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Contributions of watercourse-associated greenways to green infrastructure: a comparison between two case studies in Arizona and Maryland, USA

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Cover Page Footnote

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Contributions of watercourse-associated greenways to green infrastructure: a comparison between two case studies in Arizona and Maryland, USA.

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Introduction

Greenways have historically played a significant role in the development of green infrastructure design and planning. As one of the many components of greenways, vegetated buffers along urban and suburban watercourses are typically well-suited for recreational uses such as biking, walking trails and wildlife-viewing. However, development pressures in cities and suburban environments can lead to fragmented and redirected watercourses to accommodate other land uses. In some cases, unplanned access increases erosion and loss of vegetation and potential wildlife habitat in these areas. It is critical for future conservation of these natural and restored areas that appropriate access be explored. This paper presents two case studies of watercourse-associated greenway development in two distinctly different regions, arid and temperate, and compares the approaches and contributions to green infrastructure in their respective regions.

Background

Study areas

Case study one: secondary watercourses in Tucson, AZ

The city of Tucson, AZ is located at the northeastern boundary of the Sonoran Desert, which reaches from southeastern California to southwestern Arizona, and south to the state of Sonora, Mexico. This study evaluated the suitability of trail development along smaller, secondary watercourses located throughout Tucson. These semi-natural spaces have become more valuable to city residents for a variety of recreational and urban wildlife uses (Rohde and Kindle, 1994). In addition, they are very accessible to urban dwellers and can effectively highlight some of the biological context of the region. It has been suggested that daily exposure to these types of areas can potentially aid in informing people about their role in conservation of nature (Noss, 2004). Pima County Parks and Recreation (PCPR) officials are responsible for planning buffer areas along many of these watercourses, and partnered with University of Arizona faculty and graduate students to investigate feasibility of future access points and trails along these areas. The study area was composed of thirteen secondary watercourses within Tucson's urban core, each with a water capacity greater than 2,000 cfs and less than 10,000 cfs. These corridors feed into three major watercourses surrounding central Tucson.

Case study two: greenway along the Patuxent River, Prince George's County, MD

Prince George's County, MD, is located in the upper coastal plain physiographic province. This case study research documents the process and products of a service learning studio. The Patuxent River Greenway is a proposed greenway in Prince George's County, MD which will eventually link high ecologically-valuable properties principally owned by the Maryland-National Capital Park & Planning Commission (MNCPPC). The proposed Patuxent River Greenway offers an opportunity to protect vegetation and potential wildlife habitat in these areas while providing appropriate human uses.

Goals

Our overarching goal of the paper emphasizes the similarities and differences in approaches used and contributions in each site, and this is the focus of the discussion and conclusion. Specific goals of these case studies included 1) researching and documenting site inventory, and 2) informing and creating envisioning design and planning products that could be used by public planning agencies (PCPR and MNCPPC). These are discussed in the following methods and results sections.

Methods

Arizona case study

Methods included field evaluation of eighth-mile segments of each watercourse studied and ranking of the corridors based on their suitability for access and trail development. Field data were collected and ranked for different wash attributes: watercourse composition, watercourse vegetation, walkability, path development, and connectivity (road crossing types and linkages).

Data categories:

1. Watercourse composition: a) bank treatment (natural/treated), b) streambed treatment (natural/treated), and c) upland vegetation (natural/graded)
2. Walkability: streambed surface (evenness, geology)
3. Path development: upland presence/absence of buffer available for paths
4. Connectivity: a) road crossings (types and frequency), b) underpass characteristics (height, rise), and c) links (alleys, drainageways, other watercourses)

Preliminary indices were generated to evaluate the accessibility and pedestrian experience categories for each wash within the study area.

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Accessibility index: ***2(path development) + (linkages) + (road crossings) + (streambed walkability)***, and
Pedestrian experience index: ***(bank treatment) + (streambed treatment) + (upland vegetation) + (native vegetation).***

Path development was given twice the weight compared to other values in the index, based on the importance of this characteristic for greenway success as emphasized by expert opinions. Underpass height was not included in the index, as it was determined to be uncertain if underpasses could be used for pedestrian crossings, given the liability concerns suggested by Pima County planners at this time. It was restricted to point data within GIS for small scale site analysis and for future use in trail design.

Prior to calculation of a final feasibility index (FFI), census data from Pima County, Arizona was used to determine washes with the greatest adjacent population density and therefore having greater potential for public use. The formula used to calculate the final index for trail feasibility was the following: ***2(population density) + (accessibility index) + (pedestrian experience index).***

The feasibility study identified Alamo Wash as a relatively high-ranking wash relative to public access, and further spatial data analysis was done for planning an urban greenway along this corridor. In addition, an extensive vegetation inventory was done to evaluate wash and upland plants along Alamo Wash, including neighboring planted areas, to reveal opportunities and constraints relative to habitat opportunities. Results from these analyses included a proposed trail route and design strategies for trail and habitat development along Alamo Wash.

Maryland case study

Initial methods included evaluation of GIS data supplied by the MNCPPC. The general approach to understand and envision the greenway was to divide the proposed greenway into eighteen greenway river areas. Each student was assigned a segment and the surrounding area. It was at this level that students conducted inventory, analysis, programming and composite analysis and ultimately envisioning ideas for the greenway. The ABC approach was adopted to document the abiotic, biotic and cultural inventory of each designated area (Ndubisi, et. al., 1995)

A class field trip allowed the students to better familiarize themselves with their individual areas. Students returned to the individual sites later to take photographs of their assigned areas to be used on their photo boards. The class held meetings with representatives from the MNCPPC to gather feedback on the way the project was progressing. Students looked at precedent greenway case studies from around the country and produced a case study graphic poster that included innovative features for ideas. Ideas and readings from relevant greenway literature was also introduced (e.g., Fabos and Ahern, 1995; Flink and Searns, 1993; Hellmund and Smith, 2006) at this time. The students were then asked to develop small ideas for their area and larger overall ideas for the entire greenway.

During the final two weeks before the project was to be formally presented, the students developed planning and design solutions boards for their respective area. Utilizing the inventory and analysis information, master plan and site-scale envisioning documents for each area were created. The master plans refined the original alignment of the trail and also proposed new secondary loops that supported interpretive integration. The site-scale proposals sought to integrate abiotic, biotic and cultural interpretive opportunities and constraints and the dominant programmatic needs of trail users.

Results

Arizona case study

The feasibility results indicated Alamo and Christmas Wash ranked highest in the final feasibility index. Alamo Wash was chosen for the design application portion of this project, as it will likely reach a greater number and variety of people due to its greater length (approx. 5 mi.) compared to Christmas Wash (approx. 1.5 mi.). This process included integration of spatial data with the collected attribute field data to determine trail routes along the Alamo Wash and application of design guidelines. A brief history and previous trail development plans and studies of the Alamo Wash were investigated to determine design implications for trail development. Further site inventory and analysis was done to aid in the planning and design phase of a trail such as defining areas where circulation and destination nodes could occur. Inventory of neighborhood character included analysis of existing neighborhood associations and demographic information for the determination of possible user groups. Design treatments included trailheads, signage and wayfinding, crossing strategies, and interpretive materials focusing on urban wildlife (Figures 1 and 2).

Figure 1. Vacant lot is transformed into a parking lot for easy trail access. Wayfinding elements and trailheads are included to welcome and orientate visitors (Jennifer Balsa).

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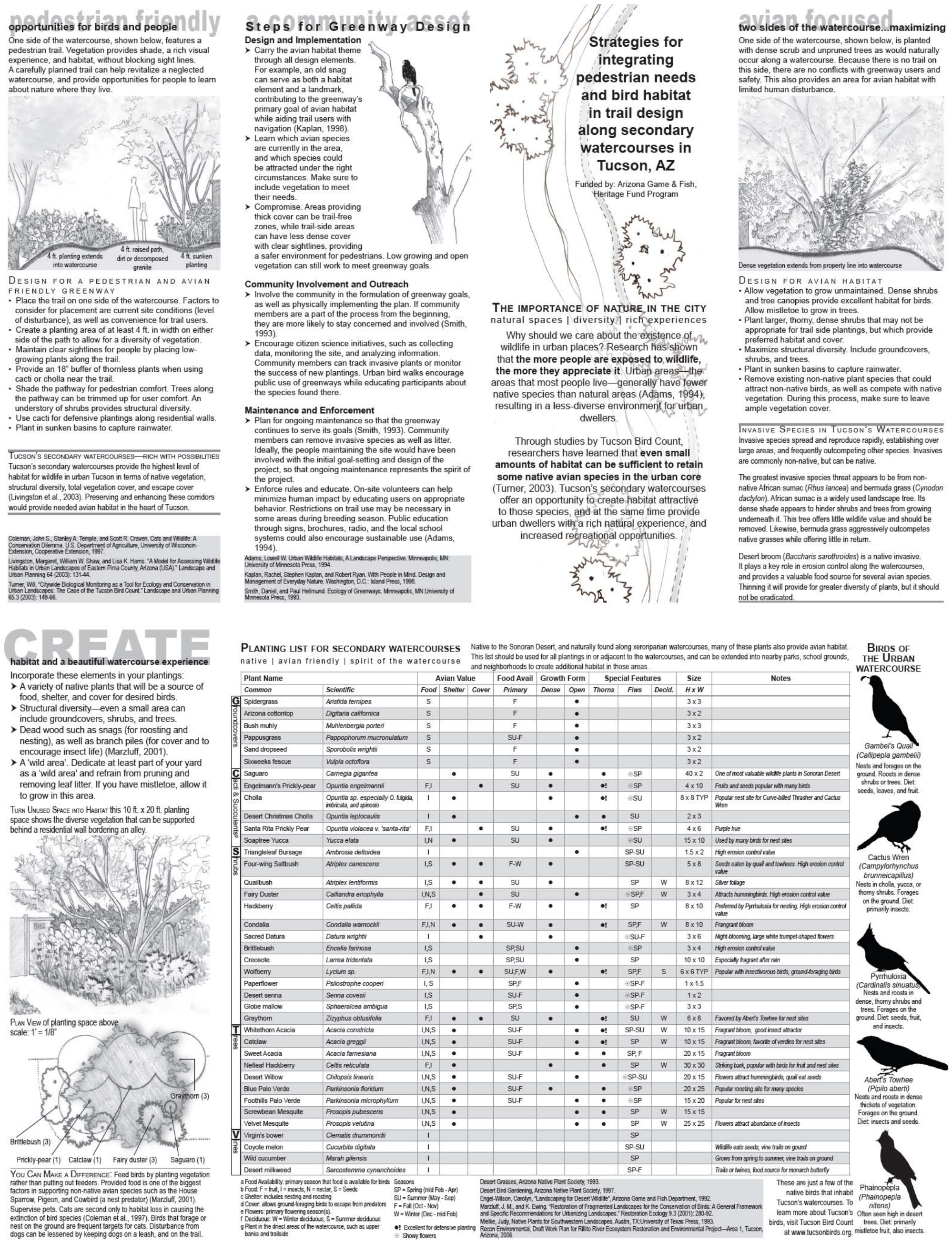


pedestrian friendly
opportunities for birds and people

One side of the watercourse, shown below, features a pedestrian trail. Vegetation provides shade, a rich visual experience, and habitat, without blocking sight lines. A carefully planned trail can help revitalize a neglected watercourse, and provide opportunities for people to learn about nature where they live.

4 ft. planting extends into watercourse | 4 ft. raised path, dirt or decomposed granite | 4 ft. sunken planting

DESIGN FOR A PEDESTRIAN AND AVIAN FRIENDLY GREENWAY
- Place the trail on one side of the watercourse. Factors to consider for placement are current site conditions (level of disturbance), as well as convenience for trail users.
- Create a planting area of at least 4 ft. in width on either side of the path to allow for a diversity of vegetation.
- Maintain clear sightlines for people by placing low-growing plants along the trail.
- Provide an 18" buffer of thornless plants when using cacti or cholla near the trail.
- Shade the pathway for pedestrian comfort. Trees along the pathway can be trimmed up for user comfort. An understory of shrubs provides structural diversity.
- Use cacti for defensive plantings along residential walls.
- Plant in sunken basins to capture rainwater.

TUCSON'S SECONDARY WATERCOURSES—RICH WITH POSSIBILITIES
Tucson's secondary watercourses provide the highest level of habitat for wildlife in urban Tucson in terms of native vegetation, structural diversity, total vegetation cover, and escape cover (Livingston et al., 2003). Preserving and enhancing these corridors would provide needed avian habitat in the heart of Tucson.

Coleman, John S., Stanley A. Temple, and Scott R. Craven. Cats and Wildlife: A Conservation Dilemma. U.S. Department of Agriculture, University of Wisconsin-Extension, Cooperative Extension, 1997.
Livingston, Margaret, William W. Shaw, and Lisa K. Harris. "A Model for Assessing Wildlife Habitats in Urban Landscapes of Eastern Pima County, Arizona (USA)." Landscape and Urban Planning 64 (2003): 131-44.
Turner, Will. "Citywide Biological Monitoring as a Tool for Ecology and Conservation in Urban Landscapes: The Case of the Tucson Bird Count." Landscape and Urban Planning 65.3 (2003): 149-66.

a community asset
Steps for Greenway Design

Design and Implementation
- Carry the avian habitat theme through all design elements. For example, an old snag can serve as both a habitat element and a landmark, contributing to the greenway's primary goal of avian habitat while aiding trail users with navigation (Kaplan, 1998).
- Learn which avian species are currently in the area, and which species could be attracted under the right circumstances. Make sure to include vegetation to meet their needs.
- Compromise. Areas providing thick cover can be trail-free zones, while trail-side areas can have less dense cover with clear sightlines, providing a safer environment for pedestrians. Low growing and open vegetation can still work to meet greenway goals.

Community Involvement and Outreach
- Involve the community in the formulation of greenway goals, as well as physically implementing the plan. If community members are a part of the process from the beginning, they are more likely to stay concerned and involved (Smith, 1993).
- Encourage citizen science initiatives, such as collecting data, monitoring the site, and analyzing information. Community members can track invasive plants or monitor the success of new plantings. Urban bird walks encourage public use of greenways while educating participants about the species found there.

Maintenance and Enforcement
- Plan for ongoing maintenance so that the greenway continues to serve its goals (Smith, 1993). Community members can remove invasive species as well as litter. Ideally, the people maintaining the site would have been involved with the initial goal-setting and design of the project, so that ongoing maintenance represents the spirit of the project.
- Enforce rules and educate. On-site volunteers can help minimize human impact by educating users on appropriate behavior. Restrictions on trail use may be necessary in some areas during breeding season. Public education through signs, brochures, radio, and the local school systems could also encourage sustainable use (Adams, 1994).

Adams, Lowell W. Urban Wildlife Habitats, A Landscape Perspective. Minneapolis, MN: University of Minnesota Press, 1994.
Kaplan, Rachel, Stephen Kaplan, and Robert Ryan. With People in Mind. Design and Management of Everyday Nature. Washington, D.C.: Island Press, 1998.
Smith, Daniel, and Paul Hellmund. Ecology of Greenways. Minneapolis, MN:University of Minnesota Press, 1993.

Strategies for integrating pedestrian needs and bird habitat in trail design along secondary watercourses in Tucson, AZ

Funded by: Arizona Game & Fish, Heritage Fund Program

THE IMPORTANCE OF NATURE IN THE CITY
natural spaces | diversity | rich experiences

Why should we care about the existence of wildlife in urban places? Research has shown that **the more people are exposed to wildlife, the more they appreciate it**. Urban areas—the areas that most people live—generally have fewer native species than natural areas (Adams, 1994), resulting in a less-diverse environment for urban dwellers.

Through studies by Tucson Bird Count, researchers have learned that **even small amounts of habitat can be sufficient to retain some native avian species in the urban core** (Turner, 2003). Tucson's secondary watercourses offer an opportunity to create habitat attractive to those species, and at the same time provide urban dwellers with a rich natural experience, and increased recreational opportunities.

avian focused
two sides of the watercourse...maximizing

One side of the watercourse, shown below, is planted with dense scrub and unpruned trees as would naturally occur along a watercourse. Because there is no trail on this side, there are no conflicts with greenway users and safety. This also provides an area for avian habitat with limited human disturbance.

Dense vegetation extends from property line into watercourse

DESIGN FOR AVIAN HABITAT
- Allow vegetation to grow unmaintained. Dense shrubs and tree canopies provide excellent habitat for birds. Allow mistletoe to grow in trees.
- Plant larger, thorny, dense shrubs that may not be appropriate for trail side plantings, but which provide preferred habitat and cover.
- Maximize structural diversity. Include groundcovers, shrubs, and trees.
- Plant in sunken basins to capture rainwater.
- Remove existing non-native plant species that could attract non-native birds, as well as compete with native vegetation. During this process, make sure to leave ample vegetation cover.

INVASIVE SPECIES IN TUCSON'S WATERCOURSES
Invasive species spread and reproduce rapidly, establishing over large areas, and frequently outcompeting other species. Invasives are commonly non-native, but can be native.

The greatest invasive species threat appears to be from non-native African sumac (*Rhus lancea*) and bermuda grass (*Cynodon dactylon*). African sumac is a widely used landscape tree. Its dense shade appears to hinder shrubs and trees from growing underneath it. This tree offers little wildlife value and should be removed. Likewise, bermuda grass aggressively outcompetes native grasses while offering little in return.

Desert broom (*Baccharis sarothroides*) is a native invasive. It plays a key role in erosion control along the watercourses, and provides a valuable food source for several avian species. Thinning it will provide for greater diversity of plants, but it should not be eradicated.

CREATE
habitat and a beautiful watercourse experience

Incorporate these elements in your plantings:
- A variety of native plants that will be a source of food, shelter, and cover for desired birds.
- Structural diversity—even a small area can include groundcovers, shrubs, and trees.
- Dead wood such as snags (for roosting and nesting), as well as branch piles (for cover and to encourage insect life) (Marzluff, 2001).
- A 'wild area'. Dedicate at least part of your yard as a 'wild area' and refrain from pruning and removing leaf litter. If you have mistletoe, allow it to grow in this area.

TURN UNUSED SPACE INTO HABITAT this 10 ft. x 20 ft. planting space shows the diverse vegetation that can be supported behind a residential wall bordering an alley.

PLAN VIEW of planting space above
scale: 1' = 1/8"

Graythorn (3) | Brittlebush (3) | Prickly-pear (1) | Catclaw (1) | Fairy duster (3) | Saguaro (1)

YOU CAN MAKE A DIFFERENCE: Feed birds by planting vegetation rather than putting out feeders. Provided food is one of the biggest factors in supporting non-native avian species such as the House Sparrow, Pigeon, and Cowbird (a nest predator) (Marzluff, 2001). Supervise pets. Cats are second only to habitat loss in causing the extinction of bird species (Coleman et al., 1997). Birds that forage or nest on the ground are frequent targets for cats. Disturbance from dogs can be lessened by keeping dogs on a leash, and on the trail.

PLANTING LIST FOR SECONDARY WATERCOURSES
native | avian friendly | spirit of the watercourse

Native to the Sonoran Desert, and naturally found along xeroriparian watercourses, many of these plants also provide avian habitat. This list should be used for all plantings in or adjacent to the watercourses, and can be extended into nearby parks, school grounds, and neighborhoods to create additional habitat in those areas.

	Plant Name		Avian Value			Food Avail	Growth Form		Special Features			Size	Notes
	Common	Scientific	Food	Shelter	Cover	Primary	Dense	Open	Thorns	Flws	Decid.	H x W	
Groundcovers	Spidergrass	*Aristida ternipes*	S			F		●				3 x 3	
	Arizona cottontop	*Digitaria californica*	S			F		●				3 x 2	
	Bush muhly	*Muhlenbergia porteri*	S			F		●				3 x 3	
	Pappusgrass	*Pappophorum mucronulatum*	S			SU-F		●				3 x 2	
	Sand dropseed	*Sporobolis wrightii*	S			F		●				3 x 2	
	Sixweeks fescue	*Vulpia octoflora*	S			F		●				3 x 2	
Cacti & Succulents	Saguaro	*Carnegia gigantea*		●		SU	●		●	⊛SP		40 x 2	*One of most valuable wildlife plants in Sonoran Desert*
	Engelmann's Prickly-pear	*Opuntia engelmannii*	F,I		●	SU	●		●!	⊛SP		4 x 10	*Fruits and seeds popular with many birds*
	Cholla	*Opuntia sp. especially O. fulgida, imbricata, and spinosio*	I	●			●		●!	⊛SU		8 x 8 TYP	*Popular nest site for Curve-billed Thrasher and Cactus Wren*
	Desert Christmas Cholla	*Opuntia leptocaulis*	I	●				●	●	SU		2 x 3	
	Santa Rita Prickly Pear	*Opuntia violacea v. 'santa-rita'*	F,I		●	SU	●		●!	⊛SP		4 x 6	*Purple hue*
	Soaptree Yucca	*Yucca elata*	I,N	●		SU	●			⊛SU		15 x 10	*Used by many birds for nest sites*
Shrubs	Triangleleaf Bursage	*Ambrosia deltoidea*	I					●		SP-SU		1.5 x 2	*High erosion control value*
	Four-wing Saltbush	*Atriplex canescens*	I,S	●	●	F-W	●			SP-SU		5 x 8	*Seeds eaten by quail and towhees. High erosion control value*
	Quailbush	*Atriplex lentiformis*	I,S	●	●	SU	●			SP	W	8 x 12	*Silver foliage*
	Fairy Duster	*Calliandra eriophylla*	I,N,S		●	SU		●		⊛SP,F	W	3 x 4	*Attracts hummingbirds. High erosion control value*
	Hackberry	*Celtis pallida*	F,I	●	●	F-W	●		●!	SP		8 x 10	*Preferred by Pyrrhuloxia for nesting. High erosion control value*
	Condalia	*Condalia warnockii*	F,I,N	●	●	SU-W	●		●!	SP,F	W	8 x 10	*Frangrant bloom*
	Sacred Datura	*Datura wrightii*	I		●		●			⊛SU-F		3 x 6	*Night-blooming, large white trumpet-shaped flowers*
	Brittlebush	*Encelia farinosa*	I,S			SP,SU		●		⊛SP		3 x 4	*High erosion control value*
	Creosote	*Larrea tridentata*	I,S			SP,SU		●		SP		10 x 10	*Especially fragrant after rain*
	Wolfberry	*Lycium sp.*	F,I,N	●	●	SU,F,W	●		●!	SP,F	S	6 x 6 TYP	*Popular with insectivorous birds, ground-foraging birds*
	Paperflower	*Psilostrophe cooperi*	I, S			SP,F		●		⊛SP-F		1 x 1.5	
	Desert senna	*Senna covesii*	I,S			SU-F		●		⊛SP-F		1 x 2	
	Globe mallow	*Sphaeralcea ambigua*	I,S			SP,S		●		⊛SP-F		3 x 3	
	Graythorn	*Zizyphus obtusifolia*	F,I	●	●	SU	●		●!	SU	W	6 x 8	*Favored by Abert's Towhee for nest sites*
Trees	Whitethorn Acacia	*Acacia constricta*	I,N,S	●		SU-F		●	●!	SP-SU	W	10 x 15	*Fragrant bloom, good insect attractor*
	Catclaw	*Acacia greggii*	I,N,S	●		SU-F		●	●!	SP	W	10 x 15	*Fragrant bloom, favorite of verdins for nest sites*
	Sweet Acacia	*Acacia farnesiana*	I,N,S	●		SU-F		●	●	SP, F		20 x 15	*Fragrant bloom*
	Netleaf Hackberry	*Celtis reticulata*	F,I	●			●		●	SP	W	30 x 30	*Striking bark, popular with birds for fruit and nest sites*
	Desert Willow	*Chilopsis linearis*	I,N,S	●		SU-F		●		⊛SP-SU		20 x 15	*Flowers attract hummingbirds, quail eat seeds*
	Blue Palo Verde	*Parkinsonia floridum*	I,N,S	●		SU-F	●		●	⊛SP		20 x 25	*Popular roosting site for many species*
	Foothills Palo Verde	*Parkinsonia microphyllum*	I,N,S	●		SU-F		●	●	⊛SP		15 x 20	*Popular for nest sites*
	Screwbean Mesquite	*Prosopis pubescens*	I,N,S	●				●	●	SP	W	15 x 15	
	Velvet Mesquite	*Prosopis velutina*	I,N,S	●				●	●	SP	W	25 x 25	*Flowers attract abundance of insects*
Vines	Virgin's bower	*Clematis drummondii*	I							SP			
	Coyote melon	*Cucurbita digitata*	I							SP-SU			*Wildlife eats seeds, vine trails on gound*
	Wild cucumber	*Marah gilensis*	I							SP			*Grows from spring to summer, vine trails on ground*
	Desert milkweed	*Sarcostemma cynanchoides*	I							SP-F			*Trails or twines, food source for monarch butterfly*

a Food Availability: primary season that food is available for birds
b Food: F = fruit, I = insects, N = nectar, S = Seeds
c Shelter: includes nesting and roosting
d Cover: allows ground-foraging birds to escape from predators
e Flowers: primary flowering season(s).
f Deciduous: W = Winter deciduous, S = Summer deciduous
g Plant in the driest areas of the watercourse, such as upper banks and trailside

Seasons
SP = Spring (mid Feb - Apr)
SU = Summer (May - Sep)
F = Fall (Oct - Nov)
W = Winter (Dec - mid Feb)

●! Excellent for defensive planting
⊛ Showy flowers

Desert Grasses, Arizona Native Plant Society, 1993.
Desert Bird Gardening, Arizona Native Plant Society, 1997.
Engel-Wilson, Carolyn, "Landscaping for Desert Wildlife", Arizona Game and Fish Department, 1992.
Marzluff, J. M., and K. Ewing. "Restoration of Fragmented Landscapes for the Conservation of Birds: A General Framework and Specific Recommendations for Urbanizing Landscapes." Restoration Ecology 9.3 (2001): 280-92.
Mielke, Judy, Native Plants for Southwestern Landscapes. Austin, TX:University of Texas Press, 1993.
Recon Environmental, Draft Work Plan for Rillito River Ecosystem Restoration and Environmental Project—Area 1, Tucson, Arizona, 2006.

These are just a few of the native birds that inhabit Tucson's watercourses. To learn more about Tucson's birds, visit Tucson Bird Count at www.tucsonbirds.org.

BIRDS OF THE URBAN WATERCOURSE

Gambel's Quail (*Callipepla gambelii*) Nests and forages on the ground. Roosts in dense shrubs or trees. Diet: seeds, leaves, and fruit.

Cactus Wren (*Campylorhynchus brunneicapillus*) Nests in cholla, yucca, or thorny shrubs. Forages on the ground. Diet: primarily insects.

Pyrrhuloxia (*Cardinalis sinuatus*) Nests and roosts in dense, thorny shrubs and trees. Forages on the ground. Diet: seeds, fruit, and insects.

Abert's Towhee (*Pipilo aberti*) Nests and roosts in dense thickets of vegetation. Forages on the ground. Diet: insects and seeds.

Phainopepla (*Phainopepla nitens*) Often seen high in desert trees. Diet: primarily mistletoe fruit, also insects.

Figure 2. An educational pamphlet (front and back page) was developed for neighborhoods focusing on use of secondary watercourses as habitat and wildlife viewing opportunities (Jennifer Patton).

Maryland case study

The location of existing park land and slope (Figure 3a) were the dominate criteria that guided the alignment of both short term and longer term trail systems in the

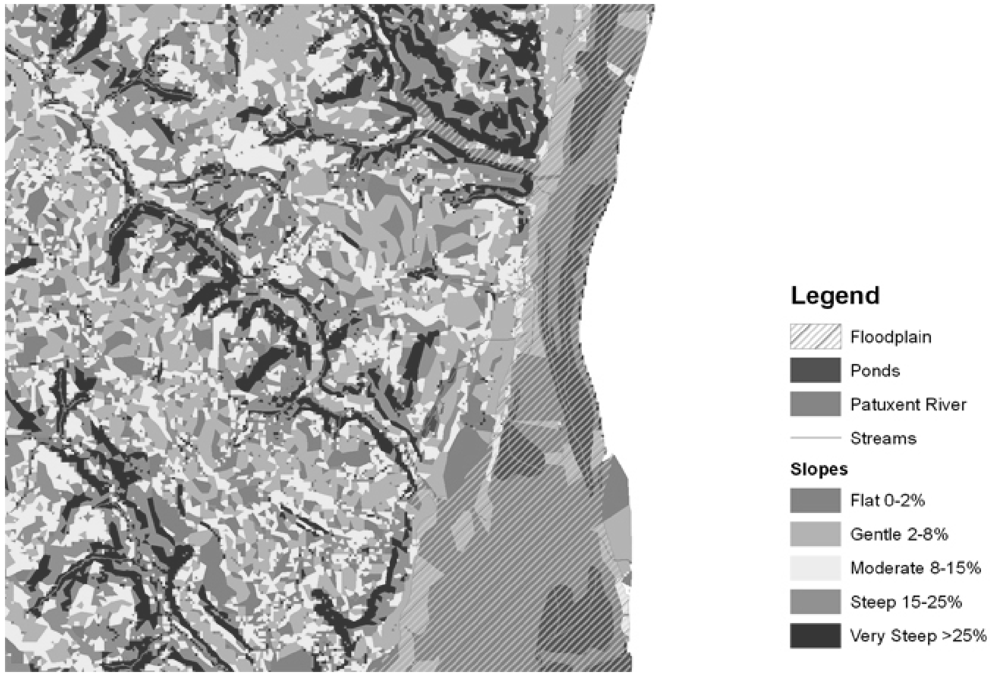
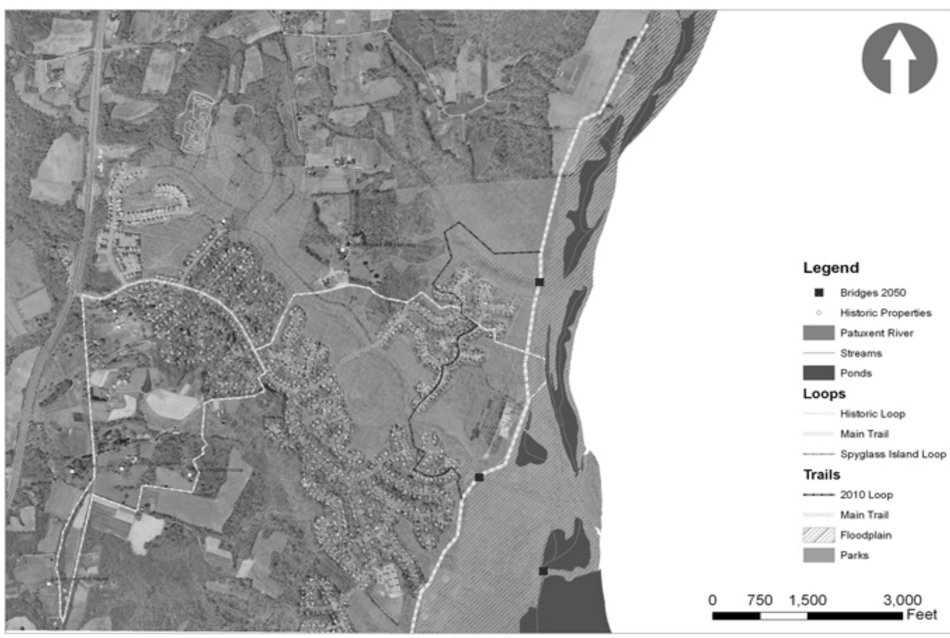


Figure 3a and 3b. Figure 3a (left illustration) is a typical plan (of eighteen) indicating significant abiotic elements (e.g., slopes, floodplains, and waterbodies).



Master Plan of 2010 and 2050 Trail

Figure 3b (right illustration) is a typical master plan (of eighteen) indicating proposed 2010 trail alignment and proposed 2050 trail system alignment and amenities, including focus areas, in the region (Lauren Kovach).

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resultant master plans (Figure 3b) and focus areas (Figure 4). While this process used GIS information for opportunities and constraints for trail alignment in all eighteen master plans, students did not execute them in the same manner as the other case study. A more explicit suitability model of each of the alignments would have provided a more accurate feasibility as to the degree that slopes was used in alignment and the percentage that the proposed trails were located in existing park lands. Like the first case study, further site inventory and analysis of primary cultural attributes was done to aid in the planning and design phase of a trail such as defining areas where circulation and destination nodes could occur. Inventory of neighborhood character included analysis of existing neighborhood associations and demographic information for the determination of possible user groups. Design focus areas included both water based focus amenities (e.g. canoe launch, water interpretative center, etc.) and non water based focus amenities (e.g. farm museum, airport memorial, etc.). These reflected the specific opportunities and capabilities of the site area (Figures 3b and 4).

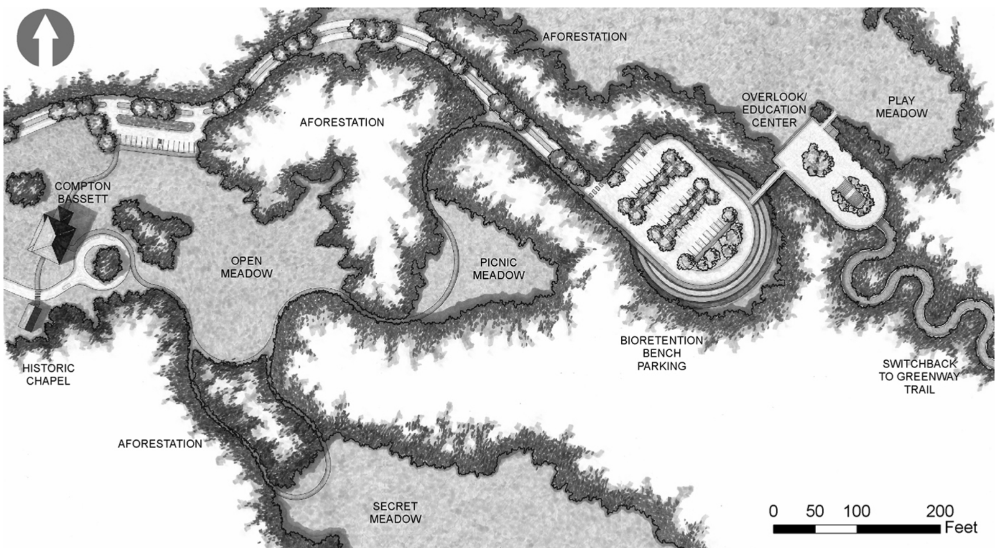

Figure 4. One example of a focus area for the proposed Patuxent River Greenway. This historic oriented proposal also includes reforestation, access to the river and parking as well as secondary trail systems to accommodate mutliple user types (John Lightle).

Discussion and conclusion

Comparison of these case studies demonstrated some of the limitations experienced when evaluating greenways for green infrastructure development. For example, the first case study had minimal existing data to work with to determine suitability of greenway trails, and a majority of the study work focused on creating data layers for analysis at this scale. The second case study had significantly more existing data which allowed for more site-specific information as the focus of the results. Regional limitations of the greenways may partially explain these differences; arid

cities such as Tucson are relatively recent in their interest in integrating trail systems along smaller, ephemeral watercourses where stormwater drainage is historically the primary function of these corridors. It can sometimes be difficult for city residents and officials to recognize these areas as valuable corridors for recreational use as well as wildlife opportunities (linkages) compared to greenways in more temperate areas where these corridors tend to have more year-round flows. In addition, the design focus may slightly vary among the regions; in Maryland, emphasis is predominantly on streams and the open-bodied waters that are often the primary focus areas and primarily determine the alignment of the trail and short boardwalk sections. In arid areas, design focus is often related to enhancing connections to surrounding amenities and urban pedestrian and bike paths and to highlighting wildlife viewing opportunities, particularly urban birds (as highlighted in Figure 2). Typically, these dry streambed corridors attract walkers, runners, wildlife watchers, and bicyclists, perhaps a narrower user group than those corridors in temperate areas. In terms of similarities among the research, the case studies share the issue of determining where related elements can be integrated into existing city and suburban sites, retrofitting the design into the urban and suburban matrix. Finally, lessons learned from the comparison, regardless of region, are that the tools of investigation have been developed thoroughly enough to effectively enable students to assess trail suitability in a more explicit manner (i.e. a explicit suitability or constraint model). Such tools allow them to explore the use of ground-truthing and GIS analysis for suitability assessment of greenways under a variety of conditions. Furthermore, these student-based outcomes have provided a valuable foundation for development of greenways in urban and suburban areas where funding for these projects can be limited.

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