ENVIRONMENT

One Step Forward, Two Steps Back on U.S. Floodplains

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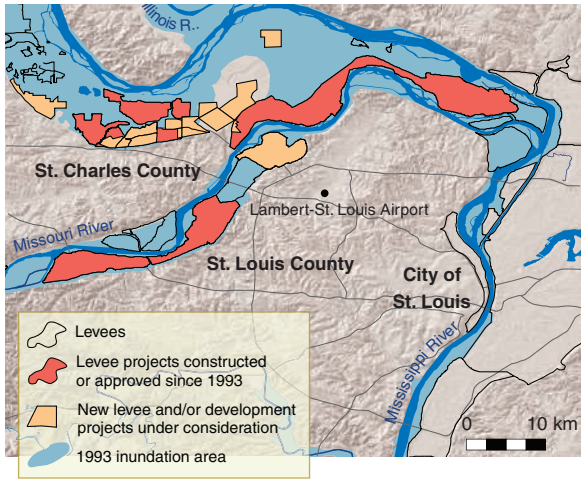
The great Midwestern flood of 1993 broke flow records along 1600 km of the Mississippi and Missouri rivers and caused up to $16 billion in damages (*1*, *2*). Formal reviews of U.S. flood-control policy, both before and after the 1993 flood, concluded that the optimum strategy for reducing flood losses is to limit or even reduce infrastructure on floodplains. New emphases on flood-damage prevention included widely publicized Federal Emergency Management Agency (FEMA) buyouts of floodplain properties. In Illinois and Missouri, the two most heavily impacted states, 7700 properties were acquired at a cost of $56.3 million, including the relocation of the town of Valmeyer, Illinois (*3*). Unfortunately, these buyouts are now being massively counterbalanced by new construction on the floodplains. The center of this recent rush onto the floodplain is the St. Louis metropolitan region (see figure, right). This paper explores the impacts of such encroachment, including raising future flood levels, and outlines alternatives that have been proposed and implemented worldwide.

It has been asserted that flood-control structures prevented $19 billion in damages during the 1993 flood; however, most infrastructure on the floodplain would not be there were it not for the historic reliance on levees [e.g. (*4*–*7*)]. Since 1993, the amount of such infrastructure has increased dramatically: 28,000 new homes were built, population increased 23%, and 26.8 km^2 (6630 acres) of commercial and industrial development were added on land that was inundated during the 1993 flood (*8*). In all, $2.2 billion in new development has occurred in the St. Louis area alone on land that was under water in 1993 (*3*).

The majority of this floodplain development has occurred in the state of Missouri, and around St. Louis in particular. Of the total new commercial and industrial development in the 1993 inundation area, 76% was located in Missouri, and 60% in St. Louis and St. Charles counties alone (*8*). Since 1993, projects now complete, under way, and in planning have put or will put 72.8 km^2 (18,000 acres) of the Mississippi and Missouri floodplains near St. Louis behind new levees, enlarged enlarged levees, or floodplain land raised above the 100-year to 500-year protection level (see figure, above). Most of these projects have been financed or heavily subsidized by local governments in each area. The U.S. Army Corps of Engineers also has spent $197 million working on nine local levees in its St. Louis District since 1993 (*3*).



A surge of floodplain development. Levee and floodplain development projects in the greater St. Louis, Missouri, area. This map includes new and enlarged levees and elevation of floodplain land completed since 1993 and development projects under review or proposed. Data sources: levee boundaries and inundation area (*33*), completed projects (*3*), and projects under review, courtesy of Great Rivers Habitat Alliance.

Floodplain development projects in the United States are constrained by FEMA guidelines under the National Flood Insurance Program (NFIP), by wetlands protections specified in the Clean Water Act and administered by the Corps of Engineers, and in some locations by more stringent state and local regulations. The NFIP guidelines limit development in the central portion of the floodplain (the "floodway"), but allow virtually unlimited development across the rest of the floodplain so long as developed areas are either raised above the level of the 100-year flood (the event with a 1% chance of occurring in any year) or protected by levees with at least 100-year protection.

Among the broadest criticisms of flood control by levees is that development in levee-enclosed areas promotes the false expectation that flood risk is reduced to zero. As a National Academy of Science panel concluded, "it is short-sighted and foolish to regard even the most reliable levee system as fail-safe" (*4*). Currently, FEMA removes areas protected by 100-year levees entirely from their flood-hazard maps. Proposals to elevate or protect areas of the floodplain by levees typically must also obtain wetland fill permits from the Army Corps of Engineers under Section 404 of the Clean Water Act. Such permit requests must demonstrate that the project will not unduly impact the "public interest," including adversely affecting flood hazard. In the St. Louis region, requests for wetland fill permits have been granted despite a long history of research documenting adverse effects of levees, including that they have contributed to increased flood levels.

The magnitudes and frequencies of flooding on the Mississippi and Missouri rivers have increased dramatically during the past century [e.g. (*9*–*16*)]. This conclusion has been sidestepped by an often-repeated assertion that "The floods of the Mississippi River Basin are ... acts of God, which man cannot prevent" (*17*). More recently, "… the Great Flood of 1993 ... was not caused by levees, loss of wetlands, navigation structures, flood plain development, or any of several other reasons that have been brought up by various individuals. The flood was caused by unprecedented rainfall" (*18*). That floods are caused by rainfall is self-evident, but this truism camouflages an implication—that various human influences on the river-floodplain system have no impact—that is controverted by extensive research. As the General Accounting Office summarized, "That levees increase flood levels is subject to little disagreement" (*19*). Along the lower Missouri River and the Mississippi River near St. Louis, increases in flood levels of up to 3 to 4 m during the past century have been documented (*12*–*14*).

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Part of the failure to recognize flood magnification owing to levees is because incremental levee expansion projects are evaluated individually, even when many projects are proposed for a given river reach. Uncertainties in modeling relatively small encroachments allow a "fuzzy math" sufficient to assert that each incremental increase in flood levels will be negligible. Corps of Engineers permit regulations state that "Although a particular alteration to a floodplain may constitute a minor change, the cumulative impact of such changes may result in a significant degradation of floodplain values and functions and in increased potential for harm" (*20*). Instead, project permits are being issued on an individual basis, resulting in a "death by a thousand blows" through the incremental loss of floodplain land to development.

To gain a broader sense of whether the surge of floodplain development in Missouri is typical of floodplains across the United States, the Lexis/Nexis full-text database was queried for all references to floodplain development or encroachment. Of 53 major newspapers tracked in the database, 62% of all articles and editorials discussing floodplain encroachment in the past 5 years were in a single newspaper, the *St. Louis Post-Dispatch*. Although St. Louis appears to be the epicenter of the problem, development is overwhelming floodplains in a number of other locations. For example, in Sacramento, California, at least 60,000 new homes and billions of dollars of new infrastructure have been recently built or are planned on several floodplain tracts of the American, Feather, and Sacramento rivers (*21–23*). In contrast, other U.S. municipalities—including Denver and Boulder, Colorado; Austin, Texas; Phoenix, Arizona; and Charlotte, North Carolina—have limited encroachment and guided development to more compatible locations and land uses. The explosion of floodplain development around the city of St. Louis and other areas of Missouri appears to be linked to state-level floodplain laws that are among the weakest in the United States. For example, although NFIP guidelines state that no construction in the floodplain should result in more than a 30-cm (1.0-ft.) increase in flood level, other states specify more stringent thresholds. Missouri has passed legislation that prohibits any county from setting any threshold stricter than the 1.0-foot limit (*24*).

The 1982 National Academy of Science report on levees and flood hazard warned that "Adoption by municipal governments of a program of constructing flood control levees raises questions of potential liability for any flood damages that result from improper design or maintenance of such systems" (*4*). A growing body of precedents, including two cases in California during the past year (*25*, *26*), have held municipal, county, and state governments liable for flood damages where those governments encouraged floodplain encroachment or managed flood-control systems that altered natural flooding patterns. Levee failures have been responsible for roughly one-third of all flood disasters in the United States (*4*), and these damages would have been avoided if different floodplain management decisions had been made at the onset (*27*).

Alternatives can be found to the heavy reliance in the United States on structural flood-control measures. In Europe, following severe flooding on the Rhine River in 1993 and 1995, the Dutch government has dramatically shifted its approach to flood control to a policy of "more room for the rivers," meaning creating new storage and conveyance space rather than indulging in new rounds of levee raising (*28*, *29*). On the Meuse River, France, Germany, Belgium, Luxembourg, and the Netherlands adopted the Meuse High Water Action Plan, focused on "land use activities from a water perspective," longer storage and slower release," and "space for the river" (*30*). These programs are not merely theoretical proposals. Since 1988, the Integriertes Rheinprogramm of the state of Baden-Württemberg, Germany, has reduced peak flood stages to 1950 levels by adding 212 million m^3 of storage on the floodplain (*31*). In the Netherlands, the "Room for the Rhine" doctrine was adopted in 1997, and the Dutch government has committed $3 billion to a broad toolbox of levee alternatives (*29*, *30*). In the United States, a blueprint for floodplain management called "No Adverse Impact" has been developed by the Association of State Floodplain Managers, in which "the action of one property owner or community [should] not adversely affect the flood risks for other properties or communities" (*32*).

Thanks to Federal guidelines, buyouts, and enlightened management in many localities, successes in managing U.S. floodplains outnumber the failures. The problem is that when these measures succumb to local economic self-interest and political pressure, small local failures—like cracks in levees themselves—allow massive increases in floodplain infrastructure that can rob the nation of all the net improvements painstakingly won elsewhere. In spite of the lessons learned during the 1993 flood, the St. Louis region and selected other localities across the United States are seeing their floodplains disappear behind new and enlarged levees and under new urban and suburban development.

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