Rivers, Systems and Models

Systems Theory is a branch of science with its own concepts and vocabulary. Rivers, by definition, are systems so can be investigated using the tools of systems theory. The most basic of these is the model. A model is a simplified representation of a system. Some models are more complicated than others, but all provide insight on how the system operates.

System Definition - An ordered interrelated set of items linked by flows of mass and energy as distinct from their surrounding environment.

Systems Have Order and discernable patterns, they are not chaotic. Material moves through the system in predictable way. Systems have boundaries, and the processes working within the system are different from the processes working beyond the system boundaries.

Open systems receive mass and energy from outside the system boundaries. **Closed systems** do not. Fluvial systems are generally regarded as open systems because they receive water (precipitation) from outside the system and also transport it to the ocean also beyond the river system. For the most part, the sediment originates inside the drainage basin, is transported and deposited within the basin. However, some portion of the sediment is carried to the ocean.

Feedbacks. **Positive feedbacks** accelerate changes in the system. They can cause instability and eventual disintegration. **Negative feedbacks** dampen out changes once they begin contributing to stability in the system. Negative feedbacks result in **homeostasis (self regulation)** of the system.

Models of River Systems
in Order of Increasing Complexity.

• **Morphological Model** is based on form or shape or visual pattern. A morphological model of a river system is the branching pattern of the stream network (like dendritic or trellis pattern). It is a simple, static representation something like a map view.

• **Cascading Model** is based on the way the volume of flow increases as tributaries merge. It is hierarchical model that reveals something about the flow of material through the system.

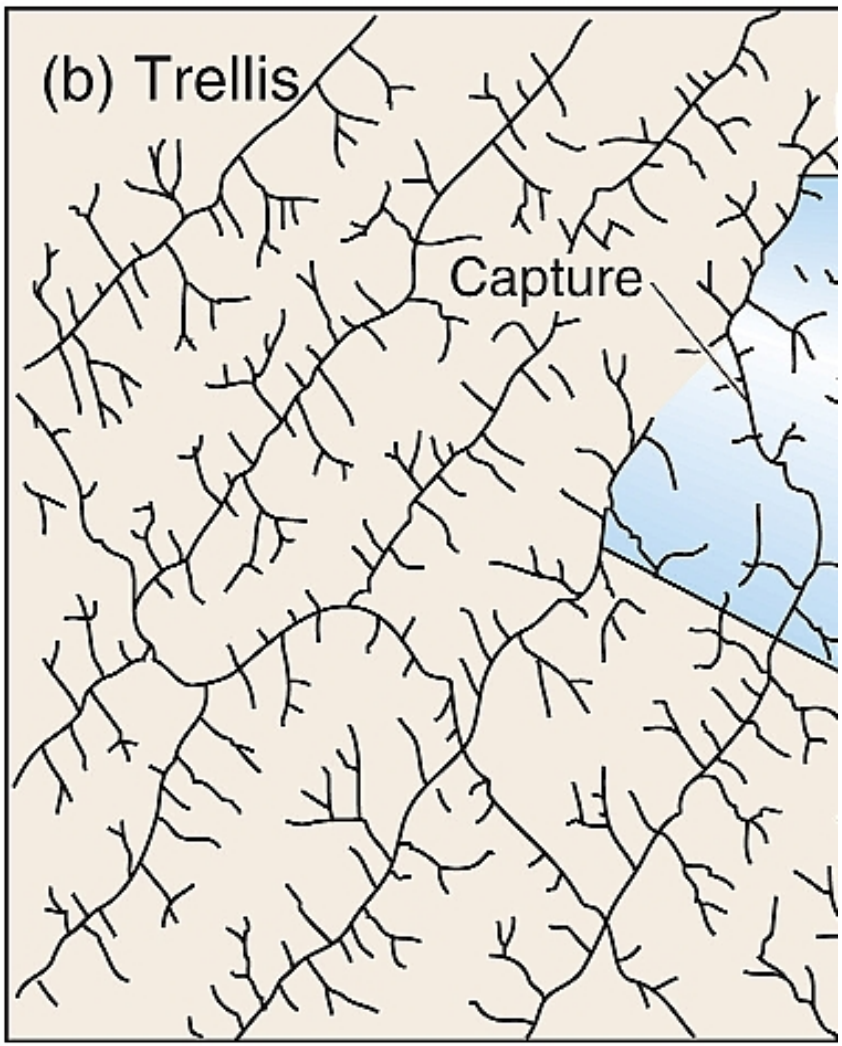
• **Process - Response Model** is based on the internal dynamics of the system including positive and negative feedbacks. Over time, the river develops a graded condition where it has achieved an equilibrium with the volume of water and sediment it usually carries. The stream table (demonstrated in class) is an example of a process – response model.

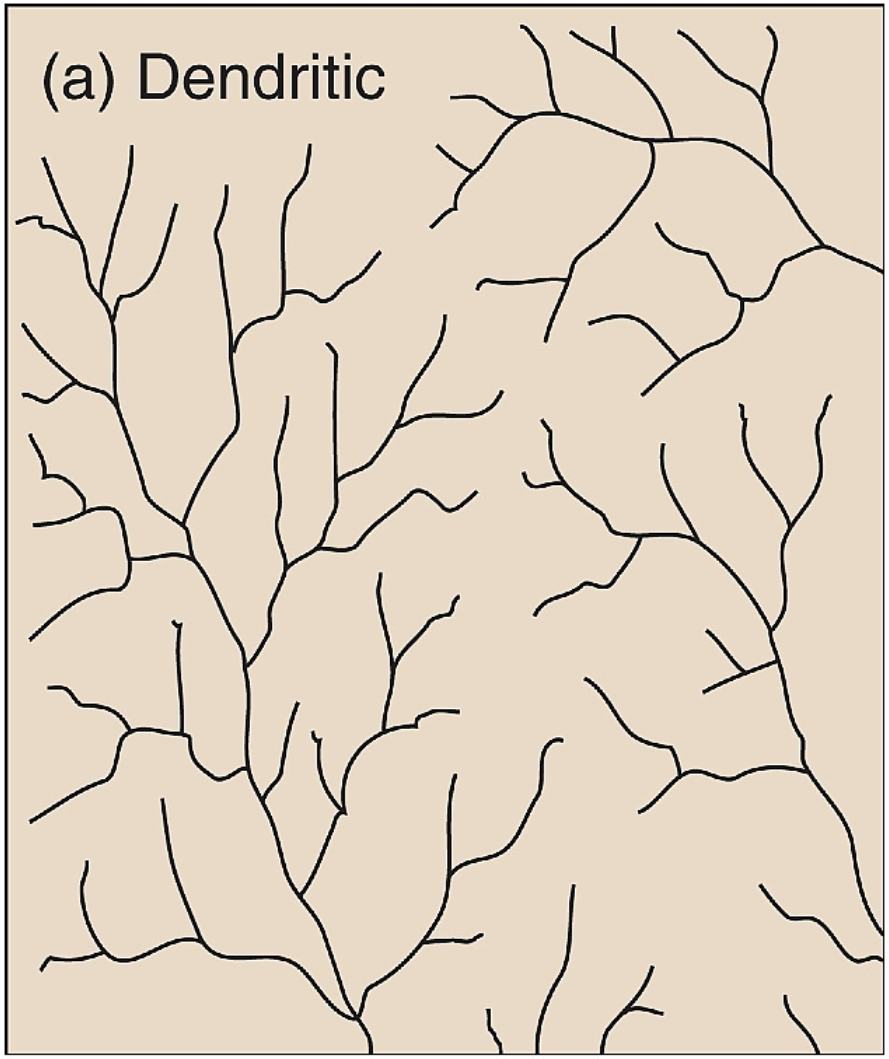
• **Intelligent Model** simulates the impact of human influence on the river. In systems theory, an intelligent system was one with substantial human control or influence. Some things that people do are intended to modify natural systems. However some things that people do result in the modification of natural systems when that was not the intent.

Model of Hoover Dam and Lake Mead.

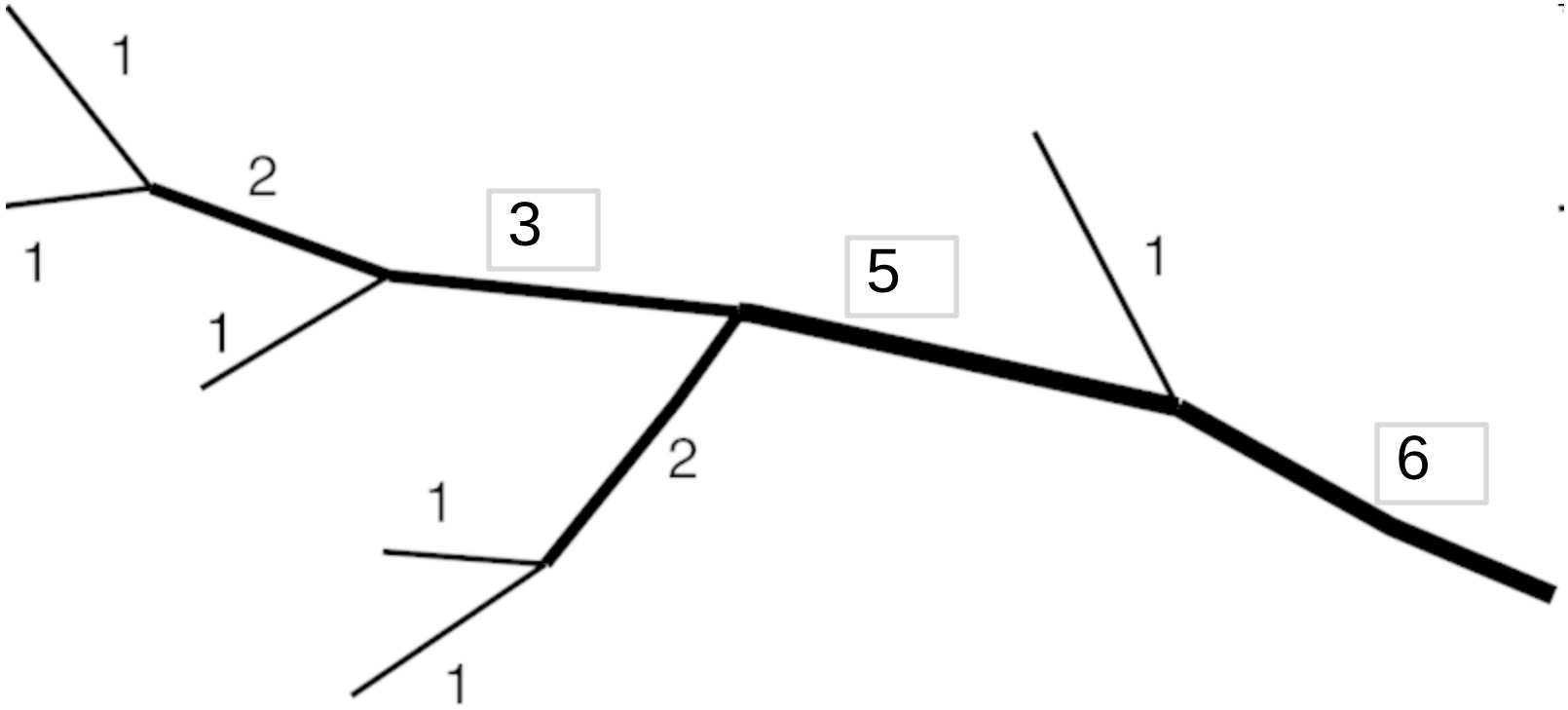
It Is an Example of a Morphological Model

Example of a Morphological Model. The River System Forms a Network of Channels that Ultimately Leads to the Ocean. These Networks Form in Different Branching Patterns, But Dendritic is the Most Common





Stream Orders Are One Aspect of a Morphological Model. This Is a Hierarchical Classification



The whole U.S. has perhaps a million first order streams, but only one 50th order stream like the Mississippi

Rivers as Cascading Systems. The Volume of Water Flowing in the River Is Proportional to the Width of the Line

The volume of the Ohio and Mississippi Rivers at their confluence is about equal. The volume of the Columbia and St. Lawrence Rivers are about equal.

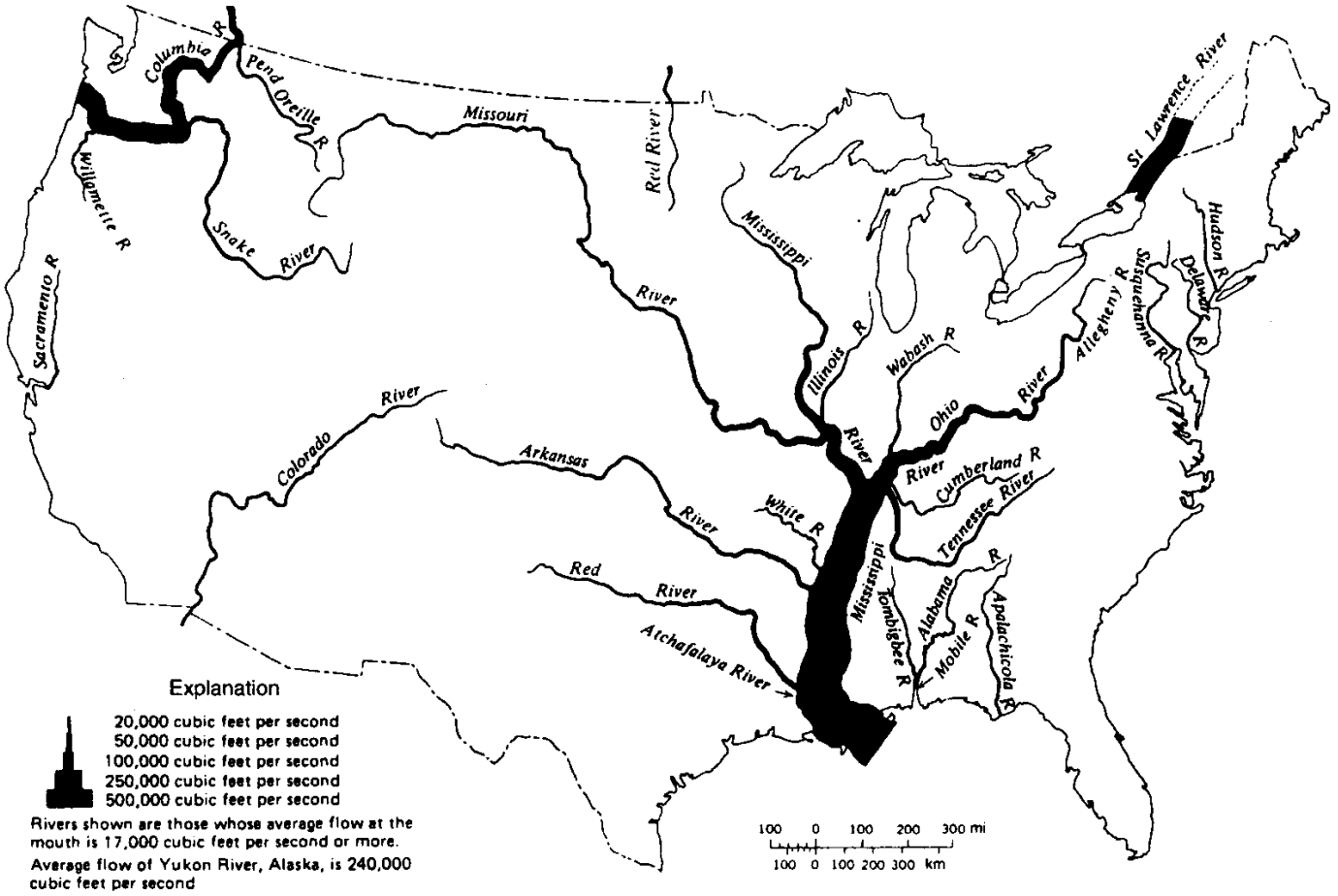
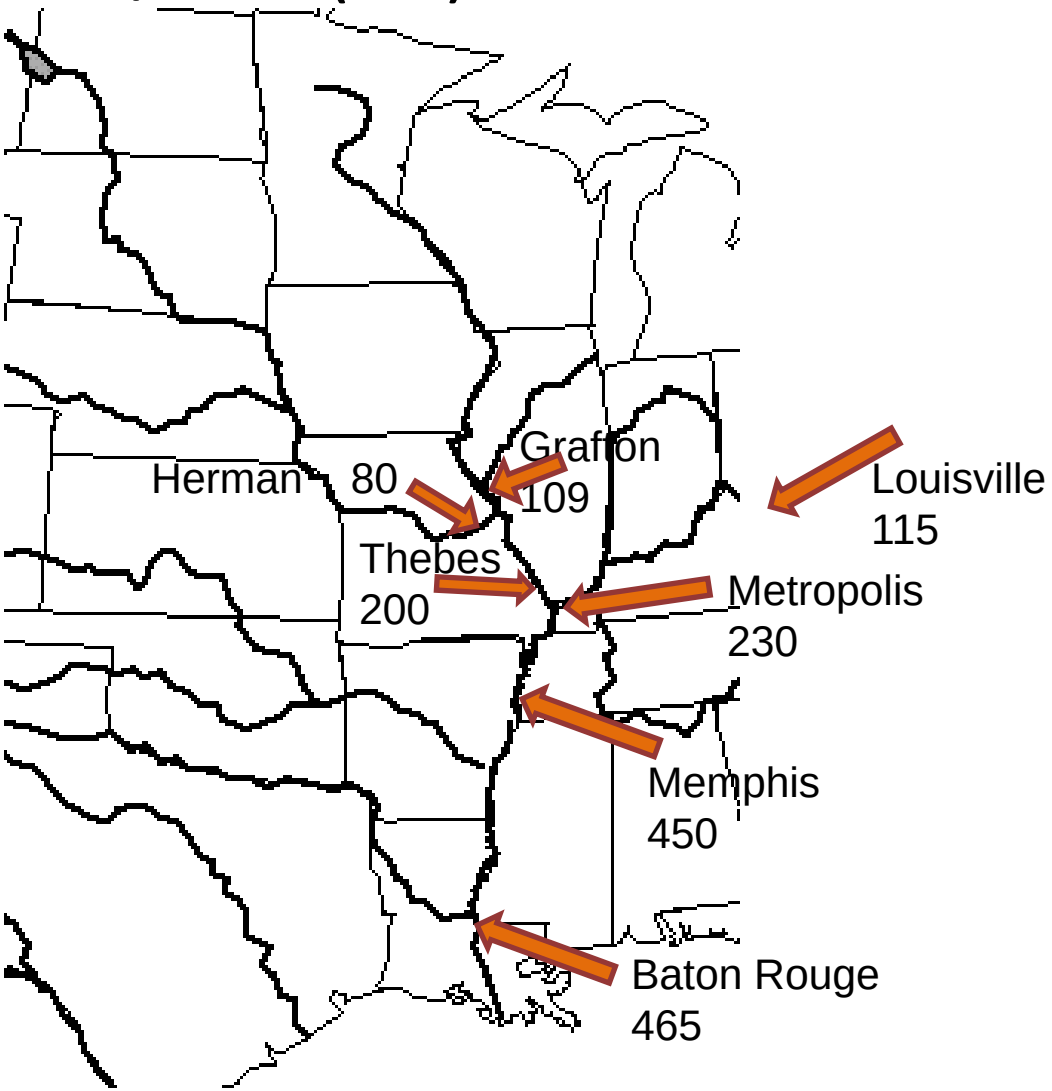


Figure 12.18 Large rivers in the conterminous United States.

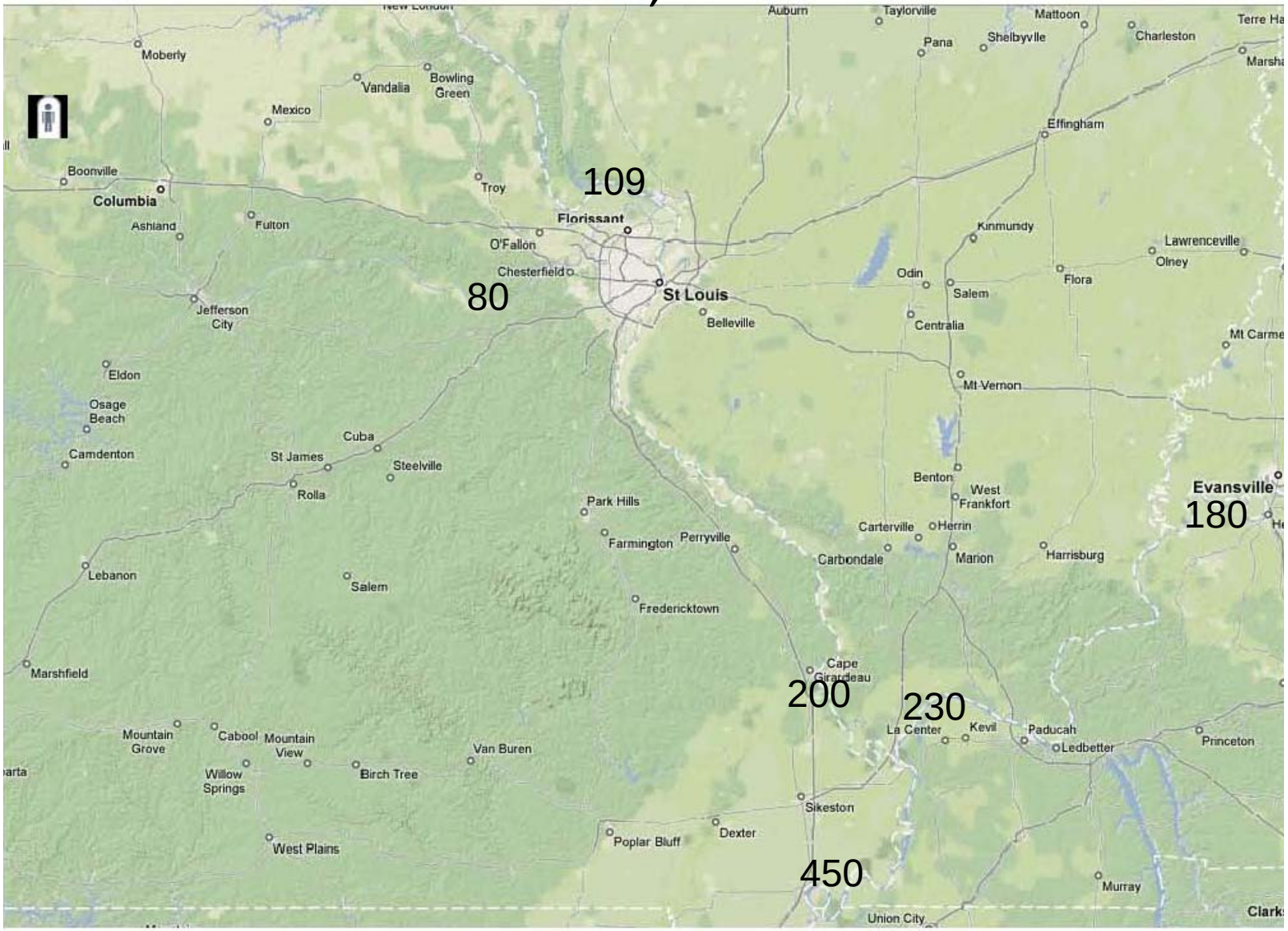
Source: K. T. Iseri, and W. B. Langbein, "Large Rivers of the United States," in *U.S. Geological Survey Circular 686,* 1974.

Cascade of Mississippi River System. Numbers Indicate Average Volume of Flow in Thousands of Cubic Feet/Sec. (cfs)



There is a mistake on this map. Can you find it.

Figures Represent Volume of Water in Cubic Feet/Sec. (cfs). The Cascade of the Mississippi River Builds from 109k near Florissant, MO to 450k near Union City, TN.



The Process – Response Model of a Stream System.
The Stream Table (Demonstrated in Class) Is a Good Example.

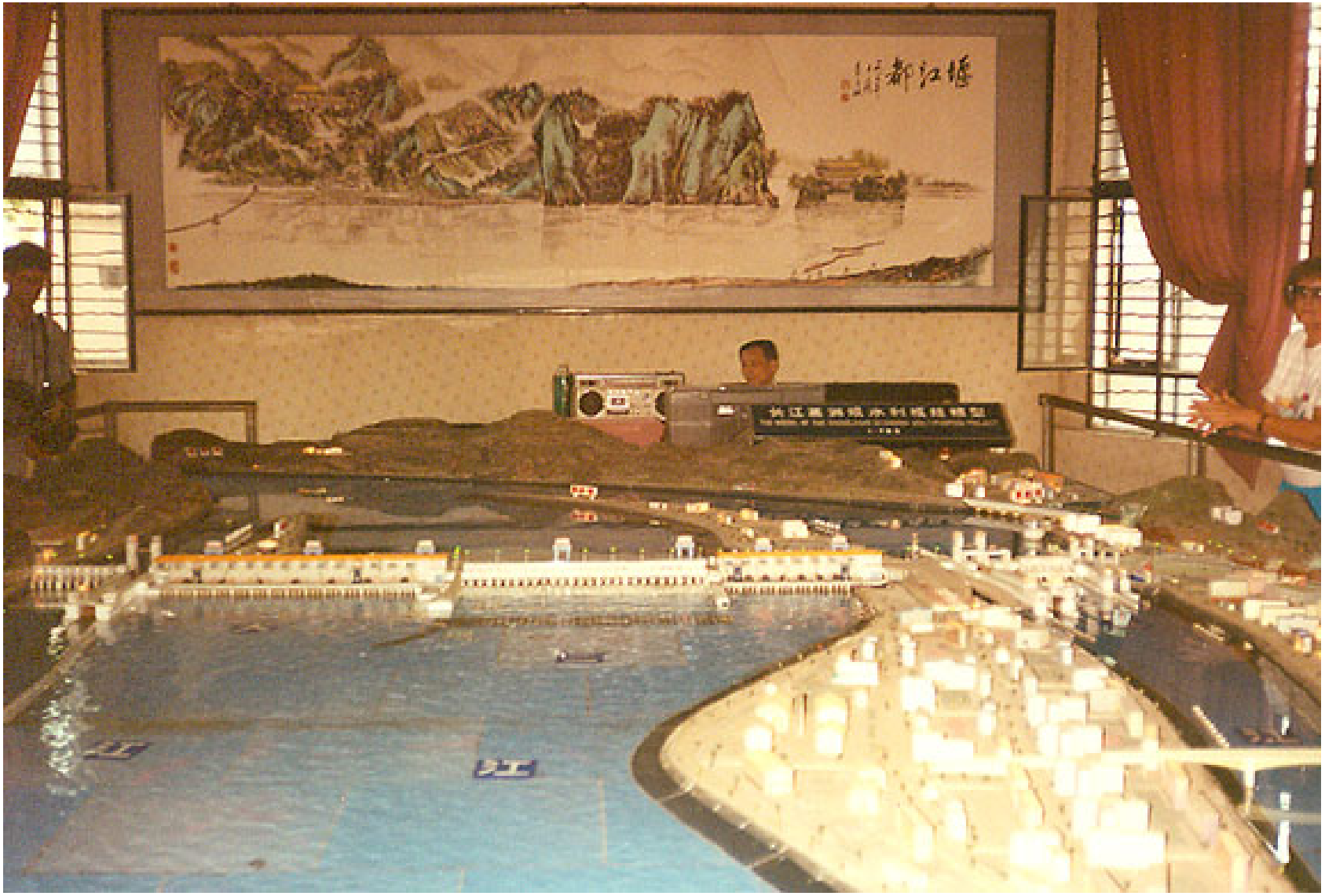
The apparatus is simply a sloping table about 6 ft. long filled with sand. It simulates the **process** of water moving down hill and the **response** of the creation of the characteristic landforms associated with a river and its floodplain and delta environments.

A sprinkler simulates precipitation falling on sand at the highest elevation on the table. The water flows down hill. It soon cuts a **channel** where most of the flow is concentrated. Given time, the channel develops **meanders** like a river. The water erodes and transports sand and sediment as it flows. When it slows down, pooling at the bottom of the table, the sand drops out creating a **delta** deposit. The flow of water across the delta splits in several channels (**distributarie**s). These change location as sediment is deposited and one portion of the delta becomes a littler higher than others causing the flow to change.

Examples of the Process – Response Model of a Stream System. The U.S. Army Corps of Engineers (USCOE or COE) Build a Working Model of the Mississippi River System. It Was Simply a Stream Table on a Very Large Scale Covering 7 Acres. It Was the World's Largest Working Model. This is All that Is Left. In the 1980s the COE Abandoned It in Favor of Computer Models.

The Three Gorges Dam in China Is the Largest Dam Ever Built. This is a Model of the Dam and Locks

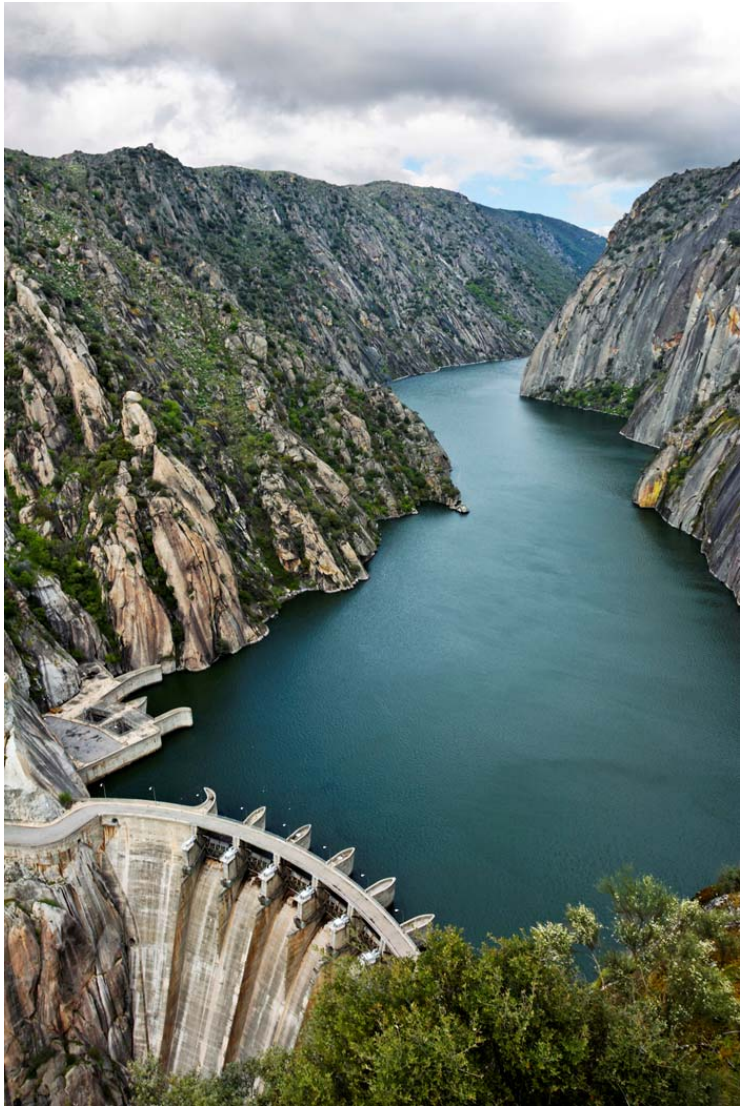
Model of the Dam and Locks. This May Look Like a Process – Response Model Since It Has Water in It, But It is Probably Closer to A Morphological Model in Reality



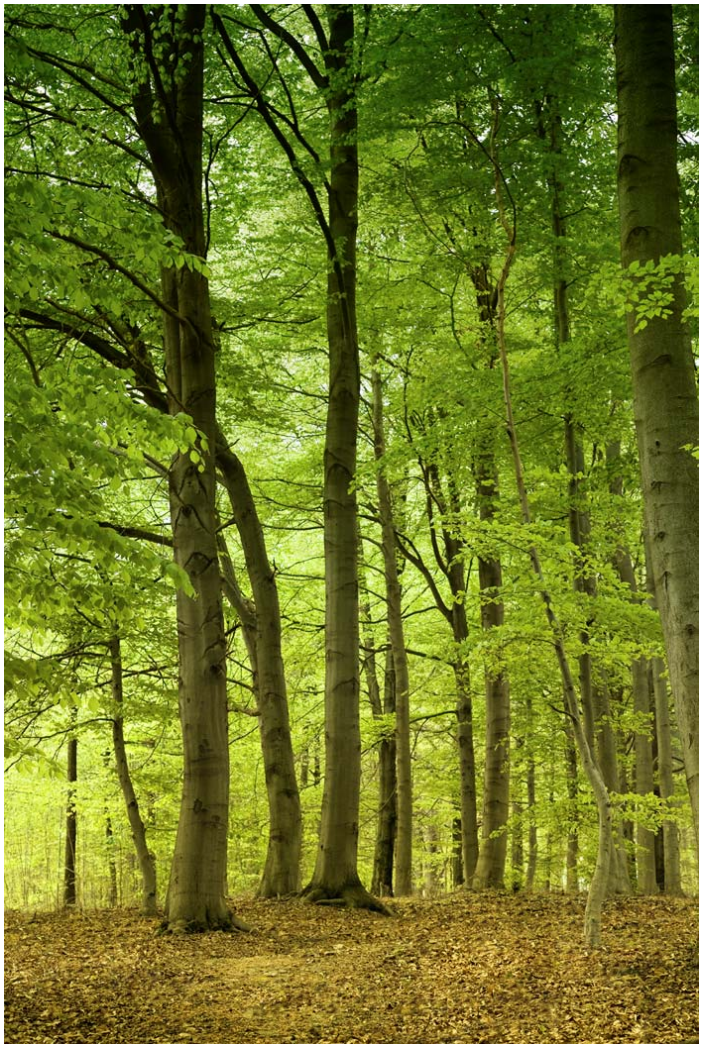
The Intelligent Model Represents the Impact of Human Actions on a River System

Some of the Results Are Intended and Some Are Not.

Actions like construction of dams is quite intentional. In contrast, changes in land cover are not intended to affect river dynamics. When a pioneer cuts down a few trees to make a farm, his main concern is economic, providing food for himself and others. However, when a million pioneers decide to cut down a forest and make a farm, the resulting soil erosion chokes the river with silt and totally changes the dynamics of the river.



Changes in Land Use Can Totally Change the Dynamics of a River System



Construction of a Levee is the Most Common Form of Flood Protection.

Flooding on Sacramento River, CA.

Levees Protect from Small Floods but Not From the Big One.

(b)