NCSE National Center for Science Education

River Team

Overview

Rivers are an important part of the hydrologic cycle. They transport water and sediment from high elevations to lower elevations. Rivers naturally adjust so that they can do the most "work" (moving water and sediment) using the least effort. Since rivers follow natural laws, scientists and engineers are able to make predictions about their behavior. This also means that when something disturbs a natural river, we can predict what interventions might help the river get back to its natural state of balance.

In this activity, you are a hydrologist traveling downriver, from the headwaters to the delta of a river in your care. Along the way, your river will experience disturbances; it is up to you to match interventions to disturbances.

Learning Goals

1. Introduction to fluvial processes.
2. Understand which interventions are appropriate to different types of disturbance in fluvial systems.

Materials

- Disturbance die
- Intervention cards
- Game pieces

Setup

1. Use the game cards to create a grid, text side up.
2. Set the disturbance die next to the grid.
3. Allow players to choose a meeple (small board game piece).
4. Place all game pieces on the first card in the grid.

Procedure

Short Form (form a 3x3 or 4x4 card grid)

1. A turn consists of rolling the disturbance die and moving your game piece if you are successful.
2. If the disturbance you roll matches the intervention card type, you are successful .
3. Move your game piece to the next card.
4. If the disturbance you roll does not match the intervention card type, your game piece does not move.
5. If you are unsure if the die and card are a match, you may look at the back of the card-matching symbols are a match.
6. Pass the disturbance die to the left.
7. The next player follows steps 2-6 8. The first player to reach the last card in the grid wins.

Definition of Success: *Players become familiar with the types of intervention used for different disturbances to river systems*.

Long Form (form a 6x6 card grid)

Follow all steps from the Short Form game, with the modification of a 6x6 grid.

Modifications and Guiding Questions

Allow players to examine cards prior to forming the grid. Allow players to move to the next card if they are able to identify whether the intervention card matches the disturbance, without checking the back of the card. Probability of dice roll matching card type on each roll: $P(A \cap B) = 0.0256$

Further Resources

- Water Quality Impacts of Forest Fires (U.S. Forest Service) https://www.fs.usda.gov/treesearch/pubs/48946
- The Legacy of Severe Wildfire on Stream Water Quality (U.S. Forest Service) https://www.fs.usda.gov/inside-fs/delivering-mission/sustain/legacy-severe-wildfires-stream-water-quality
- Wildfire and the Future of Water Supply (American Chemical Society) https://pubs.acs.org/doi/10.1021/es500130g

- How Wildfires Contaminate Drinking Water Sources (University of Colorado) https://www.colorado.edu/today/2018/06/19/how-wildfires-contaminate-drinking-water-sources
- Urbanization and water quality (USGS) https://www.usgs.gov/special-topic/water-science-school/science/urbanization-and-water-quality?qt-science_center_objects=0#qt-science_center_objects
- Nitrate: Health Effects in Drinking Water (Cornell University Cooperative Extension)http://psep.cce.cornell.edu/facts-slides-self/facts/nit-heef-grw85.aspx
- Water quality and the grazing animal https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_046596.pdf
- Water pollution: everything you need to know https://www.nrdc.org/issues/water-pollution
- USGS flood information (USGS) https://www.usgs.gov/mission-areas/water-resources/science/usgs-flood-information?qt-science_center_objects=0#qt-science_center_objects

NGSS Standards

K-ESS3-3 Earth and Human Activity

Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment.

MS-ESS3-3 Earth and Human Activity

Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

HS-ESS2-2 Earth's Systems

Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that causes changes to other Earth systems.

HS-ESS2-5 Earth's Systems

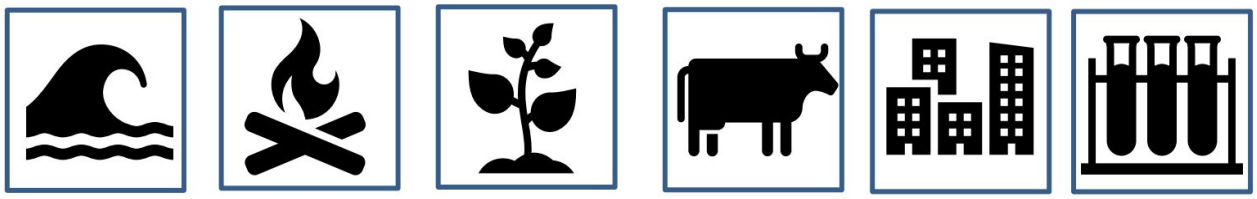
Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.

HS-ESS3-1 Earth and Human Activity

Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.

Intervention cards 6 for each (36 total)

Answer Key: Dice faces and card backs



Flood **Fire** **Nitrates** **Grazing** **Urbanization** **Pollution**

Flood

- Build or expand floodplains – ensure floodwaters have adequate space.
- Build levees – ridges of sediment can prevent floodwaters from moving outside the floodplain.
- Install streamgage – they can provide up-to-date stream height data to water managers.
- Build a diversion canal – divert stream overflow along a specific channel.
- Build retention ponds – low areas where flood waters can collect and filter into underlying soils.
- Reshape channel – a stream that regularly floods should be assessed for flow issues.

Fire

- Remove large, woody debris from the river channel- it can restrict flow and cause ponding.
- Grading and other bank protection measures to prevent excess sediment entering the stream.
- Check water quality upstream of water treatment plants – fire can introduce nutrients, dissolved organic carbon, major ions, and metals such as iron and manganese into watersheds.
- Remove household and construction debris from fire areas – rainwater over these structures can end up as runoff in streams, bringing paint, solvents, pesticides, asbestos, and other toxic materials into the stream.
- Stabilize uplands to prevent mudslides.
- Check and repair storm drains – sediment and ash may damage or block them.

Nitrates

- Install buffer strips - leave a wide strip of deep-rooted plants along ditches, streams and lakes to absorb and filter runoff.
- Keep grass clippings, leaves, and other organic matter in the lawn or swept up out of the streets so they can't wash down storm sewers that drain to streams.• Encourage better use of marginal land - plant perennial crops or convert to water retention areas to improve natural filtration.
- Use smarter drainage- install controlled drainage systems instead of traditional pattern tiling.
- Manage fertilizer use by following nutrient management plans.
- Install two-stage ditches to increase natural filtration of irrigation runoff containing fertilizer.

Grazing

- Protect banks with rip-rap – loose rock on banks protect underlying soils from erosion.
- Vegetate banks for improved bank stability – plant roots stabilize river banks that cattle can trample.
- Install barbs to protect banks from collapsing into the stream.
- Manure management plan to keep manure out of streams.
- If bank failure has occurred – raise the channel bed to reconnect floodplain.
- Reshape river banks (grading) to reduce slope that can lead to bank failure.

Urbanization

- Stormwater management – assess the city's stormwater management plan to ensure it is adequate and keeping pace with urban growth.
- Build a greenway – Do not allow development next to stream channels.
- Enforce laws about littering and control of pet waste.
- Wastewater treatment – ensure that adequate facilities exist.
- Encourage use of rain gardens and green roofs - these can filter and absorb potential contaminants from rain, keeping them out of stormwater systems.
- Require city employees to follow best management practices for mowing, fertilizer application and other maintenance work near streams.

Pollution

- The most effective way to deal with stream pollution is to prevent it in the first place.
- Soil bioengineering – plants act as natural filters for potential contaminants.
- Educate citizens about hazardous chemical disposal.
- Implement periodic chemical drop-off days to ensure proper disposal.
- Develop hazardous waste disposal practices for businesses and contractors.
- Build buffers next to stream banks with native, deep-rooted plants that can absorb and filter runoff containing potential contaminants.
- Implement periodic water quality testing programs to identify issues early.