Preserving Biological Diversity

The biological diversity of the Laguna's plants and wildlife depends on the diversity and health of the Laguna's habitats. Habitat loss is the greatest contributing factor to biodiversity losses, followed by impacts—via predation and habitat degradation—from invasive species. In most cases, it is best to focus on protecting and restoring the entire ecosystem rather than narrowly addressing the needs of one or a few species. However, some species warrant particular attention and concern. Several plants and animals are *endemic*, found nowhere else in world, to the Russian River watershed and the joint forces of environmental change and development has put their populations at risk of extinction. These species share some form of legal protection and listing by the state and federal governments. Because they are rare, often little is known about their reproductive biology or ecological interactions. Even conservation research requires special permits to handle and move these plants or animals, because so few are left to reproduce.

Endemic species

To restore populations to viable levels, we must restore habitats. Often this restoration is geared toward particular requirements of the target species: when designing restoration projects, conservation biologists would like to know which life stage of the organism is most vulnerable and limiting to its population growth. For example, oak populations are most limited by seedling recruitment, so restoration efforts must be designed to enhance seedling survival. Some fish species are limited by access to spawning grounds, so it is critical to remove barriers to fish passage. Many endangered plants are strongly affected by competition from invasive species, so restoration strategies are geared toward vegetation control. In some cases, the needs of one rare species conflict with the needs of other rare species, and regulators have to weigh a project's relative impacts. Some restoration activities (invasive species removal for example) can cause short-term disturbance, but support species recovery over the long-term. In these cases, regulatory agencies may issue a "take" permit to allow the restoration project to go forward.

Restoration targets species' requirements

Species protection laws, like the Endangered Species Act (ESA), have a goal to be even-handed or "value neutral" about which species are the

Value neutral protection under law

highest priority for protection. However, species that are small or *cryptic*—that is, anatomically indistinguishable but genetically distinct—are less likely to receive protection because they are less likely to have been studied and described. Also, animals have greater protection under the ESA than plants—especially when they occur on private property. Relatively few endangered species have been the beneficiaries, above and beyond basic protection, of active restoration efforts. Whether or not restoration funds are made available depends on more arbitrary factors. Which species are most worthy of restoration: the species closest to extinction, or the species with the greatest chance of recovery? And what are the economic implications of species loss or species protection?

Different levels of protection in practice

In the Laguna watershed, coho salmon and steelhead trout have been the recipients of the majority of restoration attention. Historically, these species were the foundation of an economically important fishing industry in the Russian River basin, but their populations have crashed in response to a variety of factors—including habitat degradation of spawning areas. Vernal pool protections came about through the sustained work of local naturalists, who in 1995 produced one of the first environmental plans for the Laguna watershed: the *Santa Rosa Plain Vernal Pool Ecosystem Preservation Plan*. The massive conservation effort to protect and restore California tiger salamander (CTS) on the Santa Rosa Plain is a result of a lawsuit by the Center for Biological Diversity, an environmental organization that litigates on behalf of endangered species. The *Santa Rosa Plain Conservation Strategy* conjoins CTS restoration activities with vernal pool plant conservation. These conservation efforts are described in detail below.

Volunteers, students and community groups can provide important momentum for species conservation. The Cotati Creek Critters, a grassroots group working on stream restoration in the southern parts of the watershed, has adopted the western pond turtle as their symbol, and plan to devote special effort toward restoring western pond turtle habitat. This turtle has been state-listed as a species of special concern, and has been strongly affected by habitat loss. Like all reptiles it is vulnerable to being run over by cars, especially during breeding season when turtles seek upland habitat to lay their eggs. Non-native bullfrogs and crayfish may be major predators. Habitat enhancement for pond turtles includes creating basking structures where they can pull out of the water and lie in the sun. However, serious population recovery will require much more research on the conservation biology of western pond turtles in the Laguna—their distribution, population growth rates, and mortality factors.

Western pond turtle habitat restoration

Another popular community-based conservation effort is to establish bird and bat boxes and raptor perches around the Laguna. A number of species of birds and bats have evolved to nest in the cavities and crevasses of old trees, which are now relatively rare in human altered-landscapes. Although restoration practitioners should attempt to keep natural cavities whenever possible, building bird and bat houses and establishing them in natural areas can act in a supplemental role to benefit cavity-dependent species. Volunteers must monitor these structures annually to insure that boxes are not colonized by starlings or other non-native species. Raptor perches and telephone poles take the place of old snags in the grasslands, where hawks can sit and wait for rodents and other prey.

Supplementing cavity-nesting habitat

Birds are probably the most visible form of wildlife in the Laguna watershed, and the Laguna has become a popular destination area for birdwatchers. Birds play very important ecological roles as predators and seed dispersers, and as they have complex habitat requirements, certain species can be excellent indicators of environmental quality, this allowing comparison and evaluation of adaptive management and restoration success. For all these reasons, birds are an important focus for conservation attention. PRBO Conservation Science, along with California Partners in Flight, has developed a series of adaptive conservation plans for the bird communities in a number of specific habitat types in California, including riparian, coniferous forest, grassland and oak woodland (see www.prbo.org). Each of these plans contains very detailed, science-based recommendations for bird conservation, including bioregional objectives, specific action recommendations, and standardized monitoring methods. Although these plans focus on birds, they provide a model for conservation plans for other groups of species in the watershed.

Bird conservation plans

Other species are so rare that they have become the focus of intense conservation research. Showy Indian clover, once an important food plant for the native peoples of the Laguna, was extirpated during the last century. This species was for some decades believed to be entirely extinct, until a single plant was found near Dillon Beach. This plant was protected and propagated, and Diana Immel, a doctoral candidate at U.C. Davis began work in 2005 to re-establish a small population at Brown Farm, near the City of Sebastopol. Experimental restoration trials have included controlled burns and protection from grazing by livestock and non-native slugs (Diana Immel, pers.com.) These types of studies are essential for population restoration. In some cases, factors that have led to declines may no longer be present, and the species may have new hope for recovery. Similar focused effort is being devoted to the Pitkin Marsh lily and other

Bringing Showy Indian clover back from the brink of extinction

Saving the Pitkin Marsh lily

rare plants endemic to upland bog areas on the western edge of the watershed. These are some of the most at-risk species in the Laguna but they have little remaining habitat in which populations can expand. Members of the California Native Plant Society, Milo Baker Chapter, are working to develop specific restoration techniques to increase their viability, and the Chapter recently commissioned a management plan for Cunningham Marsh. The Milo Baker chapter has also focused intense conservation efforts on the endemic Vine Hill and Rincon manzanita species, who's habitats have been tightly circumscribed by development.

Conservation of rare manzanita species

Historical accounts of the Laguna describe a very different landscape, highly productive, and filled with wildlife—some of which have entirely disappeared (see chapter 10). Grizzlies were exterminated because they were dangerous to man and livestock. Tule elk were shot for venison and tallow. Pronghorn antelope were also found on the Santa Rosa Plain; beaver were thought to have been present in the waterways; wolves were occassionally seen in the mountains; and condors were part of the aerial scenery. All of these have now been *extirpated*, that is, not extinct, but no longer found in the watershed. There has recently been serious discussion in the conservation community about the need and the desirability of "rewilding" North America. Restoring wolves in Yellowstone National Park is one of these efforts. While it is unlikely that active restoration of mountain lions would be popular in this rapidly-urbanizing landscape, the success of tule elk restoration at Point Reyes suggests that large herbivores like elk may do well in the Laguna. While the ecological benefit of the return of these animals is unknown, they would nevertheless have tremendous value for environmental and historical education, as well as ecotourism.

Extirpation of species

Species of special concern

During the process of developing this plan, a special stakeholder committee met to discuss biodiversity priorities in the Laguna watershed. One of the products of these meetings was a table listing all of the *species of special concern* in the watershed (see appendix B). This table was compiled from a variety of sources; it includes both federal and state listing status, as of 2005, as well as local prioritizations. The biodiversity committee recognized that conservation focus is best placed on protecting and restoring habitats, but acknowledged that some species need special attention to promote their recovery. Many of these species have federal and state protections. Individuals and organizations planning restoration projects

Species of special concern

need to consider whether their projects support or disturb the species in this table, and to consult with the CDFG, NMFS, or the FWS for regulatory guidance. Even when no legally protected species are present, baseline studies of restoration sites should be conducted by biologists that are familiar with the local flora and fauna, to minimize harm to species of local concern.

In compiling this table, the committee was concerned not only with species that are rare and endangered—species should not have to be at the edge of extinction to be the target of conservation efforts—but with keeping species from *becoming* rare. For this reason, the committee wished to recognize the value of certain native birds and wildlife, like the great blue heron and the river otter, that are signature or totem species of the Laguna. The committee gave high local priority to all the native amphibians, reptiles, and fish in the watershed, as these groups have been less well studied, and have been particularly impacted by development, environmental change and invasive species throughout the state. Fifteen plants and animals are federally listed as threatened or endangered, and thirty-eight are state listed as threatened, endangered, or species of special concern. The California Native Plant Society has designated forty-three plants as species of local concern.

15 federally-listed species

38 state-listed species

43 locally designated species

Overall, species conservation must be a joint community venture that includes standardized monitoring of all species, as well as habitat preservation and restoration. PRBO Conservation Science has developed a set of structured guidelines for developing adaptive conservation strategies, essentially joining adaptive management with science-based conservation recommendations. These guidelines emphasize close collaboration between scientists and land managers, iterative evaluations based on up-to-date monitoring data, and shared information. The adaptive conservation strategy framework complements and incorporates the bird conservation plans described above, and should serve as a model for future conservation planning.

Conservation on the Santa Rosa Plain

Aerial photos of the Santa Rosa Plain show traces of a vast network of vernal pools and swales, although many of these have been plowed and filled over the years and become overgrown with non-native grasses. The unique hydrologic quality of these pools—holding water long past the rainy season—comes from thick underlying clay layers, which in the summer is cracked and dry. This harsh environment has favored the evolution

of a unique and specially adapted plant community. There are at least four federally endangered plant species that are associated with seasonal wetlands on the Santa Rosa Plain: Sonoma sunshine *(Blennosperma bakeri)*, Burke's goldfields *(Lasthenia burkei)*, Sebastopol meadowfoam *(Limnanthes vinculans)*, and Many-flowered navarretia *(Navarretia leucocephala* ssp. *plieantha)*, as well as many other wetland wildflowers. In 1995, the Santa Rosa Plain Vernal Pool Task Force developed a protection plan for threatened and endangered plant species on the Plain. The plan outlined a prioritization scheme for land protection and wetland preservation, based on which properties had the greatest vernal pool resources, and contains detailed information on the biology of local vernal pool species. As most of this land has remained in private hands, conservation efforts have been patchy and opportunistic, and inconsistent management has degraded the quality of many protected pools.

Rare plants of the Santa Rosa Plain

Another seasonal wetland-associated species, the Sonoma population of *Ambystoma californiense*, California tiger salamander (CTS), was listed as endangered in 2002. Surveys have found CTS adults and breeding sites over much of the Santa Rosa Plain, from Cotati to north of Santa Rosa. CTS populations, like the listed plant species, have been heavily impacted by habitat loss and fragmentation. In the past several decades, much of their historic range has been the site of extensive agricultural, residential and commercial development, with more development projected for the near future.

California tiger salamander

For breeding, CTS need rain-fed seasonal wetlands, where adults mate and lay eggs, and larvae spend 3-6 months prior to metamorphosis. If the pool dries too rapidly, larvae will die. Although some have bred successfully in permanent pools or cattle watering ponds, salamander eggs and larvae are easy prey for bullfrogs and fish, so permanent ponds and wetlands fed by floodwaters are considered poor rearing habitat. Adults spend most of the year in rodent burrows in grassy uplands, migrating as much as 1000 meters (3300 feet) to breeding pools on rainy winter nights. After breeding, adults return to upland areas, followed months later by juveniles as they complete metamorphosis. CTS use of uplands is compatible with hay production and livestock grazing, providing these activities do not reduce the abundance of ground-burrowing rodent populations. Man-made obstructions such as curbs and wide roadways are difficult for CTS to cross, making this species very sensitive to habitat fragmentation. The estimated minimum preserve size to protect adults and juveniles around a breeding pool is 350 acres, although actual minimum preserve size may be much larger. Other studies have recommended a minimum

CTS need both vernal pools and nearby upland habitats

size of 470 acres and stressed the need for additional studies of the migration patterns and upland ecology of CTS. For example, establishing a 2100-foot upland buffer surrounding known CTS breeding pools at the Wright Preserve (Hall Road Preserve) would require the preservation of 675 acres (Cook 2005). The size, shape and connectivity of preserves, as well as their ratio between upland and aquatic areas (ideally 100:1) influence their habitat value.

Not all seasonal wetland rare species are *listed*

Besides the listed species, there are a number of other rare plant and animal species associated with seasonal wetlands on the Santa Rosa Plain. These include the wildflowers Dwarf downingia *(Downingia pusilla)*; Baker's navarretia *(Navarretia leucocephala* ssp. *bakeri)*; Gairdner's yampah *(Perideridia gairdneri* ssp. *gairdneri)*; Douglas's pogogyne (*Pogogyne douglasii* var. *parviflora)*; and Lobb's aquatic buttercup *(Ranunculus lobbii)*. California linderiella, *(Linderiella occidentalis)*, a species of fairy shrimp, is also found in pools. Other rare invertebrates are also likely to be present, but there has been no comprehensive survey of vernal pool biodiversity.

Restoration and management

CTS breeding pool requirements have a great deal of overlap with the habitat requirements of the listed plant species. Among the endangered plants, there is some variation in environmental preferences for soils and water-depths, but in general, these species prefer somewhat shallower pools than do salamanders, and are sometimes found in floodplain seasonal wetlands as well as rain-fed vernal pools.

Wetland creation is favored over wetland restoration

Under the Clean Water Act and the Porter-Cologne Act, the federal and state governments operate under a policy of "no net loss of wetlands." The result of this policy is that when a wetland is destroyed in the course of development, regulations favor wetland *creation* over wetland *restoration*. Since the function of vernal pools—their ability to hold water, host vernal pool plants and discourage the growth of non-native species—is dependent on their underlying soil characteristics and hydrologic integrity, created wetlands may have much lower habitat value than the wetlands they replace. However, there are a great many opportunities for the restoration or enhancement of historic vernal pools and swales, and an increasing number of examples of successful restoration projects. The connectedness of vernal pools and swales is also critical for their ecological function because seeds, soil and small invertebrates are carried between pools during periods of high rainfall. Asymmetric pools with both shallow and deep portions can provide good habitat for both plants and salamanders. For all these reasons, wetland restoration is an artful bal-

ance of science and engineering and needs careful site-specific planning by experienced practitioners and biologists.

Active management of wetland preserves is essential to their success

The success of species recovery depends on the quality of the wetlands, so preserve management is almost as important as species protection. Thatch removal through mowing, grazing, or even burning appears to be critical for the success of wetland wildflowers that cannot easily germinate through dense mats of dead grass. Non-native grasses growing in vernal pools also increase the rate of transpiration and water loss, reducing the inundation period and sometimes causing pools to dry out before salamander larvae have time to complete metamorphosis. There is active research underway to develop optimal vegetation management strategies for seasonal wetlands. Historically, the grasslands of the Laguna were grazed by herds of pronghorn antelope, elk and deer; today livestock grazing is likely to be the most sustainable practice for protecting the health of native species associated with seasonal wetlands. However, at high stocking rates grazing can also be very destructive—denuding plants, increasing erosion and impacting water quality—so grazing must be carefully managed. Cattle, horses, sheep and goats all have different grazing habits and preferences, and consequently different effects on seasonal wetland vegetation and aquatic animal species. Controlled burns may be effective in some situations, but can reduce air quality and create fire hazards. Consistency and long-term commitment is the key to preserve management. Orphan preserves, with no management plan, funding or responsible entity, can become quickly degraded.

Santa Rosa Plain conservation strategy

Critical habitat extends outside species' current range

The remaining highest-quality habitat for both CTS and the listed plant species is in the agricultural greenbelt separating Santa Rosa, Sebastopol, Rohnert Park and Cotati. When species are listed as threatened or endangered, the U.S. Fish & Wildlife Service (FWS) is required to designate *critical habitat*—specific areas considered essential to the conservation of the species. Critical habitat may require special management considerations: this includes areas outside of the species' current geographic range, to allow for future population growth as the species recovers. In areas designated as critical habitat, any activities that require federal permits or funding must be reviewed and permitted by the FWS. Critical habitat restrictions come in addition to state and federal wetland protections and Endangered Species Act (ESA) regulations, which require *incidental take permits* for any activities that may harm or disturb listed species, or disrupt their habitats. In December 2005, the FWS identified more than 17,000

acres, mostly on the Santa Rosa Plain, as meeting the criteria for critical habitat.

Even without this designation, the presence of listed species has resulted in a very complex system of regulations and permit restrictions for development on the Plain—whether urban, rural-residential or agricultural. Permits go through review and public notice by the FWS, CDFG, USACE, NCRWQCB, and Sonoma County's PRMD. Two years of surveys are required to evaluate whether CTS or the listed plants can be found on the property, leading to the development of an EIR. When habitat is destroyed by development, the developer must mitigate by making up for its loss by creating or improving habitat elsewhere. The entire process can take up to three years, and along the way there is ongoing uncertainty over eventual costs. Despite this, these layers of red tape do not ensure adequate species protection or recovery, especially if piecemeal mitigation leads to habitat fragmentation, or if monitoring and evaluating of population trends is not on a regional scale.

Mitigation can take place either on land owned by the developer, or on an off-site mitigation bank. A review team, made up of representatives from cooperating regulatory agencies (FWS, EPA, USACE, CDFG, NCRWQCB), has the responsibility for approving mitigation proposals. Typically, a *mitigation bank* consists of a parcel of land, which includes one or more restored or created wetlands, surrounded by upland areas—although banks vary somewhat in design, depending on whether they are mitigating for wetlands alone, listed plants species, CTS, or all three. The economics of wetland mitigation have favored maximizing the number of pools on each parcel and minimizing adjacent upland area; however, this can interfere with the ecology of the plants and wildlife using the wetland complex, and ultimately interfere with wetland function.

Mitigation banks tend to maximize wetland areas and minimize adjacent upland areas

The review team evaluates each proposed mitigation bank, and assigns a certain number of credits, based on its size, quality, and the ratio of wetland to upland areas. Developers then purchase credits, in a number proportionate to the area that they seek to develop. The credit purchase price, up to $550,000/acre as of 2006, includes funding to be set aside as an endowment for the long-term monitoring and management of these areas. An easement is placed on these lands, protecting them from development in perpetuity, with only a narrow list of allowed activities, such as grazing, and with specific management and monitoring requirements attached. Once all of the credits are sold, the land has no further investment value, and is often transferred, along with its management endowment, to the CDFG. In some cases, landowners retain title to mitigation sites. In

these circumstances, an easement is placed on the land, but the landowner retains responsibility for most of the monitoring and care.

There has been skepticism about how well the current system contributes to the recovery of listed species, and the goals of the ESA. Although there are ecologically-based criteria for approving mitigation plans, there has not been a coordinated strategy to ensure that mitigation is an adequate replacement for lost habitat. Also, because mitigation lands have been established under a variety of different conservation objectives, and the lands and easements are held in a variety of different public and private ownership arrangements, they are not managed in any standardized, coordinated way.

Overall, the current regulatory framework has been unsatisfactory across the board—to regulators, to biologists, and to the development and environmental communities. As a consequence, in 2004, the *Santa Rosa Plain Conservation Strategy Team* was formed to work out a more effective, pragmatic, and comprehensive solution for species protection. The goal of this team was to improve the ecological value of preserves contributing to the recovery of the species, while reducing the delay and uncertainty of the current process. The biological goals, objectives, and assumptions of this strategy are presented in appendix B. One of the key aspects of the strategy, released in 2005, are that it designates large conservation areas where mitigation should be concentrated, thus reducing habitat fragmentation caused by created wetlands that are surrounded by development. The Strategy also establishes guidelines for long-term management to increase survival and breeding success. Conservation areas are intended to provide an appropriate balance between upland and wetland habitats, as preserves and mitigation banks are established within a matrix of compatible land uses (such as grazing). Studies have suggested that raising the number and spatial distribution of breeding ponds could substantially increase CTS populations, so this is also a component of the plan.

Santa Rosa Plain Conservation Strategy Team

The FWS supports the intent and outline of this endeavor, and has provisionally excluded the Santa Rosa Plain from the critical habitat designation, "based on interim strategies and conservation measures being implemented by local agencies and because of potentially adverse economic impacts." If successfully implemented to the FWS's satisfaction, this strategy will operate in place of critical habitat. A committee formed in 2006 in order to plan the implementation of the strategy. The committee includes elected officials, staff from local jurisdictions, representatives from the FWS and CDFG, and stakeholder representatives from the agricultural, environmental and development communities. There are

Conservation Strategy in lieu of critical habitat

substantial remaining regulatory issues and questions about the balance between local and state/federal control. It is likely the Implementation Committee will move toward developing a Habitat Conservation Plan, to give "take" authorization. If properly implemented, this approach could provide more protection and potential for recovery of the listed species; however, there are still many possible pitfalls and uncertainties that need to be addressed.

The Santa Rosa Plain Conservation Strategy proposes to actively manage and monitor lands within the preserve system in perpetuity, to "ensure that habitat values are maintained or enhanced over time." There are a number of factors that make it difficult to finance this long-term management; especially the projection of future costs. Once a development is mitigated—following a monitoring period to demonstrate wetland function—and an endowment is established, the developer is absolved of responsibility for species recovery. However, the Conservation Strategy is essentially an experimental plan, and recovering CTS and endangered plants will take a concerted research program to determine the most effective ways of improving the habitat. We are in a time of environmental change: global warming, human development, invasive species, pollution and disease, among other factors, ensure that land protection alone is not sufficient for protecting sensitive species. The implementation of this plan will also require "adaptive management"—a structured way of moving forward with projects while acknowledging gaps in data and research, by altering or adapting management actions in response to changing conditions. Having adequate funding in place for land management and monitoring is thus critical for the success of the plan. Although state law requires that endowments be placed in a non-wasting trust, there is no guarantee that these funds will be sufficient to cover all potential expenses, or even to keep pace with inflation and labor cost increases.

Conservation Strategy will require a concerted research program to be successful

Long-term management of mitigation banks, for the most part, is presently the responsibility of the CDFG, and many of the existing preserve lands have been deeded, along with their endowments to the state. However, severe funding cuts to state agencies sharply curtail CDFG's capacity for preserve management, and the Department must form partnerships with local agencies and organizations in order to both manage lands and to hold title and easements. In cases where preserve land title is not transferred to a public entity or private conservation organization, there are other potential problems with long-term preserve management. The CDFG or other regulatory agency has to monitor the easements, to ensure that conservation values are being protected. If violations

occur—such as not fulfilling management requirements or building illegal structures—the only recourse is litigation. This takes time and expense. Furthermore, if the landowner is no longer able to fulfill their management responsibilities, and if there is no endowment established to take over this management, then there is a consequent loss to the conservation value of the land. For these reasons, regulatory agencies prefer preserve lands to be ultimately transferred in fee to public ownership. More uniform management standards will also greatly assist species recovery; thus systematizing preserve ownership and management is one of the responsibilities of the Implementation Committee.

Coordinated preserve management

The Conservation Strategy calls for an ambitious adaptive management program to address a range of factors: from hydrologic conditions, invasive species and habitat restoration, to fire management and public education. To be effective, this agenda will require nested management plans: plans for individual preserves, plans for conservation areas, and plans that encompass the entire Santa Rosa Plain—and thus the whole population. Plans at the level of the individual preserve are necessary to track site-specific conditions. Each parcel needs a plan for grazing or mowing to control grasses and weeds, a plan for restoring other native species, such as perennial grasses, and evaluation of current and potential conflicts between allowed uses and other potential threats. Plans at the scale of whole conservation areas are needed to coordinate area-wide practices (such as invasive species management), as well as habitat connectivity between preserves and between habitat types. A plan at the level of the entire Plain is needed for overall coordination and consistency, to identify biological goals, establish a structure for the reporting process, and to evaluate the success of the population as a whole.

Nested plans:
Individual preserves
Conservation areas
Santa Rosa Plain

The complexity of preserve planning, monitoring and management suggests a very strong need for centralized, coordinated preserve management. Each preserve needs to be accountable for maintaining habitat conditions, but if there are hundreds of independent plans and monitoring efforts, it will be difficult to ensure quality standards. At a minimum, there must be sufficient staff, working with a *Preserve Coordinator*, to manage these preserves: to visit sites, to read annual reports, to synthesize data, to work with a science advisory group, and to guide adaptive management. A good solution would be to have a single organization directing most preserve management activities. This would save costs—and provide better oversight—and better promise for species recovery.

Staffing needs for coordinated preserve management

Monitoring needs

Both research and adaptive management require rigorous monitoring to track population fluctuations of the species of concern, and a range of other environmental variables. These data are used to determine whether the conservation strategies are helping achieve their recovery goals, to evaluate whether particular management actions are having beneficial or non-beneficial effects, and to watch for emerging problems, such as invasive plants or predators. Mitigation projects always require monitoring for a certain number of years, but the Conservation Strategy proposes a more ambitious, long-term program. The following components will be required, at a minimum:

Ambitious strategy requires years of monitoring

1. Annual monitoring of listed species by a qualified biologist. For plants, population assessments should take place during the blooming period. For CTS, annual larval surveys should be conducted at each preserve. Surveys for migrating adults should be conducted at targeted preserves within the context of the research program.
2. The monitoring of other biological characteristics of the preserve, including the presence of CTS prey species, such as aquatic insects or Pacific chorus frog tadpoles, and CTS predators, such as bullfrogs or fish.
3. The monitoring of the physical characteristics of the wetlands such as water quality, length of water retention, degree of erosion.
4. The development of an information management system, such as the Laguna Ecosystem Database, with GIS capabilities for storing and retrieving program data.

It is critically important that monitoring data be collected and analyzed on several nested spatial scales, by a Preserve Coordinator: the scale of the individual preserve; the scale of the conservation area; and the scale of the entire population. CTS are thought to have metapopulation dynamics, perhaps shared by the vernal pool plant species, which means that their numbers can fluctuate widely at individual sites, while being relatively stable overall. Any individual preserve manager would not be able to properly interpret monitoring results, without having a larger idea about how their data compares with surrounding preserves and the overall population. Thus, any attempt to extrapolate the success of CTS in one conservation area as a measurement of their success in another area, would be erroneous.

CTS metapopulation dynamics

Data from individual preserves will inform, and help preserve managers adapt to, specific practices or conditions that are helping to achieve

recovery goals. Monitoring of individual preserves will also help catch emerging problems, such as invasive plants or predators (for example, perennial pepperweed, bullfrogs, crayfish or wild turkeys). At the scale of the conservation area, monitoring will help evaluate larger-scale population trends.

Research needs

Part of the difficulty in establishing a recovery program for these species is that so little research exists on their natural history and ecological interactions. Endangered species, by nature of their rarity, are difficult to study without special permits allowing their disturbance. Ideally, research projects should be initiated as preserves are established. For example, a better understanding of the relative success of CTS and the listed plant species in created wetlands versus restored wetlands, can inform the practices of later preserve construction. This will be especially valuable since the preserve network will be established over a number of years: early research can effectively guide the success of later preserves.

Research should be initiated as preserves are established

Dave Cook, a biologist with the SCWA has been comparing CTS use and reproductive rates in created versus natural pools for seven years. This research should continue to be supported and should be extended to plant populations. The success of the proposed Conservation Strategy rests, in part, on expanding the number of breeding pools, but reviewers have remarked that this is an un-tried proposition, leaving some questions unanswered: How quickly will breeding pools be colonized? Is there a relationship between colonization rates and surrounding land uses? How effective are existing migration corridors, and how can these be further improved? A recent report by Cook and colleagues (Cook 2005), described current research on salamander population dynamics, preserve requirements, and the effects of exotic predators.

The Cook report emphasized the need for long-term larval surveys to track the status of CTS populations in both individual preserves and the larger conservation areas. It also recommended the assessment of extinction risks of sub-populations as well as the status of the population as a whole. Their results show that annual dip-net sampling of pools could be an effective means for tracking CTS by determining the proportion of occupied versus unoccupied pools. It is essential to standardize methods and the timing of surveys in order to maximize the ability of monitoring to track these population trends. The most important variable to measure is the proportion of pools with CTS larvae. The same pools should be

Long-term CTS larval studies are needed

sampled every year, and the study should include all preserve pools that are of appropriate depth.

The Cook report further called for research on the ecology of adult CTS, which spend more than 95% of their lives underground in gopher burrows. CTS research in other areas increasingly suggests that population success may be greatly affected by the quality of terrestrial habitat. Future research might include radio telemetry studies of migrating adults and juveniles to determine migration patterns and occupied uplands, and studies of the relationship between gopher burrow distribution and CTS abundance. Drift fence surveys can be used to evaluate salamander densities, the direction and timing of movement, and the attributes of migration corridors; but compared to larval surveys, they are intrusive and labor intensive, and should be limited to targeted preserve locations.

As preserves are being designed and pools are being restored or constructed, it will be essential to understand the pattern and timing of how these pools are colonized by CTS. It is known in a general way that pool depth is a critical factor for successful CTS reproduction. Pools have to be deep enough to retain water until larvae go through metamorphosis, but shallow enough that they dry out in the summer and do not support predatory fish and bullfrogs. More research is needed to understand factors affecting the timing of metamorphosis, and the effects of pool depth and size on CTS reproduction. This research will help establish pool design criteria that lead to optimal CTS habitat.

Research is needed on pool depth and pool size

Invasive plant and animal species will be an ongoing problem on the Santa Rosa Plain. More research is needed to understand the effects of non-native predators, such as bullfrogs and crayfish, on CTS populations; the effects of invasive plants, including grasses and perennial pepperweed, on habitat quality and other research to determine ways to control these invasive species in ways that do not threaten sensitive plants and animals. There are closely parallel issues related to mosquito control in wetlands, and work should be done to develop wetland management practices that protect listed species without promoting mosquito production. When invasive species and other vegetation are properly managed—by grazing, mowing, burning or other means—mosquitoes can usually be kept to acceptably low levels by natural predators.

One of the most critical conservation needs is for information to guide ecologically and genetically appropriate reintroduction and restoration efforts. Maintaining genetic diversity or genetic integrity is a substantial concern, and an area of some controversy. Moving seed from one part of the county to another can dilute evolved adaptations to site-specific

environmental conditions. However, translocation is sometimes necessary to protect dwindling populations. The Santa Rosa Plain Conservation Strategy provides initial guidelines for translocation, but policies need to be backed by solid research. Genetic studies of seasonal wetland plants are used to evaluate the degree of site-specific genetic variation, and together with population viability studies can help determine optimal strategies. Although several population genetic studies were conducted in the 1990s, more work is needed to evaluate plant population growth or declines, using more recently developed DNA techniques. Currently, the CDFG is funding a study of the genetic variation in Sebastopol meadowfoam, Burke's goldfields, and Sonoma sunshine. These genetic assessments should be expanded to include other declining vernal pool plant species (e.g. Many-flowered navarretia, Baker's navarretia, Dwarf downingia; Gairdner's yampah; Douglas's pogogyne; and Lobb's aquatic buttercup), and vernal pool animal species (CTS and California linderiella). Fluctuating climatic factors may influence the germination of seeds from parents adapted to different weather conditions; this type of genetic assessment should be correlated with climatic fluctuations to deduce possible genetic variation of populations over years.

Genetic assessments should be expanded

In addition to monitoring and research, the Preserve Coordinator should institute a seed collection and conservation program to support restoration efforts. Seeds from vernal pool plants should be collected and saved at an appropriate seed storage facility (e.g. Rancho Santa Ana Botanic Gardens) in order to preserve the current population variation. This will allow the future use of these seeds in restoration projects targeting declining populations. Collections should be made over several years to capture genetic variation within species for different preferred germination conditions. See the *Santa Rosa Plain Vernal Pool Protection Plan* and *Santa Rosa Plain Conservation Strategy* for a more extensive discussion of research needs.

Seeds needed for future restoration efforts

Benefits of species preservation

The estimated costs of protecting listed species on the Santa Rosa Plain are very high, with projections ranging from 20-400 million dollars for the land alone, over the next twenty years. News stories are inevitably followed by questions over whether species protection is "worth it" to the general public. The value of species preservation has many layers, providing both tangible and intangible rewards. As a society, we have a long-standing commitment and precedent to protect our biodiversity legacy, as codified in the Endangered Species Act. Although not perfect,

this legislation attempts to be even-handed by protecting cryptic species like CTS as well as the charismatic bald eagle or the economically valuable coho salmon. Without an even-handed approach, regulators are forced to "play God," often without a full understanding of the role a given species plays in an ecosystem.

However, beyond the moral and ethical reasons for species protection, there are numerous other ancillary benefits to habitat and species preservation on the Santa Rosa Plain. Maintaining open spaces provides cleaner water and cleaner air, while providing habitat for birds, other wildlife and plant species. The Sonoma County General Plan, as well as the Long Range Strategic Plan of the SCAPOSD, and the joint sprawl-prevention plan developed by the Greenbelt Alliance and Sonoma County Farm Bureau, support urban separators between the cities of Santa Rosa, Sebastopol, and Cotati/Rohnert Park, thus preserving the character and charm of Sonoma County. The citizens of Sonoma County place great value on preserving our agricultural heritage; combining species preservation with compatible agricultural uses may increase the economic viability of existing operations.

Species preservation may increase agricultural viability

Environmental education programs will play an important role in bringing these messages to the citizens of Sonoma County. The vernal pool ecosystem of the Santa Rosa Plain is rare and beautiful, and a substantial contributor to the biodiversity of the watershed. At this time, there are very few opportunities for the public to view, even from a distance, the wildflower displays of healthy vernal pools. Carefully planned and sensitive public access to restored wetlands—along boardwalks or from observation towers—would be a great asset and eco-tourism opportunity for the community. Portions of preserve areas may be able to accommodate hiking or biking trails, thus increasing the number of linkages with the existing trail system.

Salmonid conservation

Steelhead trout *(Oncorhynchus mykiss)* is the primary salmonid species found in the greater Laguna watershed. Two other species have also been documented here: coho or silver salmon *(Oncorhynchus kisutch)* and chinook or king salmon *(Oncorhynchus tshawytscha)*. While coho may have once been frequent residents or visitors, chinook prefer more riverine habitats, and have likely always been rare. Steelhead use the main Laguna channel as a migratory passage between November and May, and spawn and rear their young in the upper reaches of the larger tributaries, most notably Mark

West and Santa Rosa creeks. They are *anadromous* fish: born in freshwater streams, migrating as juveniles to the open ocean, and then returning to breed in the streams where they hatched. Steelhead are the same species as rainbow trout, but rainbow trout are exclusively freshwater.

All salmonid species share a need for healthy aquatic and riparian environments for spawning and rearing young. Although life-history characteristics vary, these species share many habitat needs and preferences. After migrating upstream following the autumn rains, adult females dig nests, called "redds" in gravelly streambeds. Water quality is very important because developing eggs and larvae do not survive where there is excessive silt and suspended sediments, and juvenile salmonids can be sensitive to certain pollutants. The young fry feed on aquatic insects and invertebrates, and favor undercut banks and calm pools structured by fallen tree-limbs or other large, woody debris. Salmonids are cool-water fishes, thriving only in streams with high levels of dissolved oxygen. Waterways without riparian vegetation shading the water surface often become too warm for juveniles. Historically, the forested streams of the Russian River watershed supported a large fishery. Degradation of the waterways, from urbanization and agriculture, among other factors, combined with over-fishing and environmental changes in the ocean, has caused local salmonid populations to decline. All three species now share state and federal protection in the greater Laguna watershed and other Russian River tributaries.

Steelhead, coho and chinook all share state and federal protection

Regulatory overview

For regulatory purposes, salmonid species have been broken up into "Evolutionarily Significant Units" (ESUs), representing genetically distinct population segments. It is important to preserve the genetic variation within species to increase their long-term resilience to disease and climate change. Consequently, ESUs receive protection under the Endangered Species Act (ESA), even if other segments of the population are healthy and abundant. For example, the Central California Coast ESU for coho (local to the Russian River watershed) is listed as *endangered* by federal and state authorities; but coho from the Olympic Peninsula are not considered to need protection. The Central California Coast steelhead ESU and the California Coastal Chinook ESU are federally listed as *threatened*. A species is considered *endangered* when it is "in danger of extinction throughout all or a significant portion of its range" and *threatened* when it is "likely to become endangered within the foreseeable future throughout all or a significant portion of its range." The mandate for recovery under the

Threatened versus *endangered*

ESA is to bring fish numbers to the level where protections are no longer necessary, and they can be de-listed.

Listing under the state or federal ESA prohibits activities that jeopardize the survival of the species. Not only is it illegal to fish for steelhead, coho and chinook in the greater Laguna watershed, it is illegal to "harass, harm, pursue, capture or collect" them. The definition of "harming" includes the creation of barriers to fish migration; activities that pollute the water; interference with plants that salmonids might use for shelter or animals that they might use for food; and activities like filling of pools or channels, or clear-cutting riparian vegetation. Nonetheless, it isn't enough to simply protect fish from harm. Salmonids in the greater Laguna have fallen to low numbers in part because their habitats have been intensely degraded. To restore the populations, we have to restore their habitats. Even restoration activities may harm salmonids, unless they are properly timed and carefully implemented (see table 10 on page 428 for restoration-related activities that may put salmonids at risk).

Many activities may "harm" legally protected salmonids

The National Marine Fisheries Service (NMFS) has the responsibility to designate certain drainages as *critical habitat*—areas that are considered essential for the survival of the species—for listed salmonids, whether or not that species is currently present. The designation adds a layer of protection on top of the ESA listing, to focus restoration, conservation and management efforts. The ESA listing alone requires consultations for any activity that jeopardizes the species, but with critical habitat, streams are protected even if the species is not currently found there. This allows populations to expand into new habitat as the species (or ESU) recovers. In 1999 the Laguna watershed was designated as critical habitat for coho, but not for steelhead, even though steelhead are more widespread. Because all the creeks in the watershed are designated as critical habitat, all riparian and stream restoration projects that receive federal funding or permits, such as Army Corps permits, must go through a consultation process with NMFS. However, even if the designation had not been made, incidental "take" permits are required from both NMFS and the California Dept. of Fish and Game (CDFG) for in-stream projects where listed species might be present.

Critical habitat are areas essential to species survival

Prognosis

Of the three, steelhead probably has the best hope for recovery in the greater Laguna watershed. Historically these were likely the dominant salmonid in the Laguna's tributary streams. Compared to the two salmon species, steelhead have much more flexible life-history strategies and

habitat requirements, and tolerate higher stream temperatures. Young steelhead spend multiple years in freshwater, and adults can spawn several seasons before they die. Their largest numbers are currently in Santa Rosa and Mark West Creeks, which provide the best habitat potential. Smaller numbers of steelhead are regularly observed in Windsor, Copeland and Blucher Creeks. There are a number of historical accounts and anecdotal reports describing good "trout streams" in the watershed. It would be valuable to further research the historical record in order to identify which streams can best support steelhead, as well as to develop numeric targets for population recovery. Given their historic abundance, restoration efforts should focus on improving habitat for steelhead, and steelhead abundance should be the primary indicator for stream channel restoration success. Portions of Mark West Creek may also have potential for coho salmon restoration.

Restoration efforts should focus on improving habitat for steelhead

Chinook are only occasionally sighted in the Laguna, although they are often found in the Russian River. They prefer to spawn in larger, deeper streams, and were probably never abundant in the Laguna watershed. In comparison, coho like to spawn in slower moving, shallower waters. Coho are very sensitive to high temperatures, and favor well-shaded pools in streams under redwood and Douglas fir, with extensive habitat structure. Juvenile coho spend one year in freshwater streams, and two years in the ocean. In their third year, they return to their natal streams, spawn and die. Thus, one bad year can wipe out a whole cohort, and three bad years can eliminate coho from a drainage system. As a consequence, coho are vulnerable to extreme seasonal weather conditions, especially droughts, and need high-quality, mature vegetation around stream channels. They are still sometimes found in Mark West and Santa Rosa Creeks, but even with extensive restoration, they may never reach high population numbers. Nonetheless, restoring stream habitat and protecting flows to benefit any one of these species will benefit them all.

Recommendations for recovery

Each year, individual female salmonids can lay thousands of eggs. Promoting the survival of eggs, fry, and migrating juveniles gives a much better chance of restoring robust population growth. The CDFG's Native Anadromous Fish and Watersheds branch has developed a series of recommendations for coho recovery in the Russian River watershed (including the greater Laguna de Santa Rosa watershed); most of these recommendations apply equally to steelhead and chinook. The ultimate goal of the Coho Recovery Plan is to attain sustainable populations large

Coho Recovery Plan calls for their return to former habitats

enough to allow for resumption of tribal, recreational and commercial fishing. The plan explicitly calls for maintaining, enhancing and restoring habitat, increasing the number of spawning adults, and increasing the distribution of populations to streams where they have been extirpated. Recovery recommendations for habitat restoration focus on improving water quality (especially for reductions in fine sediments and water temperature), maintaining water flows in upper tributaries, supporting the health of riparian corridors, and restoring the integrity of channels for fish passage. Fisheries biologists estimate that it will take at least twenty-one years (seven 3-year brood cycles) to evaluate the success of coho recovery efforts. Steelhead populations will likely respond much more rapidly to restoration.

Water quality

A CDFG Steelhead survey of Mark West Creek from 1965 remarks that the headwaters provide an excellent spawning and nursery area but "the pollution problem arising from the Laguna de Santa Rosa should be investigated and resolved." Forty years later, salmonid issues continue to influence water quality policy for the Laguna and its tributaries. The NCRWQCB's Basin Plan identifies "Cold Freshwater Habitat" as an existing *beneficial use* to be protected in the watershed, and is developing a pollution control plan to address temperature, sediment, low dissolved oxygen and excess nutrient problems in the Laguna.

Temperature and dissolved oxygen

As salmonid recovery is one of the most sensitive beneficial uses of the watershed, their needs have determined water quality regulations. Two pending Basin Plan amendments, intended to support salmonid health, give numeric targets for water temperature and dissolved oxygen (DO) levels. Temperature requirements vary by season and life-stage, and as a consequence, by location within the watershed (see table 13 on page 437). For example, the main Laguna channel is used for migration, but not for the more sensitive spawning and rearing stages, so the main channel can be warmer than the upper tributaries. Targets for maximum temperature range from 10–22°C, with the low end representing coho spawning requirements for November–March. A recent assessment of Copeland Creek found summertime water temperatures slightly above the proposed target maximum, although monitoring sites were in shaded pools with year-round flow. This may be typical of stream conditions in the hills east of the Santa Rosa Plain, which under the best conditions may be hotter

Targeted maximum temperature range from 10–22°C

than the coastal, conifer-shaded streams favored by coho. The Basin Plan's year-round objective for DO is to have daily minimum concentrations equal or greater than 8 mg/L over a seven day moving average (table 12 on page 435). In 2004, the Community Clean Water Institute (CCWI) found DO concentrations greater than 8 mg/L for most of the monthly samples taken from Santa Rosa Creek; CCWI found that almost half of the samples taken from the Laguna channel near Sebastopol fell below this mark (See www.ccwi.org). Areas invaded by *Ludwigia* had average minimum DO levels ranging from 2-4 mg/L in the summer months (Laguna Foundation 2005).

Dissolved oxygen target is greater than 8 mg/L

Water temperature and dissolved oxygen levels can present a somewhat oversimplified standard for regulation, because different parts of the stream can vary in temperatures and DO throughout the day. Cold-water refuges can protect individuals, even if the remainder of the flow becomes excessively warm. A substantial effort has gone into modeling temperature dynamics within watersheds, and how they may affect salmonid growth and reproduction. Optimally, it would be best to have a full hydrologic analysis of the flow rates and temperature variation in the Laguna and its tributaries. "Warm Freshwater Habitat" is also listed as a beneficial use in the Laguna, and basing all regulations on a single species can undermine goals to support a diversity of freshwater habitat types. Ideally, the NCRWQCB's pollution control studies will help fine-tune these regulations on a reach-by-reach basis, to better identify appropriate water quality targets for different aquatic habitats.

Basing regulations on a single species can undermine diversity goals

Erosion and sedimentation

Excess suspended sediment, measured as *turbidity*, harms fish by coating gill tissues, limiting their ability to extract oxygen from the water. This is a problem both in the rearing and spawning habitat of the upper tributaries, and in the migratory habitat of waterways in the lower watershed. When fine sediment settles out of the water in spawning streams, it can smother developing eggs and interfere with juveniles' ability to find food. To slow sediment inputs, the first task is to find areas of active erosion, and develop plans to treat them. When the sources of sediment are so diverse and widely distributed, their solutions must also be widely distributed and diverse. Simply trapping sediment behind dams can increase erosion and channel down-cutting further downstream, and these dams may also create a barrier to fish passage. Eroded vertical banks are difficult to re-vegetate, and narrow riparian setbacks and buffer areas can further disrupt natural physical and biological processes. The best erosion-control measures are those that use re-vegetation techniques. Vegetation is self-

Sediment solutions must be distributed and diverse

sustaining and has the added benefits of trapping nutrients from surface run off, providing channel shade, and habitat for the salmonid's insect prey. Vegetated swales and buffers can very effectively trap fine sediment and other pollutants in stormwater or agricultural runoff. The CDFG has developed an extensive California Salmonid Stream Habitat Restoration Manual, with best management practices and techniques. Ideally, NMFS, FWS, DFG, the Army Corps, and Sonoma County's PRMD will allow a streamlined permitting consultation process for sediment-control and other salmonid-oriented restoration projects in the watershed.

Nutrients and other pollutants

Excess nutrients, pesticides, and other pollutants can have a variety of different negative effects on the health of salmonids. High levels of ammonia and nitrates are directly toxic to developing fish. Nutrients enter waterways as runoff from roads, agriculture and urban areas. Discharges of treated wastewater are also a source of nitrogen and phosphorus, but are considered less of a problem for spawning salmonids in the Laguna watershed, because these are restricted to the lower reaches of the main channel. However, leachate from backyard septic systems may be a substantial source of nutrients. High levels of nitrogen and phosphorus favor algae and aquatic plant growth, especially in unshaded channels. As densely-growing plants age and decompose, microbial activity depletes dissolved oxygen in the water column. Several recent court cases have highlighted the sensitivity of salmonids to certain pesticides, which, like nutrients, enter stream channels from stormwater or overground flows. The EPA has established buffer requirements for the application of some pesticides near salmon-bearing streams (generally 20 yards for ground application, and 100 yards for aerial application); although there are a number of exceptions allowed under special permit. Pesticide toxicity depends in large part on the specific formulation, as well as the concentration or dose. Riparian and grassland restoration, or any kind of filtration through vegetation and upper soil layers, can effectively clean these pollutants from overland flows. Although a TMDL pollution control plan will be essential for identifying solutions to these water quality problems, a great deal can be done with public education to reduce household and commercial use of pesticides and chemical fertilizers, and to eliminate illegal dumping into storm drains.

Ammonia and nitrates are toxic to developing fish

Nitrogen and phosphorus favor aquatic plant growth

TMDL versus public education

There are a number of efforts under way to reduce the runoff from agricultural areas, including the Fish Friendly Farming™ program, and Farm Bill programs administered by the National Soil Conservation Service and the Resource Conservation Districts, which direct funding

to private landowners for projects that improve fish habitat. Such efforts should be expanded and supported.

Flow levels

Salmon and steelhead need year-round water in creeks where they spawn. Although some ephemeral streams have deep pools where juveniles can survive the summer, in general, creeks need to be deep enough that the water stays sufficiently cool, and so that fish can travel upstream in the fall and downstream in the spring. The water level issues for fish in the Laguna tributaries are different from those in the Russian River, where regulators and biologists are evaluating whether lowering summer flow-rates, kept artificially high by dam operations, will benefit salmonids. In the Laguna tributaries, channel down-cutting and groundwater pumping threaten the sustainability of summertime flows. The Coho Recovery Plan recommends that the SWRCB review existing water diversions and that Sonoma County develop policies which minimize impervious surfaces and promote groundwater recharge. Water distribution issues, and the conflicting requirements of farmers and fish, have led to a protracted legal battle in the Klamath River Basin, which is still unresolved. This is an issue on which it pays to be proactive with land use decisions and water conservation planning. No amount of riparian restoration will bring back steelhead if there is not enough water to create cool deep pools in the headwaters.

Riparian restoration

The Coho Recovery Plan calls for identifying reaches needing restoration and implementing extensive restoration and habitat reclamation projects in these areas. Restoring the health of riparian corridors will benefit many species, but is particularly important for salmonids, which need tree cover in order to cool water temperatures and support invertebrate prey. Besides their physiological need for high dissolved oxygen levels, cool water provides more favorable conditions to salmonids than to predator species, such as the pike minnow *(Ptychocheilus grandis)*, that are adapted warm-water conditions. Mature riparian vegetation is also an important source of woody debris, which provides a structuring element to stream channels. Pools form behind debris piles, and these can improve in-stream conditions for young, developing salmonids, but can present a conflict where woody debris contributes to localized flooding of urban or otherwise developed areas. It is often possible to rearrange or restructure

Cool water favors salmonids over other fish

large woody debris piles to reduce flood or erosion concerns; and CDFG should be contacted to evaluate specific sites. The agencies responsible for flood control must work closely with landowners, CDFG and NMFS to balance conflicting management issues. See chapter 4 for more about riparian restoration.

Barriers to fish migration

In-stream conditions determine whether fish can swim from the Pacific to upstream tributaries for spawning and development, and then back again to the ocean. Culverts, bridges, and dams can make upstream movement difficult for adults, and obstruct downstream passage by juveniles. Legal diversions of waterways to fill agricultural ponds may inadvertently trap juveniles; the use of best management practices for filtering these water diversions would prevent this incidental capture. The Coho Recovery Plan recommends repairing known obstacles and extending surveys to all stream channels to assess whether existing structures create barriers to fish passage. Taylor and Associates (2003) listed numerous Laguna tributary stream crossings that present potential barriers to salmonid passage in known fish-bearing streams. These surveys were limited to public road crossings; it is likely that the list would expand if a complete survey were conducted. Further surveys are needed as soon as possible to identify barriers or other physical structures that impair channel conditions, and to support site-specific restoration planning. In the 1960's Santa Rosa Creek and the lower portions of Matanzas Creek were boxed into concrete culverts in the downtown area. Matanzas Creek does not have a fish ladder through this section, and the long, dark culvert may be a behavioral barrier to fish migration. The City of Santa Rosa has been conducting extensive restoration in other sections of these creeks, and there are redevelopment plans for downtown Santa Rosa that may include day-lighting this section. This restoration would create a wildlife corridor for birds and mammals that use the creek and it would also benefit fish populations.

Stream channel surveys should look for fish barriers

The confluence of Mark West Creek with the Laguna de Santa Rosa has been moved several times in the last century. Large quantities of sediment are produced in upper Mark West creek, and carried down to the Laguna bottomlands. Until the mid-1990s, landowners were permitted to excavate gravel at the confluence, maintaining an open channel. Subsequent regulations now prohibit un-permitted channel modifications, and landowners report substantial sediment and trash accumulation and other hydrologic changes to this area. These changes may affect fish passage, and deserve further study to develop solutions that address landowner needs

Former Mark West Creek alterations may affect current fish passage

and improve habitat conditions for fish. An alternate proposal that should also be studied is to restore a portion of the original Mark West channel, to allow salmonids to enter Mark West from the Russian River by the shortest possible route.

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For more information

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http://www.calfish.org/DesktopDefault.aspx

CDFG Fisheries Enhancement Grant Program
http://www.dfg.ca.gov/nafwb/fishgrant.html

CDFG Native Anadromous Fish and Watershed Branch
http://www.dfg.ca.gov/nafwb/

California Sea Grant
http://www-csgc.ucsd.edu/home.html

Fish Friendly Farming
http://www.fishfriendlyfarming.org

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http://fishnet.marin.org/counties_sonoma.html

NOAA Fisheries Office of Habitat Conservation Restoration Center
http://www.nmfs.noaa.gov/habitat/restoration/

Salmon Nation
http://www.salmonnation.com

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http://www.scwa.ca.gov/naturalresources.html#FEP

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