PROCESSES AND LINKAGES IN SOUTHEASTERN U.S. STREAMS

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In the mythological sense we have heard the siren's call. There is a restlessness that will not be stilled. There is a yearning for something beyond knowledge, beyond understanding, perhaps even beyond wisdom. We transcend the time frame of human experiences and enter into another realm. Civilizations pass through a few tumbling generations and then fade away, yet the rhythms of the earth continue. We are linked to these rhythms. They reverberate within us, filling us with energy. And it is in our search for their source that we have been drawn to and captured by the magic of moving water, the magic of our streams. Streams are for us reflections of ourselves, forever seeking, never ceasing to be.

Arising clear and cool, they bubble and splash, full of sparkles, exposing themselves by their clarity from surface to substrate as they tumble brightly along through the country of their birth. Along the way they pick up debris, litter, and silt, which color them, often from other streams whose journeys perhaps have placed their own unique demands as a burden to the currents. Dams will block the free flow from time to time, but relentlessly a stream seeks its lowest level, determined to cut its way to the very core of creation. A lake is only a stream waiting to go somewhere. Once away from the hills which controlled the flow of its youth, the stream begins its drifting as it meanders across the land in an endless search for its primeval source. It plays no more games with the trivial attempts of humankind to control it. Mature now, it becomes quieter, slower, deeper, relentless. It has fought its battles. Ride if you will, but never try to fight it again. It will win in the end.

Living with a stream is enhanced by understanding some basic processes of these systems. Fundamentally, it is important to recognize that a stream does not exist in isolation from its surrounding watershed. The stream is not just water in a channel. It is, rather, an integrated system, incorporating terrestrial as well as aquatic dimensions. A continuum of processes along the stream's course, upstream to downstream, and laterally away from the channel, dictate conditions, events and life forms at a given location in the stream. Internally within the channel, scour, fill, erosive processes, temperature, depth, current velocity, and substrate type (both physically and chemically) operate in concert to set the stage for biological events.

Energy driving biological events in streams originates within both the aquatic component of the stream and from its terrestrial components. Where sunlight can meet substrates in stream channels, photosynthesis by aquatic plants (including algae) occurs. Tissues from these plants, both living and dead, are utilized by animals living in the stream. In some cases, it is necessary for plant materials to be colonized by microbes (bacteria and fungi) prior to ingestion by animals. The microbes convert the plant materials into more usable forms. Although photosynthesis in the aquatic component of the stream ecosystem can be important, the major contributors to biological energetics in streams are terrestrial plants. These contributions occur throughout the year, but there are seasonal pulses, such as autumn leaf fall, that typically dominate stream ecosystem processes. This organic material (e.g., leaves) can enter the stream directly from streamside zones or can blow or wash in from more remote locations in the watershed. Once in the stream, soluble materials (for example sugars) quickly leach from the tissues and are utilized by microbes in the water. The remaining material is processed by invertebrates, primarily aquatic insects and crustaceans, but also various worms and mollusks. These in turn become forage items for fishes.

Processing of organic materials by aquatic invertebrates is oftentimes enhanced when these organic materials are concentrated (for example, in leaf packs). Concentrating potentials are determined by the type of substrate on the stream bottom. Coarse substrates such as cobblestone, root wads, water willow beds, and woody debris tend to trap organic materials drifting in the current. Smooth substrates such as sand, clay, silt, and bedrock typically allow the materials to continue drifting. Localized differences in production of aquatic invertebrates and fishes can result.

As one moves from upstream to downstream sections of a stream, organic materials are broken up and processed repeatedly. The smaller the particle size, the more surface area there is per unit volume of materials. Exposing more and more surface area provides increasingly more opportunity for microbes and invertebrates to gain nutritional and energetic benefit from a given piece of material. Each step along the way, aquatic animals have adapted to the availability of organic materials prevailing in the system. Upstream animals processing these materials tend to shred large materials into smaller materials. These smaller materials continue downstream and ultimately are captured by filter feeders that strain the water (such as net spinning caddisflies and bivalve mollusks). Additionally, as one moves downstream, water turbulence tends to decrease. This affords plankton (microscopic plants and animals) opportunity to utilize the smallest particles suspended in the water. Plankton is, however, not restricted just to big water downstream. Plankton can even be found in pools of headwater zones if there is slack water. In these upstream zones, slack water is common in deeper portions of pools and in spaces between stream gravel. By night, plankton migrates to the upper layers of water in the pool and becomes entrained in the flow. As plankton passes over riffle areas, it is filtered by invertebrates such as caddisflies (which spin nets) or blackflies (which have special collecting hairs on their bodies). This plankton is a high quality food source for these invertebrates and can enhance invertebrate productivity in the stream.

It is, therefore, important that riffle-pool sequences be maintained in headwater streams if the objective is to maximize biological production, especially that associated with fisheries resources. Artificial impoundments along a stream course also provide opportunity for plankton production. When water is released through or over the dam, plankton can be entrained and swept into the downstream tailwater. This plankton release can ultimately lead to development of high invertebrate productivity in the tailwater that has important fisheries ramifications.

Further downstream, stream characteristics typically shift. Rather than depending entirely on the influx of organic materials into the stream channel, the stream actually reaches out and gets it through flooding. Fishes and invertebrates move out onto the inundated floodplain. In the Southeastern U.S., flooding can occur at any time during the year but typically occurs during winter and spring. Leaves and other organic materials are then on the ground and available for processing as soon as they are covered by floodwaters. Additionally, because flooded areas typically are more shallow than main river channels and because the water in flooded backwater location tends to have little or no current, these waters tend to be warmer than water in the main channel. Warmer water stimulates biological activity of aquatic invertebrates and fishes in these systems. The presence of aquatic invertebrates in relatively warm, still water, encourages spawning of fishes on the inundated floodplain. The earlier this spawning can occur and the longer the fish can remain out on the floodplain, the higher the recruitment potentials for the river's fisheries. Relative to the size of the floodplain for a given river, fisheries production for a river is directly related to the height and duration of flooding. Exploitation of these fisheries usually occurs after floodwaters have receded and aquatic environments become primarily restricted to the main river channels. With fish from throughout the floodplain concentrated in the river channel, it is easy to understand why floodplain river ecosystems are considered to be some of the most productive fisheries in the world, with fisheries production focused on one to two year old (or older) fish in excess of what the river can support during minimal flow periods. The adult fish remaining after fishing or, in the case of unexploited systems, after minimum flow, are available for spawning the following season. Alterations of main river channel environments through dredging and the removal of snags (large woody debris) can potentially harm the carrying capacity of the river channel, especially during the minimum flow periods. The snags are particularly important because they provide safe refuge for fishes from predation and strong current and because in the absence of other stable substrate like rocks and boulders, snags are just about the only place where many of the aquatic invertebrates can find attachment sites. In some lowland streams in the Southeastern U.S., over 60% of the invertebrates produced originate from snags. While probably of lesser importance relative to overall fisheries production than aquatic invertebrates out on the floodplain, the aquatic invertebrates in the channel during periods of restricted inchannel flow no doubt help resident fishes maintain body condition during these critical periods. This is particularly the case for fishes such as flathead catfish that tend to remain in the river channel. The large adult flathead catfish are top predators in the system, foraging on other fishes, many of whom originated on the floodplain and became concentrated as water returned to the channel. The smaller flathead catfish, however, have dependencies on aquatic invertebrates during early life history stages.

There is, however, growing evidence that fishes of floodplain river ecosystems are pretty tough critters. These rivers are not, nor have they ever been, stable environments. Correspondingly, fishes in these systems are evolutionarily adapted to life in dynamic, variable, constantly fluctuating environments. Scour and fill, bank collapse, movement and deposition of large woody debris, channel meanders, unstable, soft shifting substrates ... this is the world of fishes in our large floodplain river ecosystems. Human impacts that fall within the range of natural variation in these rivers seem to have little influence on population dynamics of principal exploitable fishes such as catfishes and buffaloes. They tend to be opportunistic, highly fecund, and capable of exhibiting rapid growth and maturity. If the rivers are allowed to flood, if the channel has large woody debris, and if streamside corridors are broad enough to provide opportunity for channel wandering and the regeneration of forests (the principal source of large woody debris as well as organic materials for invertebrate processing), these fisheries can continue to provide substantial benefits to society.

In this last regard we are begining to understand that our streams weave themselves into the fabric of southern society in myriad ways. They are not simply conduits for the transport of water, nor just sources of power and profit. They are, for many, the source of life's pulse, defining our connections with the earth, giving character to ebb and flow of seasonal process, tempering not only the land but also the human spirit. We hear the siren's song of the streams. We follow the music, discovering something precious within us, riding the currents, probing for something deeper than the waters themselves .. discovering in the process a component of our collective identity as a culture .. that we are a people who care. Thus it is that we bind together in the spirit of teamwork as aquatic resources professionals and concerned laypersons to ensure that our treasures, our streams, are not relegated only to some mystical dreamtime, but rather can continue in the dimension of real time for us and for those who follow us on this pilgrimage.

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