Riparian Vegetation and Indigenous Southwestern Agriculture: Control of Erosion, Pests, and Microclimate[1]

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Abstract.--Native American and Spanish American farmers of the arid Southwest have managed riparian vegetation adjacent to their agricultural fields for centuries. They have planted, pruned and encouraged phreatophytic tree species for flood erosion control; soil fertility renewal; buffered field microclimates and fuel-wood production. These practices benefit wildlife and plant genetic diversity.

INTRODUCTION

Of the numerous studies of human impacts on riparian communities of the arid Southwest, several have critically analyzed the effects of modern agricultural use of water and land on riparian biota (Rea 1983; Reichhardt et. al. 1978; Johnson, 1979). Many riparian ecologists have attempted to compare human-disturbed sites with so-called "natural controls" which are assumed to be the kinds of ecosystems present in the region prior to the impact of modern man and his technologies (Barclay 1979; Conine et. al. 1978). Although bird and/or mammal species diversity appears higher in riparian woodlands than in field crops (Conine et. al. 1978) or in degraded woodlands simplified by phreatophyte control, the highest bird densities and diversity have been recorded in homogeneous cottonwood stands adjacent to field crops (Carothers et. al. 1974).

In fact, many of the so called "natural riparian stands" are sites which were in part formerly cultivated on a small scale by native Americans (Nabhan et. al. 1982). Prehistorically, irrigation systems of considerable size were developed on the Salt, Gila and Santa Cruz Rivers in Arizona (Masse 1981); and with aboriginal depopulation, some of them were abandoned and reverted to the "natural areas" studied by ecologists today. Cottonwoods, willows and elderberry are among the phreatophytic trees intentionally planted by native and Spanish American at the Quitobaquito oasis in Organpipe Cactus National Monument (Anderson et. al. in press) and along the intermittent streams of northeastern Sonora, Mexico (Nabhan et. al. 1982). Some of these artifically planted riparian stands found near fields have been mistaken by Anglo observers as "natural stands" (Nabhan and Sheridan 1977).

From ethnobiological studies done in remnant areas of indigenous agriculture, it appears that small intercroppings of domesticated and weedy annuals formed mosaics with living hedges, taller shelterbelts, vegetation-reinforced earthen ditch-banks, and open surface water (Rea 1979; Reichhardt et. al. 1983). These habitat mosaics certainly encouraged biotic diversity to a greater degree than do modern monocultural fields plowed from concrete canal clear to the nearest road or next canal. Indigenous farmers recognize certain benefits of this structural diversity of habitat, and associated biotic diversity (Nabhan and Sheridan 1977; Nabhan 1983). The following summary highlights the benefits derived from riparian plants integrated into native agriculture of the arid Southwest, particularly in the U.S./ Mexico borderlands of the Sonoran Desert.

SOIL EROSION CONTROL

Among of the major efforts made by prehistoric and historic communities in the arid Southwest were attempts to buffer themselves and their field crops from the effects of floods of short duration. Except for the last few centuries of the prehistoric era when bajadas and mountainside terraces were used for the cultivation of perennials such as agave, most native agriculture and horticulture were localized on floodplains. Where older patterns of land use and water control still persist in the region, one can see the traditional use of riparian vegetation as a buffer against floods. From the Tarahumara villages of the Rio Conchos, Chihuahua, through the intermittent streams of northeastern Sonora, clear to the Quitovac oasis in northwestern Sonora, native farmers weave brush between the trunks of lines of cottonwood, willow and mesquite adjacent to their floodplain fields to break the force of floods (Sheridan and Nabhan 1979; Nabhan 1983). This process of using living

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fencerows as permeable weirs to reduce the erosive force of floods is still practiced extensively in northeastern Sonora, from 31°N - 29°30'N, and from 111°-109°W (Sheridan and Nabhan 1979; Nabhan and Sheridan 1977).

During the winter months, farmers cut branches of cottonwood (Populus fremontii) and willow (Salix goodingii), and plant the pruned, trimmed branches 1.5m deep and 0.5-0.75m apart at field margins on the edge of the most recently developed stream channel. These cuttings sprout by March, set down roots which stabilize the field edge, and grow into large trees which are periodically, removed for fuelwood. Between their trunks, brush of seep willow (Baccharis salicifolia), burrobush (Hymenoclea spp.); and mesquite (Prosopis Juliflora are woven to form a horizontal, semipermeable barrier 1-2 m high.

This woven fence serves to slow later flood waters without entirely channelizing the primary streambed the way in which concrete or riprap channel banks would. As a result, when summer or winter floods arise which cover the entire first terrace of flood-plains, channels do not become as readily entrenched, nor is erosion as pervasive as it would be on a barren floodplain. December 1978 floods were responsible for five million dollars worth of crop, public works and machinery damage on a section of the Rio Magdalena lacking living fence rows and dozens of hectares have not yet been brought back into cultivation there. The same floods destroyed sections of living fencerows near Cucurpe on the Rio San Miguel and near Mazocahui on the Rio Sonora, and scouring was locally significant, but neither as profound nor pervasive. Within two years, farmers had made efforts to repropagate fencerows, and refill incipient headcuts running through fields from side drainages. While not foolproof, the hundreds of kilometers of propagated cottonwood and willow corridors in eastern Sonora work best in buffering fields from floods smaller in magnitude than 20 year events.

Soil Conservation Service projects near Safford on the Gila River and Canyon de Chelly on the Navajo Reservation once planted cottonwoods and willows to reduce bank erosion and lateral cutting associated with meanders. Although theoretically such woody riparian vegetation can bring stream channel erosion and aggradation into local equilibrium (Hadley and King 1977), I urge geomorphologists to set up studies to monitor the effects of these plantings in "real life situations" in eastern Sonora. Nevertheless, Sonoran farmers are correct when they say, "The trees and woven branches accept the floodwater and make it tame."

SOIL FERTILITY RENEWAL

Farmers in eastern Sonora claim that such semipermeable weirs of riparian vegetation "give soil to the fields" by trapping the rich detritus and silt suspended in floodwaters (Sheridan and Nabhan 1979). By placing now living fencerows several meters into an eroded channel from an older row on a field bank, they force modest sized floods to drop their suspended bedloads as food energy is dissipated by hitting the woven brush. Some of this detritus and silt fills up in the place between the bank and the new fencerow; if flood levels are high enough, the rest slowly spreads out across the field. As one farmer in Cucurpe declared, "The floodwater's detritus is the richest, best material for fertilization." A San Ignacio, Sonora farmer claimed his field would yield well for four years following the fencerow mediated deposition of abono del rio (river manure/nutrients).

I had the opportunity to test this hypothesis while studying the desert riparian ecosystems which nurture Papago Indian floodwater fields (Nabhan 1983). The impermeable weirs which Papago farmers now build at strategic locations on or above alluvial fans play much the same role as the living fences in eastern Sonora; before barbwire, Pima and Papago farmers lined their oval fields with dense hedges of mesquite (Prosopis spp.) and wolfberry (Lycium spp.)

Analyses published elsewhere (Nabhan 1984) verify that floodwashed detritus deposited in fields is as rich in nitrogen and certain other nutrients as are commercial organic fertilizers. A composite of debris from 14 plant species, including 5 legumes, and dung of 3-5 mammal species, this desert riparian detritus is rapidly decomposed in fields, where it contributes to plant growth and soil mositure holding capacity. The effects of this managed deposition of soil fertility is unequivocal. Nearly all Papago fields receiving organic floodwash from ephemeral streams maintained levels of soil macronutrients comparable to those recommended for commercial crop production, and need amendments only for one or two micronutrients that were geologically scarce in their watersheds. Fields that had been periodically cultivated at least since early historic times were not significantly less fertile than nearby, uncultivated floodplain soils (Nabhan 1983). The nitrogen rich detritus of mesquite and other desert riparian legumes probably have played a key role in floodplain soil fertility in the Sonoran Desert for millenia.

FIELD MICROCLIMATES

In arid and semiarid zones, the free exposure of irrigated herbaceous crops to hot, dry winds creates an evaporative pull resulting in extremely high transpiration rates (Carder 1961; El Rahman and Batanouny 1965). This herbaceous crop water loss can be diminished by planting windbreaks to reduce the clothesline or oasis effect over the crop canopy (Lomas and Schlesinger 1971). Particularly when the windbreak trees are tapping moisture reserves unavailable to crop roots, water savings from the crops far outweighs the losses from the trees. In effect, this system has been implemented by Sonoran farmers who greatly benefit from the microclimate buffering at springfed oases and along floodplain corridors. Temperature control, wind control, and partial shading interact to moderate crop microclimate. In windspeeds of 20 mph, a 20 foot tall living windbreak can reduce wind velocity 80 feet into fields by 40%, reducing evaporation and pollination losses (Al-Mutawa 1985). A more favorable crop microclimate probably translates into yield increases, but these interactions have not been empirically studied in the Sonoran Desert.

FUELWOOD PRODUCTION

Except for mesquite, which is a highly marketable firewood, none of the commonly propagated Sonoran Desert riparian species have much market value. However, cottonwood and willow prunings are used as kindling and for short-duration cooking fires by the families of the farmers who seasonally trim the fence rows. Because fuelwood resources are rapidly being depleted in arid zones globally, these local renewable energy resources should not be overlooked.

PEST CONTROL

Mesquite and hackberry hedgerows with brush woven between served farmers historically in excluding livestock from their fields. Now barbwire fulfills this function, but hedges and fencewors act as a secondary barrier. More importantly perhaps is the control of insect pests by insectivorous birds which nest or perch in the planted trees and understory. For instance, the Quitovac oasis harbored 29 insectivorous bird species in late Spring, 1982, more than any of the five other agricultural and natural vegetation sites studied by our Man and the Biosphere project (Reichhardt et. al. 1983). This site had a variety of hedge and fencerow features, as well as open water. Yet in three of the four seasonal censuses we made, the agricultural Quitovac oasis had more insectivores than non-agricultural Quitobaquito that also had open water. Overall, Quitovac had a higher Shannon-Weaver diversity value for passerine birds, including many insectivores, for three out of four seasons when compared with Quitobaquito (Reichhardt et. al. 1983). Obviously, empirical studies of insect populations and crop pest species are justified.

WILDLIFE

The above discussion suggests that fencerow habitats positively influence the diversity of bird species present in agricultural habitat mosaics within riparian ecosystems. Amadeo Rea observed that at the 6 Sonoran Desert sites which we studied, we found the following species only at farms adjacent to mesquite thickets: Crissal Thrasher; Northern Cardinal, Pyrrhuloxia, and Abert's Towhee. Rea also noted ten transient species attracted to the cool, shady microhabitats of fencerows: Epidonax flycatchers; Nashville, Yellow-Throated and Black-throated Warblers; Blue Grosbeaks; Lazuli Buntings; Pine Siskins; Savannah sparrows; Scott's Orioles, and Lincoln's sparrows (Reichhardt et. al. 1983). His earlier hypothesis (Rea 1979) that these microhabitats also support a higher diversity of small mammals was not clearly documented, in part due to habitat destruction during our study. Eric Mellink, the vertebrate ecologist on our project, is currently studying seven rodent species inhabiting non-irrigated fields on floodplains in San Luis Potosi, Mexico. It is clear from avifaunal analyses of prehistoric agricultural habitats in the Rio Grande river basin (Emslie 1981) and from recent studies of mammals and birds in Midwestern shelterbelts (Yahner 1983 a and b) that woodland and field mosaics support considerable wildlife, including numerous species valued by hunters.

WILD GENETIC RESOURCES

One hidden benefit to Southwestern agriculture of adjacent riparian vegetation is the harboring of wild plant genetic resources in the understory of floodplain bosques, fencerows and shelterbelts. These genetic resources, largely cross-compatible relatives of native American crops, are strongly associated with riparian vegetation from the U.S./Mexico borderlands, Southward. Through introgressive hybridization, these flood disturbance adapted plants contribute genes for tolerance to environmental stress, pests and diseases to crop plants with which they share pollen vectors. Laura Merrick, Steve Buchmann and I have began to document this phenomena in detail at Pima Indian fields on the Rio Yaqui floodplain, where wild Cucurbita Soronia group populations outcross with the Cushaw squash, Cucurbita mixta (Nabhan 1984; Merrick and Nabhan 1984). Introgressive hybridization between Southwestern crops and riparian understory plants potentially occurs among chiles (Capsicum), beans (Phaseolus), maize (Zea), devil's claw (Proboscidea), amaranthus (Amaranthus), sunflowers (Helianthus) and introduced Songhums (Sorghum). Recently initiated efforts to study such introgressive hybridizations in indigenous agriculture in Arizona and northwest Mexico will undoubtedly result in more evidence that riparian biotic diversity has positive benefits for agricultural genetic diversity. Clearing away wild vegetation around native fields has begun in Onavas and Quitovac, Sonora, as part of government-subsidized agricultural development programs. This land use change, if continued, will likely isolate crops from the wild plant gene pools that have enriched them over evolutionary time, resulting in increasing genetic vulnerability of the crops.

CONCLUSIONS

The above-mentioned interactions between small-scale native agriculture and riparian vegetation in the binational Southwest present a different relationship than that occurring amidst modern, mechanized agriculture. The benefits to the diversity and stability of native agriculture are difficult to assess in monetary or energetic terms, but are nonetheless significant. I urge other scientists to apply their expertise and tools to the study of riparian vegetation mosaics and

and corridors interspersed with agricultural fields. Such studies may help us better appreciate 2500 years of native, floodplan-based agriculture in the binational Southwest, and may encourage us to reconsider overlooked options for future floodplain land use.

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