Restoration and Reclamation Review
Student On-Line Journal
Vol.1, No.1, Spring 1996
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From River to Canal and Back Again

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INTRODUCTION

The restoration of the Kissimmee River floodplain ecosystem in central Florida represents the largest and most unique restoration effort ever undertaken in the United States (Koebel, 1995). Meandering for over 166 km from Lake Kissimmee to Lake Okeechobee, the Kissimmee River was once a large river-floodplain system diverse in both flora and fauna. However, record discharge following the hurricane of 1947 resulted in extensive property damage along the river basin. Because of this, the State of Florida enacted a flood-control program aimed at minimizing discharge within the Kissimmee River basin and surrounding floodplains. As a result, channelization of the river into a series of impoundments occurred between 1962 and 1971. Over 14,000 ha of wetland were lost, leading to a severe decline in plant, fish, bird, invertebrate, and amphibian populations. These resource losses led to a grassroots environmental movement aimed at not only restoring the original river basin, but significant portions of habitat surrounding the river. Subsequently, a lengthy legislative process took place. Two feasibility studies were conducted to define objectives considered necessary for the overall success of the restoration project. Along with this, an on-site restoration demonstration project was conducted between 1984-1990 to determine actual techniques that would be used to complete the restoration. A significant part of the restoration process was determined to be a large scale, comprehensive evaluation and assessment program of pre- and post-restoration changes in the Kissimmee River basin. Using computer modeling, GIS, and field data, ecosystems deemed most likely to recover after restoration will be analyzed to determine restoration success and provide valuable information for future large-scale restoration projects.

SITE LOCATION AND HYDROLOGY

The Kissimmee River, near Orlando, is considered one of the most unique river-floodplain ecosystems in North America. It once consisted of a 4,229 km2 upper basin containing Lake Kissimmee and 18 smaller lakes, draining into the main tributary and flowing down to a lower basin covering 1,963 km2, including Lake Okeechobee. As mentioned, the Kissimmee River meandered for approximately 166 km, with a 1.5-3.0 km wide floodplain system situated along the length of the river. Pre-channelization discharge records between 1929 and 1960 indicate that the hydrological regime of the river consisted of continuous flow with seasonal water level fluctuations inundating the floodplain areas. Discharge often exceeded 11 m3/s during most of the growing season, and flooding occurred along almost the entire river reach when flows exceeded 40 m3/s in the upper basin and 57 m3/s in the lower basin. Highest discharge rates generally occurred in late summer (September to November), although rates typically fluctuated throughout the season (Koebel, 1995).

Historic records indicate that, prior to channelization, over 94% of the floodplains (approximately 16,920 ha) were inundated for over 50% of the growing season. When inundated, water depths often exceeded 0.3-0.7 meters, with depths over 1.0 meter occurring in over 40% of the floodplain for one-third of the recorded period. Although the basin underwent seasonal wet-dry cycles typical of rivers in subtropical regions, only the outermost edges of the floodplains experienced consistent annual drying. This hydrologic regime is more indicative of large river-floodplain systems such as the Amazon found in the Southern Hemisphere. Even though the Kissimmee River underwent both wet and dry cycles, the near continuous connectivity of the floodplain and the length of inundation differed considerably from other river-floodplain systems found in the North America (Koebel, 1995).

PRE-CHANNELIZATION HABITAT

Prior to channelization, a large mosaic of floodplain wetland habitats supported a large variety of plants, invertebrates, fish, amphibians, and birds (Toth et al., 1995). Over 35 species of fish, 16 species of wading birds, 16 species of waterfowl, and numerous invertebrates were supported by the heterogeneous community. The physical structure of the river basin was a function of both erosion and deposition, creating a sinuous series of both wetlands and open water. Zones of submergent, emergent and floating aquatic plants formed a vegetation profile extending along an elevation, water depth, and inundation gradient from the river channel out to the floodplain periphery.

Historical records and aerial photographs indicate three dominant wetland habitats existed along the river basin. The most extensive community was broadleaf marsh, covering over 56% of the floodplains. Common plant species included pickerelweed (*Pontederia cordata*), arrowhead (*Sagittaria lancifolia*), cutgrass (*Leersia hexandra*), and maidencane (*Panicum hemitomon*). Willow, buttonbush (*Cephalanthus occidentalis*), and other shrub communities were often interspersed within the broadleaf marshes or found along the river channels, and covered approximately 14% of the floodplain (predominately in the north-central section of the basin). Wet-prairie communities also comprised about 26% of the wetlands present. Some of these habitats, found on the floodplain periphery, experienced significant wet-dry cycling, and were dominated by *Panicum hemitomon*, *Leersia hexandra*, and horned beakrush (*Rhynchospora inundata*). Others experienced only short drawdown periods, and were comprised of a diverse group of forbs, grasses, and sedges, including water-hyssop (*Bacopa caroliniana*), watergrass (*Hydrochloa caroliniensis*), flatsedge (*Cyperus spp.*), netted nutrush (*Scleria reticularis*), and short-beak baldrush (*Psilocarya nitens*). Cypress swamps, and ash/oak forests were also somewhat common along abandoned tributaries and oxbows (Toth et al., 1995).

CHANNELIZATION

The decision to channelize the Kissimmee River occurred as a result of public pressure to diminish flood-related property damage in both central and southern Florida (Koebel, 1995). Prior to 1940, human habitation was sparse within the Kissimmee River basin. Land use consisted mainly of both farming and cattle ranching. After World War II, rapid population growth and economic development occurred. Then, in 1947, a devastating hurricane resulted in peak discharge rates of over 170 m3/s, producing extensive damage within the basin. The State of Florida responded with a request to the federal government to prepare a flood-control plan for central and southern Florida. As a result, in 1948 Congress authorized the U.S. Army Corps of Engineers (USACE) to begin construction of the Central and South Florida Project for flood control. As part of the plan, the USACE began work on the Kissimmee River portion (1962-1971), which entailed a transformation of the river into a canal (C-38) from Lake Kissimmee to Lake Okeechobee, with a series of impounded reservoirs (pools A through E) controlled by six water control structures (weirs).

The effects of channelization were significant. The broad, 166 km long braided river system was transformed into a 90 km long, 9 meter deep, and 100 meter wide canal. Historic water level fluctuations were eliminated, as well as water flow characteristics. Because of this, approximately 12,000-14,000 ha of floodplain wetland habitat were drained, and 109 km of remnant river channels dried up. A build-up of organic matter in low-flow areas caused available oxygen in the system to decline, affecting both plants and invertebrates (Toth et al., 1995). Exotic vegetation such as water lettuce (*Pistia stratiotes*) and water hyacinth (*Eichhornia crassipes*) as well as native vegetation (*Nuphar luteum, Scirpus cubensis*) invaded new areas and choked out existing vegetation. A chemical weed-control program was implemented to control invasions, causing a decline in species diversity. In the floodplain wetlands that still existed at the lower borders of impoundment pools, stagnant water levels have eliminated the wetland mosaic, leaving a homogenous wetland community. Of the drained floodplains, 44% were converted to pasture land dominated by upland mesic grasses such as carpet grass (*Axonopus affinis*), forbs (virginia button-weed, *Diodea virginiana*; ragweed, (*Ambrosia artemisiifolia*), and shrubs (*Myrica cerifera*). By the early 1970's, it was clear that most biological components were affected by the Kissimmee River channelization project. Both invertebrate and amphibian communities declined or shifted to more deep-water tolerant species, resulting in a decline in food resources for birds and other wildlife. Floodplain winter waterfowl utilization declined by 92%, and wading bird populations were largely replaced by cattle egrets (*Bubulcus ibis*) (Dahm et al., 1995).

RESTORATION PLAN

Even before full completion of the canal, concerns grew over the loss of habitat and post-channelization environmental degradation. In 1971, the U.S. Geological Survey released a report documenting the loss of water quality as well as fish and wildlife resources (Koebel, 1995). This prompted the governor of Florida, along with the Florida Legislature, to establish the Kissimmee River Restoration Act in 1976. This Act created the Kissimmee River Coordinating

Council (KRCC), which was directed to utilize the `natural energy' of the river to restore pre-channelization water fluctuations, reestablish natural floodplain and wetland habitat, and recreate favorable conditions to induce both vegetative and wildlife production. As a result, the KRCC, the Corps of Engineers, and the South Florida Water Management District devised a comprehensive three-part restoration evaluation (two feasibility studies and a demonstration project) to determine the feasibility of restoring the Kissimmee River to pre-channelization conditions.

The `First Federal Feasibility Study' (1978-1985) was aimed at evaluating measures to restore the Kissimmee River basin. A list of concerns of both private and public groups as well as state and federal agencies was devised and evaluated to be used for drafting plans that appeared feasible to meet the restoration objectives. These included environmental concerns such as restoring wetland areas, improving water quality, maintaining flood protection, and meeting recreational demands. This list was submitted for public review, and as a result six restoration plans were identified: 1) backfill part of canal, 2) construct flow-through marshes, 3) create wetlands through impoundments, 4) manipulate pool stage, 5) restore Paradise Run (a series of wetlands), and 6) use Best Management Practices (BMP). Public interest ultimately led to growing support for the backfilling restoration plan as a means of restoring the Kissimmee River basin.

In 1983, the Corps of Engineers and the KRCC initiated a demonstration project on a portion of the canal to determine if backfilling would result in partial restoration of the basin and to test restoration techniques. The demonstration project, located in the upper reaches of the canal, had four major components: 1) implementation of a pool-stage fluctuation schedule to reestablish seasonal water fluctuations, 2) construction of three notched weirs across the canal to simulate backfilling by diverting flow to remnant river channels, 3) creation of a flow-through marsh, and 4) hydrologic modeling studies to evaluate the engineering feasibility of backfill and sedimentation issues. The implementation of the demonstration project resulted in pre-channelization fluctuation patterns, inundation of original floodplain habitat, rapid colonization of some historic plant and invertebrate communities in remnant river channels, and habitat utilization close to the project site by both wading birds and waterfowl.

As a result of the demonstration project, it was determined by the Corps of Engineers and the KRCC that both the structure and the functions of the Kissimmee River ecosystem could be reestablished by introducing both historic water flow and fluctuations. Based on this finding, the `Second Restoration Feasibility Study' (1990 to present) is aimed at determining design assumptions, operational procedures, and construction methodologies to a complete backfilling program (Level II Backfilling Plan). This plan will result in continuous backfilling of the canal from the mid-upper reaches (pool B) to the lower portions (pool D), and eliminate two flood control structures. Modifications were made to address land acquisition policies and structural changes to remaining water control structures, resulting in final adoption of the Modified Level II Backfilling Plan of the lower basin of the Kissimmee River. The restoration of the river, slated to begin in 1998, will include a revitalization program for the upper basin lakes to provide for greater and more natural water level fluctuations and inflow into the river. The canal will be completely backfilled using mostly spoil from canal construction stockpiled along part of the original floodplain, and will be completed in a series of construction phases projected to last until 2011. These will include both backfilling and reexcavating original river channels lost during the canal construction (Dahm et al., 1995).

RESTORATION EVALUATION

Because of the scope and scale of this restoration project, the South Florida Water Management District implemented a large scale and comprehensive restoration evaluation program to assess habitat and community responses to the restoration (Dahm et al., 1995). This evaluation program will integrate taxonomic, habitat, functional, structural, and conceptual approaches to achieve three objectives: 1) to determine if the restored channel and floodplain meet hydrologic criteria outlined in the Restoration Plan, 2) to determine if selected biological and ecological attributes have been restored, and 3) to implement an Adaptive Management Plan to improve restoration goals set in objectives 1 and 2. A scientific advisory panel combining multiple disciplines has identified five biological communities to be used to assess restoration success: floodplain plant communities, wading birds, waterfowl, fishes, and invertebrates. Both reference and baseline (pre-restoration) data will be collected and analyzed using models and GIS to determine ecosystem structure and function that will allow for a prediction of ecosystem responses to restoration. When compared to post-restoration data collected, a comprehensive documentation of ecosystem changes can hopefully be used as a measure of restoration success and a template for future management plans. It is important that, for a restoration of this magnitude, clearly defined goals be set forth before the restoration proceeds. However, these goals should not only address communities and habitats in an ecological context, but in a resource context as well.

RESTORATION CRITIQUE

It is quite clear that the channelization of the Kissimmee River basin resulted in significant habitat and resource loss - perceived almost from the beginning of construction. If not for an enthusiastic restoration movement by surrounding communities, this river-floodplain ecosystem would likely still be a canal. Fortunately, the restoration issue was taken seriously by the Florida Legislature and the Federal Government, resulting in a lengthy and incredibly detailed set of goals and feasibility studies to ensure proper implementation of the largest river restoration project in the country.

One of the main strengths of the restoration plan includes a full-scale evaluation program combining scientists from multiple disciplines and using modeling tools and field data to help define restoration goals and assess success. It also provides for a wealth of data for future research into the effects of habitat restoration on a very large scale. However, there seems to be a lack of consideration of probable management issues that will arise concerning species invasions. The plan for this restoration does not address the need for long-term management of weedy exotics which already exist on the site. It is believed that, once the original floodplains and remnant river channels are restored, inundation will remove existing weedy species. There will not be any site preparation or planting, which is common on smaller scale restoration projects. It is probable that some micro-management practices will need to be implemented, such as burning, in order to achieve success at least on the floodplain periphery.

It is unlikely that a perfect historical restoration will result from de-channelization of the Kissimmee River, yet it is believed that this will occur via re-establishment of historic water levels and fluctuations. In all likelihood, a combination of water and management will be needed to establish the floodplains as they once were, given unavoidable changes to the original river channels; perhaps this should be given more emphasis in the evaluation program.

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