The Little Colorado River

Mike Tremble

The River and its Life forms

The Little Colorado River begins in the White Mountains of Arizona on the slopes of Mount Baldy and flows northwest where it meets the Colorado River in Grand Canyon National Park. The watershed is comprised of approximately 26,964 square miles in northeast Arizona and northwest New Mexico (Arizona Department of Water Resources 1989). Over 69% of the watershed is managed by the Federal government while 21% of the watershed is privately owned. The Navajo Nation occupies the greatest portion of the public lands. The waters of the Little Colorado River and its watershed have many values; these include endangered fish, recreation, industry, irrigation, and sites sacred to Native-Americans.

The principal plant species of the riparian zone are *Tamarix chinensis* (salt cedar), *Salix exigua* (coyote willow), *Baccharis glutinosa* (seepwillow), *Tessaria sericea* (arroweed), *Typha latifolia* (cattail), *Phragmites australis* (giant reed), and *Alhagi camelorium* (the introduced species, camelthorn). *Prosopis* (mesquite) occurs on the high terrace of the Little Colorado River gorge. A few old stands of cottonwood also occur.

Neotropical migratory birds, waterfowl, bighorn sheep and waterfowl are found in the Little Colorado River gorge.That gorge is also the only regional spawning habitat for the endangered fish, *Gila cypha* (the humpback chub). Another endangered fish, the Little Colorado River spinedace occurs in tributaries including Chevelon Creek.

Management Considerations

Any attempt at effective management of the Little Colorado River for the purposes of any entity must address a full range of proximate and ultimate controls over a full range of spatial and temporal scales. Ultimate controls are those factors that operate over large areas (<1 square km.), are stable over centuries and are responsible for a range of conditions in the watershed network (Naiman 1992). Proximate controls are geomorphic and biotic processes that operate at small scales (<10 square m.) and change the stream over time periods of less than a decade. These processes include discharge, temperatures, erosion, channel migration, sediment transport, reproduction, disease, and competition (Naiman et. al. 1992). Stream processes function over 16 orders of magnitude (Minshall 1988).

Therefore managers need to address particular problems or goals by examining processes that operate over many spatial and temporal scales. This paper will describe the dynamic processes that operate at different scales in the Little Colorado River watershed;

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it will also address how organizational and cultural scales must be examined in the development of any management strategy.

The Watershed

On a large spatial scale, it is important to consider the watershed of the river. The watershed is the Coconino aquifer. This aquifer receives recharge from the Defiance uplift on the Navajo Nation and the Mogollon Rim/ Flagstaff area. This water migrates to the lowest topographic exposure at Blue Springs where it discharges from a series of springs from the Redwall Limestone into the gorge of the Little Colorado River (Arizona Department of Environmental Quality 1991).

The Coconino aquifer contains 413 million acre-feet of water; it can be tapped in most areas (Arizona Department of Environmental Quality 1991). Major withdrawals from this aquifer total about 100,000 acre feet and these withdrawals are for power, forest industries, irrigation, municipalities and coal. The aquifer supports many reaches of perennial flow in the southern portion of the watershed. This perennial flow could be impacted by extensive pumping of the Coconino aquifer (Arizona Department of Water Resources 1992).

The Little Colorado River surface water flow is ephemeral except for the Blue Springs, which occur between 3.7 and 20.9 mi above the confluence of the Little Colorado River and the Colorado River (Loughlin 1983). The Little Colorado River gorge receives less than 8 in. of annual precipitation while the San Francisco peaks receive more than 35 in. (Loughlin, 1983). The river has two principal runoff periods; these are the summer and spring. Most of the summer run-off that reaches the Navajo Nation originates from the Puerco River. Extensive grazing has removed vegetative cover and compacted the soil. Any effort to develop a downstream reservoir to divert the sporadic summer flows would have to address the high sediment loads from the Puerco River (Arizona Department of Water Resources 1992). In fact, the sediment loads of the Little Colorado River are among the highest in the world due to cyclic climate change and localized influences of grazing. Spring run-off is the most dependable continuous streamflow in the watershed. At this time, evaporation is low, phreatophytes are at a low activity period, and snowmelt is available (Arizona Department of Water Resources).

There is a significant correlation between regional precipitation and discharge from the Little Colorado River. A reconstruction of the annual discharge through time demonstrates that discharge has varied considerably due to climate change. Departures from the median and mean discharge (165,800 and 189,890 acre-feet) include over 800,000 acre feet in 1973 and less than 20,000 acre-feet in 1974. In general 1892-1904 was a low discharge interval and 1905-1941 was a high discharge interval. Subtle changes in climate are probably responsible for the variations in discharge and the consequent periods of erosion and aggradation. Erosional phases were associated with a 1 degree Centigrade rise in annual temperature, a 50 mm. decline in precipitation, and a period of large floods. Aggradation of the floodplain was associated with rising precipitation and discharge and declining temperature (Hereford 1983). Spring discharge from two rivers in New Mexico were 6-7.4 times higher in El Niño years (Dahm and Molles 1992). It is predicted that predicted large global climate changes will affect arid regions more than others.

Historic Changes

An examination of the historical record of observers of the Little Colorado River demonstrates these changes in the watershed. In 1598, the Spanish explorer, Quesada crossed the river and named it Rio Almeda, the river of groves, because of the great groves of cottonwoods. Sitgreaves was blocked by extensive swamps near what is now Winslow in 1851. In 1858, Beale noted, "what good stock country, I have never seen anything like it and I predict for this part of New Mexico, a large population" (Colton 1937). Beale proved to be prophetic; however the large population consisted of sheep rather than people. In the 1880s Navajos were forced to feed young cottonwoods to their sheep during a drought.

In the 1890s Navajos named the river, Big Timbers, because large floods uprooted old cottonwoods and sent them riding down the river (Colton 1937). A co-worker relates that, during floods, his Navajo father would travel to the river in order to lasso floating cottonwoods and bring them to shore for firewood.

Tamarisk

Tamarisk or salt cedar was not present in the channel until after 1937, although it was cultivated as an ornamental 1 km. from the river in 1909. In 1939, 1200 cuttings were planted by Holbrook citizens along banks in order to halt river spreading and blowing sand. Until 1941 large annual floods prevented salt cedar invasion and controlled flood plain development. After 1941 flood frequency declined, vegetation stabilized the banks and trapped sediment. By 1954 the channel width had decreased by 54% (Hereford 1982).

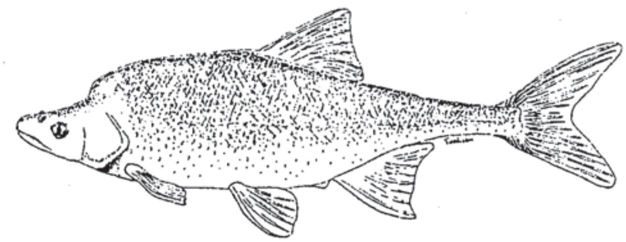
Consideration has been given by managers to control the phreatophytes because they deplete water. If all cultural activities, including reservoirs, irrigation and industrial diversions were halted south of the Navajo Nation, the streamflow at Winslow could increase by 60,000 acre-feet (Arizona Department of Water Resources 1989). However the already extensive phreatophyte population would increase due to the larger amounts of available water. In fact tamarisk could cover over 60% of the 5,700 acres of pasture and cropland within the floodplain (Arizona Department of Water Resources 1989). Tamarisk resists the effect of prolonged inundation during flooding, and therefore it survives better than the natives (Stevens and Waring 1985). When the species establishes itself on a floodplain or channel, there is an increase in overbank flooding and sediment deposition. Vegetated channel bars could stabilize and therefore change the fluvial geomorphology of the river and this in turn could affect the development of backwater habitats for fish.

The Navajo Nation in 1992 set aside a wetlands in the flood plain of the Little Colorado River near Winslow as the Hugo Meadows Wildlife Refuge. The Navajo Natural Heritage Program is currently weighing options for the management of the wetlands. Can the wetlands be restored to a historical condition that facilitates biodiversity? Should tamarisk be exterminated? What native species can outcompete and replace the introduced species? Can that native species survive under the current hydrological conditions? Will the wetlands be jeopardized by development that lowers the water table and at what distance will the development affect the water table? What will the cyclic climate change effects be on the erosion and aggradation of this part of the floodplain? These are questions that must be addressed at several scales.

The Humpback Chub

An important stream segment of the Little Colorado River is that .perennial portion, the Little Colorado River gorge. Here the humpback chub spawns and enters Grand Canyon National Park in the Colorado River. This segment has been proposed as critical habitat by the USFWS. It has also been proposed as a candidate for wild and scenic river designation by some groups. The gorge is also of cultural significance to the Navajo and Hopi tribes. Traditional salt gathering areas are located in the gorge.

The Little Colorado River also provides a significant amount of the sediment to the Colorado River; this sediment is important to maintaining beaches. In this deep canyon, a series of springs, Blue Springs, discharge 211 cubic feet of water per second (Loughlin 1983). The Blue Springs fault strongly influences the water chemistry and



Humpback chub

temperature of water from the individual springs. Springs west of the fault have lower water temperatures and higher dissolved solids than springs east of the fault. Carbonate mineralization upon diatoms and debris have created travertine dams. Below these dams pools have developed. One travertine dam may form a barrier to the upstream migration of the humpback chub. The riffles, pools,rapids, and dams are subunits of the stream segment. At each of the spatial scales there are processes operating that are undoubtedly important to the life history of the humpback chub. The fish depends upon the aquatic productivity of the stream which in turn depends upon detritus brought into the gorge by seasonal floods. Decadal scale variability in precipitation can influence these factors (Grimm and Fisher 1992).

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Arizona State University and the Navajo Natural Heritage Program have tagged and recaptured over 4,000 fish in order to delineate the life history and ecology of the humpback chub. The USFWS is mapping the streambed habitat. These studies are among the conservation measures for the Biological Opinion on the humpback chub. The information collected is also being utilized for the Environmental Impact Statement on the Operation of Glen Canyon Dam. The operation of the dam may affect the confluence where the humpback chub apparently stages for spawning migration. Humpback chub are found in the Grand Canyon; however reproduction has probably ceased there due to the cold temperatures of the water created by the dam; non-native fish also prey upon the humpback chub in the Grand Canyon. Therefore, whereas the Little Colorado River is historically an important habitat for the humpback chub, it is probably now also an important refugia for this endangered fish. Current management efforts for the Little Colorado River are being driven by the Endangered Species Act.

Questions that need to be addressed in managing the humpback chub include those on several scales. On the longitudinal scale, how does climate change and water diversion affect thermal loading, and transport of sediment, nutrients and toxic material. For example, a uranium tailings pile broke and released radionucleides into the Rio Puerco. Has the material dispersed into the Little Colorado River gorge? Has it bound to sediment and if so where was that sediment transported and under what discharge? If a reservoir impounded seasonal flow upstream, could this affect the behavioral spawning cues of the humpback chub? Would the impoundment prevent nutrient transport? Would sediment fill the pools because floods no longer flushed the silt out of the gorge? How much sediment is needed to maintain beaches in the Grand Canyon? On the transverse scale, riparian vegetation contributes shading to the stream as well as invertebrate biomass. On the vertical scale the connection between groundwater and surface water needs to be addressed. A fundamental question to be asked is whether a management plan for the Little Colorado River should be developed from studies that examine only one species in the system?

Issues of scale have received increasing attention in the scientific community. It has been suggested that scaling issues be a primary focus of research efforts (Wiens 1989). However, issues of organizational and cultural perspectives of scale also need to be addressed in any effective riparian management planning.

Information Flow Pathologies

Management of water basins has traditionally been viewed as best done by large scale organizations (Lee 1992). Large organizations however may not best understand the ecosystem due to "information flow pathologies" (Lee 1992). McGovern (1988) identified six of these pathologies.

1. **False Analogy.** Managers bring their understanding of one ecosystem to bear on another. In the EIS on the operation of Glen Canyon Dam the Bureau of Reclamation brings its perspective as a dam building agency to the role as directing agency of the associated Glen Canyon Dam Environmental Studies (GCES). Some studies under GCES have been negatively evaluated by the National Academy of Science.

2. **Insufficient Detail.** The manager may have an overgeneralized model of the ecosystem. For instance, current Little Colorado River management planning addresses only the habitat of the endangered fish, the humpback chub. A larger scale is necessary to even manage this small segment of river.

3. **Short Observational Series.** Managers have a short term memory and cannot separate short term and long term processes (Lee, 1992).Studies under the conservation measures for the humpback chub must be completed within the time frame of funding. Plans may therefore may miss important life history characteristics of the fish which lives in a different ecological scale.

4. **Managerial Detachment.** Managers are detached spatially and culturally from the local users. For instance agencies have condemned waste products flushed into the river from the Navajo Nation. The waste is assumed to originate from the Navajos and the condemnation is made without the managers knowing that there are currently no approved landfills available.

5. **Reactions Out of Phase.** The manager does too little too late in order to ameliorate an impact. For instance, Glen Canyon dam was built; only now they will develop a management plan to preserve the native fish. Another example is the adjudication of the Little Colorado River water rights. This adjudication has been underway for several years. All parties want the water. They will decide what to do with the water when they get it.

6. **Someone Else's Problem.** Managers may only take an action when their short term interests are benefited. Bureau of Reclamation employees may change their policy under a new four year administration; the current Secretary of Interior, Bruce Babbitt once proposed abolishing the Bureau of Reclamation.

7. **Ideological Beliefs.** (Lee 1992). Managers overlook ecological information because it does not conform with their ideology whether it be capitalism (electric power) or environmentalism (no active management is needed).

I would like to identify another information flow pathology, cultural clashes, to the list of information flow pathologies. Initially tribes were not included as cooperators in the EIS on the operation of Glen Canyon Dam. This was despite the clear responsibilities of the Navajo, Hualapai, and Havasupai tribes in particular, as these tribes have lands along the Colorado River as well as important sacred sites. After political pressure, however tribes were reluctantly accepted into the planning process. However, in this process it has been apparent that cultural differences make communication of information and goals difficult. This problem will be identified from the perspective of Navajo culture.

A Navajo World View

In the Navajo world view, mind and language cause events. One needs to control one's thinking in order not to cause bad events. In order to plan things, pure thoughts can be used (Remington 1982). Consequently there may be a reluctance to see the need to write a management plan. Navajos intuit the whole in order to understand things, whereas Anglos understand by deducing the parts (Remington 1982). Navajo society operates on consensus and everyone having a voice; Anglo society is based on majority rule and control by an elite. Navajos view time as circular while Anglos view time as linear.

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Navajo institutions are informal. The Navajo tribe did not exist as a political unit until the 1920's when the federal government imposed one because oil was discovered on the reservation (Griffin-Pierce 1992). Therefore, traditionally, responsibility was to one's relatives or local groups rather than to the tribe; disputes were solved by individuals meeting to resolve differences (Griffin-Pierce 1992). The Navajo Nation is currently studying decentralization in effort to return to a more appropriate and workable scale of organization.

Graf (1986) describes how cultural differences and inadequate scales of study led to a misguided federal policy regarding fluvial erosion on the Navajo Nation. In the 1920s the Hoover Dam project was developed in order to protect irrigation works in southern California and to regulate the flow of the Little Colorado River. These strong political forces led to the first study of sediment in the Colorado River. These studies found that most sediment was derived from the Navajo Nation. Federal planners concluded that sediment eroded from the Colorado Plateau threatened to fill the reservoir behind the dam. Overgrazing by Navajos was blamed for the silt problem. A government report concluded that "the Navajo Nation is practically 'Public Enemy No.1' in causing the Colorado Silt problem" (Graf 1986). The federal government decided the problem could be solved by instituting a large livestock reduction plan on the Navajo reservation.

However, it is now widely believed that hydroclimatic change was responsible for 95% of the fluvial erosion; stocking levels in fact were responsible for only 1-5% of the variation in sediment and water yields (Graf 1983). Navajos to this day cite the livestock reduction as one principal reason that the Federal government is to be distrusted. Currently the Navajo Division of Resources is attempting to change the Grazing Code. The legacy of this misguided federal policy is a major obstacle. This demonstrates the fact that policies have temporal scales of their own.

Recommendations

An examination of issues of scale with regard to management of the Little Colorado River leads to more unresolved questions than answers. However some tentative recommendations can be made. There is no correct scale for describing a system (Levin 1992). The principal problem is not choosing the correct scale, but rather to acknowledge that change is happening on many scales at the same time; the investigator needs to study the interaction among processes on different scales (Levin 1992).

Managers need to beware of the numerous information flow pathologies and be cogniscent that cultures and agencies have perceptual biases. Wiens (1989) demonstrates that studies conducted over a long time at fine spatial scales have a low predictive capacity; short term studies conducted at broad scales have high apparent predictability. This mixing of different spatial and temporal scales can lead to pseudopredictions. Pseudopredictions are a common resource management problem (Wiens, 1989). Methods of spatial statistics may be useful. These methods include fractals, nested quadrant analysis, spectral analysis, and correlograms (Levin 1992). Lee (1992) postulates that local communities may be more effective and efficient organizations to develop ecological sustainable watershed management. However, there may be no correct scale of human organization; but rather, what is essential are people who care enough about the river to be attentive enough to make a concerted effort to understand the mechanisms that operate across the scales of the physical, biological, and cultural processes.

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