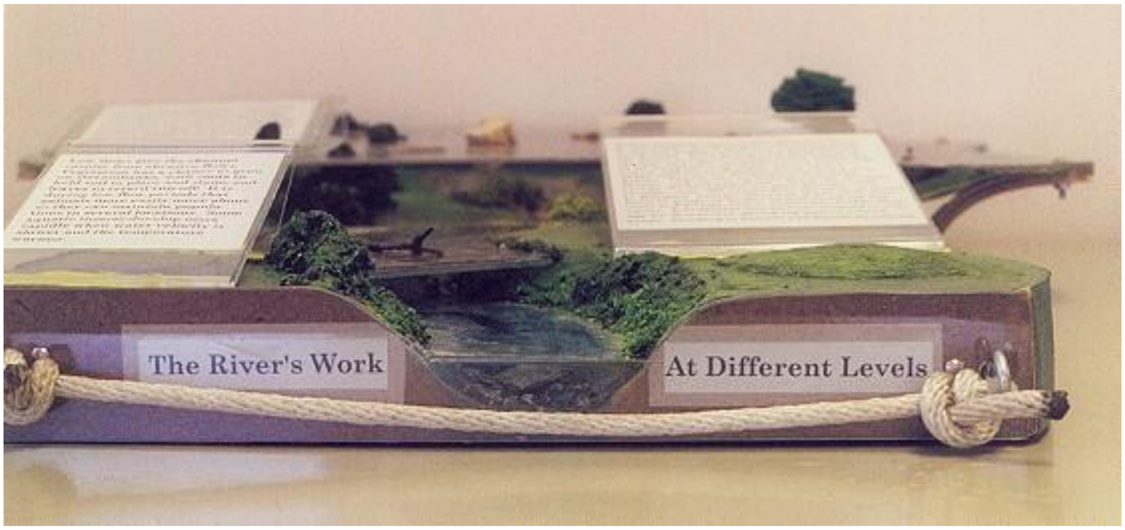
WORK AND BEHAVIOR OF RIVERS: PART 3

The efficient work of rivers is dependent upon its width, depth, the velocity of water, the amount of water at any time (discharge), the gradient or steepness, the roughness of materials in the channel, the sediment load it carries, and the size of sediment. If one factor or variable changes, one or more of the other variables must increase or decrease proportionally if the equilibrium is to be maintained. Because certain physical laws are involved in the energy of water, there are efficient width/depth ratios for carrying water and sediment given the factors listed above. The most efficient way for a river to carry water and sediment is to have a deep and narrow channel. This is what our rivers work at creating when it is possible in order to be stable. "Stable" does not mean stationary; rivers must always adjust to varying conditions.

Because all rivers work at being efficient, there are also predictable distances between pools (generally every 5 to 7 river widths apart), and predictable wavelengths of meanders (10 to 14 times the width of the river). Indeed, given the different variables, any section of any river anywhere in the world can be classified into distinct types. This classification is useful because it lets us understand how a river will react to natural changes, changes we make it the watershed, and ways we might help them restore their stability. As long as the river channel stays in equilibrium, the migrating channel stays the same average shape and size, neither downcutting ("degrading") or building up ("agrading").

Rivers transport most of their sediment when at "bankfull." Bankfull generally means when water just begins to flow over a streambank's inside bend. Even during a flood, most of the power to move sediment occurs within the channel area. We can predict when a river will be at "bankfull" stage (once every 1.5 to 2 years), and the probability of how frequently a river might spill into the floodplain it created and at what depths. That is why we have the terms "10-year flood; 50-year flood; 100-year flood." Since rivers will occupy the floodplain, we must give the river enough room. We cannot deny the river its desire to dissipate energy, otherwise it has even more force to gouge its banks, its bed, to rip out culverts and houses, and to undermine bridge abutments.

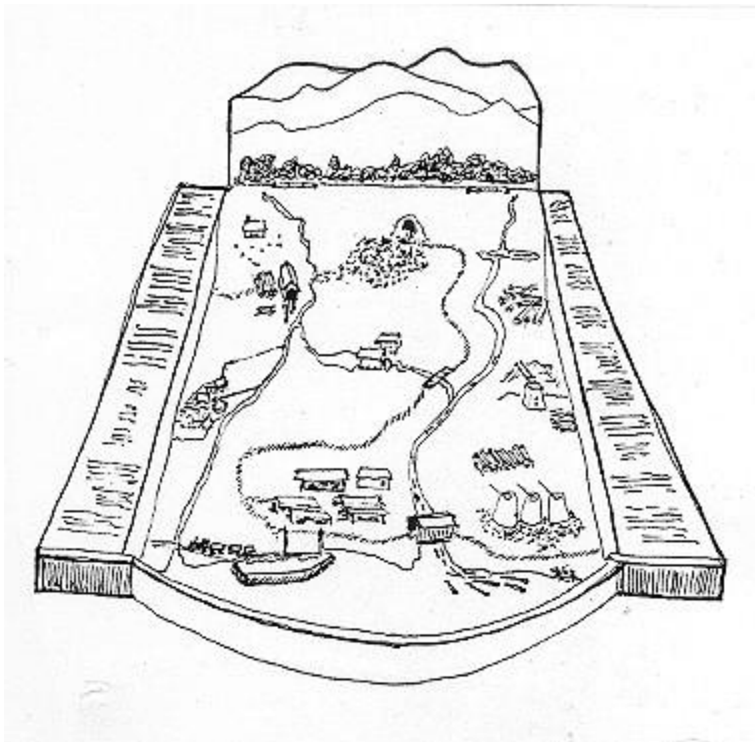


Floodplains provide temporary storage space for floodwaters and sediment, giving lag time to a flood event. Flooding is natural and mostly beneficial. Floods are when sediment gets transported, when streambed materials are cleansed and sorted, and when floodplains are nourished with sediments and nutrients. Flood pulses create, renew, and alter the habitat for invertebrate communities, amphibians, reptiles, and fish spawning. And in the fall, waterfowl need floodplain wetlands for foraging habitat .

But, constant bankfull or flood conditions would mean massive scouring, erosion, and high water tables. Low flows give the river channel respite from abrasive flows. Vegetation has a chance to grow on the streambanks, with roots to help hold soil in place and stems and leaves to retard run-off. It is during low flow periods that animals more easily move about so they can maintain populations in several locations. Some aquatic insects develop more rapidly when water velocity is slower and the temperature warmer.

The work of rivers is sometimes made difficult by Mother Nature. A landslide up in the mountains, or an extra-heavy rainfall eroding a hillside or field will bring more sediment than the river is accustomed to carry. But, most sediment and imbalance problems of our rivers are caused by how people use the land. Settlers in the Lake Champlain Basin cleared floodplain forests for farming; cleared upland forests for timber, and dug mines and made roads to transport logs and ore; built roads in the river floodplains; built dams to power their mills; drained wetlands for farming and development, and–in some instances–straightened river channels thinking to control them.

Although the work of rivers is sometimes made difficult by landslides or heavy rains causing severe erosion, most sediment and imbalance problems of our rivers are caused by how people use the land. Settlers in the Lake Champlain Basin cleared floodplain forests for farming, upland forests for timber, and dug mines and made roads to transport logs and ore. They built roads in the river floodplains, dams to power their mills, drained wetlands for farming and development, and–in some instances–straightened river channels thinking to control them.



In the 19th century, rivers were the highways for transporting from upland forests the logs that fueled the industries in the Champlain Basin. Much of the timber was turned into charcoal for use by the iron industry. It is estimated that on the New York side of the lake, between 200,000 and 250,000 acres of Adirondack-Champlain forest were cleared just for the manufacture of charcoal iron.

Throughout the Basin, heavy cutting of forests led to hillside and streambank erosion, streams clogged with sediment, and loss of habitat for birds and animals. Heavy logging exposed the soil to sunlight so the soil was dried out and had less ability to hold water.

In addition to their use for charcoal, logs were burned to make potash, cut into lumber for building and for export, made into pulp for paper, used as fuel for trains and steamboats, and for heating buildings and kilns. The bark from hemlock logs was ground to make the tannin that turned animal hides into leather.

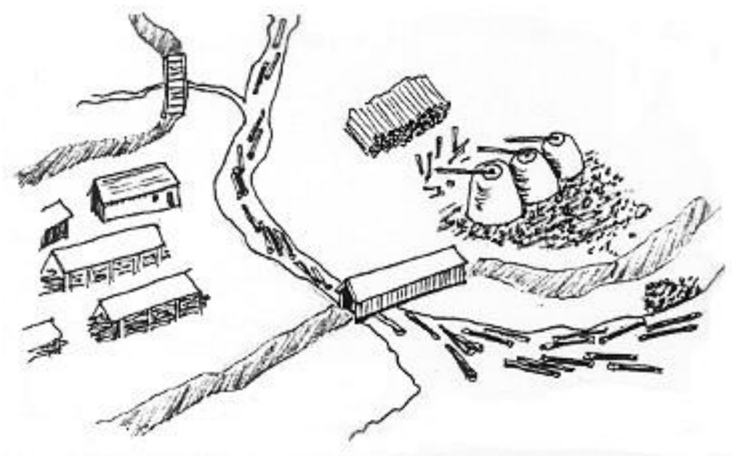
The rivers were also the power source for industry. Water-driven machinery ground grain (grist mills), processed cloth (carding and fulling mills), cut logs into lumber, cut stone, worked the bellows and created the blast for the fires that melted the iron, and operated the forges and trip hammers that worked the iron. Pulp mills for paper-making depended on a large and steady supply of water.

From all that industry, the rivers carried away waste such as chaff from grist mills, sawdust, stone dust, burned charcoal, used tannin, iron slag, and dirt from the washing of tons and tons of iron ore.

Iron Mine

In Vermont in 1849, iron ore cost $1.75 per ton at the mine or $2.50 per ton after washing. In the 1880's New York's Clinton and Essex Counties bordering Lake Champlain produced 10% of the nation's iron ore.

Charcoal Kilns



Charcoal in the early years was made in sod-covered mounds, and later in brick beehive kilns. Thirty to thirty-five bushels of charcoal were made from one cord of wood. In 1849, Vermont charcoal cost $5 per 100 bushels. In 1864, thirty northcountry New York forges consumed a total of 6,700,000 bushels of charcoal.

Iron Works

The bloomery forge was a direct ore-reduction process for turning ore into molten metal. A water blast created air pressure to make the charcoal fire burn hotter. The water-powered trip hammer hammered out impurities in the bloom, the lump of iron produced by the forge. On the average it took 4 tons of ore and 300 bushels of charcoal to make one ton of iron.

Logging

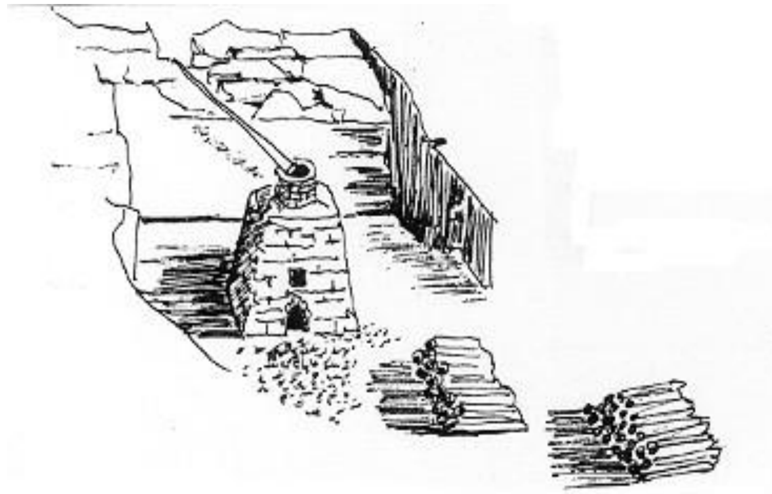
Trees were generally cut during the winter and the logs moved downstream on spring high water.

Lumber Mill

Twelve to fourteen sawmills were not uncommon in a Vermont town; in 1840 there were more than 1,000 sawmills in the state of Vermont. New York State led the nation in the production of lumber in 1860.

Lime Kiln

Lime was made by baking limestone until it could be crumbled, using wood for fuel. Lime was used for bleaching, tanning leather, making plaster, cement and potash, as a farm fertilizer, and mixed with iron ore to make iron.



Potash Making

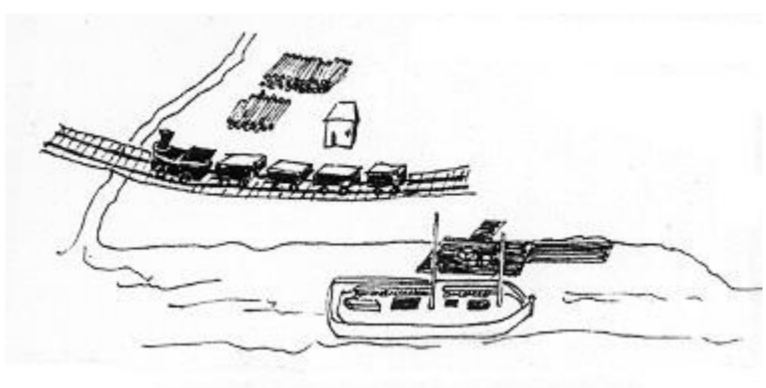
Making potash was the first way a farmer could profit from clearing his land. Hardwood ashes mixed with water and lime, filtered, boiled and cooled became like grey stone. This substance, potash, was used in soap, glass, bleaching and dyeing. Four to five tons of wood made about 40 pound of potash.

Leather Tanning

Perhaps as much as a million and a half acres of the Adirondacks were cut over for hemlock bark used in tanning hides. Large tanneries were usually on the edge of the wilderness and created their own towns. Each year they needed as much as 6,000 cords of bark cut from 1,000 acres.

Many upland hills were clearcut for charcoal production and, later, for logs to make paper pulp.

Locomotives burned great numbers of logs. By 1874 Vermont railroads used 500,000 cords of wood annually.



The network of rivers flowing into Lake Champlain made industry in the Basin profitable. In the first month (September 1823) of the Champlain Canal, among other goods transported to the Hudson and markets south were 59 tons of nails, 28 tons of iron, 2 tons of iron castings and 95 tons of ore, all locked through in boats like this one.

Note: These industries were active in the 1800's, but not necessarily at the same moment in the century.

Another action that causes instability is the removal of gravel from a river. For many years, gravel has been extracted from the Basin's rivers for road work due to its quality, proximity and--therefore--low cost. But, the amount of gravel in a stable river is a careful balance of the river's work (handling erosion in the watershed, and transporting water and sediment). If you take out gravel, the river works harder to fill in what was lost.

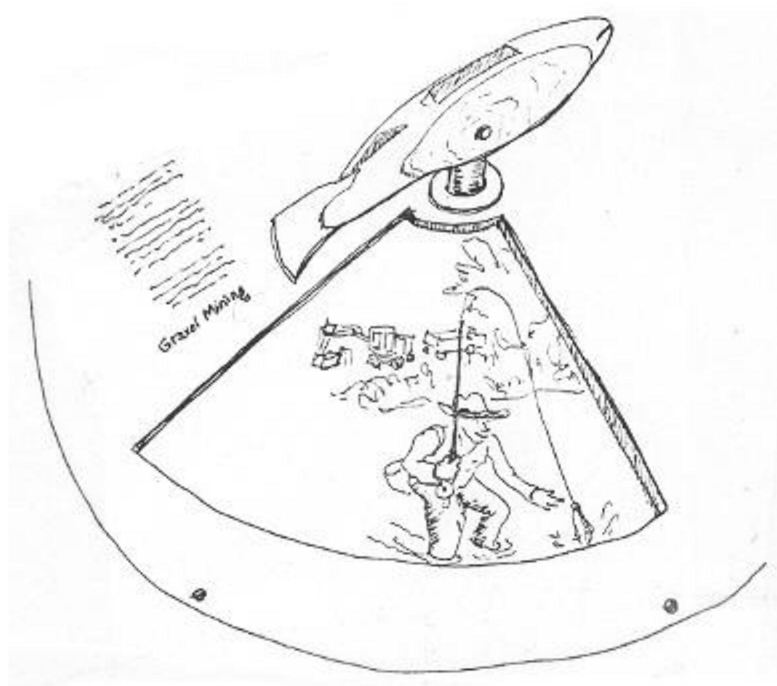
Even if a river is unstable due to increased upland sources of sediment, gravel extraction is not advised except in cases where careful study of stable river geometry has been incorporated into a restoration design. Restoration projects are expensive. So, instead, efforts should be made to control sediment entry to the river from human activities that caused the imbalance. (Note: Exhibit #12 demonstrates a study of river geometry for restoration purposes.)

Today the forests have largely grown back on the upland slopes and many dams and mines are gone. But, our bridges and culverts constrict the flow of water; riverside roads and buildings take away water storage area in the flood plain; storm drains carry large pulses of water and sediment from urban areas during heavy rain or snow melt; trees have been removed along riverside farm fields and residential lots; and hydro-power and water withdrawal continue to make rivers unstable.

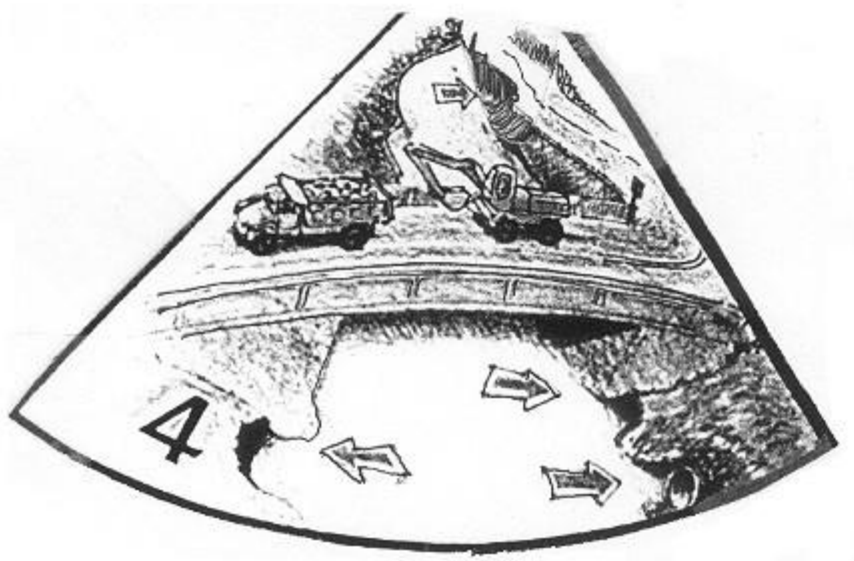
Knowing the principles of a healthy "stable" river system gives us hints at how we can help restore unstable rivers. There is not much we can do in urban areas, and moving people and infrastructure out of floodplains is enormously complex and expensive. However, one of the most important actions we can take elsewhere is to accurately map flood prone areas to

(As the viewer turns the fish handle on top of the "lazy susan" box, beautiful rainbow trout swim along the side and various pictures come into focus in the top cut-out area. The pictures are numbered and are referenced by text on the top of the box.)

1. Many of Lake Champlain Basin's streams and rivers are designated trout and salmon fisheries into which state environmental agencies have put time and money; in return, agencies hope for healthy river eco-systems and economic return from fishing licenses and tourist income. Gravel mining in rivers may give towns a cheap source of material for roads and buildings, but the cost of persistent gravel mining may be enormous.



2. When gravel is removed, a river adjusts upstream by eroding gravels from its streambanks or streambed to replace what was taken.
3. Convenient places to mine gravel are riffle areas. But, riffles are the river's filter and home to insects eaten by fish. Frequent gravel mining causes imbalance in the river, destroys the riffle filter and insects, and fish leave or become less abundant.
4. Not only riffle areas are damaged. Gravel mining can cause the undermining of bridge supports, roads and culverts. This undermining causes even more bank erosion.



5. The result of undermining and streambank erosion is a widened and shallower river. As a river becomes wide and shallow, the propensity for flood damage of adjacent properties heightens. Rivers can recover from gravel mining over distance and time, but not if frequent removal of gravel continues.