Noteworthy Collections from Tempe Towne Lake Riverbed

Elizabeth Makings
Lane Butler
Matthew Chew
Juliet Stromberg
School of Life Sciences
Arizona State University
Tempe AZ 85287-4501
Elizabeth.Makings@asu.edu

Tempe Towne Lake is a water body created by inflatable bladder dams that were constructed along the highly regulated and formerly-perennial Salt River in Phoenix, Arizona. The dam ruptured on 20 July 2010, exposing organic and clay-dominated lake bed sediments that had been submersed for approximately 10 years. A riverine marshland developed on the wet sediments, and during a site visit on 27 Sept 2010 twenty taxa were collected (Table 1). Below is a discussion of 3 species of interest.

Ammannia coccinea Rottb. (Lythraceae)

Significance: *Ammannia coccinea* has been popping up in the state flora occasionally for some 80 years, so it's presence in the Salt River is not remarkable. What is noteworthy, however, is that this plant was scarce in Arizona until around 2000, and has suddenly appeared in large numbers in this particular reach of the Salt River (Figures 1,2,3). *A. coccinea* was co-dominant in abundance with cattail (*Typha* sp.) in the community of wetland plants that we observed in September 2010. Why? And why now?

Ammannia L. is a cosmopolitan genus of about 25 species distributed in both temperate and tropical zones with a center of diversity in Africa (Graham 1985). *Ammannia coccinea*, variously referred to as scarlet Ammannia, scarlet toothcup, or valley redstem, is a native, annual, obligate wetland plant found throughout most of the US except for some northwestern states (USDA, NRCS 2010). The conservation status of this species varies from secure (IA, KY) to imperiled (NC, PA, WV), to critically imperiled (DC, DE) (NatureServe 2010). In Arizona, it is 'not ranked.'

Ammannia coccinea grows in a variety of riparian habitats, including marshy wetlands such as cienegas[1] and muddy flats along reservoirs, streams and playas. In New Mexico, *A. coccinea* occurs along the Rio Grande River wetlands in three general areas: greater Albuquerque; the Bosque del Apache National Wildlife Refuge, Soccoro New Mexico; and Elephant Butte Reservoir, near Truth or Consequences (SEINet 2010).

In Arizona, *A. coccinea* was collected for the first time in Arizona in 1936 by C. W. McLellan and L. L. Stitt, in "Papago Park Tempe Edge of Lake." It was not collected again until 1964, when E. Lehto documented it at Lake Pleasant Regional Park, "east shore of lower lake." There is a C. Irwin collection from Yuma County along the Colorado River in 1975, and then, in 1998, J. Boudell vouchered it from the Agua Fria River below New Waddell Dam (south of Lake Pleasant). She was investigating propagule (seed) banks from soil samples collected at various depths, and *A. coccinea* emerged in a growth chamber. There have been 5 more collections since 1998: L. McGill 7196 - north of the Willcox Playa, Cochise County, in 1999; E. Makings 1620 – St. David Cienega along the San Pedro River, Cochise County, in 2003; J. White 163 – Salt River at Price Drain under Loop 101 in Tempe, Maricopa County, in 2006; D. Jenke 164 – Salt River Bed at the Tres Rios Wetlands, Maricopa County, in 2007; and most recently, E. Makings et al. 3535 – in the river bed of Tempe Towne Lake, 9 weeks after the failure of the bladder dams.

In an e-mail communication, Shirley Graham, a Lythraceae expert from the Missouri Botanical Garden, confirmed the identity of this particular species, and had this to say regarding the genus: "A drying, previously flooded habitat is ideal for *Ammannia* and the irregular appearance of the genus at any one locality of this kind is absolutely typical. In Tanzania where *Ammannia* was in a rice field in great quantity one year according to collection data, when I visited the next year at the same place, same time, there was no sign of it. As for seed source, it might have been introduced by dispersal down river from rice cultivation or some previous local site. It floats nicely and is adapted to varying water levels, often starting in standing water and fully developing on dry mud flats."

The J. White collection in 2006 was just upstream of Tempe Towne Lake at a small wetland sustained in part by storm drain runoff. Considering the small size of the seeds (mass of 0.02 mg) (Royal Botanic Gardens Kew Seed Information Database, 2008) as well as the number of fruits on an individual plant (150-300 seeds/capsule) (Graham 1979, 1985), it is reasonable to assume that seed dispersal of only a few plants upstream could be responsible for establishment of the large population we observed. Alternatively, it may have been present in the soil seed bank of the lake bed, or even dispersed by waterfowl.

Figure 1. Habitat of *Ammannia coccinea*, abundant in this wetland among *Cyperus* spp., *Typha* sp., *et.al.*

Figure 2. *Ammannia coccinea* habitat nine weeks after the bladder dam failure. Soon after the riverbed was exposed, a cienega-type wetland emerged. Botanists/ecologists: Frankie Coburn, Lane Butler (background) Julie Stromberg.

Whether this *Ammannia* is from upstream water transport, a relict taxon in the seed bank, or a recent introduction by waterfowl, are topics of conjecture. Whatever the source, the potential for mass germination is well documented. *Ammannia* seeds retain viability for many years (vigorous up to 12 years) and are able to persist through prolonged dry periods (Graham 1979). Even after herbarium fumigation treatments, 5% of the seeds of *A. coccinea* from herbarium specimens 27 years old germinated (Graham 1985). The "boom and bust" nature of the genus was displayed in a spectacular way via the environmental conditions created at the Tempe Towne Lake site in September 2010.

Figure 3. *Ammannia coccinea*, aka "scarlet toothcup"

A taxonomic note: There are three species of *Ammannia* that have been identified in Arizona – *A. auriculata* Willd., *A. coccinea* Rottb., and *A. robusta* Heer & Regel. At the University of Arizona Herbarium (ARIZ), there are seven records of *A. robusta*, and duplicates of the Arizona State University (ASU) collections of *A. coccinea* from the Colorado River, San Pedro River, and the McClellan and Stitt specimen from Papago Park. Diagnostic characters of *A. coccinea* and *A. robusta*, such as peduncle length and fruit size, frequently overlap. Additionally, the species occupy identical habitats, are known to hybridize, and field characters that separate them such as flower and anther color may be impossible to discern from herbarium specimens (Graham 1979). Since the species are so weakly delimited, it is possible Arizona material is actually variation of a single taxon. Even if this is the case, the Salt River phenomenon is no less intriguing. '*Ammannia robusta*' was collected first by J. J. Thornber in 1905 in the Hooker Cienega in Sulpher Springs Valley, Cochise County. But collections that follow are similarly infrequent and far between, suggesting a previously marginal presence in the state.

Cyperus michelianus subsp. *pygmaeus* (Rottb.) Asch. & Graebn. (Cyperaceae). (Figure 4)

Significance: First confirmed North American collections of this taxon.

Cyperus michelianus subsp. *pygmaeus* was first collected in Arizona about the same time in two different localities. One of them was "Maricopa County; Agua Fria River; South of Lake Pleasant; below New Waddell Dam. Associated with *Tamarix ramosissima/ Salix gooddingii*. 33.8334999, 112.2756653, 400m. Propagule Bank Investigation with collections emerging from soil samples in growth chamber 1998-2000, soil depth=2-5cm; J. A. Boudell CG2-102, (ASU)." The other was "Gila County, Tonto National Forest; Roosevelt Lake; School House Point lake bottom. 33.6500493, -111.0101175, 645m, 21 October 1998, J. Hurja sn. (TEUI)." The date of the Hurja collection from Roosevelt Reservoir in 1998 is clear, but the date for Boudell is ambiguous as the plants may have emerged from the soil seed bank samples in either 1998 or 1999.

Figure 4. *Cyperus michelianus* subsp. *pygmaeus*

The soil was collected from the mostly-dewatered floodplain of the Agua Fria River below Lake Pleasant Reservoir, and the location of the parent plants and their year of production remain unknown (Boudell 2004).

C.yperus michelianus subsp. *pygmaeus* is an annual, typically of sandy or silty riverbanks and similar disturbed sites from hot (often arid) areas of the Old World (Anton Reznicek, personal communication). Specimen occurrence data from electronic databases accessed through the Global Biodiversity Information Facility (GBIF 2010) and the Missouri Botanical Garden's Tropicos website (TROPICOS 2010) suggest it is common in Australia, India, China, the Middle East, and Mediterranean. Other combinations/ synonyms for this taxon are *Cyperus pygmaeus* Rottb., *Dichostylis pygmaea* (Rottb.) Nees, *Juncellus pygmaeus* (Rottb.) C.B. Clarke (Tropicos 2010). The type specimen of *C. pymaeus* Rottb. is from Orillas del Sebú, Morocco, Africa (GBIF 2010). We chose to use the Tropicos taxonomy which lowers *C. pygmaeus* to the subspecific level, but also note the comments of Dr. Reznicek: "...*Cyperus pygmaeus* Rottb... is part of a taxonomic mess, and sometimes included in *Cyperus mechelianus* (as subsp. *pygmaeus*). *Cyperus michelianus*, however, differs in having more or less tristichous glumes and typically 2 stigmas. Your plant appears to have more or less distichous scales (hard to see however, in dried material) and many flowers with 3 stigmas".

In 2005 E. M. was given several sedges and other wetland plants from along the Salt River in the Phoenix area for identification on behalf of graduate students at ASU. This small *Cyperus* was among them. It resisted all available dichotomous keys so the inefficient and desperate technique of randomly thumbing through the ASU herbarium specimens of the genus in hopes of a lead was undertaken. There was one sheet of '*C. pygmaeus*' from Bharatpur, Rajasthan, India, collected in 1971 by M. Sing 68. It matched perfectly, and duplicates sent to Anton Reznicek at the University of Michigan were confirmed. The two previous collections of '*C. m. pygmaeus*' mentioned above were both originally misidentified as *Cyperus acuminatus* Torr. & Hook., but now with the recognition factor, annotations of these and several other sheets were made.

There is anecdotal evidence that the Roosevelt Reservoir population has increased since first collected. In July of 2009, a Tonto National Forest Service colleague collected it along the mouth of Tonto Creek at its confluence with Roosevelt Reservoir (the opposite end of the reservoir from the 1998 Hurja collection). It was growing in alluvium that had been submerged to a depth of at least 2 feet when the lake was higher in the spring (Debbie Cress, personal communication). She noted this population grew as a single-species patch covering about two acres. The lower Salt River populations are also on the rise as evidenced by more frequent collections: J. Poznick s.n., Salt River at Price Road (near the confluence with Indian Bend Wash) in 2005; D. Jenke 526, 708, 723, at the Tres Rios Wetlands (near the confluence of the Salt, Gila, and Agua Fria Rivers) in 2008 and 2009; and most recently E. Makings et al. 3542, in the river bed of Tempe Towne Lake, 9 weeks after the failure of the bladder dams (27 September 2010), where it was common (Figure 5).

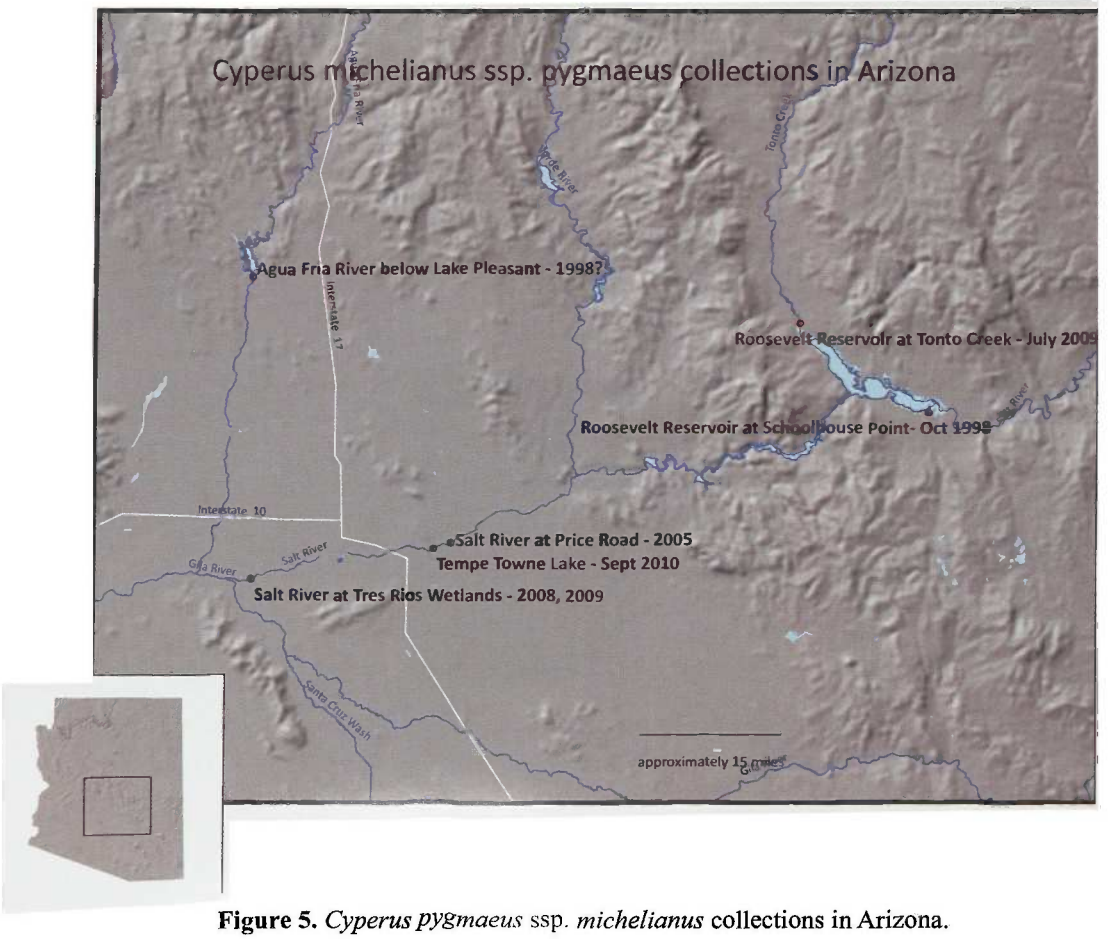

Figure 5. *Cyperus pygmaeus* ssp. *michelianus* collections in Arizona.

We may never know exactly how *C. m. pygmaeus* arrived at these rivers and reservoirs, but it's logical to assume it was introduced by people (vs. birds or wind). Migrating birds are occasionally blown by storms off their north/south trending migration corridors, but it is improbable that the seeds would have been carried across oceans. Most likely it was recreation related – in the tackle box of a visitor from Australia, or the dried mud on the boot of a Gulf War veteran. Tempe Towne Lake was not the first collection of *C. m. pygmaeus* in Arizona, but the site was notable for its abundance of this particular plant. Watercourses are ideal corridors for dispersal of plants, and the Salt River riparian zone is providing suitable habitat for *C. m. pygmaeus*. We will likely see expansion of its range throughout the larger Colorado River system in the near future.

Ludwigia erecta (L.) H. Hara (Onagraceae) yerba de jicotea

Significance: First collection for Arizona.

Ludwigia erecta is an obligate wetland species (USFW 1988) distributed in tropical regions of South America, Central America, central Mexico, and the Caribbean. In "A Flora of Tropical Florida," (Long & Lakela 1971) it is described as "pan tropical." In the United States, *L. erecta* occurs in southern Florida, with scattered collections in the Florida Panhandle, and one somewhat disjunct collection from Hinds County, Mississippi (GBIF 2010; USDA, NRCS. 2010).

Ludwigia erecta was collected during the 27 September 2010 excursion to the Tempe Towne Lake bottom. It was scattered, but not uncommon, and conspicuous because of its height – several plants were 4-5 feet tall (Figures 6,7). Having some experience with the wetland flora of the state, it was exciting to see something unfamiliar. After some research, nothing in the known state flora was a candidate, so duplicates were sent to experts at Missouri Botanical Garden for determination. Drs. Peter Hoch and Peter Raven were gracious and prompt with their response: "We agree that your material is *Ludwigia erecta* (L.) H. Hara. Based on known distributions, this is somewhat surprising (it seemed more likely to be *L. decurrens* based on its wider distribution), since this species is currently known in the USA only from southern Florida. However, it ranges widely across South America, the Caribbean, Central America at least to central Mexico, and – probably naturalized – in Africa, so it is not unexpected that it should show up in Arizona, and we might look for more occurrences in northern Mexico... I think your collection warrants some sort of published note, since this is a significant range extension, and will be of interest to many, especially those working on invasive plants (some Ludwigias in California have become serious problems) and on the predicted spread of species northward in association with climate change...." Indeed, using the Google Earth "ruler" tool, the distance to the nearest collections of *L. erecta* in the US is approximately 1,200 miles (Mississippi, Hinds County), and in Mexico, 950 miles (Nayarit).

Ludwigia erecta was "discovered" and "extirpated" within two weeks time from Tempe Towne Lake, but it's reasonable to assume it will persist. There are several plants upstream of the Lake that were vouchered on a botanical visit 24 November 2010. Those that remain are afforded a limited, yet suitable habitat in the shallows of the Salt River, and seeds from the Tempe Towne Lake population may have been washed downstream. To verify this, summer 2011 explorations of ephemeral and permanent wetlands along the urban reaches of the River bed should be undertaken.

Overview

In conclusion, the temporary wetland at Rio Salado and Rural Road in Tempe contrasted sharply with the lake environment that the City decided to construct 10 years ago. Policy makers marketed the area as 'lake front' and were obligated to repair the dam and return the property to the landscape they promised. Public sentiment seemed to agree. The mainstream media wrote of mostly negative perceptions of the site and a desire to restore the lake as soon as possible, including such quotes from local newspapers "...a muddy swamp hazardous to our health," "...odor and decay rising from the marshy water," "...smell of standing water and fish," and that "the lake is like the symbol of Tempe." The habitat is, of course, gone now – herbicide was applied to the vegetation in order to control

Figure 6. *Ludwigia erecta* – habit and stature contrast with surrounding graminoid vegetation.

Figure 7. *Ludwigia erecta*, aka "yerba de jicotea"

the growth of cattail, the bladder dams were replaced, and the Lake refilled in early October 2010.

In some ways, it's not surprising that this area produced novelties given the surrounding influences – there are several storm drains, it is immediately downstream from the confluence of Indian Bend Wash, which empties a large urban watershed, and there are two major freeways that pass over the river. However, considering the flora that emerged was remarkably "native" or at least "non-horticultural" given the number of potential non-natives available from the perimeter, something else is going on here.

Ironically, the formation of the Lake inadvertently created the substrates suitable for the establishment of this specialized suite of wetland plants. At the time of its construction, Tempe Towne Lake was lined with clay to reduce water infiltration. The lake bed sediments we sampled were anaerobic, and had an abundance of clay, silt, and organic matter (Estella Ruth personal communication) and our hypothesis is this created a habitat reminiscent of cienega wetland soils that historically blanketed many rivers in the region, quite different from the sandy soils that typify many of our rivers today. The Salt River will continue to be a "managed system," but what some saw as "muddy swamp" was actually a rare glimpse of the resilience of a desert riparian ecosystem, with its self-assembling diversity, evidence that our rivers and their connection to cienegas is not lost (Figures 8, 9).

The restoration implications of these plant findings are important. The Salt River in the Phoenix area seems to have a particular wetland flora that is persisting (or re-assembling) despite all the regulation, and restorationists need to become aware of this. Restoration of riparian habitats often includes constructed wetlands with the "re" introduction of native species incorporating active techniques such as plantings and earth moving. These tend to be costly and even temporary given high mortality rates of transplants, and the tendencies of rivers to redirect themselves. In light of the remarkably short amount of time it took for this particular wetland to emerge, restoration emphasis toward more "passive" techniques may be more expedient and economical. Seed banks of former wetlands are time sensitive, but effective management tools to be considered.

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[1]Cienega- a marsh or wetland. Cienegas can form where layers of rock or impervious clay hold water at the surface or through the continuous upwelling of numerous small springs and seeps. These conditions produce a rare plant community of sedges, grasses, reeds, and cattails because the soil is permanently saturated see: http://www.blm.gov/az/st/en/prog/recreation/hiking/stdavid.html

All photographs by Elizabeth Makings in September, 2010.

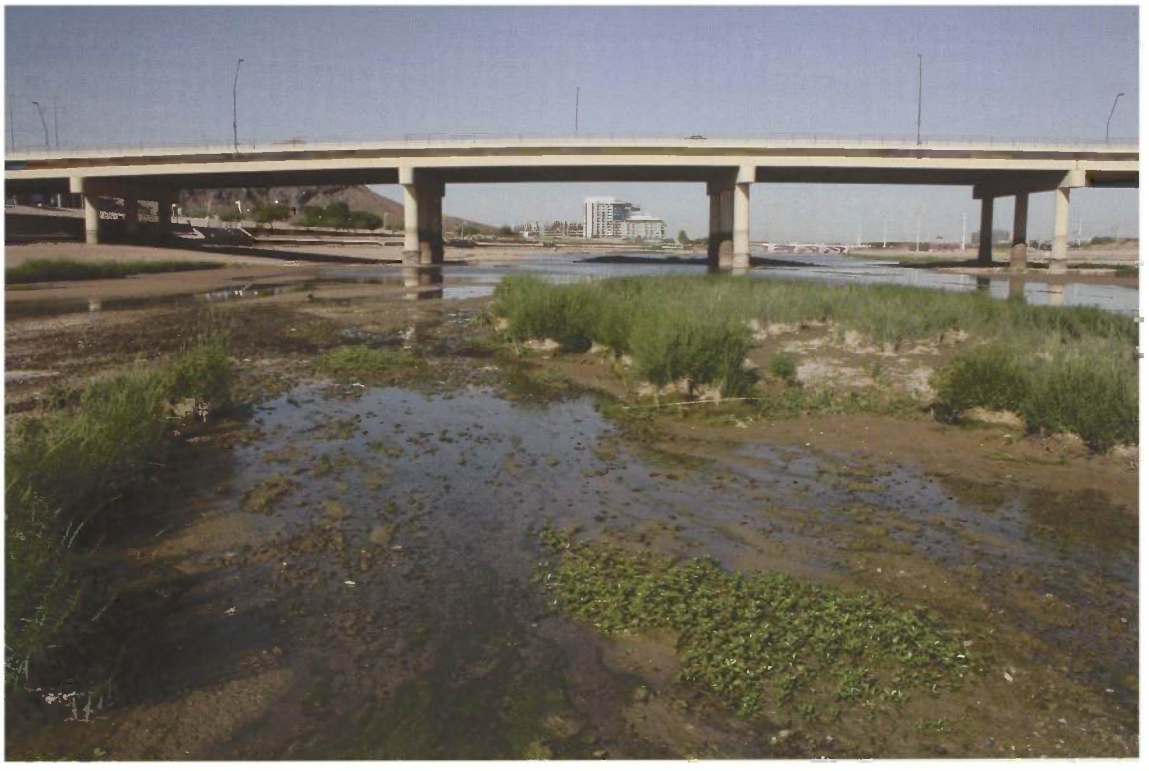

Figure 8. Tempe Towne Lake temporary wetland at Rural Road: 33. 4309,-111.925; 1160 ft. Low sprawling species in the foreground is *Ludwigia peploides*.

Figure 9. Looking west from Rural Road. Birds identified in photo by Matt Chew: **Great egret** (*Ardea alba*, **snowy egret** *Egretta thuls*, **cattle egret** *Bubulcus ibis*, **great blue heron** *Ardea herodias*, **blacknecked stilt** *Himantopus mexicanus*, **great-tailed grackle** *Quiscalus mexicanus*; two unidentifiable ducks in the distant puddle that are probably **mallards**. Other birds that made appearances during low water (not pictured): **turkey vultures** *Cathartes aura*, **ospreys** *Haliaeetus leucocephalus*, **mallards** *Anas platyrhynchos*.

Table 1. Species collected at Salt River, Tempe Towne Lake. September 2010

Family	**Species**	**Wetland indicator status#**
Amaranthaceae	**Amaranthus albus*	FACU
Asteraceae	*Eclipta prostrata*	FAC
Asteraceae	*Pluchea odorata*	OBL
Asteraceae	*Xanthium strumarium*	FAC
Boraginaceae	*Heliotropium curassavicum*	OBL
Cyperaceae	**Cyperus difformis*	OBL
Cyperaceae	*Cyperus erythrorhizos*	OBL
Cyperaceae	*Cyperus odoratus*	FACW
Cyperaceae	**Cyperus pygmaeus*	No information
Cyperaceae	*Eleocharis geniculata*	FACW,OBL
Cyperaceae	*Schoenoplectus maritimus*	OBL
Lythraceae	*Ammannia coccinea*	OBL
Onagraceae	*Ludwigia erecta*	OBL
Onagraceae	*Ludwigia peploides*	OBL
Poaceae	**Echinochloa colona*	FACW
Poaceae	*Leptochloa fusca ssp. uninervia*	FACW
Poaceae	*Leptochloa viscida*	FACU
Polygonaceae	*Persicaria lapathifolia*	OBL
Portulacaceae	**Portulaca oleracea*	FAC
Typhaceae	*Typha* sp.	OBL

*introduced

#Indicator Code Wetland Type (USFW 1988)

OBL Obligate Wetland occurs almost always (estimated probability 99%) under natural conditions in wetlands.
FACW Facultative Wetland usually occurs in wetlands (estimated probability 67%-99%), but occasionally found in non-wetlands.
FAC Facultative equally likely to occur in wetlands or non-wetlands (estimated probability 34%-66%).
FACU Facultative Upland usually occurs in non-wetlands (estimated probability 67%-99%), but occasionally found on wetlands (estimated probability 1%-33%).
UPL Obligate Upland occurs in wetlands in another region, but occurs almost always (estimated probability 99%) under natural conditions in non-wetlands in the regions specified.