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FEATURE

# Impacts of 2008 flooding on agricultural lands in Illinois, Missouri, and Indiana

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The 2008 spring rains in Illinois, Missouri, and Indiana delayed planting, drowned corn and soybean plants, and resulted in significant replanting. From May 30, 2008, to June 12, 2008, the previously saturated soils could not retain any more rainfall, and the wetlands, potholes, and depressions in the upland landscape filled with water (figure 1) and then began to runoff through waterways and into small streams (figure 2). As much as 30% of the upland soils in south central Illinois, northern Missouri, and southern Indiana were affected by ponding. Approximately one-third of that ponded acreage was not replanted in 2008. As overland flow started to occur, so did sheet, rill, and gully erosion. Where significant topsoil loss occurs, it can eventually result in the erosion phase change of the soil. Any soil erosion phase change from slightly to moderately or severely eroded can reduce the crop yield potential from 0.3 to 1 Mg ha$^{-1}$ (5 to 15 bu ac$^{-1}$), depending on whether the soils have favorable or unfavorable subsoils for rooting. One year's erosion events do not change the erosion phase of the soil unless gullying occurs. However, the 2008 soil loss, when added to the soil loss from erosion in previous years, could eventually result in a soil erosion phase change.

Corn and soybean planting in Illinois and Indiana was more than three weeks behind schedule by May 30, 2008, due to the wet and cool weather conditions. Many of the soils remained near saturated conditions at that time. During the next two weeks, much of southern Indiana and south central Illinois received 20 to 30 cm (8 to 12 in) of rain with little being stored in the soil. This resulted in local flooding by mid-June of 2008 with levees breaking on the Embarras (figure 3), White, and Wabash rivers which drain into the Ohio River. Towns affected by flooding and levee breaks included Maysville, Indiana; Meyers, Illinois; and Lawrence, Illinois.

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**Figure 1**

Photograph taken from a plane showing ponded depressions and pot holes on the uplands in central Iowa after heavy June 2008 rain. Photo credit: Eddie Miller, Benson Motor Inc., Ames, Iowa.

**Figure 2**

Waterway in central Iowa full of rapid runoff water moving and overflowing into the surrounding pasture on May 30, 2008. Photo credit: Lois Wright-Morton, Iowa State University, Ames, Iowa.

**Figure 3**

**Full temporary storage ponds surrounded by flooding from Embarras River near Sainte Marie, Illinois, in June of 2008. Photo credit: Ken Flexter, Jasper County NRCS Field Office, Newton, Illinois.**

Thousands of hectares (thousands of acres) of agricultural lands were impacted. Much of the 2008 corn crop planted by June 8, 2008, on floodplain soils was lost due to flooding, and many areas did not dry out sufficiently for crop planting until after July 15, 2008, making it too late to replant. In these areas, the 2008 crop loss was total.

The areas that were not protected by levees and flooded only received a thin layer of silt and clay. The 2008 crop was lost, but soils did not suffer permanent damage. This was not the case where levees failed. Water removed hundreds of meters (hundreds of feet) of the levee embankments (figure 4) and eroded thousands of cubic meters (thousands of cubic feet) of soils and underlying outwash parent material to depths of 3 to 6 m (10 to 20 ft) below the base of the earthen levee when the levees broke (figure 5). The force of the rushing water uprooted trees growing between the river and the levee prior to the break and deposited them on the previously protected floodplain (figure 6). The 2008 crop on the floodplain soils behind the broken levees was a total loss.

This situation happened at two levee breaks southeast of Sainte Marie, Illinois. About 90 m (295 ft) of levee was lost at each break. Blowout holes or craters were created that were 0.4 to 1.2 ha (1 to 3 ac) in size and held water. One to three meters (3 to 10 ft) deep gullies extended a few hundred meters (few hundred feet) into the previously protected floodplain, and hundreds of 20 m (65 ft) high trees were transported hundreds of meters (hundreds of feet) onto the previously protected floodplain. Deltaic sand deposits up to 0.5 m (1.6 ft) thick covered 30 ha (74 ac) or more on the floodplain at each site, with an additional 80 ha (198 ac) covered with a few centimeters (few inches) of sand. The remaining hundreds of hectares (hundreds of acres) of previously protected floodplain soils received a thin coating of silt and clay and remained under floodwaters long enough to drown out this year's crop if it was planted and not already removed by the wall of advancing water. The road and drainage ditches on the previously protected floodplain were also filled with sand more than 2 km (1.2 mi) from the levee break. By June 23, 2008, the water had drained from the floodplains and back into the Embarras River, sufficiently for the local farmers to hire contractors with bulldozers, pans, graders, back hoes, and buckets to begin the task of moving the trees from near the blowout holes and floodplain and to begin filling in the craters and gullies (figure 7). In addition, they began creating temporary levee embankments either around the blowout hole or across it to prevent any future flooding. The material for the temporary levee was obtained from the thick sand deposit beyond the blowout holes, transported to the edge of the blowout hole or crater and then compacted by a bulldozer. Other equipment was used to scrape and pile the

**Figure 4**

**The Embarras River cutting through a levee near Sainte Marie, Illinois, in June of 2008. Photo credit: Ken Olson, ACES, University of Illinois, Urbana, Illinois.**

**Figure 5**

In the background is the Embarras River, Illinois, adjacent to the missing 90 meter section of the levee and the crater lake that was created by rushing waters. Photo credit: Ken Olson, ACES, University of Illinois, Urbana, Illinois.

**Figure 6**

Agricultural fields covered by deltaic sand deposits, water, and trees moved and deposited by rushing water through a levee break on Embarras River, Illinois. Photo credit: Ken Flexter, Jasper County NRCS Field Office, Newton, Illinois.

sand either for use in the temporary dam or to fill in parts of the craters and gullies. Tillage equipment, such as chisel plows and moldboard plows, were used on the areas with thin sand deposits (<15 cm [<6 in]) in an attempt to mix the sand into the underlying silty and clayey topsoil.

The first question raised by an equipment operator was: "Where did all the sand come from?" He seemed to know that most of the surrounding Illinois soils were low in sand content. In fact, most of the upland soils formed in loess have less than 3% sand, and even the bottomland soils in the area have less than 15% sand. Apparently, the sand came from sand bars that may have developed in the river as the fine silts and clays were carried beyond where the sand dropped onto the river bed. Also, the area is just south of the Wisconsin terminal moraine that was also topped thousands of years ago by rising water moving rapidly and depositing sandy outwash in the existing Embarras River valley. This underlying outwash is higher in sand and may have been used to create the levee embankment in the 1920s and 1930s. It is the parent material under the current alluvial soils at depths from 1 to 8 m (4 to 26 ft). The levee itself contained a higher sand content than the soils in the area, and significant sections of the levee were removed in addition to soil from the deep blowout hole. When the current Embarras River cut through the levee and dissipated sufficient energy to slow the water flow down, the sand dropped out and the remainder of the finer soil materials were carried further out into the valley floodplain.

Landowner questions included, "Are the current soils in the floodplain without levees or with levees that broke damaged by flooding?" and if so, "How can they be restored?" When water flows over alluvial soils not protected by a levee, the rising water level does not normally cause significant soil erosion damage in the form of sheet, rill, or gully erosion. The unprotected alluvial soils often receive a thin layer of sediment which can usually be mixed into the underlying topsoil with tillage equipment. However, when a levee fails, a few-hectare (several-acre) blowout hole becomes a pond, resulting in the permanent loss of floodplain soils and agricultural land. Additional damage can be caused by the adjacent thick sand deposits, burying the underlying soils with up to 0.5 m (1.6 ft) of sand and creating a deposit or delta which can cover 30 ha (74 ac) or more. This sand deposit has to be removed or the soils will remain too droughty for growing row crops in future years. The soils in the area that receives less than 15 cm (6 in) of sand can often be mixed with the underlying silty and clayey soils and farmed in future years. Future crop yields may or may not be affected depending on the success of the mixing.

During the same May 30, 2008, to June 12, 2008, time period, 20 to 30 cm (8 to 12 in) or more of rain also fell on all of Iowa, southern Wisconsin, north-

## Figure 7

Sand being piled with a backhoe bucket for transport off the agricultural lands previously protected by a levee. Photo credit: Ken Olson, ACES, University of Illinois, Urbana, Illinois.


ern Illinois, southeastern Minnesota, and northern Missouri. Most of the national news coverage focused on Iowa where Cedar and Iowa rivers flooded the towns of Cedar Rapids and Iowa City. Later, the Mississippi and Missouri Rivers flooded farmland not protected by levees and where levees broke during the next few weeks as floodwaters peaked down river. The Mississippi River peaked at St. Louis, Missouri (near the point where the Missouri River flows in) on July 1, 2008, but at a lower height than during the 1993 flood. In 2008, there were no levee breaks on the Mississippi River south of St. Louis, but there was flooding of agricultural lands and local roads in the floodplain. The raising floodwaters on the Mississippi River did cause evacuation of residents in towns such as Winfield, Missouri, Meyers, Illinois, and Keithsburg, Illinois; closed many local roads and bridges; and flooded adjacent agricultural lands. These levee breaks had the same effects on adjacent floodplain soils as noted above in the Ohio River tributaries discussion.

How did various soil conservation practices fare? During the last 30 years, many soil and water conservation practices and structures were no longer utilized and soil erosion standards were met using conservation tillage and no-till systems. Most remaining terraces, contour farming, strip cropping, and waterways were effective. However, many waterways were filled above capacity and were eroded by fast-moving water or had significant sediment deposition. Culverts and other drainage structures were often plugged by soybean and corn residue, primarily from no-till systems residue. No-till systems did reduce raindrop impact and erosion, but once overland flow started on sloping lands, the residue was transported into the streams, blocked drainageways and structures, and resulted in local flooding of fields and even highways. Water storage structures, such as retention ponds, filled quickly with water and in some cases were covered by floodwaters. Risers and tile outlets were often insufficient to drain crop areas within 24 or 48 hours, resulting in significant numbers of corn and soybean plants lost. Some areas were eventually replanted to corn or soybeans.

Floodwaters in 2008 on floodplains without levees resulted in 100% crop loss, and floodplain soils often received thin silt, sand, or clay deposition, which could be mixed with tillage equipment into the topsoil prior to planting the 2009 crops. Floodplains with levees that held usually had little 2008 crop lost, except where tributary streams ponded water behind the levees. However, floodplains with levees that broke lost both the 2008 crops and agricultural land. Lands adjacent to levee breaks were subject to rushing water which often created blowout holes or craters, resulting in total loss of soil profiles as the area became a pond. Thick sand deposits often tens of hectares (tens of acres) in size occurred adjacent to the blowout hole in the form of a sand delta. These deposits could lower future yields of buried alluvial soils and resulted in up to 100% crop loss in 2008. Thin sand and silt deposits on hundreds of thousands of hectares (hundreds of thousands of acres) in floodplain (alluvial soils) will probably have limited impact on future soil productivity if sediment is tilled into the topsoil despite 2008 total crop loss.

Why were Illinois, Missouri, and Indiana vulnerable to flooding in 2008? The Mississippi River received a lot of floodwater from Wisconsin, Minnesota, and Iowa at a time when there was also a lot of local (Illinois and Missouri) runoff. Both sources contributed to levees breaking north of St. Louis, Missouri. Indiana was obviously not affected directly by the Upper Mississippi River flooding event but was affected by Ohio River tributary flooding. Central Indiana, northern Missouri, and south central Illinois received 12 to 30 cm (5 to 12 in) of rain in the 2 weeks at the end of corn and soybean planting season (late May and early June) when the soils were already saturated. Other watersheds had a high slope gradient with even greater runoff potential. The hydrologic soil groupings in some watersheds also affected the runoff rate. The crop rotation in Illinois, Missouri, and Indiana is up to 90% corn and soybeans, with limited acreage in small grains and forages. Further, urban and highway development in floodplains within the Mississippi, Missouri, and Ohio River watersheds contributed to flooding problems. Drainage systems in the upland designed to remove excess water to open outlets in 24 hours reduced crop plant loss but contributed to higher flooding levels on floodplain soils. Currently, fewer soil conservation structures and retention ponds are being built and maintained than in the past. Many levee breaks occurred despite efforts to rebuild, raise, and strengthen the Mississippi and Missouri levees following the 1993 flooding. In Missouri, significant acreage of unprotected agricultural lands was converted to fish and wildlife use.

Agricultural lands were permanently lost when adjacent to levee breaks. In some situations, the land owners were patching the private levees, filling in the craters and gullies, removing the thick sand deposits, and tilling the thin sediment deposits into the topsoil to prepare for the next year's planting season.

## RECOMMENDATIONS

If one only focused on agricultural land and perhaps what could have been done to reduce the flooding impact, it would be important to separate watersheds with well-drained soils and high-slope gradients from watersheds that are relatively flat with poorly drained soils. In flat watersheds with poorly drained soils, such as the Embrarras River watershed (Illinois), most soil and water conservation practices only include waterways, conservation tillage, and no-till systems. Historically, the biggest management problem was soil drainage. Many of the soils were too wet to grow row crops. This was addressed with the 1879 Illinois drainage law which permitted digging drainage ditches, channelization, surface drainage, and subsurface tile drainage with the goal of removing surface ponding within 24 hours to prevent corn plants (soybeans had not yet been introduced) from drowning and to permit cropping. The only measures taken to reduce flooding in wet years were to build private levees near the banks of the streams and rivers which reduced the width of the floodplains but protected, in most years, the adjacent agricultural cropland on the floodplain soils from crop loss. Significant crop loss and damage to floodplain soils only occurs when levees break. Potential solutions to reduce the flooding impact on agricultural lands in flat watersheds with poorly drained soils could be to create temporary water storage structures (which would take additional agricultural lands out of production), change the crop rotation in the upland to include more forages rather than row crops, convert more of the agricultural land to timberland or grassland that can utilize or store more water, build higher and stronger levees that are located farther from the river banks to widen the river flow channel, accept periodic levee breaks and associated damage as a consequence of agricultural production in the floodplain, consider removal of existing levees, or stop using the floodplain soils for agricultural crop production (land ownership might have to be transferred from private to public) and convert land to conservation use (wildlife, prairie, and timber) and restore the periodic water storage function to the natural floodplain.

In more sloping watersheds, such as the Iowa and Cedar River watersheds (Iowa) or similar ones in Missouri, southern Indiana, and southern Illinois, most of the soil and water conservation practices have focused on soil erosion control and have included terraces, waterways, contour farming, strip cropping, grass waterways, and upland water storage dams. Soil drainage is not required for most well-drained soils in the upland, and drainage systems (drainage tile and waterways) have been used to safely remove water from the upland without soil erosion. Terraces usually drain to tile outlets or waterways. In the sloping watersheds, the heavy rains create both soil erosion and flooding problems. Ways to reduce the impact of flooding on agricultural lands on the floodplains would be to slow the runoff and land drainage rate, temporarily store more water on the uplands, change the upland crop rotation to include more forages rather than row crops, convert additional agricultural land to pasture, timber, or forages so the soils can infiltrate, use or store more water, build stronger and higher levees on the floodplains but further away from the streams and rivers to widen the stream or river channel, or stop farming the floodplain soils and change the land use to ones that do not sustain damage during periodic flooding.

In conclusion, the 2008 flooding severity within the Mississippi River basin depended on where the watershed was located. In Southern Wisconsin or Iowa, it was the worse flooding in 500 years; in the Embarras River watershed (Illinois), it was the worse flooding in 100 years; and near St. Louis, Missouri, on the Mississippi River, it was the most severe flooding in past 15 years. The National Oceanic and Atmospheric Administration weather map of the May 30, 2008, to June 12, 2008, time period clearly shows that where 25 cm (10 in) of rain fell on already saturated soils, the result in Upper Mississippi River and tributaries was flooding, crop loss, and erosional damage to levees and adjacent agricultural bottom lands. However, as these waters moved southward during the month of July, it was a rather uneventful period for the Lower Mississippi River south of Illinois, Missouri, and Indiana.