Impacts of Levees on Floodplain Ecosystems

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Summary

- Levee
  - Levee/levee system
  - Levee Types

- Floodplain
  - What is a floodplain?
  - Monetary benefits of floodplains

- Floodplain Ecosystems
  - Interaction between Levees & Floodplains Ecosystems
  - Ecosystems restoration
  - Impacts of levees on floodplain ecosystems
Levees & Levee Systems

- Levee?
  - A man-made structure
  - Designed and constructed in accordance with sound engineering practices
  - Provides protection from temporary flooding?
    By Containing, controlling or diverting the flow of water

- Levee System?
  - A group of levee segments and flood control structures having features in common:
    1) protect the same area from the same waters
    2) function as one homogeneous unit.
Levees / Floodwalls
Levee Categories

- Urban Levees
- Agricultural Levees
Levee Types

- Mainline & Tributary Levees
- Spur Levees
- Ring Levees
- Sub Levees
- Setback Levees
Levee Types

1) **Mainline and Tributary levees**
   - Generally parallel to the channels.

2) **Ring levees**
   - Completely encircle an area.

3) **Setback levees**
   - Generally built as backup to an existing levee, which has become endangered because of river migration etc.
Levee Types

4) Sub-levees
- Constructed for under-seepage control
- Encircle areas landside of main levee flooded by seepage water
- Counterbalance the hydrostatic pressures beneath the top stratum

5) Spur Levees
- “Project-out” from the main levee
- Protect the main levee by directing erosive river currents towards the river
Floodplains

1. Floodplain?

- Floodplains are the low, flat, periodically flooded lands adjacent to rivers, lakes and oceans and subject to geomorphic (land-shaping) and hydrologic (water flow) processes.

- For land use planning purposes, the regulatory floodplain is usually viewed as all lands within reach of a 100 year flood. The Federal Emergency Management Agency (FEMA) produces floodplain maps, defining what’s in and out of the 100-year (or “regulatory”) floodplain in order to implement the National Flood Insurance Program.
Floodplains

- A floodplain represents a natural filtering system, with water percolating back into the ground and replenishing groundwater.

- Floodplains are extremely productive ecosystems both in quantity and diversity.

- A floodplain can contain 100 or even 1,000 times as many species as a river.

- Wetting of the floodplain soil releases an immediate surge of nutrients: left over from the last flood, and from the rapid decomposition of organic matter that has accumulated since then.
Floodplains

- Monetary Benefits

  - Flood Attenuation
    - Floodplains provide floodwater storage and conveyance, reduce velocities and flood peaks

  - Fisheries
    - Floodplains provide an excellent habitat for fish and wildlife by serving as breeding and feeding grounds.

  - Groundwater Recharge

  - Wetlands and Marsh
Floodplains

- Monetary Benefits
  - Habitats for endangered species
  - Water Filtration
  - Recreation
    - Wetlands provide countless hours of recreation through hunting, photography, and study of the nature
Floodplains

- Monetary Benefits
  - Agricultural benefits

  The production of nutrients peaks and falls away quickly; however the surge of new growth endures for some time.

  This makes floodplains particularly valuable for agriculture.
Ecosystem Restoration

- Nonstructural Flood Damage Reduction Measures
  - Modify the characteristics of buildings and land use within floodplain without changing flood characteristics.

- Structural Measures (Levees & Dams)
  - Modify flood characteristics & do not modify characteristics of buildings or land use within the floodplain.
  - Levees disturb or alter floodplains by disconnecting the floodplains from their main channel.
Levees and Natural Systems

- The relationship between levees and natural systems is complex.

- Levees reduce flood risk and protect thousands of lives and billions of dollars of critical infrastructure.

- Their timely maintenance is imperative.
  - The maintenance may have some negative environmental impacts, that can not be ignored.
  - The environmental impacts caused by maintenance must be minimized.
Vegetation, Trees and Shrubs

- Compromise the structural integrity of levees by providing pathways for seepage, destabilizing soils.
- Provide obstacles in the ability for levee operators to inspect the levee and perform emergency operations.
- Such vegetation can be necessary for the survival of some aquatic and terrestrial species.
- Provides shade that lowers water temperatures, providing habitat for threatened or endangered species.
- Water side vegetation may also be beneficial to the levee by providing erosion protection or discouraging burrowing animals.
Negative Environmental Impacts of Levees

- Cut off the river from its floodplain.
- Alter the natural hydrology of the area
  - by reducing recharge of aquifers.
  - preventing seasonal overbank flooding that can provide needed nutrients to soils.
- Enabling increased development that can lead to destruction of ecologically important riparian and coastal ecosystems such as wetlands and marsh.
Floodplains & Ecosystem

- Human Activity
- Floodplains
- Flood Pulses
- Ecosystem Structure & Function

Disturb
Govern
Floodplains & Ecosystem

• Flood pulses facilitate exchange of energy and nutrients between river and floodplain.

• Play a key role in plant distribution by affecting seed dispersal, vegetation establishment and sedimentation.
Stanley and Kang (2005) studied the effects of levees on soil attributes in a temperate river floodplains.

Floodplain associated with a 21 km long reach of Wisconsin River between Wisconsin Dells and Portage, Sauk County, WI was selected.

Study focused on physical and chemical characteristics as well as biological attributes including distribution of coarse woody debris and litter, and soil microbial activities inside levees, outside levees, and in no-levee floodplain areas.
The Stanley and Kang study concluded:

- No significant differences in the amount of organic matter or coarse woody debris, in areas outside the levee, compared to inside the levee.

- Significantly higher microbial activities (dehydrogenase, β-glucosidase, phosphatase) per gram organic matter for soils inside the levee.
LEVEE EFFECTS ON FLOODPLAIN SOILS

Source: Stanley and Kang, 2005
Microbial activities in the soils of the plots inside the levees, outside the levees and in no-levee areas in 1999 (A) and 2000 (B).

Source: Stanley and Kang, 2005
The above changes were attributed to:

- Modified hydrology
- Tree species composition
  e.g. higher number of Oaks outside the levee
Levees and Hydrologic Regime

Levees

Restrict the flow of inundation

May conversely increase flood duration and depth in the floodplain area between the river and levee
The hydrologic modification

- Has far-ranging ecological effects on the floodplain on both sides of the levees,
  1) modifying the forest composition,
  2) primary productivity,
  3) organic matter decomposition and
  4) nutrient cycling.
- Alters plant communities and the organic matter dynamics of floodplain.
Effects of Levees on Wetland Habitats

- Levees

- Prevent the lateral flow of sediment, nutrients, and organism between rivers and floodplains.

- Stop formation of temporary ponds and wetlands that form throughout the floodplain after flood events.

- Adversely impact wetland habitats. Temporary ponds and wetlands are used by a wide variety of species from waterfowl, fish, frogs, salamanders, and a wide variety of aquatic invertebrates.
Impacts of Human Alterations on Floodplains

• Hupp et al. 2009, studied impacts of human alterations on floodplain geomorphic and ecological processes. These include:

1. Dams along the lower Roanoke River, North Carolina.

2. Stream channelization in west Tennessee.

3. Multiple impacts including canal and artificial levee constructions in the central Atchafalaya Basin, Louisiana.
Impacts of Human Alterations on Floodplains

• These human alterations along stream channels and within catchments have affected fluvial geomorphic processes by reducing the ecosystem services that functioning floodplains provide.

• These alterations may negatively impact the natural ecology of floodplains through reduction in suitable habitats, biodiversity, and nutrient cycling.
We MUST protect wetland animals!
We must protect, natural wetland areas.
Conclusions

Construction of levees:

1. Decrease species diversity.
2. Decrease groundwater recharge.
3. Prevent lateral flow of nutrients and sediments.
4. Adversely impact wetland habitats.
Questions?