# Toward an Ecosystem Approach to Vernal Pool Compensation and Conservation

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Abstract. Current federal regulatory limitations in protecting vernal pools can be attributed to incomplete data on the status of vernal pools statewide, lack of a methodology for assessing the functions of vernal pool ecosystems, failure to incorporate contemporary ecological principles into the development of compensatory mitigation strategies, and a piecemeal regulatory approach that results in administrative inconsistencies and uncertainty for the regulated community. This paper presents an ecologically-based compensatory mitigation rationale and strategy to maintain and restore the functional integrity of vernal pool wetland ecosystems. Our recommendations for an ecologically-based mitigation strategy that can be incorporated into the existing regulatory framework include development of: 1) a scientifically sound classification and assessment of vernal pools statewide; 2) compensation strategies that take a landscape perspective and attempt to protect vernal pool complexes within an ecosystem context rather than as isolated fragments unrelated to larger landscapes; 3) a methodology to assess the functions of vernal pools; and 4) a prioritization methodology to protect the functional integrity of vernal pool ecosystems over their natural range of ecological variability. We present a conceptual ecosystem approach hierarchy for use in assessing vernal pool compensation options.

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## Introduction

California's population of approximately 32 million people continues to grow at a remarkable rate. Rapid population growth has resulted in the loss of approximately ninety-five percent of the state's wetlands (Dahl, 1990) . One class of wetlands suffering particularly extensive losses are vernal pools. Vernal pools are depressional wetlands underlain by impervious claypan, hardpan, or basalt soil horizons. California's vernal pools are found within the Great Central Valley, on raised marine terraces and bluffs of coastal southern California, on the Santa Rosa Plateau in southern California, and in some valleys of the Coast Ranges.

The California Department of Parks and Recreation (1988) estimated vernal pool loss at approximately ninety percent. This loss is attributable primarily to urban development, agriculture, land levelling, and mining activities. In evaluating the geographic and edaphic distribution of vernal pools in the Great Central Valley, Holland (1978) estimated losses between seventy and ninety-five percent. Bauder (1986) estimated losses for San Diego County at ninety-seven percent.

Under existing laws, regulations, and guidelines, government agencies and communities are experiencing difficulty in protecting vernal pool ecosystems. In some cases, it appears that agencies are interpreting and applying regulations in ways that do not contribute to the long-term viability of vernal pool ecosystems. We are uncertain as to the long-term viability of small, fragmented preserves and artificially-created vernal pools. Therefore, there is an urgent need to incorporate contemporary ecological principals into the development of compensatory mitigation strategies for vernal pools. Factors that contribute to regulatory limitations in protecting vernal pools include: 1) incomplete data on the locations, extent, and functional integrity of vernal pool complexes statewide; 2) lack of a methodology for assessing the functions of vernal pools; and, 3) a piecemeal regulatory approach that fails to protect vernal pools, resulting in administrative inconsistencies and causing uncertainties for the regulated community. For the purposes of this paper, we define function as the natural processes that are necessary for the maintenance of an ecosystem.

This paper responds to a critically urgent need to provide a rationale for the development of an ecologically-sound approach to vernal pool compensation that will be incorporated into an overall vernal pool conservation strategy. To this end, we discuss the development of an ecologically-based compensatory mitigation rationale and strategy to maintain and restore the functional integrity of vernal pool wetland ecosystems. We believe vernal pool conservation can be accomplished within the existing federal, state, and local regulatory framework, while simultaneously increasing efficiency and certainty for the regulated community.

## Statement of Issues

Under existing laws, regulations, and guidelines, government agencies and communities are experiencing considerable difficulty in protecting vernal pool ecosystems. In some cases, it appears that agencies are interpreting and applying regulations in ways that do not contribute to the long-term viability of vernal pool ecosystems. There is uncertainty concerning the long-term viability of small, fragmented preserves and artificially-created vernal pools. Therefore, there is an urgent need to incorporate contemporary ecological principles into the development of compensatory mitigation strategies for vernal pools. Factors that contribute to regulatory limitations in protecting vernal pools include: 1) incomplete data on the locations, extent, and functional integrity of vernal pool habitats statewide; 2) lack of a methodology for assessing the functions of vernal pool complexes; 3) a poor understanding of basic ecological processes in vernal pools, especially critical ecological linkages between vernal pools and adjacent upland landscapes; and 4) a piecemeal regulatory approach that fails to protect vernal pool ecosystems, resulting in administrative inconsistencies and causing uncertainties for the regulated community.

We begin by discussing some of the more controversial issues surrounding vernal pool compensation such as definitions of mitigation, the no-net-loss goal for wetlands, in-kind versus out-of-kind compensatory mitigation, on-site versus off-site compensatory mitigation, mitigation ratios, the status of the science of vernal pool compensation, and vernal pool compensation in practice. From the discussion of these issues we then propose a strategy that leads toward an ecologically-based approach to vernal pool conservation. The proposed strategy includes an outline of dual hierarchical processes that may provide the foundation for an ecosystem approach to the conservation and management of vernal pool ecosystems. Below we discuss the significant issues regarding vernal pool compensation.

### *Definitions of Mitigation*

Mitigation often is defined inconsistently and this has led to confusion when discussing wetland compensation projects. The "Regulations For Implementing The Procedural Provisions Of The National Environmental Policy Act" at 40 CFR 1508.20 define mitigation as:

(a) Avoiding the impact altogether by not taking a certain action or parts of an action.

(b) Minimizing impacts by limiting the degree or magnitude of the action and its implementation.

(c) Rectifying the impact by repairing, rehabilitating, or restoring the affected environment.

(d) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action.

(e) Compensating for the impact by replacing or providing substitute resources or environments.

The above definition contains the following basic elements of compensatory mitigation that we have incorporated into this document and have defined as follows:

*Preservation* - Setting aside of existing natural resources that are managed and protected in perpetuity.

*Restoration* - Return of an ecosystem to a close approximation of its previously existing condition (NRC, 1992). Restoration attempts to emulate the processes, structure, function, and diversity of a specified ecosystem.

*Enhancement* - Manipulation of an ecosystem in order to improve one or more of its structural or functional attributes (NRC, 1992) .

*Creation* - Construction of a habitat or ecosystem that previously did not exist on a site (NRC, 1992).

### *The No-Net-Loss Conundrum*

In 1987, at the request of EPA, The Conservation Foundation convened the National Wetlands Policy Forum to study and make recommendations on how the United States should manage its remaining wetland resources. Two years later the National Wetlands Policy Forum recommended, in part, that federal agencies take action to further a goal of no overall net loss of the Nation's remaining wetland base as defined by acreage and function and to restore and create wetlands, where feasible, to increase the quantity and quality of the nation's wetlands resource base (The Conservation Foundation, 1989). The intent of setting this goal was to ensure that the nation's overall wetland base remain in dynamic "equilibrium between losses and gains in the short run and increase in the long term" (The Conservation Foundation, 1989, p.5). The goal specifically recognizes that no-net-loss in wetland acreage and function need not be achieved on each individual permit action, as long as the overall trend results in increases in the wetland base.

In 1990, the EPA and Corps signed a Memorandum of Agreement (MOA) concerning the determination of mitigation under the CWA Section 404(b)(1) Guidelines endorsing a goal of no overall net loss of wetland values, functions, and remaining acreage base. In reference to the no-net-loss goal, the MOA states:

"However, the level of mitigation determined to be appropriate and practicable under Section 230.10(d) may lead to individual permit decisions which do not fully meet this goal because the mitigation measures necessary to meet this goal are not feasible, practicable, or would accomplish only inconsequential reductions in impacts. Consequently, it is recognized that no net loss of wetlands functions and values may not be achieved in each and every permit action. However, it remains a goal of the Section 404 regulatory program to contribute to the national goal of no overall net loss of the nation's remaining wetland base. EPA and [the Department of] Army are committed to working with others through the Administration's interagency task force and other avenues to help achieve this national goal."

The above policy guidance clarifies that the no-net-loss goal may not be met fully for cases where mitigation is not practicable, that is, capable of being done, considering costs, logistics and existing technology, or where the mitigation would not achieve a significant offset in impacts. In these cases, alternative mitigation strategies may be appropriate. For example, the creation of wetland habitats for which the technology is not sufficiently developed to ensure a reasonable chance of successfully recovering lost acreage or functions may require alternative approaches that combine wetland preservation, restoration, and/or out-of-kind creation.

Following avoidance and minimization of impacts to the maximum extent practicable, achievement of a goal of no-net-loss of wetland acreage and function for remaining unavoidable impacts may require other compensation options such as restoration, enhancement, preservation, and/or creation. Of these four options, only the replacement of "natural" wetlands with the creation of substitute wetlands or the restoration of historical wetlands has the potential to achieve the overall goal of no-net-loss of wetland acreage and function. However, because of the variable success of wetland creation, particularly the creation of vernal pool wetlands, full replacement of lost acreage and function rarely may be attained. A mitigation plan is more likely to achieve no-net-loss of wetland acreage rather than function. While we may be better able to create or restore "wetland" acreage per se, historically we have lacked the tools to measure whether the created or restored wetlands have replaced the full range of functions provided by the impacted wetlands.

### *In-Kind Versus Out-of-Kind Compensation*

In-kind compensation refers to the process of mitigating with the same generic type of wetland that is impacted or lost. For example, in-kind mitigation for impacts to a tidal brackish marsh would be compensated in the form of enhanced, restored, created and/or preserved tidal brackish marsh. Stated advantages of in-kind mitigation include: 1) replacement of the impacted wetland habitat type with a similar habitat that reduces or avoids a net-loss of acreage and possibly function of the impacted habitat type; and, 2) a greater potential for successful implementation of mitigation of similar wetland habitat types within the same hydrogeomorphic setting (i.e., on-site compensation). As a rule, wetland regulatory agencies have considered in-kind mitigation as preferable to out-of-kind mitigation.

In contrast, out-of-kind compensation refers to the process of mitigating the loss of one wetland habitat type with a different type of wetland. Thus, in the above example, out-of-kind mitigation could allow full or partial replacement of tidal brackish marsh with a different wetland habitat type (e.g., diked seasonal ponds, riparian wetland). An assumption is that out-of-kind mitigation may be appropriate in situations where replacement of one wetland type with a different wetland habitat type results in increased benefit to the overall ecosystem, as determined by some measure of wetland function. From a landscape perspective, out-of-kind replacement may be acceptable for wetland types that: 1) are regionally abundant; 2) no longer function because natural processes have been disrupted or eliminated; and 3) are perceived as low "value" by society. This policy approach may be especially advantageous if a demonstration can be made that the overall ecosystem would benefit from increases in the acreage base of out-of-kind wetland types. For example, the wildlife support function of large, monotypic stands of cattails (*Typha* spp.) may be enhanced by interspersion with other (i.e., out-of-kind) wetland habitats. In practice, however, many failed attempts at in-kind compensation often result in out-of-kind compensation. For example, siting a particular wetland type within an inappropriate geomorphic setting may result in creation of a different wetland type than that which was impacted.

Wetlands are naturally dynamic ecosystems physically bound by site-specific hydrologic and geomorphic controls. Thus, the functional properties of wetlands are determined largely by their hydrogeomorphic context. Wetland ecosystems are part of a shifting mosaic of various habitat patches and their characteristic features are maintained largely through natural "disturbance" processes such as flooding. However, in landscapes where the natural geomorphic setting and hydrologic and hydraulic patterns have been altered by human activities, wetland ecosystems may no longer function as they did historically. We suggest that issues of in-kind verses out-of-kind compensation must be viewed within the context of natural ecological processes and the extent to which such processes have been eliminated or altered by human activities.

The importance of understanding historical and current ecological processes, as well as issues of spatial and temporal scale in the context of in-kind or out-of-kind mitigation is often not appreciated. Many ill-conceived mitigation efforts provide ample evidence for the lack of ecological understanding of natural systems. It may be inappropriate to require in-kind mitigation for an impacted wetland formed and maintained under ecological processes that no longer operate because of human activities. For example, the in-kind creation, restoration, or preservation of vernal pool wetlands may seem appropriate when viewed within an historical hydrogeomorphic context (i.e., at a spatial scale that historically supported or currently supports vernal pools). However, because the vernal pool compensation area may be surrounded by urban development, the ecological processes necessary to maintain the long-term viability and integrity of the pools, such as unimpeded runoff from the contributing micro-watershed, may no longer exist. In the case of vernal pools, wetland *and* upland processes must be maintained for long-term ecosystem viability. Thus, out-of-kind mitigation may offer a more ecologically sound alternative to in-kind mitigation.

There is a critical need to understand the relative importance and interactions of large- and small-scale phenomena in developing sound wetland conservation strategies. For example, the ecological importance of maintaining habitat linkages between vernal pool wetland complexes and adjacent upland habitats is only beginning to be appreciated. For vernal pool ecosystems, ecological processes that operate on relatively small temporal (e.g., weeks to several months during a wetting-drying cycle) and spatial (e.g., tens of $m^2$) scales are influenced by processes that operate at larger watershed/landscape scales (e.g., runoff, dispersal of plants and animals). Without consideration of ecological context and spatial and temporal scales, simple rules of in-kind verses out-of-kind, or on-site verses off-site compensation for lost wetland acreage and function are unlikely to result in the development of sound ecologically-based compensation strategies.

### *On-site Versus Off-site Compensation*

On-site refers to mitigation performed at the same location, or in proximity to, the location of the impact. On-site mitigation typically occurs within the same ecosystem and in the immediate vicinity of the area of impact. In contrast, off-site refers to mitigation performed at a location physically removed by some distance from the impact site. Operationally, “on-site” and “off-site” may be defined at several different spatial scales, leading to difficulty in defining their geographic limits. For example, “on-site” may refer to areas within the boundaries of a particular ecosystem (e.g., salt marsh, lake, river) or to one of many habitats that comprise an ecosystem. This has led to practical difficulties in defining the functional boundaries of the ecosystem for purposes of determining on-site and off-site mitigation.

It has often been assumed that on-site combined with in-kind mitigation has the greatest potential to minimize disruption of remaining ecological functions by recognizing the importance of position in the landscape as opposed to simply quantities of habitat (Race and Fonseca, 1996). Thus, the accepted preferred mitigation sequencing dogma is as follows: 1) on-site, in-kind; 2) on-site, out-of-kind; 3) off-site, in-kind; and 4) off-site, out-of-kind. There are several reasons for this assumption: 1) on-site compensation will mitigate for lost functions and acreage within the impacted ecosystem and offset incremental degradation of that ecosystem; 2) there is greater success because the mitigation may be contiguous with already existing similar wetland types and provide propagules for recolonization of the mitigation site; 3) reference wetlands with which to judge the success of the mitigation may be in close proximity; and 4) it is more difficult to assess the functional equivalency of wetlands from different geographic areas (i.e., comparison of the functions of the impacted wetland with a wetland from an off-site location). However, onsite mitigation may only be practicable where functional linkages within the landscape have been maintained. As noted by Race and Fonseca (1996), there may be little justification for on-site mitigation in highly disturbed or fragmented landscapes with limited opportunities for restoration of functional linkages. Thus, in the case of vernal pools systems, the expenditure of limited resources to mitigate in areas already embedded in an urban matrix may not be the best use of resources from an economic and ecological perspective. In addition, the practice of “packing” vernal pools into landscapes at much higher densities than a site naturally supports in order to mitigate “on-site” may result in significant adverse impacts to critical interactions between the remaining vernal pools and adjacent upland communities.

### *Mitigation Ratios*

The Council on Environmental Quality defines the term “mitigation.” However, the “Memorandum of Agreement Between the Environmental Protection Agency and the Department of the Army Concerning the Determination of Mitigation Under the Clean Water Act Section 404(b)(1) Guidelines” presents the policy and procedures used in determining the type and level of mitigation necessary to demonstrate compliance with the Guidelines. Mitigation ratios are designed to compensate effectively for the lost function and acreage associated with the impacted aquatic resource. Mitigation required by a regulatory agency is based upon a ratio in recognition of the our nation’s goal of no-net-loss of wetlands. Under Section 404 of the CWA, once the Corps makes a determination that impacts have been avoided to the maximum extent practicable, and remaining unavoidable impacts have been minimized, compensation for remaining impacts is determined. This sequencing process is described in the Guidelines.

Mitigation compensation for remaining unavoidable impacts may be in the form of restoration, enhancement, preservation, or creation. With the intent of mitigation being the 1:1 functional replacement of wetland, the MOA includes, “an adequate margin of safety to reflect the expected degree of success associated with the mitigation plan recognizing that this minimum requirement may not be appropriate and practicable and thus may not be relevant in all cases.”

Federal and state agencies have set ratios greater than 1:1 when a high functioning wetland is replaced with a low functioning wetland, the likelihood of success of the mitigation project is low, and when there is temporal loss of the wetland functions. While some state agencies have standard mitigation ratios, the federal government does not. The MOA provides guidance on setting compensation ratios that are appropriate for the impacted habitat. The ratios must be high enough to ensure functional replacement of the impacted habitat yet still be reasonable and economically feasible.

The range of mitigation requirements for similar impacted habitat types vary broadly. It is important that when setting a ratio, site conditions and large-scale management planning is taken into consideration. Because certain wetlands perform multiple functions, assessing wetland function may be highly complex. Therefore, it is necessary to assess a wetland based on many factors including its contribution to the ecosystem (e.g., watershed), and its proximity to other ecological components of the system. Historically, regulatory agencies have not assigned multiple ratios based on the number of wetland functions being impacted. Comparing the existing and proposed wetland requires a decision on which functions are necessary to retain, and which functions will be lost or compromised in order to achieve a different goal for the ecosystem (King et al., 1994).

There are various functional assessment models and techniques such as the Wetland Evaluation Technique (Adamus, 1987) and Habitat Evaluation Procedures (USFWS, 1980); however, these methodologies cannot assess the functional success of a proposed mitigation wetland. Few agency staff members are trained in functional assessment methods. In addition, the time required to conduct a functional assessment may be greater than that allowed under certain regulatory processes. Currently, there is inconsistency within and between federal and state agencies on mitigation ratios for the same project. The Corps permit may require a ratio that is smaller than that identified in the U.S. Fish and Wildlife Service's biological opinion for an endangered species. Additionally, state resource agencies such as the California Coastal Commission may require a different mitigation requirement. For the same wetland, different agencies may identify different functions and assign a different risk of failure to the proposed mitigation. Often agencies assign ratios without conducting any formal functional assessment. This inconsistency between agencies results in a piecemeal regulatory approach that often fails to protect wetland resources, and results in uncertainty for the regulated community.

Avoidance and minimization are within a mitigation sequence that the federal government is required to implement. However, currently is no further federal guidance on preferable mitigation measures. Due to the well documented failure of compensatory mitigation for created wetlands (Race, 1985; Eliot, 1985; Quammen, 1986; Race and Fonseca, 1996), many regulatory agencies prefer enhancement or restoration of wetlands. Some also consider the preservation of diminishing high functioning wetlands as mitigation in a geographic area. Through restoration or enhancement, an agency evaluates the proposed mitigation site to account for the existing functions prior to establishing a ratio for compensation. As with all mitigation conducted in advance, success can be monitored and if the wetland functions increase at the mitigation site, then lower ratios are allowed since risk of failure is reduced.

### *Overview of the Status of the Science of Vernal Pool Mitigation*

Issues regarding the success of vernal pool mitigation are controversial. This controversy is largely the result of: 1) the low success rate of mitigation projects (Zedler, 1991; Race and Fonseca, 1996); 2) an inability to scientifically document the existing functions of vernal pools, which in turn limits our ability to determine whether various mitigation measures result in improved wetland functions and fully offset impacts (NRC, 1992; Race and Fonseca, 1996); and 3) the lack of regulatory mechanisms to effectively monitor the success of mitigation projects.

Two forms of vernal pool mitigation, enhancement and restoration, have met with limited success. Enhancement efforts typically involve the removal of fill from portions of vernal pools or their watersheds, restriction of access, removal of exotic plants, and/or the contouring of disturbed soil (Ferren and Gevirtz, 1990). Enhancement is likely to have a greater degree of success because the vernal pools already perform some functions and these may be improved with relatively minor manipulation of the pools. Restoration involves the return of vernal pools to a close approximation of their previously existing condition. Because vernal pool restoration attempts to emulate the processes, structure, function, and diversity of previously existing pools there is a moderate to high risk of failure. For example, in San Diego County the restoration of vernal pools through the removal of fill material from historical pools has shown promising results over the short-term; however, success over the long-term remains to be seen (E. Bauder, pers. comm.).

Vernal pool creation continues to be the most controversial form of mitigation because of the high rate of failure and general disagreement among regulators, consultants, permit applicants, and academics over whether reconstruction of vernal pools, where they never historically existed, is technically feasible. While there is increasing evidence within the Central Valley that from a strict engineering standpoint certain aspects vernal pool habitats can be created (i.e., associations of vernal pool plants), there is little scientific evidence that created vernal pools fully replace lost functions over the long-term. Vernal pools occur as integral parts of a larger grassland ecosystems and, as such, are functionally dependent upon the surrounding grasslands. The practice of creating vernal pools by "packing" new pools into an existing matrix of natural pools raises several questions regarding the effects of such practices on overall ecosystem function. Creation of vernal pools adjacent to existing pools truncates watersheds, destroys uplands important to the overall health of the ecosystem, allows for the creation of smaller preserves in terms of acreage, and may ultimately result in decreased functions for created and existing vernal pools.

Preservation of vernal pools does not require the use of costly ecological engineering techniques and may allow for the protection of high functioning vernal pool complexes with little risk. However, an important issue that remains is our ability to design vernal pool preserves that maintain ecosystem processes and wetland functions. Many existing vernal pool preserves are small and fragmented and may not remain viable over the long-term. Preservation as an approach to vernal pool compensation will be most valuable when implemented as part of a larger ecosystem or watershed complex.

### *Vernal Pool Mitigation in Practice*

Given the current federal guidance and the evaluation of wetland mitigation ratios discussed above, how is the federal government going to compensate effectively for vernal pool ecosystem impacts? There are regional differences in vernal pool mitigation that are due in part to the status of the remaining vernal pools in the state, the economic needs of the region, the ecological differences between the vernal pools and the advancement of vernal pool mitigation techniques that must be considered.

The differences identified previously manifest themselves when we compare the status of vernal pool habitat in southern California to central and northern California. Southern California has lost the majority of its vernal pools; this is best documented in Los Angeles and San Diego counties. There is only one remaining vernal pool complex in Los Angeles County and studies have found losses exceeding ninety-seven percent of the pools formerly present in San Diego County (Bauder, 1986). This is attributed to the rapid urbanization of southern California and inadequate federal protection of the vernal pool resources. Due to failed attempts at creation of vernal pools, for the past five years mitigation has been strictly in the form of restoration, enhancement and preservation. While preservation and enhancement result in a net loss of wetlands, the federal agencies evaluating projects in southern California no longer will risk greater losses from failed creation attempts. Vernal pools are preserved in areas where there is adequate buffer, adjoining ecological value and they are protected in perpetuity. This form of mitigation is a last-ditch effort in attempting to preserve the remaining natural pools in San Diego County. When considering the ratios for vernal pool preservation in southern California, the ratios differ based primarily on the species diversity of the pools being impacted. Low functioning pools may be preserved at 1:1, whereas vernal pools with endangered species may require a preservation ratio of up to 5:1.

Central and northern California do not have the same percentage of vernal pool loss as does southern California, yet researchers fear that the rest of the state is heading in the direction of southern California. Due to urbanization and agriculture, vernal pools are continually being lost. Mitigation for vernal pool impacts has not been mandatory in all cases, and creation of vernal pools is the most common form of mitigation. Once again, there is no standard assessment methodology for assigning mitigation ratios to vernal pool impacts.

*The Piecemeal Approach to Compensation*. Following an evaluation of the status of natural vernal pools and the vernal pool mitigation authorized by federal and state agencies in the state of California, we question whether the type of mitigation used is compensatory and what effect the piecemeal regulatory approach has on vernal pool ecosystems. Regarding the type of mitigation used as compensation, there is an obvious disparity when this question is discussed between researchers and the environmental consulting community. While vernal pool creation is accepted by the Corps as mitigation, and promoted by many environmental consultants, little is known about the long term viability of these pools. To date, the created vernal pools are young and monitoring of the vernal pools has been limited primarily to species diversity, vegetative cover, and duration of inundation. Research has been conducted that indicates that species diversity and density decreases through time (Ferren and Gervitz, 1990), and federal agencies have documented unsuccessful vernal pool creation. Should vernal pool impacts be fully compensated through creation? With little known about these complex ecosystems, should we continue to allow vernal pool creation in preexisting ecosystems? Are we compromising the upland-vernal pool habitat relationship? It is clear that vernal pool mitigation has not taken into account the landscape position where these pools are created. While we target the establishment of an idicator of a function such as inundation, have we lost functions such as their contributions to the bioregion through habitat interspersion and connectivity?

Compensatory mitigation often addresses the type of mitigation that successfully compensates for the loss of vernal pool habitat; however, it fails to recognize the importance of assessing the ecological processes necessary in order to maintain the long-term viability and ecosystem functions of the vernal pools. In reviewing our regulatory decisions regarding vernal pool resources we have found that there is little interagency coordination and little large scale management planning. These have have resulted in a "piecemeal" approach to compensation for impacted vernal pool resources and management of the remaining vernal pool habitat. The piecemeal approach has resulted in a mosaic of very small preserves in growing urbanized areas, failed creation of vernal pools as mitigation, lack of contiguity of vernal pool habitat with other ecosystems, and continued degradation of existing vernal pool habitat.

## Toward an Ecologically-Based Approach to Vernal Pool Compensation

### *Classical and Contemporary Paradigms in Ecology: Implications for Vernal Pool Conservation*

The classical or "equilibrium" paradigm in community organization has provided the ecological underpinnings for all existing U.S. environmental legislation. The classical view holds that natural ecosystems are best described as "closed" with stable equilibria, and are regulated by such interspecific mechanisms as competition, predation, or both. The equilibrium view of community organization provided clear benchmarks for management of species - i.e., presumed climax communities with a predictable species complement and organization, or explicitly defined successional habitats for wildlife (Fiedler et al., 1993). The application of this theory to wetlands compensation often meant the acceptance by resource agencies as mitigation, many small, fragmented habitats no longer connected to the physical and biological processes under which they evolved. This approach may have the practical result of consigning many rare or threatened species to extinction.

Over the last twenty years, resource managers have begun to recognize that ecosystems do not always behave in patterns predicted by the prevailing equilibrium theories of community dynamics. The "classical paradigm in ecology, with its emphasis on the stable state, its succession of natural systems as closed and self-regulating, and its resonance with the non-scientific idea of the balance of nature, can no longer serve as an adequate foundation for conservation. The new paradigm, with its recognition of episodic events, openness of ecological systems, and multiplicity of locus and kind of regulation, is in fact a more realistic basis for conservation planning and management" (Pickett et al., 1992, p.2). A central focus of the contemporary paradigm in ecology is an appreciation of the complexity of patch dynamics and multiscalar phenomena in the structuring and functioning of ecosystems. Of interest are those physical and biological processes that structure and sustain communities, ecosystems and landscapes. We suggest that the contemporary paradigm is not aimed at "wholesale replacement of equilibrial states and conditions as descriptors of ecological phenomena, but a broadening of our embrace of ecological theory accepting equilibrial and non-equilibrial phenomena as scale-dependent..." (Fiedler et al., 1996, p. 4).

What then are the implications of the contemporary paradigm in ecology for the conservation and management of wetlands, particularly vernal pool wetlands? First, we must learn that natural systems are not simple and linear; the health of vernal pools is linked with the larger landscape within which they are embedded. We must recognize that any effective conservation strategy for vernal pool communities requires that we learn to manage the "processes" that create and sustain these communities. The processes that sustain vernal pool structure and function operate at multiple spatial and temporal scales that are not adequately maintained within a system of small, fragmented preserves. We are not advocating the wholesale replacement of equilibrium states and conditions as descriptors of ecological phenomena, but the broadening of our embrace of ecological theory accepting equilibrial and non-equilibrial phenomena as scale-dependent, and that as a consequence equilibrial conditions can exist with non-equilibrial ones (Fiedler et. al., 1996). Secondly, we must recognize the implications of patch dynamics to vernal pool ecosystems. Thus, vernal pools are subjected to, and maintained by, a wide array of disturbances and these disturbances are at once destructive and creative. Thirdly, if we accept that our past approaches to vernal pool conservation have been oversimplified, we must begin to appreciate that effective conservation strategies for vernal pools should be implemented as part of an approach to preserve species within their ecosystems.

Ecosystem approaches take into account both biotic and abiotic factors and the processes that characterize an ecosystem, rather than focusing on individual species or habitats. Bedford and Preston (1988) and Zedler (1995) argue persuasively that the inability to document cumulative impacts to wetlands has resulted in a continued focus on impacts bounded by the arbitrary definitions of a given project without proper consideration of the linkages between communities and ecosystems. An ecosystem approach to vernal pool compensation recognizes that single- or few-pool mitigation sites provide only a small range of wetland functions (e.g., maintenance of the characteristic plant and vertebrate communities) as compared to a complex of vernal pools (Holland and Jain, 1981; Taylor et al., 1992). At a landscape scale, processes that create and maintain vernal pool ecosystems are more likely to persist over time when compared to small, fragmented preserves. One cannot manage vernal pool complexes without recognizing that they are part of a larger ecosystem and watershed complex. Thus, the interspersion and connectivity of vernal pool complexes with other natural communities (e.g., native grasslands, other palustrine and riverine wetlands), are often important to the health of vernal pool ecosystems by maintaining hydrological integrity and providing habitat for vernal pool specific amphibians and insect pollinators (The Nature Conservancy, 1995).

### *Assessing Wetland Functions: The Hydrogeomorphic Approach*

Vernal pool wetlands perform many functions including elemental cycling, removal of dissolved elements and compounds, modification of the characteristic hydrologic regime, retention of particulates, maintenance of characteristic plant communities and faunal habitat, maintenance of food webs, maintenance of habitat interspersion and connectivity among wetlands, and maintenance of the characteristic invertebrate and vertebrate communities. A vernal pool wetland compensation strategy should include a methodology that assesses the relative success of various compensation measures in replacing lost wetland functions. One methodology that lends itself to the assessment of vernal pool functions is the hydrogeomorphic (HGM) approach. HGM is based on the recognition that hydrologic and geomorphic controls are responsible for determining and maintaining the various functional attributes of wetland classes and the use of reference systems as the foundation for assessing changes in wetland functions (Brinson, 1993; Lee, 1994). The HGM approach classifies wetlands based on their: 1) geomorphic setting or landscape position; 2) water source and transport; and 3) hydrodynamics (i.e., direction of flow and strength of water movement within the wetland; Brinson, 1993).

HGM can be used to classify vernal pools into regional subclasses based on the hydrogeomorphic characteristics of a particular geomorphic setting, water source, and hydrodynamics. For example, Keeler-Wolf et. al. (1995) has classified vernal pools based, in part, on geomorphic setting within California as follows: northern hardpan; northern claypan; northern basalt flow; northern volcanic mudflow; southern interior basalt flow; San Diego Mesa hardpan; San Diego Mesa claypan; and several undescribed categories. At a more localized spatial scale, Ferren et al. (1995; 1996) have classified vernal pools into six major hydrogeomorphic units types for central and southern coastal California as follows: coastal terrace vernal pools; mesa vernal pools; river-terrace vernal pools; coastal valley and plain vernal pools; foothill-valley vernal pools; and alkali-vernal plains, ponds, or lakes. HGM allows an index to be developed to measure the functional capacity of vernal pools within classes relative to regional reference standards. Reference standards would reflect the range of conditions within various vernal pool classes within a particular region. The functional indices that result from HGM provide a measure of vernal pool functional capacity. Measures of vernal pool function can then be applied in the review of Section 404 permit applications by: 1) analyzing alternatives; 2) avoiding and minimizing project impacts; 3) assessing pre- and post-impact conditions; 4) developing appropriate levels of compensatory mitigation; and 5) monitoring the success of compensatory mitigation.

## VERNAL POOL COMPENSATION STRATEGY

Below we present our recommendations and steps for the development of an ecologically-based mitigation strategy that can be incorporated into the existing regulatory framework.

1) *Develop a scientifically sound classification and assessment of vernal pool resources statewide.* A critical initial step in the development of a conservation or compensation strategy is the development of a classification that captures the full range of ecological attributes of all vernal pool types (refer to Ferren et al., 1995; Keeler-Wolf et al., 1995). Such a classification should not be based solely on vegetative descriptors or soil types, such single focus efforts will fail to adequately capture the great diversity of vernal pool types, but rather, should describe the hydrogeomorphic or ecosystem context under which the particular vernal pools formed. At the same time, there is also an urgent need to conduct statewide mapping of vernal pool ecosystems statewide. While there are several ongoing projects to map vernal pools within California's Central Valley, efforts should be made to ensure that information collected from these separate studies are compatible and at a scale that is useful for conservation and regulatory planning purposes.

2) *Compensation strategies should take a landscape perspective and attempt to protect vernal pool complexes within an ecosystem context rather than as isolated fragments of larger ecosystems.* Ecosystem processes that sustain vernal pool structure and function operate at multiple spatial and temporal scales and therefore, are not adequately maintained within a system of small, fragmented preserves. Therefore, strong preference should be given to vernal pool compensation strategies that: a) manage the processes that create and sustain vernal pool ecosystems; b) protect vernal pool functions within an ecosystem and watershed context; and c) intersperse and connect vernal pool complexes with other natural communities.

3) *Develop a prioritization methodology to protect the functional integrity of vernal pool ecosystems over their natural range of ecological variability.* Upon completion of a statewide assessment of vernal pool resources in the context of an acceptable classification, a prioritization methodology should be developed to identify the best remaining vernal pool ecosystems over their range of ecological variability. In addition to assessing the full range of vernal pool functions, any prioritization scheme should include other prioritization criteria such as the diversity of vernal pool classes (e.g., size, depth, shape, soil series diversity, proximity to other types of wetland and terrestrial habitats) and habitat integrity (e.g., watershed condition, land use, and vulnerability/defensibility), among other possible factors.

4) *Compensation requirements for impacts to vernal pools should be based on a methodology that assesses wetland functions.* We recommend the adoption of the HGM approach to assessing wetland function. The HGM approach is based on the recognition that hydrologic and geomorphic controls are responsible for determining and maintaining the various functional attributes of wetland classes and the use of reference systems as the foundation for assessing changes in wetland functions. HGM can be used to as an effective tool to develop

appropriate levels of compensatory mitigation and can be used to monitor the success of compensatory mitigation.

5) *Compensation strategies must be consistent with applicable provisions of the Clean Water Act, including EPA's 404(b)(1) Guidelines.* Vernal pool compensation plans should be consistent with the CWA's goal of maintaining and restoring the physical, chemical, and biological integrity of the Nation's waters. Impacts to vernal pools should be minimized and/or avoided if practicable, as long as avoided vernal pools are likely to remain ecologically viable. Thus, the acid test of any vernal pool compensation strategy should be whether a particular approach makes "ecological sense" within the framework of current ecological theory.

6) *Any strategy must be consistent with applicable provisions of the Endangered Species Act.* The vernal pool conservation strategy should be implemented such that any federal action will not likely jeopardize the continued existence of endangered or threatened species or result in the destruction or adverse modification of the critical habitat of such species. Compensation strategies that take a landscape perspective and attempt to protect vernal pool complexes within an ecosystem context rather than as isolated fragments of larger ecosystems are fully consistent with the development of species' recovery plans.

7) *Any strategy must improve the existing regulatory system and increase the efficiency and certainty of actions for the regulated public.* To be effective, a vernal pool conservation strategy must be: a) integrated into on-going efforts to build partnerships with federal, state, and local entities, and non-governmental organizations to insure permanent community-based stewardship of vernal pool resources; b) promote certainty among agencies and permit applicants, and promote economic revitalization of local communities; and c) integrate regulatory and non-regulatory tools to achieve the highest possible level of resource protection.

### *A Conceptual Ecosystem Approach to Vernal Pool Compensation*

Below we present a conceptual ecosystem approach hierarchy (EAH) for use in assessing vernal pool compensation. The EAH implements an ecosystem approach to vernal pool compensation that takes into account both the biotic and abiotic processes that characterize a wetland through the application of an appropriate functional assessment methodology.

*Scenario 1.* Implementation of the EAH begins with a determination as to whether vernal pool impacts can be avoided or minimized (Figure 1). If the answer is "yes", then a determination is made whether avoidance or minimization of impacts "makes sense ecologically." For example, if we avoid the impact, will it result in setting aside a small number of pools embedded in a fragmented landscape? Will there be degradation of vernal pool function through time due to the loss of habitat contiguity, or an inadequate buffer? If a determination is made that avoidance or minimization is an ecologically-sound approach, then the EAH goes no further, and impacts are avoided or minimized. However, if a determination is made to the contrary, then one would proceed to the next step in the EAH which calls for assessment of the remaining mitigation options or mitigation resolution (Figure 2). A determination that avoidance or minimization does not make ecological sense and that alternative forms of mitigation may be considered requires at a minimum the application of a functional assessment, such as the HGM methodology. The HGM provides the scientific rationale for determining whether avoidance or minimization makes sense from the perspective of the maintenance of wetland functions over time.

*Scenario 2.* Following the EAH, if impacts cannot be avoided or minimized, then other forms of compensatory mitigation are considered following the protocol outlined in Figure 2. In further identifying and quantifying the appropriate mitigation resolution, HGM, or another appropriate functional assessment methodology, may be utilized. As stated above, measures of vernal pool function provided by HGM can then be applied in the review of Section 404 permit applications by: 1) analyzing alternatives; 2) avoiding and minimizing project impacts; 3) assessing pre- and post-impact conditions; 4) developing appropriate levels of compensatory mitigation; and 5) monitoring the success of compensatory mitigation. When assessing appropriate mitigation, all options (i.e., restoration, enhancement, preservation, and creation) are considered "tools" that can be used either separately, or in combination. The working goal should remain no-net-loss of wetland acreage or function, as long as the mitigation resolution makes ecological sense.

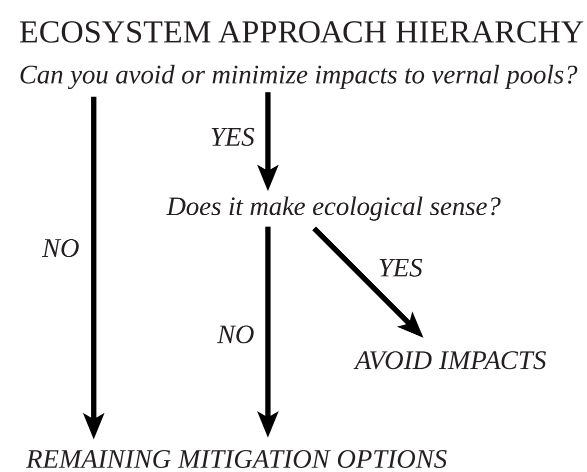


Figure 1. Ecosystem approach hierarchy to vernal pool compensation.

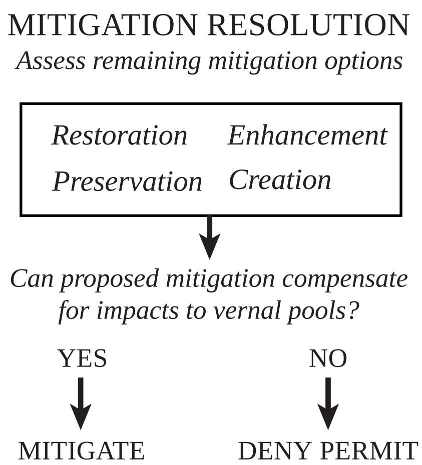


FIGURE 2. Mitigation options for vernal pool compensation.

*Scenario 3.* Finally, if a determination is made that impacts to vernal pool wetlands will result in significant degradation of the aquatic ecosystem (i.e., impacts cannot be mitigated to the point where significant degradation does not occur), then no permit authorizing these impacts will be issued (Figure 2).

## CONCLUSIONS

Under existing laws and regulations, government agencies and communities are experiencing great difficulty in protecting vernal pool ecosystems. Current regulatory limitations in protecting vernal pools can be attributed to incomplete data on the status of vernal pools statewide, lack of a methodology for assessing the functions of vernal pool ecosystems, failure to incorporate contemporary ecological principles into the development of compensatory mitigation strategies, and a piecemeal regulatory approach that results in administrative inconsistencies and uncertainty for the regulated community. This paper presents an ecologically-based compensatory mitigation rationale and strategy to maintain and restore the functional integrity of vernal pool wetland ecosystems. We believe that compensation strategies should be based on the preservation of vernal pool complexes within an ecosystem context rather than the current approaches that set aside pools as isolated fragments of larger ecosystems. Such a landscape perspective requires that we adopt contemporary ecological principles, especially the non-equilibrium paradigm, which recognizes the importance of episodic events, patch dynamics, the openness of ecological systems, and the multiplicity of locus and kind of community regulation. Adoption of the HGM approach to assessing wetland function, which recognizes that hydrologic and geomorphic controls are responsible for determining and maintaining the various functional attributes of vernal pools, will provide a scientifically-defensible methodology that may used to determine mitigation requirements for impacted vernal pools.

## LITERATURE CITED

Adamus, P.R., et al. 1987. Wetland evaluation technique (WET), volume II- methodology. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.

Bedford, B.L. and E.M. Preston. 1988. Developing the scientific basis for assessing cumulative effects of wetland loss and degradation on landscape functions: status, perspectives and prospects. Environmental Management 12: 751-771.

Bauder, E.T. 1986. Vernal pools, recent and projected losses; their condition; and threats to their existence 1979-1990, volume I. Prepared for the Endangered Plant Program, California Department of Fish and Game, Sacramento, CA.

Brinson, M.M. 1993. A hydrogeomorphic classification for wetlands. Wetlands Research Program Technical Report WRP-DE-4. Prepared for U.S. Army Corps of Engineers Waterways Experiment Station. U.S. Army Corps of Engineers, Washington, D.C.

California Department of Parks and Recreation. 1988. California wetlands, an element of the California outdoor recreation planning program. California Department of Parks and Recreation, Sacramento, CA.

Dahl, T. E. 1990. Wetland losses in the United States 1780's to 1980's. U. S. Fish and Wildlife Service, Washington, D.C.

Eliot, W. 1985. Implementing mitigation policies in San Francisco Bay: a critique. State Coastal Conservancy. Oakland, CA

Ferren, W.R., Jr. and E. M. Gevirtz. 1990. Restoration and creation of vernal pools: cookbook science or complex science? Pages 147-178 *in:* R. Schlising and D. Ikeda (Editors). Vernal pool plants: their habitat and biology. Studies from the Herbarium No. 8, California State University, Chico, CA.

Ferren, W.R., P.L. Fiedler, and R.A. Leidy. 1995. Wetlands of the Central and Southern California Coast and Coastal Watersheds: A Methodology for their Classification and Description. Final report prepared for the U.S. Environmental Protection Agency, Region IX, San Francisco, CA.

Ferren, W.R., P.L. Fiedler, R.A. Leidy, K.D. Lafferty, and L. A.K. Mertes. 1996. Wetlands of California, part II: classification and description of wetlands of the central and southern California coast and coastal watersheds. Madrono (43)1, Supplement: 125-182.

Fiedler, P.L., R.A. Leidy, R.D. Laven, N. Gershenz, and L. Sahl. 1993. The contemporary paradigm in ecology and its implications for preserving endangered species. Endangered Species Update (Special issue) 10(3-4): 7-12.

Fiedler, P.L., P.S. White, and R.A. Leidy. 1997. The paradigm shift in ecology and its implications for conservation. Pages 83-92 *in:* S.T.A. Pickett, R.S. Ostfeld, M. Shachek, and G.E. Likens (Editors). The ecological basis of conservation: heterogeneity, ecosystem and biodiversity. Proceedings of the 1995 Cary Conference. Chapman & Hall, New York, NY.

Holland, R.F. and S.K. Jain. 1981. Insular island biogeography of vernal pools in the Central Valley of California. American Naturalist 117: 24-37.

Holland, R.F. 1978. Geographic and edaphic distribution of vernal pools in the Great Central Valley, California. Special Publication

No. 4. California Native Plant Society, Sacramento, CA.

Keeler-Wolf, T., D. R. Elam, and S.A. Flint. 1995. Draft California vernal pool assessment preliminary report. Prepared by the Resources Agency, California Department of Fish and Game, Sacramento, CA. 70 pp.

King, D.M., C. Bohlen, and K. Adler. 1994. Watershed management and wetland mitigation: a framework for determining compensation ratios. Project No. 22-92MT 92006.00. Prepared for the U.S. Department of Energy and EPA Cooperative Agreement CR 818-227, with the University of Maryland, Center for Environmental and Estuarine Studies. Chesapeake Biological Laboratory, Solomons, MD.

L.C. Lee & Associates, Inc. 1994. A preliminary framework for assessing the functions of waters of the U.S., including wetlands, in the Santa Margarita watershed, Riverside and San Diego Counties, California. Prepared for the U.S. Environmental Protection Agency, Region IX. L.C. Lee & Associates, Inc., Seattle, WA.

National Research Council (NRC). 1992. Restoration of Aquatic Ecosystems. National Academy Press. Washington, D.C.

Pickett, S.T.A., V.T. Parker, and P.L. Fiedler. 1992. The new paradigm in ecology: implications for conservation biology above the species level. Pages 65-88 *in:* P.L. Fiedler and S.K. Jain, Editors. Conservation Biology: The Theory and Practice of Nature Conservation, Preservation, and Management. Chapman and Hall, New York, N.Y.

Quammen, M.L. 1986. Summary of conference and information for mitigation in wetlands. Pages 151-58 i*n:* R. Strickland, (Editor). Wetlands Functions, Rehabilitation, and Creation in the Pacific Northwest. The State of Our Understanding. Washington State Department of Ecology, Olympia, WA.

Race, M.S. 1985. Critique of present wetlands mitigation policies in the United States based on an analysis of past restoration projects in San Francisco Bay. Environmental Management 9:71-82.

Race, M.S. and M.S. Fonseca. 1996. Fixing compensatory mitigation: what will it take? Ecological Applications 6(1): 94-101.

Taylor, D.W., G.L. Cliflon, R.F. Holland and C.W. Witham. 1992. Vernal pools along the PGT-PG&E Pipeline Expansion Project, California. Contact No. 9-A177-90, J-569-205. Submitted to Pacific Gas Transmission Co., San Francisco, CA.

The Conservation Foundation. 1989. Recommendations for federal wetlands legislation. National wetlands policy forum. The Conservation Foundation, Washington, D.C.

The Nature Conservancy. 1995. Scoping document for the Sacramento Valley vernal pool protection strategy, San Francisco, CA.

U.S. Fish and Wildlife Service (USFWS). 1980. Habitat evaluation procedures. Ecological Services Manual 102-ESM1, Fish and Wildlife Service, Department of the Interior, Washington, D.C.

Zedler, J.B. 1991. The challenge of protecting endangered species habitat along the southern California coast. Coastal Management 19: 35-53.

Zedler, J.B. 1995. Coastal mitigation in southern California: the need for a regional restoration strategy. Ecological Applications 6: 84-93.