Forty Years of Controversy and Achievement in North American Fisheries — Riverine Fisheries

Jerry L. Rasmussen
U.S. Fish & Wildlife Service
P.O. Box 774
Bettendorf, IA 52722-0774

Abstract

Rivers and riverine fisheries are perhaps the most used, abused and impacted natural resources in North America. This paper describes (1) some of the impacts man has had on these important resources, (2) discusses current thinking in riverine fisheries resource management, and (3) proposes some actions to offset man's impacts and return our rivers and portions of their floodplains to a more natural state.

Introduction

Floodplain rivers in their natural form are in a constant state of change, roaming about across unrestricted floodplains, creating and destroying side channels, backwaters, oxbow lakes, and a variety of other habitats. In this process, over long time periods, rivers maintain a relative balance between these various habitats (Figure 1), a situation called "Dynamic Equilibrium" (National Research Council 1992). The floodplain serves as an important part of the river itself, acting as a check valve to absorb high flows or flood pulses, as a kidney to cleanse runoff waters, as a mechanism of energy exchange, and as temporary and seasonal habitats for its biological components. In fact the presence of a periodic flood pulse is a key factor in maintaining a healthy river ecosystem (Bayley 1991 and Junk et al. 1989).

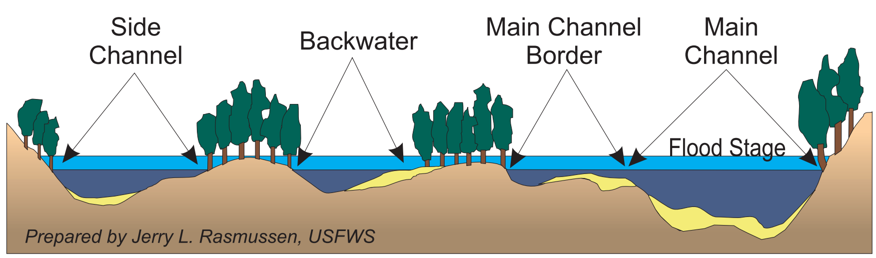

Figure 1. Natural floodplain habitats are a constantly changing mix of shallow floodplain channels, backwaters, and terrestrial habitats, maintaining a situation called "dynamic equilibrium".

The floodplain's alternately flooded and dried habitats are known to biologists as the Aquatic Terrestrial Transition Zone or ATTZ (Figure 2). This area of periodically flooded vegetation plays an extremely valuable role in

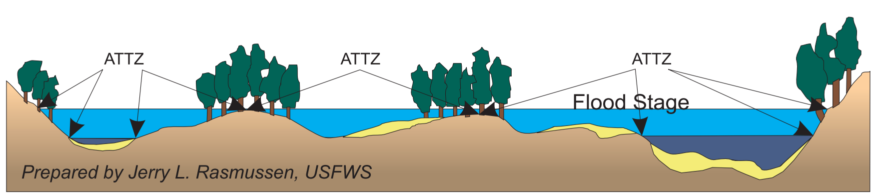

Figure 2. In alternating between its aquatic and terrestrial situation, the ATTZ allows for rapid recycling of nutirients and serves as a seasonal fish feeding and spawning habitat.

cleansing runoff waters and in the transfer of nutrients between a river and its floodplain (Junk et al. 1989). It is also used extensively by riverine fishes for spawning, feeding, and rearing of their young. The native fishes of any river have evolved and adapted to habitats created by these natural processes, and are themselves impacted when "Dynamic Equilibrium" and the "ATTZ" is lost. Unfortunately, the very purpose of man's development projects has been to control our rivers and to disrupt these dynamic processes — therein lies the conflict between natural and man-made systems.

At the turn of the century our riverine commercial fisheries were seen as resources to feed the nation; yet today most of these fisheries are either restricted or completely closed. This is in part due to contamination by both domestic and industrial wastes, but equally or perhaps more important, is the impact of channelization and impoundment to meet the needs of flood control, hydropower, water supply, and commercial navigation. In recent years, our society has made major strides in addressing serious water quality issues, but little has been done to restore the habitats lost to major water resource developments.

The Mississippi and Missouri rivers are two of the largest and most managed rivers in the United States, and both (Figure 3) are significantly impacted by development for hydropower, navigation and flood control. The impacts that occur are typical of those man has had on other rivers nationwide. In addition to the mainstem dams and levees shown in Figure 3, there are many more dams, levees, and channelization projects throughout the watersheds.

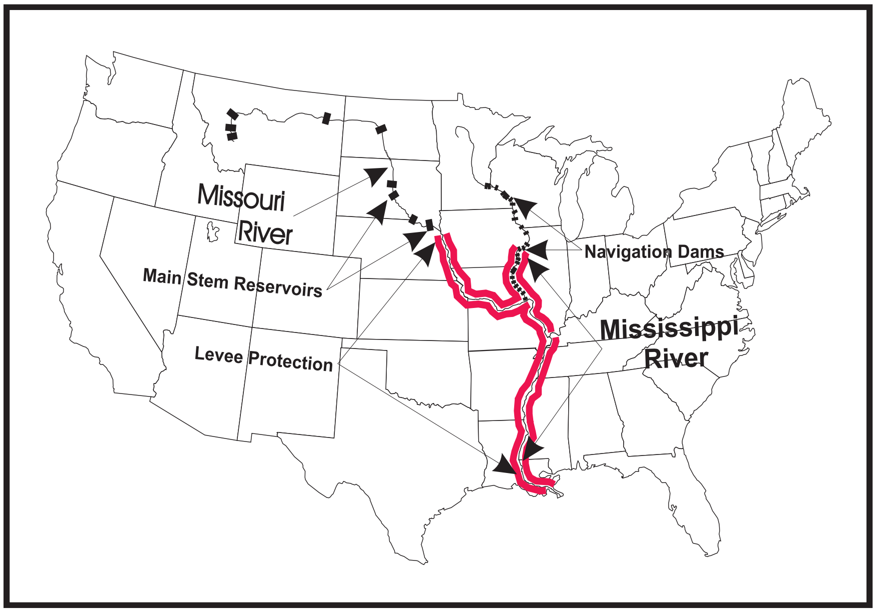

Figure 3. Mainstem flood control and navigation projects of the Mississippi and Missouri rivers.

During the first half of this century, rivers in the United States such as the lower Missouri River (Figure 4) were becoming little more than major sewer systems, seen only as mechanisms to carry away wastes, and as "common enemies" that had to be controlled, and if possible, harnessed for hydropower and navigation. In fact able bodied men were drafted, military style, to fight the river, our "common enemy" in the event of flooding. Little or no consideration was given to river ecology, to the importance of natural processes, or to man's connection to ecological integrity. These terms weren't even known, much less understood.

In the case of the lower Missouri River a federal program called Pick Sloan was used to place several major dams on the mainstem, and to channelize downstream reaches for commercial navigation. Development and draining of floodplain lands for agriculture came about as a result of both the Pick Sloan Program and something called the Swamp Act. Swamps, or wetlands as we know them today, were also considered common enemies. Our society, had little understanding of the role

Figure 4. Development of the lower Missouri River for commercial navigation and flood control. Photos courtesy of the Missouri Department of Conservation.

that these floodplain wetlands played in controlling floods; in serving as the “kidneys” of the landscape, cleansing runoff waters; or in maintaining ecological integrity. Our vision has been one of dominion over nature.

By the late 1970’s the Missouri, the lower Mississippi, and many other rivers and tributaries in the United States had been totally channelized, and their natural floodplain ecosystems had been almost totally converted to farmland or other purposes. In the process, we lost many of our commercial fisheries, many sport fisheries are threatened, and today we face growing lists of threatened and endangered aquatic species.

In terms of numbers, on the lower Missouri River alone, just in conversion of what was former river channel and erosion zones (not the entire floodplain) we lost over 100,000 acres of aquatic habitats, over 65,000 acres of island sandbars, over 114,000 acres of wetlands, over 190,000 acres of woodlands, and over 127 miles of shorelines (Table 1). The result of this basinwide development and channel straighten-

Table 1

Missouri River Habitat Lost to Channelization 1912-1980*

Aquatic Habitats	100,000 Acres
Island Sandbars	65,000 Acres
Wetlands	114,000 Acres
Woodlands	190,000 Acres
Shorelines	127 Miles

*Includes only the former natural river channel and meander belt, not the entire river floodplain.

Source: U.S. Fish & Wildlife Service, 1980 ing became evident on the lower Missouri and parts of the Upper Mississippi river basins after the high water event, or flood of 1993. The Missouri River flooded bluff to bluff on two different occasions, pretty much having its own way, recovering or recreating many new or former aquatic and floodplain habitats. Wet areas on the floodplain left by the flood were a mix of newly scoured areas and old depressions or channels where prior wetlands had been drained for farming. Some floodplain farmlands were left covered with sands ranging from a few inches up to ten feet deep (Figure 5), and many floodplain homes were destroyed (Figure 6). Depending on point of view, this can either be considered tremendous destruction of farmlands, or from the river's point of view as tremendous rehabilitation of former aquatic habitats — the river's natural method of restoring its biological systems.

Figure 5. Former Missouri River floodplain farmlands impacted by the 1993 floods. Photo courtesy of the Missouri Dept. of Conservation.

Figure 6. Floodplain farm house destroyed by the 1993 floods. Photo courtesy of the Missouri Dept. of Conservation.

The flood fight during the 1993 flood was largely unregulated, with each landowner or group of landowners fending for themselves. In fact some federally sponsored levees were raised as much as two feet higher than their authorized level (Figure 7). One such levee near Quincy, Illinois blocks off over 100,000 acres of floodplain, or put another way over 150 mi^2 of floodplain. It seemed that,

Figure 7. The raising of this federal agricultural levee during the 1993 "flood fight" threatened neighboring lands by further constricting the floodplain and forcing flood waters to higher elevations. Photos courtesy of the U.S. Fish and Wildlife Service.

during the flood, all previous agreements were off and farmers could raise their levees as high as they thought necessary to protect their crops. Public funding assisted in many ways in helping to raise these levees, and then paid to reconstruct them once they failed — and many levees did fail in several places. This despite the fact that the taxpayers had originally payed to construct the levees only to a specified elevation. Also by raising these large agricultural levees, nearby developed lands as well as cities and towns in the area, on both sides of the river, were faced with increased flood levels.

Nearly the entire Mississippi River floodplain downstream from Rock Island, Illinois, the Missouri River downstream from Sioux City, Iowa, and the Illinois River have been isolated from the river by levees and converted to agriculture (Figure 3). This problem occurs to a lesser extent on many of the smaller tributaries. These isolated floodplains are areas that the river once had not only as part of its Aquatic Terrestrial Transition Zone, but also for use in flood water storage and conveyance. Water from all of these rivers ultimately ends up at St. Louis, where the Illinois, Upper Mississippi, and Missouri rivers merge.

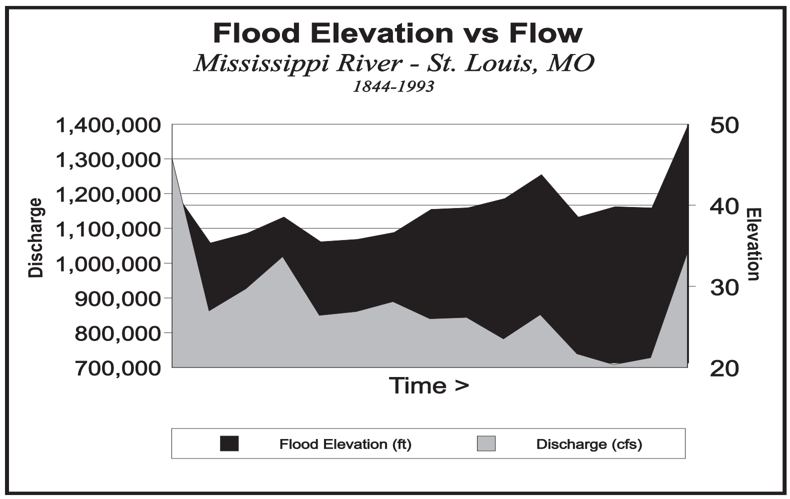

Figure 8. The relationship between discharge or flow and flood elevation, as impacted by isolation of river floodplains with levees.

In essence, while destroying prime riverine and floodplain habitats, our society has created many of our own flooding problems. Figure 8 shows the relationship between flood elevation and discharge at St. Louis, Missouri between 1844 when flood control developments first began and 1993 when our last great high water event or flood occurred. As we have continued to build levees over time, and blocked off floodplains, flood elevations have risen accordingly. You will note in Figure 8, comparing discharge to flood elevation, that discharge was actually higher than flood elevation in 1844, and then over time, flood elevation has risen disproportionately to discharge as the river lost its floodplain to development. In 1993 when many of the levees broke, you will note that the two once again rose in concert, in a more natural way.

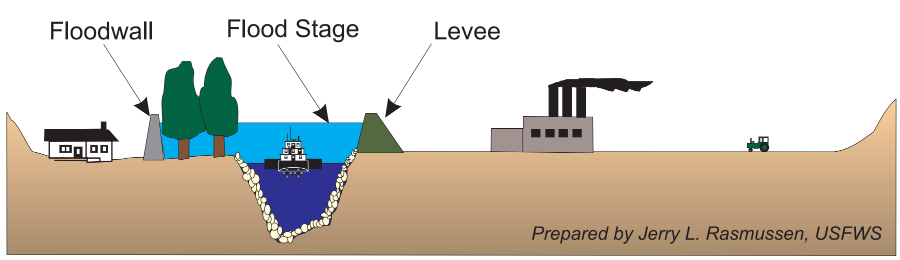

Figure 9. Flood control levees isolate river floodplains; increase flood stage; impact water qualtiy, and destroy wetland, riparian, and instream habitats.

Looking at levees in cross section (Figure 9) you can see how these high levees cause water levels to rise. As long as they hold, the water has no place to go but up, essentially forcing flood waters to pass through a narrow funnel-like opening between the levees. Waters impounded upstream cause rapidly rising, higher than normal flood elevations, and people who may never have been flooded before, now find their homes under water. In self defense these newly flooded people now face the need to build their own levees, usually through taxpayer assistance. And so it goes upstream, until virtually everyone has a levee, and virtually the entire floodplain is isolated from the river.

When these levees break, because the water is stacked so high, a tremendous amount of energy is released. This energy is released in the form of what hydrologists call a "dam break floodwave", creating huge scour holes adjacent to the channel as diagramed in the river cross section shown in Figure 10. Sands from these holes are then scattered about across the floodplain, as shown in Figure 5, to depths of up to ten feet. Damages caused by the 1993 flood cost the American taxpayer somewhere between $14 and $16 billion. Aquatic organisms, on the other hand, regained access to their historic floodplain habitats and enjoyed a banner year, with production levels up across the board (Sparks 1995).

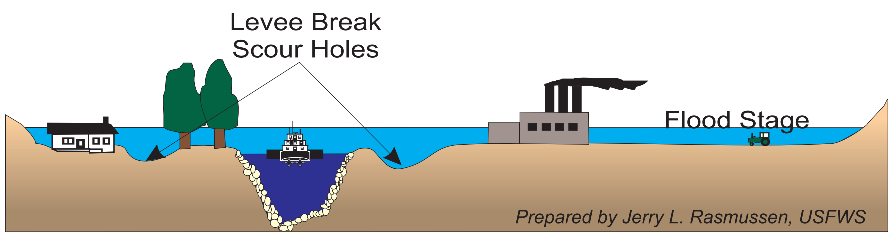

Figure 10. Broken flood control levees cause increased flood damages and floodplian scour because flood heights are increased and induced developments are not protected from flooding.

As noted previously, most of the levees on the Upper Mississippi River occur downstream from Rock Island, Illinois. Upstream from that point the floodplain is kept largely intact by the Upper Mississippi River National Wildlife and Fish Refuge which stretches over a distance of 285 miles from Rock Island upstream to Wabasha, Minnesota. Flood damages in areas adjacent to that refuge were minimal during the 1993 flood.

Unfortunately, a slackwater navigation project is layered over the top of that refuge. The navigation project isn't designed to provide for flood protection, and may actually reduce it by keeping the floodplain partially inundated. But the presence of the Upper Mississippi River Wildlife and Fish Refuge still provides flood protection by keeping the floodplain largely undeveloped and open (Figure 11).

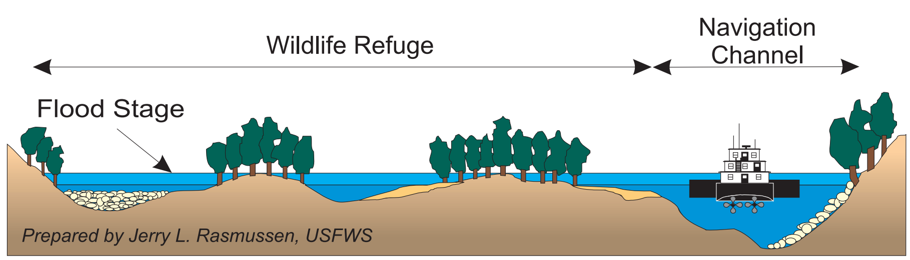

Figure 11. Floodplain wildlife refuges provide significant space for conveyance and storage of flood waters.

Slackwater navigation projects present other unique environmental problems for riverine fisheries. Water in these slackwater pools is actually somewhat tilted into the watershed, creating a river-like environment immediately below the dams, a lake-like environment immediately above, and a tremendous diversity of habitats in between, created by many partially submerged islands. These projects suffer from erosion immediately below the dams, sedimentation immediately above, and dredging in mid-pool reaches to maintain the navigation channel.

The bedload naturally carried by the river, plus materials eroded below the dams is carried downstream into the pools where it begins settling out. Rock closing dikes, wing dams, and river flow produce a sorting effect on sediments (Figure 12), with the coarser grains of sand staying in the main channel and the finer grains of silt being transported into the backwaters. Along with these silts go all the major pollutants and heavy metals with an affinity to attach themselves to clay particles. These contaminated, and sometimes toxic, silts are thus being deposited right in the middle of prime fish and wildlife habitats where aquatic organisms are attracted to live and feed.

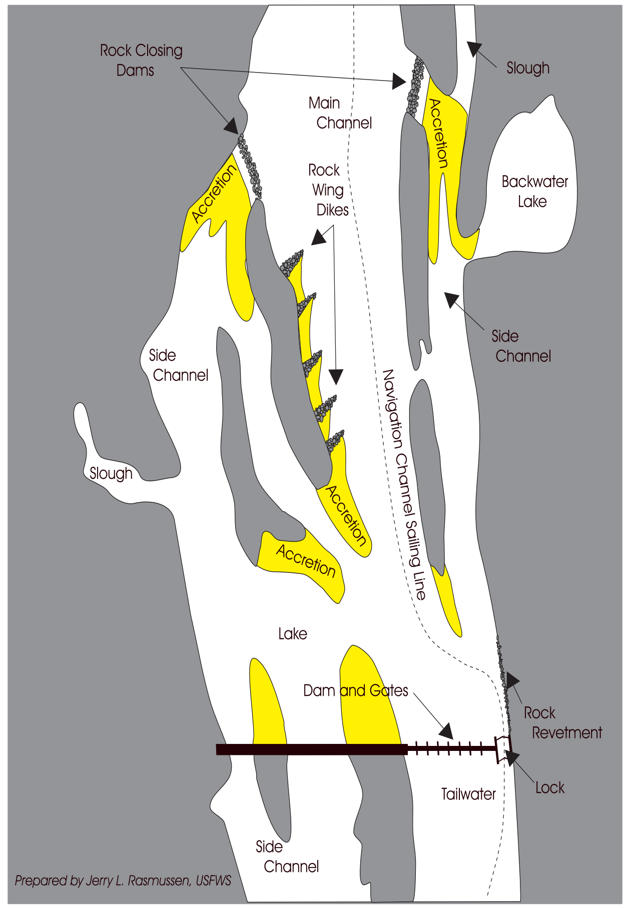

Figure 12. Dredging, wing dikes, and closing dams cause accretion of sediments in off channel habitats of slackwater navigation projects.

The sands that remain in the navigation channel occasionally block navigation traffic. But these are promptly removed by U.S. Army Corps of Engineers (Corps) channel maintenance dredges and pumped downstream into the main channel (thalweg) or side cast to nearby shorelines, or oftentimes in the past into sensitive backwater areas, destroying fish and wildlife habitats.

Figure 13. Adult lake sturgeon washed ashore in Upper Mississippi River navigation Pool 15, the apparent victim of injury by a large boat propellor.

As backwaters are lost, fish are forced into the main channel and right into the path of towboat traffic. The huge nine-foot diameter towboat props can pull even large adult fish such as lake sturgeon (Figure 13) and paddlefish into their blades; to say nothing of the impact on smaller fish and fish larvae and eggs that are entrained in their propwash and destroyed by the sharp currents and shear forces.

In narrower river reaches these huge towboat props essentially process all the water in the main channel, even pulling some water and small fish out of nearby backwaters, acting like huge blenders. The concentric white lines shown in Figure 14, reaching all the way to the channel bottom, simulate the shear and shock waves produced by towboat prop wash. It’s easy to see how small bottom dwelling fish are dislodged and carried right into the props of these huge boats.

Backwater sedimentation and dredged spoil disposal in slackwater navigation projects eventually reach the point such as they have on the Upper Mississippi River where the need for fish refuges and more active fish management becomes more and more apparent as the projects age.

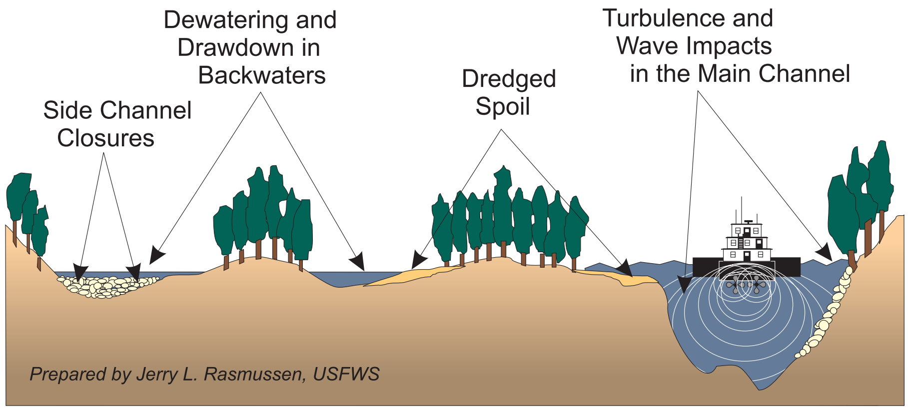

Figure 14. Commercial towboats significantly impact main channel and back-water fisheries habitats in narrow reaches of slackwater navigation projects.

Large flood control, hydro-power, and water supply reservoirs, on the other hand, produce another whole series of impacts on riverine fisheries. These are primarily related to the blocking of fish movements, and disrupting of sediment transport mechanisms and river flows or hydrographs. Sediments are trapped in reservoir sediment storage pools (Figure 15), while waters in their flood pools are used to produce water level fluctuations to serve the needs of hydropower and flow augmentation for downstream commercial navigation traffic. Little account is taken of the effects of these water level manipulations either on the river's biota downstream of the dams, or in the reservoir itself.

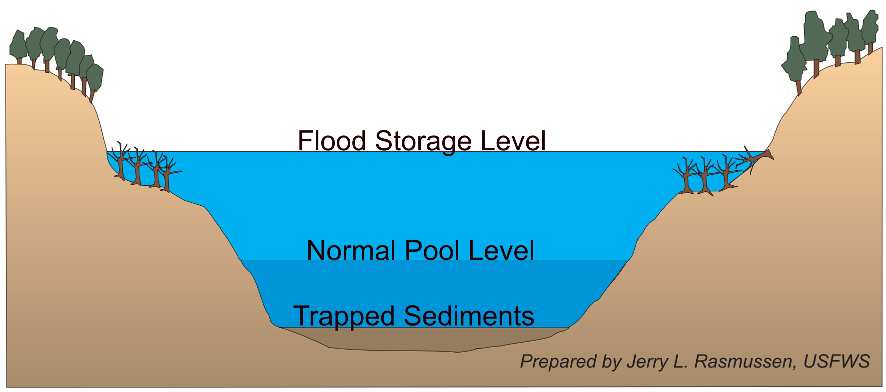

Figure 15. Flood control and hydropower reservoirs block fish movements; disrupt natural hydrographs and sediment transport; and alter water quality, water levels, and nutrient outputs.

Because reservoirs trap river sediments, their outflow waters are relative clear and sediment free (Figure 16). These are what hydrologists refer to as hungry waters, hungry in the sense that they

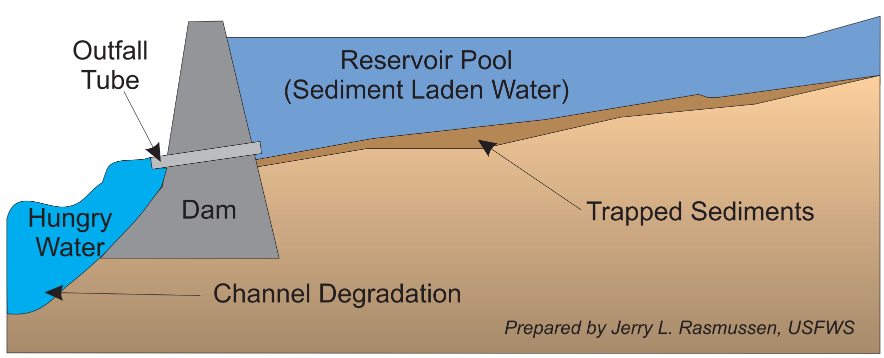

Figure 16. Reservoir outfall waters are relatively sediment free, or "hungry" to pick up and carry sediments. These "hungry waters" cause stream bed erosion or degradation downstream.

want to pick up and carry a sediment load. Because of the rock lined channels of bank stabilization and navigation projects that usually occur below these reservoirs, the only place these hungry waters can find the sediments they need is in the stream bed or navigation channel (Figure 17). This leads to channel deepening or bed degradation, which in turn lowers water tables and drains floodplain channels and backwaters (Figure 18).

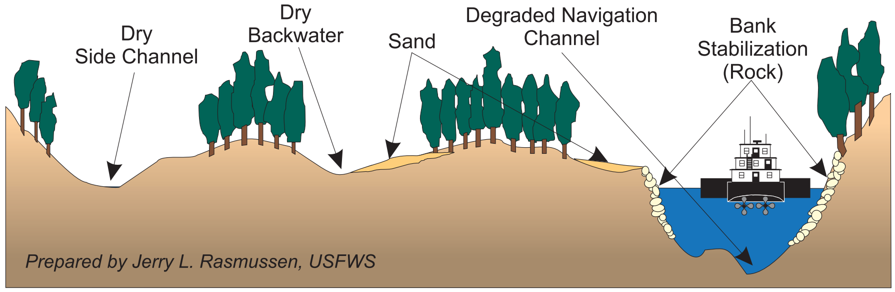

Figure 17. Main channel bank stabilization and bed degradation on channelized rivers dewater floodplain backwaters and side channels, destroying native fish and wildlife habitats.

Figure 18. A typical side channel on the Middle Mississippi or Lower Missouri rivers as seen during high water stages (left) and during normal or low water stages (right). This is caused by degradation of the main channel river bed which produces significant impacts on the aquatic biota.

This same dewatering or draining takes place in tributary mouths and starts an upstream erosion process called “head cutting”, which continues upstream in the tributaries until the grades or elevations between the river and the tributary are equalized. But before this happens, “head cutting” can wash out roads and bridges, and the Corps is called in to stop it. They do so by installing concrete grade stabilization structures. These structures are nothing more than small concrete check dams, which create small waterfalls.

These small waterfalls are large enough to prevent upstream fish movements (Figure 19), thus eliminating fish access to many tributary habitats which are among the last remaining spawning and nursery areas available to large river fish. Small hydropower projects produce similar impacts. Fish passage devices installed on these structures have been largely unsuccessful.

Another problem with flood control and hydropower reservoirs is their influence on a river’s hydrograph. Historically, normal river hydrographs looked something like the one shown in Figure 20a. They featured a rise in water level elevation corresponding to spring rains, and a summer or fall rise corresponding to snowmelt in the mountains, or fall rainfall. Native species evolved under these scenarios and used such water level rises to trigger spawning movements onto floodplains and in the case of birds, for nesting on islands. Additionally, they were important in providing feeding and resting areas for spring and fall waterfowl migrations.

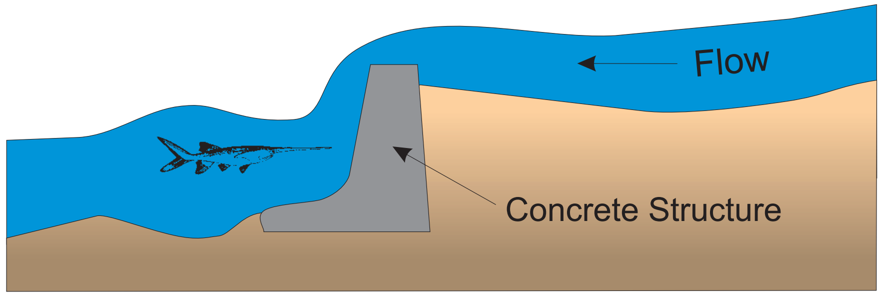

Figure 19. Grade stabilization structures used to stop head cutting also block fish from reaching important tributary spawning areas.

Under management scenarios for commercial navigation, river water level elevations are raised in the spring and held stabile throughout the navigation season as shown in Figure 20b, virtually eliminating the triggering mechanisms native species used to reproduce and complete their life cycles. Because of this, many of our native riverine species often fail to spawn or nest, and are becoming increasingly threatened.

River ecosystems are thus faced with monumental problems. State and Federal biologists have been working on mitigation efforts since the 1940's, and these efforts have largely been piecemeal, showing only marginal success; and most of these successes have been off-channel in off-site tradeoffs providing little or no benefit to riverine fisheries.

In response to this problem, a team of international scientists gathered in La Crosse, Wisconsin in 1994 to discuss restoration of the ecological integrity to floodplain rivers (Delaney 1995). Their meeting reached several important conclusions which management biologists can and are using to supply their arsenal of scientifically supported information and guidelines. They include the following:

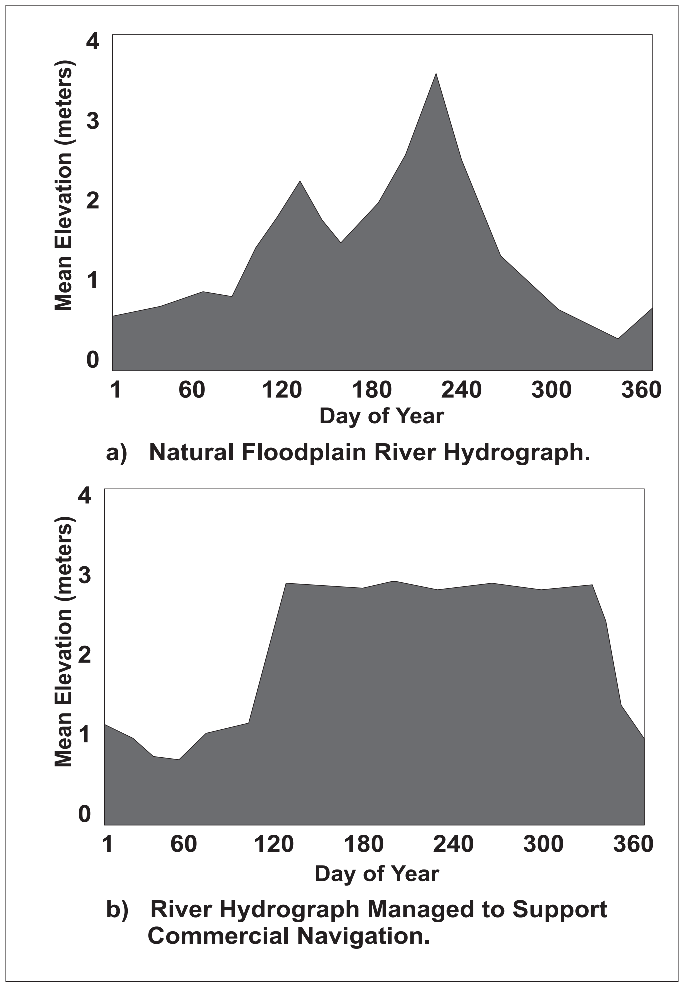

Figure 20. Stable water levels serving commercial navigation (b) eliminate water level fluctuations (a) which native organisms used as ques for timing their spawning and nesting activity.

- River form is a function of the totality of land use patterns in the basin.
- There is an integral relationship between a river's main channel and its floodplain.

● The flood pulse and morphological diversity arising from it are the major driving factors in floodplain river ecosystems.
● A primary attribute of river integrity is the connectivity of floodplain habitats with the main channel.
● The biggest stresses on large rivers are produced by high dams, reservoirs, and floodplain levees.
● Restoring integrity involves freeing the river to some extent to maintain, rebuild and rejuvenate itself by the natural processes of scouring and deposition.
● General guidelines that can now be advocated by scientists include (1) the removal or setting back of levees to allow the river to adjust locally; (2) local floodplain restoration; and (3) removal of lock and dam systems or lateral levees that are no longer socially or economically justified.
● Alternatively, water regulation procedures at navigation locks and dams could be modified to increase floodplain connectivity during appropriate seasons.
● The area needed for an improvement to the biota is probably relatively small, and may take the form of a series of floodplain patches connected by more restricted river corridors.
● Ultimately, integrated management should be extended into the river catchments to reduce inputs of sediment, nutrients and chemicals.

In essence, what these scientists have said is that in order to restore a river's ecological integrity, one thing that must be done is to reconnect it to some portion of its floodplain — this means that we must work closely with engineers in the design of future flood control measures.

Also in 1994, as part of the White House response to the 1993 midwest flooding, USGS scientists said that on channelized alluvial rivers like the Missouri, the best way to provide for flood control is to enclose the river's entire meander belt within a system of setback levees. The meander belt is the zone immediately adjacent to the river. It is the area most susceptible to flooding, the area where old active river channels occur, and where most of the major levee breaks occurred during the 1993 flood. The meander belt is thus that portion of the floodplain least desirable for farming or other developmental uses. So there is a situation here where both biological and physical scientists agree that we must loosen the strangle-hold we have had on our rivers and their floodplains, and a win-win situation may exist, where we can address both economic and environmental objectives at the same time.

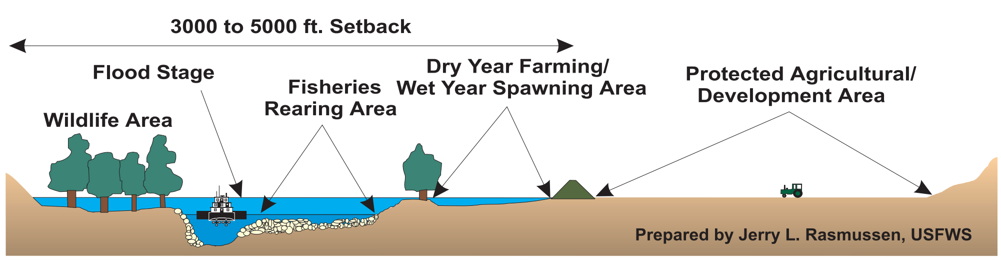

Figure 21. Setback levees provide for ecosystem management, balancing developmental and environmental needs, while preserving river floodplain integrity.

The proposed system of setback levees would look something like the diagram shown in Figure 21. Permanent farmland would be well protected behind the setback levees. Compatible land uses could occur between the levees. The higher ground, riverward of the levees, would serve nicely as dry year farmland, and as fish spawning areas during wet years. Farming of such lands, however, should be completed at the sole risk of the farmer. Those areas that were abandoned for farming and became wooded, would likely become permanent wildlife habitats or open pastures. Channel margin areas would provide permanent fish rearing areas. So its easy to see how such a systemwide approach or vision for flood control, coupled with seasonal inundations, could also achieve acceptable levels of ecosystem restoration and meet the needs of many of our threatened species.

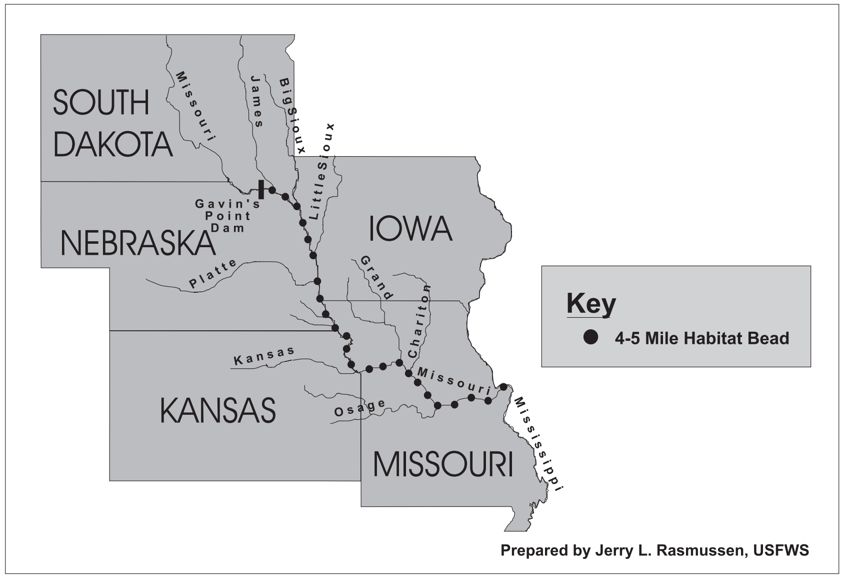

Figure 22. Map showing a hypothetical proposed habitat restoration program along the lower Missouri River using the 4-5 mile

But while a system of setback levees may be needed to address flood control, purely from an ecological perspective, we feel that far less land and habitat restoration is needed to restore a river's ecological integrity. Based on the scientific literature and the consensus reached at the international meeting in La Crosse, WI (Delaney 1995), restoration of a river's ecological integrity could be achieved by simply restoring a series of key habitats, stretched over its length, like a string of habitat beads or pearls (Figure 22). These habitat beads would be managed in an attempt to restore some semblance of the river's natural features, or "Dynamic Equilibrium" in localized areas.

Such a habitat bead might appear as in Figure 23. It would incorporate the use of setback levees and include several habitat features (e.g. side channels, wetlands, wet meadows, bottomland hardwoods, etc.) and attempt to incorporate tributary mouths and low lying areas. These areas are the most vulnerable to flooding, and would be easy to periodically inundate with small seasonal rises in water elevation. Such water level rises could be accommodated by controlled water releases from upstream flood control and hydropower dams. Operation and maintenance costs would thus be low, and because these areas lie on the lowest floodplain elevations, flooding impacts on nearby landowners

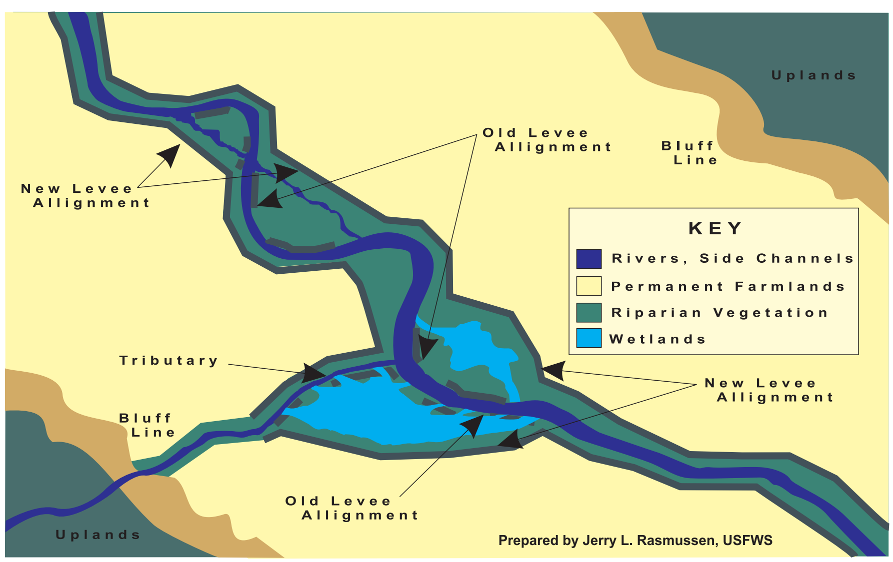

Figure 23. A hypothetical river reach showing a series of habitats functioning as an ecological "bead" or "patch" of habitat necessary to restore or maintain ecological integrity.

would be minimized.

When a navigation or bank stabilization project is present, the ability to inundate adjacent lands with lower elevation flood pulses could be enhanced by removing some of the existing bank stabilization features along shorelines adjacent to target habitats. This would allow lower elevation flows to reach floodplain habitats within the habitat bead (Figure 24).

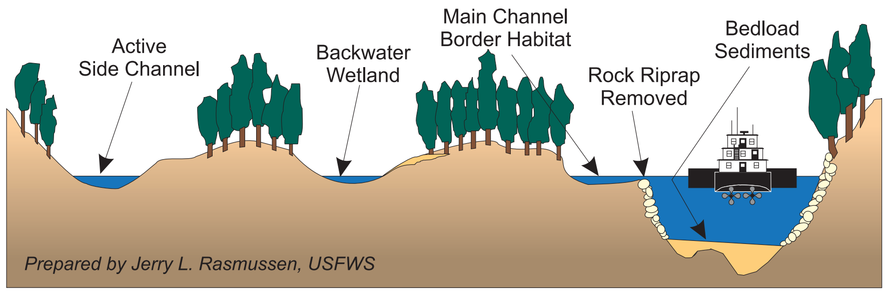

Figure 24. Removing some rock riprap widens river top width, recovers some bedload sediments, and allows excess channel water to "spill" onto the floodplain, rewatering habitats.

Looking closer at such a habitat bead from above (Figure 25), notched inlet structures could be placed at the upstream ends of any new channels. This would serve a dual purpose, preventing river bedload sediments from entering and filling the new channels and wetlands, and also preventing the new channels from capturing too much of the main channel flow, avoiding disruption to any navigation or water supply needs.

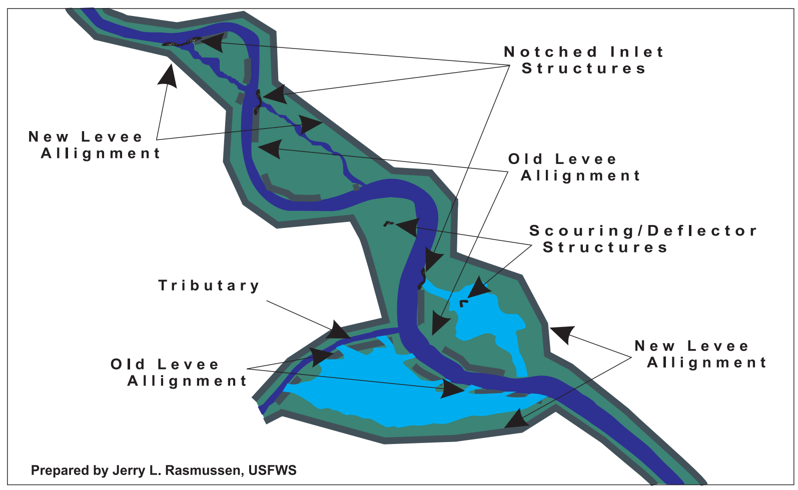

Figure 25. Notched inlet structures and deflecting/scouring devices would protect main channel integrity and promote floodplain scour in desired areas.

Even within many habitat beads, dry year farming would be desirable (Figure 26). As with refuges on other rivers, farmer cooperators could operate on a crop share basis, sharing the risk of gain or loss with the public or non-public owners. These habitats could thus be owned by any combination of federal, state, local, or private entities, but to properly address ecosystem needs they should be linked together through some form of intergroup, cooperative management agreement or plan.

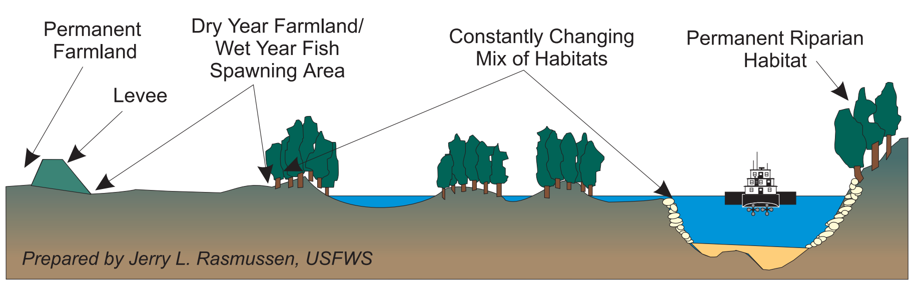

Figure 26. Dry year "cooperative farming" could be used to enhance wildlife habitat in many managed habitat beads.

Eventually in this vision, we could have restored floodplain habitats strategically placed along many of our Nation's rivers.

These habitats would not only address ecosystem needs, but would also provide significant beauty as well as space for flood water storage and conveyance, thus providing a significant margin of flood protection for nearby lands. It is likely, that once the word got out of these benefits, every city and town along our rivers would want one or more of these restored reaches nearby, not only to provide a margin of flood protection, but also as sources of revenue, beauty and recreation.

Figure 27. A comparison between a natural river (left) and a channelized river or a "river on drugs" (right).

The goal of large river fisheries managers is thus to restore some semblance of "dynamic equilibrium", at least to portions of our great rivers. Restored reaches might look something like that shown on the left in Figure 27, moving away from the more sterile paradigm of the past shown on the right. Through proper management, we can maintain both quality economic and ecological systems, but to accomplish such a goal, every stakeholder must be willing to share these great resources. We must move beyond the age of domination by single purpose uses such as commercial navigation, flood control, or hydropower.

Many scientists and resource managers worked on that issue with the White House Floodplain Management Review Committee in response to the 1993 midwest floods (Interagency Floodplain Management Review Committee 1994). Collectively, physical and biological scientists developed the vision shown in Figure 28 for future floodplain management. It incorporates a balance of both artificial and natural means of flood control. This vision would include:

- High elevation (100 year) levees to protect metropolitan areas and critical infrastructure,
- Medium elevation (50 year) levees to protect other prime development zones, and
- Low elevation (10 year) levees to protect farmlands,
- Many levees would be:
  - setback away from the river to provide for flood water storage and conveyance, as well as for wildlife habitats,
  - provided with gates to allow freshwater to enter old sloughs during dry periods, and
  - provided with spillways at the lower ends to prevent upstream breaching during extreme high water events, and to avoid the tremendous floodplain scour seen in the aftermath of the 1993 flood,
- Floodplain wildlife refuges or "habitat beads" would be strategically placed at tributary confluences and in low lying areas of the floodplain,
- Highways and railroads crossing floodplains would be elevated to encourage flood water conveyance by avoiding any floodplain obstructions,
- Small towns would be relocated out of the floodplains,
- Parks and bottomland forests would be encouraged in some open space areas,
- Upland land treatments would be improved to slow runoff, and
- Wetlands would be restored to the landscape wherever possible.

While this 21st Century floodplain vision is based on science as well as common sense, it will take time and political will to implement. Attitudes and old paradigms are difficult to change.

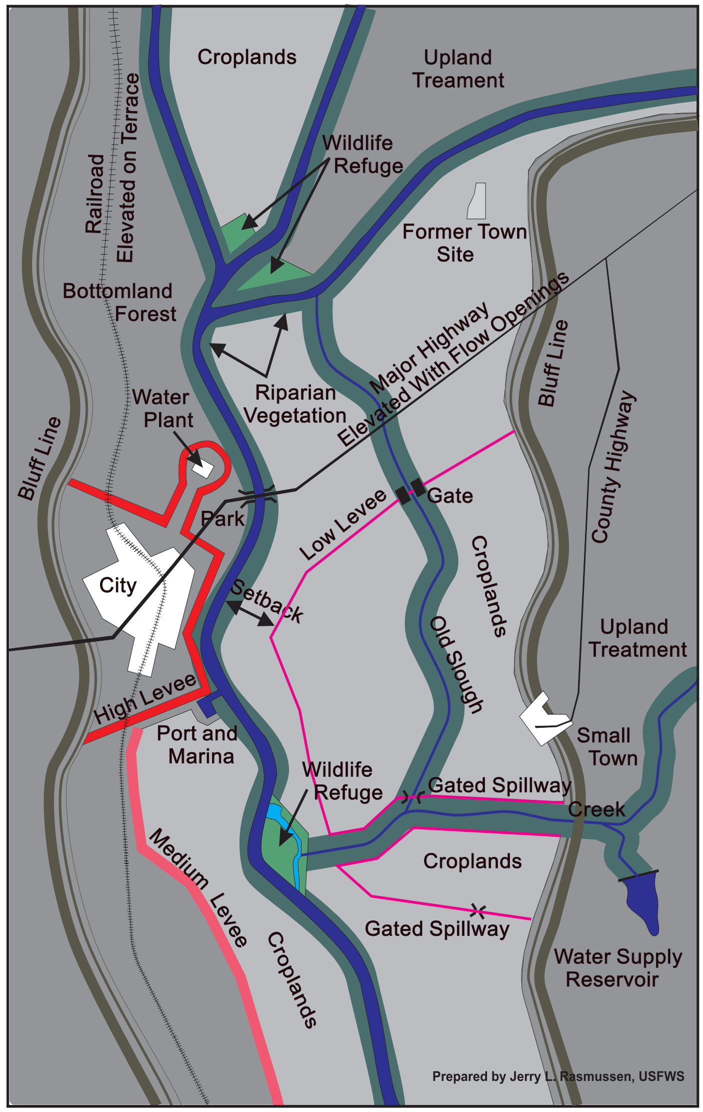

Figure 28. Vision for 21st century floodplains.

We were able to implement some features of the vision in the aftermath of the 1993 flood, but the public memory of such disasters is short, and its easy for unscrupulous politicians and greedy landowners to persistently push new flood control projects through Congress, once the memory of flooding and the cost of recovery is dim in the public mind.

Resource managers and scientists will have to remain equally persistent to continue implementation of this new floodplain vision. The American Fisheries Society (AFS) is developing its own floodplain management policy for just this purpose (Rasmussen 1996). It was largely based on the vision shown in Figure 28.

As scientists, citizens, taxpayers, responsible adults, parents and grandparents we owe it to ourselves, but more importantly we owe it to our children and grandchildren to pursue this vision and to be involved in the decision making process and help shape the future of our rivers and their biota. The era of massive river development projects seems to be coming to an end, and we need to be players in bringing common sense and continued relief to our long over stressed river ecosystems.

References

Bayley, P.B. 1991. The flood pulse advantage and the restoration of river-floodplain systems. *Regulated Rivers: Research & Management*, Vol. 6, pp. 75-86.

Delaney, R. L. 1995. Sustaining the Ecological Integrity of Large Floodplain Rivers; Synthesis of International Conference, July 12-15, 1994. La Crosse, Wisconsin. In: *The Upper Mississippi River: Sustainable Redevelopment Alternatives*. Northeast-Midwest Institute. 218 D. Street S.E., Washington, D.C. pp. 41-43.

Interagency Floodplain Management Review Committee. 1994. Sharing the Challenge: Floodplain Management into the 21st Century. Washington, D.C. 189 pp + Appendices.

Junk, W.J., P.B. Bayley, and R.E. Sparks. 1989. The flood pulse concept in river-floodplain systems, pp. 110-127. In: D.P. Dodge (ed.) *Proceedings of the International Large River Symposium.* Can. Spec. Publ. Fish. Aquat. Sci. 106.

National Research Council. 1992. Restoration of Aquatic Ecosystems. National Academy Press, Washington, D.C. 552 pp.

Rasmussen, J.L. 1996. Floodplain Management. AFS Position Statement. *Fisheries*. 21(4):6-9.

Sparks, R. E. 1995. The Great Flood of 1993: Environmental Effects and Recommendations. In: *The Upper Mississippi River: Sustainable Redevelopment Alternatives*. Northeast-Midwest Institute. 218 D. Street S.E., Washington, D.C. pp. 5-9.

U.S. Fish & Wildlife Service. 1980. Fish and Wildlife Coordination Act Report - Missouri River Stabilization and Navigation Project Habitat Restoration. U.S. Fish & Wildlife Service, Ecological Services, North Kansas City, MO. 77 pp.

Please Cite As Follows:

Rasmussen, J. L. 1996. Forty Years of Controversy and Achievement in North American Fisheries — Riverine Fisheries. Paper Presented at American Institute of Fishery Research Biologists Symposium: *"Forty Years of Controversy and Achievement in North American Fisheries"*. Held in conjunction with the 126th Annual Meeting of the American Fisheries Society, August 28, 1996. Dearborn, MI. 19 pp.

Other suggested reading:

Cowx, I.G. and R.L. Welcomme. 1998. Rehabilitation of Rivers for Fish. Fishing News Books, a Division of Blackwell Science, Ltd., London. 260 pp.

Calow, P. and G.E. Petts. (Eds.). 1994. The Rivers Handbook, Blackwell Scientific Publications, London. Volumes 1 and 2.