Appendix D. Selection and Recommendations for Replenishment Projects with Co-benefits

Purpose: This document outlines key considerations for landowners pursuing projects that maximize groundwater replenishment and create species habitat and community benefits.

Figure 1. Support Table for Selection of Replenishment Projects with Co-benefits

Replenishment Method	Habitat Potential	Site Characteristics	Community Benefits
Recharge Ponds with Intermittent Wetland Habitat	- Intermittent wetland and upland habitat - Migratory bird and other wetland species habitat	- High soil infiltration rates (0.1-1 foot/day) usually associated with coarse textured soils without claypans - Low soil salinity, selenium, and nitrate levels - Ideally located nearby existing wetland areas - Access to seasonal water available for replenishment, preferably direct from rivers or streams	- Education, recreation, and aesthetic benefits associated with waterfowl and wetland species - Improved groundwater quality - Improved municipal well reliability - Reduced downstream flood risk
On-farm Recharge	- Predatory bird species foraging habitat - Waterfowl foraging habitat - Pollinator habitat	- Flooding tolerant crops, such as alfalfa, vineyards, almonds, and pistachios - Low levels of residual nitrogen in soil after growing season is completed	- Improved groundwater quality - Improved municipal well reliability - Reduced downstream flood risk
Fallowing (with Upland Habitat Restoration)	- San Joaquin Valley saltbush scrub land habitat - Supports bird, small mammal, and reptile species - Pollinator habitat	- Ideally located nearby or between existing wildlife areas	- Reduced soil erosion and associated surface water quality benefits - Reduced dust emissions, improved air quality

Management Strategies to Enhance Replenishment Project Co-benefits

1. Recharge Ponds with Intermittent Wetland Habitat
    a. Pond Construction
        i. Natural topography should be utilized where possible, with low earth berms used as levees. Including microtopography will provide a range of water depths to help support a broader spectrum of species and life stages.
        ii. Berms should be planted with grasses and shrubs from local seed to prevent bank erosion and provide peripheral species habitat. Seeding should occur in the winter or fall, prior to this first rain event of the season.
        iii. Inter-basin structures are needed to control movement, flow rate, and water levels in and between basins. Controlling the movement of water will allow for strategic management of the basins.
    b. Pond Management
        i. Vegetation
            1. A balance between aquatic vegetation and open water is essential to providing habitat and mitigating potential issues, such as excessive mosquito and algal growth. Approximately 30% of the shallow area of the pond should host rooted, floating, and submersed aquatic vegetation with the remaining 70% of the pond left as open water.[1]
            2. Native vegetation growth should be encouraged on the basin floor to provide habitat for upland species during dry periods between pond fillings. However, invasive plants, such as Russian thistle, may create blockages in flood gates and canals and should be actively removed.
                a. Disking and heavy equipment use is not recommended for vegetation removal as this can result in soil compaction and reduced infiltration.
                b. Grazing is the recommended method for vegetation removal due to its low cost and effectiveness when managed correctly. There is a risk of soil compaction if herds are too dense or grazing is used for an extended duration. Grazing should be used when soil conditions are dry to avoid compaction.
        ii. Filling ponds
            1. Pond depth should be managed to ensure basin turnover rates high enough to avoid negative effects associated with stagnant water including algae build up, mosquito breeding, and avian disease. Deeper ponds should be avoided as they tend to compress clogging layers into the recharge pond floor, reducing recharge basin infiltration rates over time.[2]
            2. Basin series should ideally be filled in a hierarchical pattern so that some basins are used more frequently while others are only filled

occasionally. Designating basins for high, medium, and low frequencies of inundation will help support a broader diversity of vegetation and wildlife that prefer a range of soil moisture levels.

3. When possible, use natural water sources to supply recharge basins as these will help expedite the introduction of wetland vegetation, fish, and invertebrate species.

iii. Sediment management

1. Over time, fine sediment can build up in recharge basins clogging soil pores and decreasing infiltration rates. Excess sediment can be removed using a grader and a scraper can be used to build islands within the recharge basins, providing additional habitat for nesting waterfowl.
2. Establishing marsh vegetation at the pond's inflow can help filter water and reduce sediment transport through the system.

iv. Rodent management

1. Rodents such as ground squirrels and pocket gophers can cause structural damage to earthen levees. As traditional methods of pest control can be harmful to target species, alternative methods for rodent population and damage control are suggested.
    a. The installation of owl boxes and maintenance of perching structures for hawks and falcons can help encourage predation to control rodent populations.

v. Mosquito management

1. Mosquito abatement techniques that do not adversely impact groundwater quality or wildlife are encouraged where possible. These techniques include:
    a. Locating constructed wetlands in open areas where wind can produce waves in the wetland
    b. Introducing Mosquito fish (*Gambusia affinis*) that prey on mosquito larvae
        i. Some regional vector control or mosquito districts may be able to supply mosquitofish at little or no cost to the pond operator.
    c. Conserving predators such as dragonflies and backswimmers by avoiding broad-spectrum insecticides to support larvae predation
    d. Providing cover and foraging habitat for bird species that consume mosquito larvae
    e. Installing aeration systems that introduce water movement to help decrease mosquito coverage

f. Employing targeted chemical controls by a certified pesticide applicator as a last resort if physical and biological controls are ineffective
    i. A narrowly targeted larvicide such as Teknar can be particularly effective without harming other species.

2. On-farm Recharge
    a. Timing
        i. Field inundation for on-farm recharge should occur in the winter or during the crop's dormant period prior to bud break. During this time, the risk of root damage is greatly reduced.[3] The most current research from the UC Davis Groundwater Recharge Research Project should be consulted in determining the most appropriate duration of on-farm flooding for various crop types.
        ii. On-farm recharge can help mitigate downstream flood risk by diverting storm water from streams and rivers. Ideally, on-farm recharge projects should be designed to capture storm water from surface flows. This can be accomplished by selecting fields adjacent to rivers or streams or fields with conveyance systems that can intercept surface flows.
        iii. Timed reservoir releases can provide another opportunity for landowners to access water available for replenishment to be used in on-farm recharge.
    b. Species Support
        i. Pond filling events can often expose prey species such as moles, gophers, and ground squirrels. Owl boxes and perching structures should be maintained adjacent to fields selected for on-farm recharge in order to support predatory bird species such as owl, hawks, and falcons.
    c. Pollinator Habitat
        i. Landowners are encouraged to plant vegetation that may attract and support pollinators, such as birds and butterflies. Consult Xerces's California Planting Guide to select pollinator plants best suited to your area.

3. Upland Habitat on Fallowed Land
    a. Defining Restoration Objectives
        i. Existing local reference sites should be identified to define success criteria for restoration. In the San Joaquin Valley, much of the pre-development landscape was dominated by desert shrubland habitat with minimal herbaceous cover. Managing fallowed land to achieve targeted ecosystem functionality will largely depend on balancing vegetation cover and structure to meet the needs of focal species that are representative of the broader ecosystem community. In the San Joaquin Valley, kangaroo rats are often targeted as the focal species for desert shrubland restoration projects.
    b. Selecting Vegetative Cover

i. Selecting vegetation for planting will depend upon the site's soil texture, structure, and chemistry. In areas with degraded soil, plants used for restoration may need to be selenium and/or saline tolerant.

ii. Some plant species fare better in restoration projects and require fewer inputs to establish and maintain. Preferred qualities of restoration plant species include:

1. Seeds readily available for collection with a low cost associated with harvest, cleaning, conditioning, and storage
2. Strong establishment capabilities, with high germination rates and seedling vigor
3. Ability to suppress and resist weed competition
4. Native, with seeds available for collection at a similar elevation and within a fifty-mile radius of the project. However, native plant species are not always superior to non-natives in their usefulness in achieving restoration goals. In some instances, non-native species may be a preferable substitute to a native analog due to its relative resiliency or target species utility.

c. Preparation and Maintenance

i. Minor topographic variation should be preserved or introduced to the landscape in order to provide upland refuge for small animals during flood events and low lying areas that will form sandy, alkaline playas that provide habitat for desert shrubland species.

ii. Where invasive grasses and sedges have become dominant, livestock grazing can be used to clear excess herbaceous vegetation in preparation of restoration planting.

iii. Whenever possible, plantings should be done just prior to rain events to enhance seedling establishment.

iv. Maintaining open space and light herbaceous cover is critical in maintaining habitat for scrubland species. Where herbaceous cover is too thick, small mammals and other species are unable to move freely and predatory birds may have difficulty targeting prey. Grazing can be used in these situations to optimize vegetative cover and help mitigate wildfire risk.

v. Dense shrubs should also be avoided as this can provide a predatory advantage to coyotes that prey on kit foxes and other target species. Shrub cover between 5% and 10% is optimal for desert shrubland target species.[4]

d. Irrigation

i. Limited irrigation may be used in the first season following native seed planting to encourage growth and establishment.

ii. After the first year, restoration plantings should only be irrigated if the rainfall totals for the year are more than 20% below average.[5] Irrigation may help the native plantings, but it will also encourage weed species invasion.

e. Pollinator Habitat
    i. Landowners are encouraged to plant vegetation that may attract and support pollinators, such as birds and butterflies. Consult Xerces's California Planting Guide to select pollinator plants best suited to your area.

References

1. Ladd, B. & Frankenberger, J. *Management of Ponds, Wetlands, and Other Water Reservoirs to Minimize Mosquitos*. (2003).
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4. Saslaw, Larry, *Interview August 4th*. (2017).
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