3 ANALYSIS

3.1 Landscape Analysis

3.1.1 Landscape and Land use Change

Inventories

Section 2.2 discussed land-use patterns and anthropogenic alterations in the Illinois River Basin and the Hennepin Levee District (HLD). According to the Public Lake Survey in 1821, when Europeans settled in the Putnam County area of the Illinois River Basin, the upland terrace was thinly timbered with oak (*Quercus* spp.), poplar (*Populus* spp.) and ash (*Fraxinus* spp.) growing on poor soil. The bluff was forested with maples (*Acer* spp.), willows (*Salix* spp.) and ash. In the center of the floodplain was a bottomland lake bordered by marsh and wet prairie.[1] The floodplain provided resting and feeding areas for migratory waterfowl and became a logical place for hunting clubs through the 1800's.

The HLD floodplain was subject to seasonal climatic variations and periodic Illinois River flooding (Section 2.1). As a result, the size and the shape of the floodplain wetlands varied seasonally and annually. Evidence of variation is found among maps drawn in 1871, 1896, and 1904. The 1871 map, although somewhat indistinct, shows a major lake on the bottomland connected to the Illinois River. Also shown is a swampy area in the north and forest and prairies surrounding the lake (Figure 3.1.1-1). The 1896 map, drawn by W. K. Reed, a member of the Hennepin Shooting Club, shows the Hennepin Lake on the west and numerous small patches of fragmented water bodies connected by several small drains. At that time forest and prairie were the dominant communities associated with the wetlands (Figure 3.1.1-2). The U.S. Army Corps of Engineers' 1904 map distinctly shows Hennepin and Hopper lakes as the major water bodies on the floodplain (Figure 3.1.1-3). Detailed one-foot contour lines provide explicit information about topography and surface water elevation data. Likely the wet and dry seasons, determined by the variable flood pulse and climate, resulted in the differences among these maps.

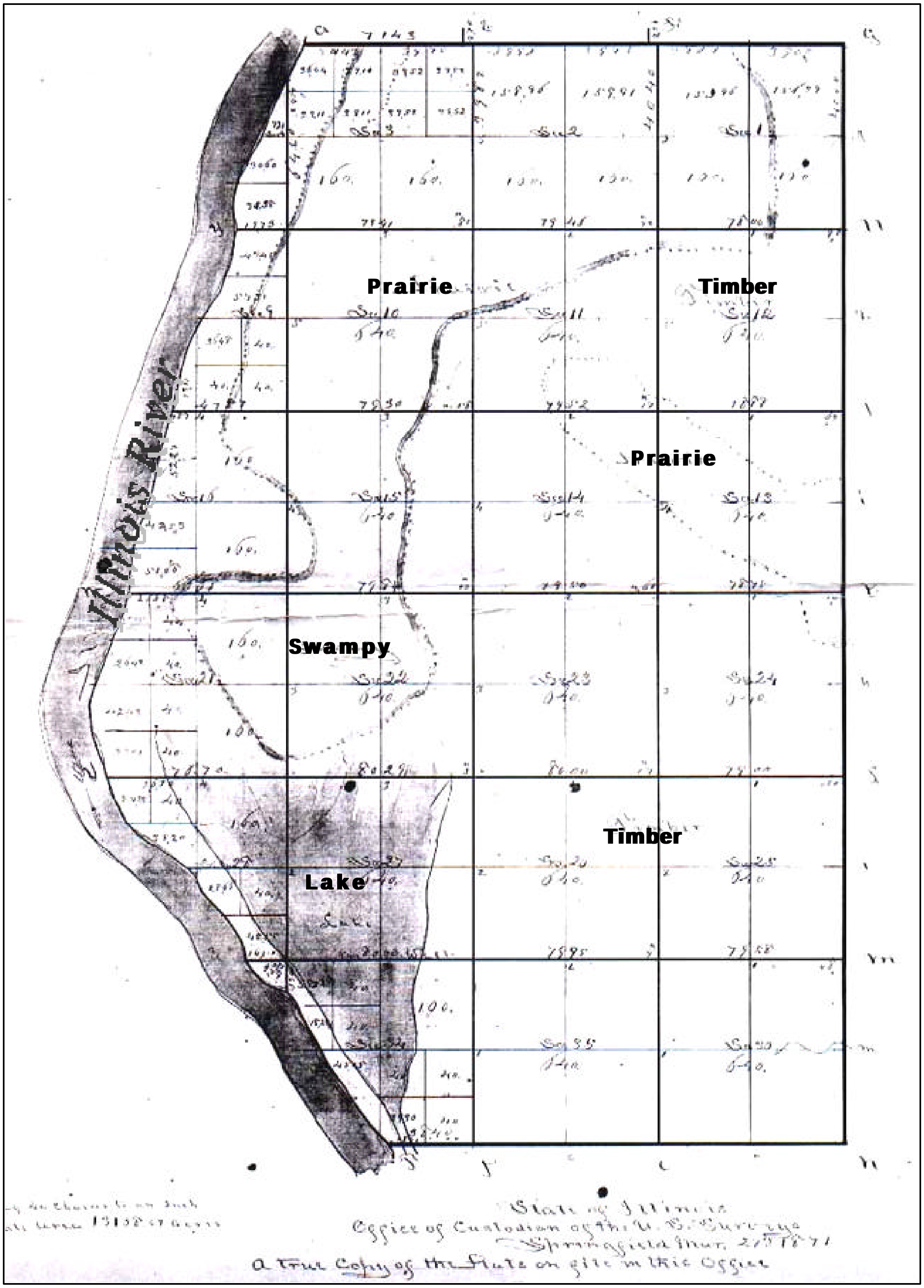

Figure 3.1.1-1 A map showing the backwater lake and vegetation types of the HLD and its surroundings in 1871.[2]

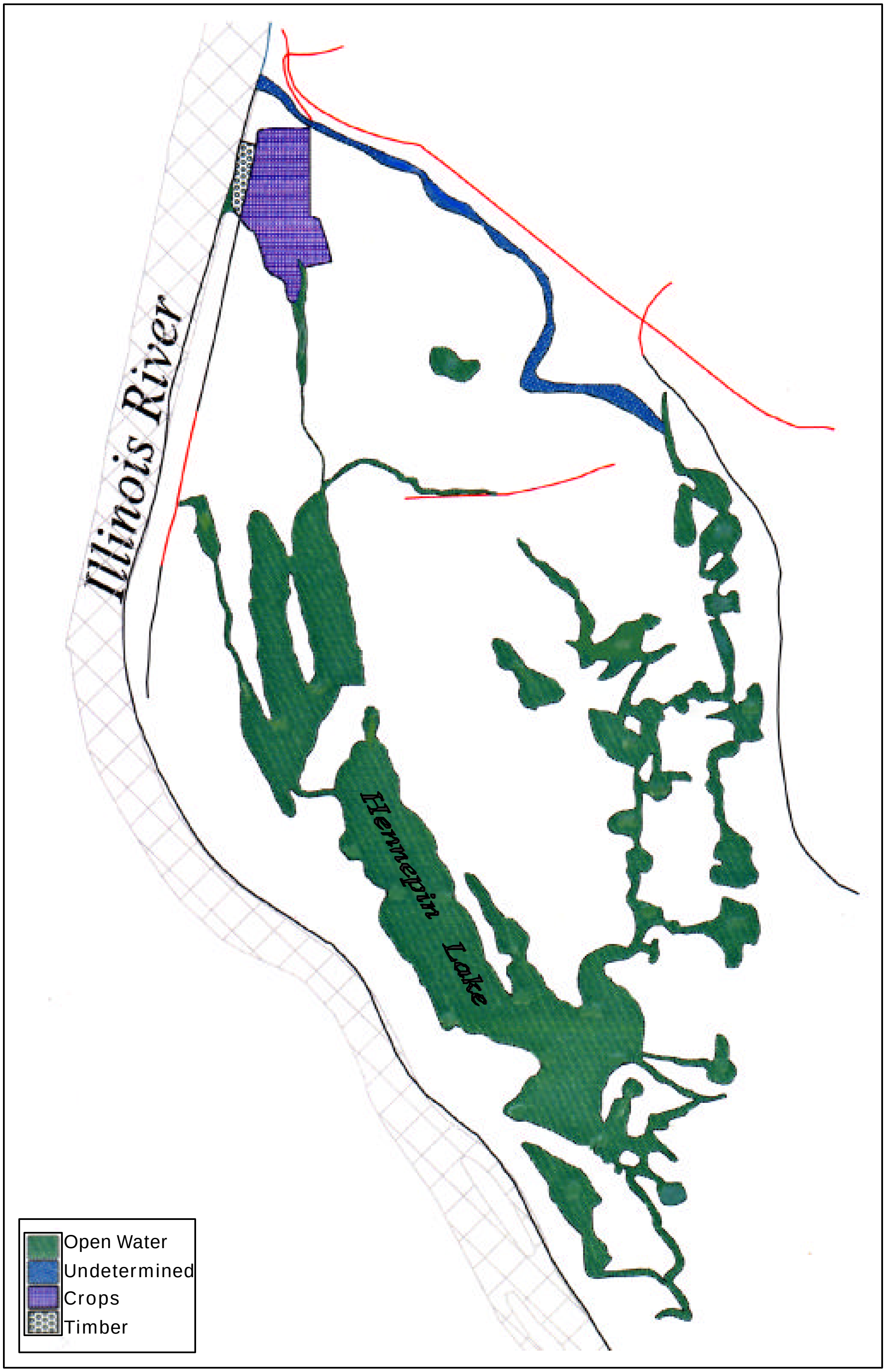

Figure 3.1.1-2 A map showing the backwater lake and vegetation types of the HLD in 1896.

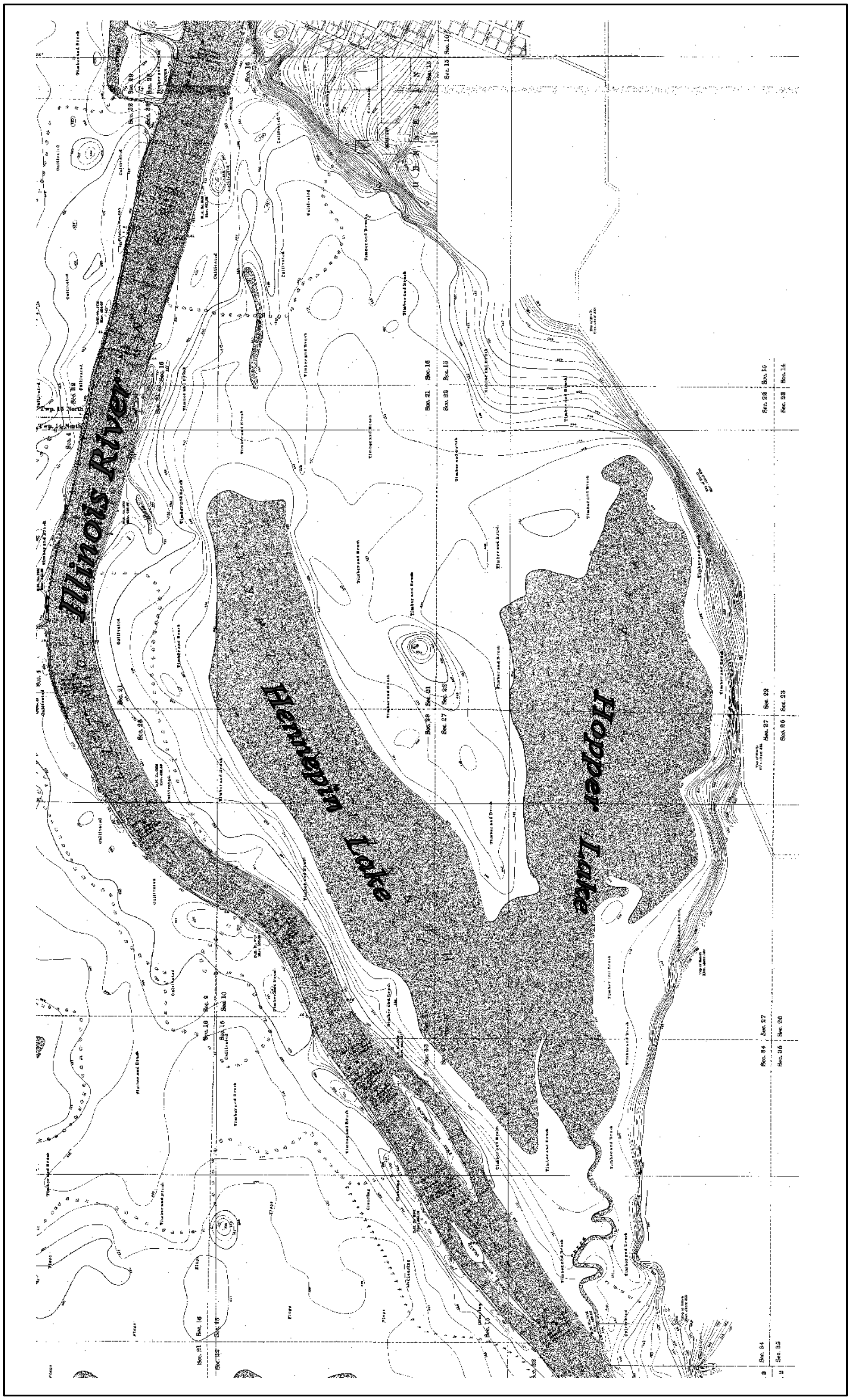

Figure 3.1.1-3 A map showing the Hennepin and Hopper Lakes and one-foot contour lines in 1904.[3]

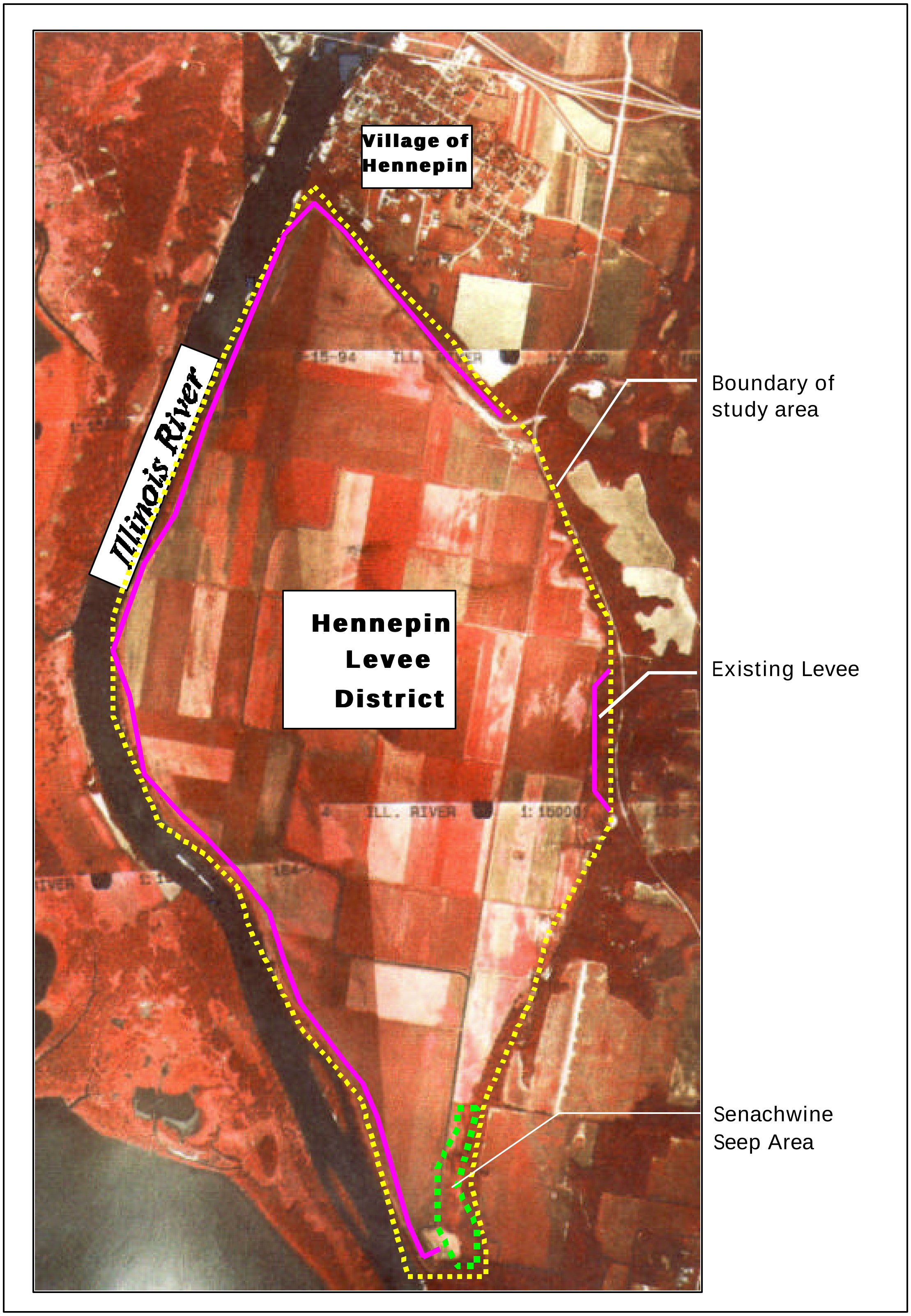

Figure 3.1.1-4 An aerial photo (taken in 1994) showing current land use condition of the HLD from 1994 to present (2000).

After the HLD was converted to agriculture, levees were built to keep the agricultural lands from flooding. Ultimately, the wetlands were filled and most of the floodplain ecosystems were lost (Section 2.2). Figure 3.1.1-4 shows the current land use condition from 1994 to present (2000).

Evaluation

Opportunities

One principle of restoration design (Section 2.4) states that to restore a historical wetland is more feasible than to create a wetland. According to historical information about the HLD, there used to be wetlands with two backwater lakes. The old maps also provide information about the appearance of the HLD, including the composition of the existing vegetation. Therefore, the maps can be used as a guideline for the restoration design for the HLD.

Constraints

The old maps show the approximate wetland shape and vegetation groups. However, specific data of flora and fauna species and composition are not sufficient to understand the wetland types and functions of the ecosystem in the past. In addition, the manipulation of landscapes and land use throughout the 20th century has led to the loss of wetland functions and significant alteration of the surroundings in the HLD. The lack of sufficient presettlement data makes restoring the HLD to its previous status a challenge. Furthermore, how the restored floodplain would accommodate contemporary and even future local and regional land use is a critical issue in the restoration plan.

3.1.2 Landscape Spatial Analysis

Inventories

Section 2.1 discusses the spatial relationship in hydrology between the Illinois River and its watershed. Rivers are natural corridors in a landscape. The river channel and riparian vegetation provide a conduit for wildlife movement.[4] In addition, a vegetation buffer along the river corridor is essential in filtering polluted water discharged into the river. Furthermore, the greenway network — a system connecting river, natural areas, and open space — provides recreational opportunitiess for humans. As a result, the spatial analysis plays a critical role in analyzing the connectivity of the natural areas and open space both for wildlife movement and human values.

In the Illinois River Basin, only small patches of open space are preserved along the Illinois River. Open space here includes Illinois natural areas and natural preserves, state conservation areas, state forest, state fish and wildlife areas, and state parks. They are fragmented and unevenly distributed along the Illinois River (Figure 3.1.2-1). The HLD lies in the Illinois River corridor but is lacking a linkage in the greenway network (Figure 3.1.2-1).

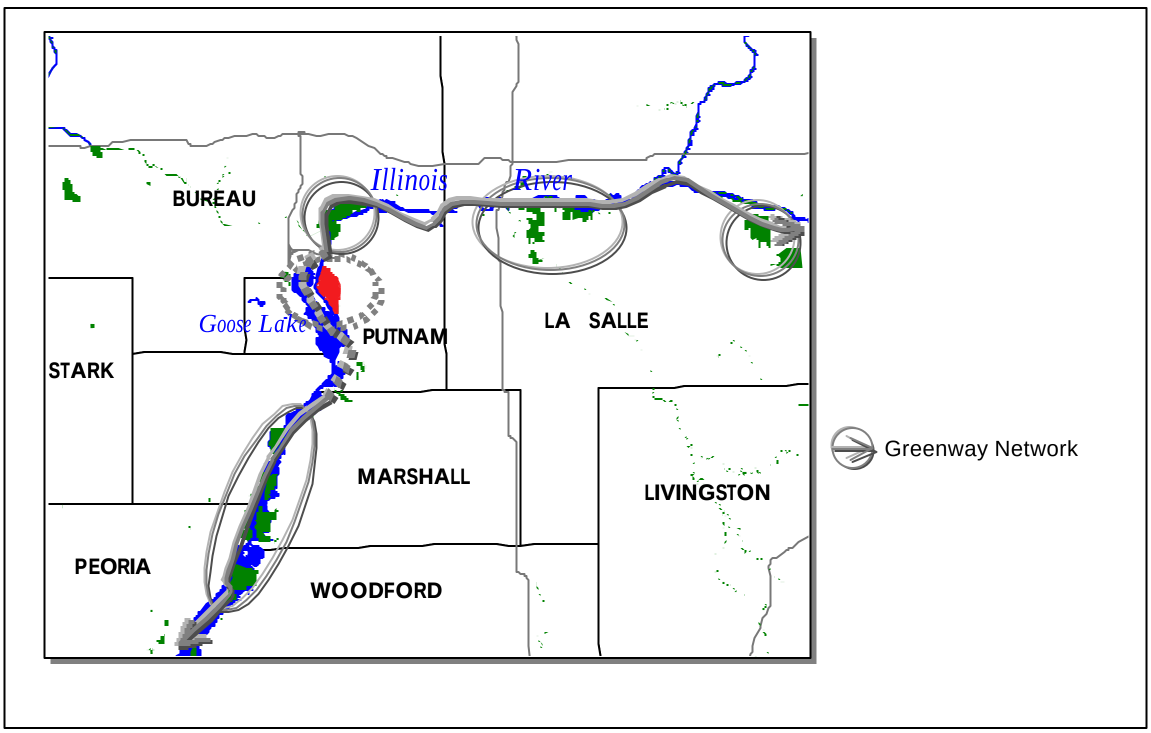

Figure 3.1.2-1 Landscape spatial analysis of the Illinois River region surrounding HLD. The HLD serves as a critical linkage along the Illinois River greenway network.

Opportunities

The HLD may play an important role in connecting the Illinois River greenway system. It holds the potential to provide a buffer zone along the Illinois River, cover for wildlife movement, and a recreational area for the surrounding communities. Goose Lake, a riparian ecosystem adjacent to the HLD, improves the HLD's potential to become a significant node in this network. Nearby wetland ecosystems also provide for the potential exchange of floral and faunal species.

Constraints

Open space along the Illinois River is too fragmented and scattered to provide a continuous buffer zone along the river. More efforts should be made to acquire land along the Illinois River and restore the river channel to a natural corridor, as well as to establish the terrestrial network in the whole region. The HLD itself cannot connect the entire network, but it provides a useful piece in approaching the overreaching goal of a greenway network.

3.1.3 Hydrology

Inventories

Section 2.1.2 discussed the artificial water level maintained in the HLD. In addition, the hydrologic alteration of the HLD includes the modification of Coffee Creek, which is rerouted by a levee and drainage channel to discharge to the Illinois River directly. Two of the three tributaries flowing into the HLD are controlled by a levee. As a result, the surface water source from Coffee Creek watershed is restricted from the HLD. Thus, the hydrologic function of the floodplain wetland ecosystem in the HLD is entirely lost.

Current water budget

Water budgets are tools describing the water input and output of a system. They provide a comprehensive understanding of how hydrology functions in an ecosystem. Precipitation, surface water inflow, and groundwater inflow are the main categories of water input whereas evapotranspiration, surface water outflow, and groundwater outflow describe water output. In the HLD, precipitation is considered equal to evapotranspiration because the floodplain lacks woody plants, which can reduce water loss from evapotranspiration in an ecosystem.[5] Water input primarily comes from groundwater inflow because the surface water sources from the Illinois River and Coffee Creek watershed are obstructed by levees. Water output within the HLD is managed by the pumping system. Irrigation was not prevalent in the HLD agriculture because of the groundwater inflow. The current water budget in the HLD is described as an equation below and the diagram in figure 3.1.3-1:

$$\mathbf{V_{HLD} = I - O = (P + Gi) - (ET + Spo)}$$

Where V_{HLD} = volume of water storage in the HLD

I	= input	O	= output
P	= precipitation	ET	= evapotranspiration
Gi	= groundwater inflow	Spo	= surface water outflow by pumping

When P = ET, the equation can be further transformed into

$$\mathbf{V_{HLD} = (Gi) - (Spo)}$$

This implies that groundwater determined the water input while pumping controlled the water output in the HLD. The levees prevented surface water input and output from the watershed.

Through hydrologic measurement, the volume of water that will recharge and discharge in the wetlands can be estimated. For restoration purposes, the data can be applied to regulate the water table at the initial stage of establishing the abiotic environment and vegetation communities. In addition, the amount and duration of water retention influences sediment deposition rates and nutrient removal processes. For example, the volume of surface water from the Coffee Creek watershed, the nitrogen load, and the time necessary to remove excess nutrients can be estimated. Consequently, this data is used to design the volume of the detention area in the HLD.

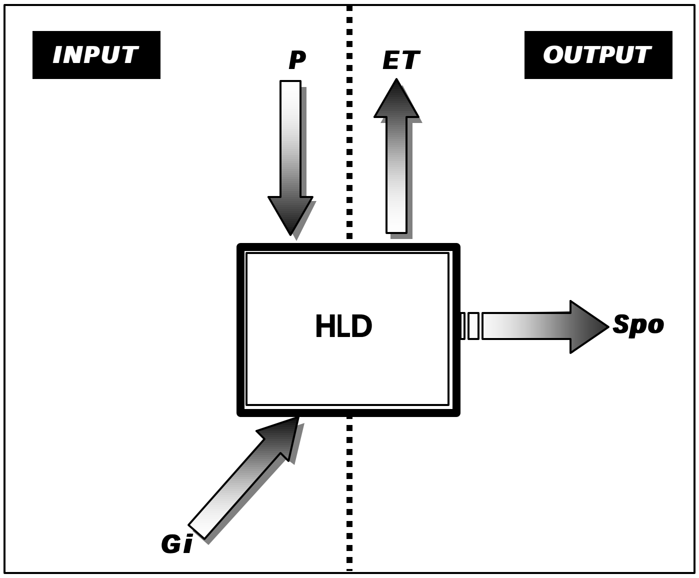

Figure 3.1.3-1 Schematic current water budget in HLD. Precipitation is assumed equal to evapotranspiration. Groundwater inflow is the main input. Surface water outflow is controlled by pumping.

Expected water budget

An ideal water budget diagram in the HLD, once the hydrology connects to the watershed, should adjust to seasonal flood pulses of Illinois River. Precipitation remains assumed equal to evapotranspiration. During floods, backwater from the Illinois River and surface water from Coffee Creek watershed flow into the HLD. Groundwater also contributes to the water input, but surface water inflow becomes the main source for standing water in the restored floodplain. Surface water will flow out of the HLD when the levee is breached but the volume of output is less than the surface water inflow. Groundwater recharges to the east side of the HLD will occur at all times of the year. However, the volume of groundwater output during flooding season will be more than it is in non-flooding season. When not in the flooding seasons, surface water from Coffee Creek watershed and groundwater inflow determine water input. Lacking surface water inflow from the Illinois River, the volume of surface water input, however, will be insufficient to flow out of the HLD. The summary of expected water budget during the flooding seasons and out of flooding seasons in the HLD is described by the following equation and illustrative diagram (Figure 3.1.3-2).

When the HLD floods,

$$\mathbf{V_{HLD} = I - O = (P + Si + Gi) - (ET + So + Go)}$$

where V_{HLD} = the volume of water storage in the HLD

I	= input	O	= output
P	= precipitation	ET	= evapotranspiration
Si	= surface water inflow	So	= surface water outflow
Gi	= groundwater inflow	Go	= groundwater outflow

While P = ET and Si > So, the equation can be further described as:

$$\mathbf{V_{HLD} = (Si + Gi) - (So + Go) > 0,}$$

Which indicates surface water from Illinois River inundates HLD while flooding.

When out of flooding seasons, while P = ET and So = 0, the equation can be further described as:

$$\mathbf{V_{HLD} = (Si + Gi) - (Go)}$$

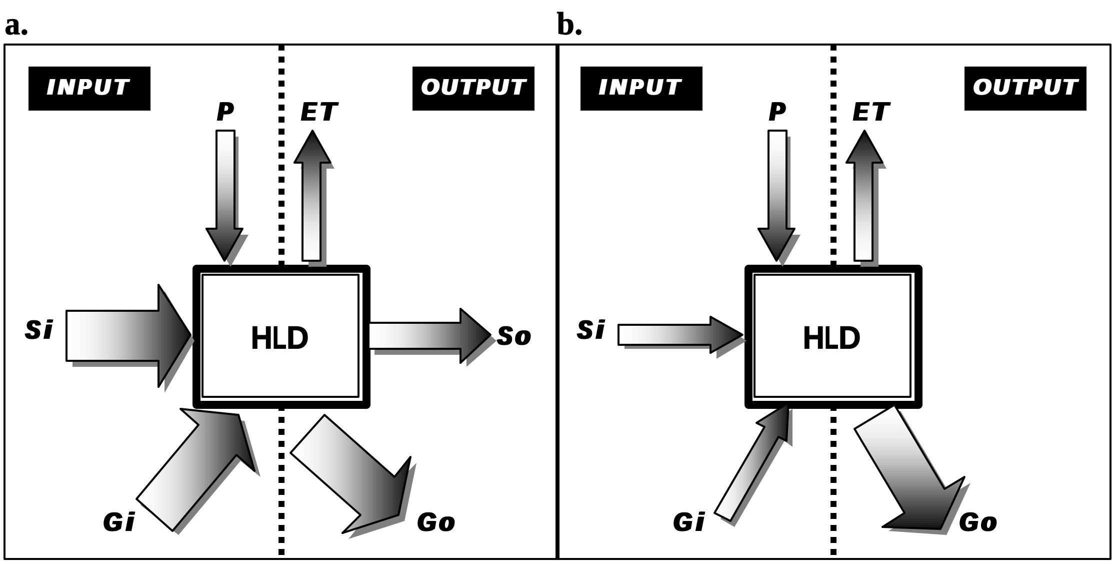

Figure 3.1.3-2 Schematic expected water budget in the restored HLD when (a) flood season and (b) out of flooding season.

The water level in the restored floodplain will be subject to the flood pulses and climate change. However, the ability to control the water level by pumps and water control gates can occur when warranted by special management concerns.

Evaluation

Opportunities

According to the water budget analysis, the HLD can regain surface water input from the Illinois River and Coffee Creek through reconnection. Groundwater will be a constant water input in the HLD. In addition, since the Starved Rock and Peoria dams are navigation and not flood control dams, flooding can still occur in the HLD. Subsequently, the backwater lakes, which result from the flood pulse, can also be restored. On a regional scale, the potential exists for the restored HLD floodplain to improve surface water quality through sediment control and nutrient removal.

Constraints

The levee is a major constraint in restoring the hydrologic function. It is designed to prevent the one-hundred-year flood so that its height is beyond the functioning that a natural levee historically provided. The levee blocked the connection between the surface water sources and the HLD. Financial and legal constraints prevent the removal of the entire levee. In addition, the surface water from Coffee Creek watershed is severely polluted and needs pretreatment before discharging to the Illinois River. Considering the constraints, restoring the natural hydrologic function is a challenge in the HLD restoration plan.

A technical constraint in this project is a lack of a precisely quantified water budget. This limits the explicit design of the restored wetlands, such as grading and construction details.

3.1.4 Soils

Inventories

The U.S. Department of Agriculture Soil Conservation Service prepared a Putnam County soil survey in 1992 showing major and minor soil associations in the HLD.[6] The soil survey provides extensive information about the general character of the environment and physical and chemical properties of specific soil type. The major soil type covering most areas in the HLD is Sawmill Association. It is defined as poorly drained, frequently flooded, silty soils formed by river stratification on floodplains. Minor associations include well-drained Lands soil in higher areas and poorly drained Moundprairie soil in lower areas that are subject to seasonal water table variation. Five subcategories of soil types are identified in HLD, which are labeled as 7107, 7302, 8304, 1480, 93 E, and 93 G (Figure 3.1.4-1) (Appendix 2).

7107 and 7302, occupying about 90% area of the HLD, are classified as Mollisols, which are dark-colored soils developed under prairie vegetation.[7] The soil texture of 7107 is silt-clay loam up to 60 inches deep, whereas 7302 comprises only 16 inches deep and becomes sandy clay loam underneath. Organic matter content is higher in 7107 (4-5 %) than that of 7302 (2 to 3%). The pH ranges from 6.1 to 8.4 in 7107, compared to 5.1 to 8.4 in 7302.

8304 soils are well drained with a fine, sandy-loam texture. According to the location shown on the soil map, this soil is found under the outwash plain of tributary creeks on the east side of the HLD. This location supports the historical evidence that Coffee Creek used to discharge into the HLD.

1480 is a silt-clay loam and poorly drained soil, saturated throughout the growing season and frequently flooded by rivers, creeks, and groundwater seepage. This soil type occurs on the flooded areas near the tributary creeks on the east of the HLD and groundwater seepage on the southeast of the HLD. 93 E and G are gravelly sandy loam soil distinguished by different slopes of 12 to 30 percent and 30 to 60 percent, respectively. They occur on the upper lands in the margin of the HLD.

Evaluation

Opportunities

The soil properties of the HLD influence the restoration design. The soil texture of silt-clay loam provides higher water-holding capacity than that of sandy clay loam. In contrast to the silty soil, sandy soil has more porous space and greater permeability, a measure of how quickly water moves downward through a soil. As a result, 7107 has a greater potential to retain water and dissolve chemicals than the 7302 soil. Its greater organic matter content also improves its soil structure and increases the aeration of clay soil. The intermediate organic matter content (2-5%) in 7107 and 7302 favors the development of floodplain wetland ecosystems.[8]

High groundwater level, within 2 feet of the surface during the spring flood in the HLD, contributes to a relative alkaline soil (pH = 6-8) with more dissolved calcium carbonate ($CaCO_3$). The mild alkaline condition in soil favors wetland development.[9]

Combined with the historic hydrology data, the location of the 8304 soil type provides information about where Coffee Creek used to discharge to the HLD. This information assists in reconnecting HLD to Coffee Creek watershed in the restoration design.

Constraints

Decades of agricultural activity in the HLD changed soil properties in several aspects. Practices such as plowing and harvesting disturbed the soil structure by mixing the upper and lower soil layers, caused soil compaction and modified the physical properties such as porosity, bulk density, and water-holding capacity. In addition, these activities removed much plant material and left little residue to replenish the organic matter content in soil. Fertilizers altered the chemical properties of the soil such as organic matter content, pH, cation exchange capacity, and nutrient availability. Finally, the fertilizers may increase salinity in the soil, which causes infertility of the soil, and may influence the water quality when dissolved chemicals discharge to the Illinois River or into groundwater.[10]

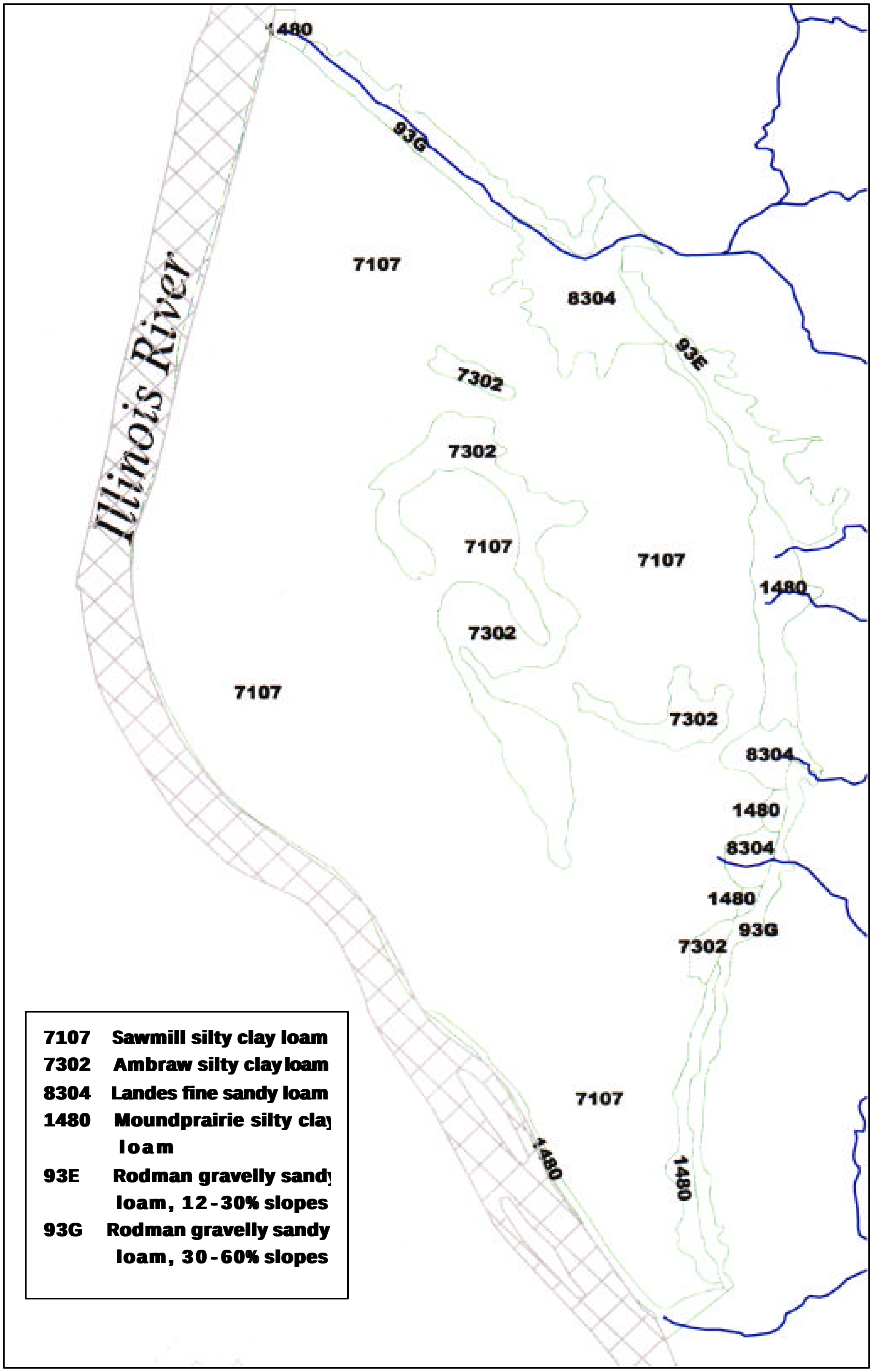

Figure 3.1.4-1 A map of soil servey showing soil types n the HLD

3.1.5 Vegetation

Inventories

Wild vegetation in the HLD is scarce. One state endangered species, the yellow monkey flower (*Mimulus glabratus*), and two rare plants, the bog twayblade orchid (*Liparis loeselii*) and the crested shield fern (*Dryopteris cristata*) (Figure 3.1.5-1), occur in the Senachwine Seep in the southeast corner of the HLD (Figure 3.1.1-4, 3.1.5-2). The seep, where groundwater fans out widely, feeds a 36-acre marsh and surrounding bottomland forest. Other associated dominant species include sandbar willow (*Salix interior*), pussy willow (*Salix discolor*), false indigo (*Amorpha fruticosa*), common cattail (*Typha latifolia*) and Joe-pye weed (*Eupatorium aculatum*).[11]

The HLD contains a remnant island of black oak (*Quercus velutina)* and white oak (*Quercus alba)* savanna, associated with dry prairie species. Riparian forests remain along the Illinois River. Some remnant woodlands and shrubs exist in the upland terraces of Coffee Creek watershed.

Invasive species in the HLD include sweet flag (*Acorus calamus*), late goldenrod (*Solidago gigantean*), cocklebur (*Xanthium* sp.), blackberry (*Rubus* sp.), and reed canary grass (*Phalaris arundinacea*), which mostly invade grazed and disturbed areas.[12]

Evaluation

Opportunities

Seedbank is a crucial factor in restoring the wetland vegetation. While the original seedbank is lost through years of agriculture, the Senachwine Seep and remnant oaks povide possible seedbanks for the HLD. Bird-transported seeds, along with water-borne seeds carried from nearby wetlands to the HLD by the reconnected Illinois River, will also facilitate the reintroduction of floodplain vegetation. The existing oak savanna and other remnant riparian forests also provide cover and nesting areas for birds and small mammals and thus facilitating restoring habitat for wildlife.

Constraints

The endangered species habitat constrains the restoration plan in terms of protecting and preserving the habitats. For example, water level, sedimentation, nutrients, pesticides, and human activities need to be managed to prevent any negative impact on the sensitive habitats.[13]

Non-native species aggressively compete with native species, especially in the initial phase of the successional process; therefore, they are considered undesirable species in the restoration plan. Reed canary grass, for example, invades shallow marshes and prevents other species from developing communities.[14] Thus, effective control of the invasive species is critical for a successful floodplain restoration.

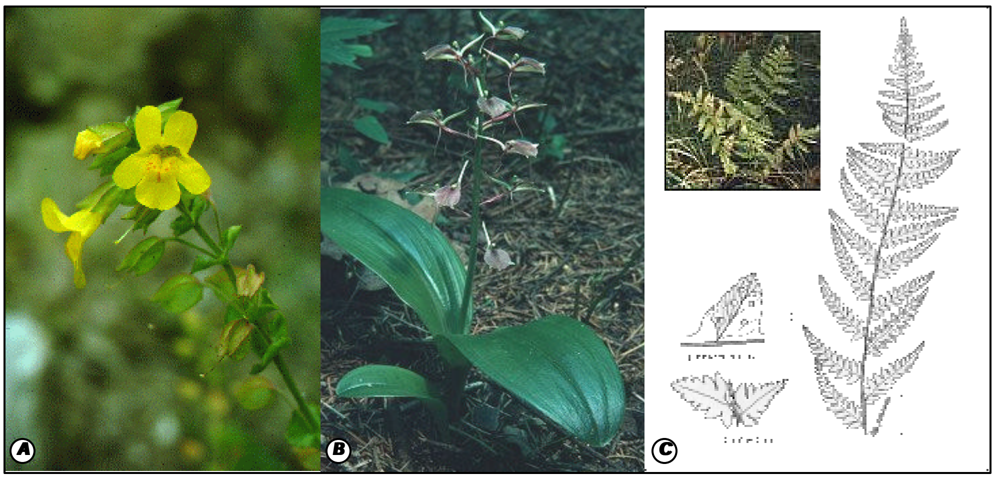

Figure 3.1.5-1 A state endangered species, (A) yellow monkey flower,[15] and two rare plants, (B) bog twayblade orchid[16] and (C) crested shield fern,[17] occur in the HLD

Figure 3.1.5-2 The Senachwine Seep provides habitats for endangered and rare plants

3.1.6 Wildlife

Inventories

Wildlife on the HLD is limited due to the agricultural and human activities. Goose Lake, opposite the HLD, provides valuable habitat for migrant birds on the Mississippi Flyway. The Lower Illinois River Basin Waterfowl Survey in 1999 and 2000 lists various species of waterfowl at Goose Lake, including mallard, black duck, pintail, gadwall, wigeon, blue-wing tail, green-wing tail, common merganser, scaup, ring-necked duck, northern shoveler, goldeneye, and Canada goose.[18]

Evaluation

Opportunities

The location of the HLD on of the Mississippi flyway creates the potential to provide habitat for waterfowl, migrant birds and other wildlife in the Illinois River Basin. As mentioned in 3.1.2, the HLD may play an important role in the Illinois River greenway network system, promoting wildlife movement in the region.

Constraints

Loss of habitats due to the alteration of landscape and land use in the HLD and its surroundings caused declining wildlife populations. In order to restore the wetland ecosystem and enrich wildlife population in the HLD, two methods may be applied in the HLD. One is to introduce species into the HLD restoration area; the other is to encourage wildlife to migrate and move from surrounding regions to the HLD. However, constraints occur in both methods. Since data are insufficient to show the wildlife composition in the past and present, it is hard to estimate the number and the species to reintroduce to the HLD. In addition, migration patterns and movement conditions vary from animal to animal: a lake can be a barrier for red foxes to move across and white-tailed deer tend to move in a linear pattern among a wide range of swamps. Wildlife can have more choices if there is significant heterogeneity in a landscape structure such as mixed composition of forests, prairie, swamps, and river corridors.[19] The landscape structure in the HLD region became homogeneous as a result of long-term agricultural use. In addition to the loss of habitats, this factor may constrain wildlife movement from other region to the HLD.

3.1.7 Accessibility

Inventories

Hennepin is accessible via automobiles by an interstate highway (I-180) and a state highway (S-26) (Figure 3.1.7-1). There are several unpaved service roads in the HLD. Bypassing the HLD is a state road with access from the east (Figure 3.1.7-1). From the village of Hennepin, there is a path toward the HLD. People must cross a drainage ditch to reach the levee (Figure 3.1.7-2). However, at high water levels, the ditch is flooded and the access restricted. Another seasonally flooded point of access is across a creek on the south end of the HLD. This access is the nearest to the Senachwine Seep area (Figure 3.1.1-4). Alternative accessibility may be available by the Illinois River. Currently, there is a dock in the river at Hennepin (Figure 3.1.7-3).

Evaluation

Opportunities

In the regional context, the HLD is accessible by automobile and the Illinois River. The most tangible entry is on the east side of the HLD from the state road. Parking is available near this entrance. Another possible access with parking on this road is where it intersects Coffee Creek, if the nearby buildings are removed and Coffee Creek reconnected. Access from the north and south is possible if the seasonally flooded waterways are bridged.

Constraints

Using some of the existing private roads might not be an option because access may be denied. The seasonally flooded ditches and creeks restrict access from the north and the south ends. In addition, access to the endangered and rare species habitats from the south

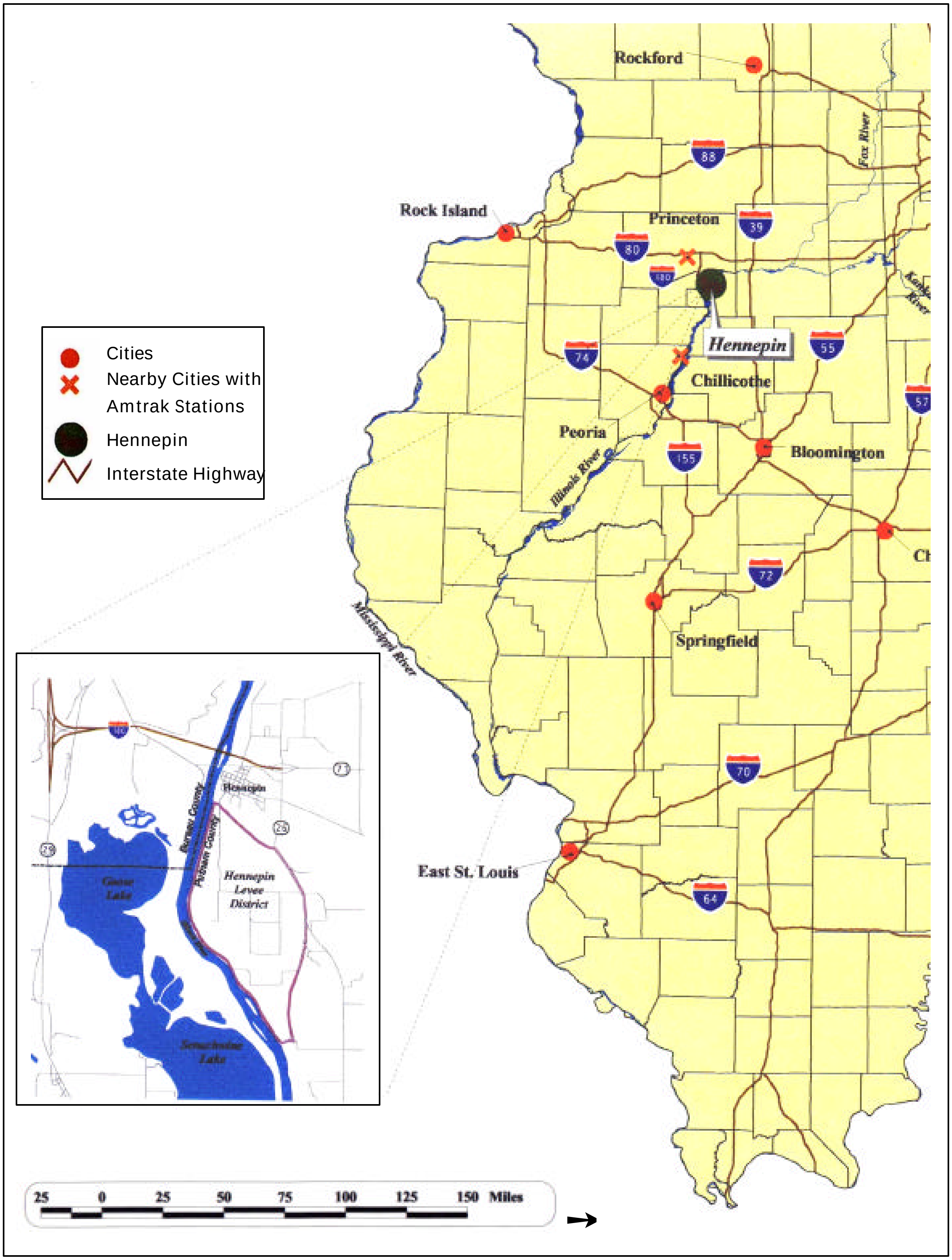

Figure 3.1.7-1 An interstate highway (I-180), a state highway (S-26), and transportation hubs around Hennepin on a regional scale, are shown on the right. A close up shows the roadways adjacent to the HLD and onsite sevice roads.[20]

end of the HLD may result in negative impacts on the sensitive habitats. Therefore, managing access is a challenge in the restoration and recreation plan.

Figure 3.1.7-2 A pathway from Hennepin town to the HLD is blocked by a seasonlly inundated diversion ditch.

Figure 3.1.7-3 The existing dock in Illinois River at Hennepin.

3.1.8 Case Studies

The following two case studies provide examples of successful wetlands restoration projects. Each case has insights to offer for the design possibilities for the HLD.

Ridgefield National Wildlife Refuge[21]

Ridgefield National Wildlife Refuge (NWR), established in 1965 and operated by the U.S. Fish and Wildlife Service (USFWS), is located around 20 miles north of Vancouver, Washington. NWR's mission is the protection of waterfowl migrating along the Pacific Flyway (Figure 3.1.8-1).

Ridgefield NWR contains 5,150 acres between the joining of Lake River, Gee Creek, and the confluence of the Lewis River and the Columbia River (Figure 3.1.8-2). The refuge supports a diversity of wildlife, but most importantly it is used as a migration stop for thousands of geese and ducks each year. Carty Unit, the most naturally preserved management unit in the refuge, contains wetlands and oak savanna that provide habitat for diverse flora and fauna. In addition to its natural heritage, the Carty Unit exhibits significant archaeological and cultural resources. The Chinook, a Native American tribe, settled along the Columbia River thousands of years ago. Another archeological site, Wapato Portage, is where Lewis and Clark camped for a night in their expedition in 1805.

Natural and cultural resource issues and accessibility issues guide the management of this refuge. The natural resource issues include threats to water quality, land use impacts on hydrology, the dominance of non-native invasive species and reduced wildlife and fisheries habitat quality. Cultural resource issues include the protection of historic sites, inadequate interpretation at the archaeological sites, cooperation with the Chinook and a lack of long-term storage for artifacts. Accessibility issues include poorly defined access to the refuge, development of local infrastructure, and a need for visual, physical, and aesthetic connections.

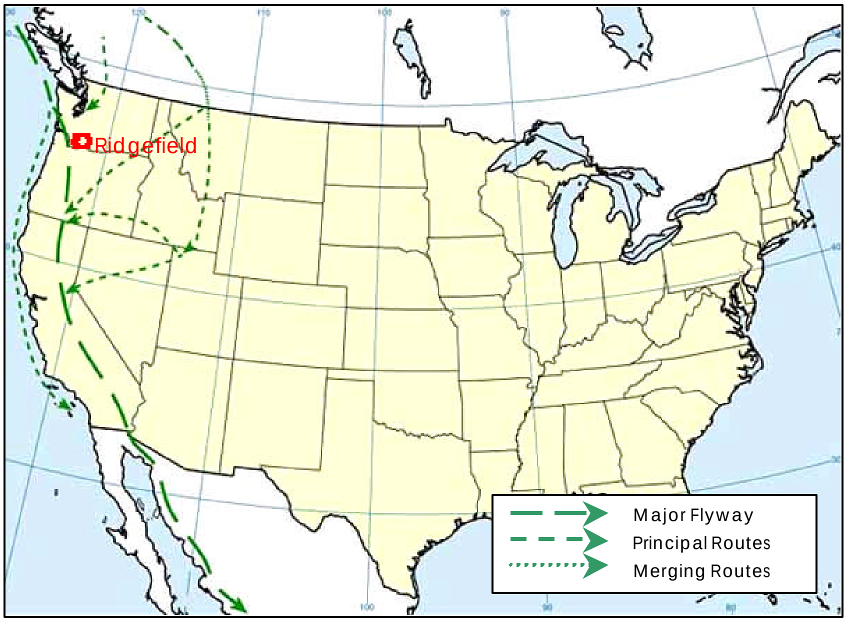

Figure 3.1.8-1 Ridgefield is on the major Pacific flyway[22]

As a result of the complexity in this project, multiple goals were established in the restoration and interpretation plan:

- protect natural hydrologic processes on the Carty Unit;
- protect and restore native species composition on the Carty Unit;
- protect sites of cultural and historic significance on the Refuge, in partnership with the Chinook Tribe;
- improve visitor access to the Refuge from Ridgefield and the wider region;
- provide a range of interpretation opportunities on or near the Refuge to promote awareness and appreciation of Refuge values, including an interpretive facility and trail network; and
- ensure interpretation facilities provide for a range of visitor requirements and expectations.

The proposed restoration plan addresses the rehabilitation of wetland flora, oak savanna and riparian corridors. Connection to the adjacent Gee Creek naturally controls the surface water table and water flows. Invasive plants are controlled by prescribed burns and flooding. The sewer system of the industrial site adjoining the Carty Lake requires enhancement to ensure water quality in the lake.

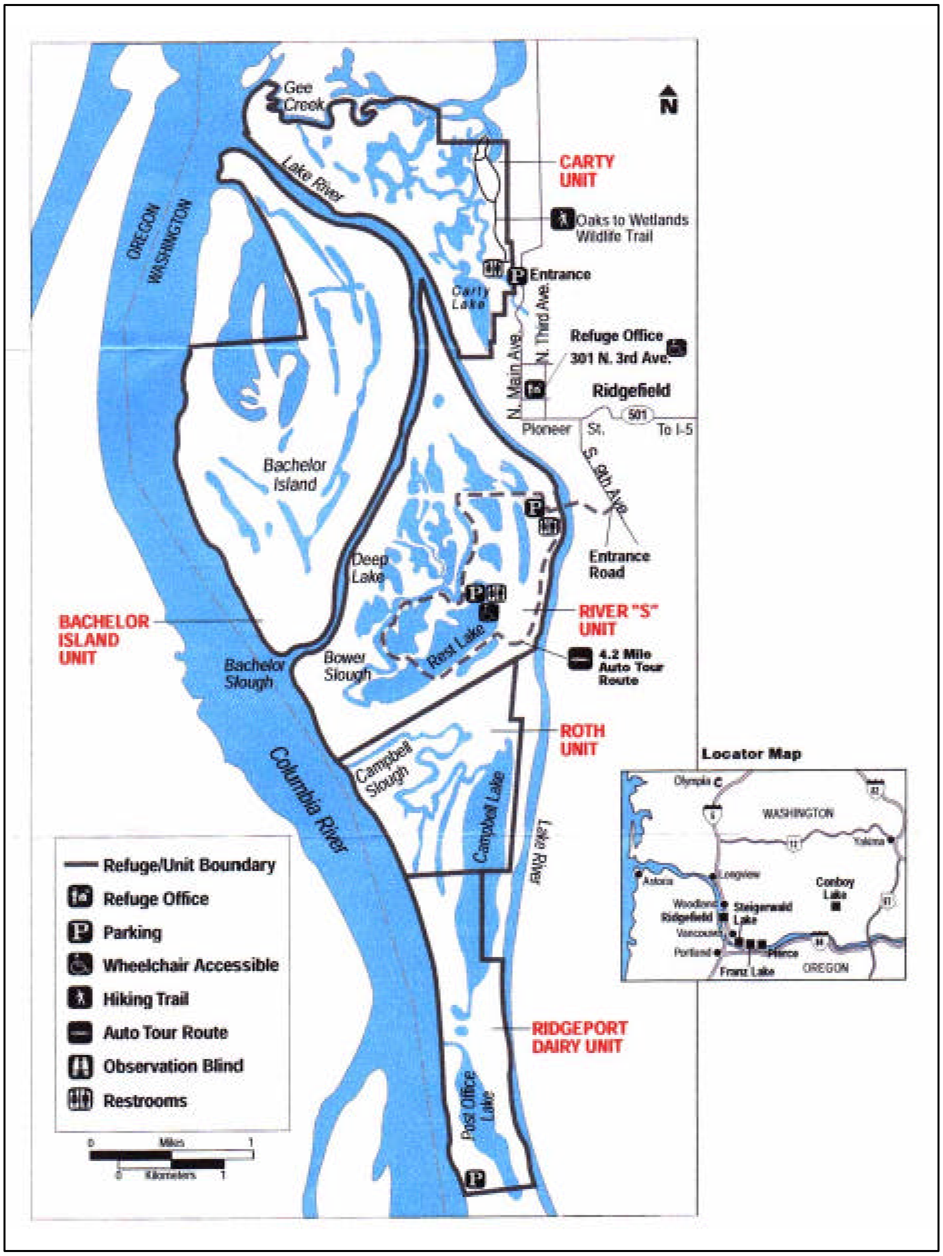

Figure 3.1.8-2 Location and management units of the Ridgefield National Wildlife Refuge.

Diverse transportation media such as roads, bicycle pathways, rail and waterways provides a range of accessibility to the refuge. Explicit signage and gate images are illustrated through comprehensive designs.

The proposed interpretation plan integrates information on natural and cultural resources. Importantly, planned exhibits account for the diverse learning preferences of visitors. This plan examines the "nature of nature" and the "nature of people," including the region's Native Americans and early explorers.

The interpretive trail protects natural habitat and accommodates visitors. Access to vulnerable and sensitive habitats is only allowed from a certain distance or through a wildlife observation shelter. Low, medium, and high skilled trails are designated in complementing various needs of people, including the physically disabled.

Two types of management strategies are employed in the refuge. Natural management in Carty and Roth Units preserve natural resources for wildlife habitats. Intensive management in the River S Unit and Bachelor Island uses pumps and sloughs to control water level in the restored wetlands. Remaining crops and pastures from previous agricultural lands provide food for waterfowl. Community support for Ridgefield and the USFWS is an essential factor for ensuring long-term management in Ridgefield NWR.

Ogden Nature Center[23]

The Utah State Department of Landscape Architecture and Environmental Planning developed an enhancement plan for the Ogden Nature Center, in Utah (Figure 3.1.8-3). The existing wetland is comprised of deep, open water surrounded by a wide belt of cattails (*Typha latifolia*) within 127 acres. A lack of diverse vegetation communities (in both the horizontal and vertical orientation) limited the biodiversity of the Ogden Nature Center. Enhancing the wetland for the richest possible diversity of faunal and floral communities was the primary goal in this project.

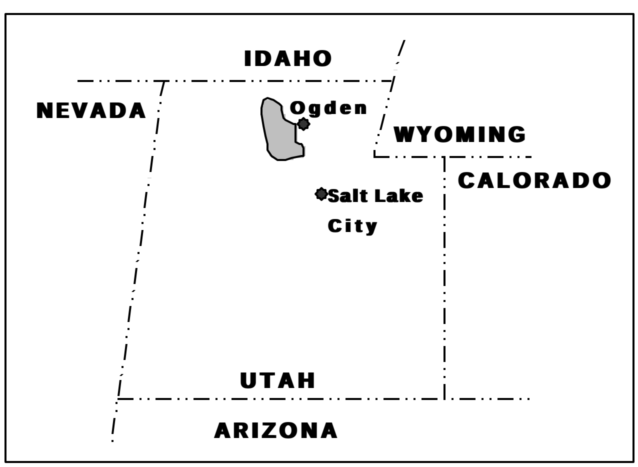

Figure 3.1.4-3 Location of the Ogden Nature Center.

Sempek and Johnson, who developed this plan, chose mallards (*Anas platyrhynchos*) and redheads (*Aytha Americana*) as wetland indicator species, assuming that other wildlife species would benefit from habitat improvements made to accommodate the indicator species. A literature review revealed the habitat needs for these species such as food, cover, water and nest areas.

The proposed wetland habitat model includes several components: a central pond, islands, nesting cover, a food plot area, a water control structure, and resting sites (Figure 3.1.8-4). The central pond was planned to provide a deep marsh to open water condition with 1:1 water-cover ratio and a minimum depth of 3.5 feet. The shoreline was graded to a 5:1 slope. The island was designed to replicate natural areas that provide safe nesting and resting habitats. The minimum dimensions of the island are 20 feet in diameter with a height of at least 2 feet above the water level. Nesting cover was developed to meet the needs of a wide range of avian species with an emphasis on emergent vegetation for diving ducks (redhead) and upland vegetation for puddle ducks (mallard). An accessible and productive food plot, adjacent to the pond, was intended to adjust to the water level alteration of the pond. Increment of 2 to 3 inches of water level regulation is the most desirable strategy. Sempek and Johnson suggested a simple water control structure with a concrete supported stop log of 2×4-inch boards would be sufficient. Resting sites were areas semi-open with a view of the shoreline. Alternative resting sites could be floating logs, piles of stones, bales of straw or hay, floating rafts and islands.

The ideal horizontal zonation and vertical stratification of wetland vegetation ranges from submerged and floating aquatics, deep marsh emergents, shallow marsh emergents, wet meadow and wetland low prairie accordingly to the water depth (Figure 3.1.8-5).

Lessons Learned

The Ridgefield project has a great deal of similarity to the HLD restoration project. They are large-scale projects in riparian ecosystems located on major migration flyways with archaeological and cultural heritage. The restoration plan focuses on restoring the hydrologic function of a small watershed (Gee Creek) through reconnection to a major river (Columbia), controlling invasive species, enhancing native communities and lessening the

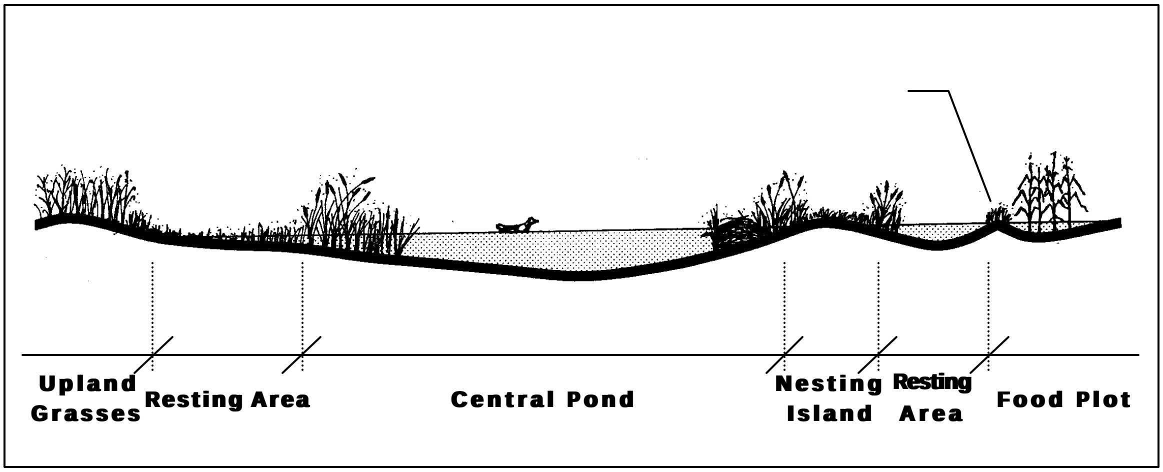

Figure 3.1.8-4 Proposed wetland configuration in cross section

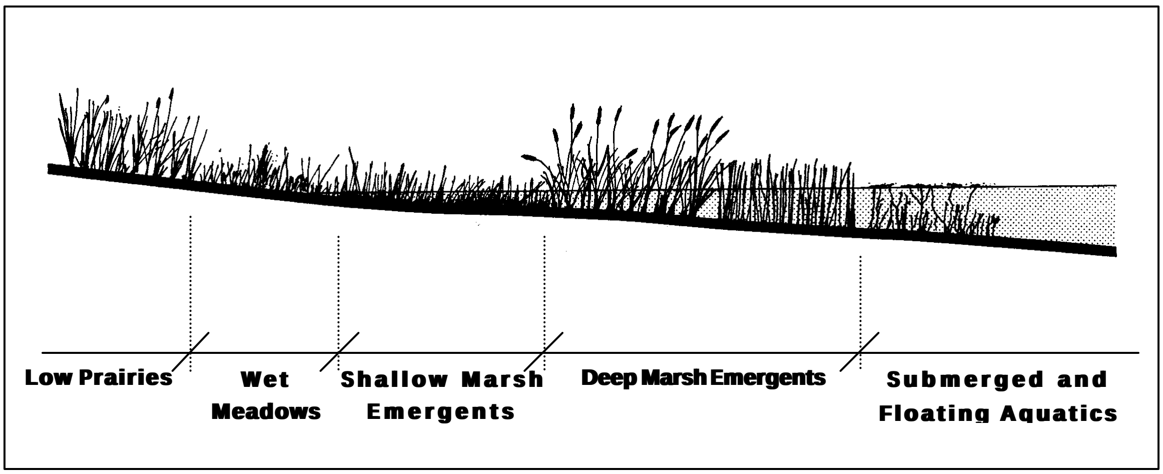

Figure 3.1.8-5 Schematic idealized wetland vegetation zonation

impacts on sensitive plant species. In the HLD project, these same important issues are undertaken in the restoration plan.

For wetland habitat enhancement, the Ogden Nature Center example provides insights into increasing the horizontal and vertical diversity of wetland structure. Creating different areas for waterfowl such as nesting islands, resting areas, and food plots is easily replicated. This example successfully employed knowledge of wetland ecosystems and grading design to create diverse vegetation zones, thereby enriching the biodiversity of the wetland.

This habitat enhancement model designed habitat using two avian species, redhead and mallard, as indicators. Though the study mentioned their habitats might accommodate most other waterfowl, there are limitations for other species. Therefore, whether it is desirable to use indicator species for habitat creation is questionable.

The Ridgefield interpretative plan employed both indoor and outdoor interpretation including interpretive trails for natural and cultural resources. To protect vulnerable archaeological sites and sensitive habitats, visual access is provided instead of physical access. The interpretation center is well organized and designed to present the native peoples and nature of the Ridgefield area through diverse media. These ideas are applicable to the HLD interpretation plan.

A thorough accessibility analysis for the Ridgefield project shows a diversity of transportation possibilities to meet the needs of the public, including the physically disabled. A range of trail systems was designed to accommodate different activities. These concepts are useful for the site analysis and trail system plan in the HLD recreation plan.

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