

The Pecan Orchard as a Riparian Ecosystem¹

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Abstract.--The world's largest irrigated pecan orchard is located 20 miles south of Tucson, Arizona, in the Sahuarita-Green Valley area. The mature orchard is a dense woodland of tall deciduous trees, with abundant weeds as understory and surface water generally available. Native animals have invaded the orchard and adapted to it.

INTRODUCTION

The decline of native riparian habitat in the southwestern U.S. has been well documented and much lamented. The Santa Cruz River runs northward from Mexico, up through southern Arizona to join the Gila River just south of Phoenix. Johnson and Carothers (1982) summarized the transformation of the riparian habitat along the Santa Cruz River. Irrigated agriculture has flourished in the Santa Cruz valley for hundreds of years. Native American farmers were replaced by Spanish who were in turn replaced by Anglos. All practiced the same basic flood irrigation techniques and grew many of the same crops. But the scale of agriculture changed over time. In the 1950's, the Sahuarita-Green Valley area 20 miles south of Tucson had more than 6000 acres of cotton and small grains. A few mesquite trees remained in places along the river banks, but essentially the native riparian habitat was gone, and with it the native animals that require riparian habitat. Agricultural development may have significant adverse impact on wildlife communities when riparian habitat is converted to agricultural uses (Connie et al. 1978).

In 1964, the Farmers' Investment Company (FICO) began conversion of their cotton and small grains acreage to pecans (Walden 1970). Presently about 4500 acres are devoted to pecans, making this the world's largest irrigated pecan orchard. Wells et al. (1979) have published apparently the only paper on use of western orchards by native wildlife. Apparently no published reports on wildlife uses of pecan orchards exist, with the exception of one paper (Couch 1981) on wildlife pest control in pecans.

The pecan tree is a native of the southern United States and northern Mexico. Wild pecans are found from west central Texas to western Alabama in the east and extend up the Mississippi River and its tributaries into southern Illinois. In its native range the pecan tree is largely confined to bottomlands and floodplains bordering rivers and streams. In prime habitat, the wild pecan is so successful as a competitor that virtually all other significant tree species are eliminated, leaving almost pure stands of pecans (Wolstenholme 1979). Pecans are not native in Arizona, but were introduced in about 1920. By 1978 there were over 12,000 commercial acres of pecan trees in Arizona, mostly in Pima, Pinal and Maricopa counties (Miekle and True 1981). All pecan culture in Arizona depends upon irrigation; the climate is much too dry to support the trees without the growers providing a large amount of water. Drip or trickle irrigation has been used successfully on some of the smaller plantings of pecans (Bach and Kuykendall 1971), but the largest orchards use flood irrigation, on a two-week schedule.

Over the years, the pecan trees on the FICO farm have grown and appear to be maturing into a biotic community that is very similar to the native riparian community in some ways, yet is also different from it. The information presented here was gathered incidental to a study of pest mosquitoes that breed in the orchard.

DESCRIPTION OF THE AREA

The orchard presently consists of approximately 4500 acres of pecan trees, divided by roads and canals into fields ranging in size from 5.3 to 143 acres. The fields are more or less contiguous along the east side of the Santa Cruz River for approximately 10 miles. The southern half of the farm has had the land on the west side of the river developed as the Green Valley retirement community. Green Valley presently is a thriving retirement community of approximately 11,000 residents. It is rapidly growing, with projections for a population of approximately 100,000 residents in the year 2000. Most of the development will be

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on land that is presently in pecans. The development grew up on the west side of the orchard, paralleling the orchard and the river. Between the orchard and the houses, in the area designated as floodplain, golf courses and recreation centers were created. The development plans call for more golf courses in some of the floodplain, with about 1800 acres remaining in pecans. The northern half of the farm has the land on both sides of the river in pecans, where it is about 1.5 miles wide. Adjacent to the orchard, at widely scattered locations are individual houses, the communities of Continental and Sahuarita, and a trailer park.

Irrigation water is pumped from wells and distributed about the farm in a system of concrete-lined ditches. At each field, when irrigation time arrives, the ditch at the head of the field is filled with water, and water siphoned from the ditch into the areas between tree rows, called borders. The borders are 30 feet wide, and may be two or three hundred yards long. Borders are filled with water to a depth of six inches to a foot. Each day sections of several fields are irrigated, with a complete rotation around the farm approximately every two weeks. During the drier parts of the year, water percolates through the soil rather quickly, but the soils on approximately 20 percent of the farm are high enough in clay content that puddles may last for several days to a week. During the rainy season in July and August, parts of some fields may remain wet continuously, creating a swamp that may last for several weeks.

The trees were originally planted at a density of 96 trees per acre on 2,500 acres, 80 trees per acre on 1,000 acres, and 48 trees per acre on 2,500 acres. Thinning has occurred on most of the land, so that present density does not exceed 48 trees per acre, and in the fields with the largest trees, density is now 24 trees/acre. Eventually a density of 12 trees/acre is anticipated. With the exception of trees planted to replace the very few that have died, all trees in a given field are the same age, and very similar in size. As a general management policy, no tillage is done in the fields. Dense weeds grow in the borders. The farmers attempt to keep the weeds down by mowing, but stop during the rainy season because the soil is too muddy. The dominant weed species is barnyard grass, Echinochloa cruzgalli, which can grow to more than six feet tall and is a major producer of seeds that are potentially valuable as food for wildlife (Martin et al. 1951). Shrubs are not present, and would not be tolerated. Around the edges of many of the fields there are slash piles, where cuttings from the trees are dumped.

ANIMAL USE OF THE ORCHARD

Invertebrates

The most abundant invertebrates appear to be mosquitoes and aphids. Two species of floodwater mosquitoes, Aedes vexans and Psorophora columbiae,

breed prodigiously in the orchard and are a serious pest for farm workers and residents of the area. There is also a large dragonfly population, with at least nine species of dragonflies found in the orchard. They are probably eating the adult mosquitoes. The amount of permanent water suitable as breeding habitat for dragonflies seems insufficient in the area to support the dragonfly population. The larvae require long-lasting water (Corbet 1980), and the only water I have found in the vicinity that seems suitable is in cowponds and golf course water hazards, which are heavily stocked with fish that might eat or compete with dragonfly larvae. I have found a few larvae in some irrigation ditches, and seen adults ovipositing in ditches and flooded borders, but I have not found water in the orchard that would last long enough for dragonfly larvae to grow to maturity. The abundant adults may be immigrants or transients. Damselflies of several species are also abundant. Several aquatic insects are common, including the giant water scavenger beetle Hydrophilus triangularis and several species of notonectidae. These insects rapidly colonize newly flooded borders and attempt to reproduce, but usually the water is gone before the insects mature. I have also found crustaceans, including seed shrimp, clam shrimp, and fairy shrimp occurring in the flooded borders. A systematic survey of the invertebrates of the pecan orchard would probably turn up many more taxa that are characteristically found in our native riparian habitats.

Vertebrates

The vertebrate fauna is more conspicuous and easier to note with casual observation than the invertebrates. Birds are the only vertebrates for which I have kept consistent records, the other vertebrates being observed incidentally during my other studies. The only species of fish found in the orchard is the mosquito fish, Gambusia affinis. The fish were originally planted in stockponds adjacent to the orchard, one of which is filled by a ditch bringing water from one of the irrigation canals. Occasionally some fish swim upstream and get out into the orchard when irrigation is occurring. They live for a few days and then either have to find a way back home or die when the water dries up.

Amphibians

Several species of toads are abundant in the orchard. The large Colorado River Toad, Bufo alvarius, breeds in the ditches and also in some of the waterlogged borders. Red spotted toads, Bufo punctatus, and Great Plains toads, Bufo cognatus, are abundant and breed successfully in some of the borders, although most of the tadpoles are stranded when the irrigation water seeps into the soil. Early in irrigation season, most of the amphibians' reproductive effort is wasted, since water does not remain long enough for tadpoles to mature. Once the summer rains have begun, many puddles in the orchard originally created by

irrigation water are replenished by rain water and last long enough for successful toad reproduction. Couch's spadefoot toads, Scaphiopus couchi, breed very successfully in parts of the orchard during the summer rainy season.

Reptiles

Reptiles are much less common in the orchard than amphibians. Apparently the ground-living reptiles can not survive well when the land is flooded so often. I have seen a few tree lizards, Urosaurus ornatus, and desert spiny lizards, Sceloporus magister, but lizards appear to be, at least to casual observation, rather scarce. Snakes also are uncommon. In three summers, I have not seen a rattlesnake in the orchard, although farm workers have told me that they have seen rattlesnakes. I have seen two gopher snakes, Pituophis melanoleucus, and one garter snake, Thamnophis sp. The gopher snakes were both outside the flooded area, along ditchbanks. The garter snake was in the area that is flooded, and appeared to be feeding on toadlets.

Birds

Birds are abundant in the orchard. A list of the birds observed in the orchard is presented in Table 1.

I would like to briefly mention a few of the more interesting species, and point out what they may be doing in the orchard. Hawks are abundant: Red-tailed Hawks are present all year, apparently feeding on rock squirrels which are extremely abundant. I have observed no Red-tailed Hawk nests in the orchard; good nest sites may be a limiting factor for the population. The farmers are considering erecting artificial nest platforms in the hope of increasing their density, in an attempt to decrease the squirrel population. Other hawks are seasonally common to abundant. Most are apparently migrating through the area and discover the abundant squirrels, so stay for a few days or weeks.

Several species of birds characteristically found in native riparian habitats have settled in the orchard. Yellow-billed Cuckoos, which are scarce and declining in native habitats (Gaines 1977) appear to be abundant in the orchard. I have not attempted a systematic count, but that there is approximately one nesting pair per ten acres. This is approximately the same density observed by R. R. Johnson (personal communication) in mature cottonwood forests on the Salt and Verde Rivers, Arizona. Black Phoebes, although uncommon, are probably nesting. Lucy's Warbler and Yellow Warblers are abundant nesting birds in the orchard, as they are in native riparian woodland (Phillips et al. 1964). Blue Grosbeaks are common nesting birds here. Lazuli Buntings are present but uncommon, and they are probably summer visitors rather than nesters. Lesser Goldfinches are abundant throughout the summer. Song Sparrows,

which are characteristically found in reed-sedge-brush types along major permanent rivers (Phillips et al. 1964) are present and singing all summer long in the weeds around the orchards and in slash piles, but their breeding status is unknown. Albert's Towhees are also present in and around the slash piles. Red-winged Blackbirds are abundant and appear to follow the irrigators, glean insects flooded out of the soil by the irrigation water. I have found no nests of these birds, but they are abundant throughout the summer, probably only as transient foragers. Both Hooded and Northern Orioles, common birds in native riparian woodlands (Phillips et al. 1964) are not common in the orchard and their nesting status is not known.

Some birds that might be expected in riparian habitat are apparently absent in the orchard. The Cardinal and Bell's Vireo are apparently not present. They typically live in brushy areas along streams (Phillips et al. 1964), and in the orchards there is no shrub midstory of vegetation. The vegetation profile in the orchard is limited to an understory of weeds, sometimes very tall and dense, although the farmers try to keep the weeds down, and a tall canopy of pecan trees. This limits the diversity of foliage layers for foraging and nesting, and would effectively eliminate species that prefer the shrub midstory that is characteristic of some native riparian woodland. Slash piles around the orchard may be suitable for some species of midstory-frequenting birds, such as Albert's Towhee, and not others. The slash piles are not covered by a canopy of trees, and this may reduce their usefulness to some species. Hole-nesting birds are rare. Woodpeckers apparently do not make holes in the pecan trees, although 3 species of woodpeckers are occasionally seen in the orchard. Tree holes caused by rot setting in where branches have broken off apparently do not occur because the trees are well care for, and broken limbs treated to prevent fungus infection. A native fungus, Cytospora sp., which invades broken limbs has created problems for the growers. It is characteristically found in cottonwood trees. Careful treatment of the trees has kept infection with the fungus to a minimum. Snag nesting birds are also absent, because dead trees are removed and replaced by the farmers.

Mammals

A number of species of mammals live in or use the orchard. I have made no attempt to investigate the mammal fauna, except very casually. Because most species are nocturnal, casual observation has been insufficient to get any but the most superficial picture of the fauna. Bats are rather abundant and appear to be of several species. They are probably feeding on adult mosquitoes (Hinman 1934). Coyotes, Canis latrans, are very common, as are javelina, Pecari tajacu. Both of these probably eat some of pecans. Raccoon, Procyon lotor, tracks and skunk tracks are very common. Remains of road-killed striped skunks, Mephitis mephitis, are frequent along the highway running through the orchard. Burrowing mammals appear rare

Table 1.--Birds observed in the pecan orchard. Nomenclature and order follow A.O.U. Checklist 1983. Abundance and status refer only to the orchard, not the surrounding desert and urban areas. Codes: Abundance: A=Abundant, C=Common, U=Uncommon, R=Rare; Status: V=Visitor B=Breeds, ?=Unknown; *=Characteristically Riparian Habitat Dependent.

Turkey Vulture <u>Cathartes aura</u> CV	Cactus Wren <u>Campylorhynchus brunneicapillus</u> CV
Northern Harrier <u>Circus cyaneus</u> RV	Bewick's Wren <u>Thryomanes bewickii</u> U?
Sharp-shinned Hawk <u>Accipiter striatus</u> UV	Ruby-crowned Kinglet <u>Regulus calendula</u> UV
Cooper's Hawk <u>Accipiter cooperi</u> CV	American Robin <u>Turdus migratorius</u> UV
Harris' Hawk <u>Parabuteo unicinctus</u> RV	Northern Mockingbird <u>Mimus polyglottos</u> UV
Swainson's Hawk <u>Buteo swainsoni</u> CV	Curve-billed Thrasher <u>Toxostoma curvirostre</u> UV
Red-tailed Hawk <u>Buteo jamaicensis</u> AV	Water Pipit <u>Anthus spinoletta</u> UV
American Kestrel <u>Falco sparverius</u> CV	Loggerhead Shrike <u>Lanius ludovicianus</u> RV
Peregrine Falcon <u>Falco peregrinus</u> RV	European Starling <u>Sturnus vulgaris</u> AV
Gambel's Quail <u>Callipepla gambelii</u> AB	Lucy's Warbler <u>Vermivora luciae</u> AB
Killdeer <u>Charadrius vociferus</u> RV	Yellow Warbler <u>Dendroica petechia</u> AB*
Rock Dove <u>Columba livia</u> RV	Yellow-rumped Warbler <u>Dendroica coronata</u> AV
White-winged Dove <u>Zenaida asiatica</u> AB	Western Tanager <u>Piranga ludoviciana</u> UV
Mourning Dove <u>Zenaida macroura</u> AB	Black-headed Grosbeak <u>Pheucticus melanocephalus</u> UV
Inca Dove <u>Columbina inca</u> CB	Blue Grosbeak <u>Guiraca caerulea</u> CB*
Common Ground-Dove <u>Columbina passerina</u> CB	Lazuli Bunting <u>Passerina amoena</u> RV*
Yellow-billed Cuckoo <u>Coccyzus americanus</u> CB	Abert's Towhee <u>Pipilo aberti</u> RB*
Greater Roadrunner <u>Geococcyx californianus</u> CV	Chipping Sparrow <u>Spizella passerina</u> UV
Common Barn-Owl <u>Tyto alba</u> RV	Lark Sparrow <u>Chondestes grammacus</u> UV
Lesser Nighthawk <u>Chordeiles acutipennis</u> CV	Song Sparrow <u>Melospiza melodia</u> U?*
Common Poorwill <u>Phalaenoptilus nuttallii</u> CV	White-crowned Sparrow <u>Zonotrichia leucophrys</u> AV
Black-chinned Hummingbird <u>Archilochus alexandri</u> CV	Red-winged Blackbird <u>Agelaius phoeniceus</u> AV*
Gila Woodpecker <u>Melanerpes uropygialis</u> CV	Western Meadowlark <u>Sturnella neglecta</u> CV
Ladder-backed Woodpecker <u>Picoides scalaris</u> CV	Yellow-headed Blackbird
Northern Flicker <u>Colaptes auratus</u> CV	<u>Xanthocephalus xanthocephalus</u> RV*
Black Phoebe <u>Sayornis nigricans</u> U?*	Brewer's Blackbird <u>Euphagus cyanocephalus</u> UV
Say's Phoebe <u>Sayornis saya</u> CB	Great-tailed Grackle <u>Quiscalus mexicanus</u> A?*
Vermilion Flycatcher <u>Pyrocephalus rubinus</u> R?*	Bronzed Cowbird <u>Molothrus aeneus</u> UB*
Western Kingbird <u>Tyrannus verticalis</u> AB*	Brown-headed Cowbird <u>Molothrus ater</u> CB
Purple Martin <u>Progne subis</u> UV	Hooded Oriole <u>Icterus cucullatus</u> U?*
Violet-green Swallow <u>Tachycineta thalassina</u> UV	Norther Oriole <u>Icterus galbula</u> U?*
Northern Rough-winged Swallow	House Finch <u>Carpodacus mexicanus</u> AB
<u>Stelgidopteryx serripennis</u> UV	Lesser Goldfinch <u>Carduelis psaltria</u> AB*
Common Raven <u>Corvus corax</u> AV	House Sparrow <u>Passer domesticus</u> UV

or uncommon, probably because their homes would be flooded by the irrigation water. Pocket gopher, Thomomys bottae, sign is uncommon. No rodent trapping has been done in the area, so the rodent fauna is largely unknown. Cotton rats, Sigmodon hispidus, have been seen in the orchard. Rock squirrels, Citellus variegatus, are extremely abundant and are considered an important pest. They burrow in ditch banks and also live in the slash piles. The farmers estimate that over \$100,000 worth of nuts are consumed by rock squirrels each year (R. K. Walden, personal communication). Farm workers attempt to poison and shoot the squirrels.

MANAGEMENT

The farmers had no intention of creating wildlife habitat when they planted the orchard. But they do recognize the value of the wildlife that has moved into their farm. As part of their farm management, the farmers would like to minimize

negative effects of cultural techniques on the native wildlife and are reluctant to contaminate the environment with insecticides. The only economically important insect found in the orchard is the blackmargined aphid, Monellia caryella. The floodwater mosquitoes are not considered an economic pest, but a nuisance and public health pest. Considerable political pressure has been applied on the growers to combat the mosquitoes. Options for mosquito control are limited. Few chemical insecticides are legally labeled for us on pecans, and no insecticide is specifically labeled for killing mosquitoes in pecans. Several chemicals are labeled for use for aphid control on pecans. Most of those chemicals will also kill mosquitoes, and were formerly used in an inefficient attempt to control mosquitoes. The growers are concerned that overuse of chemicals to combat mosquitoes may cause resistance to chemicals to develop in the aphids and might kill beneficial insects. My research over the past three years has been primarily directed toward development of techniques for the use of a bacterial mosquito larvicide, Bacillus

thuringiensis israelensis, also called BTI. BTI is an effective mosquito larvicide that is harmless to nontarget organisms (Garcia et al. 1981), Mulligan and Schaefer 1981, and is exempt from tolerances on food crops because of its proven safety. The treatment regime proved to be highly successful in the 1984 irrigation season. For the first time in many years, not a single mosquito complaint was received by the county health department, and it was possible to work comfortably in the orchard.

In conclusion, it appears that a land-use decision based upon economic considerations has resulted in the creation of a new type of agricultural ecosystem that closely resembles a declining native habitat. The new habitat has been settled by native animals, and the development of a distinctive biotic community is apparent and should be studied over time. Some native animals that are becoming rare because their habitat is disappearing are becoming settled and abundant in the pecan orchard. At the same time, mosquitoes, undesirable residents of native riparian wetlands, have found good habitat as well, and created problems for the human population. A management plan for the pests has been developed that takes into account the value of the nontarget organisms in and around the orchard and works with the biology of the mosquitoes, using the softest possible approach to solving a difficult problem.

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