What do you see when you look at a river? You probably see peacefully flowing water, between riverbanks that hopefully support a leafy tapestry of green. But seeing only gentle water and verdant vegetation blinds us to most of the natural processes that actually produce the beautiful cottonwood groves and willow thickets that make our river valleys what they are. In fact, rivers are always changing, sometimes forcefully, through the seasons and over the decades. When we take a closer look, our rivers and their streamside life are ever-changing movies, instead of simple snapshots frozen in time.

2.a] High mountain stream flowing through a bedrock valley

In its mountainous upper headwaters, a river probably cascades down steep, rocky valleys that are almost entirely bedrock and boulders, with little soil or valley-bottom sediment. Before it has flowed very far down from its mountain origins, though, the river valley becomes broader and less steep, and bedrock is buried beneath increasing quantities of sediment—rock, gravel, sand, and silt—carried down by the river itself. Sediment filling the valley may be thousands of feet deep, as it is where the Rio Grande flows through Albuquerque; or perhaps only a few dozens of feet deep, in the case of many streams in mountainous areas. However deep the sediment may be, the sediment surrounding a river channel fills with water, and the flowing stream also moves some of the sediment along with it. A river is not just the water we see flowing. It is an integral system of surface and sub-surface water, and the sediment it flows over and carries with it.

A river in its high mountain headwaters flows where its bedrock valley makes it flow. However, when it gets to a valley big and flat enough, a river meanders back and forth across the valley bottom. When the river rises, with snowmelt in the spring or torrents of runoff after a big thunderstorm, the high water carries some of the sediment of the banks and riverbed along with it. Rapidly moving water scours the riverbed and erodes some of the riverbank on the outside of meander bends. As the water slows down some of the sediment drops out, in backwaters, on point bars along the inside of meander bends, and on the floodplain, enriching these areas with nutrients and organic debris. Almost all this re-arrangement of the river channel happens during high flows—what we think of as a "flood", which is just a normal, unavoidable part of a river's annual cycle of low and high flows. Over time, this process tends to accentuate the meander pattern, and sometimes it becomes so pronounced that eventually high water cuts off a bend entirely and creates a new river channel, leaving the old channel as a cut-off meander or oxbow. And the never-ending pattern continues. Even though we do not usually see riverbanks moving as we watch, over time they are constantly moving and changing, meandering back and forth across the floodplain.

2.b] Meander bends in a valley bottom

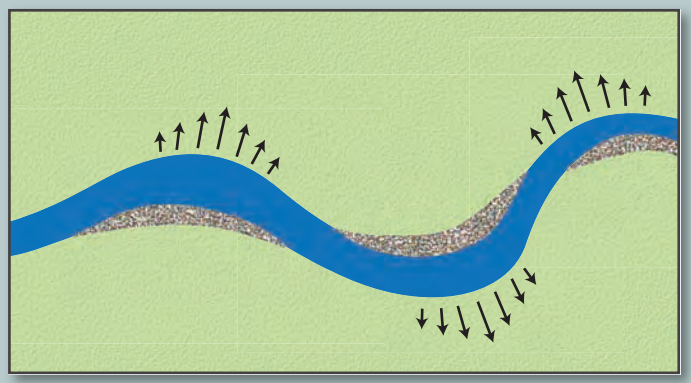
The plants and animals that live along riverbanks in the southwest have evolved to depend on the pattern of natural disturbance caused by river flooding and meandering, and the periodic erosion and re-deposition of river sediment. In fact, without that disturbance many of them could not survive. Cottonwood trees are a good example of riverside vegetation totally dependent on disturbance caused by the cycle of flooding, meandering, and sediment deposition. Cottonwood seeds can only sprout in soaking wet soil, and their seedlings will only grow in wet soil and full sunlight. These are exactly the conditions that exist after spring runoff, when floodwaters have saturated the soil, scoured away dead

leaves and competing vegetation, and have left new islands and point bars along the riverbanks. These are the places, and time of year, when new cottonwoods (and other emergent seedlings) can sprout. There is no such thing as a stable climax woodland of cottonwood trees, with younger trees of different ages growing up beneath the older trees. Instead, a new "generation" of cottonwoods sprouts after a flood, and with luck grows to maturity while succeeding generations of seedlings sprout on other sandbars in other places. Riparian willows and many other plants also cannot reproduce well without flooding and the sunny, wet sediment of newly deposited sandbars.

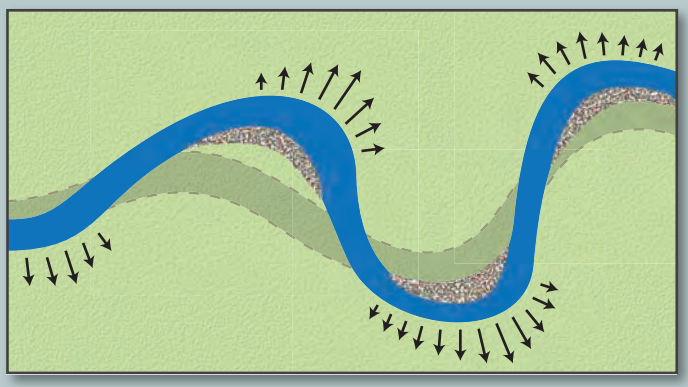
2.c] New cottonwoods sprout when soil is saturated

Once a community of new vegetation gets established, it begins an inexorable process of change as little cottonwoods and willows grow taller and begin to out-compete their neighbors for sunlight, water, and nutrients. The first rapidly-sprouting spikerushes, horsetails and cockleburs give way over time to slower-growing but taller and more persistent sedges, rushes, or perennial grasses. After a few years, as the cottonwoods, willows, and other trees grow taller and closer together, they may shade out many of the smaller ground-level plants as they develop into the dense thickets that provide habitat for songbirds, rodents, insects, and countless other animals. As more years go by, the cottonwoods keep growing taller and their leafy canopies shade out the sun-loving plants they grew up with.

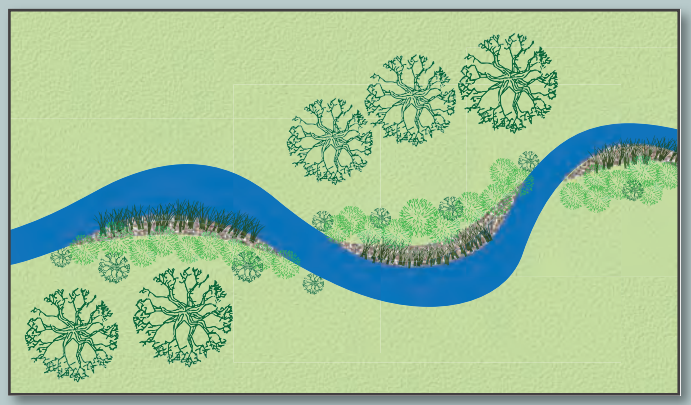
River meanders (top) and resulting ecological succession (bottom)



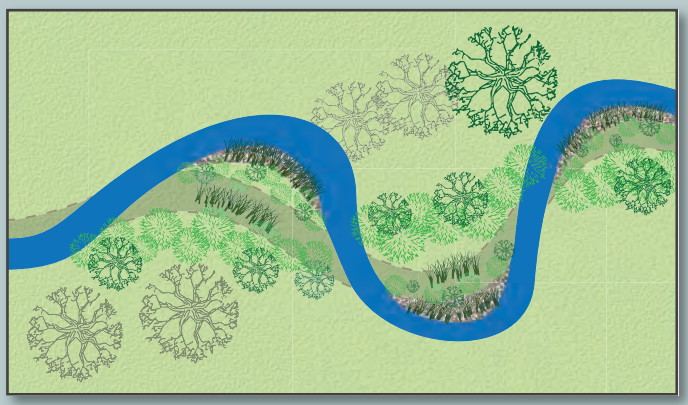
Banks erode on the outside of bends; sediment is deposited on the inside.



Erosion and deposition make the meander bends more pronounced over time.



New plants sprout on newly-deposited sediment. Over time taller plants like willows or sedges grow on sediment bars deposited years before. Mature cottonwoods grow along abandoned river channels where they sprouted decades earlier.



New growth follows the moving river channel. Willows mature into dense thickets, and young cottonwoods grow taller, while older trees eventually die. Old river channels, lower than the surrounding floodplain, may remain wet for years to come.

Beneath a mature cottonwood gallery are plants that can take the shade—like New Mexico olives, wild plums, or many varieties of grasses. As the trees grow and pioneer plants and animals give way to others in the process of ecological succession, the river may have meandered far away across its floodplain, repeating the process of flooding and meandering, erosion and sandbar deposition, and the ecological succession that goes with it, over and over again.

Riparian ecosystems change over time as plants grow and riverbanks move in response to floods and meandering. Plant communities also change to some extent in response to changing climatic conditions, especially in drier parts of a bosque farther from the current location of a river. Wet soil near a stream may be little affected by wet or dry years, but a few inches higher in elevation, or farther away from the stream, drier plants like chamisa, four-wing saltbush, Apache plume, along with saltgtrass or dropseeds may expand their range in drier years.

For many reasons, the bosque is not only a mosaic of different plant communities and habitats, it is (or should be) an ever-changing mosaic, and one with moving boundaries. The different plant communities that typically make up southwestern riparian ecosystems are never quite the same in any two places, and often grade into one another, but the examples that follow illustrate some of the typical stages in the ecological succession that happen as the newly-emergent fuzzy green carpet that appears after spring floods develops through the years and decades. One stage will gradually develop into the next over the years, and there are lots of variations in which species are present and exactly what it all looks like, but the vegetation communities illustrated below are typical stages in the succession pattern in most southwestern riparian areas.

2.d] Bosque flooded by annual spring snowmelt, new cottonwoods sprout

But isn't erosion a bad thing?

Erosion, like fire in pine forests, is a periodically occuring natural process. The cycle of erosion, deposition, sediment transport along a river, and the formation of new sandbars, is absolutely indispensable for many riparian plants to survive. Rivers generally maintain a rough equilibrium of erosion, deposition, and sediment movement along their length, where erosion in some places is more or less balanced by sediment deposition in other places. This equilibrium can be disrupted, however, sometimes massively.

A forest fire which can remove soil-binding vegetation, for instance, can send far more sediment suddenly into a river system than river flows can carry downstream. When that happens, a lot of sediment gets eroded off upland slopes and deposited in the river channel. Existing banks can be covered up, and major changes may happen to the riverbed and banks. As the vegetation in a forest regrows, the natural ecological succession will return and native vegetation will reestablish.

Soil damage and exposure caused by human activities like badly managed grazing, poor logging practices, or poorly planned and excessive road-building can have similar effects. So can massive increases in runoff from roofs and paving in developed areas. However, activities like road building and increased runoff from impervious surfaces are usually not reversed over time and can have permanent deleterious affects on a river system. Conversely, dams stop all sediment transport along a river. Reservoirs behind the dam fill up with the captured sediment. Water released below the dam can cause severe erosion because it carries none of the sediment it used to carry and will recapture its sediment by eroding the bed and banks of the river. The consequences are total disruption of the natural equilibrium of the river's plant and animal communities.

Erosion and sediment are neither good nor bad by themselves. They can, however, create problems when an existing balance is disrupted.

Ecological succession

The first new plants

The first plants to sprout on new soil, or where other vegetation has been cleared away, are likely to include spikerushes, rushes, grasses, cattails, little cottonwood or willow sprouts, and fast-growing annuals like cockleburs.

2.e]

Vigorous growth and expansion

After a few years (if the new plants are not washed away by the next year's high water), the woody plants like coyote willow, or perhaps alder, box elder, or Goodding's willow at different elevations, grow taller and closer together and begin to shade out some of the smaller plants. Other shrubs or larger herbaceous plants like seepwillow, false indigo, sunflowers, New Mexico olive, or mesquite, depending on altitude and location, may also be present. Taller trees, like cottonwoods or box elder, will begin to grow above the shrubs, providing singing perches for many birds.

2.f]

In other places, if trees and shrubs do not become densely established and shade out many herbaceous plants, a vigorous wet meadow may develop. Wet meadows occur in places with frequently-saturated soil and often include plants like yerba mansa, Nebraska, field, or Emory's sedges, nutgrass, horsetail, Baltic or Torrey's rushes, three-square bulrush, and dropseed, sprangletop, or salt grasses.

Mature overstory

In 20 or 30 years, cottonwood trees, or perhaps box elders or Goodding's willows in some places, overtop all the other trees and shrubs and may form a closed canopy that shades everything beneath them. Once that happens, plants that need full sun (like willows) no longer do well and tend to die out. Only plants that can tolerate partial shade continue to grow under the mature trees. Often these are grasses, but they may be shrubs like New Mexico olive, sumac, hackberry, or seepwillow as well. In other places, the taller trees may be spread further apart and sun-loving willows or wet meadow plants may thrive around them.

2.g]

Marshland and aquatic plants

In places that are too wet for willows or other woody plants, aquatic plants like cattails, many different bulrushes, pondweeds, smartweeds, duckweeds, water milfoil, hornwort, and duck potatoes grow. Often cattails and bulrushes will form dense and persistent stands.

2.h]

Succession to upland communities

Riparian trees grow fast but do not live for a long time. It is very rare for a cottonwood to live more than 100 or 150 years, and when mature trees die and the bosque dries out, the bosque may develop into an upland community that is hardly riparian at all, unless flooding and river meandering once again create the conditions for new cottonwoods and other wetland plants to sprout. Without new flooding, cottonwoods and willows will give way to juniper, chamisa, sage, apache plume, saltbush, and upland grass.

2.i]

Rivers in the southwest, and the bosques that grace their banks and floodplains, create a dynamic mosaic that is always in the process of becoming something else, even if it changes slowly to human eyes. Along a natural river, the creative disturbance caused by floodwaters is the lifeblood of the bosque and the ultimate reason that it can exist at all in the way we know it. Where natural flooding has been prevented by channelization or dam control, native riparian vegetation usually depends on intentional ecological restoration work that mimics some of the disturbances that flooding would have provided (such as excavation to provide more water, and planting native species like cottonwoods that cannot reproduce without flooding-induced disturbance). In a restored riparian area, just as in one of the few places where a stream can still maintain a healthy native ecosystem on its own, the bosque is always gradually changing into something else in a natural process of ecological succession.

But if streamside vegetation is always changing, how can we tell how our riparian area is doing? Are there some useful milestones to know about on the way? Are there things that can go wrong? The next section offers some suggestions about how to find out.

Bank stability?

Just as erosion is not necessarily bad, stable riverbanks are not automatically good. It is all a matter of degree. Any riparian ecosystem needs enough stability over time that vigorous riverbank vegetation can develop to shade and cool river water, overhanging sedges can help create good aquatic habitat, and rushes, willows and other plants can capture sediment where new plants can sprout. However, a completely stable, unchanging riverbank will not sustain southwestern bosque vegetation in the long run. Because so many riparian plants have to have newly deposited sandbars and islands, or flood-scoured bare soil in order to reproduce, they will eventually disappear if these conditions never happen. If the banks of the Rio Grande, for example, never again flooded, and there was no more bank erosion and never another sandbar formed, eventually nearly all the cottonwoods, willows, and many other bosque plants would disappear and be replaced by plants like juniper, apache plume, chamisa, or grasses. Natural flooding disturbance, and a certain degree of instability of riverbanks and sandbars, is what makes a southwestern bosque possible at all.

Of course, there is such a thing as too much disturbance, and too much instability of a river's banks and channel. If massive flash floods scour out any new vegetation every year before it can really get established, or smother it with too much new sediment, healthy riparian vegetation will never develop. Similarly, excessive, badly-managed grazing can damage a streamside so much that trampled and denuded banks are constantly washing away downstream. A damaged stream tends to cut down rapidly into its banks and bed leaving its natural floodplain high and dry. The result is too little moisture in floodplain soils to support water-loving riparian vegetation any more. The key to healthy riparian ecology is the right amount of disturbance, including a certain degree of change and meandering of riverbanks over time—not too much, and not too little.

A healthy degree of bank disturbance is different for different rivers. For instance, a healthy high-altitude trout stream will have lush vegetation that requires very little bank erosion and sediment input, even at flood stage. Riparian ecosystems in other natural settings are not necessarily adapted to the scale of change and disturbance that our bosques are in the southwest, and their riverbanks may be much more stable over time.