Tubac Riparian and Grassland Evaluation and Restoration Plan

Prepared for:

Tubac Nature Center

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Plan Purpose

Tubac Nature Center's Conceptual Master Plan created a management framework for an envisioned Nature Preserve. While efforts to secure long-term protections for the site are ongoing, Tubac Nature Center has committed to advancing the plan's goals where appropriate. The plan describes a preserve that will be a restored, healthy ecosystem for the benefit of the community. Notable habitat degradation has occurred along the Santa Cruz River between Clark Crossing and Bridge Road. At the same time, the area west of Ron Morriss Park presents a significant opportunity for habitat improvements. The Santa Cruz River has also recently been designated by American Rivers as one of the most endangered rivers in America, warranting restorative action.

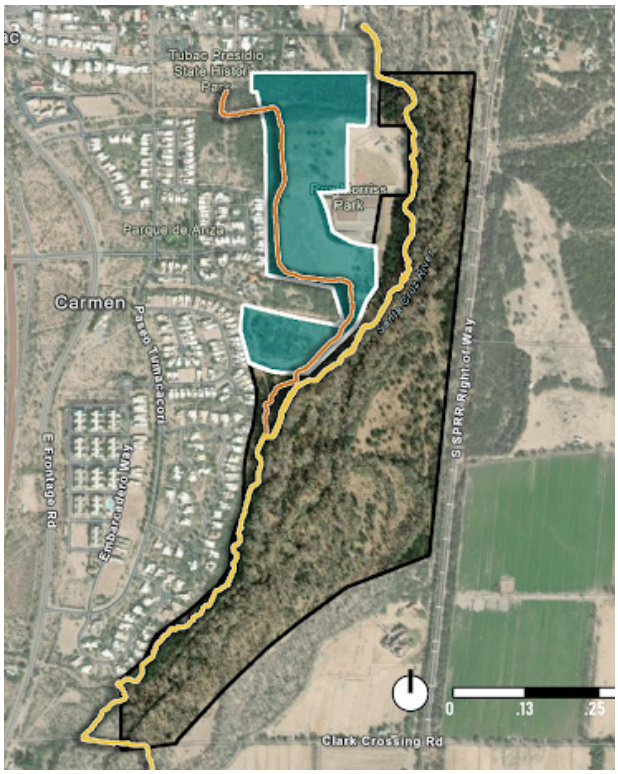

Figure 1. Anticipated preserve boundaries, courtesy of the Tubac Nature Preserve Conceptual Master Plan

Developing a long-term restoration strategy for the three habitat types present is a primary goal of the master plan. A Wetland Restoration Plan provides recommendations for the borrow pit, while this plan focuses on the riparian and grassland habitats within the anticipated preserve boundaries. This plan aims to assess current conditions, determine suitable restoration strategies, and provide guidance on effective site management. The Tubac Nature Preserve Conceptual Master Plan is available at tubacnaturecenter.org.

Figure 2. Example image of semidesert grassland, National Park Service

Figure 3. Example image of riparian habitat in Aravaipa Canyon, Navid Serrano

Watershed Overview

Tubac is located in the Lower Colorado Basin's Upper Santa Cruz Watershed (HUC15050301). The watershed is a semi-arid region that receives an average of 16 inches of rainfall per year, primarily during the monsoon and winter seasons. Tubac's topography, nestled between the Santa Rita and Tumacacori mountain ranges, influences local drainage and sediment patterns that contribute to the hydrology of the Santa Cruz River. The river receives treated effluent from the Nogales International Wastewater Treatment Plant, which contributes to near year-round water availability. However, approximately 80% of the effluent originates from Nogales, Mexico, leading to unreliable flows during periods of diversion. Effluent discharge from 2013 to 2018 periodically decreased by an average of over 650 million gallons and continues to fluctuate (Sonoran Institute, 2022). Additionally, seasonal rain from Rio Rico and the Montosa Canyon Basin east of Tubac further supports river flow and groundwater recharge.

The water table varies significantly along the Santa Cruz River. Shallow aquifers and highly permeable alluvium create a dynamic system that rebounds quickly in response to rains but also drops rapidly in response to drought. Sections of the river are showing modest recharge gains due to better management practices. Water levels from Rio Rico to Tubac rose during the 1950s to 1980s as a result of flooding and agricultural withdrawals. However, on average, most stretches of the river have experienced lowered water tables since 2010, despite reductions in reported agricultural water use (ADWR, 2020). Groundwater monitoring at Tubac Golf Course and Tumacacori National Historic park both show relatively stable water tables (fig. 4 and 5). Tubac also experiences slower flows than upstream, conditions that have the potential to enhance recharge locally due to increased infiltration.

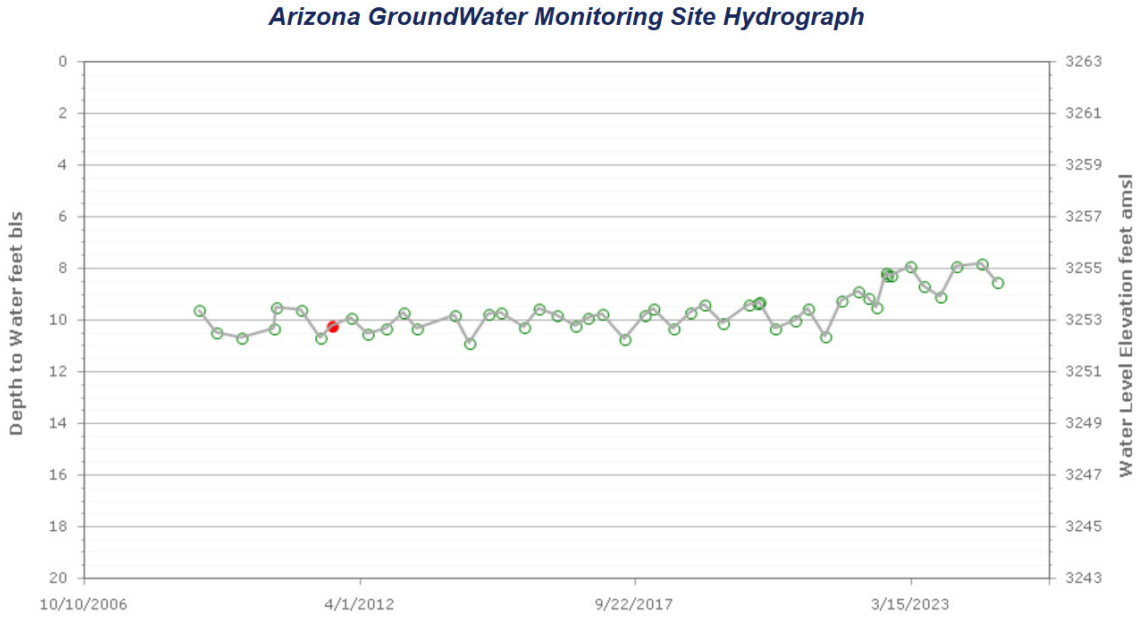

Figure 4. Groundwater Hydrograph for Tubac Golf Course, Arizona Department of Water Resources

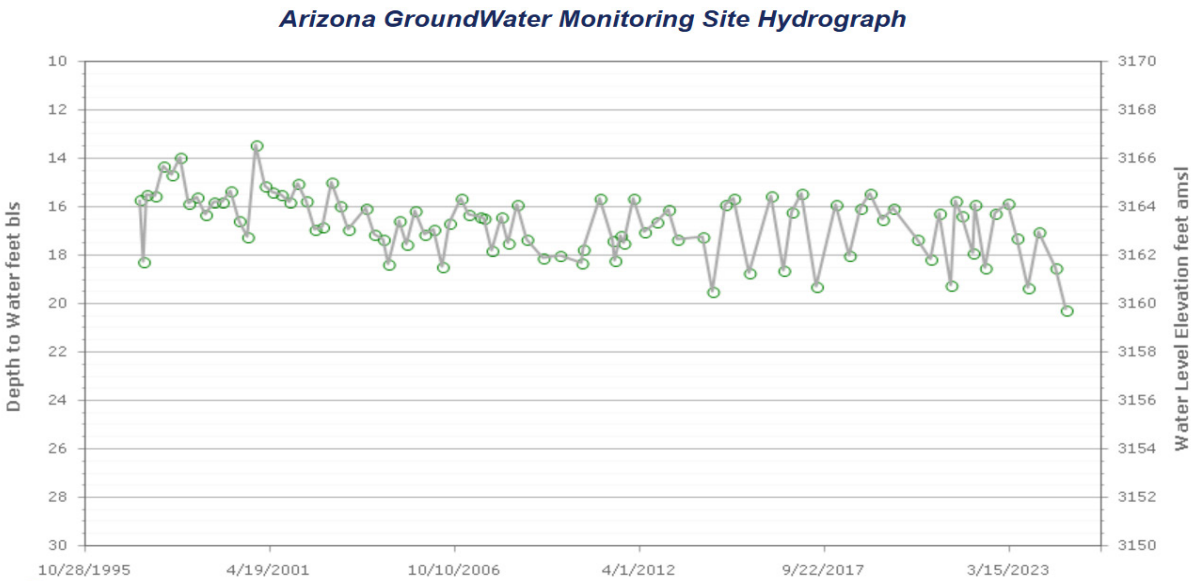

Figure 5. Groundwater Hydrograph for Tumacacori National Historic Park, Arizona Department of Water Resources

Riparian Corridor

Cottonwood-willow forests are one of the most endangered habitats in the southwest, primarily due to groundwater pumping, water diversion, land clearing, and salt cedar (*Tamarix spp.*) invasion. Lowered water tables, channel incision, and irregular flood events threaten the natural reproduction strategies of Fremont cottonwood (*Populus fremontii*), leaving many forests without a new generation of trees. The gallery forest often supports a higher diversity of mid- and understory plants than the surrounding floodplain and upland zones, including fruit-bearing and other high-habitat value plants, as well as a host of native annuals, which further increases this zone's value to wildlife (Stromberg, 1993).

Figure 6. Southwestern Willow Flycatcher, Jim Rorabaugh/USFWS

As riparian forests occur along vital migratory routes throughout southern Arizona, specifically along the Santa Cruz and San Pedro Rivers and their tributaries, this forest type is home to myriad wildlife that rely on its characteristic large trees for cover, forage, and nesting. Riparian forests are vital for migratory birds who travel along rivers. The two most notable species that utilize riparian forests include the Western Yellow-billed Cuckoo and the Southwestern Willow Flycatcher, both of which are federally listed species.

Habitat Assessment

The riparian forest throughout the project area shows clear signs of degradation. Tree age class and structural diversity are the key indicators of healthy riparian forests. The project area is dominated by a mature canopy, invasive understory species, and occasional midstory species. In a healthy riparian forest, young trees should be the most abundant age class, with reduced populations of older trees. As a reference point, tree population counts along the San Pedro River per hectare revealed 200,000 seedlings, 8,000 saplings, 1,500 young trees, and 500 mature trees (Stromberg, 1993). In the project area, Fremont cottonwood age classes range from one year to approximately ninety years, but most trees fall within the 40–60-year range. New cottonwood recruitment is occurring in limited areas. TBA observed several sandy banks with clusters of 5–10 young cottonwoods, likely between one and two years old. In-channel cottonwood recruitment is susceptible to flooding, with cattle grazing also limiting the likelihood of successful establishment. The pace of recruitment is not sufficient to sustain the forest over time. Habitat degradation worsens toward Clark Crossing Road, where river incisioning and straightening are notable.

Habitat degradation is likely due to several factors. Nearby development limits the area's ability to support natural flood regimes due to floodplain encroachment and the county's obligations to reduce flood damage. USGS gage height data collected at Bridge Road shows that overbank flooding hasn't occurred since monitoring began in 1993. Overbank flooding occurs at 28' gage height in this stretch of the river, depicted by the orange line in Figure 7. Overbank flooding is crucial in riparian ecosystems for establishing new generations of cottonwoods and native vegetation. Other contributors to habitat degradation may include cattle grazing, recreation, invasive species, drought, and altered hydrology.

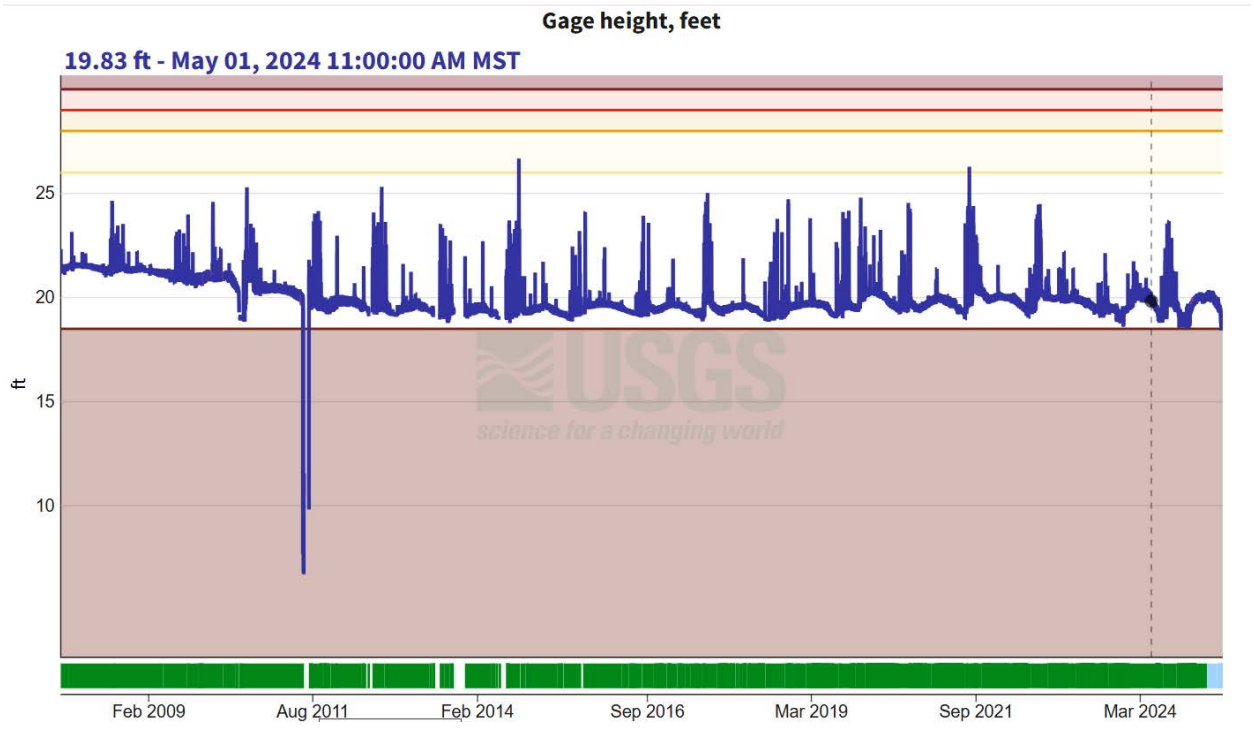

Figure 7. USGS gage height data: yellow line=flood watch, orange line=minor flooding, red line=moderate flood, purple line=major flood

Other riparian vegetation in the area is dominated by native species, with healthy stands of netleaf hackberry (*Celtis reticulata*) and Goodding's willow (*Salix gooddingii*) interspersed throughout the cottonwood forest and an understory dominated by coyote willow (*Salix exigua*), elderberry (*Sambucus nigra ssp. canadensis*), and graythorn (*Ziziphus obtusifolia*). However, invasive species are established in multiple areas and continue to pose a threat to riparian function and plant community structure. Species identified include salt cedar (*Tamarix spp.*), tree tobacco (*Nicotiana glauca*), Bermuda grass (*Cynodon dactylon*), poison hemlock (*Conium maculatum*), tumbleweed (*Salsola tragus*), and giant reed (*Arundo donax*).

Habitat Restoration

Given the unreliable flood regime, long-term drought, and warming due to climate change, low- tech restoration efforts at the site will require ongoing efforts to be successful. Restoring ecosystem function is only possible with highly engineered projects that safely return flooding to the project area, through induced meander strategies, oxbows, or overflow channels. However, revegetation, grade control structures, and invasive species treatment will improve riparian forest health and habitat value and are feasible projects to pursue.

Without flooding, ensuring new generations of cottonwoods will require repeated cycles of planting efforts. Riparian restoration is most likely to be successful along narrow corridors parallel to the river, where groundwater and mid-sized equipment are able to access, with vegetation transitioning to more climate-resilient, drought-tolerant native species further away. Mesquite bosques should form the most xeric habitats along the edges of the project boundary where groundwater cannot be reached. Assisting with this natural transition to a reduced riparian forest and mesquite bosque will increase the site's future resilience and also enhance site conditions to support existing habitat. TBA recommends a pilot pole planting project to determine riparian, mesic, and xeric boundaries. Where severe channel incision occurs and channel restoration is needed, primarily the southern third of the project area, riparian revegetation efforts should wait until the target outcomes are achieved.

Prioritize revegetation efforts along river banks, low points, and in areas treated for invasive species. Where access to groundwater exists, cottonwood pole planting is an effective strategy. The existing cottonwood population provides a reliable source of poles as they have not yet reached full maturity and are still accessible. Tall poles, with a minimum height of 9', should be sourced due to fluctuating flows and groundwater. Planting tall poles can be challenging, as holes must be dug to the depth of the lowest seasonal water table, often requiring the use of an auger and heavy equipment. Holes readily collapse, often necessitating the abandonment of specific sites after considerable efforts have already been made. Harvest and plant cottonwood poles while the trees are dormant, following best practices for collection, storage, and planting. Plant poles as close as 15' apart and select locations that have an open canopy and are protected from future peak flow events. Pole plant seep willow (*Baccharis salicifolia*) along point bars, areas where sediment is deposited within the river channel, to encourage continued meander. As natural cottonwood recruitment has occurred in point bars, reinforcing them with a wall of vegetation will help protect the young trees during peak flows.

Invasive species removal should be a primary component of the restoration strategy. In addition to ongoing understory invasive species management throughout the project area, clearing salt cedar and other water-demanding invasive species may help open the canopy and reduce competition for

groundwater, benefiting native plant establishment. Regular monitoring and follow-up treatments will be necessary to prevent reinvasion and allow native vegetation to take hold.

Figure 8. A young cottonwood on a point bar, Kari Hackney

After the first or second year of invasive species treatment, revegetation efforts may begin. TBA recommends a variety of revegetation strategies to restore the mesic and xeric zones along the Santa Cruz River. The xeric zone, for the purposes of this project, is the western and occasionally eastern perimeter of the project area, often where velvet mesquites are already established. As the channel incision worsens, the xeric zone expands closer to the river. The mesic zone occurs between the river and xeric zone, where cottonwoods dominate the canopy, but groundwater remains inaccessible. Establish shrubs and trees utilizing Groasis Waterboxxes, a relatively new and successful technology for establishing trees in dryland environments. The Waterboxx collects rainwater and slowly releases it through a cotton wick; however, extended periods without rain may require manual filling. Trees sourced in one-gallon pots or tall pots are ideal, with trees larger than five gallons being poorly suited to transplanting. All container and pole plantings should be caged to prevent herbivory.

Seeding should occur, in addition to outplanting, in all areas treated for invasive species. Seed with native species sourced as local as possible to the seeding location. The species recommended below serve as a starting point for developing a seed mix; additional species should be selected based on availability from seed suppliers. Best practices for dryland seeding include hand broadcasting, lightly raking into the soil (to no more than ¼" depth), and covering with a hydro/wood mulch to enhance the likelihood of germination.

River Channel Assessment

The river channel across most of the project area retains a generally healthy structure, with active meanders and a range of geomorphic features still functioning well. However, incision and isolated bank erosion are present in specific reaches, likely due to changes in sediment transport resulting from development. Erosion is particularly evident in the upstream (southernmost) portion of the project area and along several cut banks on the eastern side of the river, some of which reach heights of up to eight feet. These conditions, if left unaddressed, could worsen and compromise both riparian habitat and channel stability. Channel incision can lead to lowered water tables, increased incision, channel straightening, reduced overbank flooding, and reduced infiltration. However, nearby housing will compromise Santa Cruz County's ability to approve restoration strategies that promote natural overbank flooding.

Figure 9. Channel erosion within the project area, Kari Hackney

Channel Restoration Strategies

Straightened or constrained river channels tend to concentrate flow energy, often leading to incision and accelerated erosion. In contrast, naturally meandering streams slow water velocity, disperse erosive forces, promote sediment deposition, and allow for riparian tree seedling recruitment. Reintroducing or encouraging meander in straightened sections can deflect flow away from cut banks, reducing shear stress, and has been shown to help aggrade sediment, reduce cut bank severity, and interrupt self-reinforcing erosion cycles (Zeedyk & Clothier, 2012). Inducing meander comes with risks, especially at urban interfaces such as this project site. Inducing meander, even in one direction (eastward in this case), will naturally encourage matching downstream westward meander and, if not carefully executed, could threaten nearby structures. It also runs the risk of partially collapsing the alluvial banks opposite of baffles, which could harm water quality and aquatic habitat.

Should TNC opt to explore induced meander strategies with an engineer, baffle and weir systems could be an appropriate strategy for the site. Picket baffles could induce meandering in straightened sections of the river, although they require careful site selection and sizing to match the river's flow regime and sediment load. Appropriately angling the baffles is also essential for achieving the appropriate level of sinuosity over time: the more protruding the angle, the higher the sinuosity, and vice versa.

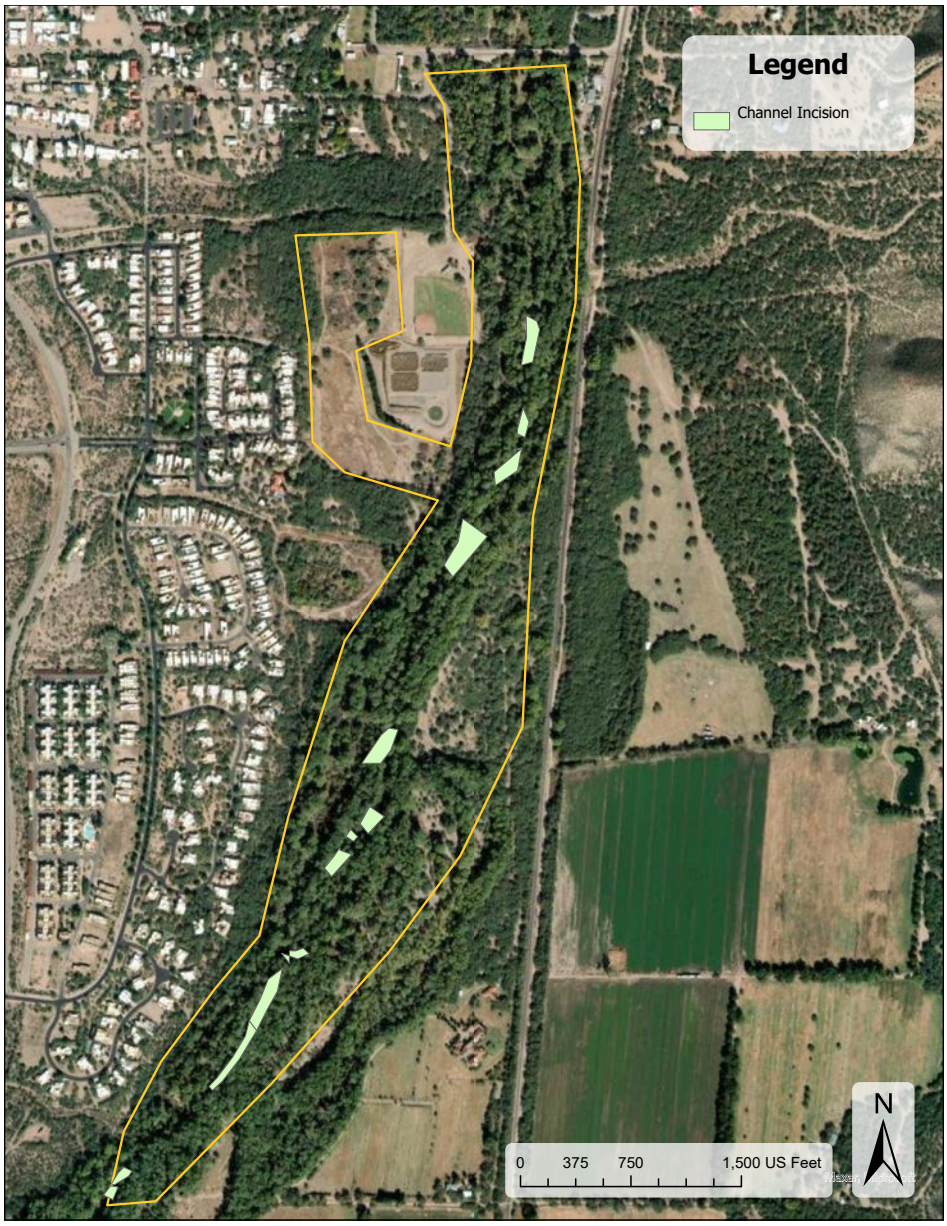

Figure 10. Map of channel incision

Weirs, such as picket weirs or one rock dams, should be implemented alongside baffles to help control bank levels and slow the flow. These strategies, when paired, offer a significant amount of control when inducing meanders in a channel. Figure10 shows locations with severe incision that should be targeted for treatment.

According to Santa Cruz County's Flood Insurance Study, the river runs at 3,150 cubic feet per second (cfs) in two year flood events and up to 45,000 cfs during a 100 year event. These flows could undermine in-channel and channel adjacent restoration efforts if not properly engineered. If TNC opts to proceed with induced meandering strategies, projects will require strong collaboration with Santa Cruz County and require Floodplain Impact Permits and a Section 404 Permit from the Army Corps of Engineers. Grading permits, a Letter of Map Change, and Letter of Map Revision may also

be required depending on impacts to the channel, flow, and 100-year flood events. TBA recommends contacting the U.S. Geologic Survey to determine their interest in leading in channel work, due to the cost and complexity of these projects.

If TNC opts out of induced meandering, they can still take meaningful steps to stop and reverse erosion in the river. One-rock dams are shown to be effective in incrementally raising the streambed over time, requiring minimal intervention. Material access to the river is challenging, although limited quantities of rock are available to source from within the project area. Additionally, pole plantings will also contribute to bank protection and sediment buildup.

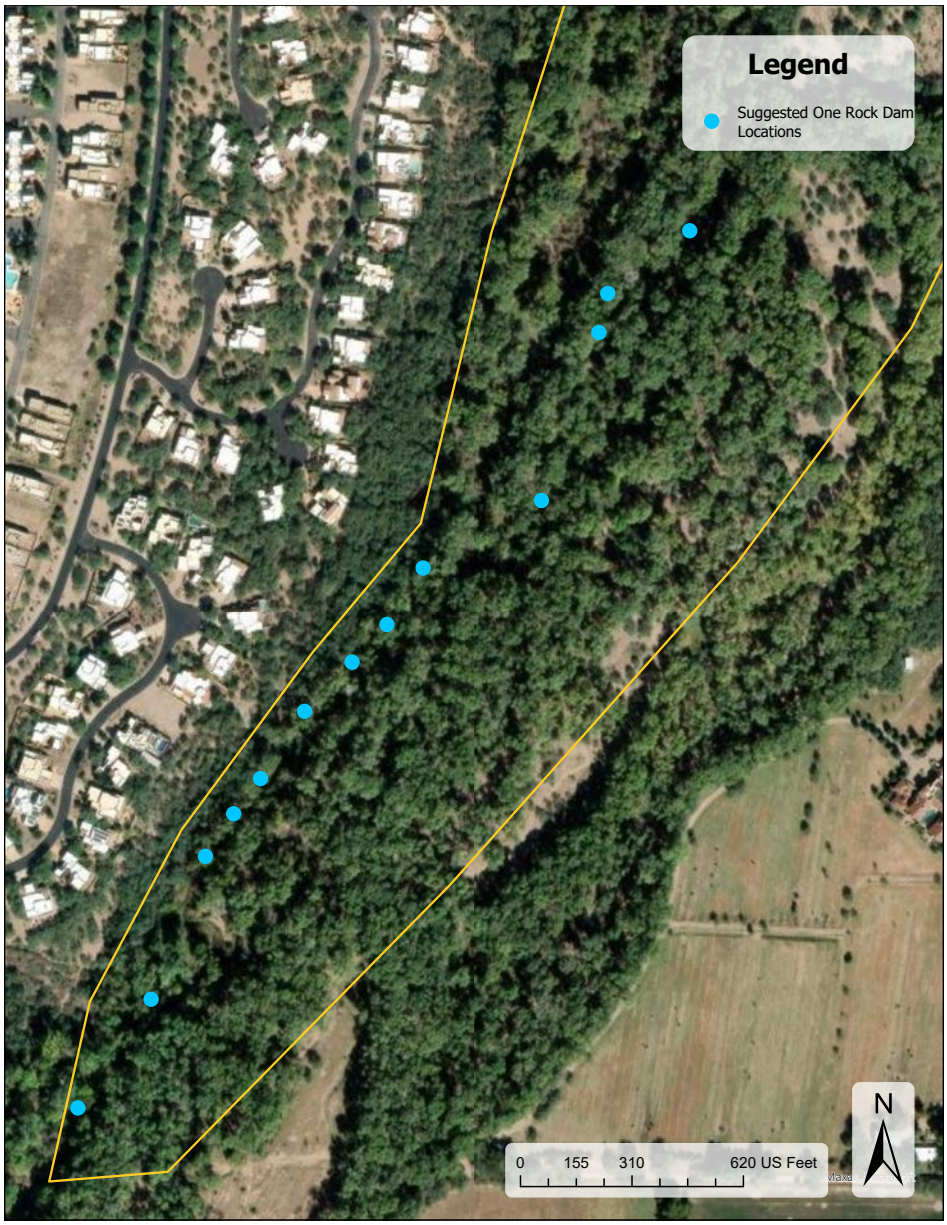

Figure 13. Suggested one rock dam locations within project area (yellow border)

After constructing any induced meandering, bank armoring, or stream aggrading structures, TNC must continue to monitor for bank erosion. If erosion worsens or speeds up compared to its prior rate, this could be a result of construction activities changing stream flow dynamics, and mitigative action is warranted. If erosion continues at the current pace, it could indicate that the structures are not having their intended effect, and TNC should consider more drastic measures to reverse these trends. TNC can monitor for erosion by establishing reference points before placing any structures, perhaps looking over a bank onto an opposite and incised bank. These points can be for documenting observations, photomonitoring, or both.

For more information on induced meandering strategies, reference the Quivira Coalition.

Riparian Species List

Common Name	Scientific Name	Form	Container	Seed	Xeric Zone	Mesic Zone
Netleaf hackberry	*Celtis reticulata*	Tree	x	x	x	x
Desert willow	*Chilopsis linearis*	Tree	x	x		x
Arizona walnut	*Juglans major*	Tree	x	x	x	x
Velvet mesquite	*Neltuma velutina*	Tree	x	x	x	
Mexican elderberry	*Sambucus neomexicana*	Tree	x		x	x
Catclaw acacia	*Senegalia greggii*	Tree	x	x	x	
Desert honeysuckle	*Anisacanthus thurberi*	Shrub	x		x	x
Desert hackberry	*Celtis pallida*	Shrub	x	x	x	
Arrowweed	*Pluchea sericea*	Shrub	x	x		x
Golden currant	*Ribes aureum*	Shrub	x	x		x
Graythorn	*Ziziphus obtusifolia*	Shrub	x	x	x	
Vine mesquite	*Panicum obtusum*	Grass	x	x	x	x
Giant sacaton	*Sporobolus wrightii*	Grass	x	x	x	x
Old man's beard	*Clematis drummondii*	Vine		x	x	x
Snapdragon vine	*Maurandya antirrhiniflora*	Vine		x	x	x

Grassland Restoration

The area west of Ron Morriss County Park has the potential to showcase two invaluable habitat types in Arizona: desert grassland and mesquite bosque. Historically, this area was a mesquite bosque, with notable stands of native mesquite trees left intact, bordering the project area, as seen in Figure 12. Since the forest was cleared, numerous mesquites have re-established and are continuing to reseed. If left untouched, the site is likely to return to a low-diversity mesquite bosque. However, the neighboring community has stated a preference for low-growing vegetation, warranting the designation of both grassland and mesquite bosque, where appropriate. Given the site's proximity to housing, interpretive signage and an expanded trail network provides a worthwhile opportunity to expand on TNC's mission.

Maintaining the site as a grassland will have ongoing challenges due to mesquite encroachment and mismatched site conditions. Desert grasslands typically occur at elevations from 3,600'-5,900' (McClaran, 1995), with Tubac at 3,209'. However, replicating a desert grassland is feasible with

site-appropriate species. Designating the grassland as a meadow, which has a higher composition of forbs, will attract birds and a variety of pollinators.

Desert grasslands in Southeast Arizona support populations of meadowlarks, sparrows, buntings, and quail. However, grassland birds require expansive patches of connected grasslands to meet their habitat needs. The meadow is approximately 6.5 acres in size with limited connectivity to nearby grass-lands, decreasing the parcel's ability to support grassland bird species through restoration efforts. However, grasslands are also known to support wetland and riparian birds, and the site is an ideal location for pollinator habitat should site managers adopt practices that complement the life cycles of pollinators. Critical pollinator habitat components include shelter, nectar plants, and larval host plants. Bunch grasses are popular locations for pollinators to shelter and overwinter. Include a variety of larval host and nectar plants to attract a variety of species.

Figure 12. Habitat zones west of Ron Morriss park, within project area (yellow border)

Figure 13. West of Ron Morriss County Park, Kari Hackney

The existing meadow is a mix of native and invasive species. The site is heavily infested with Bermuda grass (*Cynodon dactylon*) and smaller populations of tumbleweed (*Salsola tragus*), Johnson grass (*Sorghum halepense*), yellow bluestem (*Bothriochloa ischaemum*), and London rocket (*Sisymbrium irio*). Native grasses include Arizona cottontop (*Digitaria californica*), tanglehead (*Heteropogon contortus*), spidergrass (*Aristida ternipes*), cane beardgrass (*Bothriochloa barbinodis*), feather fingergrass (*Chloris virgata)*, and sprangletop (*Leptichloa panacea*). Other native plants include lacy tansyaster (*Xanthisma spinulosum),* prickly poppy (*Argemone pleiacantha*), fingerleaf gourd (*Cucurbita digitata),* and buffalo gourd (*Cucurbita foetidissima).*

The extensive size of the meadow warrants a blend of revegetation strategies. Seeding is the most budget-friendly approach for revegetating large areas, although some risk is inherent in dryland seeding projects as unpredictable rainfall leads to high failure rates. Following best practices for seed selection and storage, species selection, soil preparation, and timing will ensure the best results. The recommended seed application rate is 20 pounds per acre with application timed with summer rains; however, if hydromulch is applied post-seeding, the application may occur year-round.

Strip seeding may be a cost-effective strategy for revegetating this parcel, with initial seeding covering only a portion of the area. One study found that after four years, plots which had seed applied to 33% and 66% of the total project area yielded similar benefits to plots with 100% cover, with a slightly greater abundance of forbs (Shaw, 2022). Large-scale grassland revegetation projects often prioritize seed application to a smaller parcel, with strong adherence to best practices for site preparation and seeding application, which yields greater long-term success than seeding an entire project site with limited resources. The seeded parcel then becomes a free seed source to spread across the remainder of the site in time.

TBA recommends treating invasive plant species for one full year prior to seeding. Then either select strips to seed that were previously dominated by invasive species or seed the entire site. Ongoing invasive species spot treatment will be necessary for an additional two to four years to ensure successful seeding efforts. Excavating shallow depressions that collect rainwater can enhance seeding efforts. Additionally, shallow furrows at depths of ⅛” to ¼” perpendicular to the site’s grade will encourage rainwater collection in the seeding areas. Create furrows with a UTV rake or by hand with a rock rake. Ensure the seed is dry and well-mixed. Apply seed by hand at a rate of 120 seeds per square foot or 20-30 PLS (pure live seed) pounds of seed per acre. Within 48 hours of seeding, cover the seed with hydromulch at a rate of 2,500 lbs per acre, being careful not to damage existing

Figure 14. Gambel's quail, Alan D. Wilson

vegetation. Irrigating seeded areas will ensure higher germination rates and overall success, but must be done with caution to ensure plants have established before slowly weaning them off irrigation. The soil will need to remain moist for 7-10 days to ensure germination, with irrigation gradually being tapered after that. Improper irrigation strategies will result in lower project success than unirrigated projects. Irrigation may not be an appropriate strategy unless TNC can commit the time and resources.

TBA recommends outplanting to establish select species that aren't readily available via seed. For a meadow, this includes a strong focus on larval host plants, generalist nectar plants, and year-round blooms. The Santa Cruz watershed is a fall migration corridor for Monarchs, warranting some plantings dedicated toward enhancing their habitat, specifically milkweeds. Unique funding opportunities are available to support Monarch habitat, which could also meet the restoration needs of the site. Outplanting requires establishment watering for a minimum of 18 months, warranting the installation of an irrigation system. Some existing irrigation infrastructure is present along the Baca Float Wastewater Treatment Plant, which may be a possible irrigation source. If irrigation is unavailable, a cistern and a frequent water delivery service may be a viable option for plant establishment. Both municipal and cistern systems can be automated and connected to a drip irrigation system. Irrigation systems in wildland-urban interface settings are particularly vulnerable to punctures caused by wildlife, and additional funding should be allocated for repairs. Utilizing Schedule 40 PVC will limit the need for repairs, but comes with added cost and is only practical when used with a pressurized water source.

Include shrubs, subshrubs, succulents, and annuals in revegetation efforts. The recommended species are listed below as a starting point, although some variation of this list is acceptable. Many seed vendors sell their own seed mixes, which should have a significant overlap with the species recommended below. For seeding efforts, TBA recommends a 50:50 mix of grasses to forbs. For outplanting, TBA recommends 1-gallon plants sourced from Borderlands Nursery, Nighthawk Natives, or Desert Survivors. Cacti, especially cholla and prickly pear, are common in grasslands and should be sourced as cuttings from nearby populations.

Occasional mowing of bunch grasses may be desired to mitigate fire hazards or promote healthy growth. However, mowing at inappropriate times of the year is detrimental to pollinator populations. The ideal time to mow is mid-spring. Never mow grasses from November to March while pollinators are overwintering. Mowing should be delayed for at least four years to ensure plants are established and promote a healthy native seed bank. Additional guidance on managing habitat for pollinators is available at Xerces.org.

Grassland Seed Mix

Common Name	Scientific Name	Form
Purple threeawn	*Aristida purpurea*	Grass
Spidergrass	*Aristida ternipes*	Grass
Sixweeks grama	*Bouteloua barbata*	Grass
Sideoats grama	*Bouteloua curtipendula*	Grass
Blue grama	*Bouteloua gracilis*	Grass
Slender grama	*Bouteloua repens*	Grass
Arizona cottontop	*Digitaria californica*	Grass
Vine mesquite	*Panicum obtusum*	Grass
Green sprangletop	*Leptochloa dubia*	Grass
Plains bristlegrass	*Setaria macrostachya*	Grass
Sand dropseed	*Sporobolus cryptandus*	Grass
Sacred datura	*Datura wrightii*	Forb
Desert fleabane	*Erigeron divergens*	Forb
Common sunflower	*Helianthus annuus*	Forb
Arizona poppy	*Kallstroemia grandiflora*	Forb
Peppergrass	*Lepidium lasiocarpum*	Forb
Desert penstemon	*Penstemon parryi*	Forb
Woolly indianwheat	*Plantago patagonica*	Forb
Fendler's globemallow	*Sphaeralcea fendleri*	Forb
Burroweed	*Isocoma tenuisecta*	Subshrub
Desert zinnia	*Zinnia acerosa*	Subshrub

Figure 15. (top) adult monarch butterfly, Thomas Bresson; (bottom) larval form, Judy Gallagher

Pollinator Species for Outplanting

Common Name	Scientific Name	Bloom Period	Larval Host
Sonoran Indian Mallow	*Abutilon mollicomum*	Fall	Skippers
Dwarf Indian mallow	*Abutilon parvulum*	Year-round	Skippers
Dwarf desert peony	*Acourtia nana*	Spring	Snout plume moth
Desert honeysuckle	*Anisacanthus thurberi*	Spring	Checkerspot
White sagebrush	*Artemesia ludoviciana*	Fall	Flower moth, Tortrix moth
Pineleaf milkweed	*Asclepias linaria*	Year-round	Queen, Soldier, Monarchs
Arizona milkweed	*Asclepias angustifolia*	Summer	Queen, Soldier, Monarchs
Antelope horns	*Asclepias asperula*	Spring-Summer	Queen, Soldier, Monarchs
Horestail milkweed	*Asclepias suberticillata*	Summer	Queen, Soldier, Monarchs
Chocolate flower	*Berlandiera lyrata*	Spring-Fall	
Fairy duster	*Calliandra eriophylla*	Winter-Spring	Blues
New Mexico thistle	*Cirsium neomexicanum*	Spring-Summer	Crescents, Painted lady
Rubber rabbitbrush	*Ericameria nauseosa*	Summer	Checkerspot
Desert evening primrose	*Oenothera primiveris*	Spring	White lined sphinx moth, Flower moth
Arizona sunflower	*Tithonia thurberi*	Fall	Bordered patch, Painted lady
American threefold	*Trixis californica*	Spring	Crescents

Mesquite Bosque

Figure 16. Mesquite bosque within the project area, Kari Hackney

Bosques are the second most productive habitat in the Southwest for breeding birds, second only to cottonwood-willow forests (Stromberg, 1993). This habitat value is partially attributed to the strong insect associations of mesquites, which serve as an essential dietary component for breeding birds. High canopy cover, overall plant diversity, and plant density at each height strata also contribute to high habitat value. Insectivorous birds, such as Verdins, Black-tailed Gnatcatchers, and Ash-throated Flycatchers, are most abundant in bosques, but these habitats can also support frugivorous birds, such as Phainopeplas and Pyrrhuloxia or granivorous birds, such as sparrows (Stromberg, 1993).

Mesquite bosque vegetation communities vary widely in their assemblages, but the tree canopy is usually comprised of at least 75% velvet mesquites (Stromberg, 1993). Catclaw acacia (*Senegalia greggii*), netleaf hackberry (*Celtis reticulata*), and Mexican elderberry (*Sambucus mexicana*) are also bosque-associated trees with high habitat value, worth including in replanting efforts. The midstory consists primarily of fruit-producing shrubs known to attract Northern Cardinals, Pyrrhuloxia, and Phainopeplas. Graythorn (*Ziziphus obtusifolia*), wolfberry (*Lycium spp.*), and pigeonberry (*Rivina humilis*) are all suitable for this site. Vines are common in mesquite bosques, including old man's beard (*Clematis drummondii*) and climbing milkweed (*Funastrum cynanchoides*). Other shade-loving species, such as wild petunia (*Ruellia nudiflora*) and Arizona foldwing (*Dicliptera resupinata*), reseed readily and provide ground cover. Giant sacaton (*Sporobolus wrightii*) and alkali sacaton (*Sporobolus airoides*) are important riparian grasses to include in areas with lower canopy cover.

Much of the area directly west of Ron Morriss Park is naturally returning to a mesquite bosque through the re-establishment of young trees. This process can be supported and enhanced by strategically removing seedlings and saplings to favor a selected tree, preferably the largest in the grouping, thereby limiting resource competition and encouraging rapid growth. A velvet mesquite thinning project along the San Pedro River found that efforts enhanced the bosque's wildlife habitat value by creating a bosque vegetation structure. Trees also demonstrated increased growth rates, with a 2.5 cm increase in the test plot, compared to a 1.5 cm increase in the control population (Simpson, 2018). Remove the small-est trees using a weed wrench; otherwise, a cut stump herbicide treatment is recommended, with multiple follow-up treatments required.

Figure 17. Map of mesquite bosque seeding zones

Revegetation efforts should focus on enhancing the diversity of the bosque. Plant trees and shrubs utilizing Groasis Waterboxxes. Seeding in this environment requires a more tailored approach, primarily due to the varying microclimates. Divide the area into three microclimates: full sun, partial shade, and full shade. Although velvet mesquites are reestablishing, the understory and midstory are primarily comprised of invasive species. The extensive presence of invasive species warrants a similar approach to grassland restoration strategies, involving one year of invasive species treatment followed by seeding at a rate of 20 pounds per acre. Of the 6.1-acre mesquite bosque, 1.3 acres are considered full shade, 2.1 acres are partial shade, and 2.7 acres are full sun, as shown in figure 17.

Mesquite Bosque Plant List

Common Name	Scientific Name	Form	Container	Seed	Full Sun	Partial Shade	Full Shade
Whitethorn acacia	*Acacia constricta*	Tree	x	x	x		
Desert hackberry	*Celtis pallida*	Tree	x	x	x		
Netleaf hackberry	*Celtis reticulata*	Tree	x	x	x		
Desert willow	*Chilopsis linearis*	Tree	x	x	x		
Arizona walnut	*Juglans major*	Tree	x	x	x		
Mexican elderberry	*Sambucus mexicana*	Tree	x	x	x		
Desert honeysuckle	*Anisacanthus thurberi*	Shrub	x	x	x	x	
Wild cotton	*Gossypium thurberi*	Shrub	x	x	x	x	
Wolfberry	*Lycium spp.*	Shrub	x	x	x	x	x
Pigeonberry	*Rivina humilis*	Shrub	x				x
Graythorn	*Ziziphus obtusifolia*	Shrub	x	x	x	x	
Cane beardgrass	*Bothriochloa barbinodis*	Grass	x	x			x
Desert saltgrass	*Distichlis spicata*	Grass	x	x	x	x	
Alkali sacaton	*Sporobolus airoides*	Grass	x	x	x	x	x
Giant sacaton	*Sporobolus wrightii*	Grass	x	x	x	x	x
Southwestern pipevine	*Aristolochia watsonii*	Vine	x				x
Old man's beard	*Clematis drummondii*	Vine	x				x
Mexican passionflower	*Passiflora mexicana*	Vine	x				x
Dwarf desert peony	*Acourtia nana*	Forb	x	x		x	x
Hoary bowlesia	*Bowlesia incana*	Forb	x	x		x	x
Arizona foldwing	*Dicliptera resupinata*	Forb	x	x		x	x
Climbing milkweed	*Funastrum cynanchoides*	Forb	x	x			x
Tansyleaf aster	*Machaeranthera tanacetifolia*	Forb	x	x	x		
Wid petunia	*Ruellia nudiflora*	Subshrub	x	x		x	x
American threefold	*Trixis californica*	Subshrub	x	x	x	x	

Figure 18. Verdin, Doris Evans

Figure 19. Phainopepla, Joan Gellatly

Adaptive Management

Invasive Plant Management

Invasive plants are defined as any plant that is non-native to the ecosystem and is likely to cause economic harm, environmental harm, or harm to human health. Due to their exotic nature, invasive plants lack natural checks and balances on their growth, such as herbivory. This allows them to spread readily, easily outcompeting native plants and threatening the area's biodiversity and habitat value.

Tucson Bird Alliance, along with our partners in the Sonoran Desert Cooperative Weed Management Area (including the University of Arizona and multiple federal and local agencies), believes that careful and precise herbicide application is an effective strategy within an integrative pest management approach. Herbicide bypasses the downsides of manual removal, such as prohibitive labor costs, increased soil erosion, and negative impacts on native vegetation, animals, and insects. For more information on TBA's herbicide philosophy, please see the Invasive Plant Management Fact Sheet on our website.

An Arizona Pest Management Department Certified Applicator should supervise all herbicide applications. Rates below are suggestions and applicators must follow the herbicide's label for exact amounts. If invasive plants are growing in or near water, use aquatic safe formulations.
Below are the invasive plant species that TBA has documented within the project area, along with their treatment recommendations.

Invasive Trees and Shrubs

Common Name	**Scientific Name**
Salt cedar	*Tamarix spp.*
Mexican palo verde	*Parkinsonia aculeata*
Chinese pistache	*Pistacia chinensis*
Chinaberry	*Melia azedarach*
Tree of Heaven	*Ailanthus altissima*
Siberian elm	*Ulmus pumila*
Firethorns	*Pyracantha spp.*

In general, invasive trees should be felled and low-stumped to 1" above the ground. Apply herbicide cut-stump treatments to the cambium of the stump within 5 minutes of low stumping. Treat stumps with Triclopyr at full strength. Treatments are most successful in late fall when trees are entering dormancy for peak effectiveness, though follow-up treatments will be inherently necessary over the next 2-3 years. Special cases are outlined below.

Some trees, such as Siberian elm, may send out root sprouts after a cut stump treatment. These sprouts will be within a few feet of the stump. Treat the foliage of any sprouts with 4% glyphosate + 0.5% nonionic surfactant.

Tree of Heaven is a particularly invasive tree due to its extensive root system and prolific seed production. Treatment will require special care and multiple steps.

1. Begin by treating trees in late summer with stem injections of undiluted triclopyr at a rate of one injection per 3" of stem diameter. If treating a clump of trees, treat with a rate of one injection per 6" of combined stem diameter. Treat the largest stems first. Leave the treatment for at least 4 months.
2. Fell and low-stump the trees, then apply full-strength Triclopyr to the cambium within 5 minutes of low-stumping.
3. Monitor for root sprouts, which may grow up to 50 feet away from the tree. Treat the foliage of any sprouts with 2-4% glyphosate + 0.5% nonionic surfactant.
4. Monitor for seed sprouts. Treat the foliage of seedlings with either 2-4% glyphosate + 0.5% nonionic surfactant or 1-2% Triclopyr + 0.5% nonionic surfactant. Treat seedlings as early as possible. (DiTomaso, 2013)

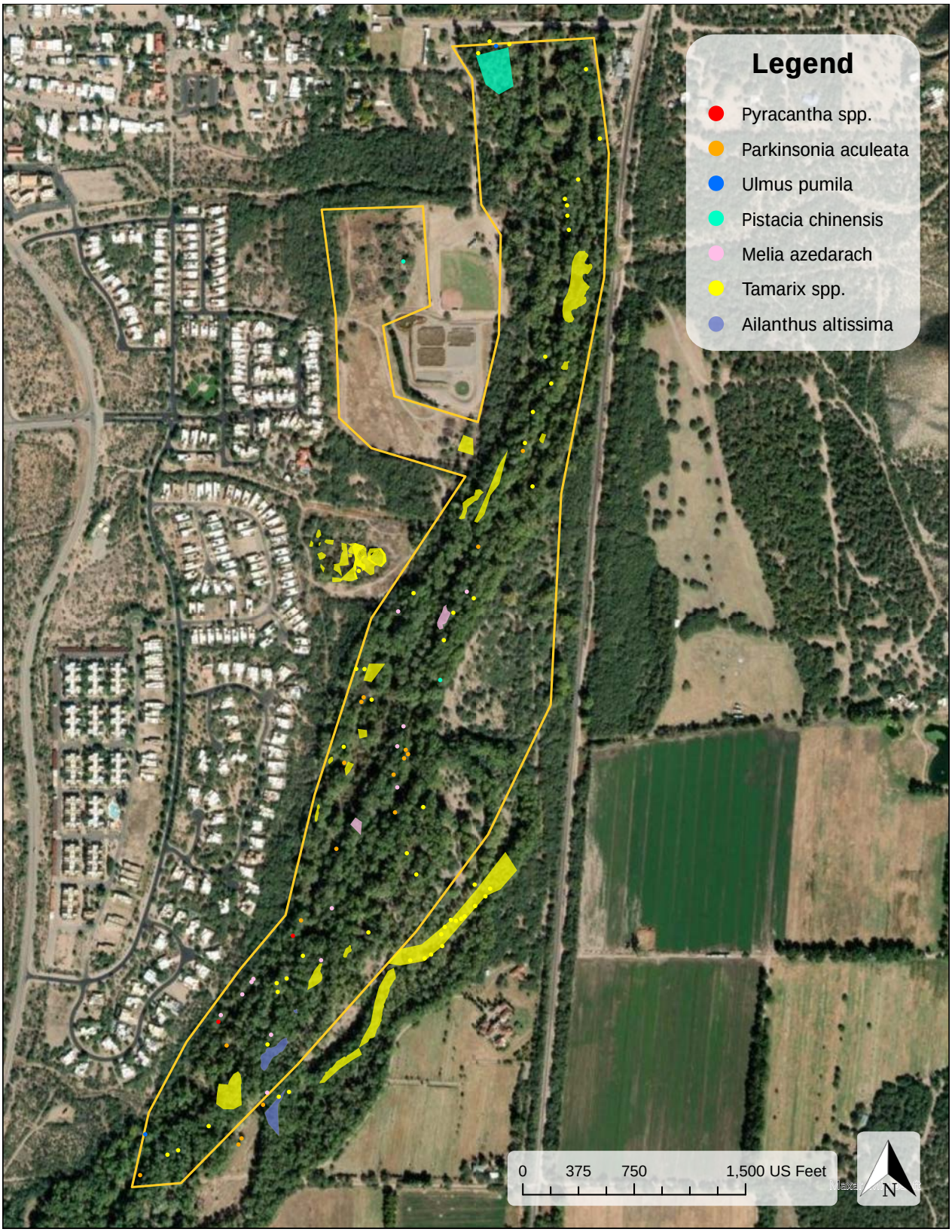

Figure 20. Map of invasive tree and shrub populations within the project area

Figure 21. Invasive trees and shrubs in the project area from top left to bottom left: Salt cedar, Prahlad balaji, Mexican palo verde, Krzysztof Ziarnek, Chinese pistache, Peter Chadzidocev, Chinaberry, Anna Anichkova, Tree of Heaven, Josep Gesti, Siberian elm, Ronnie Nijboer, Firethorns, SAplants

Invasive Grasses and Forbs

Common Name	Scientific Name
Buffelgrass	*Pennisetum ciliaris*
Bermuda grass	*Cynodon dactylon*
Tumbleweed	*Salosola tragus*
Johnson grass	*Sorghum halapense*
Yellow bluestem	*Bothriochloa ischaemum*
Barnyard grass	*Echinochloa crus-galli*
Tree tobacco	*Nicotiana glauca*
Poison hemlock	*Conium maculatum*
Giant reed	*Arundo donax*

In general, treat invasive grasses and forbs using a mix of 2-4% glyphosate + 0.5% nonionic surfactant. For best results, treat grasses and forbs when green and growing, typically after rainy seasons. Treat all grasses and forbs for 5 years, 3-5 times each growing season to maximize efficacy. Space treatments apart by 2-4 weeks. Glyphosate does not affect seeds, warranting five years of treatment to fully eradicate the existing invasive seed bank. See the following special cases:

Tree tobacco treatment is feasible with manual removal. Remove the entire root to prevent resprouting. Chemical treatment is most effective on smaller plants, waist-high or shorter.

Treat poison hemlock seedlings with 2-4% glyphosate + 0.5% nonionic surfactant. Larger plants can be removed manually, but always wear gloves when handling them as the sap may cause a harmful medical reaction. Remove the entire taproot to present resprouting. Manual removal is best before the plant has bloomed to prevent seed dispersal. Repeated mowing can be an effective method for managing large populations. (DiTomaso, 2013)

Manual removal is an effective management strategy for small populations of giant reed. Ensure the entire rhizome and root system are removed to prevent resprouting. Chemical treatment is recommended for large populations of giant reed. Cut the plant to below knee height. Once resprouting occurs, treat with 2-4% glyphosate and 0.5% nonionic surfactant. Repeat as needed, with a mini-mum of 2 to 4 weeks between treatments. (Newhouser, 1999)

Monitoring and Maintenance

Continued monitoring for regrowth and retreatment as necessary is essential to effective invasive plant management. Between chemical treatments, manual removal of buffelgrass, yellow bluestem, and Russian thistle can increase the overall efficacy of the treatments. When manually removing invasive grasses, bag and discard any seed heads to prevent further spread.

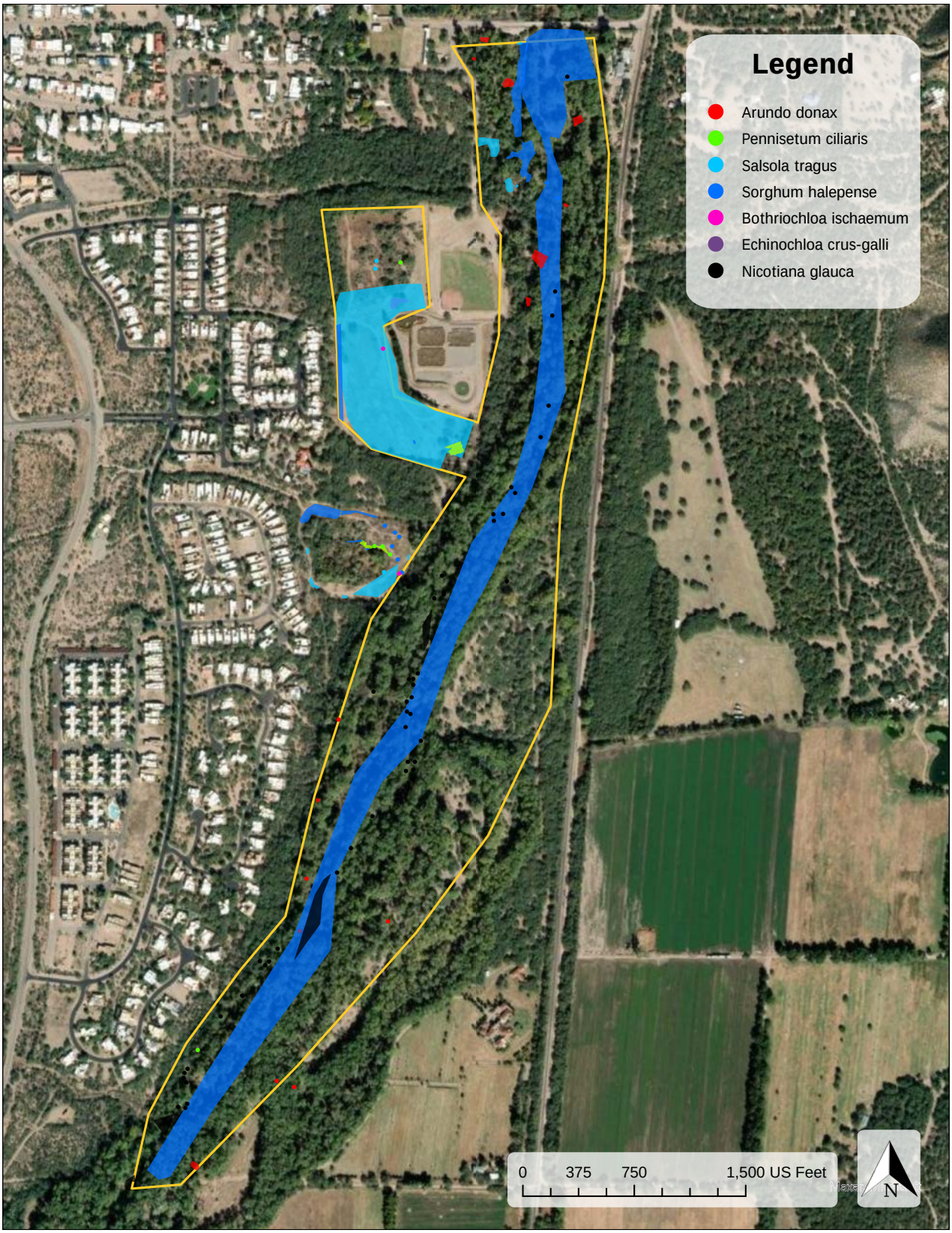

Figure 22. Map of invasive grasses and forbs in the project area, excluding poison hemlock and Bermuda grass. Approximate percent cover of Johnsongrass = 5%.

Figure 23. Maps showing the extent of the poison hemlock population (left, in orange, approximate percent coverage in polygon = 5%) and Bermuda grass (right, in yellow, approximate percent coverage in polygon = 10%)

Figure 24. Invasive grasses and forbs in the project area, from top left to bottom right:
Giant reed, Shizhao,
Bermuda grass, Stefan Lefnaer,
Yellow bluestem, Stefan Lefnaer, Barnyard grass, Krzysztof Ziarnek,
Tree tobacco, Mark Marathon,
Tumbleweed, Jane Shelby Richardson,
Johnson grass, Daniel Villafruela,
Buffelgrass, Harry Rose,
Poison hemlock, Mick Talbot

Habitat Management for High Visitation Areas

Fire

Fire is a growing concern in the Sonoran Desert, primarily due to the grassification of desert landscapes caused by the spread of invasive species. Not all biomes within the Sonoran Desert are fire-adapted or fire-prone, requiring caution when prescribing firewise treatments uniformly to all landscapes. Improperly applied firewise practices often have the opposite effect, clearing native vegetation and creating ideal conditions for invasive species to establish and spread. Currently, firewise standards, as written, should only be applied to conifer forests and grasslands, with ecologically appropriate strategies for other biomes.

Within the project area, the desired grassland carries the most significant fire risk to the nearby homes. Maintaining a 30' fuel break between the housing and the meadow is recommended. Fuel breaks require treating invasive grasses, removing dead wood and lower tree limbs that can carry a fire up into a tree's canopy. Native vegetation should otherwise be left intact. While grasslands benefit from occasional burns, the altered vegetative structure of the meadow would not benefit from such management. The seasonality of prescribed burns often conflicts with the lifecycle of pollinators, as pollinators will overwinter in the grasses. Neither prescribed burns nor mowing is a recommended wildfire mitigation strategy for the grassland.

Fire risk in mesquite bosques and riparian forests is due to the presence of invasive species. Treating invasive species in both areas is adequate to manage fire risk. There are no documented fires that have occurred in healthy riparian forests in Arizona. The deciduous trees of riparian forests and bosques retain greater moisture than their fire-prone counterparts, such as conifers, reducing their flammability. However, degraded riparian habitats have had wildfires fueled by invasive species, such as saltcedar, Johnson grass, and buffelgrass, all of which are present in the project area. Excessive dead wood also contributes to increased fire risk but should be individually evaluated to determine if removal is appropriate, as dead trees provide many habitat and ecological benefits. Often, mimicking the natural vegetative patchiness of the desert is adequate to prevent fires (Wilder, 2024).

Tree Hazards

The fast-growing nature of cottonwood trees, compounded with their soft wood, makes them prone to breakage during inclement weather or due to old age and disease. Cottonwood trees along trails should be evaluated for widow makers (detached or broken limbs) after significant weather events to ensure the safety of visitors.

Figure 25. Widow maker, Kari Hackney

Pruning

Pruning is frequently required to maintain trails or remove hazardous limbs. Still, pruning a tree creates a wound that can attract damaging insects or open the tree to disease. Decreasing a tree's canopy negatively impacts its ability to photosynthesize and create important growth hormones. As such, any action must weigh these risks against the benefits of pruning before making any cuts.

Prioritize the use of thinning cuts, in which tree branches are removed at their point of origin on the trunk or another branch. Care should be taken to maintain the tree collar, which contains specialized cells that allow the wound to seal.

Heading cuts (made in the middle of the branch at buds) should be used very sparingly, as they create entry points for insects and diseases.

Tree Care for Birds and Wildlife

Trees serve as a major habitat for many species of birds and other wildlife. When pruning, it is crucial to consider the effects of removing a branch on the animals using the tree.

One of the most critical steps to take when pruning is to search for active nests. While adult birds will likely flee when tree care workers approach, eggs and chicks are unable to do so. If left alone by their parents, the young are exposed to the elements and predators. During the heat of the summer, even a few minutes lapse in incubation can cause irreparable damage to eggs. This is particularly critical during peak breeding season, which spans from January to July, depending on the species. Additionally, many of our native birds are cavity nesters, which can be very hard to detect. Spend a few minutes observing a tree before work begins. Look for the following signs of an active nest:

1. Visible nest with eggs or young
2. Tree cavities (If possible, use an endoscope to check for cavity nests. Without this tool, workers must instead rely on observing bird behavior to determine if a nest is present)
3. Bird breeding behaviors such as carrying sticks/nesting material or food to the tree
4. Agitated activity such as distress calling or dive-bombing
5. Concentrations of bird droppings near the tree

Do not work on a tree that is determined to contain an active nest. If a nest is present but determined to be inactive, work may occur on the tree, but best practices recommend leaving the nest undisturbed.
Under the Migratory Bird Treaty Agreement, it is illegal to kill native or migratory birds or destroy their nests or eggs in the US. This treaty covers nearly 1100 bird species, a large number of which are found in Arizona, depending

Figure 26, Gila woodpecker, a cavity nester (Joan Gellatly

on the time of year. Other bird species and their eggs and nests may also be protected under the Endangered Species Act.

While birds are most affected by pruning activity, other wildlife species may also be impacted. TBA recommends careful observation of a work area for signs of wildlife before work begins. Wildlife may be hiding in nearby tree litter or using the shade to stay cool. Approach trees slowly, giving wildlife time to flee. While there is no broad federal law to protect reptiles, mammals, and amphibians like the Migratory Bird Treaty Agreement, many species are protected under the Endangered Species Act or Arizona specific regulations. (Bassett, 2022)

For more information about best management practices in reference to wildlife, please visit treecare-forbirds.com.

Snags

Snags, or dead upright trees or limbs, are important components of habitat for a number of wildlife. Consider leaving snags whenever possible. Any snags within falling distance of a trail should be evaluated for safety by an ISA certified arborist.

Brush Piles

Downed limbs or necessary pruning for trail maintenance provide a great resource to enhance the habitat. Medium-sized and small limbs are ideal for creating brush piles that provide incredible habitats for birds, reptiles, and small mammals. For the greatest habitat value, brush piles should be placed near water and/or food sources but away from places with heavy foot traffic. Brush piles should be loose and airy: too much compaction means that animals cannot easily enter. Alternatively, brush could be chipped on site to enhance soil health and increase moisture rentention.

Mistletoe

Mesquite bosques tend to host desert mistletoe (*Phoradendron californicum*), which is native to the Sonoran Desert and most often infects mesquite trees. While it is a parasite, it rarely kills the host tree because it cannot survive without its host. Furthermore, cutting out mistletoe is ineffective in removing it from the tree. This is because, by the time the vegetative body is visible, mistletoe has already rooted deep into the tree. Despite its parasitic nature, mistletoe is likely a keystone species, having an invaluable impact on its ecosystem. Desert mistletoe, in particular, produces berries that are a favorite food for Phainopepla and other birds. Consider leaving mistletoe alone, allowing it to serve this important role in the food web. (Yule, 2016)

Social Trails

Proper trail management is crucial for providing both a positive visitor experience and protecting the habitat. Unwanted social trails can have detrimental effects on the existing habitat and threaten the success of restoration efforts. Trail signage and maps can help deter off-trail travel. Close access to social trails with downed limbs and smaller brush. Designate active restoration zones and enforce closures to these areas.

Grazing

Areas undergoing revegetation must be inaccessible to cattle for at least two years to ensure the successful establishment of plants. Although cattle are primarily grass browsers, they also consume forbs, shrubs, and young trees, which can threaten the success of revegetation efforts. Ideally, cattle should not have access to the river, especially during the wet season when banks are most fragile and prone to crumbling. The Tubac Nature Center should engage with landowners and livestock ranchers to develop a sustainable grazing plan that addresses herd size, rotational grazing, and alternative strategies to prevent cattle from accessing sensitive riparian areas. If cattle cannot be removed from active restoration areas along the river, new plantings must be protected from herbivory with fencing.

Wildlife Encounters

Some wildlife encounters can be dangerous for humans, the wildlife itself, or both. Preventing negative encounters encourages a positive visitor experience and protects wildlife.

Nesting birds should not be disturbed. Do not publicly share the locations of nests to prevent disturbance, and encourage visitors not to do so. If an endangered bird species or an Arizona Species of Greatest Conservation Concern are nesting within Tubac Nature Center, enforce a temporary closure of the area within 50 feet of the nest.

Rabid animals are a rare but serious danger. Visitors should be discouraged from feeding or otherwise interacting with wild animals. Any visitor bitten by a wild animal should immediately seek medical attention. Visitors should contact Arizona Game and Fish, animal rehabilitators like Liberty Wildlife, or local animal control if they observe an animal that is injured or acting strangely. (AZDHS, 2025)

Several beehives were observed in the project area by TBA. Beehives are made by European honey-bees, an introduced species. If beehives are observed along a trail, close the trail until the beehive is relocated by a trained apiarist.

Arizona is home to over 1,000 species of native bees. The vast majority of Arizona native bees are solitary, nesting in the ground, snags, or woody stems. Some native bumblebees are social ground-nesters, building homes in abandoned rodent burrows. Unlike European honey bees, native bees are not aggressive and rarely sting. If native bee nests are observed along trails, consider enforcing a temporary closure surrounding the nest. To support native pollinators at all stages of their life cycle, do not use insecticides within the project area. (XSIC, 2019)

Project Funding

Applicable Grants

National Fish and Wildlife Foundation (NFWF), Five Star and Urban Waters Restoration Grant Program:

The Five Star and Urban Waters Restoration Grant Program provides funding for projects focusing on a variety of different priority focus areas, including:

- On-the-ground wetland, riparian, in-stream, and/or coastal habitat restoration
- Meaningful education and training activities, either through community outreach, participation, and/or integration with K-12 environmental curriculum
- Measurable ecological, educational, and community benefits
- Partnerships: Five Star projects should engage diverse community partners to achieve ecological and educational outcomes. (NFWF)

Details

- Funding Range: $20,000 to $50,000
- Application Timeline: Opens in November and closes in January; awarded annually.
- Applicability: High. Supports projects that restore and improve wetlands while engaging and educating the nearby community.

National Fish and Wildlife Foundation (NFWF), Monarch Butterfly and Pollinator Conservation Fund:

The Monarch Butterfly and Pollinator Conservation Fund provides funding to restore and enhance pollinator habitat, with a focus on native milkweeds and nectar plants

- Prioritizes habitat for Monarchs and additional at-risk pollinator species
- Project size must be 500 acres, warranting collaborative projects with partners

Details

- Funding range: $200,000-$300,000; no match required
- Application Timeline: Due in July
- Applicability: Medium. Supports pollinator focused habitat enhancements at a large scale.

U.S. Fish and Wildlife Service (USFWS), Partners for Fish and Wildlife Program:

The Partners for Fish and Wildlife program provides technical and financial assistance to private landowners interested in restoring wetlands and other habitats. Activities such as invasive species control and native seeding are eligible for funding. To apply, site managers should identify a federally listed species their project seeks to support (most applicable: Yellow-billed cuckoo, Southwestern Willow Flycatcher, Gila Topminnow) and simply contact the program to set up a meeting or begin the conversation.

- “Our staff provides free technical and financial assistance to plan, design, supervise, and monitor

customized habitat restoration projects. These projects range in size from a wetland of a few acres to a grassland restoration covering several hundred thousand acres." -USFWS

Details
- Funding Range: Varies widely; typically up to $25,000 per project.
- Application Timeline: Rolling basis; applications accepted year-round.
- Applicability: High. Provides support for habitat restoration and invasive species treatment (FWS).

Arizona Water Protection Fund (AWPF)

The AWPF provides financial assistance for projects aimed at protecting and enhancing Arizona's riparian habitats, including stream restoration, riparian vegetation planting, and water quality improvement.
- Funding is awarded as 100% reimbursement, making it ideal for projects that can cover upfront costs.

Details
- Funding Range: Up to $300,000, with grants as 100% reimbursements.
- Application Timeline: Opens in July and August, with project funding available for up to five years.
- Applicability: High. The AWPF fund directly supports riparian habitat restoration and enhancement, aligning well with this project's wetland and riparian restoration elements (AWPF).

Arizona Game and Fish Department, Heritage Fund Grants:

Funded annually through the Arizona lottery, Heritage Fund Grants provide funding for projects that seek to conserve and protect the state's wildlife and natural resources. Site managers could apply under the Public Access ($50,000/yr total) or the Urban Wildlife and Urban Wildlife Habitat ($130,000/yr total) programs. Since a primary mandate for this program is to protect endangered species, it will be helpful for site managers to apply with a target conservation species for proposed habitat restoration activities. Applicable endangered species include
- Critical habitat overlap: Yellow-billed Cuckoo, southwestern Willow Flycatcher - Each relies on and is supported by riparian canopy.
- Other birds: Mexican Spotted Owl, Cactus Ferruginous Pygmy-owl
- Fish and amphibians: Chiricahua Leopard Frog, Gila topminnow - may require population establishment actions in cooperation with AZGFD
- Monarch Butterfly (candidate for federal listing) - pollinator and milkweed planting is easily achieved and has direct positive impacts on monarchs.

Details
- Funding Range: Up to $50,000 per project.
- Application Timeline: Typically opens in spring; deadlines in early summer.
- Applicability: High. Specifically aimed at habitat restoration, including invasive species treatment and native plantings (AZGFD).

Arizona Game and Fish Department, Habitat Partnership Committee (HPC) Grants:

The HCP grant program administers funds received from the sale of big game tags in order to improve game habitat via: Habitat enhancement/restoration, water developments, and other activities. To qualify for this opportunity, site managers would need to identify a species of big game their restoration activities seek to target and support. The project area's location along the Santa Cruz River, an important and imperiled wildlife corridor, could be a strong argument in support of receiving funding through this program. Applicable big game could include: mule deer, white tail deer, black bears, and mountain lions.

Details

- Funding Range: Varies; typically $10,000 to $50,000.
- Application Timeline: Opens in the fall; deadlines in late fall.
- Applicability: Medium. It focuses on wildlife habitat improvement but seemingly on more of a landscape scale (AZGFD).

Arizona Department of Forestry and Fire Management (DFFM), Invasive Plant Grant (IPG)

IPG projects primarily focus on invasive species treatment in areas that will both improve habitat value and/or prevent wildfires. However, projects can have a secondary goal of native planting and habitat restoration and potentially receive sizable funding for such activities alongside invasive species treatment. Invasive species treatment throughout the entire project area could be partially funded through this opportunity.

- Funding Range: Up to $200,000 per project
- Application Timeline: Typically opens in early spring; deadlines are usually in late spring or early summer. Awards are given annually.
- Applicability: High. (AZDFFM)

Arizona Department of Forestry and Fire Management, Hazard Fuel Incentives (HFI) Grant

The HFI Grant aims to reduce wildfire risk by managing hazardous fuels, which can include invasive plant removal and vegetation management. While the primary focus is on wildfire mitigation, this project's invasive species treatment and habitat restoration efforts may qualify, especially if site managers can demonstrate a reduction in wildfire risk broadly, and in a Wild-Urban Interface (WUI). Despite being located in a direct WUI area, the scope for the grassland restoration project may be too small to qualify for this opportunity - site managers could consider combining the meadow project components with nearby Santa Cruz River invasive species work if pursuing this. This opportunity likely will not fund habitat restoration activities beyond invasive species management.

Details

- Funding Range: $60,000-500,000 per project
- Application Timeline: Opens in the fall, with deadlines typically in late fall or early winter. Awards are given annually.
- Applicability: Medium. There is a strong chance that an IPG proposal will get deferred to this

funding source. However, it is not the most applicable grant for a habitat restoration-forward project.

Arizona State Parks and Trails – Recreational Trails Program (RTP)

The RTP is a federal program administered by Arizona State Parks that funds the creation, maintenance, and accessibility improvements for recreational trails. Eligible projects include trail development, accessibility upgrades, and recreational infrastructure on public lands. The Anza Trail's accessibility to the public makes it a qualified candidate for funding to support and enhance visitor experience at the site.

Details
- Funding Range: Up to $150,000 per project. $10,000 for education projects.
- Application Timeline: Applications are accepted year-round; funding availability starts in July of the following year if applied after June.
- Applicability: High. Supports development and maintenance of recreational trails, aligning well with any plans for accessible paths along the meadow or enhancements to the Anza Trail.

Sonoran Joint Venture (SJV) Awards Program

The SJV Awards Program provides competitive funding for projects that contribute to bird conservation and habitat preservation within the Sonoran Joint Venture region. Ideal for smaller-scale habitat restoration efforts, the program focuses on improving habitat for migratory and resident bird species.

Details
- Funding Range: $5,000 to $15,000 per project.
- Application Timeline: Opens annually, typically in early fall with a rolling deadline.
- Applicability: High. Supports conservation of bird habitats within the SJV region, making it well-suited for projects that include wetland restoration benefiting bird populations (SJV).

Project Concepts

Bundle projects by funding opportunities. All invasive plant treatment should be readily fundable by an Arizona Department of Forestry and Fire Management grant. National Fish and Wildlife Foundation and the U.S. Fish and Wildlife Service provide funding to support pollinator focused restoration projects and are well suited to fund seeding and outplanting efforts in the meadow. A riparian focused restoration project, that includes both mesquite bosque and riparian project areas, is a competitive bundle for Arizona Water Protection Fund or National Fish and Wildlife Foundation funding.

TBA recommends only pursuing low-tech channel restoration strategies until engineers can be consulted. At this time, one rock dams and pole plantings are the only recommended strategies to pursue and thus are included in the budget estimates below.

Project Implementation Budget Estimates

Activity	Materials	Material Cost	Labor Hours	Labor Cost	Total	2 Year Establishment
Grassland and Bosque Invasive Plant Treatment	Herbicide, adjuvants, PPE, chainsaw oil & fuel	$6,000.00	1,440	$86,400.00	$92,400.00	N/A
Grassland Seeding	130 lbs seed, hydromulch	$24,000.00	250	$15,000.00	$39,000.00	N/A
Grassland Planting	Cistern (optional), irrigation, 400 plants	$14,000.00	700	$42,000.00	$56,000.00	$16,000.00
Mesquite Thinning	Chainsaw oil and fuel, chipper	$2,000.00	600	$36,000.00	$38,000.00	$4,500.00
Mesquite Revegetation	80 lbs seed, 75 Waterboxxes, 75 container plants	$9,000.00	250	$15,000.00	$24,000.00	$3,000.00
Riparian Invasive Plant Treatment	Herbicide, adjuvants, PPE, chainsaw oil & fuel	$10,000.00	5,800	$348,000.00	$358,000.00	$35,000.00
Grade Control Structures	13 one rock dams with 3 treatments	$2,400.00	3,600	$219,960.00	$222,360.00	$24,000.00
Pole Planting Pilot Project	Loppers, auger rental, mallets	$1,800.00	360	$21,600.00	$23,400.00	N/A
Riparian Revegetation	Equipment rental	$1,500.00	720	$46,200.00	$44,700.00	$4,400.00
Mesic and Xeric Revegetation	1000 trees and shrubs, 500 Waterboxxes, 200 lbs native	$95,000.00	2,200	$132,000.00	$227,000.00	$18,000.00

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