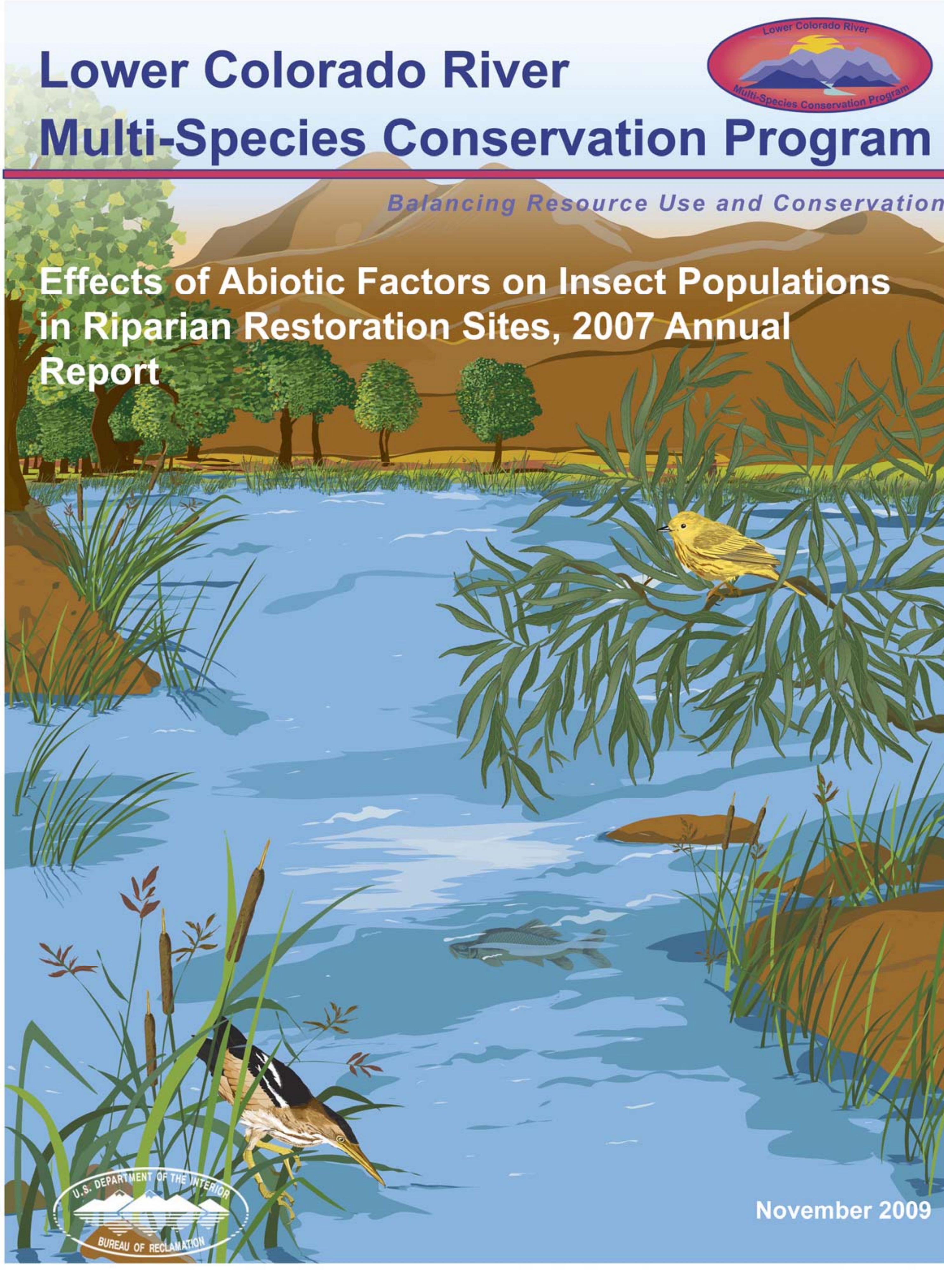
Lower Colorado River Multi-Species Conservation Program

Balancing Resource Use and Conservation



Effects of Abiotic Factors on Insect Populations in Riparian Restoration Sites, 2007 Annual Report

U.S. Department of the Interior
Bureau of Reclamation

November 2009

Lower Colorado River Multi-Species Conservation Program
Steering Committee Members

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National Park Service
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Western Area Power Administration

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Lower Colorado River
Multi-Species Conservation Program

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Lower Colorado River
Multi-Species Conservation Program
Bureau of Reclamation
Lower Colorado Region
Boulder City, Nevada
http://www.lcrmscp.gov

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Abstract.
Two studies were conducted during 2007 on the effects of nitrogen and water on arthropod (spider and insect) populations. The first study examined the effects of plant water and nitrogen contents on arthropod numbers and masses on branches cut from cottonwood trees in a restoration plot at Cibola National Wildlife Refuge, near Cibola, Arizona. Most arthropods captured on branches were spiders. Arthropod mass, but not abundance, increased with increasing leaf percent-nitrogen on 24 August 2007 when arthropods were most abundant. Branch percent-water was homogenous among trees and did not influence arthropod numbers or masses. Percent leaf-nitrogen of trees planted for bird habitat should be monitored, and possibly increased, to maximize arthropod prey. The second study examined the effectiveness of small pools, installed to retain irrigation water, on increasing taxa of arthropods at Beal Lake, Havasu National Wildlife Refuge. Arthropods (mostly flies, gnats, and moths) were collected with three Malaise traps. One trap placed over a pool containing standing water, and one trap placed away from pools, captured insects comprising more bees and wasps and fewer flies and gnats than one trap placed between two pools. Artificial pools were not effective at Beal Lake where restoration plots are bordered by large marshes that produce abundant, emigrant insects.

Introduction.
Eight species of birds (southwestern willow flycatcher, yellow-billed cuckoo, gilded flicker, Gila woodpecker, vermilion flycatcher, Bell's vireo, Sonoran yellow warbler, and summer tanager) and four species of bats (western red bat, western yellow bat, California leaf-nosed bat, and pale Townsend's big-eared bat) included in the Lower Colorado River Multi-Species Conservation Program (LCR MSCP) eat arthropods (spiders and insects). Creating and maintaining habitat for these species will require providing an adequate supply of arthropods for food. This may be especially difficult at several LCR MSCP habitat creation sites being developed, because riparian vegetation is being planted in non-riparian farmland (i.e. where water tables are lowered, soil salinities may be elevated, and spring flood flows are absent). Growing plants will not by itself guarantee arthropod abundances large enough to feed and support bird and bat populations. Two abiotic factors, plant water content and plant nitrogen content, greatly influence abundances of plant-feeding insects (Bernays and Chapman 1994). Nitrogen is especially limiting, because plants contain approximately 3% nitrogen (% of dry weight) and insects contain approximately 10% nitrogen. Insect survival and fecundity increases with increasing levels of plant water and nitrogen (Scriber, 1984). Levels of plant water and nitrogen can be manipulated, depending on soil conditions, by controlling plant irrigation and fertilization.

The primary objective of this work task is to determine the response of insect abundance to plant water and nitrogen contents in created riparian habitat. We initiated this work during 2006 by developing a method for measuring plant nitrogen at Reclamation's regional laboratory in Boulder City, Nevada. The effectiveness of small, artificial pools for increasing insect abundances in restored riparian vegetation was examined. During 2007 two investigations were performed:

(1) <u>Effects of Plant Water and Nitrogen</u>. The effects of these nutrients in planted cottonwood trees on arthropod abundance and mass were examined.

(2) <u>Artificial Pools</u>. The effectiveness of artificial pools on increasing taxa of arthropods was examined.

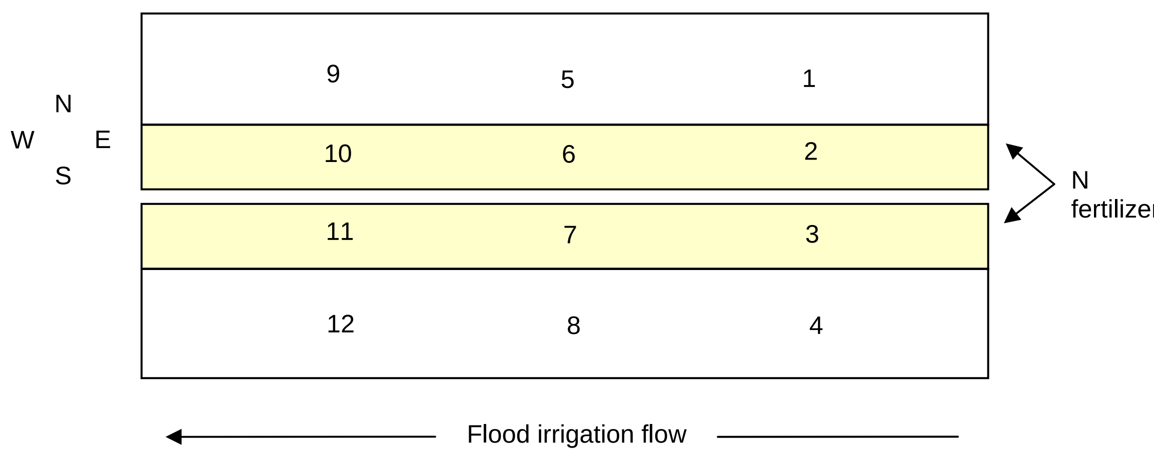
Study Areas.

(1) Effects of Plant Water and Nitrogen. This study was performed at the Mass Planting Site, Cibola National Wildlife Refuge, near Cibola, Arizona. The site (1 ha) contains large (5 m high) cottonwood trees (*Populus fremontii*) planted during 2005.

(2) Artificial Pools. This work was conducted in cell K of the Beal Lake restoration site, Havasu National Wildlife Refuge near Needles, California. The cell contained small (< 2 m high), planted *Salix gooddingii* and *Salix exigua*.

Methods.

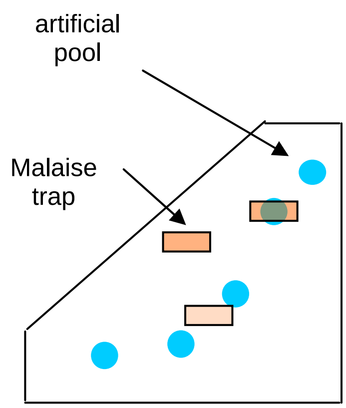
(1) Effects of Plant Water and Nitrogen. Trees on both sides of an east-to-west clear strip down the center of the field were fertilized on 5 June 2007 with 300 lbs/acre of urea containing 45% nitrogen. Trees were sampled for spiders and insects on three dates: 16 August, 24 August, and 20 September 2007. One tree was sampled at each of 12 sites on each date. Different, randomly-selected trees were sampled on each date. Sites were laid-out as follows:



One arbitrarily-selected branch on each tree was covered with a fine-mesh bag, and insects and spiders captured within the bag were killed with insecticide fumigant. The branch was cut, and arthropods were shaken into a plastic container and later placed into 70% ethanol. The branch was weighed with a spring scale. Two side-branches cut from the bagged branch were also weighed. Side branches were brought back to the laboratory.

Side branches were dried overnight in an oven and reweighed, and percent water was calculated. Dried leaves were homogenized and sieved to produce a powder. A subsample of powder was weighed and digested in concentrated sulfuric acid following the Total Kjeldahl Nitrogen procedure of Isaac and Johnson (1976). The resulting solution was analyzed for nitrogen with a flow analyzer. Correlation was measured between percentages of leaf nitrogen and branch water. Arthropods were sorted into three classes: 1) spiders, 2) plant-feeding insects, and 3) other insects. Arthropods in each class, and from each branch, were counted and weighed (± 1 µg) with a microbalance. Arthropod numbers $(n + 0.5)^{1/2}$ and wet mass (log [mg + 1]) were regressed simultaneously against plant percent-water and leaf percent-nitrogen within each date. Branch mass was included in the regressions to control for branch size. Arthropod numbers and masses were adjusted for branch mass with regression and then plotted against percentages of branch water and leaf nitrogen.

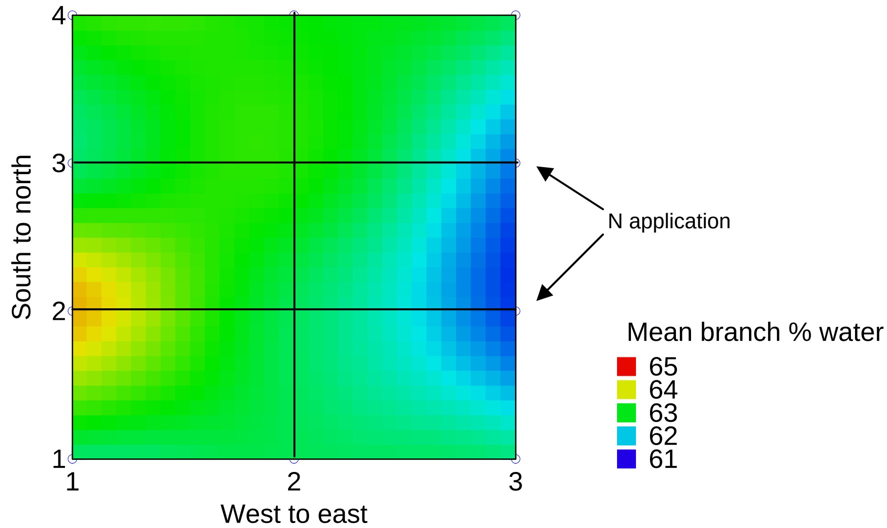
(2) Artificial Pools. Three Malaise traps were placed within cell K where several artificial pools had been installed. Pools were 2 m-diameter plastic wading pools that were sunk into the ground and partially filled with soil. By trapping irrigation water, the pools provided standing water or moist soil for extended periods. Malaise traps were constructed with fine-mesh netting and resembled tents. Insects and spiders that flew or walked into each trap moved upwards and were collected into a plastic bottle containing 70% ethanol. One trap was placed above a pool, one trap was placed between two pools, and one trap was placed away from pools:



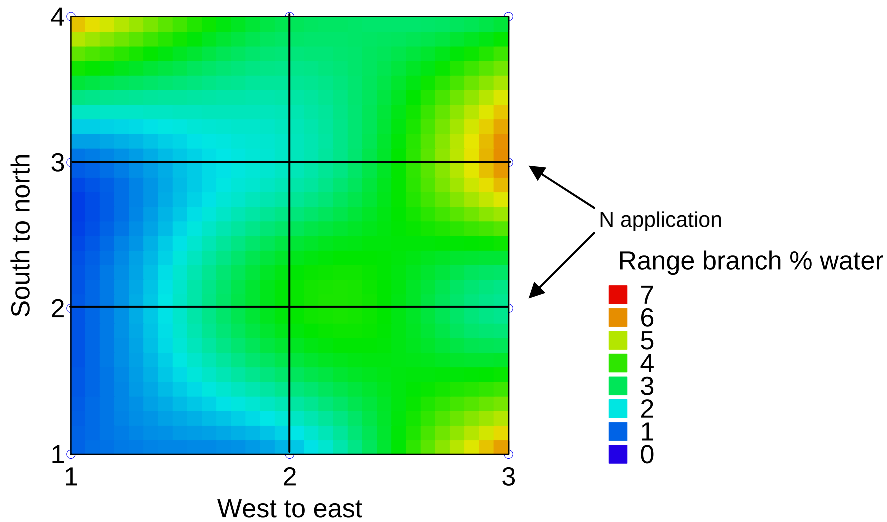
Malaise traps capture flying insects, mainly flies, bees, and wasps. The trap above the pool was to collect insects aggregating around, or emerging from, the water or moist soil within the pool. The trap between pools was to collect insects responding to increased relative humidity provided by the pools. The trap away from pools was to serve as a control. Spiders and insects were trapped during one 24-hour period on 2-3 May 2007. Pools during this period contained standing water. Collected insects were sorted by order (e.g. flies, wasps and bees, beetles) and counted. Insect abundances in orders with greater than five individuals were compared among traps by a chi-square test.

Results.

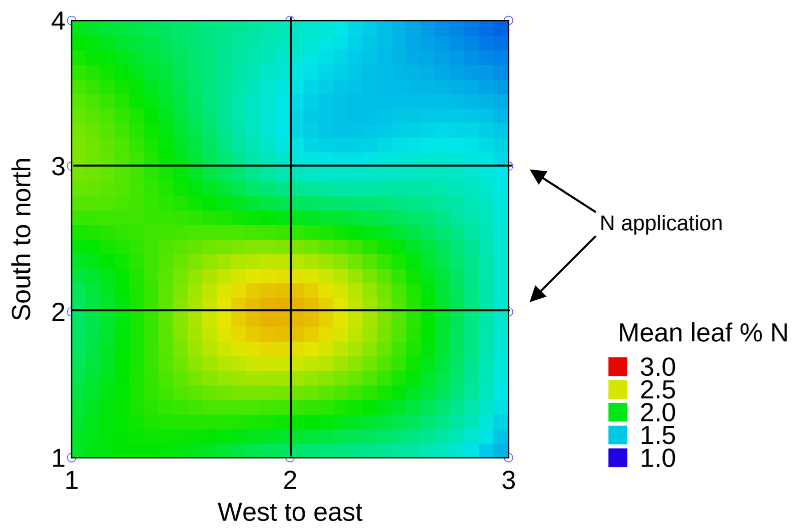
(1) Effects of Plant Water and Nitrogen. Cottonwood trees at the Mass Planting Site contained high water contents that averaged 63%. Water contents were slightly lower on the east side of the plot where irrigation water entered the plot and slightly higher on the opposite side where water drained. On the following four figures, the 12 sampling points are represented by the corners of the six rectangles:



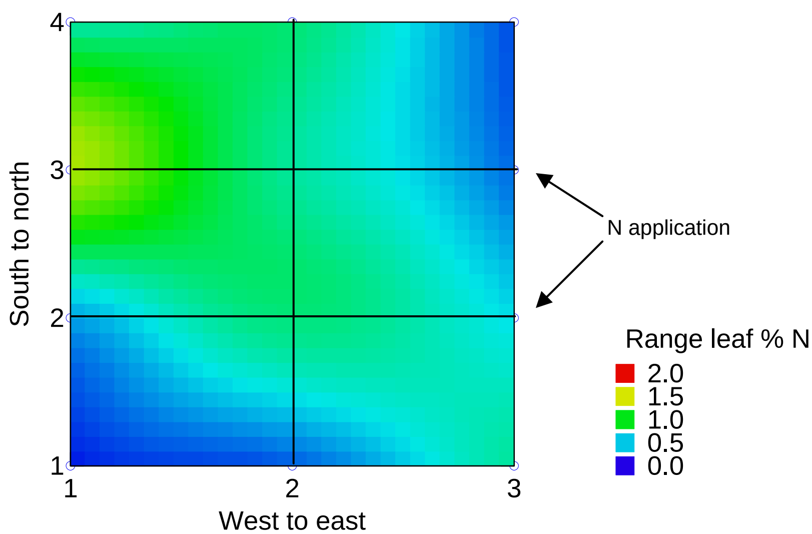
Percentages of water in branches showed little variation across the four dates with most sites exhibiting a range of 4% water content. Variation through time was greatest on the east side of the plot where water entered and least on the west side of the plot where water drained.



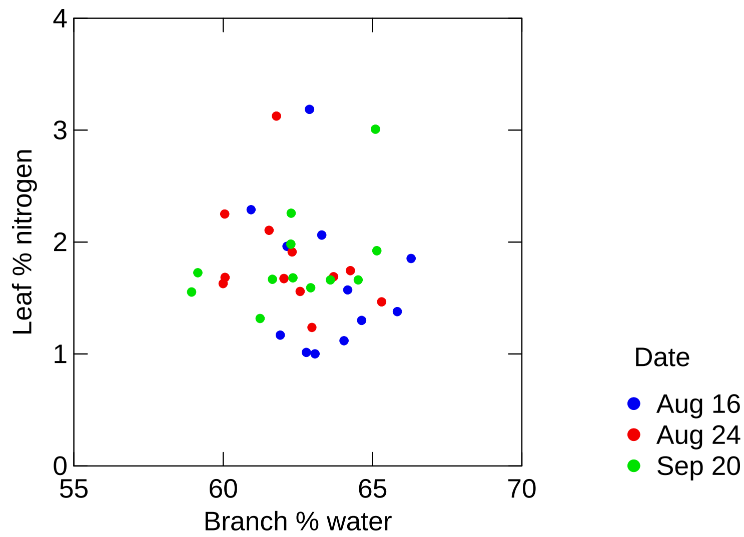
Leaf nitrogen was low on all trees sampled, averaging 1.8% of dry mass. In general, trees supplied with supplemental nitrogen did not contain higher leaf-nitrogen concentrations except for trees at one sampling point:



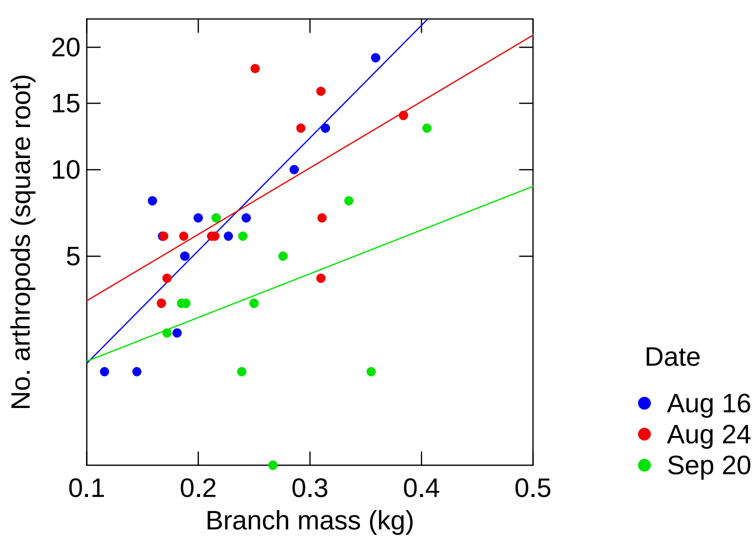
Leaf percent-nitrogen also varied little across dates with most trees varying by 1%:



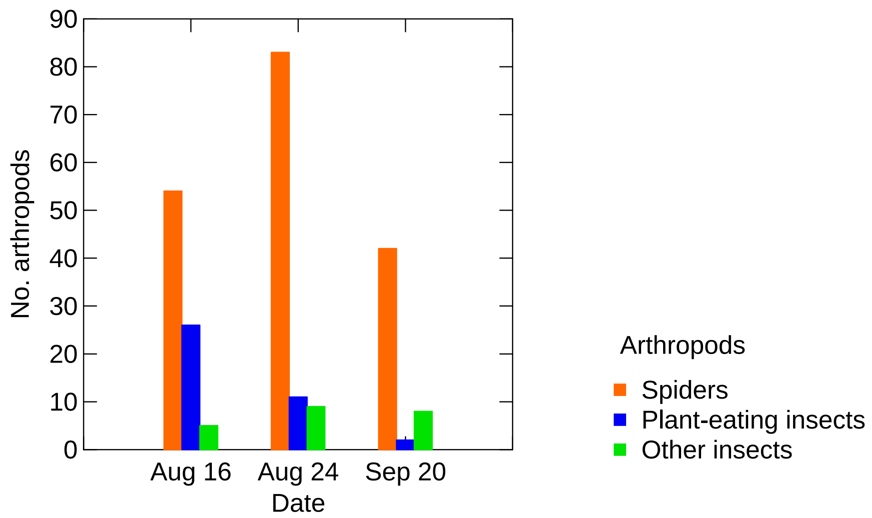
Percent nitrogen of leaves (% of dry mass) was not correlated ($r = -0.08$, $P = 0.64$) with percent water of branches:

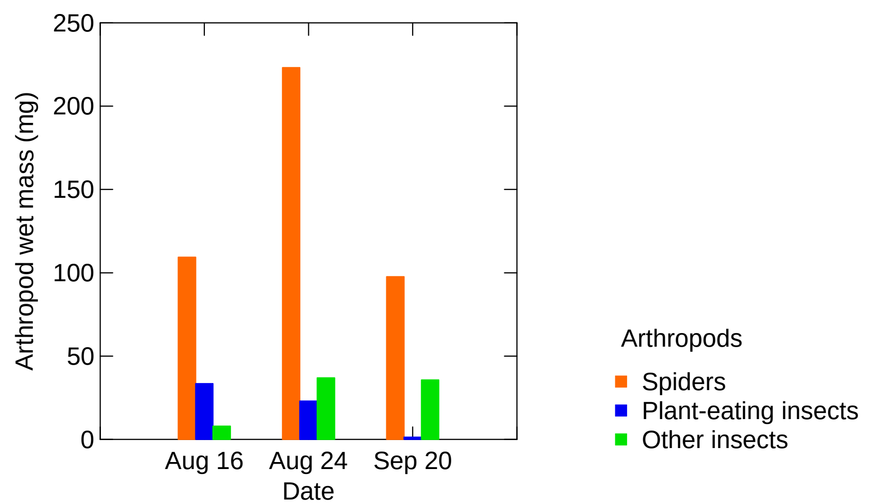


Two hundred forty spiders and insects from 36 cottonwood branches were collected on the three dates. Numbers of arthropods collected from branches increased as branch wet mass increased:

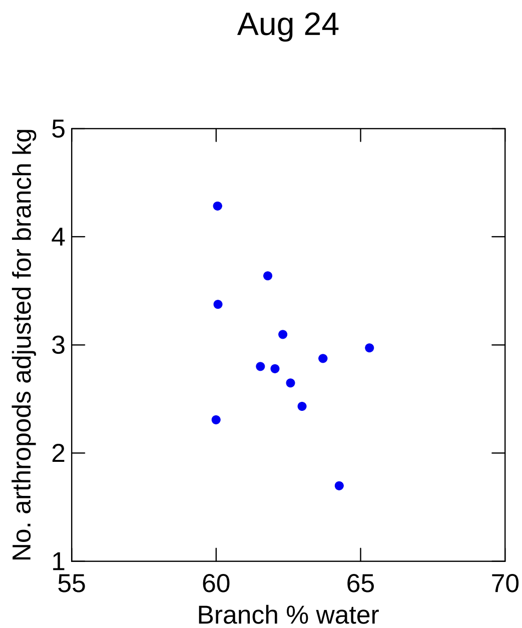


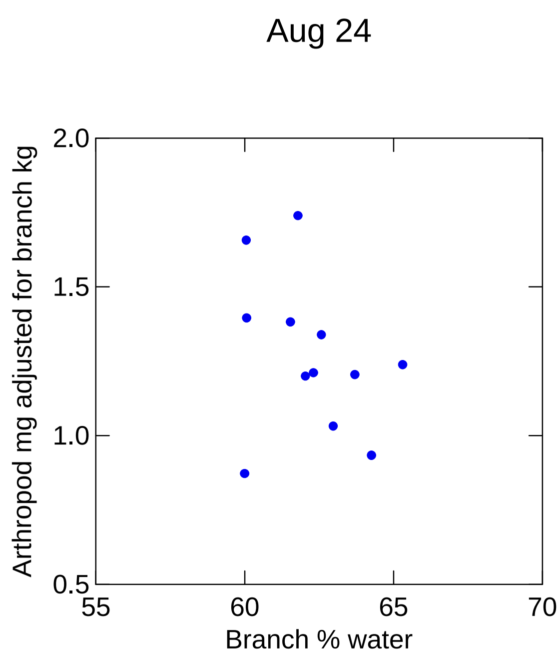
This provides confidence that most spiders and insects were collected from each fumigated branch. Spiders were the most numerous and comprised the greatest wet mass of the arthropods collected. Numbers and wet masses of spiders and insects were greatest on 24 August 2007:



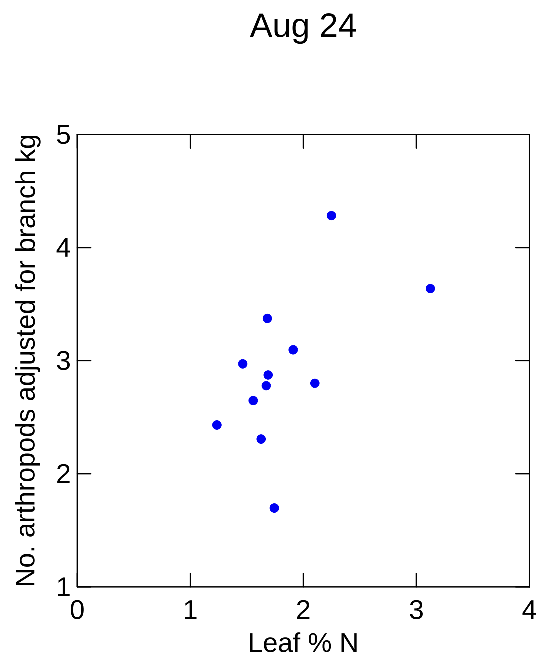


Numbers and wet masses of arthropods were not related to percentages of branch water or leaf nitrogen on 16 August 2007 or 20 September 2007 when abundances were low. Percentages of water and nitrogen produced different effects when arthropods were more abundant on 24 August 2007. Leaf percent water on this date did not influence arthropod abundance or mass:

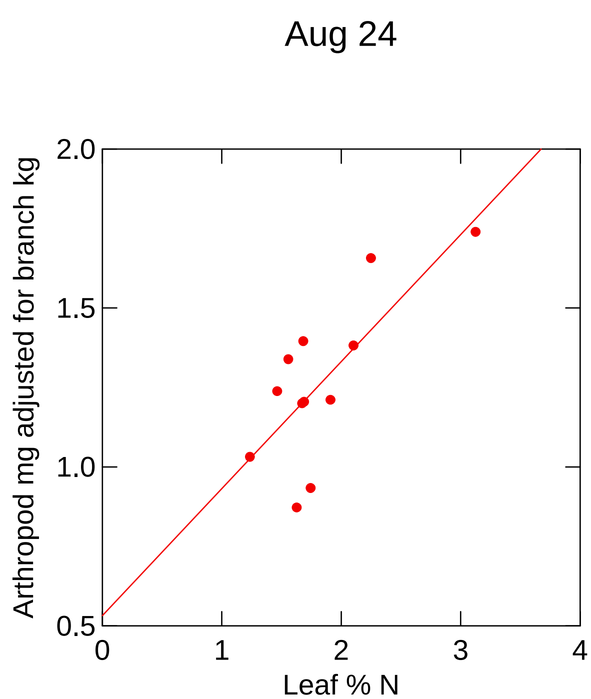




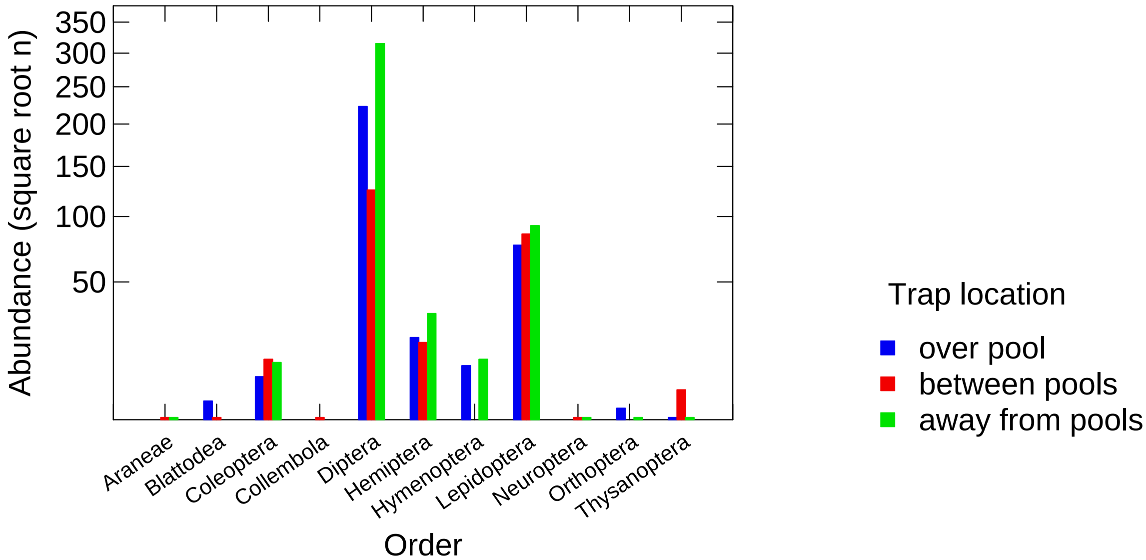
Leaf-nitrogen content also did not affect numbers of spiders and insects:



Total wet mass of arthropods was influenced by leaf nitrogen content on 24 August 2007. Greater wet mass of arthropods was related ($b = 6.1$, $t = 3.32$, df = 8, $P = 0.011$) to greater nitrogen content of leaves:



(2) Artificial Pools. We collected 1,275 spiders and insects in the three Malaise traps during the 24-hour period of trapping. The trap straddling a pool collected 345 arthropods, the trap between pools caught 461 arthropods, and the trap away from pools collected 469 spiders and insects. Arthropods in traps were distributed across orders as follows:



Six orders contained more than five arthropods: Coleoptera (beetles), Diptera (flies and gnats), Hemiptera (leafhoppers and planthoppers), Hymenoptera (bees and wasps), Lepidoptera (moths), and Thysanoptera (thrips). Orders with fewer arthropods were Araneae (spiders), Blattodea (cockroaches), Collembola (springtails), Neuroptera (lacewings), and Orthoptera (crickets and grasshoppers). Trap location influenced abundances of arthropods in orders with more than five individuals (chi-square = 20.5, df = 8, $P = 0.009$). The traps atop a pool and away from pools caught more bees and wasps and fewer flies and gnats than average. The trap between pools caught the opposite—more flies and gnats and fewer bees and wasps than average.

Discussion.

(1) Effects of Plant Water and Nitrogen. Cottonwood trees at the 2005 Mass Planting Site are not underwatered. Branch water contents were high and mostly uniform throughout the site and over the season. Percent water of branches higher on the east side of the plot than on the west side indicates that irrigation water is draining and pooling away from the inlet.

In contrast, leaf-nitrogen contents were low. Typical leaf nitrogen contents are 1.5-5.0% of dry weight (Allen et al. 1986). At a mean of 1.8%, nitrogen contents of cottonwood trees are at the low end of this range. Low branch nitrogen likely resulted from large trees being grown in previously-farmed, nutrient-depleted soil. Application of nitrogen fertilizer to six of the sampling sites elevated branch percent nitrogen at only one of the sites. This suggests that nitrogen applied to the roots of trees is more likely to increase tree size rather than concentrations of leaf nitrogen.

Lack of correlation between percentages of leaf nitrogen and branch water is atypical. Greater plant water content, resulting from greater soil moisture, usually produces greater levels of leaf nitrogen. This relationship is due to the plant's requirement for water to absorb nitrogen from soil and transport it to the leaves. The finding that nutrient concentrations were not associated is probably due to the frequent (twice per month) flood irrigations and resulting high, uniform plant water contents. If plants do not vary in water content, they are unlikely to contain nitrogen levels associated with percent water.

The sampling technique used to collect arthropods was effective. Large numbers of spiders and insects were captured, and numbers increased with the mass of the branch fumigated. Greater number and mass of predaceous spiders compared to plant-feeding insects on all three dates was unexpected. Biomass of primary consumers should exceed that of secondary consumers. Declining numbers and masses of phytophagous insects, and increasing numbers and masses of spiders, from 16 August 2007 to 24 August 2007 suggests insects were being eaten by spiders. Still, spider populations seemed unsustainably high. One possibility is that immigrant insects to the plot, such as from surrounding agriculture, are providing food for spiders.

Branch water content did not influence arthropod numbers or masses. This again likely was due to the lack of variation in percent water of branches, both spatially and temporally. Leaf percent nitrogen only influenced arthropod populations when arthropods were most abundant on 24 August 2007. Arthropod populations appear to respond to leaf nitrogen when arthropods are abundant. Greater mass of spiders and insects with greater leaf-nitrogen content, and depressed leaf nitrogen levels overall, suggest that nitrogen is a limiting factor affecting arthropod populations. Ability of restored stands of riparian plant to provide abundant arthropod food for birds and bats may be improved by increasing soil nitrogen levels.

(2) <u>Artificial Pools</u>. Malaise traps are mostly effective in capturing insects that are strong dispersers. The insects caught at Beal Lake were dominated by strong-flying flies and moths. The latter also likely were abundant, because we trapped insects throughout the night when moths are active. Pools may have influenced numbers and compositions of insects caught in traps by two processes: 1) insects may have developed (i.e. passed through their immature stages) within pools, or 2) insects may have aggregated near pools due to the presence of water. Water and moist soil within the pools could not have produced the large number of insects trapped. Flies and gnats that were trapped were more likely to have developed in either Topock Marsh or Beal Lake, two large wetlands straddling the riparian restoration site. Moths may have developed in a variety of habitats including the surrounding desert. The water and moist soil provided by the pools were dwarfed by the adjacent marshes. Nearby marshes likely also would have driven relative humidity within the cell. Similar compositions of insects captured in traps above a pool and away from pools indicate that pools did not aggregate a significant number of insects. Although trap placement had a small, but statistically-significant, influence on orders of insects caught, the composition of spiders and insects was unlikely to have been caused by proximity to pools.

Artificial pools may be more effective in increasing insect populations at riparian restoration sites not bounded by large marshes. Although pools are unlikely to increase the food base for birds at Beal Lake, we found the restoration plot to contain large numbers of insects. We previously have been concerned about the sandy soil at this site and its inability to retain soil moisture and support well-watered trees. Insects produced by riparian plantings at Beal Lake, even if low in number, will be greatly supplemented by insects immigrating from Topock Marsh and Beal lake. This restoration site may be successful if planted trees provide structure for cover and nesting and nearby marshes provide insects for food.

Recommendations.

(1) Effects of Plant Water and Nitrogen. Percent nitrogen should be monitored in trees planted in riparian restoration plots. If nitrogen levels are low (i.e. $< 3\%$), methods should be explored for raising concentrations. Possible methods include: 1) growing nitrogen-fixing plants such as clover or alfalfa, and cultivating the plants into the soil, prior to planting trees, or 2) applying fertilizer containing nitrogen along with other soil nutrients (phosphorus and potassium).

Additional work should be performed on the effects of plant water and nitrogen levels on arthropod populations. Irrigation of trees planted in farmland should be fined-tuned to mimic the capillary-fringe zone that natural riparian trees exploit with their roots. Effects of water on arthropod populations should be investigated at a site with different watering regimes, hopefully producing trees with varying water contents. Sampling branches on a wider range of dates would help clarify the influence of leaf nitrogen on insects and spiders. Alternative methods for spiking trees with nitrogen should be considered.

(2) Artificial Pools. This approach for increasing insect populations at the Beal Lake restoration site should be abandoned. We should continue to examine artificial pools as a means of increasing the prey base for birds at other sites without adjacent marshes. Channellized river will not produce insects in the abundance trapped at Beal Lake. Artificial pools may be effective at Cibola Valley Conservation Area, Palo Verde Ecological Reserve, and other sites where marshes are absent.

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