spawning occurs in mid-November. Most fall-run Chinook salmon spawn in the area predominately below Durham Mutual Dam to the Western Canal siphon (Pers. com., Ward, 1998), although they are known to spawn above Adams Dam during some years. Fall-run fry begin to emigrate in January and February and continue through April to May. However, juveniles are often entrained at diversions (Brown, 1993).

Fall-Run Chinook Salmon Population

CDFG has estimated that fall-run population varies between a few to as many as 1,000 (Brown, 1993; Reynolds et al., 1993).

Late-Fall-Run Chinook

Although little is known about the late-fall-run Chinook, they probably enter Butte Creek from December through February, spawning above Parrott-Phelan Dam during January through March. Few barriers, except during extremely dry years, impede the passage of late-fall-run adult salmon. Fry and smolts are thought to emigrate from April through June (later than Fall-run) and face the same potential losses to diversions as fall-run.

Late-Fall-Run Chinook Population

There are late Fall-run in Butte Creek; however, their numbers are unknown (Reynolds et al., 1993).

Chinook Restoration Potential

Restoration of habitat in Butte Creek would allow the spring-run Chinook population to return to an annual spawning population of about 4,000 fish and fall-run Chinook to about 2,000 fish. In *Restoring Central Valley Streams-A Plan for Action*, CDFG assessed the Butte Creek spring-run Chinook population as having a "high" potential for restoration (Reynolds et al., 1993). The steelhead run would also increase.

Regarding the opening of the reach of Butte Creek above Centerville Head Dam to spring-run, Johnson and Kier (1998) concluded "there is no doubt in the authors mind that Butte Creek Canyon (above Centerville Head Dam) would prove an excellent opportunity for rebuilding the watersheds natural spring-run numbers." Others have raised serious concerns about the number and height of barriers, especially a 35-foot waterfall a third of a mile above the Centerville structure. This proposal is now under discussion as a policy decision.

Steelhead

Steelhead are the anadromous form of rainbow trout, a salmonid native to California. They used to support a major sport fishery. Steelhead trout use the Sacramento River as a migration corridor to and from spawning grounds in Butte Creek. They are present in the Sacramento River year-round, either as juveniles migrating downstream or as adults migrating upstream or downstream.

Steelhead are similar to some Pacific salmon. They are born in fresh water, then emigrate to the ocean where most of their growth occurs, and then return to fresh water to spawn. Steelhead ascend Butte Creek in the late fall and winter (August through March). They spawn in tributaries such as Dry Creek (Brown, 1992b) and in the main stem of Butte Creek above Parrott-Phelan diversion in winter and spring (generally December and April). They prefer to spawn in clean gravel at the pool-riffle transition (McEwan and Jackson, 1993).

Unlike Pacific salmon, steelhead do not always die after spawning. Post-spawning survival rates are generally quite low, and vary considerably between populations. Fish that survive spawning return to the ocean from April to June.

The life history of steelhead differs from that of Pacific salmon in two aspects: juveniles have a longer fresh water rearing requirement (usually from one to three years) and they do not migrate at any set age. Juvenile migration generally occurs during the spring after at least one year of rearing in upstream areas. Some individuals remain in a stream, mature, and even spawn without ever going to sea. Others will migrate to sea as fry. In Scott and Waddell Creeks (Santa Cruz County), the majority of adults returning to spawn spent two years in fresh water and one or two years in the ocean. Other steelhead from these streams spent from one to four years in fresh water and from one to three years in the ocean (Shapovalov and Taft, 1954). "Generally,.in California the most successful steelhead spend from one to two years in fresh water before migrating downstream" (Reynolds et al., 1993).

All steelhead in California are *0nchorynchus mykiss irideus*. CDFG has traditionally grouped steelhead into seasonal runs according to their peak migration period: summer steelhead and winter steelhead. This describes run timing but doesn't reflect stock characteristics or spawning strategies (McEwan and Jackson, 1993). These terms are synonymous with stream-maturing and ocean-maturing steelhead.

There is substantial gene flow between anadromous and resident trout. It is not uncommon in anadromous steelhead for males to mature and then assume a resident life style. Butte Creek, like all stream systems in California, is subject to extreme variations in rainfall which can result in high volume, flash flood runoff, or droughts lasting several years. The lower reaches of streams have in the past become intermittent during the dry season. Juvenile steelhead rearing in the perennial headwaters of these streams during drought times may have no ocean access for several years (McEwan and Jackson, 1993).

The fact that anadromous and resident rainbow trout can form a single interbreeding population in a particular stream has important management implications. Management of native steelhead populations must include measures to protect and restore native resident trout.

Steelhead Trout Population

Steelhead trout populations have greatly declined over much of the species range, including the Sacramento River basin, and the species is under consideration for federal listing as a threatened species. The causes of decline in steelhead trout are the same as those described for spring-run salmon. Presently, the most viable, self-sustaining populations of steelhead are found in Deer and Mill Creeks, but small populations also persist in Big Chico and Antelope Creeks (Reynolds et al., 1993). Steelhead have been reported in Butte Creek principally through reports by DFG wardens of angler catches. Steelhead juveniles were caught in Dry Creek (Brown, 1992b), but no steelhead were caught in studies of salmonid losses in agricultural diversions (Brown, 1992a). The Sutter Bypass is used by juveniles in the vicinity as rearing habitat (Hill, 1997).

No estimate of Steelhead numbers in Butte Creek were found in this review of the available literature.

Habitat Requirements of Salmonids

In the Butte Creek Watershed, there is increasing concern how human activities effect salmonid habitat. The requirements of these unusual fish must be known before we can understand the effects human and natural disturbances have on salmonid's ability to reproduce and sustain themselves and their population. Salmonid needs vary according to life cycle stage and season of the year. Upstream and seaward migration, spawning, incubation of eggs, juvenile rearing, and residence, will be examined.

Upstream Migration of Adults

Adults returning to natal streams must arrive in good health and at the proper time for successful spawning. Detrimental flows, elevated temperatures, turbidity, and water quality can impair or prevent fish from completing their journey. No specific water quality problems were identified in this review of the literature.

Temperature

Some salmon have completed migration in water temperatures from 37º - 75º F (see Table 6.3). During migration, steelhead prefer temperatures from 46º - 60º F (Reiser and Bjjorn, 1973; McEwan and Jackson, 1993).

Table 6.3
Optimum Temperatures for Anadramous Salmonids

	Optimum (°F)	Range (°F)
Chinook Salmon		
Spawning	42-60	37-73
Eggs	42-56	38-63
Fry	42-65	36-75
Juvenile	53-64	32-75
Steelhead		
Spawning	46-52	39-61
Eggs	50	--
Fry	55-60	55-72.5
Juvenile	44-52	43-63

Source: US Bureau of Reclamation, Central Valley Project, Guide to Upper Sacramento River Chinook Salmon Life History, July 1991, David A. Vogel and Keith R. Marine.

Dissolved Oxygen

Reduction of dissolved oxygen concentration can impair swimming performance of adults. Maximum sustained swimming speeds of juvenile and adult salmon were reduced when oxygen concentrations were reduced from air saturation levels (Davis et al., 1963). Large decreases in swimming ability was observed at 6.5-7.0 mg/l for all temperatures. Low dissolved oxygen may also cause avoidance behavior (Whitmore et al., 1960) and migration to cease. Oxygen levels recommended for spawning fish (minimum 80% saturation with temporary levels not less than 5.0 mg/l) should prove adequate.

Turbidity

Salmon will avoid or cease migration in water with high silt loads. Turbid water may absorb more sunlight and create a temperature barrier for migration.

Barriers

Debris jams, waterfalls, and excessive velocities can also slow or stop migrating fish. Barriers observed at some flows may be accessible under other flows. For example, Kathy Hill of CDFG documented the presence of 29 Spring-run salmon above Butte Creek's barrier falls. Whereas, it is known that the vast majority of Spring-run and steelhead activity takes place below the barrier falls.

Jumping conditions for salmon are optimized when the pool depth below is 1.25x the height of the barrier (see Figure 6.3). Salmon have been observed jumping 6.6 - 9.9 ft. Woody debris jams can block or slow upstream migration. Debris jams can cause large pools to form, and both small and large woody debris function as beneficial cover.

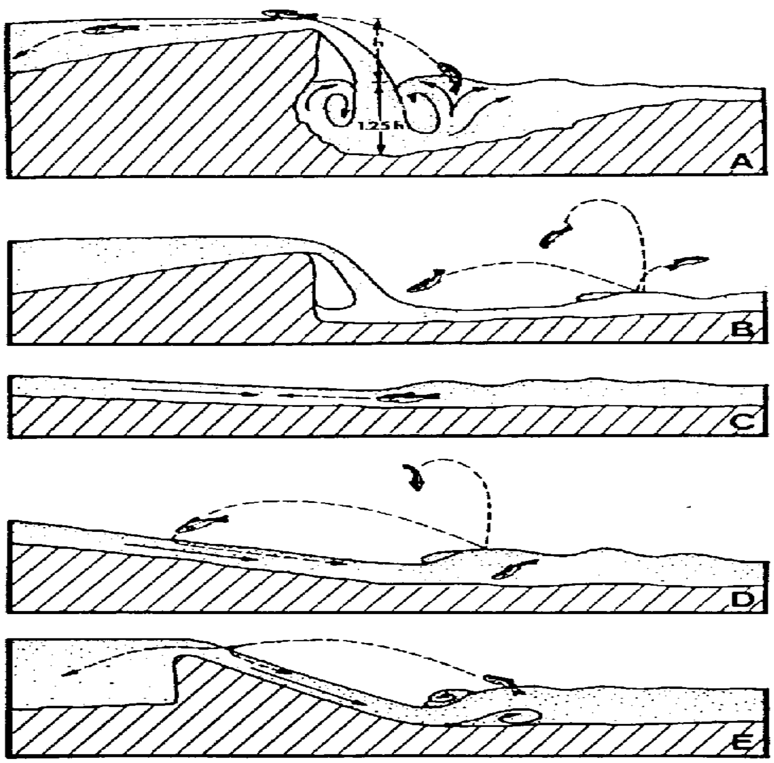

Figure 6.3
Leaping Ability of Salmon Under Various Conditions (Reiser and Bjornn, 1979)
A) Optimal. B) Suboptimal (no staging pool). C) Velocities too high, incline too long. D) High velocities section too long for fish endurance. E) Standing wave poorly developed. Note that condition B, C, and D occur at Butte Creek diversion dams.

Velocities at channel constrictions such as culverts, bedrock projections and boulders, narrow bridges, etc. during high water events can exceed the swimming ability of adults. Fish resume migrating when water flows decline.

Salmonid swimming abilities fall into the following three categories:

1) Cruising speed: the speed at which fish can swim for hours. Generally 2-4 body lengths/second (bl/sec) (For a 32 inch chinook this is 5.3 - 10.7 ft. per second.)

2) Sustained speed: the speed the fish can maintain for several minutes. Four to seven body lengths/second (bl/sec) (For a 32 inch chinook this is 10.7 - 18.7 ft. per second)

3) Burst speed: maintained for a few seconds. Eight to twelve body lengths/second (bl/sec) (For a 32 inch chinook this is 21 - 32 ft. per second).

Cruising speed is used for migration, sustained speed is used for passage through difficult areas, and burst speed is used for escape and feeding.

Streamflow

When water is too shallow migration can be impeded. The question of flow is complex, but our level of knowledge is increasing rapidly. Flow cannot be properly addressed in this document and requires much more study.

Spawning Requirements

Cover

Fish cover protects fish from disturbance and predators and provides shade. Cover is supplied by overhanging vegetation, logs, small woody debris, rocks and boulders, aquatic vegetation, turbulence (bubble curtains, etc.), and water depth.

Spring-run and steelhead enter Butte Creek months before spawning. Cover is essential to protect fish from disturbance (Hill, 1997). Spawning areas are usually very open, therefore adjacent cover may be a factor in selection of redd sites by some salmonids (Johnson et al., 1966). Reiser and Wesche (1977) observed that brown trout spawners selected areas close to undercut banks and overhanging vegetation and speculated that early spawners and dominant fish selected sites by cover. Smaller and later fish were forced to select unprotected sites. Implications for management are the protection and restoration of riparian (streamside) vegetation and large woody debris for cover.

Temperature

Spawning has been accomplished by salmonids in temperatures from 37º - 73º F. Abrupt drops in temperature can cause spawning activity to cease. The steelhead temperature range for spawning is somewhat lower, ranging from 46º - 52º F (Reiser and Bjjorn, 1979; McEwan and Jackson, 1993). In Butte Creek shading of the creek by riparian trees is important to reduce temperatures in spawning and holding reaches.

Substrate

Fish size is a primary factor that affects substrate selection for spawning. Larger fish can utilize larger substrate gravels. In general, the substrate chosen by salmon for spawning is composed mostly of gravels from 0.75 - 4.0 inches in diameter with smaller percentages of coarser and finer materials and no more than about 5 percent fines. Although spawning will occur in suboptimal substrates, incubation success will be lower. Gravel is completely unsatisfactory when it has been cemented with clays and other fines, or when sediments settle out and cover eggs during the spawning and incubation period. Gravel deposited for enhancement purposes should consist of 80 percent 0.5 - 2.5 inch diameter, and 20 percent 2.5 - 4.0 inch diameter (Reynolds et al., 1993).

Gravel particle sizes selected by steelhead vary from about 0.25 - 3.0 inches in diameter, somewhat smaller than those selected by Chinook salmon.

Implications for management: Dams can impound stream gravels making them unavailable for spawning. High flows can flush out existing spawning gravels especially if the stream lacks large woody debris which tends to catch and hold gravels in the system. When Butte Creek is artificially narrowed through the placement of riprap and the hardening of banks, velocities are increased and gravels are scoured from a reach of stream.

Redd Area

For successful reproduction, Chinook salmon require clean and loose gravel that will remain stable during incubation and emergence. The average size of Chinook salmon redds is approximately 165 square feet. In areas of heavy activity, the redds dug by late spawners may overlap with those dug by early spawners by more than 60%. The territory required for pre-mating activity has been estimated at 200-650 square feet for salmon but this varies according to population density.

Where spawning occurs through a protracted spawning season, as many as three or four redds may be dug in the territorial requirement of one pair. A conservative range for minimum spawning area per female is 75-100 square feet. Requirements also appear to vary according to the size of the fish and the characteristics of the stream. For example, actual redd areas in the San Joaquin basin range from 60 to 90 square feet (Reynolds et al., 1993). Johnson and Kier estimated that 196 square feet of gravel is needed per pair (1998).

Implications for management: assuming a restored population of 4000 Spring-run, 1000 Fall-run, and 1000 steelhead, then 525,000 square feet of clean spawning gravels would be required as an average minimum (a rough calculation).

Water Depth and Velocity

Salmon select spawning areas within a range of water velocity and depth. Spawning requires well-oxygenated, cool water. Velocity is generally regarded as a more important parameter than depth for determining the suitability of a particular site for spawning. The velocity determines the amount of water which will pass over the incubating eggs. In general, optimum velocity is considered to be between 1.5 feet per second (fps) (Reynolds et al., 1993) between 1.67 fps (Healey, 1991), and ranging from 1.0 to 3.5 fps. Depths under 6 inches can be physically prohibitive for spawning activities (Reynolds et al., 1993). An average based on several studies by Healey equaled a mean depth of between 1.0-1.1feet (Healey, 1991). Central Valley salmon typically spawn at depths ranging from 1-5 feet and exhibit some differences in preferred depths for spawning based on race and watershed.

Criteria for spawning of steelhead differ slightly from those for salmon. Velocity is about the same as for Chinook salmon at 1.5 fps but depth is slightly less, to about 0.75 feet.

With increasing flows, spawning area increases to the point where velocities become too high in some areas, while the area available for spawning increases more slowly. As velocities exceed maximums, available spawning area slowly decreases.

Depth and velocity relate strongly to the adequacy of stream flows. Diversions may reduce flows to the point where depths over spawning gravels are less than 0.5 feet or velocities are less than 1.5 fps making spawning difficult or impossible. Agreements regarding diversions must be carefully crafted to assure sufficient flows for spawning and holding.

Egg Incubation Requirements

Incubation is related to spawning but habitat conditions for embryos are different from those for adults.

Egg Quantities (Reynolds et al., 1993)

An average female Chinook Salmon produces 3,000 - 6,000 eggs depending on size and race of the fish. For steelhead, an average of 550 - 1,300 eggs are deposited in each redd.

Surface Stream/Intergravel Relation

To be available to eggs, oxygen must be dissolved into water, transported by water to the stream bottom, and exchanged into streambed gravels. Exchange is controlled by the stream surface profile, permeability of the gravel, depth of gravel, and irregularity of the streambed. High intergravel oxygen is related to highly permeable gravels and increased stream gradient. Temperatures of intergravel water lags 2-6 hours behind surface waters. Intergravel velocity increases as surface water depth increases. Thus as the width to depth ratio decreases and water depth increases (characteristic of healthier streams), oxygen exchange will increase.

The inter-gravel percolation rate (velocity dependent) is considered the most important factor determining the available oxygen for salmon eggs. Water flow brings oxygen to eggs and removes waste products. In two different redds, one with high dissolved oxygen levels and a low inter-gravel percolation rate and the second with low dissolved oxygen and high velocities, embryos may develop better in the second. When inter-gravel percolation rates are low, as for example when gravels are clogged with fines, little oxygen will be available to salmon eggs.

Fine sediment deposits reduce the interchange of water and the velocity through the gravels. In general, gravels chosen by salmonids should have no more than 5% fines (Reynolds et al., 1993). Steelhead are less tolerant of fines than Chinook salmon. (see Figure 6.4.)

The Johnson and Kier study (1998) above the Centerville Head Dam found that 75.13% of the spawning gravels in that reach of Butte Creek had embededness ratios greater than 26% (see Table 6.4). This indicates a significant problem with fines in the watershed. During the survey, Johnson noted and photographed two large landslides into Butte Creek. One is approximately 1.5 miles upstream of Forks of Butte (Pers. com., Boeger, 1998) the other is on the F-1 road near Butte Meadows (Pers. com., Johnson, 1998).

Table 6.4
Summary of Embeddedness in Stream Gravels On Upper Butte Creek

Gravel Class	Percent of Gravel	Embeddedness
3's	51.84%	50%+
2's	23.29%	26-50%
1's	42.29%	0-25%

(Johnson and Kier, 1998)

Watershed surveys to identify sediment transport corridors (STCs) together with action to repair the STC's are important to improving salmonid survival and restoration.

When stream gravels are clogged by fines the stream must flow over rather than through gravels which increases stream temperatures. Butte Creek stream temperatures are being studied by DWR.

The Johnson and Kier study (1998) was not an intensive gravel study. The quanity and condition of Butte Creek's spawning gravels is a data gap.

Dissolved Oxygen

Researchers found that sac fry from embryos incubated under low and intermediate dissolved oxygen conditions tended to be smaller and weaker, and took longer to hatch. These conditions may increase the percentage of defects and stimulated premature hatching (Silver et al., 1963). Comparisons of sockeye salmon fry reared at different dissolved oxygen levels found size differences and showed that the smaller ones eventually achieved almost the same weight (Brannon, 1965), though fry would be more vulnerable to predators during the time they were smaller.

Temperature

Temperatures can be too low or too high for successful incubation, though, low temperature is not generally a problem in Butte Creek. The preferred temperature for Chinook salmon spawning is 52º F with lower and upper threshold temperatures of 42º F and 56º F. Temperatures above these ranges result in reduced viability of eggs or heavy mortality of developing juveniles. As temperatures went from 43º F to 54º F the average weight of fry went from 690 mg to 604 mg, a 12.5% decrease (Heming, 1982 in Healey, 1991) Within the appropriate temperature range, eggs usually hatch in 40 - 60 days, and the young "sac fry" usually remain in the gravel for an additional four to six weeks until the yolk sac is completely absorbed. The rate of development is faster at high water temperatures. Significant egg mortalities occur at temperatures in excess of 57.5º F. Total mortality normally occurs at 62º F. The total time from spawning to emergence at 50º F is approximately 79 days (Reynolds et al., 1993).

For steelhead, the preferred incubation and hatching temperature is 50º F and the range is 48º - 52ºF, (McEwan and Jackson, 1993). During the egg's "tender" stage which may last for the first half of the incubation period, a sudden change in water temperature may result in excessive mortality. In stream gravels at 50º F, hatching occurs in 31 days and at 55º F in 24 days (Reynolds et al., 1993). Egg mortality begins to occur at 56ºF. Fry emerge from the gravel usually about four to six weeks after hatching, but factors such as redd depth, gravel size, siltation, and temperature can speed or retard this time (Shapovalov and Taft, 1954). Thus steelhead eggs hatch in less than one third the time of Chinook. This may be advantageous as Butte Creek warms up during springtime.

Again, overhanging riparian vegetation and adequate flows are essential to maintaining temperatures within the appropriate range for egg incubation.

Biochemical Oxygen Demand (BOD)

The presence of organic material in inter-gravel water may lower available oxygen to eggs. Organic impacts depend on hydraulics, gravel size, percentage of fines, chemical qualities, and ability of the stream to re-aerate. The presence of large quantities of organics, such as from fallen leaves, septic tank leachate, or other organic materials washed into the stream, can lower dissolved oxygen to the point where eggs are damaged. In Butte Creek Canyon where houses are located close to the creek and leach lines are in the coarse gravel substrate derived from tailings, the water table may be shared and can cause elevated nutrient levels. However, because of the large flow in the creek compared to the volume of waste water, it is unlikely that septic systems could cause measurable oxygen depletion (Pers. com., Dykstra, 1998).

Substrate Or Gravels

Substrate composition must be low in sand and fines so that it is highly permeable to water for successful incubation and emergence of fry. The oxygen requirements of developing eggs and alevins increase with increasing temperature. For these reasons, the minimum intra-gravel percolation rate needed to ensure good survival of incubating eggs and alevins can vary considerably according to flow rate, water depth, and water quality (CDFG, 1993). Fine sediments deposited on redds reduce percolation through the gravel and can suffocate eggs.

Researchers have found that highly productive spawning streams have gravel with high permeability (Reiser and Bjornn, 1979). High permeability is regarded as less than 5% fines and low permeability is more than 15% fines. Fry emergence can be slowed or prevented by sand and silt (fines) in gravels (see Figure 6.4). Fry emergence is generally inversely related to the amount of fines (Philips et al., 1975).

Streamflow

The assumption is that spawning flows are adequate for incubation. U.S. Fish and Wildlife has at times recommended increased flows. Watershed practices that include road building and logging can increase flows and contribute to flooding and unusually high flows which scour redds and cause deaths (Reiser and Bjornn, 1979). Moderately higher flows increase oxygen interchange of inter-gravel and surface waters and benefit eggs.

Juvenile Rearing Requirements

After emergence, fry attempt to hold position in the water column and feed in low velocity slack water and back eddies. They move to higher velocity areas as they grow larger. Length of rearing and migration timing vary for salmonids from months, for Fall-run, up to years for Steelhead. Newly emerged Steelhead fry move to the shallow, protected areas associated with the stream margin. They soon move to other areas of the stream and establish feeding locations, which they defend (Shapovalov and Taft, 1954). Most juveniles inhabit riffles but some of the larger ones will inhabit pools or deeper runs.

In California most young Chinook salmon enter the ocean as zero age smolts where they remain until their third or fourth year at which time they return to their home stream to spawn (two and five year old fish also participate in small numbers). The most successful young Steelhead spend from one to two years in fresh water before migrating downstream (McEwan and Jackson, 1993). Rearing happens through out the stream system with fry and yearlings rearing wherever they find habitat (Ward, 1997).

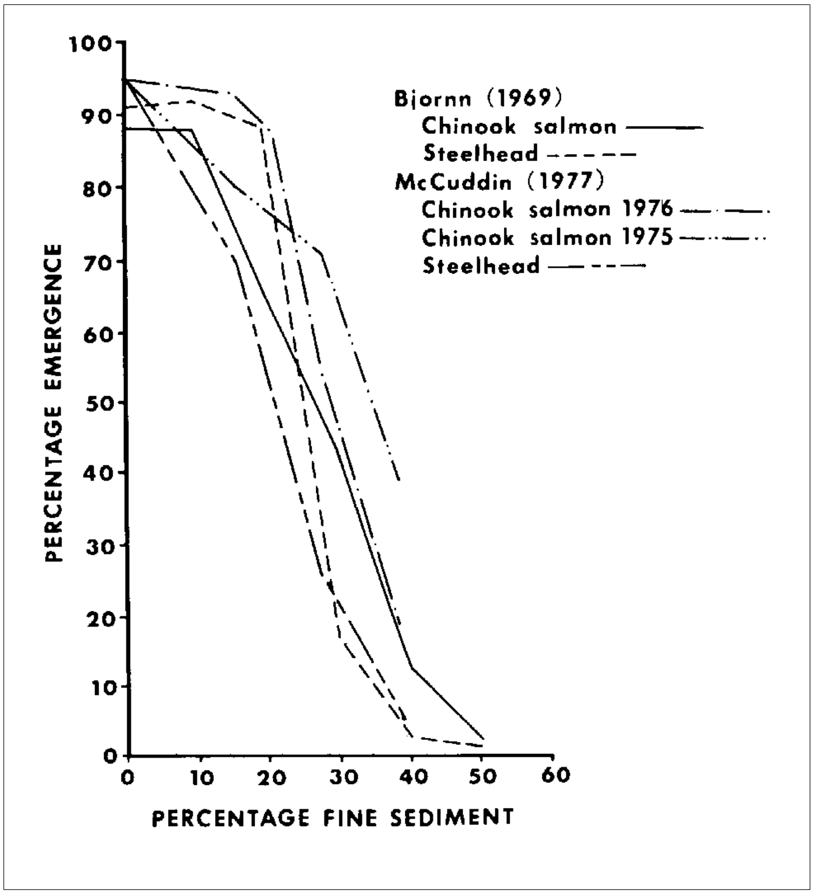

Figure 6.4

Percent Emergence of Fry from Fertile Eggs in Gravel Sand Mixture (Reiser and Bjornn, 1979) Note the sharp decline in survival rates for steelhead down to 70% at the 15% threshold of low permeability and Chinook survival down to an average of 85% at 15% fines.

Turbidity

One review concluded that salmonids ability to find and capture food is impaired at turbidities of 25-50 ntu (nephelometric turbidity units) (Lloyd et al., in MacDonald et al., 1991). Other studies indicated that growth is reduced and gill tissue damaged after 5-10 days of exposure to water with turbidities of 25 ntu (Sigler et al., 1984 in MacDonald et al., 1991). Turbidity varies according to discharge, occasional events such as road runoff, debris flows or landslides, etc.

The impact of recreational and other in-stream mining activities in the BLM reach of Butte Creek below Forks of the Butte (Black Prince and other mines) on rearing trout is a data gap.

Temperature

In Butte Creek's Watershed, low temperatures are not as great a concern as high temperatures, especially high temperatures that occur during juvenile rearing. Because juveniles rear in freshwater for at least 1 year, adequate stream flows and water temperatures are necessary year round. Steelhead prefer rearing temperatures of 45º- 60º F (McEwan and Jackson, 1993). In Butte Creek's rearing area, the Covered Bridge to the Quartz Bowl a mile below the Centerville Head Dam, summer flows generally keep temperatures below 68º F (Brown, 1993). In the Johnson and Kier (1998) study temperatures taken 1/2 mile above De Sabla Powerhouse remained between 62º - 48ºF during late July and August of 1997. Temperatures below Centerville Head Dam in critical spring-run holding and rearing area need to be studied. CDFG and DWR are conducting temperature studies of Butte Creek at this time (Reynolds et al., 1996).

Optimal rearing temperatures are between 45º - 60º F, but salmonids are known to rear in the Sutter Bypass where temperature are somewhat higher (Hill, 1998).

Good rearing habitat for salmonids consists of pools and riffles (in a 50/50 ratio), adequate cover, food (mostly macroinvertebrates), dissolved oxygen at saturation, and sixty percent of the riffles should be covered by stream flows. Riffles should contain less than 20% fine sediment for optimum macroinvertebrate production (Reiser and Bjornn, 1979).

Side Channel Rearing

Recent research has shown that side (or secondary) channels are the most productive habitats for salmonids in rivers (Sedell et al., 1980; Tuska et al., 1982). In the pristine South Fork Hoh River in Alaska they found that the greatest crop of salmonids occurred in side channels and in spring fed flood-plain tributaries. The main river channel had the lowest salmonids densities and biomass. Side-channel and terrace-tributary habitats accounted for 6 percent of the total salmonid habitat on the South Fork Hoh and reared about 70 percent of the potential smolts (Tuska et al., 1982). For the Upper Queets River system, side channels and terrace tributaries accounted for about 23 percent of the available fish habitat and 54 percent of the potential Coho salmon smolts. Both Sedell et al. (1980) and Tuska et al. (1982), reported that large woody debris was important in creating, stabilizing, and providing cover in these productive habitats. A stream habitat survey of Butte Creek can confirm or deny if side (secondary) channel habitat is a limiting factor. These channels are generally associated with unconfined stream reaches with floodplain access and plentiful large woody debris.

Nonnatal Rearing

Salmon will rear in nonnatal intermittent streams such as Dry Creek. Paul Maslin, CSUC Professor of Fisheries Biology, discovered salmon rearing in Sacramento River tributary creeks (Maslin et al., 1997). He found that 24 small tributaries with a near-mouth gradient of less than 1% contained juvenile chinook. He found a lot of "variation in numbers present and distance as they moved upstream." He concluded that the Chinook had grown rapidly, to the extent that it made race determination based on size questionable. The tributaries generally flowed long enough for juveniles to smolt and emigrate. Most streams observed by Maslin showed degradation from human activities including barriers, removal of woody debris and riparian vegetation and watershed alteration (Maslin et al., 1997). Brown (1993) caught steelhead smolts in Dry Creek. Salmonids may rear in Dry Creek or other intermittent tributaries of Butte Creek that offer suitable habitat.

Sutter Bypass

The Sutter Bypass serves as a rearing area for Butte Creek fish (Hill; Ward, 1997). During most of the year the Sutter Bypass functions as an extension of Butte Creek because the Butte Slough outfall gates are closed (Ward, 1997). It is the major route for migration through the Sacramento Slough. The Sutter Bypass is "very productive water" (Ward, 1997). In the Bypass salmonids grow well. Hill, in 1996-1997, trapped fish in a screw trap and found that Spring-run had grown (from 32mm to 80mm) (Hill, 1997). Unfortunately the Bypass has a large population of predators, including bass. CDFG Biologist Kathy Hill captured "hundreds" of juvenile rainbow trout in the Sutter Bypass. More work is needed to determine their origin, etc., as Sacramento River water can enter the Bypass over three weirs during high flows (Hill, 1997).

Fish Food Production For Rearing

Terrestrial insects are important food items for salmonids. They may enter streams by falling or being blown off riparian vegetation and by being washed in from shoreline areas by wave action or rapid flow fluctuations. Once in the stream, they become a part of the drift, and are fed upon by fish. Plant material that falls into the stream from riparian vegetation is an important source of food to aquatic invertebrates. Researchers found that terrestrial insects were second only to *chironomids* (midges) in importance as food for juvenile anadromous salmonids in the streams they studied.

Groups of insects and other arthropods that may become a part of terrestrial drift include: *Diptera* (flies), *Orthoptera* (grasshoppers and crickets), *Coleoptera* (beetles), *Hymenoptera* (bees, wasps, and ants), *Lepidoptera* (butterflies and moths), *Homoptera* (leaf hoppers), and *Araneida* (spiders). Becker's (1973) detailed study found that insects made up 95% of the fresh water Chinook diet year round. *Diptera* (flies) declining from (99-70%) from March to May, and increasing to 85% by July, *Nonectidae* were dominant in May, *Collembola* in April and May, and *Tricoptera* (caddisflies) dominant in June and July. Terrestrial based insects were dominant the rest of the year.

While in fresh water, juvenile chinook salmon take a wide variety of terrestrial and and aquatic insects (Moyle, 1976). This suggests that they feed in the water column or at the surface on drifting food. Their diet is similar to other salmonids in streams. Competition for food among salmonids is unknown but probably reduced by habitat segregation (Healey, 1991).

Density of juvenile anadromous salmonids may be regulated by the abundance of food in some streams (Chapman, 1966). Food for juveniles comes primarily from the surrounding land and from the substrate within the stream. The importance of terrestrial and aquatic insects varies with stream size, location, riparian vegetation, and time of year. Juveniles that rear in intermittent streams may be highly dependent on terrestrial insects from riparian vegetation early in the year before aquatic insect populations have rebounded (Pers. com. Maslin, 1998).

The importance of insects for salmonid food confirms that Butte Creek's riparian vegetation plays a critical role it is a production area for these insects.

Depth

The influence of water depth on aquatic insect production is poorly understood, generally the largest numbers of organisms are found in shallow areas typically riffles. Hooper (1973) reported that areas of highest invertebrate productivity usually occur in streams at depths between 0.5 and 3 feet if substrates and velocities are suitable.

Substrate

Stream substrate composition is another factor that regulates the production of invertebrates. Substrate size is a function of water velocity, with larger materials (cobble and boulder) associated with fast currents and smaller materials (silt and sand) with slow-moving water. Researchers noted a decrease in number of benthic invertebrates in the progression: cobble-bedrock-gravel-sand (Reiser and Bjornn, 1979). In general, diversity of cover for invertebrates decreases as substrate size decreases. Cobble seems to be the most productive substrate and supports the most diversity. Large cobble substrate provides insects with a firm surface to cling to and also provides protection from the current (Reiser and Bjornn, 1979). Higher coho production was found in pools with large riffles upstream than in pools with small riffles upstream (Reiser and Bjornn, 1979). A substrate (stream gravels) clean of fines is required for optimum aquatic insect production. Scouring of stream gravels from Butte Creek canyon above Centerville Head Dam, as reported by Johnson and Kier (1998), reduced aquatic insect production in that reach.

Large Woody Debris (LWD) and Rearing

Sedell (1988) describes how almost all juvenile anadromous fish are reared on stream edges in a wood rich environment. Table 6.5 demonstrates that in the presence of large woody debris, Juvenile Chinook densities increased from 5 individuals to 292, a 5,840% increase!

Table 6.5
Juvenile Chinook Densities in Different Woody Habitat Types in The Chickamin River, Southeast Alaska, March-April 1984

Woody Habitat Type	Number of Sample Sites	Average Number of Chinook Salmon
No woody habitat slack water along edges	3	5
Rootwads without boles, stumps	12	56
Single downed trees rootwad and trunk	14	87
Log Jam with several down trees	7	29

(Adapted from Sedell, 1988).

Temperature

Water temperature during rearing influences growth rate, swimming ability, availability of dissolved oxygen, ability to capture and use food, and ability to withstand disease outbreaks. Brett (1952, in Bjornn and Reiser, 1979) lists the upper lethal temperature for Chinook salmon as 77.2º F. The upper lethal temperature for rainbow trout lies between 75.2º - 85.1º F, depending on oxygen concentration, fish size, and acclimation temperature. In general, salmonids cease growth at temperatures above 68.5º F because of increased metabolic activity. Fall Chinook fingerlings had increasing percentage weight gains as temperature was increased from 40º to 60º F, and then weight decreased with a further increase in temperature to 65º F.

CDFG fishery biologist, K. Hill found lethal temperatures in lower Butte Creek in the West Borrow. From 6/28/95- 7/13/95 all days sampled and 6/1/96-7/8/96, she found 28 days that water temperatures at the surface exceeded 77º F, lethal for chinook. On 6 days in the sampling period in 1996 she found dead chinook juveniles in the screw trap (Hill, 1998).

Riparian vegetation moderates temperature in Butte Creek. Shade or lack of it can increase temperature by 11.7º -18º F (Reynolds et al., 1993). Scouring of riparian vegetation by the January 1997 storm exposes Butte Creek to more sunshine and will increase summer water temperatures maximums and decrease winter minimums.

Dissolved Oxygen

Rainbow trout swimming speeds were reduced 30 and 43 percent when oxygen was reduced to 50 percent of saturation at temperatures of 70º - 73.4º F and 16.4º - 40º F, respectively (Jones 1971, in Reiser and Bjornn, 1979). Generally in Butte Creek water quality is protected by Regional Water Quality and EPA requirements and dissolved oxygen levels are high (Dykstra, 1998).

Suspended And Deposited Sediment

Suspended and deposited fine sediment can adversely affect salmonid rearing when present in excessive amounts. High levels of suspended solids may abrade and clog fish gills, reduce feeding, and cause fish to avoid areas. Most frequently indirect, rather than direct, effects of too much fine sediment damage fish populations. Indirect damage to the fish population by destruction of the food supply, lowered egg or alevin survival, or changes in rearing habitat probably occurs long before the adult fish would be directly harmed.

Bjornn et al. (1977) added fine sediment (less than 6.4 mm in diameter) to natural stream channels, and found juvenile salmon abundance decreased in almost direct proportion to the amount of pool volume lost to fine sediment. In the Butte Creek watershed, sources of fines are typically development activities, agricultural activities, road construction and maintenance, wet season dirt road use, landslides, bank erosion, etc. A study of fines in Butte Creek's pools and riffles will be needed to determine fine levels in the system and to identify Sediment Transport Corridors (STC's) and suggest repairs.

Cover

Cover is perhaps more important to anadromous salmonids during rearing than at any other time. This is when they are most susceptible to predation. Cover needs of mixed populations of salmonids are not easily determined. Shelter needs may vary diurnally and seasonally and by species, and by fish size. Overhead cover, riparian vegetation, turbulent water, logs or undercut banks are used by most salmonids. Beside providing shelter from predators, overhead cover produces areas of shade near stream margins. These areas are the preferred habitat of many juvenile salmonids. Submerged cover, large rocks in the substrate, aquatic vegetation, large woody debris etc., are also used by rearing salmonids. Newly emerged salmonids tend to hide under stones.

Large wood controls the stream's flow in its channel and facilitates and maintains salmonid spawning habitats and some of the best habitat for young vertebrates. Trout and salmon require sites where food is plentiful within or close to cover and where little effort is needed to hold a position against the current while feeding. These sites are called by some biologists “focal points.” Stream riffles that are composed of small gravel have few such sites. Those that do exist are normally occupied by juvenile steelhead trout.

Habitat selected by fish is influenced by their age, ability and the availability of food. The importance of cover is illustrated by experiments in which salmonid abundance declined when cover was reduced and in experiments where salmonid abundance increased when cover was added to a stream. Quantities of fish cover in rearing areas of Butte Creek may be limiting to population restoration and should be investigated.

Space

Space needed by fish increases with age and size. For Chinook salmon 0+ fish require 8 - 18.2 ft.^{2}/fish, steelhead at 0+ require 10-20.7 sq. ft. per fish. 1+ Steelhead ranged from 60.04-358.6 sq. ft.per fish. Chapman (1966) suggested that salmonids have a minimum spatial requirement that has been fixed over time by the minimum food supply. Measurement of rearing areas especially preferred side channel areas is a data gap to determine the rearing capacity of Butte Creek's system.

The Delta

Many chinook fry migrate downstream immediately after emerging from the spawning beds, take up residence in the river estuary, and rear there to smolt size. Recently emerged Chinook fry are known to rear in the Sacramento River estuaries (Rich, 1920; Kjelson et al., 1982). Rich (1920) reported observing Chinook fry early in October and November in the Sacramento River Estuary. More recently, Kjelson et al. (1982) provided more detailed observations on the Sacramento - San Joaquin River estuary. Most rearing occurs in freshwater habitats in the upper delta area, in the Sutter Bypass, and along the seaward migration of juvenile salmon. Juveniles do not move into brackish water until they smoltify.

Sasaki (1966) observed that young chinook salmon were most abundant in the Sacramento-San Joaquin River delta during April and June. However, Kjelson et al. (1981, 1982) observed that fry were most abundant in February and March in the Sacramento/ San Joaquin River system, and that these fry were replaced by smolts from upriver in April to June. These would include Butte Creek fish. In the Sacramento-San Joaquin River estuary, fingerling smolts were most abundant from April to mid-June but were scarce during summer months.

There was a small secondary peak in smolt abundance in the fall, representing fish that had remained in cooler water upstream over the summer (Kjelson et al., 1982, in Groot and Margulis, 1991).

Delta Pumps (From NMFS, 1997)

In 1948, the CVP began delivering water from the Delta. In 1951, an increased supply of Sacramento River water was directed south across the Delta to the Tracey Pumps. Under initial plant operations, water was exported primarily during the agricultural season (April - early Fall). As early as 1953, exports were so high that net flow in the San Joaquin River was reversed (Ganssle and Kelley, 1963, in NMFS, 1997).

In 1959, the State Water Project (SWP) was authorized. Its main components were the H.O. Banks Pump Plant, it's intake channel and forebay, the California Aquaduct, San Luis Resevoir, and Oroville Dam. The new SWP pumps had a capacity of 6,300 cfs, more than doubling the existing potential. The SWP began delivering water in 1962 but total water exports did not increase until 1967, when the SWP began to export water via the San Luis Reservoir and the California Aquaduct. In 1968, exports climbed from an average of 1.4 MAF (1958-67) prior to the SWP to 2.5 MAF (1968). Exports continued to increase over the next 20 years reaching an annual average of 5.3 MAF (1985-87). In addition to summer and fall irrigation seasons, water was exported during winter and spring to fill San Luis Reservoir. Eventually, a second peak in pumping developed typically between December and April.

Spring-run Chinook Salmon Problems

During wetter years, irrigators delay diverting Butte Creek water until mid-May. Most salmon have passed the diversion by then and are resting in pools in the canyon. Some spring-run Chinook salmon run late and those fish can be trapped in pools between 0.5 and 1.0 miles downstream of the Highway 99 Bridge. Those fish are usually rescued by DFG wardens and biologists.

Below the Western Canal Siphon, spring-run adults normally have sufficient water to migrate upstream. During dry years, there are several areas that must be carefully monitored to assure adequate passage, as diversions can substantially reduce Butte Creek flows as early as February or March. Most of the run is then trapped behind one of the upper diversion dams. Gorill Dam has never been put up until after April 1 (Pers. com., Hefren, 1998). Mortalities are high from elevated water temperatures and poaching until DFG can rescue the remaining fish. Above the Western Canal Siphon, spring-run adults encounter low, warm flows. CDFG has seined adult salmon from the Gorrill and Durham Mutual Dams and transporting them upstream into Butte Creek Canyon. Until flow conditions improve, it is anticipated that rescue operations for adult spring-runs will continue. Flows have improved with the new M&T Agreement.

Adult spring-run Chinook salmon are lost as they attempt to ascend Butte Creek in the spring. Salmon are drawn to relatively high irrigation return flows at Five Points and Drumheller Slough where they are stranded (Flint, 1972). Some late running spring-run salmon are drawn to surplus irrigation (spill) water from White Mallard Diversion. Migrating adults are attracted to these flows and are unable to pass outfall structures. Salmon stay in the area until they are lost to poachers or predators (CDFG, 1974).

Salmon are also attracted to the Cherokee Canal by high flows. They may find their way back to Butte Creek through Sanborn Slough, but many are thought to be lost in the channels and fields of the adjacent duck clubs (Flint, 1972).

Fall-run Chinook Salmon Problems

Fall-run adults enter Butte Creek during late September and early October. Their passage upstream is often delayed or blocked at diversion dams or blocked by dewatered sections caused by diversions for flooding duck clubs. Most fall-run salmon spawn in the area from Durham to the Parrott-Phelan Dam, although some are known to spawn above. Spawning generally takes place October through December. Below the Western Canal Siphon, adult fall-run fish encounter impassable barriers, dewatered areas, siltation, a lack of suitable gravels, and inadequate cover and shade. "During the peak irrigation season, nearly all of the creek's flow is diverted by the time it reaches Durham" (Beak Consultants, 1997). Above the Western Canal Siphon, several barrier dams exist which impede the adult migration until high flows occur. Water temperatures in excess of 73º F occur an average of six days per month at the Gorrill monitoring station (Beak Consultants, 1997). Extended periods of temperatures greater than 73º F can be lethal.

Migrating Fall-run Chinook salmon are susceptible to poachers. They are especially vulnerable because they swim upstream during periods of very low flows. They reach dead ends and congregate near outfalls from agricultural diversions, or are trapped in pools between Highway 99 and Adams Dam in wetter years. Migrating adult salmon that reach spawning areas above Highway 99 crossing find that spawning gravel is scarce and of poor quality. (Note: this information is from before the 1997 high water event. Conditions may have changed - data gap). Low flows force them to choose areas of marginal or poor quality toward the center of the channel to spawn.

Young Fall-run emigrate during April and May and are heavily impacted by diversions and poor water quality when diversions are active. Losses are higher than for spring-run Chinook salmon because agricultural diversions are generally in full operation as the juveniles leave their natal areas. These young salmon suffer heavy losses from diversions in the middle and lower reaches of Butte Creek, in some cases leaving little or no water in the creek bed, especially from Sanborn and White Mallard diversions (Brown, 1992a).

Outmigrant Fall-run Chinook salmon that survive diversions are passed into Butte Slough because the gates at the mouth of Butte Creek are closed to bypass water for agricultural diversions. Salmon that reach the twin borrow pits bordering Sutter Bypass are subject to high water temperatures and concentrations of very active predatory fishes such as largemouth bass, green sunfish, and squawfish. Outmigrants are also drawn into irrigated fields by diversion from the borrow pits (Brown, 1993).

Young Fall-run Chinook salmon are also lost as they migrate down the Sacramento River and through the Sacramento-San Joaquin Estuary. Like spring-run, their numbers are reduced by agricultural diversions in the Sacramento River, predators in the river and estuary, and by state and federal export pumps in the estuary (Stevens and Miller, 1983).

Late Fall-run Chinook Salmon Problems

Little is known of the late fall-run Chinook salmon in Butte Creek. They typically migrate in mid-winter and spawn in the gravel upstream from Parrott-Phelan Dam January through March. Their young emigrate in late May and June when they are especially susceptible to diversions in the Valley section of Butte Creek and in the Butte Basin. They share many of the same risks as the Fall-run (Brown, 1993).

Special Status Fish

Current Status of Chinook Salmon

Central Valley spring-run chinook salmon which includes Butte Creek fish, were designated as a "Candidate Species" for listing under the California Endangered Species Act on June 27, 1997. The designation initiates a one year status review by the California Department of Fish and Game, with a final report to be presented to the California Fish and Game Commission by June 1998. A decision by the Commission whether to list or not, is expected after August 1998.

In addition, the National Marine Fisheries Service listed the Central Valley steelhead as threatened under the Federal Endangered Species Act during March 1998, and has proposed a Federal listing of Central Valley fall/late fall-run. The proposed listings of spring-run and fall/late-fall-run initiates a one year review, with a final decision by the National Marine Fisheries Service during 1999.

Effects of Channel Stabilization

In most locations where flood related repairs are made, riprap is used. In particular, Parrott-Phelan Ranch Dam which was screened during 1993, was abandoned by the creek during the January 1997 flood event. A NRCS emergency project put Butte Creek's channel back to the dam and rip rapped a section of Butte Creek. A weir was built from stream gravels, "hardened" with rock facing and transformed into a overflow structure with one ton rip rap armoring during the summer of 1997. Many other sites including homes and bridges received riprap treatment.

G. Mathias Kondolf, U.C. Berkeley Professor of Geomorphology (writing as a private citizen), stated in a letter that "the hard engineering structures proposed will be detrimental to Butte Creek,“ and that negative environmental impacts of such projects have been well documented...” They include "loss of aquatic habitat area and diversity, reduction of shading of the channel with attendant increase in water temperature, loss of riparian habitat for wildlife, especially loss of undercut banks, and overhanging vegetation, loss of pool riffle structure, and loss of spawning habitat" (Kondolf, 1997). Kondolf further discussed that "hardening river banks in one location typically produces a reaction elsewhere along the channel, because flows speed up or slow down, or change in direction and as a result erosion is initiated elsewhere, and new bank protection is proposed for the new site of erosion, initiating a cycle of costly and damaging "serial engineering" (Mount, 1995).

He recommended that analysis be "based on explicit analysis of historical and channel dynamics, the potential interactions of the proposed structural measures and the ecological impacts of the proposed structural measures. Far better to step back, attempt to understand the river and propose a management approach that permits the river to behave as naturally as possible, leading in the long run to fewer maintenance headaches and optimizing the remarkable ecological resources of Butte Creek" (Kondolf, 1997).

Another approach that could have been used is that of Bioenginering - using plants as engineering matierials. Bioengineering techniques have been used in Europe since the early 1800's (Schliechtl, 1980). A project on Lindo Channel in Chico that utilized Bioengineering combined with a geomorphically guided approach used approximately one eighth of the riprap of the standard riprap proposal that proceeded it (Cole, 1991).

Large Woody Debris for Restoration

Improving fish habitat using large wood will not be easy because the long-term stability of woody debris in Butte Creek cannot be exactly predicted (Although CDFG has successfully cabled logs in place on some streams). Leaving debris in place has a high probability of enhancing rearing and spawning habitat for salmonids, either in the original location, or downstream after a storm. Streams are dynamic, and evolve within their physical and chemical constraints. Predicting with certainty the stability of debris at a point in space will only occur if the stream is 'trained" throughout its entire length, and thus damaged (Mount, 1995). Dam construction, bank revetments, levees, and chanellization efforts have shown the obvious whenever you tinker with a stream, it makes an adjustment. These natural adjustments may or may not be compatible with watershed-wide efforts towards habitat improvement (Sedell, 1982).

Butte Creek Fisheries Stressors

Wildlife Refuges and Hunting Clubs

The wildlife refuges and hunting clubs are dependent on Butte Creek water and provide some of the most valuable wildlife and waterfowl habitat in the Sacramento Valley. The timing of the need for water among duck clubs, agriculture, and anadromous fisheries causes competition. Seasonal flooding of refuges and duck clubs can conflict with the need for flows for spawning fall-run Chinook salmon and overlaps with the need for transportation flows for both spring-run adults and juvenile salmon in April and May.

Poaching

Loss to poachers is the largest threat to the continued existence of spring-run Chinook salmon in some streams in California (Moyle et al., 1989). Poaching is common in areas where adult salmon are blocked. Although most poaching may occur in Butte Creek Canyon, poaching also occurs at White Mallard Spill Dam, pools below Highway 99, in water behind any of the other diversion dams, and at control structures in the Sutter Bypass.

Warden Gayland Taylor confirmed that Spring-run salmon are tempting for poachers. CDFG allotted overtime for apprehending poachers of Spring-run and created the Spring-run Enhancement Project 1994 - 1997. The majority of 304 tickets were posted to Butte Creek (Pers. com., Taylor, 1998).

Diversion Losses and Competition for Flows

Each water diversion in Butte Creek can divert out migrant salmon and steelhead into rice fields, orchards, and waterfowl areas. Those that take the heaviest toll include Sanborn Slough, and White Mallard Outfall (CDFG, 1974). As an example: Brown (1992) estimated that during a sampling period that lasted December to June in 1991, 6,004 fry and 47 yearling were lost at the Parrott-Phelan Dam (Parrott-Phelan is now screened). Sampling was also conducted during spring at the Durham Mutual, Adams, and Gorrill Diversions. An estimated 350 salmon fry and smolts were lost at Durham Mutual; most were caught in February. An estimated 263 were lost at Adams; and no salmon were caught at Gorrill. Other sampling for outmigrant loss in diversions was conducted by Hallock and VanWoert (1959). They found "no fingerlings . . . present in spring of 1956 and none after mid-March in 1957, they were recovered in fair numbers in six of the eight diversions in 1955" (see Issues and Concerns chapter, #2).

The timing of the need for water among duck clubs, agriculture, and the anadromous fisheries causes competition for water. Irrigation of rice fields overlaps with the need for transportation flows for both spring-run adults and juvenile salmon in April and May.

Although no studies have been conducted to estimate losses of out migrants at all diversions over the entire migration period, they are considered sources of loss of salmon based on the portion of outflow they divert (Hallock and VanWoert, 1959). Fish ladders and screens at all diversion dams require continuous monitoring and maintenance to operate successfully.

Recreational impacts

Campbell and Moyle (1992) studied the effect of rafting activity on Butte (1990) and Deer (1991) Creeks, and found that human rafting activity caused an increase in spring-run Chinook salmon movement in pools, and may stress them if rafting is common. (See Scenic and Recreational Resources chapter). They documented substantial evidence of possible harassment and poaching of salmon in a 2.3 km study stretch of Deer Creek during 1991. This evidence included the presence of heavy line and treble hooks in pools containing adult salmon. They even observed people with snorkeling equipment trying to capture adult spring-run salmon with a dipnet (see Issues and Concerns chapter, # 1).

Trout Fishery Losses Due to the DeSabla-Centerville Project

In a CDFG Report, fishery biologists R.A. Flint and F.A. Meyer estimated the trout fishery losses at "approximately 38,000 (6 inch) trout in 15 3/4 miles of Butte Creek" (Flint and Meyer, 1977). The project canals support trout to varying degrees depending on substrate composition and flow. These estimates were before the current agreement with PG&E to provide 40 cfs in the low flow sections of Butte Creek, which has improved conditions for salmonids.

The current flow regime conditions and it's effect on resident trout population in the effected reach is a data gap.

Habitat Restrictions

It had been thought that PG&E's Butte Head and Centerville Head Dams in Butte Creek eliminated steelhead access to the headwaters of the Butte Meadows basin (Brown, 1992), and that steelhead were now restricted to the lower reaches of the canyon and tributaries such as Dry Creek. However, Holtgrieve and Holtgtrieve (1995) searched the literature and found that in feet no evidence exists of their presence in the upper watershed.

In *A Preliminary Assessment of the Salmon Habitat Potential of Butte Creek Between the Butte Head Dam and Centerville Diversion Dam*, Johnson and Kier (1998) concluded that "the eleven mile canyon section contains pools, spawning gravel and water quality sufficient to meet the summer holding and early fall spawning requirements of spring-run salmon. The number of barriers is daunting, however most of the falls and chutes may be surmountable by adult salmon at the higher flows.during springtime migration. If fish migration beyond.Centerville Dam were made possible then the accessibility of the upper.canyon would be determined largely but not exclusively by streamflow availability. They acknowledged several barriers would require modification.

Concerns expressed by CDFG and others include the presence of a 35-foot barrier approximately 0.34 miles above the Centerville Dam. This is one of the largest barriers on the entire reach.

These concerns must be weighed against the opportunity of accessing habitat capable of supporting 199 - 521 pairs of spring-run salmon (or steelhead). Another benefit might be the possibility of a "closable" fish ladder to separate spring-run spawners from fall-run in some years.

Sport Fishing

Butte Creek is closed to fishing for trout and salmon all year from confluence with the Sacramento River, in Butte Slough, the East and West canals of the Sutter Bypass, and Sacramento Slough upstream to the PG&E Centerville Head Dam. It is open all year to fishing for other species from the Oro-Chico Bridge crossing to the Sacramento River and in Butte Slough, the East and West canals of the Sutter Bypass, and the Sacramento Slough.

Butte Basin and Butte Sink (see Issues and Concerns chapter, #2)

Flint (1972) described the Butte Sink as the "greatest single hazard to downstream migrants on Butte Creek." Butte Slough outfall gates may cause losses in juvenile and adult salmon. DWR opens the gates to control flooding in winter and early spring; adult and juvenile salmon can pass freely from Butte Creek to the Sacramento River during this period.

Reclamation District 70 closes the gates later in the spring and in summer to retain water in the Butte Slough for irrigation. Young salmon are diverted into Butte Slough and may be lost to agricultural diversions when the Butte Slough outfall gates are closed (Brown, 1993). High temperatures (70º - 85º F) in summer threaten juvenile salmon and steelhead (Brown, 1993).

Numerous predators are present in this area including the Striped Bass, an introduced species and one of the most efficient predator fish in the Butte Creek system. Very evolutionarily advanced and well known for taking great numbers of prey items, Striped Bass are known predators of salmonids in the Delta and elsewhere (Maslin, 1998). They are often found in screw traps in the West Borrow (Hill, 1998). CDFG has acquired an incidental take permit under the Endangered Species Act for incidental take of Winter-Run chinook for the Striped Bass management program (CDFG, 1997).

High Temperatures

- PG&E in a two year (1992-3) water temperature and flow monitoring study (PG&E, 1993) found the following temperatures data:
- Lower Centerville Diversion Dam range: 54º.3 - 69.8º F, in 1992 and, 47º - 66ºF in 1993.
- Average July temperatures in 1992 were 63.1º F and 60.4º F in 1993.
- Average August temperatures in 1992 were 64.6º F and 60.4º F in 1993.
- Helltown Bridge range: 57.4º - 75.2º F in 1992 and 56.7º F - 73.4º F in 1993. Average July temperatures were 67.6º F in 1992 and 66.4º F in 1993.
- Average August temperatures were 68.4º F in 1992 and 66º F in 1993.
- Lower Centerville Canal range: 56.1º- 80.6º F in 1992 and 47.7º - 68.7 º F in 1993.
- Average July temperatures were 65.8 ºF in 1992 and 61.5 ºF in 1993
- Average August temperatures were 66.9º F in 1992 and 61.5 ºF in 1993. The maximum temperature occurred during a canal outage at 80.6 º F.
- At Pool 4, range: 54.7º - 75.4º F in 1992 and 48.2º - 72.1º F in 1993. Average July temperatures were 66.2º F in 1992 and 64º F in 1993
- Average August temperatures were 67.1º F in 1992 and 64º F in 1993.
- Butte Creek below Centerville Powerhouse range: 55.2º F - 76.5º F in 1992 and 48.2º F - 70º F in 1993.
- Average July temperatures were 66.7º F in 1992 and 62.4º F in 1993
- Average August temperatures were 67.1º F in 1992 and 62.8º F in 1993.
- Note that 1992-93 were drought years and flows were below "normal" (see Hydrology chapter)

Potential Improvement Due To Screening

Some idea of the possible improvement from installing fish screens is evident from a CDFG study at Roaring River Slough (1981-1982) In this study the screens were leaky and had to be removed for cleaning. They still reduced Chinook losses by 88% (37/284) and overall fish losses by 90% (565/5609 fish).

For a list of restoration actions and evaluations from the Revised Draft Anadramous Fish Restoration Program see Table 6.6.

Further Recomendations from USFRH

1) Conduct an in stream flow study.
2) Develop hydrologic model (Butte Basin Water Users have a model which is available (pers. com., Hefren, 1998).
3) Monitor water temperatures and water quality in Butte Creek (Ongoing DWR effort).
4) Develop genetic marker for racial identification.
5) Correct water temperature and agricultural drain problems as they significantly effect water quality.
6) Implement habitat restoration work in lower Butte Creek, such as sediment control and revegetation of stream banks.

Additional Findings (primarily data gaps)

1) The presence, quantity (pieces/mile), and quality of large woody debris in Butte Creek is a data gap. Numerical comparisions with similar stream types (such as Rosgyns' stream classification system) in more pristine areas would enable stakeholders to evaluate Butte Creek's condition.
2) The status of Butte Creeks aquatic insect population is a data gap that can be filled by the application of the Rapid Bio assessment technique (Harrington et al., 1997).
3) The scouring of Butte Creek by the January 1997 storm has increased width to depth ratio in some stream reaches, scoured out gravels, and decreased inter-gravel percolation rates. The quantity and condition of Butte Creek's spawning gravels is a data gap. Stream surveys can fill this data gap.
4) The impact of recreational and other in-stream mining activities in the BLM reach of Butte Creek below Forks of Butte (Black Prince and other mines) on rearing trout and holding spring-run salmon is a data gap.
5) Quantity of rearing areas, including pool/non-pool ratios and especially preferred side channel areas is a data gap. Stream suveys should be performed to determine if the rearing capacity of Butte Creek's system is a limiting factor.
6) Migrating adult salmon that reach spawning areas above the Highway 99 crossing find that spawning gravel is scarce and of poor quality. (Note: this information is from before the 1997 high water event. Conditions may have changed).
7) The current flow regime conditions and its effect on resident trout population in the effected reach of the De Sabla-Centerville Project is a data gap.

Historic Context for Butte Creek

Butte Creek's anadromous fish stocks evolved in streams that were obstructed by fallen trees, beaver dams, and vegetation growing in and beside the channels. Main stream channels contained abundant gravels and fine sediments. Habitat complexity was great due to scour around boulders and fallen trees, and the presence of multiple stable side channels and over flow sloughs. In the Butte Creek Watershed, logging, hydraulic mining, development, and agricultural operations removed the fallen trees and filled the side channels and sloughs, reducing habitat complexity and it's biological productivity. Human efforts seem focused on expediting the transportation of water for one human use another. As stated earlier Butte Creek's productivity of aquatic insects is partially based on decomposing woody debris as an energy source. After last January's storm, tons of logs were cut up into firewood and allowed to flush out of Butte Creek's system. A very large source of potential nutrients and diversity was removed from Butte Creek's ecosystem, and future aquatic insect populations were very likely reduced both in diversity and numbers. Additionally, other human efforts have simplified Butte Creek's habitat.

Restoration of wild stocks of salmonids is imperiled when present habitats appear to be so unlike their historic conditions. To the extent that we can incorporate the structure and processes of undisturbed habitats, like those where wild salmonids developed; protection and enhancement efforts will have a more effective direction (Sedell, 1982).

Limiting Factors Analysis (based on Kaczynskij, 1996)

Past land management, flood control, and road practices have resulted in some reaches of Butte Creek with: 1) low volumes of large woody debris; 2) loss of riparian areas in agricultural and urban areas; 3) riparian areas in forests that are dominated by small hardwoods; 4) loss of off channel, pond and attached wetland habitat; 5) loss of secondary channels, and; 6) especially the loss of critical deep pool, and off channel, winter flood, refuge habitat.

Table 6.6
Restoration Projects from Revised Draft Anadromous Fish Restoration Program 1998

Action	Involved Parties	Status
Obtain additional instream flows from Parrott-Phelan Diversion.	Diverters, CDFG, USFWS, USBR	
Maintain a minimum 40 cfs instream flow below Centerville Diversion Dam.	CDFG, PG&E, USFWS, USBR	
Purchase existing water rights from willing sellers.	Diverters, CDFG, USFWS, USBR, SWRCB	Ongoing
Build a new high water volume fish ladder at Durham Mutual Dam.	Diverters, CDFG, TNC, USFWS, USBR	
Install fish screens on both diversions at Durham Mutual Dam.	Diverters, TNC, USFWS, USBR, NMFS, CDFG, CDW	
Remove the Western Canal Dam and construct the Western Canal Siphon.	Western Canal Water District (WCWD), TNC, CDFG, USBR, USFWS, CALFED, CUWA	Complete
Remove McPherrin and McGowan dams and provide an alternate source of water as part of the Western Canal removal and siphon construction.	Diverters, WCWD, CDFG, USBR, USFWS, CALFED, CUWA	In progress.
As available, acquire water rights as a part of the Western Canal Siphon project.	WCWD, CDFG, SWRCB, USBR	
Adjudicate water rights and provide water master service for the entire creek; enforce or initiate legal action on Diverters who are violating water right allocations.	Diverters, CDFG, CDWR, SWRCB, USFWS, USBR	No Action
Build a new high water volume fish ladder at Adams Dam.	Diverters, CDFG, USFWS, USBR	In progress
Install fish screens on both diversions at Adams Dam.	Diverters, USFWS, USBR, NMFS, VDFG, CDWR	In progress
Build a new high water volume fish ladder at Gorrill Dam.	Diverters, CDFG, USFWS, USBR	In progress
Install fish screens on both diversions at Gorrill Dam.	Diverters, USFWS, USBR, NMFS, CDFG, CDWR	
Install a fish screen at White Mallard Dam	Diverters, Conservancy, CDFG, CDWR, NMFS, USFWS, USBR	
Eliminate chinook salmon stranding at White Mallard Duck Club outfall.	Diverters, Conservancy, CDFG, USFWS, USBR	
Rebuild and maintain existing culvert and riser at Drumheller Slough outfall.	Diverters, Conservancy, CDFG, USFWS, USBR	
Install screened portable pumps in Butte Creek as an alternative to the Little Dry Creek diversion.	Diverters, Conservancy, CDFG, USFWS, USBR	No Action. Deemed unnecessary.
Install a fish screen at White Mallard Dam.	Diverters, USFWS, USBR, NMFS, CDFG, CDWR	
Develop land use plans that create buffer zones between the creek and agricultural, urban, and industrial developments; and restore, and protect riparian and spring run chinook salmon summer-holding habitat along Butte Creek.	City and county government agencies, Conservation groups, Conservancy, CDFG, USFWS, USBR	
Install fish screens and fish ladder at Parrott-Phelan Diversion Dam.	Diverters, Conservancy, CDFG, USFWS, USBR	
Develop a watershed management program	Conservancy, USFWS, USBR, NMFS, CDFG, CDWR	In progress. Strategy expected in Fall 1998.
Establish operational criteria for Sanborn Slough Bifurcation.	Diverters, Conservancy, CDFG, USFWS, USBR	
Establish operational criteria for East Barrow pit and West Barrow pit.	Diverters, CDFG, USFWS, USBR	See findings, The Lower Butte Creek Project, Final Report.
Establish operational criteria for Nelson Slough.	Diverters, Conservancy, CDFG, USFWS, USBR	See findings, The Lower Butte Creek Project, Final Report.

Evaluation Studies from *Revised Draft Anadromous Fish Restoration Plan 1998*

How can we objectively and reasonably evaluate the conditions of Butte Creek relative to potential enhancements? One answer is by conducting a limiting factors analysis. To do a limiting factor analysis we must have basic stream condition information. Some stream survey is needed. The next step is an evaluation of the existing stream conditions. Professional judgment is then applied (or a more detailed and intensive study that we rarely can afford), to identify potential limiting factors and to select the most probable ones. In the Coast Range of Oregon, thousands of miles of stream habitat surveys have revealed some common patterns, and identified juvenile over wintering habitat (refuge from floods) as the most common limiting factor. This generality could very well apply to northern California and to Butte Creek.

This knowledge will help Butte Creek stakeholders narrow the list of potential enhancement efforts and make more cost effective walk through stream surveys.

The Shape of the Solution

Rebuilding salmon runs in Butte Creek will require a negotiated balance among wildlife, agriculture, urban, and fishery needs. Evaluating and determining water rights, water use, in-stream flow needs, flooding problems, riparian resources, property issues, and recreational needs will be a long-term effort requiring the involvement of irrigation districts, private landowners, agency personnel, anglers, environmentalists, and other stakeholders.