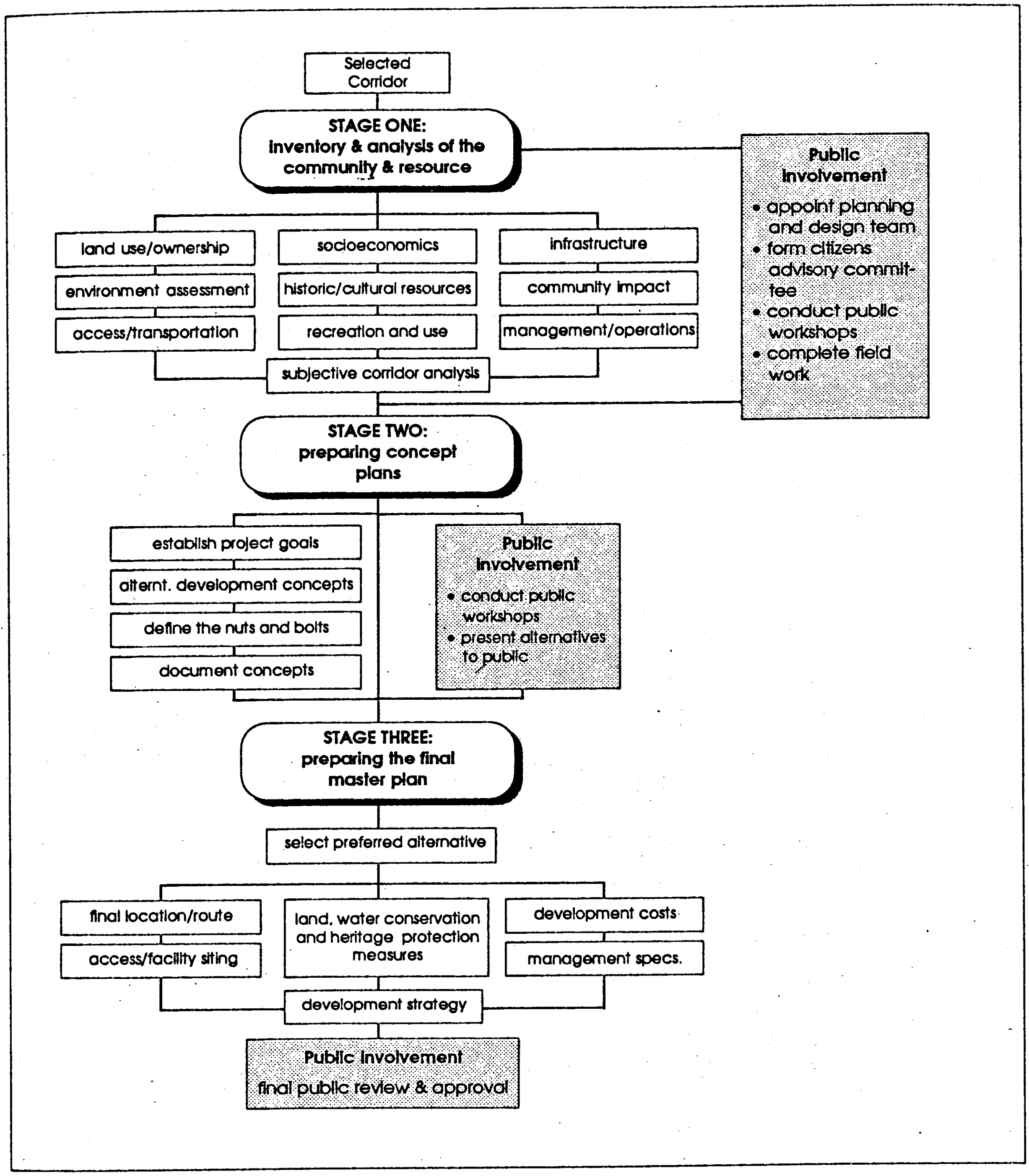


Figure 2-1 The greenway planning process.

Determining Who Should Be Involved

Even if a group of local citizens and agency personnel developed the plan, the time comes when more diverse input is needed. Who are the people who need to be involved? Why? What do you need from them? What are you prepared to offer them? How long should they remain

Staff Report

Philip J. Prete
Town of Carrboro
Planning Department
Phone 919-918-7326

Greenways: Environmental Issues

Background:

Greenways are areas of open space that are generally linear in nature and can be located along stream or river corridors or used to surround and/or connect community features. Greenways provide excellent chances to create recreational opportunities, and protect natural resources even in close proximity to highly developed urban and suburban areas. Similarly, water quality buffers tend to be linear in nature; they are areas of natural or planted vegetation along streams, rivers, lakes, or wetlands through which stormwater flows in a diffuse manner so that runoff does not become channelized and so that infiltration of the runoff and filtering of pollutants is possible. Vegetated buffers play a vital role in protecting water quality by reducing erosion and by trapping nutrients and preventing them from entering waterways and wetland areas. Greenways and riparian buffers can be used in conjunction to protect water quality by creating a vegetated corridor along surface waters. "Greenways can be an effective, attractive, and useful means of protecting water quality and enhancing the aesthetic and recreational amenities of a community."[1] This report addresses the environmental considerations of multiple functions of a greenway as a buffer, landscape corridor for wildlife, and transportation / recreation corridor.

Policy Background

EXCERPTS FROM THE CARRBORO VISION 2020

2.1 Avoidance of Adverse Effects on Public Health and Safety

2.11 The town should limit development in sensitive areas such as the watershed, wetlands, and other areas the development of which could adversely affect water supplies and habitat. The town's restrictions on development within the University Lake Watershed should be retained and enforced.

2.2 Preservation of the Natural Environment

2.21 The Town should continue to require the preservation and maintenance of open space when land is developed, to enforce restraints on clear-cutting, and to require adequate buffers.

2.22 Where development is deemed acceptable, there should be well-defined dense development with areas of well-preserved open space.

[1] "Greenways and Stream Buffers" in *STREAMLINES* Volume 3, Number 1, March 1998

5.30 Open Space, Greenways, and Natural Areas

5.31 Carrboro should work to preserve open space and greenways through all available means, such as direct purchase, conservation easements, donations, and federal and state grants.

5.32 The town should map a connected series of greenways that are large enough to serve as wildlife corridors.

EXCERPT FROM: THE CARRBORO SMALL AREA PLAN

*****

Natural areas along the Bolin Creek Basin, in the Meadow Flats area, and in other areas will either be preserved, or strictly limit forms of development subject to performance standards described in a Conservation Area policy. For a review of sensitive environmental areas identified in the Study Area, refer to the Environmental Constraints Map in Section 2.

*****

The Town in its review of the Horace Williams Tract supports the designation of Bolin Creek, its flood plain, adjacent steep slopes, and associated hardwood areas as "Non-Buildable Areas." The northwest corner of the Horace Williams Tract is particularly well suited for preservation since it is one of the few remaining stands of hardwood forest in the Chapel Hill-Carrboro area. The Town continues with its earlier position that the northwest corner be redesignated as "Non-Buildable" and included as a part of the Bolin Creek Natural Area Corridor. Additional issues associated with the Bolin Creek Corridor that warrant further discussion include public access, appropriate types of Bike/Pedestrian facilities, and systematic linkages with public places such as parks, schools and related facilities. To advance the discussion of these issues the Town of Carrboro has proposed a process to plan for the preservation of the Bolin Creek corridor and for the potential use of this area as a natural area

FROM THE SMALL AREA PLANNING WORK GROUP

The following concepts represent the Small Area Planning Work Group's proposal as revised through the facilitated planning conference process:

Conservation of Natural and Environmentally Sensitive Areas

The issue of appropriate buffer widths along streams, creeks, and lakes involves many variables depending on the characteristics of the particular water corridor.

In addition to providing access to pedestrians and cyclists, linear open space corridors may be designed to filter storm water run-off from adjacent development. These corridors often function as traps for pollutants and nutrients. Phosphorus and nitrogen were reduced by 80 and 89 percent respectively by a forested buffer 165-feet deep. (Correll and Peterjohn, 1984) Leaf litter and ground cover can also slow down storm run-off, thereby reducing soil erosion and stream sedimentation. The minimum width for water quality buffering depends on factors such as soil permeability, steepness of the slope, and the amount and type of plant material.

Wider corridors are generally needed for wildlife habitat. The value of providing buffers for wildlife and water quality concerns has been well demonstrated. However, width requirements range dramatically depending on their purposes. Many variables should be considered and flexibility should be applied when determining the optimal corridor widths. A conservation overlay zone could be established that would base the establishment of the appropriate widths of stream and open space corridors on the consideration of site-specific conditions.

GOAL 3. ***CONSERVATION OF NATURAL AND ENVIRONMENTALLY SENSITIVE AREAS, AND THE PROTECTION OF ENVIRONMENTAL QUALITY.***

OBJECTIVES:

3.A. Use conservation overlay zone standards to determine appropriate streamway buffer widths for new development.

3.B. Prohibit development of natural and environmentally sensitive areas through the creation of a resource conservation district or open space conservation district.

3.C. Identify strategies for various types of acquisition or dedication that would protect important natural areas, including Bolin Creek.

3.D. Mitigate potential impacts of development on streams and creeks. (e.g. erosion, sedimentation, pollution)

PERTINENT RECOMMENDATIONS FROM LANDSCAPE WITH WILDLIFE IN ORANGE COUNTY (TRIANGLE LAND CONSERVANCY)

- **PRESERVE AND REHABILITATE FORESTS** flanking streams and rivers
- **PRESERVE AND REHABILITATE MIXED OR PINE FOREST** in overland corridors that connect otherwise isolated patches of hardwoods.

EXCERPT FROM ORANGE COUNTY LANDS LEGACY PROGRAM:

Develop a map and plan for a pilot project trail (paved greenways in urban settings, rustic woodland trails in rural areas) linking Chapel Hill and/or Carrboro Town parks, less-sensitive areas of Duke Forest, future County parks and Eno River State Park.

Greenway – Multiple Objectives:

Any given part of the landscape affects other parts. When designing a greenway, it is important to consider what impact it will have on natural processes. Greenways, like natural environmental corridors can provide the following basic functions:

1. Protecting and enhancing existing riparian buffers, and maintaining riparian function as a filter for water and a sink for sediments, toxins, and nutrients;
2. Providing habitat and corridors for plant and animal communities, and as a source for animals or seeds to migrate to other parts of the landscape;
3. Developing conservation areas and fostering natural area and stream stewardship;
4. Providing a pedestrian, bicycle, and recreation corridors.

5-4

Buffer Function of Greenway:

Stream Quality Value of Riparian Zone:

- Provide opportunity for dispersion and infiltration to favor subsurface over overland flow.
- Maximize sediment stripping by maximizing infiltration rates.
- Removal of nutrients by subsurface flow – phosphorous sequestered with trapped sediment and nitrogen reduction via denitrification.
- Root structure helps to maintain soil strength and channel stability, and prevent channel erosion.
- Trees provide fine organic matter (leaf litter) and coarse woody matter as food substrate for heterotrophic organisms and provide structure and habitat for benthic and fish populations.
- Tree cover moderates stream water temperature.

There are several ways to make the water quality protection aspect of greenways more effective[2]:

- Make greenways continuous along the river or stream.
- Locate greenways on both sides of the river or stream, if possible.
- Include the river's flood plain, riparian forest, associated wetlands, intermittent tributaries, gullies, and swales in the greenway.
- Establish width of undisturbed buffers based on how much sediment load is entering the riparian zone and how much it will need to filter.
- Make greenway widths site-specific as opposed to jurisdiction-specific. Greenways which neighbor intensive land uses such as clearcutting, dense residential development, or shopping malls should be wide enough to absorb excess nutrients and toxins.
- Maintain or re-plant a band of natural vegetation along the stream bank to protect against temperature increases and improve habitat.
- Avoid mowing streamside vegetation because it may decrease filtering effectiveness.

Wildlife Corridor Function of a Greenway:

A wildlife corridor is a protected avenue along which a wide variety of animals can travel, plants can propagate, genetic interchange can occur, and populations can move in response to development pressures and environmental changes[3]. The avenue consists of rows of trees, fruit bearing shrubs, and herbaceous plantings - alone or in combination - which provide food and

---

[2] Ibid
[3] "WILDLIFE CORRIDOR DEVELOPMENT," NOV 1997, CONSERVATION MANAGEMENT SHEET BIOLOGY SERIES 645-1, Natural Resources Conservation Service, Michigan

secure cover for wildlife. Corridor development is most beneficial in areas where habitats are fragmented. Corridors should be located in a manner that will connect two or more areas of wildlife habitat across areas in which the habitat is missing. These habitat areas include woodland, old field, wetlands, or grassland types. Buffers around, and connections between core large forested and natural areas are important to prevent fragmentation and edginess of forests. Agricultural areas where fencerows have been removed or narrowed may be opportunities for corridor development. "Forested river corridors are particularly important."[4]

Considerations for Wildlife Corridor Design

Creating wildlife corridors is not the ultimate solution to slowing loss of habitat, but it is an important step in the right direction. However, corridors will offer little real protection if they are too small to provide enough habitat or genetic diversity for species to successfully adapt to a constantly changing world.[5] The suggested minimum corridor width is 60 to 200 feet.

At the largest scale, Wildlife Corridors must be wide enough to allow easy movement for the largest mammals in the region. However, Wildlife Corridors can serve at smaller scales to provide habitat connectivity for other species, including amphibians, fish, and birds. They are particularly beneficial along riparian corridors, where they can provide both aquatic and terrestrial connectivity. In urban areas, they can provide important linkages in a highly fragmented landscape. Whenever possible, urban, and rural parks and open spaces should be linked to form functional wildlife corridors, which can then be ultimately joined to outlying core habitat reserves.

Proper corridor design is essential and may require re-establishment of trees, shrubs, and herbaceous vegetation. When re-vegetating, select plant composition to replicate the habitats being connected. For example, if two hardwood woodlots are being connected, use hardwood trees in the corridor. Native plant species should be selected that are adapted to the soil and site conditions. A combination of appropriate deciduous trees, conifers, fruit bearing shrubs, and herbaceous plants including grasses, forbs, and wildflowers is preferred.

The plantings provide important food and cover for many species of wildlife. Consider both "travelers" and corridor "dwellers" when designing the wildlife corridor. Travelers include the species that will be moving along the corridor, including deer, turkeys, fox, raccoons, birds, etc. Corridor dwellers include insects, amphibians reptiles and small mammals such as mice and voles, which extract all life requirements from within the corridor. Conifers provide year around, low growing protective cover, and dense wind, snow and sight breaks. Fruit bearing shrubs provide cover as well as high quality fall and winter food sources for many species of wildlife, especially birds. Herbaceous plantings provides cover, food for grazers and important areas for insect production.

Maintenance

Weed control will be required for 2-3 years following the planting of seedlings. Undesirable species that become established should be trimmed back and removed on an established schedule. Developers should be required to do site inventories and prepare approved maintenance plans and schedules for any segment of greenway to be maintained in private ownership.

---

[4] Luddington, Livy, Steve Hall, and Haven Wiley, "A Landscape with Wildlife for Orange County." 1997, Triangle Land Conservancy.

[5] "Wildlife corridors give species breathing room," David Suzuki, Environmental News Network, October 19, 2001

Greenway Trail Design Considerations:

Trails are paths used for walking, bicycling, horseback riding, or other forms of recreation or transportation. The size, cross section, and surface of the trail should be designed based on the planned use.

Some conflict in purposes exists between greenway development as recreation area, versus transportation corridor, versus nature preservation, versus riparian buffer. For example, the most important factors for most pedestrian users are having enough room and having a smooth, regular surface. From an environmental standpoint, the most important factors are minimizing the width, minimizing disturbance, and maximizing perviousness of the surface. These competing design considerations should be recognized, and optimized in planning and design on a segment specific basis according to intended and best use for that segment.

Size:

The trail should be designed to minimize the footprint, and hence the impact on the stream corridor while providing for safe passage for users. The width of a greenway trail depends on the types of users that will be permitted access to the trail, the potential for conflict between users, environmental sensitivity, and the cost of trail construction[6]. Based on volume use, the recommended widths for urban trails is as follows:

- **Main trunk: Pedestrian/non-motorized transport: 8-12 feet**
- **Pedestrian only (two-way travel): 5- 8 feet**
- **Nature trails / stream side trails: 5 feet**

Distance from Stream:

Trails can have disruptive effects on stream corridors due to a number of factors. Construction activities on a trail too close to a stream can degrade the buffer or floodplain, can release sediment into the stream, and can promote future erosion. Impervious surfaces place within the buffer can result in loss of buffer function. Pedestrian and bike traffic can deter use by wildlife of a streamside corridor. Based on these considerations, trails should be placed as far outside the buffer as practical, but the following minimum guidelines[7] are useful:

- **Main trunk: Pedestrian/non-motorized transport: outside flood plain, minimum 60 feet from stream bank where feasible**
- **Pedestrian only (two-way travel): 30 to 60 feet from stream bank**
- **Nature trails / stream side trails: 15 – 30 feet from stream bank**

Surface:

The July, 1998 issue of the Colorado State Trails News reported that ".... one of the persistent debates in the trails world concerns selecting the best type of paving to use for trails."

The choice of material for the trail surface will depend on intensity and type of use, impacts on the environment, user preference, and cost constraints. A list of possible trail surface types would include,

[6] Forsyth County: The Expanded Greenway System

[7] Ibid

5-7

but not be limited to, asphalt, concrete, wood, soil hardeners, gravel, limestone, crusher fines, sand, wood chips or bark, brick or masonry, cobblestone and grass. Use of trails by roller-bladers, cyclists, handicapped users, and parents pushing baby strollers is increasing and a majority of these users generally require or prefer the smooth, joint-free travel that asphalt provides.

Construction cost of an asphalt trial is significantly less than a concrete trail. The cost for a 10 ft. wide concrete trail is approximately $35 per linear foot versus $20 per linear foot for a comparable asphalt path. An 11 mile Umstead Park Trail is being re-surfaced with "a more foot-, hoof- and tire-friendly surface" of finely screened and rolled gravel at a cost of $803,100, which comes out to about $13.80 per linear foot (for a ___ foot-wide trail).

TRAIL DESIGN CONSIDERATIONS - SUMMARY

Type Trail	*Exclusive use*	*Trail width*	*Trail surface*	*Distance from Stream*
Main trunk	**Pedestrian/non-motorized transport**	**8 - 12 feet**	Porous asphalt or rolled, finely screened gravel	**Minimum 60 to 200 feet from stream bank**
Pedestrian only	**Two-way walking travel**	**5 - 8 feet**	Rolled, finely screened gravel	**30 to 60 feet**
Nature trails / stream-side trails	**Light foot traffic – <u>no bikes</u>**	**5 feet**	Wood chips or natural soils with minimal grading or disturbance	**15 – 30 feet**

Undisturbed, forested buffers are necessary for proper functioning of the buffer. The vegetated buffer or greenway protects the stream from pollutants transported in urban stormwater runoff. Unpaved paths could be allowed in the buffer; however, paved pathways should be located outside the vegetated buffer area.

<u>ATTACHMENTS:</u>

1) EXCERPTS FROM: June 25, 2002 James City County, Virginia Greenway Master Plan
<u>http://www.james-city.va.us/pdf/greenway/section9.pdf</u>

2) Natural Resources Conservation Service Planning and Design Principles

EXCERPTS FROM: June 25, 2002 James City County, Virginia Greenway Master Plan

http://www.james-city.va.us/pdf/greenway/section9.pdf

Trail Width Standards

Pedestrian AASHTO76 Multiuse bike & pedestrian
Wilderness trails 2-6' n/a 6-8'
Interpretive trails 7' n/a 8-10'
Rural trails 4-8' 8' 8-10'**
Suburban trails 6-10' 12' 10-12'
Urban trails 8-14' 14-16'* 12-14'

(* 16' width is a VDOT recommendation; 10' for bikes and 3' pedestrian shoulders)
(** While a 10' minimum width is preferred, Virginia Outdoor Plan recommends 12', p.320)
(Note: The following standards are general and require width modifications if the number of users increase beyond safety tolerances.)

Corridor Width Standards
Several trail elements influence the width of a corridor: the trail width design, safety clearances, grading and drainage, shoulder amenities and rest areas, site furnishings, signage, and visual aesthetics. Buffers may also be added to the corridor width to buffer off-site factors such as environmentally sensitive areas, residential or commercial developments, roadways, or to help separate multiple trails within the same corridor. Undulating terrain and steep topography will influence the corridor width significantly. For example, an 8' wide trail located on 15% slopes will require a corridor width of 22.28' for trailside grading to create a level trail with a 2' drainage channel and 3:1 side slopes. The same trail on 25% side slopes requires 28.28' of trailside grading. Additional corridor width should be planned if other trail elements are factored into the trail design, such as buffers.

Some jurisdictions establish a consistent policy on corridor widths that vary between 50', 75', and 100'. In much the same way a two-lane roadway, 22' wide requires a right-of-way (corridor) width of 50-90'; an 8-12' trail requires a corridor width of 35-100' (depending on the type of trail surface elements, such as buffers, that are included in the design). In general, a 50-foot corridor is sufficient for most trail systems, except where neighboring residential areas need additional buffering or where environmental constraints (steep slopes and wetlands) make trail development difficult. The actual width should be determined in the preliminary design phase.
9.1.c Trail Cross-Sections and Clear Zones

In addition to the trail surface width, the trail corridor must include 2-foot shoulders and 2-4' clear zone widths of on each side for safety. In most cases, 2-foot shoulders can be incorporated as part of the clear zone alongside trails. These shoulders should be soft surface and graded at 2-3% for drainage. For example, a 6' wide hiking trail should employ 2-4' clear zones on each side creating a corridor 10-14' wide. If bikes are included as an approved use, the clear zone must be 4' minimum to help reduce user conflicts and trailside impacts. Clear zones must be free of trees, shrubs, signposts, utility poles, sharp objects, benches, trashcans, or any other obstruction that creates a visual obstruction, tripping hazard or potential injury. Clear zones enhance the public perception of a safe trail corridor.

Trail Surface Materials

The type of surface material also plays a factor in trail width design. If a natural surface is proposed, high use may increase user conflicts and/or cause rutting to occur forcing trail users to migrate off the approved trail creating un-programmed trails. This action might require changing the alignment to reroute the trail or create costly repairs to the damaged trail. Ruts on trails increase ponding, subsidence, and erosion. As soil materials diminish over time, tree roots become exposed creating increased tripping hazards. These issues must be factored into the long-range management plan for the trail, and not considered a secondary maintenance program after minimal trail improvements are initially installed. When improved surfaces such as gravel, asphalt paving, and timber construction are proposed, the trail width must allow for ingress and egress of construction equipment, preferably from multiple access points, and also accommodate access for future maintenance upgrades to the trail.

There are numerous surface materials to choose from depending upon the expected use and planned trail type. Though not exhaustive, seven main types of trail surfaces are:

Option 1 - All natural surface primitive trail with minor clearing and 2' clear zones.

Option 2 - All natural surface hiking trail 4-8' wide with 2-4' clear zones and minor trail surface improvements to improve drainage or minimize steep cross-slopes.

Option 3 - Primarily a natural surface 4-8' wide with improved sections of gravel, culverts, or wooden footbridges in wetland areas. Horizontal alignments are less than 5% and cross slopes are less than 3%. Minor drainage improvements are necessary. Provide 4' wide clear zones. Shoulder improvements optional.

Option 4 – Improved surfacing 6-10' uses gravel or cinders as a soft surface multiuse trail. Horizontal alignments are less than 5% (maximum 300 LF without grade change) and cross slopes less than 3%. Full site improvements require drainage, signage, parking, public access, and 4' clear zones. Shoulder improvements optional.

Option 5 – Modified gravel and/or paved surface 6-10' wide with 4' soft surface shoulders. Horizontal alignments are less than 5% and cross-slopes are less than 2%. Full site improvements require drainage, signage, parking, public access, and 2-4' clear zones.

Option 6 – Paved surface 8-14' wide multiuse asphalt, concrete, or other impervious paving. Horizontal alignments are less than 5% and cross-slopes are less than 2%. Full site improvements require drainage, signage, parking, public access, 4'soft shoulders, and 2' clear zones.

Trail Surface Drainage

Water on the trail surface plays a significant factor in the long-term health of the trail. Predicting stormwater impacts on a trail must consider how rutting, ponding, and erosion may compromise the trail surface. Most trail surfaces allowing stormwater to sheet flow over the trail cause little if any damage. If water collects on the trail surface in puddles, subsidence will degrade the integrity regardless of whether it is natural soil, graveled, or asphalt. A cross slope of 2% is generally sufficient to cross drain water off the trail. This detail should be noted on the design details in order "for all surfaces to drain properly."

When possible, drainage is best accomplished using cross drainage (moving left or right) off the trail surface. If water is moving horizontally along the length of the trail, special care should be exercised to prevent erosion. Creating grade changes (rolling humps and valleys) every 200-300' provides the easiest way to limit the length water must flow down a trail surface. The employment of waterbars (a raised log or series of rocks typically constructed several inches above the trail at 45-60 degree angles to the trail) helps divert water off the trail into channels or discharge points to eliminate soil erosion. Waterbars are acceptable for nature trails and wilderness trails, but (for those trails requiring a smooth accessible surface) it creates a tripping hazard. Bikers may enjoy the challenge of rough terrain but they may slip on wet waterbars. In some cases, drainage swales may be necessary to collect water and channel it away from the trail. Minor surface water collection and directional changes may result from the installation of ramps and turnpikes. The collection and movement of water to drainage pipes should not significantly alter current drainage patterns nor disrupt microhabitat situations. Make sure all trail surfaces drain and adjacent areas do not erode the trail.

Tree preservation

Trail planners understand the key role that trees play in trail planning. User surveys consistently value tree-lined trails as most desirable and very pleasant to walk on. They create shaded walkways and add scenic interest. There are some negatives associated with trees. If tree root barriers are not included in the trail material cross section, tree roots will invade the trail subgrade causing asphalt to heave, concrete to crack, and tripping hazards on nature trails.

In areas where trails are woven through existing trees, impacts to surface roots must not compromise the health and vigor of the tree. The depth of tree roots varies according to tree type, soils, and proximity to water. Tree roots need oxygen in the soil for optimum health, so roots growing in hydric soils with high quantities of water will grow very close to the surface. On average, trees in James City County have roots that are typically 14-18" deep, with some roots as deep as 24". When trail grading to a depth of 8" occurs, surface feeder roots will be removed but large subsurface roots will remain. If large roots are broken during construction, they must be re-cut to produce a clean wound that allows the root to heal.

A woven geotextile installed under the trail and continuous up the sides will prevent tree roots from growing large enough to compromise the trail. In most cases, trees can have 20-25% of their roots removed with little damage to the trees' health; however, this may weaken the structure of the tree and cause it to become wind-thrown. It is good horticultural practice to include a fertilization maintenance program by a certified arborist for 3-5 years to help impacted trees recover. This cost is easily recouped should a dead tree have to be removed later on, or dead limbs fall on unsuspecting trail users.

Cost estimates for trail construction Width Unit cost*
Soft surface/natural, typical 6' $5.00 LF
Greensprings Trail- gravel/natural surfaces 5-6' $5.31 LF
Gravel trail surface w/easy access 6' $10-12 LF
Gravel trail surface w/difficult access 6' $18.50 LF
Greensprings Trail/all surfaces 5-6' $17.85 LF **
Asphalt trails 6' $17.00 LF
Asphalt multiuse trails 8-10' $25.00 LF
Sidewalks 4" concrete 4' $31-36 LF
Puncheons 6' $67.00 LF
Boardwalk on piles 6' $125.00 LF

(Note: These costs vary depending upon terrain, other environmental factors, economies of scale, etc.)

* Installed costs do not include design, engineering, project management or land acquisition.
** These numbers reflect historical costs for all improvements on the Greensprings Trail.

USDA Chapter 5: Planning & Design Principles

Natural Resources Conservation Service (NRCS)

INTRODUCTION

Landscapes consist of patches, corridors, and a matrix. Specific arrangements of these three elements define habitats for wildlife species that inhabit or migrate through a landscape. The structural characteristics of each element, plant succession, species interactions, and wildlife behavior further determine species presence or absence and habitat use. In turn, wildlife modify the habitats they occupy. These dynamics occur within the context of an agricultural matrix and a system of values held by the farmers and ranchers who manage the landscape. The wildlife planning challenge for the NRCS is to:

- Establish and maintain self-sustaining wildlife populations at levels in dynamic equilibrium with the ecological, social, and economic values of the human community.
  - Preserve, enhance, or restore the function and structure of existing patches and corridors.
  - Propose new patches or corridors in appropriate locations to restore lost habitat.
  - Minimize the negative impacts that originate in the matrix.
  - Maximize the positive habitat attributes the matrix provides.
  - Incorporate the other functional benefits that patches and corridors provide.
  - Restore natural disturbance regimes.

CONCEPTS AND PRINCIPLES

Landscape ecologists and conservation biologists have formulated several basic concepts and principles that can be used to guide wildlife planning at the watershed scale. They focus on the spatial relationships between patches, corridors, and the matrix. Developed for regional landscapes and large protected patches (national parks, wildlife refuges, etc.), they are equally effective at smaller scales. Understanding these concepts and principles can help land managers make informed decisions about how best to use corridors to recreate landscapes that are more functional.

CONCEPTS

Noss and Harris observed that areas of high conservation value occur as nodes in the landscape. These nodes can exist in varying forms at varying scales - for example: a "champion" tree, a remnant wetland complex, or a county park, national park, forest, or rangeland. The patterns of these nodes and related corridors strongly influence the presence or absence of wildlife species and their use of the landscape.

Planning and designing wildlife reserves and corridors at a watershed scale should be centered around preserving, linking and buffering high value nodes. Three basic concepts emerge:

- Core reserves (nodes)
- Buffer zones
- Linkages

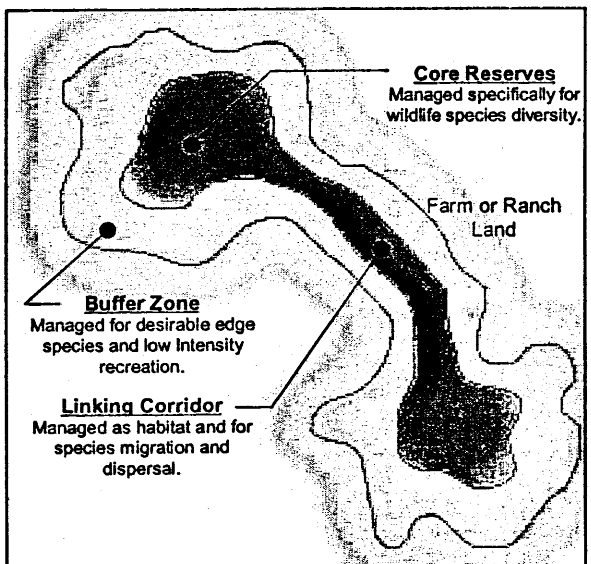
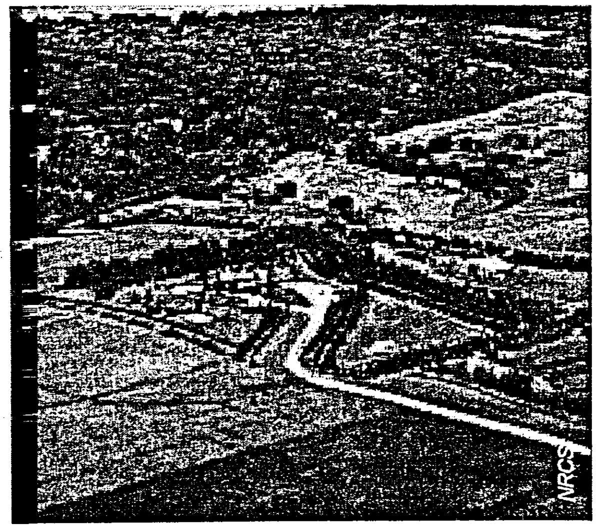


Figure 5-1: Core Reserves, Buffer Zones, and Linkages (after Adams and Dove, 1989).

An ideal pattern for wildlife conservation would preserve important nodes (core reserves), provide corridors (linkages) between nodes, and establish multiple use (buffer zones) around the nodes and corridor. This pattern satisfies wildlife needs and buffers potential adverse impacts originating in the matrix. It also provides opportunities for low-intensity human use of the buffer zones around the reserves (Figure 5-1).

In addition to these three concepts, a number of ecological principles can be used by land managers to configure patterns of landscape elements most beneficial to wildlife.



PRINCIPLES

Patches

- Large reserves/patches are better than small reserves/patches.
- Connected reserves/patches are better than separated reserves/patches.
- Unified reserves/patches are better than fragmented reserves/patches.
- Several reserves/patches (redundancy) are better than one reserve/patch.
- Nearness is better than separation.

Corridors

- Continuous corridors are better than fragmented corridors.
- Wider corridors are better than narrow corridors.
- Natural connectivity should be maintained or restored.
- Introduced connectivity should be studied carefully.
- Two or more corridor connections between patches (redundancy) are better than one.

Matrix

- Manage the matrix with wildlife in mind.

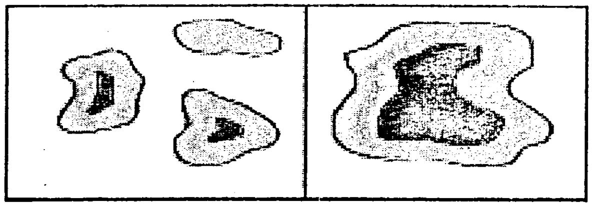
Structure

- Structurally diverse corridors and patches are better than simple structure.
- Native plants are better than introduced plants.

Each of the concepts and principles presented in this section are applicable at various scales in the landscape. However, the relative importance of different patch, corridor, and matrix functions may change at different scales. For example, the habitat function of corridors at the conservation plan scale is typically more important than the conduit function. Similarly, the corridor components that provide structural diversity are scale dependent. A structurally diverse regional corridor would consist of a diversity of plant communities (forest, meadow, riparian, etc.), whereas a structurally diverse grassed waterway would include a variety of plant forms (grasses, forbs, and shrubs). The application of these concepts and principles needs to be evaluated on a project by project basis depending on the needs of specific species.

PATCH PRINCIPLES

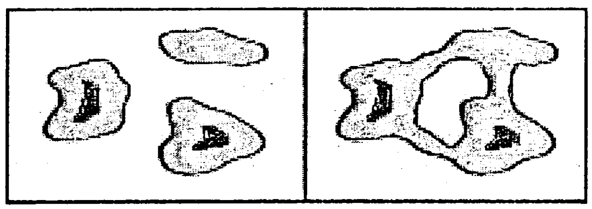
LARGE RESERVES / PATCHES ARE BETTER THAN SMALL RESERVES / PATCHES.



Large reserves typically capture and preserve a greater diversity and quality of habitats. They often serve as core reserves/patches. Large reserves/patches offer advantages that should be exploited in wildlife planning efforts. These advantages include:

- *Positive area effects are increased:* Wildlife species with large home ranges are more likely to survive in large patches. Larger population sizes are possible, decreasing the likelihood of local extinction due to disasters or inbreeding. Wildlife and plants are more likely to achieve a dynamic equilibrium. The potential for including all plant community/habitat types within the region or area is increased. Competition for resources within and between species may be diminished.
- *Edge effects are reduced:* A larger percentage of the reserve is interior habitat, benefiting interior species, which are often the most vulnerable to local extinction. Population sizes of edge species and potential associated negative effects may be reduced.
- *Diversity is increased:* Large reserves/patches typically have greater habitat diversity, which may result in greater wildlife species diversity.

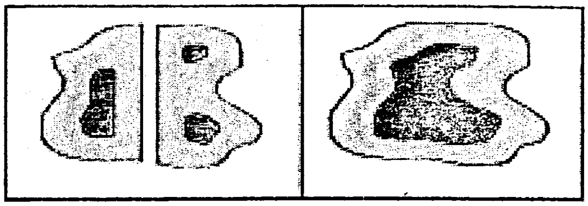
CONNECTED RESERVES / PATCHES ARE BETTER THAN SEPARATED RESERVES / PATCHES.



Connected reserves/patches are superior to separated reserves/patches in several ways. They enhance the habitat, conduit, filter/barrier, and source functions of corridors.

- *Increased Habitat:* Connected reserves/patches provide wildlife populations access to larger total areas of habitat - increasing numbers, sizes, and viability of individual populations and metapopulations. Corridors are a significant habitat component for many species, particularly in highly fragmented landscapes. In addition, the connecting corridors often serve as transitional habitat for animals moving through them. Connected patches at the conservation plan scale allow individuals safe access to a variety of habitats within their home range.
- *Presence of Conduits:* Communities and populations can move in response to seasonal disturbance or long-term environmental change. Genetic material, plant seeds, and dispersing juveniles can move between connected reserves, increasing viability within ecosystems.
- *Filter/Barrier Functions:* Movement of exotic plant and animal species may be inhibited by connections between reserves/patches. Patches and corridors can block or filter the movement of wind, airborne particles, pollutants, and wildlife attempting to move perpendicular to the long axis of the corridor. However, corridors can also facilitate the movement of undesirable species and disease between patches.
- *Source Functions:* Several reserves/patches connected by corridors are more likely to serve as a source (adding individuals to the population) than separated reserves.

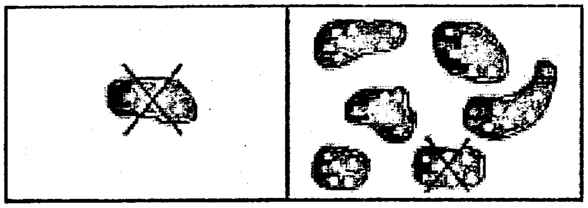
Unified Reserves / Patches Are Better Than Fragmented Reserves / Patches.



Of two reserves or patches having exactly the same area, one fragmented and one unified (as shown above), the unified reserve/patch will be of far greater value. Its increased value stems from the same factors that make larger reserves/patches better than small reserves/patches (see the SLOSS discussion on pp 5-5).

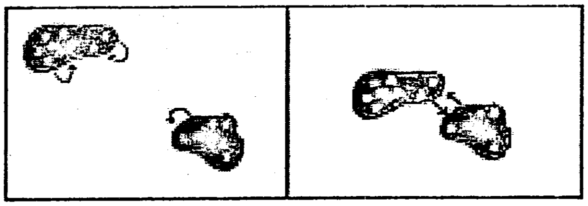
- *Positive area effects are increased.*
- *Edge effects are reduced.*
- *Diversity is increased.*

Several Reserves / Patches (Redundancy) Are Better Than One Reserve / Patch.



- Redundancy is an essential component of healthy ecosystems at all scales. Populations and individuals frequently rely on more than one patch to fulfill life requirements. If only one reserve/patch exists at either the regional, watershed, or conservation plan scale, population and community viability may decline. Also, if only one reserve/patch exists and it is degraded or destroyed through natural causes or management mistakes, the habitat for entire communities of organisms may disappear. If several reserves/patches exist in a watershed, one of those reserves can be lost without seriously threatening the integrity of wildlife communities within the watershed (see the SLOSS discussion on pp 5-5).
- Redundancy may also contribute to larger total numbers of individuals, greater genetic diversity, viable metapopulations, and the increased probability of recolonization after local extinction in one reserve/patch.

Nearness Is Better Than Separation.



- The chance that wildlife inhabiting reserves/patches will interact becomes disproportionately greater as the distance between patches decreases. Individuals or groups of individuals occasionally venture outside of their primary habitat. While that distance varies by species, they are more likely to encounter, and thus use, a nearer patch. Juvenile dispersal and recolonization are more likely to succeed between patches close to each other.
- Far-ranging movement patterns of individual species, shorter distances between patches, and less contrast between patch and matrix result in higher potential for movement between patches.