United States
Department of
Agriculture

**Natural
Resources
Conservation
Service**

National Biology Handbook

Subpart B—Conservation Planning

# Part 613

# **Conservation Corridor Planning at the Landscape Level**—Managing for Wildlife Habitat

(190-VI-NBH, November 2004)

# Part 613

# Conservation Corridor Planning at the Landscape Level—Managing forWildlife Habitat

Contents:

Cover photo courtesy Lynn Betts, USDA NRCS

## Tables



## Figures

# Subpart B — Conservation Planning

## Part 613 — Conservation Corridor Plaanning at the Landscape Level—Managing for Wildlife Habitat

***(Part 613 was originally distributed in August 1999 as Part 614.4 National Biology Handbook. It is revised and reformatted to fit within the format of this issue of the handbook.)***

## 613.00 Introduction

### (a) Background

Conservation corridors are linear strips of vegetation that differ from the adjacent surroundings and function to conserve soil, water, plants, wildlife, or fish resources. Natural corridors of woody and herbaceous riparian vegetation occurring along the edges of streams, rivers, and lakes, are visually dominant in many landscapes. Windbreaks, field borders, roadsides, contour buffer strips, and grassed waterways are introduced (planted) corridors in agricultural landscapes (fig. 613–1). Corridors may also be created by disturbance; for example, a cleared powerline right-of-way. Both natural and planted corridors can be an ecological and aesthetic resource if properly managed and can yield significant benefits (value) to the landowner and society.

Corridors preserved or planted for soil and water conservation provide wildlife habitat for a variety of species. Riparian corridors are used by over 70 percent of all terrestrial wildlife species during some part of their life cycle, including many threatened and endangered (T&E) species. Corridors provide food and nesting, brooding, loafing, and protective cover for game and nongame wildlife. They also afford wildlife relatively safe access to adjacent resources and serve as travel ways for species dispersal and migration in our increasingly fragmented landscape.

**Figure 613–1** Conservation corridors plants on this farm include field borders,vegetated terraces, grasssed waterways, windbreaks, and forested riparian buffers, which are carefully linked to make this farm a haven for wildlife (photo courtesy Lynn Betts, USDA NRCS)

Many birds and bats that either nest or roost in corridors are insectivorous, consuming thousands of insects that could damage crops and pester livestock. Others are important game species providing recreational opportunities and generating revenues that supplement rural economies.

## (b) The problem

The quality and quantity of our Nation's conservation corridors have declined for the last several decades. Natural corridors are frequently squeezed by adjacent land uses or severed by roads, utilities, dams, or other types of human development. Narrow and segmented corridors are less effective as travel lanes for wildlife dispersal and other ecological functions. Hundreds of miles of fence rows, windbreaks, and other planted corridors are removed annually to accommodate changing agricultural practices and suburban sprawl. Long neglected shelterbelts and windbreaks planted in the 1930s are dying out; few have been replaced. Many contour buffer strips, grassed waterways, and roadsides are planted in one species of grass. Single-species stands of introduced grass provide few wildlife benefits and are of little value as winter cover. Untimely mowing, heavy grazing, repeated burning, and spraying further reduce their habitat value.

While corridors decline, remnant fragments or patches of relatively large undisturbed habitat are also becoming less common, smaller, and increasingly isolated. In some cases they are no longer capable of supporting viable populations of native plants or wildlife. The resulting threat to plant and wildlife species diversity in all regions of the country has become a national concern. Many ecologists believe that connecting remnant habitat patches with corridors should be one part of a comprehensive plan to address this growing problem.

## (c) Planning areawide solutions

The Natural Resources Conservation Service (NRCS) is committed to assisting in the revitalization and linkage of the Nation's landscape corridors. The Agency is actively promoting the preservation, enhancement, restoration, and reclamation and new plantings of conservation corridors at the watershed scale. NRCS encourages establishment of conservation corridors for the following reasons:

- Corridors are a valuable resource to both the landowner and the public.
- The benefits of conservation corridors for wildlife habitat in particular are optimized when corridor systems are planned and established at a landscape or watershed scale.
- Corridors function most effectively when used in conjunction with other soil and water conservation measures in a conservation plan.
- Both ecological and economic principles must be applied to corridor planning, design, establishment, and management to optimize benefits and reduce negative impacts.

How corridors are arranged and connected within the larger landscape context determine their wildlife value. This principle provides land managers with a tool to manage wildlife species diversity effectively. The cumulative effect of corridor arrangement influences wildlife population dynamics. Designing corridor systems is a task of creating strategic configurations across ownerships and land uses. The objective is to restore targeted ecological functions at watershed scales.

Opportunities exist in every state to plan, design, and manage corridors, optimizing their multiple benefits. Thousands of acres of potential high quality habitat exist in roadsides, windbreaks, riparian areas, grassed waterways, and other types of corridors.

Implementing a successful system of integrated corridors requires the cooperation of private landowners, local governments, private nonprofit conservation organizations, and State and Federal agencies working at both landscape and site-specific scales.

The NRCS is the USDA agency charged with providing technical assistance to private landowners who voluntarily wish to initiate an areawide plan. NRCS conservationists play a key role in promoting areawide planning and facilitating the planning process once it is initiated. Landowners, farmers, ranchers, partnering agency personnel, and other proponents all share in the work. The NRCS *National Planning Procedures Handbook* provides a structure within which these tasks can be completed in an orderly and efficient way.

### (1) A planning tool

Part 613 of the National Biology Handbook was designed for NRCS conservationists and other partners as a complement to the *National Planning Procedures Handbook*. It is a source of information about conservation corridors and their benefits and a reference for use in the field. Part 613 emphasizes planning, designing, and managing corridors to optimize wildlife habitat. In addition, it includes general plant community guidelines to enhance the habitat value of each NRCS corridor-type conservation practice.

The material in part 613 provides the conservationist with

- a review of the causes and consequences of habitat fragmentation,
- an overview of the types and ecological functions of corridors,
- a summary of the benefits corridors provide landowners, communities, and the environment,
- watershed-scale wildlife corridor planning principles,
- examples and case studies documenting the importance of planning systems of conservation corridors for wildlife at watershed scales, and
- illustrations and case studies showing how an individual farm, ranch, or community conservation corridor project can be knitted into an areawide plan.

In addition, part 613 provides the conservationist with tools that facilitate conservation corridor planning at the areawide, farm, ranch, and community scales. As a field reference, it includes information for planning and implementation.

**Strategic planning:**

- Strategies for organizing an areawide planning team, establishing goals, and allocating responsibilities
- Procedures for preparing base maps
- A diagram of the National Planning Procedure process with emphasis on planning for wildlife
- Detailed descriptions of how to include wildlife conservation in each step of the planning process
- An areawide inventory checklist that emphasizes wildlife habitat information
- A step-by-step description (with illustrations) of how to prepare plan alternatives
- Procedures to integrate individual farm, ranch, or community conservation corridor projects within an areawide plan
- Lists of sources of watershed resource information

**Technical tools:**

- Worksheets for evaluating the habitat condition of existing corridors
- Criteria for locating conservation corridors to optimize their habitat function
- Criteria for designing plant community structure for each conservation corridor type to enhance habitat value
- Procedures for evaluating the impact of conservation practices on wildlife populations

Partnerships are at the heart of all conservation initiatives linking land and people. They foster a cooperative environment promoting those factors necessary for success:

- Exchanging information, experience, and expertise
- Sharing responsibilities and tasks
- Involving a cross-section of community residents
- Planning and implementing projects across mixed ownership and jurisdictions
- Leveraging resources
- Building a sense of shared community

### (2) Trust, cooperation, and implementation

Fundamentally, areawide plans are templates delineating an integrated system of conservation corridors and practices at scales larger than an individual farm or corridor. They are seldom large, single projects completed quickly. Rather, they are implemented incrementally one farm, ranch, or community open space at a time. The resulting cumulative effect contributes to the sustainability of the land and wildlife populations. Indeed many areawide plans originated with an individual landowner or community that volunteered to work with a conservationist to plan, design, and install conservation corridors and employ conservation practices. Neighboring farmers or communities liked the conservation corridor projects they saw, sought

NRCS assistance, and over time a system of conservation corridors spread across the watershed.

Building trust with landowners and community groups by working one-on-one is the traditional role of the conservationist and must remain at the very heart of the conservation corridor effort if it is to succeed.

Corridors are only one piece of the conservation puzzle. The other important pieces are the various land management practices applied by farmers, ranchers, and communities to the natural resources on their land. **The long-term value of corridors is highly dependent on the health of the adjacent landscape and large patches of native vegetation.** Landowners and communities participating in land and water conservation programs using sustainable agricultural and other land use practices enhance habitat quality and quantity. The puzzle can be completed through public and private landowner partnerships, passing on to future generations the rich wildlife and scenic heritage our Nation has come to cherish.

## (d) Case study

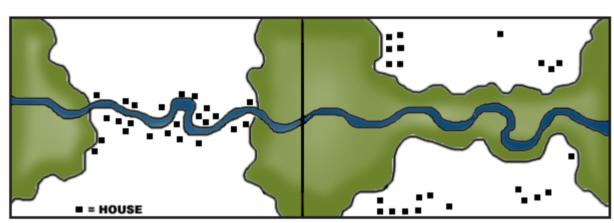
The following case study, Possible Futures for the Muddy Creek Watershed, illustrate two corridor planning principles—maintaining or restoring natural connectivity and managing the matrix with wildlife in mind.

# Case Study:

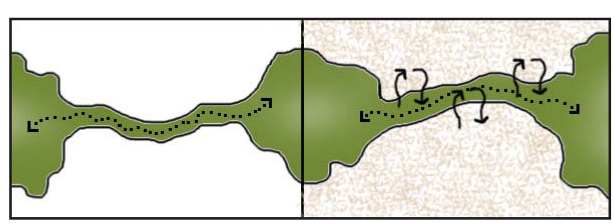
# POSSIBLE FUTURES FOR THE MUDDY CREEK WATERSHED

Corridor Planning Principles described in section 613.04 that are exhibited by this case study include:

**NATURAL CONNECTIVITY SHOULD BE MAINTAINED OR RESTORED.**




**MANAGE THE MATRIX WITH WILDLIFE IN MIND.**



# Case Study: Possible Futures for the Muddy Creek Watershed

*This case study illustrates a process for planning at a watershed scale and the role that landowners and communities can play in developing alternative plans for land conservation and development.*

This report documents a two year case study research endeavor exploring how human population growth and land use change in the Muddy Creek watershed of Benton County, Oregon may influence biodiversity and water quality. The case study illustrates a framework for helping local communities create alternative scenarios for land conservation and development. The project employed previously existing information and relied on the regular participation of local stakeholders to produce a series of mapped possible future scenarios depicting land use in the watershed in the year 2025 (Figure 1). The possible futures were evaluated for their effects on biodiversity and water quality using best available information, ecological and hydrological effect models.

The biodiversity evaluative model measured the change in potential habitat area for each of the 234 breeding species, in each future scenario and the past, by calculating the ratio of future or past habitat area to the present habitat area. The water quality evaluative model, a non-point pollutant source/geographic information system model, simulated a series of five storm events to calculate the mean pollutant load for each of the five possible futures, present and past. The model assessed volume of surface flows and levels of total suspended solids, phosphorus and nitrate, using field data collected from base line flows and two storm event flows monitored in 1996.

Results from the biodiversity model show that all native species have at least some habitat in all future land use scenarios. However, if land use trends in the watershed continue unchanged (Plan Trend Future) or become more highly developed over the next 30 years (Moderate and High Development Futures), there will be an increased risk to the abundance of the 212 existing species, particularly birds, mammals, and amphibians. Of the 220 species native to the watershed throughout its recent history, 26 species have lost more than half of their habitat since 1850. Under the High Development Future, 12 species are estimated to lose more than half of their present habitat in the next 30 years. Only 2 species – the California condor and marbled murrelet – are common to both lists. This acceleration and shifting of risk from one set of species to another suggests that the kinds of habitat changes from past to present are different than those envisioned in the possible futures (Figure 2).

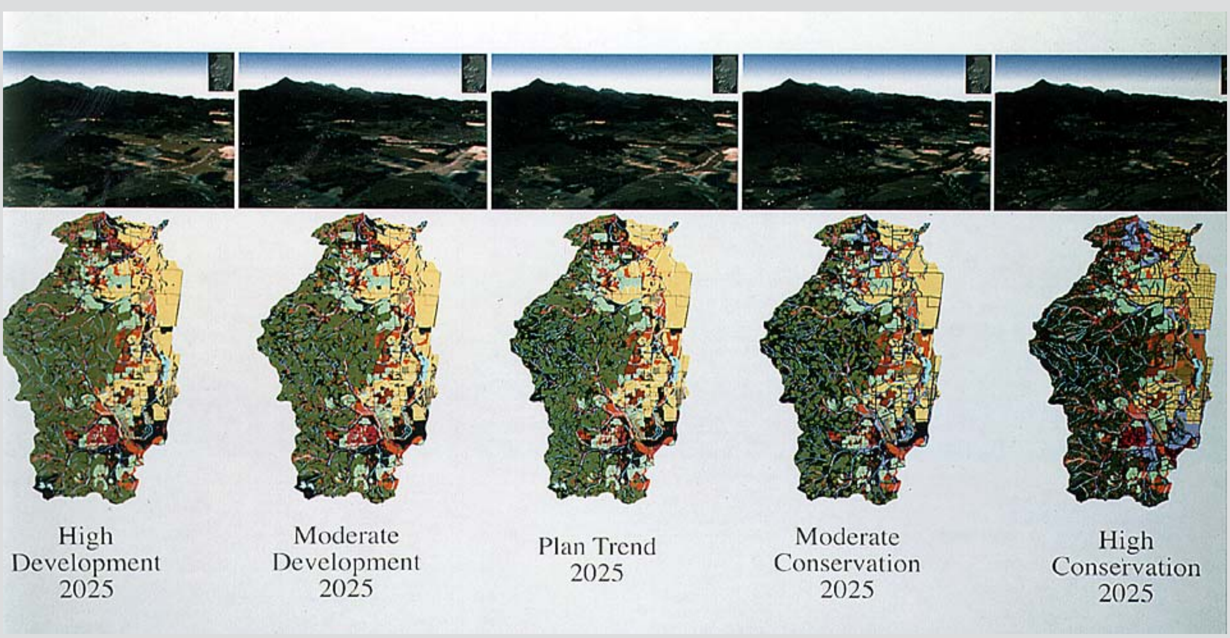



***Figure 1:*** *Five mapped possible future scenarios depicting land use in the watershed in the year 2025.*

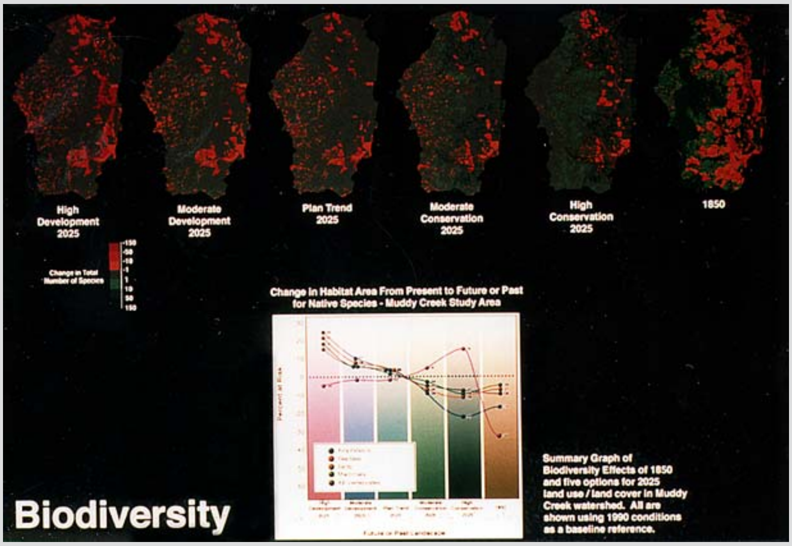



*Figure 2:* *An assessment of the possible impacts of future scenarios on biodiversity.*

*Additional information can be obtained via the Internet at http://ise.uoregon.edu*

This case study was prepared by David Hulse[1], Joe Eilers[2], Kathryn Freemark[3], Denis White[4] and has been included in this document with their permission.

[1]Institute for a Sustainable Environment, University of Oregon, Eugene, OR 97403

[2]E and S Environmental Chemistry, 2161 NW Fillmore Ave., Corvallis, OR 97339

[3]Canadian Wildlife Service, Environment Canada, Ottawa, Quebec, Canada K1A 0H3

[4]U.S. Environmental Protection Agency, 200 SW 35th Street, Corvallis, OR 97333

This work was funded by cooperative agreement CR822930 between the U.S. Environmental Protection Agency and University of Oregon, cooperative research agreement PNW 92-0283 between the U.S. Forest Service and Oregon State University, interagency agreement DW 12935631 between the U.S. Environmental Protection Agency and the U.S. Forest Service, and the U.S. Department of Defense Strategic Environmental Research and Development Program Project #241-EPA.

These graphics are not intended for detailed scrutiny. Detailed information is available at the Internet address noted above.

Results from the water quality model show increases in volume of surface water runoff and total suspended solids under the Moderate and High Development Futures in sub-basins undergoing significantly increased residential development or having a high percentage of area in erosive soils on steep slopes (Figure 3). Crops located on steep slopes were the greatest contributors of total suspended solids and total phosphorus in the agricultural lowlands. Land uses on gentle slopes or in natural vegetation were the lowest contributors of total suspended solids and total phosphorus.

In summary, if the residents of the Muddy Creek watershed desire a future presenting no greater risk to biodiversity and water quality than the present pattern of land use, then they should plan toward a future with a land use pattern between the Plan Trend Future and the Moderate Conservation Future for biodiversity protection, and between the Moderate Conservation and the High Conservation Future for water quality protection.

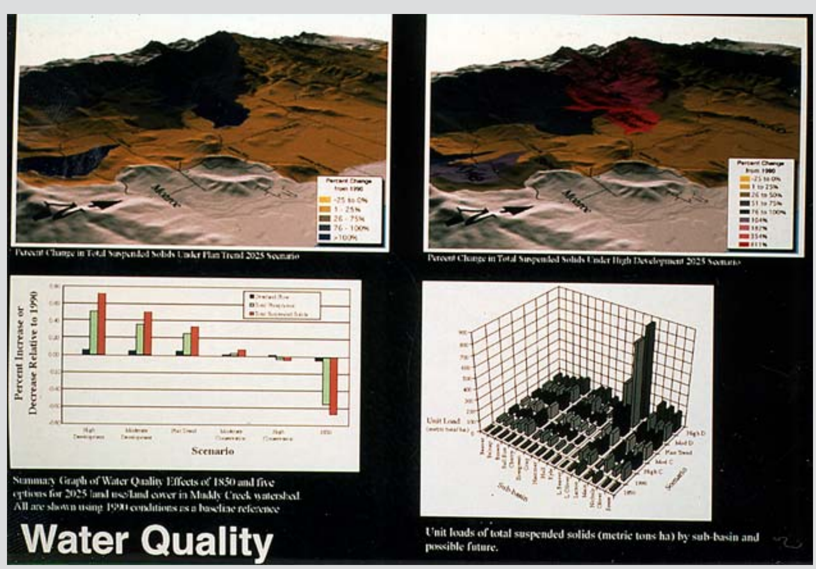



*Figure 3:* *An assessment of the possible impacts of future scenarios on water quality.*

# 613.01 Habitat fragmentation

## (a) Introduction

Fragmentation, the breaking up of large patches of native vegetation into smaller and increasingly isolated patches, is a process as old as civilization (fig. 613–2). It intensified as hunter/gatherer societies settled in permanent locations and began planting crops and herding livestock. Research suggests that the initial impacts on biodiversity were minimal, disturbed areas were small and regenerated when no longer cropped or grazed. But as human populations increased and technology became more sophisticated, the effects of fragmentation spread across the landscape. Archeological evidence suggests that many wildlife species were displaced and local populations eliminated.

Fragmentation continues today, driven by an exploding human population and growing demand to produce more food and fiber from a finite land resource. The contemporary rural landscape is the result of the cumulative impacts of past and present human land use practices including urbanization, agriculture, ranching, and logging.

Fragmentation of a landscape reduces the area of original habitat and increases the total lineal feet of edge, favoring species that inhabit edges at the expense of interior species that require large continuous patches. Ecologists, such as Wilcox and Murphy, believe that habitat fragmentation is the most serious threat to biological diversity and is the primary cause of the present extinction crisis.

## (b) Habitat fragmentation

Prior to the age of mechanized agriculture (circa 1890), rural American landscapes were fine grained. Hedgerows often surrounded small fields of diverse crops while wetlands, steep slopes, swales, and rocky areas were left undisturbed (fig. 613–3). Fields of 40, 80, and 160 acres were common. With today's mechanized agriculture, fragmentation occurs at a much coarser scale resulting in more homogenous landscapes (fig. 613–4). Small fields are combined to form larger tracts of land to accommodate farming with large machinery. Many fields are enlarged at the expense of windbreaks, fence rows, and other valuable wildlife habitat. Several areas in the Midwest have lost over 60 percent of their windbreaks because of the declining health of windbreak trees, expanding field size, and urban sprawl. The resultant loss of habitat diversity in agricultural landscapes has adversely

**Figure 613–2** Little remains of the prairie and wetlands that once existed in this fragmented landscape (photo courtesy Lynn Betts, USDA NRCS)

impacted wildlife populations. Wildlife biologists studying bobwhite quail (*Colinus virginianus*) in Nebraska discovered that a county with five times more acreage in hedgerows than a neighboring county also had an estimated population of quail almost four times greater.

For a species to survive in a landscape or watershed, it must have access to habitat resources sufficient to maintain a viable population. A minimum viable population (MVP) is the smallest number of individuals required to sustain a population for the long-term. A projected MVP is based on estimates of a population

**Figure 613–3** These small Pennsylvania fields have been integrated with patches of nontillable land, providing habitat for wildlife (photo courtesy Frank Lucas, USDA NRCS)

**Figure 613–4** Large fields of row crops dominate this North Carolina landscape, leaving little habitat for quail or other species (photo courtesy North Carolina State University)

size that can counter the negative effects of genetic variation loss, population fluctuations, and environmental changes.

Maintenance of an MVP is often dependent on functioning metapopulations, wildlife populations that are spatially separated but interact through the dispersal of animals. Metapopulations in small patches can "wink" on or off (experience local extinction) because of local variation in sex ratios, disturbance (such as fire), and other local factors. A metapopulation is more likely to persist if immigration and colonization are facilitated by corridors or "stepping stone" patches. Linkage between patches is critical in sustaining healthy metapopulations in highly fragmented landscapes (see the Louisiana Black Bear case study in section 613.03, Corridors—an overview).

Habitat fragmentation diminishes the capacity of the landscape to sustain healthy populations or metapopulations in five primary ways:

- Loss of original habitat
- Reduced habitat patch size
- Increased edge
- Increased isolation of patches
- Modification of natural disturbance regimes

### (1) Loss of original habitat

Perhaps the most significant adverse impact of fragmentation is simply the loss of original habitat. Research findings suggest loss of habitat has a much greater impact on wildlife populations than the change in spatial arrangement of habitat areas.

Over 90 percent of the grasslands east of the Mississippi River are gone, approximately 90 percent of Iowa's wetlands have been removed, and 80 percent of Indiana's forests have been eliminated (fig. 613–5). Habitat losses of this magnitude will permanently displace many species and dramatically depress the population levels of others. It forces remaining species into the few remnant patches available, increasing competition, crowding, stress, and the potential for disease outbreaks. The number of currently listed federal and state threatened and endangered species suggests that many populations are at or near MVP levels.

Even in areas where fragmentation is not readily apparent, subtle but equally devastating effects of habitat loss can exist. A grassland invaded by exotic grasses may look natural but be functionally fragmented. For example grasslands infested by cheatgrass (*Bromus tectorum*) look similar to native grass patches, but provide no habitat of value for sensitive species, such as the pronghorn (*Antilocapra americana*) and the greater prairie chicken (*Tympanuchus cupido*).

### (2) Reduced habitat patch size

Reduction in habitat patch size is a principal consequence of fragmentation. Biologists MacArthur and Wilson (1967) suggested that the rate of species extinction in an isolated patch of habitat is inversely related to its size. As remnants of native habitats become smaller, they are less likely to provide food, cover, and the other resources necessary to support the native wildlife community. Small patches are also

**Figure 613–5** Wildlife are often crowded, stressed, and subject to high levels of predation when only disconnected remnants of habitat remain in a watershed (photos courtesy Craig Johnson, USDA NRCS, and Kristen Rol)

more susceptible to catastrophic disturbance events, such as fire or severe weather that can decimate local populations.

Fragmentation also decreases the area of interior habitat (fig. 613–6). Interior habitat is the area far enough from the edge to maintain communities of the original larger habitat. For example, when large tracts of sage/grassland are cleared and seeded into grasses or alfalfa, sage/grassland patch size and interior habitat are reduced. Not surprisingly, populations of an interior-dwelling cold desert species that requires large patches of sagebrush like the sage grouse (*Centrocercus urophasianus*) are in serious decline.

### (3) Increased edge

Although an increase in edge (the boundary between two plant communities) caused by fragmentation may benefit some species, some researchers believe that increasing edge may be detrimental to the protection of native biodiversity. Edges act as barriers, causing some predators to travel along them. High predator densities along edges can result in higher mortality for edge dwelling prey species or species moving through narrow corridors. Nest parasitism by brown-headed cowbirds (*Molothrus ater*) also appears to be higher in species nesting in edge habitat. Least bell's vireo (*Vireo bellii pusillus*) is an endangered species that inhabits the edges of riparian corridors in southern California. Parasitism by cowbirds appears to be as significant as the loss of riparian habitat in the decline of the least bell's vireo on Camp Pendleton, California.

### (4) Increased isolation

Fragmentation leads to increased isolation of patches (fig. 613–7). Wildlife populations in isolated patches can be sustained by immigration of species from surrounding patches. However, as fragmentation continues, distances between patches get longer and dispersal and immigration rates decrease. The diversity of species moving between patches also decreases; small species with limited mobility are particularly distance sensitive. As immigration rates decrease, such factors as inbreeding and catastrophic disturbances can cause the number of species in a patch to decline to zero over a long enough period.

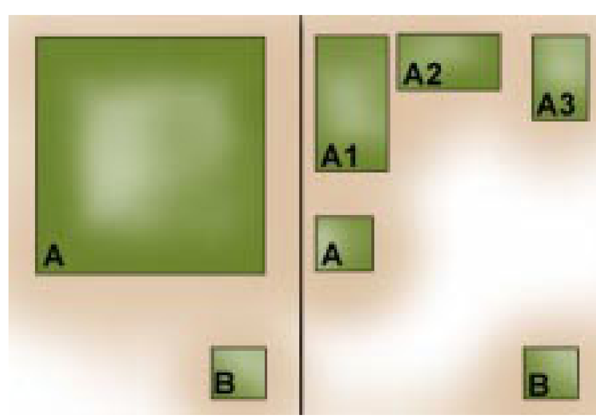
Biologists studying chaparral bird species extinction rates in remnant patches in southern California found that on average, less than one chaparral bird species survived after 40 years of isolation in canyons less than 125 acres.

### (5) Modified disturbance regimes

Fragmentation and associated land management activities, such as fire suppression, alter the flow of natural disturbances. For example, fire, a disturbance factor essential to the maintenance of tall grass prairies, has virtually been eliminated in the Midwest. Remnant prairie plant communities separated by miles of row crops and protected from fire are being overtaken by less fire-tolerant woody species. Wildlife dependent on prairie ecosystems are being displaced.

**Figure 613–6** The fragmented landscape on the left has less interior habitat and over 50 percent more edge than the block of habitat on the right


**Figure 613–7** Patch B is more isolated from the remnants of patch A when A is fragmented, limiting movement between A and B for some wildlife species



### (6) Cumulative effects

The cumulative impact of habitat fragmentation results from the combined incremental effects of habitat loss, reduced patch size, increased edge, and patch isolation. The impacts are cumulative across scales and over time affect populations of organisms as well as individuals. These impacts are not related linearly to the extent of original habitat. There are thresholds where local extinction for a species may be imminent even though only a small percentage of original habitat has been lost. Unfortunately, understanding of these thresholds is limited.

### (7) Corridor connections

In many regions of the country, agriculture and urbanization are dominant forces in land conversion; most land is in private ownership, habitat patches are small, scarce, and often isolated. The probability of increasing the size of existing patches or creating new patches in these landscapes is remote. However, one realistic opportunity to begin to rebuild functional ecosystems and conserve biodiversity is to employ natural and introduced corridors that knit the landscape back together (fig. 613–8). An integrated system of conservation corridors not only benefits wildlife, but also conserves soil, water, air, and plants.

**Figure 613–8** Recently restored riparian corridor is reconnecting the structural elements in an Iowa watershed (photo courtesy Lynn Betts, USDA NRCS)

# 613.02 Corridors—an overview

## (a) Introduction

Landscape ecologists Forman and Godron (1986) suggest that a landscape is a heterogeneous land area consisting of three fundamental elements: patches, corridors, and a matrix (figure 613–9). They define each element as follows:

**Patch**—Generally a plant and animal community that is surrounded by areas with different community structure; however, a patch may be devoid of life.

**Corridor**—A linear patch that differs from its surroundings.

**Matrix**—The background within which patches and corridors exist (the matrix defines the flow of energy, matter, and organisms).

Patches, corridors, and the matrix interact in ecologically significant ways. Consequently, this conceptual model is very useful in the study of function, structure, change, and the conservation potential of corridors in the landscape.

## (b) Types of corridors

Corridors can be natural (a tree-lined stream channel) or the result of human disturbance to the background matrix (a strip of native prairie left unplowed between two fields). Corridor structure may be narrow (line), such as a hedgerow; wider than a line (strip), such as a multi-row windbreak; or streamside vegetation (riparian). Corridors may be convex, taller than the surrounding matrix like a shelterbelt between wheat fields; or concave, lower than the surrounding vegetation, such as a grass strip between two woodlots. Line or strip structure may be in many kinds of corridors. Five commonly used categories of corridor origin are

- environmental corridors,
- remnant corridors,
- introduced corridors,
- disturbance corridors, and
- regenerated corridors.

**Figure 613–9** The three elements of landscape structure—patch, corridor, and matrix—are clearly evident in this photograph (photo courtesy Don Anderson, USFWS)

In recent years, engineered corridors, such as overpasses and underpasses, have been designed specifically to accommodate wildlife movement.

***Environmental corridors***—Environmental corridors are the result of vegetation response to an environmental resource, such as a stream, soil type, or geologic formation. They are typically winding (curvilinear) in configuration with widths that are highly variable. Sinuous strands of riparian vegetation paralleling stream courses are prominent examples in all regions of the country (fig. 613–10). Environmental corridors are frequently the most important habitats in the watershed.

***Remnant corridors***—Remnant corridors are the most obvious products of disturbance to the adjacent matrix (fig. 613–11). Strips of vegetation on sites too steep, rocky, or wet to put into production are left as remnants after land is cleared for agriculture or other uses. Some remnants are line corridors left to identify property boundaries. The width and configuration of most remnant corridors vary considerably. Remnant corridors often have the last assemblages of native flora and fauna in a watershed.

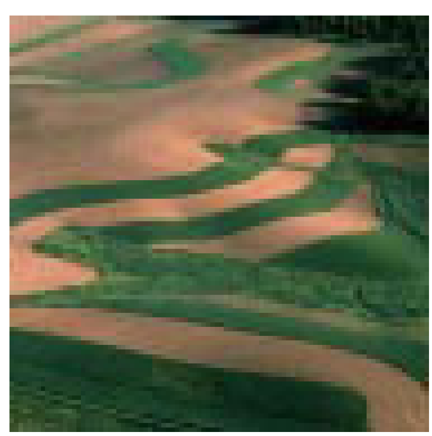
***Introduced corridors***—Introduced (planted) corridors date back to circa 5000 BC. More corridors may have been planted between the 14th and 19th centuries in England than at any other time or place in history. Under the Statute of Merton, 1236, proprietors were granted the right to enclose portions of woodland and pasture. Over the next 500 years, thousands of miles of hedgerows were planted. Some of these hedgerows persist to this day and are valued as national landscape treasures. In the United States, the Shelterbelt Project of the 1930s was the largest conservation project of the Depression Era; over 200 million seedlings were planted into shelterbelts, and many were maintained by Civilian Conservation Corps work crews (fig. 613–12). In agriculturally dominated landscapes, introduced corridors are critical habitat for many wildlife species.

***Disturbance corridors***—Disturbance corridors are produced by land management activities that disturb vegetation in a line or strip; a mowed roadside or brush-hogged powerline right-of-way are examples (fig. 613–13). Continued disturbance of the strip is often required to maintain vegetation in the desired successional stage. The widths of disturbance corridors vary, but they tend to be more strip-like. Configuration is typically straight line. They may be sufficiently wide to constitute a barrier for some wildlife species, splitting a population into two metapopulations. Disturbance corridors are often important habitats for native species that require early successional habitat.

**Figure 613–10** Environmental corridor (photo courtesy Gary Bentrup, USU)

**Figure 613–11** Remnant corridor (photo courtesy Craig Johnson, USU)

**Figure 613–12** Introduced corridors (photo courtesy Lynn Betts, NRCS)



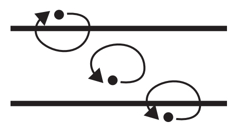
***Regenerated corridors***—Regenerated corridors result when regrowth occurs in a disturbed line or strip (fig. 613–14). Regrowth may be the product of natural succession or revegetation via planting. Regrowth in abandoned roadways, trails, and railroad right-of-ways are examples. Corridor width and configuration are dependent upon the nature of the previous disturbance. Regenerated corridor vegetation is often dominated by aggressive weedy species during the early stages of succession. East of the Mississippi River, regenerated corridors occur as hedgerows along fence lines and roadside ditches. They are less common in the West. In highly fragmented landscapes, regenerated corridors are often important habitats for small mammals and songbirds.

**Figure 613–13** Disturbance corridor (photo courtesy Craig Johnson, USU)

**Figure 613–14** Regenerated corridor (photo courtesy USDA NRCS)

## (c) Corridor function

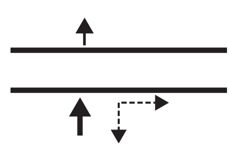
Corridors perform important ecological functions including habitat, conduit, filter/barrier, sink, and source. These five functions operate simultaneously, fluctuate with changes in seasons and weather, and change over time. Their interactions are often complex and in many cases are not well understood.



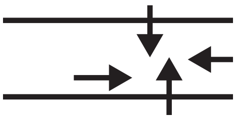
***Habitat***—A corridor may function as habitat or a component of habitat, particularly for those species with small home ranges and limited mobility, ruffed grouse (*Bonasa umbellus*) for example. For some species, large mammals for instance, a corridor may serve as transitional habitat during seasonal migrations between patches. The habitat function of corridors is described in detail in part 613.03.

***Conduit***—A corridor functions as a conduit when it conveys energy, water, nutrients, genes, seeds, organisms, and other elements. Biologist Michael Soule (1991) identified the following general categories of animal need for the conduit function of corridors:

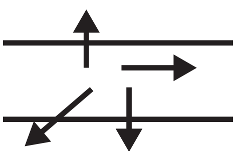
- Periodic migration to breeding or birthing sites; elk migration from wintering habitat to calving grounds, for example.
- Movement between patches within the animal's home range to access food, cover, or other resources.
- Some populations must receive immigrants if they are to persist in isolated patches; for example, male cougars migrating from one metapopulation to another to breed.



***Filter/barrier***—A corridor functions as a filter or barrier when it intercepts wind, windblown particles, surface/subsurface water, nutrients, genes, and animals. Corridors may filter out sediments and agricultural chemicals from runoff that originates in the adjacent matrix. They may also act as barriers that reduce wind velocity and decrease erosion. Some artificial corridors like highways and canals are barriers to wildlife movement and may genetically isolate populations.



***Sink***—A corridor functions as a sink when it receives and retains (at least temporarily) objects and substances that originate in the matrix; soil, water, agricultural chemicals, seeds, and animals for example. Corridors can become sinks for wildlife when the rate of mortality in the corridor from predation and other causes creates a net loss in the population of either corridor residents or migrant species.



***Source***—A corridor functions as a source when it releases objects and substances into the adjacent matrix. Corridors may be sources of weeds and pest species of wildlife. They may also be sources of predatory insects and insect eating birds that keep crop pests in check. High quality corridors are often a source of wildlife; reproduction in the corridor exceeds mortality and individuals are added to the population.

## (d) Corridor structure

The physical and biological characteristics of corridors, such as width, connectivity, plant community, structure (architecture), edge to interior ratio, length, and configuration, determine how corridors function (fig. 613–15). Corridor width, connectivity, and plant community architecture are ecologically and visually the most important of these characteristics.

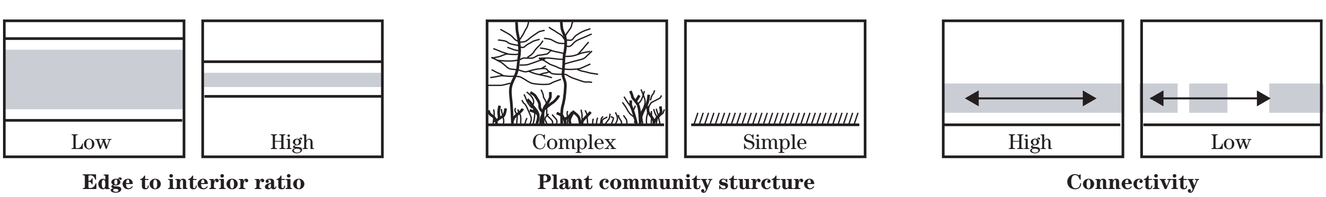
All five corridor functions are enhanced by increased width and connectivity. Corridors with the fewest number of gaps have the highest levels of connectivity. As gap width increases, the number of wildlife species for which the corridor functions as a conduit decreases. Biologist Michael Soule (1991) emphasizes the importance of connectivity for maintaining wildlife population viability in highly developed landscapes. Ecologist Richard Forman (1995) suggests that there is value in maintaining several parallel connecting corridors or patch "stepping stones" between large patches. Some ecologists caution that corridors can also be conduits for diseases, predators, exotic species, and fire, which can threaten populations. However, corridors remain among the best options for maintaining biodiversity in agricultural landscapes.

The vertical and horizontal structural characteristics of vegetation within a corridor, its architecture, also influence ecological function. The vegetative structure of corridors may vary from a single layer in a grassed waterway to four or more layers in a remnant woodlot or riparian corridor. Vertical structure is a particularly important habitat characteristic for some species of birds. Horizontal structure within corridors also varies. Patchiness (the density of patches of all types) is most common in remnant and riparian corridors. Plant spacing heterogeneity is related to bird species diversity. In general, the greater the structural diversity within a corridor, the greater the habitat value for an array of species (fig. 613–16).

## (e) Change

Plant communities change over time. Corridors typically have fewer plant species than larger patches, but species diversity appears to increase with corridor age. Disturbance and consequent succession are the principal agents of change in corridor vegetation. Disturbance may be natural, wildfire for example, or induced by land management activities in or adjacent to the corridor, such as mowing or grazing. Because most corridors have a high edge-to-interior ratio, they are particularly prone to the effects of disturbance in the adjoining matrix. Human-induced disturbance has the potential to push corridor vegetation beyond the point where it can recover through natural processes.

**Figure 613–15** Corridor structure characteristics



This may lead to degradation of the corridor ecosystem and a successional path that differs significantly from the norm.

Changes in plant community function and structure because of plant succession significantly affect wildlife. Both species composition and density may be altered. However, mature corridors, with the exception of riparian corridors, seldom achieve the wildlife species diversity of large patches.

Wildlife biologists advocate managing successional change in corridors to meet a variety of outcomes. Sensitivity to biodiversity is growing, however, even in situations driven by single species management.

**Figure 613–16** The overstory, middlestory, and understory vegetation of this woodlot provide niches for wildlife (photo courtesy Craig Johnson, USU)

Changes in plant community structure caused by disturbance or succession also affect other corridor functions. For example, windbreak efficiencies decline dramatically when the shrub layer is removed, a common occurrence when livestock are allowed to graze unmanaged in windbreaks.

## (f) Expanding perspective

NRCS project-scale conservation practices capitalize on the function and structure of corridors. Windbreaks, grassed waterways, field borders, and other conservation practices functioning as filters, barriers, and sinks reduce soil erosion, improve water quality, and increase crop and livestock production. Native and introduced plants and wildlife are the indirect beneficiaries of the habitats created by these practices.

Conservation corridors planned specifically for wildlife can preserve and enhance biodiversity at a landscape scale. Land managers now realize that emphasizing wildlife planning at these larger scales can help maintain within the landscape or watershed diverse self-sustaining wildlife populations of native and introduced species at population levels in harmony with the resource base and local social and economic values.

## (g) Status of corridors

The limited information on the quantity and quality of the Nation's corridors suggests three things:

- A decline in the number, length, and area of some types of corridors,
- A significant degradation of the function and structure of many types of corridors, especially stream/riparian corridors, and
- A general reduction in the value of corridors for human use and environmental services.

In 1992, the National Research Council completed an extensive study of aquatic ecosystems including stream corridors. They concluded that the function and structure of many stream/riparian corridors have been substantially altered and their ecological integrity compromised. Agricultural chemicals, feedlot effluent, urban runoff, and municipal sewage discharge were noted as major causes of water quality degradation. Increased sediment loading from urbanization, agriculture, grazing, and forestry and the construction of dams, channelization, and water diversions have further compounded the problem (National Research Council 1992).

In addition, the separation of many flood plains from their stream channels by levees, filling, and channel entrenchment disrupted natural cycles of plant succession (fig. 613–17). These stresses reduced the value of many corridors for wildlife habitat and for recreation and other human activities. They also eliminated or greatly curtailed the environmental services normally associated with riparian corridors; particularly flood management, pollution abatement, groundwater recharge, and floodwater dispersal.

Of the estimated 3.2 million miles of rivers in the United States, only 2 percent meet the rigorous criteria for designation as a Wild and Scenic River. About 75 percent of the Nation's streams are degraded to levels where they can only support a low-level fishery; only 5 percent of the streams support a fishery of high quality. A 1995 National Biological Service report (Noss et al. 1995) stated that 85 to 95 percent of southwestern riparian forests have disappeared since the Spaniards first settled the area (fig. 613–18a). The lost scenic values and recreation opportunities are striking. However, these habitats can respond well to proper land management (fig. 613–18b).

Researchers conducting the NRCS Natural Resource Inventory (NRI) estimated there were approximately 160,000 miles of windbreaks in 1982. By 1992, the figure had decreased to roughly 150,000 miles, a reduction of over 6 percent. During that same 10-year period, the area in windbreaks was also reduced by about 6 percent. Of equal concern is the decline in windbreak quality, the result of old age, neglect, and poor management practices. Grazing, herbicide damage, and excessive competition from introduced

**Figure 613–17** Entrenched stream no longer supports riparian vegetation (wildlife habitat) that lines its upper banks (photo courtesy Craig Engelhard, USDA NRCS)

**Figure 613–18a** Riparian corridor in poor condition because of improper grazing management (photo courtesy David Krueper, BLM)

**Figure 613–18b** The same riparian corridor after 10 years of proper grazing management (photo courtesy David Krueper, BLM)

grasses in shelterbelts can contribute to degradation. Degraded shelterbelts are less efficient as filters, barriers, sediment traps, nutrient sinks, and as habitat for wildlife.

In addition to riparian buffers and windbreaks, NRCS and others have long advocated the use of other types of conservation corridors including contour buffers, filter strips, field borders, and grassed waterways. No national database is kept on these corridor types. However, based on a survey of NRCS state and field biologists in each region, a rough estimate of conditions and trends was made.

Questionnaires were sent to NRCS state and field biologists in each of the 50 states. Thirty usable questionnaires were returned; a return rate of 60 percent. At least three questionnaires were returned from each of the six NRCS regions. The results presented tables 613–1, 613–2, 613–3, and 613–4 estimate the general status of the Nation's corridors.

The millions of miles of roadside corridors in the United States represent a potentially rich habitat resource. Many roadsides are dominated by a single (often exotic) grass species that is of limited habitat value. Roadside management practices further reduce habitat value. Roadside mowing during the nesting season is a common practice that destroys nests, kills adult birds and small mammals, and degrades roadside habitat. Roadsides that are disturbed frequently harbor numerous large patches of noxious weeds.

Some states have initiated integrated vegetation management or roadside wildflower programs that emphasize native plants and ecologically based management practices. However, the habitat and aesthetic benefits roadside corridors could provide generally go unrealized. The status of powerline, pipeline, canal, and railroad corridors is unknown. The quality of these corridor types may be similar to those of roadsides.

**Table 613–1** Estimated change in various conservation corridor types from 1988 to 1998 (data indicate number of states responding)

| Type | Increased | Same | Decreased | NA | N |
|---|---|---|---|---|---|
| Riparian/stream corridors on 1st and 2nd order streams | 4 | 9 | 16 | 0 | 29 |
| Riparian/stream corridors on 3rd and higher order streams | 4 | 13 | 13 | 0 | 30 |
| Wetland, lake, and reservoir buffers | 6 | 9 | 13 | 0 | 28 |
| Field borders | 7 | 3 | 18 | 2 | 30 |
| Field buffers (in field) | 11 | 10 | 7 | 2 | 30 |
| Filter strips | 21 | 4 | 5 | 0 | 30 |
| Grassed waterways | 18 | 11 | 1 | 0 | 30 |
| Vegetated ditches | 4 | 13 | 11 | 2 | 30 |
| Grassed terraces and diversions | 9 | 10 | 5 | 3 | 27 |
| Windbreaks/shelterbelts | 7 | 9 | 5 | 8 | 29 |
| Hedgerows | 1 | 8 | 16 | 3 | 29 |

NA = Not applicable
N = Number of states responding

**Table 613–2** Estimated habitat value of various conservation corridor types (data indicate number of states responding)

| Type | Excellent | Good | Fair | Poor | NA | N |
|---|---|---|---|---|---|---|
| Riparian/stream corridors on 1st and 2nd order streams | 2 | 10 | 11 | 6 | 0 | 29 |
| Riparian/stream corridors on 3rd and higher order streams | 2 | 8 | 13 | 7 | 0 | 30 |
| Wetland, lake, and reservoir buffers | 2 | 10 | 12 | 6 | 0 | 30 |
| Field borders | 0 | 5 | 12 | 13 | 0 | 30 |
| Field buffers (in field) | 0 | 2 | 9 | 14 | 5 | 30 |
| Filter strips | 0 | 7 | 10 | 12 | 0 | 29 |
| Grassed waterways | 0 | 2 | 10 | 14 | 4 | 30 |
| Vegetated ditches | 0 | 4 | 11 | 11 | 2 | 28 |
| Grassed terraces and diversions | 0 | 3 | 8 | 15 | 4 | 30 |
| Windbreaks/shelterbelts | 2 | 11 | 4 | 5 | 8 | 30 |
| Hedgerows | 2 | 8 | 9 | 4 | 10 | 29 |

NA = Not applicable
N = Number of states responding

**Table 613–3** Estimated importance of four non-NRCS corridor types as habitat for wildlife (data indicate number of states responding)

| Type | Very important | Important | Somewhat important | Not important | Do not know | N |
|---|---|---|---|---|---|---|
| Roadside | 4 | 11 | 10 | 3 | 1 | 29 |
| Powerline ROW | 4 | 6 | 12 | 4 | 2 | 28 |
| Railroad ROW | 1 | 10 | 15 | 2 | 1 | 29 |
| Pipeline ROW | 4 | 2 | 12 | 7 | 4 | 29 |

NA - Not Applicable
N - Total Number of States Responding

## (h) Summary

The Nation's corridors are clearly in decline. Yet the need for conservation corridors as part of an integrated approach to conserving biodiversity has never been greater. Why the apparent indifference to the loss of some types of corridors? Biologist Allen Cooperrider (1991) argues that the underlying causes of indifference toward environmental decline in general are perceptual and attitudinal. He suggests that we must begin to see, think, and act more holistically and reestablish an attachment to the land as an ecological system, of which we are an integral part, if we are to become good stewards.

> *The farmer identifies with the agricultural landscape, and this landscape represents the farmer. A farmer's work is constantly on view, and the farmer's care of the land can be readily judged by his peers. Consequently, the agricultural landscape becomes a display of the farmer's knowledge, values, and work ethic.* (Nassauer and Westmacott, 1987)

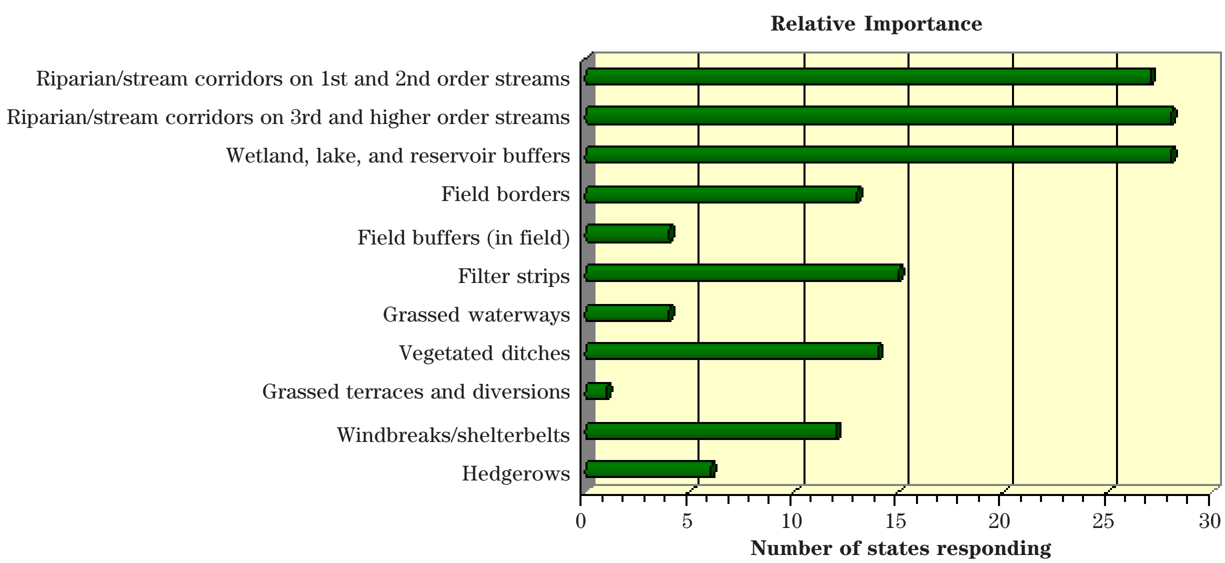
Landscapes managed on cultural concepts of nature that embrace neatness and productivity can be quite different from those managed on scientific concepts of ecological function and structure.

## (i) Case study

The following case study, Louisiana Black Bear Use of Corridors, illustrates two corridor-planning principles:

- Natural connectivity should be maintained or restored.
- Connected reserves/patches are better than separated reserves/patches.

**Table 613–4** Ranking of the overall importance of various corridor types for conservation of soil, water, air, plants, and wildlife

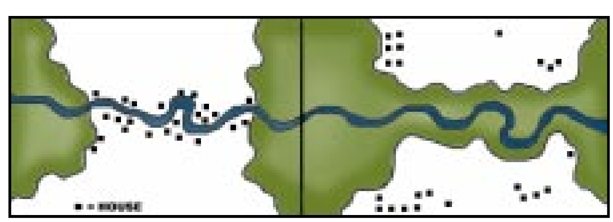


**Case Study:**

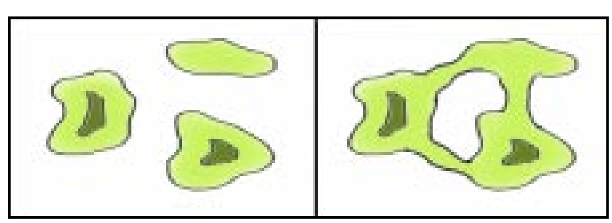
# Louisiana black bear use of corridors

Corridor Planning Principles described in section 613.04 that are exhibited by this case study include:

**Natural Connectivity Should Be Maintained Or Restored.**




**Connected Reserves / Patches Are Better Than Separated Reserves / Patches.**



# Case Study: Louisiana Black Bear Use of Corridors

*This case study illustrates the importance of conservation corridors in maintaining viable populations of large mammals in fragmented landscapes.*

The Louisiana black bear (Ursus americanus luteolus) was once abundant in east Texas, southern Mississippi and all of Louisiana. Habitat loss and fragmentation have diminished the range of the black bear by 90 to 95%. In January 1992, the U.S. Fish and Wildlife Service designated the Louisiana black bear as threatened under authority of the Endangered Species Act.

In 1994, wildlife biologists at the University of Tennessee initiated a study of corridor use and feeding ecology of black bears in the Tensas River Basin in northern Louisiana. The 350 $km^2$ privately owned study area contained four major isolated hardwood patches, some linked by wooded corridors. The patches were surrounded by agricultural fields of corn, soybeans, cotton, wheat, and other small grains.

Corridors in the study area are rivers, bayous, and ditches bordered by wooded strips 5 to 75 m wide. The corridors are typically linked to wooded tracts. Four major corridors in the study area ranged from 50 to 73 m in width. The height and density of vegetation in most corridors was sufficient to conceal bear movements.


**Figure 1:** *This cub will use corridors to access food resources outside of the wooded patches.*


**Figure 2:** *Wooded corridors become important conduits for bear movement between wooded patches, particularly during the mating season.*

Radio collars were placed on 19 Louisiana black bears, 6 males and 13 females and their movement was tracked over 18 months. Analysis of the telemetry data indicates that the bears were located in forested patches and corridors more than expected in proportion to their occurrence in the landscape. All 6 male bears in the study moved to a wooded patch other than the patch they were originally captured in; only 3 females moved to another patch. Fifty-two percent of the male bear patch-to-patch movement and 100% of all female bear movement were between patches connected by corridors. Adult male bears used the corridors most intensively in June and July, the breeding season. Sub-adult bears used the corridors for dispersal from their natal home range. Bears also used the corridors to access food resources outside wooded patches.

Researchers concluded that:

- Bears preferred corridors to agricultural fields when outside of a forest tract.
- Corridors allowed bears to move farther away from forested tracts.
- Bear movement between wooded patches connected by corridors was more frequent than between patches that were not connected.

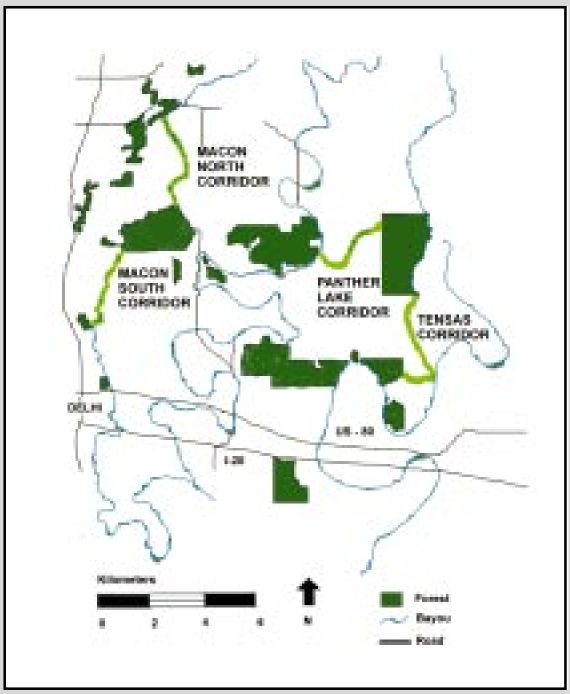



***Figure 3:*** *The importance of wooded corridors in linking wooded patches in Louisiana is clearly illustrated in this diagram.*

This study demonstrates that wooded corridors between forested tracts were used by both male and female bears. Long-term management should include maintenance and enhancement of wooded corridors that link substantial forested patches and construction of new corridors.

Numerous research projects report black bears require large unbroken tracts of suitable habitat to sustain a population. This study suggests that corridors may be vital to the survival of Louisiana black bear in highly fragmented landscapes.

The material for this case study was abstracted with permission from Anderson, D.R. 1997, *Corridor use, feeding ecology, and habitat relationships of black bears in a fragmented landscape in Louisiana*, Masters thesis, University of Tennessee, Knoxville.

# 613.03 Corridor benefits

## (a) Introduction

As habitats continue to be lost to various types of development and landscapes are increasingly fragmented, land managers are relying on the ecological functions of corridors to conserve soil, water, fish, and wildlife. Conservation of these basic resources provides benefits for individual landowners and the larger community. The benefits associated with corridors can be grouped into three categories: environmental, social, and economic.

The potential adverse impacts that also can be associated with corridors are described in section 613.03(e).

## (b) Environmental benefits

The environmental benefits of corridors come from those functions that improve the condition of the watershed. Two general environmental benefits provided by corridors are environmental services and habitat.

### (1) Environmental services

Environmental services include

- reduced flooding,
- reduced soil erosion,
- improved water quality,
- increased water quantity,
- groundwater recharge,
- bank stabilization, and
- improved air quality.

Stream/riparian corridors and attendant wetlands in flood plains provide floodwater storage, desynchronize flood flows, and slow flood velocities. Downstream flooding and the potential for flood damage are diminished when floodwater volume and velocity are reduced. Streambanks stabilized by the roots of riparian vegetation reduce bank erosion, a major source of sedimentation in some streams.

Stream corridors also function as sponges, retaining soil moisture and in some locations recharging ground water supplies. Water stored in soil is released slowly back into rivers and streams, which helps maintain streamflows and sustain aquatic life during dry seasons.

During the growing season, healthy riparian vegetation intercepts most of the sediment and agricultural chemicals in sheet and shallow subsurface flow originating in fields and pastures before they can reach streams or rivers. This filter function of riparian buffers protects many wetlands, lakes, and streams at a critical time when they are nutrient stressed and prone to eutrophication. In the fall some of the nutrients produced in riparian corridors are released when leaves, grass, needles, and limbs fall or are washed into streams and rivers. This cycling of nutrients supplies the food energy required to support diverse populations of aquatic organisms throughout the stream system. Forested stream corridors are also an important source of woody debris for fish habitat, bank armouring, and as natural grade control structures (fig. 613–19).

Continuously vegetated riparian corridors are more effective at maintaining surface and subsurface water

**Figure 613–19** Woody debris in stream channel provides critical habitat for native trout and dampens erosion of the streambank (photo courtesy Gary Bentrup, USU)

quality than those that are discontinuous. Water quality is strongly influenced by water temperature. A slight increase in water temperatures above 59 degrees Fahrenheit produces a substantial increase in the release of sedimentary phosphorus, which can result in eutrophication. Thus, a leafy canopy provided by woody riparian vegetation can reduce the adverse affects of pollutants. In addition, cool water, which has higher oxygen content, is necessary to support populations of many game fish, particularly trout and salmon. A cool, moist microclimate is also a requisite for many terrestrial species. For a more detailed description of the environmental services provided by stream/riparian corridors, see *Stream Corridor Restoration: Principles*, *Processes*, *and Practices* available at

www.usda.gov/agency/stream_restoration/

Introduced upland conservation corridors generally are designed to function as barriers, filters, and sinks. They reduce soil erosion caused by wind and water, conserve soil moisture, trap sediment, and absorb agricultural chemicals. Shelterbelts reduce wind velocity for a distance of 8 to 10 times their height on the lee side.

When wind velocity is diminished, it has less energy to dry out soil and plants and to dislodge and transport soil particles. Continuous windbreaks eliminate the problem of airflow through gaps or around the ends of windbreaks, which can significantly diminish their effectiveness. A continuous windbreak or remnant corridor is also effective at capturing and retaining snow in the field. Captured snow can represent over 20 percent of the annual soil moisture in north-central agricultural areas (fig. 613–20).

Field barriers of tall wheatgrass can reduce potential wind erosion to nearly 7 percent of open field erosion. When the volume of airborne soil particles in the watershed is reduced, air quality is enhanced.

Windbreaks, buffer strips, field borders, grassed waterways, and roadsides, like riparian corridors, are effective sediment traps and nutrient sinks. For example, an estimated 95 percent of sediment from row crop fields was trapped in grassed waterways in an Iowa study area. In Illinois, grassed waterways and forest buffers reduced nitrates in subsurface water an estimated 80 to 90 percent. Corridor vegetation can, however, be overwhelmed by sediment and chemicals, and absorption capabilities may be reduced significantly.

***(i) Environmental services value-added benefits of connectivity***—A linked system of various conservation corridor types properly sited optimize soil and water conservation in the watershed by increasing efficiencies and integrating ecological functions. When terraces, filter strips, and other conservation management practices are linked to grassed waterways and riparian buffers, the value-added benefits include longer concentration times for overland waterflows, increased infiltration, and increased retention time, which facilitates assimilation of nutrients.

Systems of upland corridors can reduce floodwater volume, sedimentation, and pollutants in adjacent receiving streams. The nutrient and sediment control system developed by the NRCS in Maine combines sediment basins, filter strips, constructed wetlands, and deep ponds into a single, connected system that has a 90 percent removal rate for sediment and phosphorus, even after extreme storm events.

### (2) Habitat

Habitat benefits include those for terrestrial and aquatic wildlife. Habitat is defined here as the ecosystem in which a species lives. Each species responds differently to physical variables in the ecosystem including the pattern of patches, corridors, and matrix.

**Figure 613–20** The windbreak captures snow, which increases soil moisture in adjacent fields and provides critical winter wildlife habitat (photo courtesy Craig Johnson, USU)

For example, wildlife differ in their ability to disperse. Species, such as reptiles, have physical limitations; other species have behavioral or physiological limitations. Most species are not limited in their ability to use corridors, but experience high levels of mortality dispersing across landscapes that do not have corridors.

Many species instinctively seek patterns that meet their needs for food, cover, water, space, reproduction, and security; others learn this information (fig. 613–21). The high edge-to-interior ratio of most corridors makes them particularly attractive to edge habitat species. However, because corridors often do not provide all the requisite resources, the home range of many species extends beyond the corridor into adjacent patches and the matrix.

The following factors affect roadside corridor use by wildlife:

- Type of vegetation in the corridor
- Type of vegetation adjacent to the corridor
- Surrounding land uses
- Corridor management
- Geographic location

Many wildlife species in agricultural landscapes have adapted to wooded corridors and expanded their range. Others that require large patches of forest or prairie have been displaced. The habitat value of corridors in highly fragmented landscapes is well documented. Riparian corridors, shelterbelts, windbreaks, and roadsides have been extensively researched. Less research has been done on the habitat value of field buffer strips, grassed waterways, conservation terraces, power line corridors, and other introduced corridors.

***(i) Stream/riparian habitat***—Stream corridors are among the most productive habitats in all regions of the country. They are particularly important in arid and semi-arid landscapes. The vegetation in most riparian zones is structurally more diverse, and biomass production is higher than the adjacent matrix. This vegetation provides an increased diversity of niches for wildlife to exploit. In addition, water, aquatic insects, and fish provide resources supporting wildlife species that require both aquatic and upland environments.

Wildlife species diversity and density are high in riparian zones. In a Blue Mountain study area in eastern Oregon, 75 percent of the terrestrial vertebrates were dependent upon or preferred riparian habitat. Biologists Stauffer and Best (1980) estimated an average of 500 breeding pairs of birds per 100 acres in riparian corridors in Iowa compared to 340 pairs in upland forests. Bird densities in riparian zones in Arizona were 66 percent higher than densities in the adjacent desert upland (fig. 613–22). Riparian corridors are also important travel lanes for many species. They may be important for dispersal as well as movement within species home ranges.

**Figure 613–21** Many large mammals use traditional migration corridors between summer and winter range (photo courtesy Kristen Rol, UT)

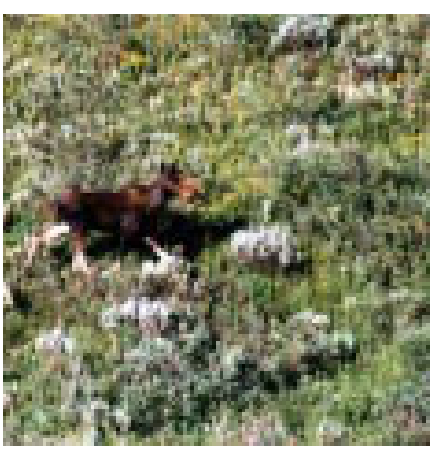
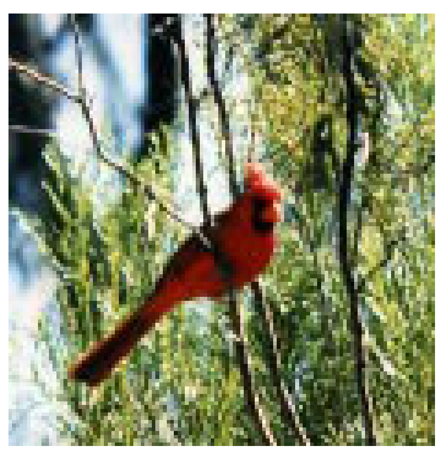


**Figure 613–22** Many birds rely on riparian habitats for food and cover (photo courtesy Craig Johnson, USU)



***(ii) Windbreaks and shelterbelts***—The diversity of ecological niches and weather protection afforded wildlife by windbreaks are particularly important in agriculturally dominated landscapes. Windbreaks provide food, nesting, brooding, loafing, thermal, and escape cover for many species of birds and mammals (fig. 613–23). They are also used as travel lanes by migratory and nonmigratory species. Windbreaks are important resting stops for songbirds during spring and fall migration. At least 108 species of birds are known to use shelterbelts for foraging, nesting, or resting.

In seven Minnesota windbreaks, a mean nest density of 36 nests per acre was reported. Researcher Shalaway (1985) reported higher nest success for low- and mid-level nesting species in fencerows than in native shrub or woodlands.

Windbreaks are an important habitat component for many game species including the ring-necked pheasant (*Phasianus colchicus*), northern bobwhite (*Colinus virginianus*), mourning dove (*Zenaida macroura*), wild turkey (*Meleagris* spp.), eastern cottontail rabbit (*Sylvilagus floridanus*), western cottontail rabbit (*Sylvilagus audubonii*), gray squirrel (*Sciurus carolinensis*), fox squirrel (*Sciurus niger*), and whitetail deer (*Odocoileus virginianus*). Windbreaks and remnant-wooded corridors are used as travel lanes by carnivores, such as the gray fox (*Urocyon cinereoargenteus*) and other midsized predators.

**Figure 613–23** Generations of woodpeckers, flickers, and bluebirds have been reared in this windbreak snag (photo courtesy Craig Johnson, USU)

***(iii) Grassed waterways and buffer strips***—Grassed waterways and infield buffer strips are typically seeded in a monoculture of exotic grasses and share similar locations embedded in the agricultural matrix (fig. 613–24). However, they are important habitats for many ground nesting species and species that prefer early successional vegetation. In one Iowa study, 14 bird species were observed nesting in grassed waterways. Nest densities of over 1,100 nests per 250 acres of grassed waterways were reported. These nest densities exceed densities found in no-till and cropped fields. Dickcissels (*Spiza americana*) daily survival rates when nesting in grassed waterways were the same as those reported for old fields and prairie remnants. Grassed waterway habitats could be even more productive if seeded with a mix of native grasses and forbs.

***(iv) Other corridors***—Roadsides and field borders also share common locational and structural characteristics. Although exceptions exist, they are typically on the edges of the agricultural matrix and are dominated by a few grass species. However, biologists working in Minnesota report that roadsides support over 300 species of plants and wildlife including some of the last remnant populations of native grass and forb species in the state.

Wildlife biologists have extensively researched the value of roadsides as habitat for wildlife, particularly game species. In intensively farmed landscapes, roadsides are a particularly important habitat component

**Figure 613–24** Unmowed grassed waterway offers habitat for ground-dwelling bird species (photo courtesy North Carolina State University)

for ring-necked pheasants (fig. 613–25), gray partridge, cottontail rabbits, and many songbirds. Researcher Lars Anderson (1996) reported 27 species of birds using Utah roadsides from April to November; 12 of these species are known to nest in roadsides. Researchers reported relatively high levels of bird species richness in upper Midwest roadsides. About 27 percent of the pheasants recruited into the fall population in Minnesota were produced in roadsides. Although losses to predation and parasitism for pheasants and songbirds nesting in roadsides are relatively high, they generally do not exceed those of the matrix.

***(v) Value-added benefits of connectivity***—Biologist Reed Noss (1991, 1993) notes that two ways to improve habitat quality while mitigating the effects of fragmentation are to increase effective habitat area and connectivity. Conservation corridors can do both. In our highly fragmented landscapes, the value of connecting habitats far outweighs the potential disadvantages. Some of the potential value-added benefits of connecting patches with conservation corridors for wildlife include

- increased habitat area,
- increased opportunities for colonization,
- habitat accessibility,
- increased niche diversity, and
- escape cover.

**Increased habitat area**
Increased habitat area is probably the most significant benefit of conservation corridors in urban or agriculturally dominated landscapes. For instance, a continuous 30-foot-wide windbreak that surrounds a quarter section of agricultural land can add over 3.5 acres of valuable wooded habitat. As Noss points out: "Corridors, even narrow ones, provide habitat in which some kinds of organisms will live and reproduce."

Additional habitat benefits can be realized if corridor width is increased (fig. 613–26). Wider corridors obviously increase total area, but they also provide for the life requirements for a greater diversity of species. In addition, wider corridors if properly designed may mitigate some of the negative effects of edge and contain some forest interior habitat.

**Increased opportunities for colonization**
Properly located conservation corridors that connect with each other and adjacent patches may facilitate immigration and colonization of habitat patches within the watershed. Researchers studying white-footed mice (*Peromyscus leucopus*) in Ontario found that a network of corridors that connected shelterbelts to woodlots was beneficial for recolonization of vacant patches.

Corridors designed to meet the specific requirements of species vulnerable to local extinction can reduce

**Figure 613–25** Pheasants are primary beneficiaries of quality roadside habitat (photo courtesy of Pheasants Forever)

**Figure 613–26** Lower end of riparian corridor is wide enough to provide habitat for interior-dwelling species (photo courtesy Bill White, USDA NRCS)

their risk. Immigration may help sustain local populations, and connected patches may facilitate recolonization of areas within the local species extinction.

When a network of several alternative corridors or "stepping stone" patches are provided within the landscape, additional value-added benefits may be achieved (fig. 613–27). A redundant network may increase dispersal opportunities in the event that one or more of the corridors are blocked, severed, or made temporally dysfunctional by disturbance, such as fire, drought, or insect outbreaks.

**Habitat accessibility**

Corridors connecting patches increase overall habitat quality within the watershed. They provide wildlife relatively safe access to a diversity of habitat resources, which are typically dispersed across the landscape and may change with climate and seasons. Corridors facilitate dispersal among subpopulations, increasing the growth rate and stability of these populations through recruitment and colonization. Corridors that connect drainageways to ridges support greater species richness and abundance than those limited to a single topographic setting (fig. 613–28). Introduced corridors aligned perpendicular to stream corridors facilitate wildlife migration from uplands to riparian areas and wetlands during times of drought. When corridors are aligned with natural wildlife travel patterns, movement and access to different habitats are greatly enhanced; for wide-ranging species, effective foraging area also may be increased.

**Figure 613–27** Parallel windbreaks in this Missouri landscape provide wildlife alternative routes from upland patches to the riparian corridor (photo courtesy Bill White, USDA NRCS)

**Figure 613–28** Network of interconnected riparian and upland corridors provides for greater wildlife diversity (photo courtesy USDA NRCS)

**Increased niche diversity**
Connected landscapes can facilitate natural ecological functioning, which in turn may increase niche diversity. Connectivity perpendicular to the long axis of a corridor (lateral connectivity) can be as important as connectivity along the long axis.

Natural flooding, channel meandering, scouring, and sediment deposition all require lateral connectivity. Natural flooding, which creates conditions for plant succession, can reset forest stand age diversity and increase the diversity of niches. Such species as the least bell's vireo (*Vireo bellii pusillus*) are highly dependent on the 3- to 5-year-old riparian vegetation fostered by periodic flooding. Increased niche diversity may also increase wildlife species richness. Biologist Schroeder, et al. (1992) found breeding bird species richness increased in shelterbelts as niche diversification was improved by the addition of snags and increased foliage height diversity (fig. 613–29). The same is true for bats.

**Escape cover**
Generalist carnivores and omnivores appear to benefit from fragmented landscapes and may be a strong factor in the decline of prey species in agricultural landscapes. Corridors connecting patches may bring prey/predator relationships into a better balance by allowing prey species more options to move with greater safety among patches.

**Figure 613–29** Diverse vegetation types, heights, and spacing make this corridor a rich habitat for many species (photo courtesy Gary Bentrup, USU)

## (c) Social benefits

Perhaps the most important social benefits are the environmental services corridors provide. After all, clear air, an adequate supply of clean water, and productive farms, forests, and rangelands are essential to all life including humans. Other significant social benefits that corridors provide include recreation, education, and aesthetics.

### (1) Recreation
Outdoor recreation has always been a significant part of American social life. Demands for outdoor recreation are increasing in today's fitness conscious society. Much of the demand has focused on the recreation opportunities corridors afford. The linear configuration of corridors makes them well suited to a variety of recreational activities, especially trail-oriented sports. Trails provide a venue for

- hiking,
- walking,
- jogging,
- inline skating,
- cycling,
- cross-country skiing,
- horseback riding,
- nature photography, and
- wildlife viewing.

Riparian corridors are especially attractive locations for trails (fig. 613–30). The presence of water, diverse vegetation, moderated climate, and abundant wildlife enhances the recreation trail experience. Boating, rafting, kayaking, tubing, fishing, and hunting are popular nontrail activities in many corridors with perennial flowing water. Some riparian corridors have become so popular that demand frequently exceeds the social and ecological carrying capacity. Social conflicts between different types of users and degradation of the riparian resource often result.

Other types of corridors are used extensively by recreationists. The highly successful Rails-to-Trails program has converted thousands of miles of abandoned railroad right of ways into recreational trails. An excellent example is the 12-mile trail along the Wood River between

Hailey and Ketchum, Idaho, used by commuters as well as recreational cyclists.

Shelterbelts, field borders, grassed waterways, canals, and other types of strip corridors become important recreational resources during the hunting season (fig. 613–31). Pheasant and quail hunters appear to be more successful in areas with shelterbelts and other types of woody cover. A survey of Kansas hunters showed they spent an average of 40 percent of their hunting time in or near shelterbelts; more than 80 percent spent at least some time hunting in shelterbelts during the season. These figures are particularly impressive given the small percentage of the Kansas landscape devoted to shelterbelts.

**Recreation value-added benefits of connectivity**

- Continuity of experience
- Safety

One value-added benefit of corridor-connected landscapes for recreationists is the continuity of experience that connectivity provides. Hunters prefer to hunt in loops to and from the point where the hunt begins allowing continual hunting in promising habitat. A system of connected corridors and patches provides this opportunity. When rivers and streams are free of obstructions, such as culverts, dams, or diversions, water-related recreationists can kayak, tube, and fish without having to continually get in and out of the water. In both cases recreationists are free to concentrate on their recreational pursuit in an environment that adds richness to the experience.

**Figure 613–30** Walkers enjoy a cool spring afternoon in an urban greenway (photo courtesy USDA NRCS)

A safe corridor can reinforce recreational experiences. Continuously linked corridors with trails are safer than corridors crossed by roads or railroads, pastures, fields, or fences. The city of Boulder, Colorado, installed expensive trail underpasses at all road crossings along Boulder Creek to minimize risks for recreationists. If road crossings and other barriers are minimized, costly retrofits can be avoided later.

### (2) Education

Rich in species diversity and typically accessible remnant, riparian, and regenerated corridors are ideally suited to outdoor education. Trails in corridors lend themselves to a variety of formal and self-guided interpretative nature programs and educational experiences including

- natural history,
- taxonomy,
- archeology,
- history,
- environmental science,
- experimental design, and
- the arts.

Increasing numbers of science teachers are taking their classes outdoors, often into corridors to collect

**Figure 613–31** Three friends enjoy a hunt in quality habitat (photo courtesy USDA NRCS)

specimens and conduct experiments (fig. 613–32). They have discovered that students learn more and retain concepts longer when involved in hands-on educational experience.

Perhaps more importantly, corridors afford opportunities to investigate nature on your own. Harvard historian John Stilgoe noted a strong correlation between adults with a strong environmental ethic and the opportunities they had at an early age to explore nature. Researcher Black, et al. (1988) found people living near riparian corridors were more knowledgeable about wildlife than those living only a few blocks away. The lessons learned in corridors may be extremely important in molding future generations of conservationists.

Archeological and cultural sites are often concentrated in riparian corridors. The juxtaposition of cultural and natural resources presents opportunities to interpret the role societies past and present have played in the evolution of a landscape. These sites are also well suited to illustrating the importance of corridors in maintaining landscape health, stability, and quality of life.

Some corridors are a valuable resource for research. National Research Council researchers argue that ecologically stable stretches of riparian corridors should be preserved as research reference benchmarks. At a smaller scale, remnant plant communities and wildlife populations are occasionally found in roadsides, railroad right-of-ways and other types of corridors. They are a valuable source of information about the ecology of native plant communities. Remnant plants may also be a source of regionally adapted seed for restoration experiments and projects within a watershed.

**Value-added benefits of connectivity**

- Safety
- Ecosystem transects

Corridors, a great education resource, are even a greater resource when not bisected by roadways. Teachers can focus on teaching rather than worrying about students wandering across roadways. Corridors can be used to connect urban and rural areas. As society becomes increasingly urbanized, people lose contact with natural ecosystems and the agricultural practices that sustain human life. Corridors that originate in cities and towns and pass through rural environments allow urban residents to experience natural and agrarian landscapes. Winding through a mosaic of hay fields, pastures, and farm buildings, greenways can provide exposure to agricultural environments (fig. 613–33). Such exposure may facilitate better understanding and appreciation of farming and ranching, increasing respect for landscapes that support these activities. Careful trail design is necessary to protect the property rights of landowners.

**Figure 613–32** Fish and aquatic insects caught here will be used in a class discussion on the aquatic food chain (photo courtesy Diane Bentrup, ??)

**Figure 613–33** The view from this trail helps the observer understand that agriculture and the natural landscape can co-exist in harmony (photo courtesy Gary Bentrup, USU)

### (3) Aesthetics

Visual resources that define a landscape's aesthetic quality are the lines, forms, spaces, colors, and textures experienced from where people live, work, recreate, and travel. The quality of visual resources is important to those who reside in and travel through a landscape. Wooded corridors are often the most significant visual lines, forms, and space defining structures in the landscape. Wooded corridors provide

- spatial structure,
- sense of place and identity,
- complexity, legibility, coherence, and mystery, and
- seasonal diversity.

Many landscapes along the eastern seaboard, in the Midwest, and across the South are a rich mosaic of woody patches and open fields defined by corridors of uncut trees along property lines. On the Great Plains and westward, shelterbelts and windbreaks give a sense of place to homesteads and rootedness to communities. These unnatural blocks and baffles of vegetation punctuate and partition the prairie. They provide a visual structure and scale against which vastness can be measured. In the West, mountains dominate the background, but it is the flowing lines of riparian corridors that give human scale to the foothills and valley floor. Place names like Wood River Valley, Verde Valley, and Snake River Plains attest to the impact of riparian corridors on the regional consciousness. Occasionally the visual richness of a riparian corridor is extended into the uplands by canals, ditches, and grassed waterways.

Corridors also enhance scenic quality at a more intimate scale. Roadsides, railroad right-of-ways, canal banks, and field borders vegetated with native plants add textural diversity and seasonal color that enrich our experience of the landscape. Corridors also screen unsightly areas and buffer noise from highways and other sources. They significantly contribute to the quality of rural life.

**Aesthetic value added benefits of connectivity**

The added visual amenities provided by a system of connected corridors include

- Enhanced sense of place
- Link to cultural resources

One lesson painting has taught us is that all things are connected. A composition is created by lines, forms, colors, and textures that knit the diverse elements of the painting together into a unified composition. As observers of paintings, humans are frequently fascinated with the skills the artist used to achieve unity.

Connected corridors, particularly wooded corridors are important lines and forms that unify diverse elements in the landscape. Research by Rachel and Steven Kaplan (1978) suggests that people prefer landscapes that exhibit coherence, complexity, legibility, and mystery. Connected corridors can create these qualities. A landscape of linked corridors and patches is a legible landscape that humans can comprehend and appreciate.

The Minnesota Valley National Wildlife Refuge is a dominant visual element for those living in the Twin Cities metropolitan region (fig. 613–34). Similarly, the Big Sioux River riparian corridor in eastern South Dakota is a visual reference for residents in this rural area.

Linked remnant corridors of woody vegetation in the upper Midwest, east coast, and Southeast are visual reminders of historic landscape. Because many of these corridors are still linked, they have a scale that projects an impression far more powerful than disconnected, isolated remnants.

**Figure 613–34** Broad expanse of river, flood plain, bluffs, and prairie make Minnesota Valley National Wildlife Refuge a visual reference for Twin City residents (photo courtesy Michael Timmons, USU)

Research has also shown that people appreciate rural settings that have a mixture of cultural and natural resources. Old roads, stone walls, canals, cemeteries, and similar historic structures are often concentrated in corridors and can be incorporated into a conservation corridor program that protects biological diversity as well as historical character (fig. 613–35). A value-added benefit of connectivity is that it can protect the special sense of place that rural areas enjoy by protecting existing connections and by reestablishing historic linkages.

## (d) Economic benefits

Natural corridors provide economic benefits and values because they satisfy human wants or needs. Often, these values are not readily apparent and are difficult to estimate because they are not traded on a market. Researchers Thibodeau and Ostro (1981) used cost/benefit analysis techniques to calculate the value of wetlands in the Charles River riparian corridor near Boston. They estimated the value of land cost increase, water supply, flood prevention, pollution reduction, and recreation at between $153,000 and $190,000 per acre. They noted that some of these benefits were realized by owners of wetlands in the corridor; however, the majority of benefits accrued to the larger community within the watershed.

**Figure 613–35** Ruins of pre-historic Native American community near Verde River flood plain in Arizona (photo courtesy Craig Johnson, USU)

Benefits from introduced corridors include

- environmental services,
- increased crop yields,
- increased crop quality,
- increased livestock production,
- improved livestock health,
- reduced energy consumption,
- increased property values, and
- recreation revenues.

### (1) Environmental services

Productive topsoil is arguably this country's most valuable resource. An estimated 240 million tons of topsoil are eroded annually from Iowa farms and washed into the Missouri River. In a 1992 report, the National Research Council suggested grassed waterways, field borders, buffer strips, conservation terraces, and other introduced corridors that reduce soil erosion and sedimentation significantly contribute to the long-term economy of rural watersheds.

Sediment deposited over river bottom sand and gravel beds cause decline in Midwest aquatic species diversity. Reduced levels of sedimentation improve fisheries and enhance their economic revenues. Lower sediment loads also reduce the rate of filling in reservoirs, canals, and drainage ditches, prolonging their utility. The economic returns from these various environmental services can be substantial.

### (2) Increased yields and quality

Corridors, like shelterbelts, grassed waterways, terraces, and other corridor type conservation practices, generate economic returns exceeding the cost of installation and maintenance. In a study in Kansas and Nebraska, small grain production on the leeward side of windbreaks increased between 18 and 38 percent for a distance of 3 to 10 times the windbreak height. In a 6-year study in Nebraska, researchers estimated a 15 percent yield increase in winter wheat in fields protected by shelterbelts. They estimated that shelterbelts would pay for themselves within 15 years.

Increases in yield of 5 to 50 percent and improved crop quality were reported by agronomists for vegetable and specialty crops protected by windbreaks. Additionally, the climate modification produced by shelterbelts enhanced production of orchard and vineyard crops. Shelterbelts also produce microclimates that reduce stress and increase fitness in livestock and increase honeybee pollination and honey production. Shelterbelts provide protection from wind and snow, increasing survival of newborn sheep and cattle. These benefits are maximized when livestock are corralled outside the windbreak on the lee side.

### (3) Reduced energy consumption

Home heating is a major consumer of energy in rural residences and small communities (fig. 613–36). Properly located and designed windbreaks are a cost-effective way of lowering home energy consumption by 10 to 25 percent. Windbreaks can reduce the time and energy required to remove snow from around farm buildings and rural roads; saving money and improving farm efficiency. Windbreaks on the outskirts of small rural communities in the Northern States protect structures and significantly reduce snow removal costs.

### (4) Agroforestry products

Products obtained from windbreaks, riparian buffers, alley cropping, and woodlots are valued in billions of dollars, annually. Farmers, applying agroforestry principles, plant and manage tree and shrub species that bare edible fruits, nuts, and berries. These products are harvested and sold in local markets or to large commercial outlets. Trees in corridors are also harvested for fuel, pulp, posts, specialty woods (walnut), and use in the horticultural industry. Mushrooms and medicinal plants, such as ginseng, grown in the shade beneath corridor trees are high-priced commodities marketed in many regions.

Marketable products can also be obtained from grass corridors. The seed of some native grass species is a high value commodity. In Iowa, for example, the 1998 price of switchgrass seed was $17 a pound. Statewide production was unable to meet demand. Wildflowers, native grass stalks, and dried forbs are also harvested in grass corridors and sold in local markets and craft outlets. Providing products for the craft industry is a growing enterprise.

### (5) Increased property values

Land appraisal information and research findings suggest property adjacent to amenities like riparian corridors is valued higher than property without proximity to these amenities (fig. 613–37). In Western States, river and stream frontage property is in high demand, short supply, and 25 to 50 percent more expensive than property without frontage. Economists Fausold and Lilieholm (1996) cited numerous examples of significant increases in property values for land abutting parks or stream corridors. A study of riparian greenbelts in Boulder, Colorado, determined that the average value of property adjacent to the greenbelt would be 32 percent higher than those 3,200 feet away, all other variables being equal.

**Figure 613–36** Windbreaks surrounding rural subdivision reduce energy consumption during the winter and lower snow removal costs (photo courtesy USDA NRCS)

**Figure 613–37** Increased value of homes in Utah subdivision attributed to proximity to the open-space corridor (photo courtesy Craig Johnson, USU)

The influence of corridors on property values also applies to privately held greenbelt land without public access according to a study done near Salem, Oregon. The greenbelt land in the study was composed of rural farmland without trails. The study concluded that land adjacent to the greenbelt was worth approximately $1,200 more per acre than land located 1,000 feet away. The increased economic value these greenbelts generated was based on enhanced visual quality they provided.

In many cases restoration or enhancement of corridors is necessary to provide the economic benefits described. In California, homes situated near seven stream restoration projects had property values 3 to 13 percent higher than similar homes located on unrestored streams.

### (6) Recreation revenues

Trails along corridors are also important generators of revenue. A 1988 study of the Elroy-Sparta bicycle trail in Wisconsin found that users spent about $15 per person per day for trail-related expenses, for an overall annual economic impact of $1,257,000. In Minnesota, where trail networks are being expanded, the number of local bed and breakfast accommodations catering to trail users has exploded. The revenues these small businesses generate in rural towns can significantly impact the local economy and provide employment opportunities for the area's people. Economic benefits are increased when corridors provide a variety of recreational options, from floating a river to hiking on a trail. In Montana, visitors to the upper Missouri Wild and Scenic River and Lewis and Clark National Historic Trail contribute $750,000 annually to the economy of the area.

The National Research Council (1992) estimated the annual economic value of fishing on flowing water in the United States at $8 billion. Hunting also generates significant revenues. Researchers estimated an annual value for wooded draws in the Great Plains at $26 million for deer hunting and $1 million for turkey hunting. Kansas windbreaks generate an annual net value of $21.5 million for hunting. Many landowners realize direct economic benefits by charging rod or gun fees or leasing hunting or fishing rights on their property. Some landowners use a portion of these revenues to enhance habitat on their farm or ranch.

Bird watchers and other nonconsumptive users of wildlife resources also contribute to the local economy. Motel rooms in North Platte, Nebraska, filled with bird watchers are at a premium during the spring sandhill crane migration. Economists estimated active birders spend between $1,500 and $3,400 on birding each year; often their activities are in or adjacent to corridors (fig. 613–38).

**Figure 613–38** Recreational opportunities provided by corridors (photos courtesy of Jill Schroeder and Craig Johnson, USU, and the USDA NRCS)

## (e) Potential adverse impacts

The list of benefits associated with corridors is impressive and well documented; however, potential adverse impacts may originate in corridors. These impacts include

- crop damage,
- disease and weed infestations,
- predation/parasitism,
- social impacts, and
- visual impacts.

Proper planning, design, and management of corridors can mitigate many of these impacts.

### (1) Crop damage

A perception in rural America is that untended vegetation in natural patches and corridors is a major source of insects that infest crops. Corridors do in fact provide habitat for both pest and beneficial species of insects. Occasionally pest populations in corridors erupt causing significant damage to adjacent crops. In Texas a $50 per acre reduction in cotton yields in fields adjacent to windbreaks that overwintered large populations of boll weevils (*Anthonomus gradis*) was reported . Alfalfa weevils (*Hypera postica*) that also overwinter in windbreak litter can cause similar reductions in alfalfa production.

Birds and mammals that inhabit or move through corridors can also damage crops in the adjacent matrix. Some evidence suggests that crop losses caused by birds are higher in fields adjacent to windbreaks. Damage to grain and forage crops by deer and elk is a significant problem in many states. In Wisconsin, most farmers report only a few hundred dollars of deer damage to corn and hay crops each year. However, in areas where deer densities approach 90 deer per square mile, damage claims average $9,000 per farm. Browsing deer, elk, rabbits, and rodents can injure or kill nursery and orchard stock. Beaver frequently raise havoc with trees in urban greenways and decimate expensive stream restoration projects (fig. 613–39). However, in other settings, beaver can be important in watershed restoration and provide an important succession of snags for wildlife.

### (2) Disease and weed conduit

Simberloff (Mann and Plummer 1995) noted that corridors can be conduits for diseases, predators, exotic species, and fire. Poorly managed roadside corridors are notorious conduits for noxious weeds (fig. 613–40). Seeds and suckers from corridors may spread into the adjacent matrix. For example, cheat grass (*Bromus tectorum*) dominates many roadsides in the Great Basin and spreads rapidly into abutting rangeland. This early curing, flashy fuel is the ignition source for many range fires.

**Figure 613–39** Cottonwood planting cut by beaver (photo courtesy Craig Johnson, USU)

**Figure 613–40** Ubiquitous tumbleweed uses roadside corridor to spread into adjacent desert grassland matrix (photo courtesy Dick Rol, USU)

### (3) Predation/parasitism

Narrow corridors are prone to high levels of predation and parasitism. Biologist Best reported that 29 percent of the songbird nests in an Iowa study (Camp and Best 1993) plot were parasitized by brown-headed cowbirds (*Molothrus ater*). Large, ground nesting birds, such as the ring-necked pheasant, and ducks can be particularly susceptible to predation in corridors. In one eastern Colorado study, an estimated 55 percent of roadside pheasant nests were terminated by predation. Biologists acknowledge high rates of pheasant mortality in roadsides, but argue that roadsides and other types of strip cover are not sinks; production exceeds losses to predation.

Michael Soule (1991, 1991a) suggests disease, predation, and parasitism concerns are most applicable for threatened and endangered species. In highly developed landscapes, he argues the benefits of corridors for most species far outweigh their potential adverse impacts.

### (4) Social impacts

Riparian corridors are susceptible to adverse impacts from recreation (fig. 613–41). The high levels of recreation activity in some riparian corridors are sufficient to displace some species of wildlife. Often the vacated habitat niches are occupied by less desirable species. Intense recreation activity can lead to the degradation of the corridor's ecosystem with potentially long-term adverse consequences.

**Figure 613–41** Riparian corridor severely impacted by anglers and other recreationists (photo courtesy Craig Johnson, USU)

### (5) Visual impacts

The alignment and management of some corridors produce highly contrasting lines and forms in the landscape. Highway, pipeline, and power line corridors routed through forests frequently produce unsightly swaths. Power transmission lines across farmland and prairies are viewed as equally unattractive. In some cases woody introduced corridors block desirable views.

### (6) Other potential impacts

Networks of corridors may not always be desirable. For example, two spatially separated populations of the same species may develop different genetic adaptations to the environmental condition. If these patches are linked and species move between them and interbreed, these adaptations could be lost. Both populations could decline or go extinct.

These potential adverse impacts may be inherent in corridors or the way society chooses to manage them. Many can be mitigated by consulting with biologists when planning, designing, and managing corridors.

## (f) Corridor benefits summary

Corridors within a watershed provide a multitude of economically and socially significant benefits for individual landowners and the larger community. Many of these benefits are complementary, but they can conflict. An example is intense recreation and wildlife habitat. Reed Noss (1987, 1991, 1993) acknowledges these potential conflicts and argues that the primary goal for conservation corridors in general should be to preserve and enhance biological diversity. Corridors are not a panacea; a landscape of corridors is a landscape populated by edge species and limited in its diversity. Patches of plant community types indigenous to a watershed and large enough to support viable populations of native wildlife species within a well-managed matrix are essential to maintaining biodiversity.

The challenge for land managers is to accommodate uses compatible with corridor resources while maintaining the ecological integrity of existing corridors. Planting new corridors to conserve soil and water and to provide connectivity between patches for vulnerable species of wildlife are equally important. The challenge must be extended to conservation of existing patches, patch restoration, and ecologically sound management of the matrix. This requires a detailed knowledge of corridor and patch resources, management practices, user demands, and landowner and Agency concerns. Sections 613–06, 613—07, 613–08, and 613–09 describe the planning process to address these issues at watershed and conservation plan scales. As recommended by the National Research Council in 1992, the process emphasizes the integration of existing conservation practices to optimize the benefits corridors provide (fig. 613–42).

**Figure 613–42** Boulder Creek in Boulder, Colorado, is a model of integrated riparian corridor resource planning (photo courtesy Craig Johnson, USU)

## (g) Case study

The following case study, Pequea-Mill Creek Watershed, illustrates three corridor-planning principles:

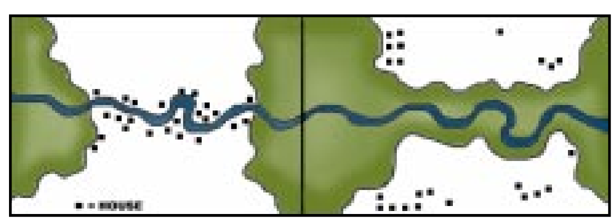
- Natural connectivity should be maintained or restored
- Manage the matrix with wildlife in mind
- Native species are better than introduced species

## Case Study:

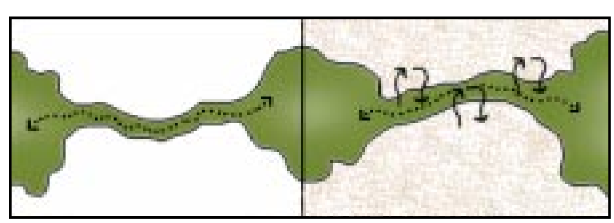
# PEQUEA - MILL CREEK WATERSHED

Corridor Planning Principles described in section 613.04 that are exhibited by this case study include:

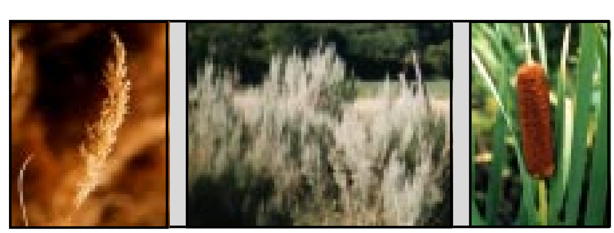
**NATURAL CONNECTIVITY SHOULD BE MAINTAINED OR RESTORED.**



**MANAGE THE MATRIX WITH WILDLIFE IN MIND.**



**NATIVE SPECIES ARE BETTER THAN INTRODUCED SPECIES.**



# Case Study: Pequea - Mill Creek Watershed

*This case study illustrates how an extensive watershed wide partnership coordinated by NRCS has produced and implemented a plan for restoring 37 miles of stream corridor and adjacent uplands. The conservation project, an on-going effort, continues to provide economic, wildlife habitat, recreation, and aesthetic benefits to watershed residents.*


***Figure 1:*** *The impacts of large numbers of cattle concentrated in a riparian zone for long periods of time can be devastating.*

The Pequea–Mill Creek watersheds are located in central Lancaster County in south–central Pennsylvania. The case study project area encompasses approximately 135,000 acres. Dairy farming is the dominant agricultural enterprise with 55,000 dairy cows distributed among 1,000 small farms located in the watershed.

The Pequea–Mill Creek Hydrological Unit Area Project, initiated in 1991, is focused on reducing potential nutrient, sediment, and bacterial losses from concentrated livestock areas around farmsteads and nutrient and pesticide management in crop fields. Barnyard management, streambank fencing, armored stream crossings, restoration of riparian plant communities, and grazing area management have been emphasized to reduce contamination from farmsteads.

These watersheds were selected under USDA's Water Quality Initiative to coordinate and increase a voluntary approach reducing agricultural nonpoint source pollution. Partners in this effort include Cooperative Extension, NRCS, Farm Service Administration, Lancaster County Conservation District, Pennsylvania Game Commission, Pennsylvania Department of Environmental Quality and numerous other agencies working with farmers, township officials and homeowners.

A partial list of accomplishments to date includes:

- Improved water quality
- 538 farmers have installed at least one conservation practice
- 180 farmers have developed contracts to install conservation practices
- 37 miles of stream have been fenced to exclude livestock on 84 farms in cooperation with the Pennsylvania Game Commission, U.S. Fish and Wildlife Service, and Lancaster County Conservation District
- 25 rotational lot management systems have been implemented to reduce the amount of runoff from livestock exercise areas
- Demonstrations of stream crossings, livestock watering and shading options have been developed with the Lancaster County Conservation District
- Information and education programs have been focused on farmer participation with involvement from the private sector in water quality efforts


***Figure 2:*** *The same reach of creek after exclosure fencing and revegetation.*


Water is a shared resource. By improving a stream, downstream neighbors benefit. Fencing sets a good example, encouraging upstream neighbors to protect their streams. Well-kept streams also make a good impression and provide a positive image of farms to the public.

***Figure 3:*** *Trout, songbirds, and butterflies inhabit this restored reach of Mill Creek.*

There are many other benefits from streambank fencing and planting in riparian corridors in addition to improved water quality. In the Pequea–Mill Creek Project, many farmers have learned that streambank fencing is an integral part of an effective dairy management program. For example, one significant benefit of streambank fencing has been improved dairy herd health. As one local expert says: "*There is nothing in the stream that is good for cows and there is nothing the cows do that is good for the stream.*" The Pennsylvania Game Commission has stocked trout in restored sections of the creek providing future recreation benefits for area residents.

Participants in the project report that streambank fencing and other conservation practices have:

- Improved dairy herd health
- Stabilized streambanks and reduced soil erosion
- Provided wildlife habitat
- Improved water quality
- Improved fish habitat
- Promoted rotational grazing

*For more information contact:*

*Pequea–Mill Creek Project*
*307 B Airport Drive*
*Smoketown, PA 17576-0211*
*Tel. (717) 396 – 9423*
*Fax. (717) 396 – 9427*

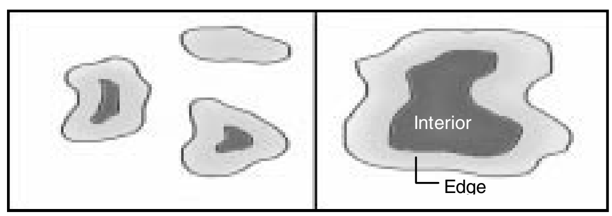
The information for this case study was abstracted with permission from Pequea–Mill Creek Information Series Bulletins 28 and 30 prepared by Pennsylvania State University, College of Agricultural Science, Cooperative Extension Service in cooperation with USDA Natural Resources Conservation Service.

## Case Study:

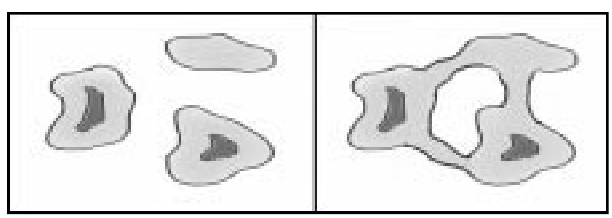
# Jefferson County Open Space Plan

Corridor Planning Principles described in section 613.04 that are exhibited by this case study include:

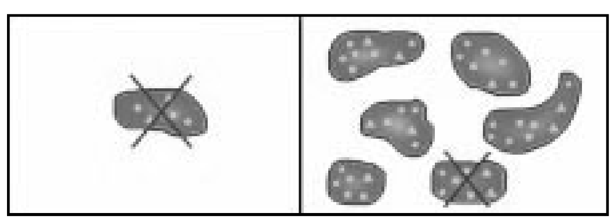
**Large Reserves / Patches Are Better Than Small Reserves / Patches.**



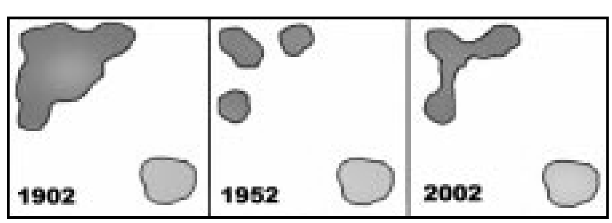

**Connected Reserves / Patches Are Better Than Separated Reserves / Patches.**



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



**Introduced Connectivity Should Be Studied Carefully.**



# Case Study: Jefferson County Open Space Plan

*This case study illustrates the value of regional scale open space planning in rapidly urbanizing watersheds. Conservation, enhancement, and restoration of wildlife habitat is an integral part of the Jefferson County Open Space Plan. Conservation corridors are a key element in linking dispersed patches of wildlife habitat. NRCS plays a major role in providing technical assistance as the plan continues to evolve.*

Jefferson County, a progressive and rapidly urbanizing county near Denver, Colorado, initiated an open space preservation program during the early 1970s (Figure 1). This program is funded by a one-half percent sales tax on retail sales in Jefferson County. The goal of the Jefferson County Open Space Program is to preserve open space as a living resource for present and future generations. The primary objectives of the program are to acquire and maintain lands, to ensure the quality of life in the county by providing open space for physical, psychological, and social enjoyment, and preserving the natural and unique landforms that define Jefferson County.

The Jefferson County Open Space planning process is inclusive and collaborative involving many different stakeholder groups. Specific goals and objectives were established through interviews with a variety of groups and extensive public scoping meetings, which provided guidance for the inventory process. Using a geographic information system, inventory maps were prepared and include:

- Existing and proposed open space, parks, and trails
- Key land uses and activities
- Wildlife, archeological, historic, and cultural features
- Vegetation, surface water, and floodplains
- Landforms and geologic hazards
- Existing and proposed roads and infrastructure
- Slopes and viewsheds


***Figure 1:*** *A view of urban development from one of the Jefferson County Open Space Parks.*

From the inception of the Open Space Program, the NRCS has played a valuable role in providing inventory data, data evaluation, and technical assistance. Specific NRCS assistance included:

- Soils information
- Vegetative inventories
- Revegetation plans (native, pasture, hayland, post-wildfire)
- Erosion control (gully, streambank, disturbed upland areas)
- Pasture/hayland management
- Grazing management for native grasslands
- Plant materials
- Pond/water development
- Wildlife habitat development/improvement

The planning process identified lands that should be preserved or managed to provide habitat for valued wildlife species (Figure 2). The proximity of critical habitat lands to urban development, roads, and other recreational resources helped determine the appropriate level and type of management necessary to protect wildlife populations. Mapping wildlife habitat provided a valuable point of discussion between the Open Space Department and appropriate wildlife agencies regarding management and acquisition options.

The plan identified five types of open space and trails. Regional preserves are the keystone elements for the protection of wildlife. They are generally large (> 500 acres) and intended to protect the natural resource or unique feature. Regional preserves are reserved primarily as open space/ habitat with development limited to less than 20% of the site. They protect floodplains, breeding areas, relict plant communities, rare and endangered species habitat, and other sensitive resources. Corridors, some with trails, are being developed to connect these significant resource areas enhancing their value for both wildlife and recreation.

Over the 25 years of its existence, the Jefferson County Open Space Program has acquired approximately 32,000 acres and has constructed over 100 miles of trails (Figure 3). This program demonstrates successful protection of wildlife habitat can be combined successfully with other uses such as recreation and aesthetics in urban/ suburban landscapes. The program also illustrates the importance of building diverse partnerships to accomplish program goals in an urban context.


***Figure 3:*** *A map of existing protected habitat areas and proposed acquisition areas.*

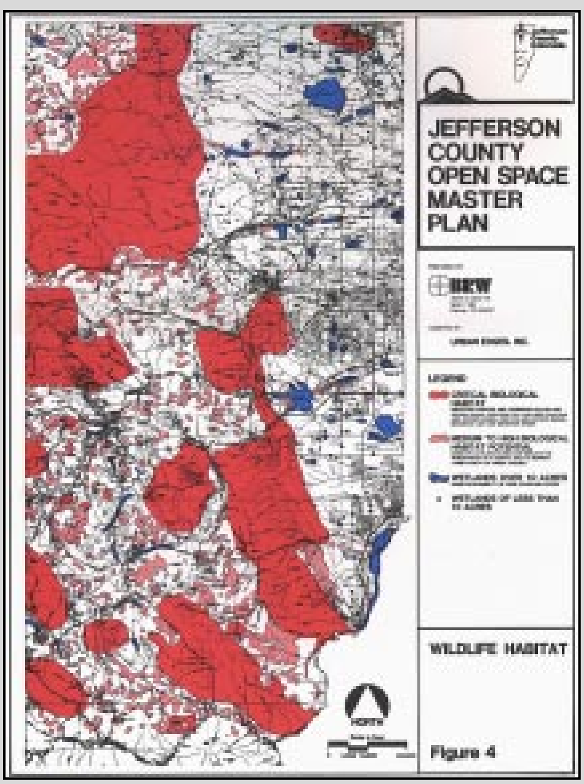



***Figure 2:*** *Mapped critical habitat and wetlands within Jefferson County.*

*For more information contact:*

*Jefferson County Open Space*
*18301 West 10th Avenue*
*Suite 100*
*Golden, CO 80401*

The information for this case study was abstracted with permission from Jefferson County Open Space brochures prepared by the Department of Jefferson County Open Space and from *The Jefferson County Open Space Master Plan, 1989*, prepared by BRW, 4643 South Ulster St., Suite 1180, Denver, CO and Urban Edges, 1624 Humboldt St., Denver, CO.

# 613.04 Planning and design principles

## (a) 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.

## (b) Concepts and principles

Landscape ecologists and conservation biologists have formulated several basic concepts and principles used to guide wildlife planning at the watershed scale. These concepts and principles focus on the spatial relationships among patches, corridors, and the matrix. Developed for regional landscapes and large protected patches (national parks, wildlife refuges), 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.

### (1) Concepts

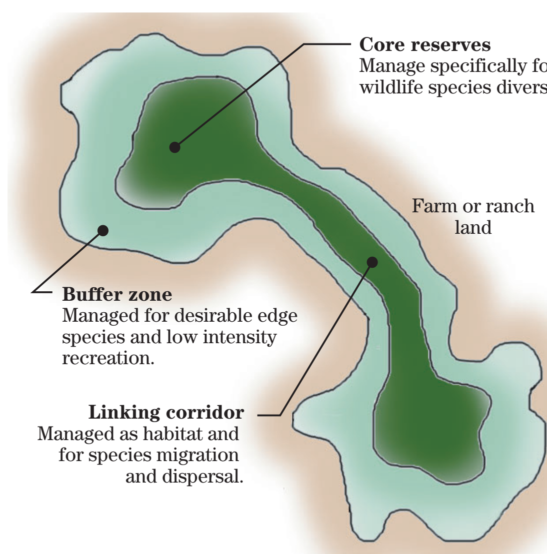
Noss and Harris (1986) observed that areas of high conservation value occur as nodes in the landscape. These nodes can exist in varying forms at varying scales; for example, a "champion" tree, remnant wetland complex, county park, national park, forest, or rangeland. The patterns of these nodes and related 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

An ideal pattern for wildlife conservation would preserve important nodes (core reserves), provide corridors (linkages) between nodes, and establish multiple uses (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 (fig. 613–43).

**Figure 613–43** Core reserves, buffer zones, and linkages (after Adams and Dove, 1989)



In addition to these three concepts, several ecological principles can be used to configure patterns of landscape elements most beneficial to wildlife.

### (2) Principles

The four major principles used to guide wildlife planning are patch, corridor, matrix, and structure. Figure 613–44 gives the basic principles for each category.

**Figure 613–44** 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**

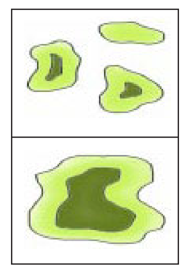
- Manage the matrix with wildlife in mind.

**Structure**

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

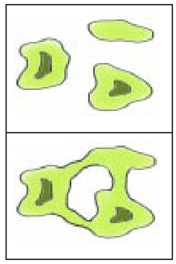
Each of the concepts and principles presented in this section are applicable at various scales in the landscape. However, the relative importance of different patch, corridor, and matrix functions may change at different scales. For example, the habitat function of corridors at the conservation plan 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), 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.

***(i) Patch principles***—The patch principles shown in figure 613–44 are described below.



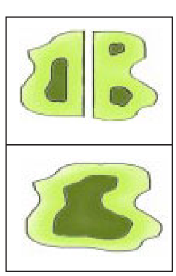
**Large reserves/patches are better than small reserves/patches.** Large reserves typically capture and preserve a greater diversity and quality of habitats. They often serve as core reserves/patches. Large reserves/patches offer advantages that should be exploited in wildlife planning efforts. The advantages:

- *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 by 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.



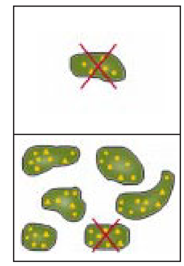
**Connected reserves/patches are better than separated reserves/ patches.** Connected reserves/patches are superior to separated reserves/ patches in several ways. They enhance the habitat, conduit, filter/barrier, and source functions of corridors.

- *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.



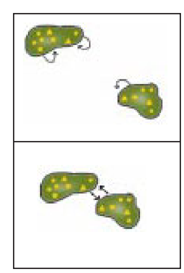
**Unified reserves/patches are better than fragmented reserves/patches.** Of two reserves or patches having exactly the same area, one fragmented and one unified, the unified reserve/ patch will be of far greater value. Its increased value stems from the same factors that make larger reserves/ patches better than small reserves/ patches. (See SLOSS at the end of this section for additional information on reserve/patch size.) The advantages of the unified patches:

- 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 eco-systems 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. The advantages of having several reserves/patches in a watershed:

- One of the reserves can be lost without seriously threatening the integrity of wildlife communities within the watershed (see SLOSS description).
- Can 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.

**SLOSS—Single Large Or Several Small**

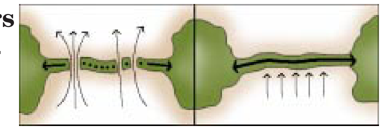
Although conservation corridors are the focus of this manual, issues relating to reserve/patch size are important. Arguments among conservation biologists continue over whether a single large reserve or several smaller reserves (having the same total area) is best for preserving biological diversity at a regional level. Several small reserves may result in highest localized species richness, but this strategy may compromise the integrity of populations of area-sensitive species. Diamond (1976) suggests, "The question is not which refuge system contains more total species, but which contains more species that would be doomed to extinction in the absence of refuges."

Conservation corridors become an important part of this debate. If regional or watershed scale corridors are impossible or unlikely to succeed, a single large reserve may be the best choice. Edge and area effects are diminished, population sizes can be larger, and species diversity higher, resulting in greater diversity within the ecosystem. If several small reserves can be created and connected by corridors, a greater diversity of habitats may be preserved and a larger geographic distribution of populations maintained. Separate populations can exist in each reserve, isolated from local disasters affecting survival in other reserves, but acting as a functional metapopulation capable of sustaining the species across the landscape. The fragmented nature of most agriculturally dominated landscapes suggests that the concept of several small reserves is most applicable.

At the conservation plan scale, the planning and design issue is generally not reserves, but patches. Large patches, like large reserves, tend to support a greater diversity of species. However, if several small patches can be preserved (or created) and connected, the wildlife resource may be equally well served.

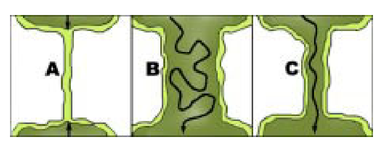
***(ii) Corridor principles***— The corridor principles shown in figure 613–44 are described below.

**Continuous corridors are better than fragmented corridors.**



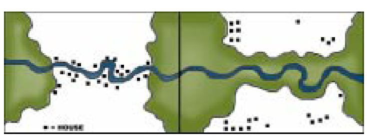
- *Conduit functions.* Corridors facilitate movement of organisms through landscapes. Gaps in corridors disrupt movement, especially for interior-dwelling species. The ability of an individual to cross corridor gaps is dependent on its tolerance for edge conditions, its movement and dispersal characteristics (i.e., how fast it moves and how far it moves at one time), the length of the gap, and the amount of contrast between the corridor and the gap.
- *Stepping stones.* While a continuous corridor is better than a corridor with gaps, corridors with gaps may be preferable to no corridor at all. It is not an optimal situation, but a series of small patches between two larger patches can serve as a steppingstone corridor if the distance between patches is not too far (see Nearness is better than separation in Patch principles section ).
- *Filter/barrier functions.* Gaps in an otherwise solid corridor seriously diminish the effectiveness of the corridor as a filter or barrier. Gaps allow plants, animals, pollutants, wind, and windblown particles access across the corridor and often result in localized concentration of these elements. However, in some instances passage through corridors may be desirable.

**Wider corridors are better than narrow corridors.**

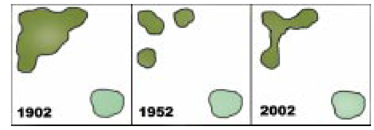



- *Habitat functions.* Corridors at the regional and watershed scales typically serve as transitional habitat for populations moving through them. The longer it takes a species to move through the corridor, the more important its habitat function becomes. Wider corridors reduce area effects and edge effects within the corridor. Thus, a broader range of species, including interior species, is more likely to use the corridor. At the conservation plan scale, corridors often play an important role as habitat as well as a conduit. Wider corridors at this scale increase the amount and diversity of habitat available and may accommodate interior species.

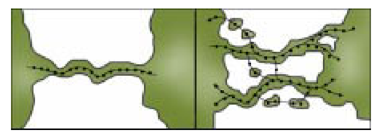
- *Conduit functions.* Wider corridors reduce edge effects for individuals and populations moving through them. Optimum width is determined by the strength of the edge effect and species requirements. In the graphic above, corridor A is too narrow—edge effects dominate the corridor and predation and parasitism may be increased. Some researchers suggest that corridor B may be too wide—edge effects are negligible, but animals may spend too much time wandering within the corridor, increasing overall mortality. This concern is generally not applicable in agricultural landscapes because landowners cannot afford to set aside overly wide blocks of land in corridors. Corridor C balances edge effects with navigability issues and represents a more desirable width.
- *Filter/barrier functions.* Wider corridors are more effective barriers to movement across them.
- *Source functions.* Wider corridors are more likely to act as a population source (adding individuals) than as a sink (removing individuals).



**Natural connectivity should be maintained or restored.** Maintaining historical connections between patches is essential in maintaining species diversity and population viability within a watershed. Preventing fragmentation of existing corridors that connect patches is less expensive than restoring connections. In many cases, however, it may be necessary to restore historical connections between patches. Historical vegetation (the vegetation that existed before fragmentation) should be used in restoring corridor connections.



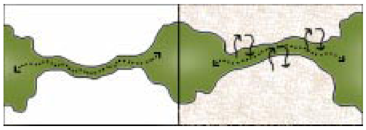

**Introduced connectivity should be studied carefully.** Connected is better than fragmented, but care must be taken to ensure that historically disconnected patches are not linked. Long-separated populations of the same species often develop specialized genetic adaptations to their particular habitat conditions. Connecting such populations through a corridor could result in the loss of those adaptations. In agricultural landscapes, connectivity between corridors and patches benefits most endemic (native) species when historic vegetation is planted in the corridor.



**Two or more corridor connections between patches are better than one.**

- *Alternate routes.* Redundancy should be built into the conservation corridor network, particularly at small scales. If multiple paths exist for an animal to get from one point to another, the animal is more likely to complete the journey. One consideration is that animals may not recognize a corridor as a conduit to a destination. They recognize it as a continuation of attractive habitat, and once inside, their movement is restricted and channeled by the corridor's linearity. It is usually a chance occurrence that they make it from one end of the corridor to the other. The more chances there are for that movement to occur, the more likely it is to occur.
- *Insurance.* Multiple corridor connections between patches safeguard the system from disturbances and disasters. If management mistakes or natural occurrences, such as fire, temporarily destroy one of the corridors, other corridors will maintain the link between the patches while the disturbed corridor regenerates. Periodic burning of corridors may be necessary for management.
- *Steppingstones.* Closely spaced steppingstone patches can be effective in providing alternate routes between larger patches. Species movement behavior, distance between steppingstones, and contrast between patch and matrix determine movement between steppingstones.

***(iii) Matrix principles***—The matrix principle shown in figure 613–44 is described below.



**Manage the matrix with wildlife in mind.** The matrix is often an important source of food and seasonal cover in agricultural landscapes. The full habitat value of corridors and patches can only be realized when the adjacent matrix is managed for wildlife. If it is not managed with wildlife in mind, the following consequences can be disastrous.

- Late spring mowing of forage crops can destroy nests and kill adults of ground nesting species, such as the ring-neck pheasant.
- Fall plowing may eliminate important food resources, critical to some species during the winter months. Conservation tillage practices leave waste grain on the surface where it is available to wildlife. However, some conservation tillage systems rely on chemical weed control and could present a significant threat to certain species.
- Grazing practices can significantly impact the value of the matrix to wildlife. Heavily grazed pastures provide little food or cover. However, managed grazing can be an important tool for maintaining healthy, vigorous grass/forb communities.

Managing the matrix to benefit wildlife can be as simple as how a hay field is mowed. Mowing from the center to the edge (toward cover) is preferable. Other techniques, such as using flush bars, rotation grazing, leaving turn rows adjacent to cover, and similar practices, can improve wildlife survival. Well-planned and designed corridors, in conjunction with a matrix managed for wildlife, should result in significant wildlife movement between corridors and the matrix. Species living in corridors lying within a matrix of low value to wildlife are restricted to the corridor, increasing competition for corridor resources.

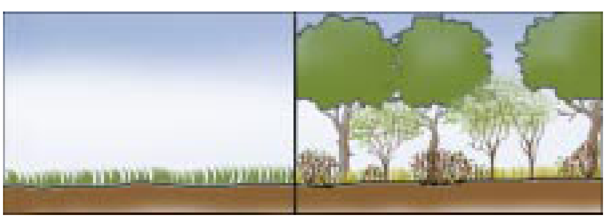
***(iv) Structural principles***—The patch principle shown in figure 613–44 is described here.

**Structurally diverse patches and corridors are better than simple structure.**

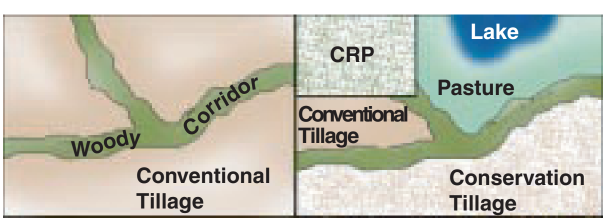
- *Vertical structure* refers to the layers of different plant forms and sizes in the plant community. Complex forested plant communities may have five or more layers. From top to bottom they are the canopy, understory, shrub layer, herbaceous layer, and forest floor. At the other extreme, a wheat field for example, usually has only one layer, wheat. These layers are best illustrated with a cross-section of the plant community (see diagram). Vertical structure significantly influences the diversity of wildlife species present in the community. Different layers offer food, water, cover, shelter, or breeding sites to different species, resulting in a rich diversity of wildlife using one habitat type. Each species fills a niche or specialized position in the habitat. However, some species that evolved in grassland habitat, such as the lesser prairie chicken (*Tympanuchus pallidicinctus*), require simple vegetative structure with diverse plant species composition.
- *Horizontal structure,* at a watershed scale, refers to the arrangement of different habitat types as seen from above. Components of horizontal structure include forests/woodlands, shrubby areas, grasslands, cropland, urban areas, lakes and streams, and wetlands. The intricacy with which these different features are woven together or interspersed affects the overall habitat quality of the landscape. For example, grasslands afford certain benefits to wildlife when they exist on their own. The same is true for a windbreak and a wetland. But when these three habitats are arranged in close proximity to each other, the overall habitat value for many species is greater than the sum of the parts. Wildlife can move safely among each habitat type, exploiting the benefits offered by each.
- *Additional benefits* on the agricultural landscape are provided by both horizontal and vertical structure. For example, windbreaks are frequently employed to control wind erosion of soil. Maximizing the benefits of windbreaks employs proper spacing of windbreaks and rows within the windbreak (horizontal structure) and inclusion of several plant heights to block wind at ground level and direct it upward (vertical structure).

- *Native plant species* in corridors benefit native wildlife. Corridors generally are intended to benefit native or desirable naturalized wildlife species. Native wildlife and plant species have co-evolved, each benefiting the other. If the goal is to provide habitat for native wildlife species, native plant species have the highest probability of providing their life requisites. Other practical reasons to use native vegetation are that native grass communities, once established, are often better at preventing invasions of exotic weeds. Also, disturbances, such as plant diseases, are usually less damaging to native plant communities than they are to monocultures of introduced or cultivated species. They are also less water consumptive and less likely to require expensive supplemental nutrients.

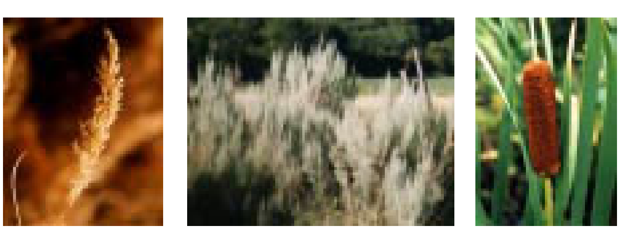
**Figure 613–44** Patch structural principle



**Vertical structure**




**Horizontal structure**



**Native plant species**

### (3) Applying principles, an overview

A general approach to using these principles in a wildlife corridor planning project involves:

- Review the historical pattern of patches and corridors, if available.
- Study the existing pattern of patches and corridors in the landscape.
- Identify locations where connectivity is both desirable and feasible.
- Use the above principles to propose the most efficient means to reconnect the landscape in a way that produces the greatest benefits to wildlife while minimizing the land area taken out of production or suburban development.

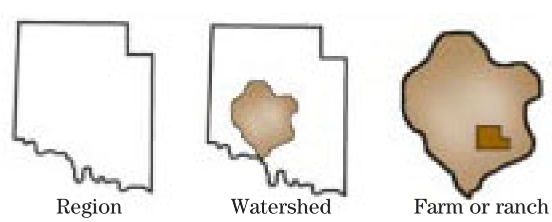
Every landscape is unique. Land planners and managers should use those principles that apply to the specific conditions inherent in the area being planned. Applications of these principles within the NRCS planning process is described extensively in sections 613.05 and 613.06.

## (c) Scale

Corridors exist in the landscape at various scales, from individual fencerows to continentally important migration routes. Researchers have explored the issue of scale as it applies to conservation corridors and in principle agree there are three scales at which corridors function in the landscape. For example, Reed Noss (1991) describes corridors at the regional or continental scale, landscape mosaic scale, and fencerow scale. These terms are redefined here to make them applicable to NRCS planning directives. The three scales of interest (fig. 613–45) thus become:

- Regional scale
- Watershed scale
- Conservation plan and practice scale

**Figure 613–45** Scales used for corridor planning



A successful overall wildlife conservation effort must encompass all scales.

### (1) Regional scale

Conservation corridors at the regional scale are large, loosely defined areas that connect large wildlife preserves or areas of high biodiversity. They are typically a diverse mix of natural and artificial plant communities, often tens of miles in width, that facilitate the movement of individuals and groups of individuals from one reserve to another. For example, neotropical birds and waterfowl make extensive use of riparian corridors during spring and fall migrations.

Regional corridors provide for the long-term health of populations and ecosystems and preserve biodiversity within the region as follows:

- Provide opportunities for wildlife populations and communities to adapt to environmental stress or change.
- Support genetic health of wildlife populations through occasional immigration and emigration of individuals between populations.
- Preserve opportunities for wildlife to meet basic life requirements, such as seasonal migrations for breeding, birthing, or feeding.

Regional corridors are generally more important for larger, more mobile animals. Corridor length, speed of travel, and space and resource requirements of individual species determine which species will use the full length of the corridor. Generally, the corridor needs of larger animals also encompass those of smaller, less mobile species. By providing for movement of cougars, bear, elk, or other large, highly mobile species, the needs of many other species may also be met.

In essence, regional corridors are narrower versions of reserves, often relatively devoid of human disturbances, which allow populations to move in response to environmental changes or other stimuli. Many regional corridors have been used by certain wildlife species for generations.

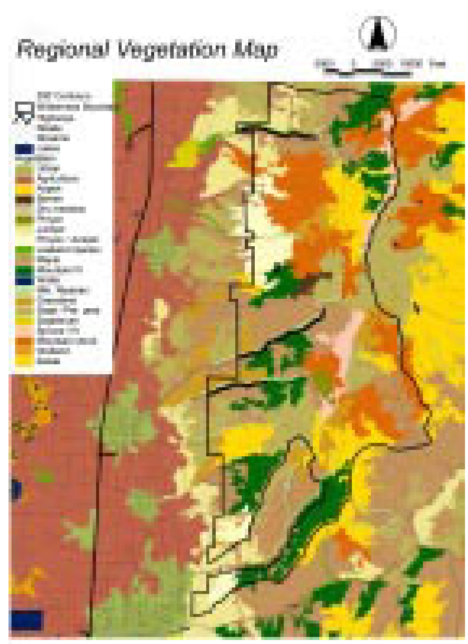
***(i) Mapping scale and methods***—Wildlife conservation can be viewed at varying levels of detail. At the regional scale, a broad-brush approach or coarse filter can be used to identify wildlife problems and opportunities at the wildlife community level. Important types of information to map for coarse filter regional scale studies follow:

- Ecoregions
- Regional soils
- Surficial geology
- Vegetation types (fig. 613–46)
- Air basins
- Topography
- Hydrology
- Major migration routes
- Special areas (winter range)
- Land cover types
- Roads, highways, railroads, and utilities
- Land ownership
- Existing wildlife preserves

Common map scales for regional mapping vary from 1:100,000 to 1:1,000,000.

Methods used to map the necessary information can be completed either by hand or by using computers.

**Figure 613–46** Regional vegetation analysis maps provide an excellent base for regional corridor planning efforts



There is currently a strong push across the Nation to inventory natural resources and make the information available in common digital formats. Geographic Information Systems (GIS) technology is being used as a tool to view, combine, and analyze large sets of spatial and tabular information. Much of these data are available for a small fee (often free) and are highly appropriate for use in regional corridor planning projects. Data are frequently interpreted from aerial photographs, aircraft-based sensors, or satellite imagery. GAP analysis is an excellent example of this approach.

Computers allow for easier and more precise management of data. If a GIS is used for analysis and map generation, the habitat requirements of many species can be evaluated relatively quickly. If hand methods are used, a few key indicator species representing a broad cross-section of biodiversity in the region may be selected.

***(ii) GAP analysis***—GAP analysis is a coarse filter wildlife planning approach that provides a quick overview of the potential distribution and conservation status of wildlife species in a region or watershed. The analysis is based on correlations between vegetation communities and potential wildlife distributions. It also considers land ownership and management practices.

GAP is based on the premise that habitat for wildlife is generally related to vegetation composition and structure. Two products from this process are a species richness map and a GAP map. The species richness map highlights areas where there exists potential for rich diversity in wildlife species (hot spots of biodiversity). The GAP map compares the geographic location of biodiversity hot spots with the location of areas managed primarily for long-term maintenance of native populations; i.e., national parks, forests, rangelands, wildlife refuges, and wilderness areas. If the two layers do not coincide spatially, there is a gap in the protection of biodiversity. Action can then be taken to conserve currently unprotected habitats and hot spots. The next step is to examine connectivity between reserves.

- If they are fragmented, have they always been fragmented or is fragmentation a result of human activities?
- If the reserves were historically isolated, should they remain isolated?
- If they were historically connected, regional corridors should be considered to reestablish the link.

A general outline for the GAP analysis process follows. Additional information is available in "GAP Analysis: A Geographic Approach to Protection of Biological Diversity" in *Wildlife Monographs* 57 (1) 1993.

**GAP Analysis Process**

1. Determine the species that occur in the region that are of concern or interest.
2. Collect and compile habitat relationship and occurrence data for those species.
3. Create a map of where the habitats occur in the region based on existing vegetation.
4. Overlay the wildlife habitat data with the habitat map to determine areas of rich species diversity.

Product: *Species Richness Map*

1. Prepare a general land ownership map that classifies lands into public and private ownership.
2. Assign a management status of **1** to areas that are managed for wildlife, such as wildlife refuges and Nature Conservancy lands.
3. Assign a management status of **2** to areas that are managed for natural conditions, such as USFWS refuges managed for recreational uses and BLM areas of Critical Environmental Concern.
4. Assign a management status of **3** to areas that are prevented from being permanently developed, including most BLM and USFS lands.
5. Assign a management status of **4** to private and public lands not managed for natural conditions.
6. Overlay this map with the habitat relationship data to determine habitats that are offered the least protection in the region, with 1 status lands providing the highest protection.

Product: *GAP Map*

This process can be completed by hand, but GIS software can add speed, flexibility, ease of duplication, and the ability to explore multiple alternatives. If the information produced will be used by many people over a long period, GIS is clearly a superior choice.

Ecoregion GIS maps of soils, crop production, and other production-oriented resources can be used to map wildlife corridors of significance at regional scales. These maps are a valuable resource for regional scale wildlife planning efforts and complement any GAP analysis study.

### (2) Watershed scale

The width of corridors important to wildlife at the watershed scale tends to be measured in miles or fractions of miles although an entire watershed or portion of a watershed may be part of a regional migration or dispersal corridor. Like regional corridors, watershed corridors facilitate seasonal migration and dispersal. Yearling beaver, for example, use a stream corridor to disperse from the area in which they were born and reared into unoccupied habitat elsewhere in the watershed. Watershed corridors also connect populations and subpopulations into metapopulations. Many species use corridors in the watershed as travel lanes linking various habitat resources within their home range. Often these corridors are used primarily as habitat by some species, birds in particular. Bats follow corridors to avoid predation from owls. The corridors' conduit function is of limited importance to these species. Where available, GAP analysis information should be integrated into areawide corridor planning.

***(i) Mapping scale and methods***—Mapping watershed scale corridors is similar to regional corridor mapping; however, the coarse filter used for regional corridors often needs to include more detail. Defining the placement and shape of corridors is needed as well as more specific information describing the wildlife uses and quality uses of landscape elements. For example, a large farm may be defined on a regional corridor map as simply agricultural. On watershed scale maps, this same farm may be further categorized into row crops, small grains, and pasture to adequately plan for a particular species. Important information to be included on watershed scale corridor maps:

- Soils
- Vegetation types by plant community
- Air basins
- Topography
- Hydrology
- Land use
- Migration and dispersal routes
- Special areas (winter range, etc.)
- Land cover types, including crops
- Roads, highways, railroads, and utilities
- Land ownership
- Locations of existing conservation practices or programs, such as CRP, WRP, or CREP

A more specific data list is in the section 613.05 under Step 3, Inventory Resources Planning Standard.

**Map scale**—Depending on the size of the watershed planning area, mapping scales could vary considerably. For most projects, scales should fall between 1:24000 and 1:100,000. The 1:24000 scale was the overwhelming choice of NRCS biologists in the 1997 survey described in section 613.02(g).

**Methods**—Both computer and hand mapping methods are appropriate at the watershed scale. High-resolution satellite imagery, aerial photographs, and USGS quadrangle maps (fig. 613–47) may be useful. If a statewide GAP analysis has been completed, much of that information can be used; however, it should be used with caution. Some states may use a relatively coarse mapping resolution in their GAP analysis, missing smaller features important at the watershed scale.

### (3) Conservation plan and practice scale

Most conservation planning and technical assistance programs operate at this scale. The widths of corridors at the conservation plan scale (farm, ranch, or community) are typically measured in feet to hundreds of feet. However, a conservation plan would be more effective for some wildlife species if it were part of a watershed scale corridor or, at a minimum, the larger landscape context of the farm, ranch, or community considered. The habitat function of corridors at the farm or ranch scale is often more important than the conduit function. For example, the cottontail rabbit may spend 80 percent of its time utilizing habitat resources within a windbreak. Corridors at this scale are, however, used by some species as travel lanes to access resources.

Quail, pheasants, and turkeys, for example, use hedgerows and fence lines to travel between cover types.

***(i) Mapping scale and methods***—Mapping at the conservation plan scale includes many details that are not applicable at the regional or watershed scales. A fine filter approach is used to make sure that all data types and features needed to successfully design and install conservation practices are mapped.

**Map scale**—Depending on the size of the farm or ranch, mapping scales could vary considerably. Typical scales fall between 1 inch = 100 feet and 1 inch = 660 feet. Most conservation plans are drawn at a scale of 1 inch = 660 feet. For small areas, a scale of 1 inch = 330 feet is typically used.

**Methods**—Patches and corridors at the conservation plan scale are inventoried and verified in the field. In some states initial mapping of these features is typically done by hand on graph paper or on photocopies of soil survey aerial photos. Field maps can be transferred to the computer later if desired. NRCS offices have increasing access to digital data, including soil surveys and digital orthophoto quads (DOQs), and from these data a GIS database will be created. These maps will show the location of all conservation corridors in the landscape, their age, condition, wildlife species known to use them, and other such information. Over time, this database would become useful at the watershed scale and possibly even the regional scale. Ground level photographs may be beneficial in addition to plan view maps. Important general types of information for conservation plan and practice scale maps follow:

- Soils (fig. 613–48)
- Vegetation types and condition (health)
- Topography
- Hydrology
- Migration and dispersal routes
- Special areas (winter range)
- Special features (snags)
- Land use
- Land cover types, including crops
- Roads and highways
- Land ownership
- Locations of existing conservation practices
- Aspect
- Airflow patterns

For a more specific data list, see section 613–06, Step 3 Inventory.

**Figure 613–47** USGS 7.5 minute quad maps are frequently used for watershed scale corridor planning

**Figure 613–48** NRCS soil maps provide a base for conservation plan and practice scale planning

### (4) Summary

Corridors exist in the landscape at three distinct scales. Functions and benefits of corridors vary with scale. A successful wildlife conservation strategy will address corridor, patch, and matrix issues at all three scales. The general principles and scale issues discussed and illustrated in this section need to be adapted to the unique resource circumstances of each region, watershed, farm, or ranch. They also must meet the particular habitat needs of wildlife communities, populations, and individual organisms. Care should be taken that activities intended to benefit one group of species does not compromise the ecological integrity of the entire community. The next section provides specific recommendations for wildlife enhancement of NRCS Conservation Practices.

## (d) Conservation practice design recommendations

Several planning concepts and principles described earlier in this section presented a set of general guidelines to follow in most wildlife planning projects. However, with wildlife benefits as a goal, a specific set of recommendations is needed when designing each individual conservation practice.

About 150 conservation practice standards are published in the National Handbook of Conservation Practices (NHCP). Each standard is designed for a specific purpose and has specific design criteria. Each state decides which standards it will use. They adapt the standards for use in their state, adding appropriate technical detail, and issue them as state conservation practice standards. NHCP state standards are available from NRCS field offices and national standards are available for download from the NRCS homepage:

**http://www.nrcs.usda.gov/technical/Standards/nhcp.html**

Most conservation corridor practices can be grouped into either grass dominant or woody species dominant structures. They can also be grouped by their function or placement in the landscape. The inventory sheets in appendix 613A provide the categorization shown in the box to the right.

The sections that follow give an overview of these four categories and present a series of recommendations for each category aimed at increasing its wildlife value. These recommendations are general and need further modification at the state level. The recommendations should not interfere with normal and proper farming practices.

### (1) Planted grass/forb corridors

A planted grass/forb corridor is a linear landscape element consisting primarily or exclusively of herbaceous vegetation. Most are relatively narrow in comparison to other corridor types. They are often typified by monotypical plantings of non-native grasses, such as smooth brome (*Bromus inermis*) or tall fescue (*Festuca* ssp.). However, recent emphasis has been placed on using mixtures that include as many native species as possible.

***(i) Purposes***—Planted grass/forb corridors are installed for several reasons.

- Wildlife habitat.
- Grassed waterways and vegetated ditches safely convey water through fields.
- Manage snow.
- Terraces and filter strips reduce erosion and filter sediment and chemicals from runoff.
- Reduce wind erosion.
- Field borders and buffers reduce competition from adjacent woodlands and provide space for maneuvering equipment.
- Provide commercial products.

**Planted grass/forb corridors**
Field borders
Field buffers
Filter strips
Grassed waterways
Grassed terraces
Vegetated ditches

**Natural remnant upland corridors**
Grass and woody types

**Introduced Woody Corridors**
Windbreaks
Shelterbelts
Hedgerows

**Stream/riparian corridors**

***(ii) Traditional design criteria***—Grass/forb corridors intended to convey water must respond to water quantity, velocity, depth, duration of flooding, and outlet characteristics. The filter and erosion reduction functions of grass corridors are dictated by numerous criteria including width, sediment and nutrient storage capacity, flow depth, slope, and grass strength. Field border and buffer design must be wide enough to achieve their desired filter and sink effects. See appropriate National or State standards for specific criteria.

***(iii) Recommendations to enhance wildlife habitat***—Planted grass/forb corridors generally constitute a relatively small proportion of the total acreage in agricultural regions, but their value per unit area to wildlife far exceeds that of adjacent cropland. The following paragraphs describe several ways to protect and enhance the wildlife value of this type of corridor.

**Add tall residual grasses and forbs in proposed seed mixes.** Most grassed waterways (and other types of introduced grass corridors) are currently planted in only introduced grass species, such as smooth brome. Habitat quality could be enhanced adding tall, persistent grasses and forbs. Biologists Bryan and Best (1994) found that tall, residual grasses are necessary or extremely beneficial for nesting for some species. The most appropriate grass mixes for wildlife vary by region.

Bryan and Best also found that nests were 1.8 times more likely to occur in grassed waterways with greater forb coverage. In their study, more nests were built in forbs than in grasses. Inclusion of a variety of forb species (with grasses) should increase the value of all introduced grass corridors to nesting birds.

**Plant trees and shrubs in grass/forb corridors.** Current NRCS practice standards specify removal of all trees, stumps, shrubs, rocks, and other objects that would impede channel flow or compete with adjacent crops. Retaining or planting occasional clumps of trees, shrubs, or forbs would enhance the habitat value of grass corridors by providing a wider variety of cover types and a diversified food supply. Careful thought should be given to placement or retention of woody vegetation so that it does not interfere with normal farming operations, waterflow, or crop vigor. Generally, trees and shrubs should be located in the periphery of grassed waterways, field borders, and vegetated ditches.

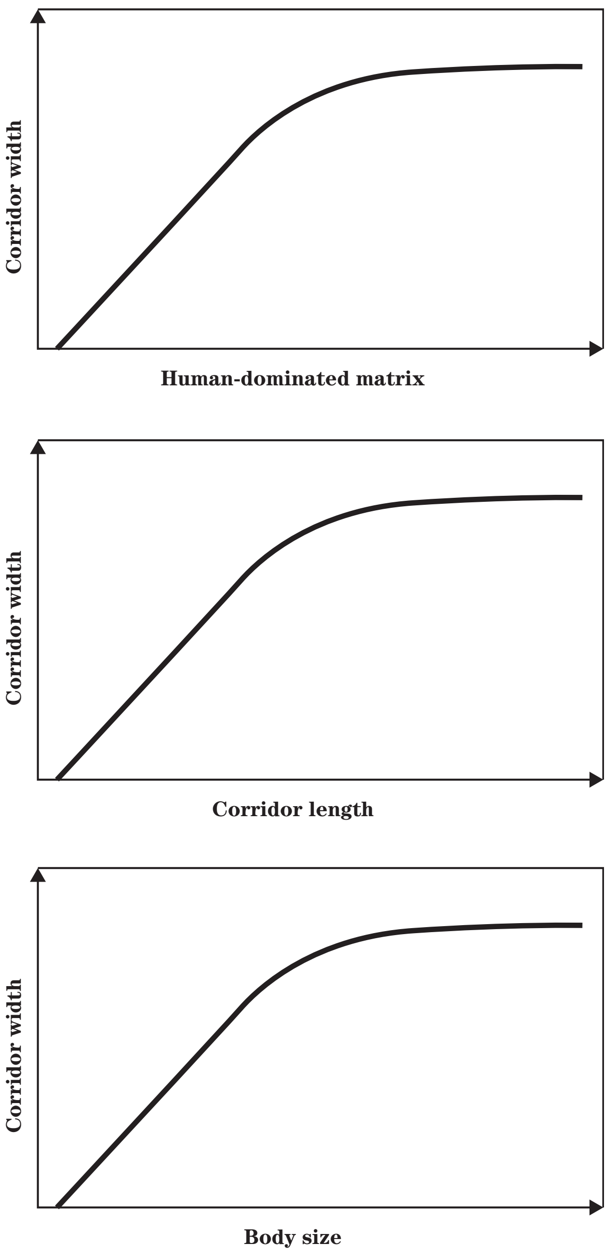
**Manage vegetation to retain plant community vigor.** Grasses and forbs may need to be mowed, burned, or disked periodically to maintain plant vigor. The most appropriate management technique and the timing of its application vary from region to region. Untimely mowing, burning, or disking can decrease nesting densities, destroy nests, and kill adult birds and mammals. Mowing lowers the height and density of vegetation, reducing habitat value accordingly. As stated in the job sheet for NRCS Conservation Practice 412, Grassed Waterway, mowing should occur when nesting and brooding will not be disturbed. Mowing should occur early enough so that new growth will exist for spring nesters, but late enough to avoid peak spring and summer nesting periods. For maximum wildlife benefit, only a portion of a patch or corridor should be treated in any one year. Unmowed corridors become even more important in late summer as other types of habitat, such as roadsides, are mowed. State biologists have region-specific information about the most appropriate management techniques.

**Adopt farming practices that result in minimal disturbance of grass/forb corridors.** Unless necessary, avoid establishing cropping patterns that require farming equipment to be driven through grassed corridors. Bryan and Best (1994) found nesting to be more likely in grassed waterways that were not disturbed by farming activities. In general, avoid unnecessary travel through field buffers, field borders, and other grassed corridor types.

**Increase corridor width as much as possible.** Increased corridor width directly increases the quantity of nesting sites, winter cover, escape cover, and food available to wildlife. It may also decrease overall edge effects, increasing the likelihood that the corridor will function as an effective travel route (fig. 613–49). The width of conservation practices must be balanced with the economics of crop production.

**Strive for connectivity.** Opportunities usually exist to connect different types of planted grass corridors. Grassed waterways frequently serve as outlet structures for grassed terraces. Waterways may flow through several field borders and field buffers before they terminate in filter strips or vegetated ditches, both of which continue across the landscape. What can result, with proper planning, is a network of connected habitat and travel routes for a variety of species across a large area.

**Figure 613–49** Effective corridor width for wildlife movement as related to human domination of the matrix, corridor length, and animal body size (graphs from Dr. Richard Knight, republished with permission)




Connections should be made to other types of natural and planted corridors, patches, or management practices, such as constructed wetlands, natural wooded draws, riparian corridors, wetland complexes, and CRP land.

### (2) Natural remnant upland corridors

Natural upland remnant corridors may be herbaceous, wooded, or a mixture of both. Size and configuration are highly variable. Whatever form they take, they are important components of a corridor network. Natural remnant upland corridors often represent the last remaining patches of a predevelopment ecosystem and are crucial to the survival of native flora and fauna.

Appropriate management techniques for remnant patches depend upon the composition of the plant community, patch size, and other site-specific variables. Management recommendations should be coordinated with the NRCS field biologists from partnering agencies.

### (3) Introduced woody corridors

A planted woody corridor is a linear element in the upland landscape consisting primarily or exclusively of woody vegetation. Woody corridor width varies considerably, from narrow hedgerows to multirow shelterbelts. Planted woody corridors are used by numerous species of wildlife for food, nesting, winter cover, escape cover, and travel.

***(i) Purposes***—Planted woody corridors provide a variety of benefits to wildlife:

- Protective cover from adverse weather
- Escape cover
- Foraging and loafing sites
- Reproductive/nesting habitat
- Travel corridors for dispersing juveniles, travel between home range resources, and movement between larger natural habitats
- Stepping stones for migrating birds

They also provide numerous other environmental services:

- Reduce wind erosion
- Protect and provide moisture for growing crops
- Manage snow
- Provide shelter for structures and livestock

- Provide tree or shrub products
- Provide living screens
- Improve farm aesthetics
- Improve irrigation efficiency

***(ii) Traditional design criteria***—The design of planted woody corridors is influenced by desired benefits. A windbreak designed to provide only wind protection is simple; however, as additional benefits are added, the complexity of the design increases. The following briefly describes the most important design elements.

- For all applications of windbreaks, one of the most important design elements is orientation. The windbreak should be oriented perpendicular to the direction of the troublesome winds (fig. 613–50).
- The area protected by the windbreak is generally agreed to be 10h (10 times the mature height of the tallest row in the windbreak). Because of the dynamics of wind patterns, the area protected is actually triangular, which is important for design height, density, and length of the windbreak.
- Choice of plant species is based on desired function, wildlife needs, and other factors including climate, soil, wind-firmness, density, height, crown spread, competitiveness, compatibility with adjacent crops, and pest and chemical resistance.

Of the farmers surveyed by Dishongh (1995) in six Midwestern States, 48 percent responded that one of the main reasons they planted windbreaks was enhancement of wildlife habitat.

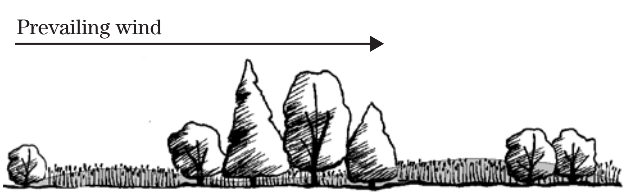
***(iii) Recommendations to enhance wildlife habitat***—Considerable research has been done on the habitat potential of windbreaks and hedgerows. Standard design criteria usually create a basic horizontal and vertical structure that produces valuable wildlife habitat. Several approaches can enhance woody corridor value as habitat and travel corridor.

**Increase corridor width as much as possible.** Modern windbreak planting practices are producing narrower windbreaks. Wildlife value is improved with greater width. Wider windbreaks provide a greater diversity of habitats, larger quantities of food and shelter, and greatly improved winter cover.

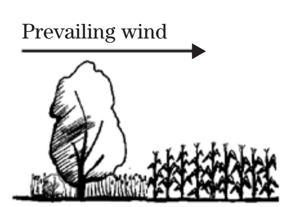
**Design a complex vertical and horizontal structure.** Planting a variety of deciduous trees and shrubs provides a habitat structure with a large selection of vertical and horizontal nesting and foraging sites. Conifers should be added to provide additional nesting and foraging sites and winter wind protection.

**Figure 613–50** Windbreak orientations

a. Cross section of a multirow windbreak enhanced with diverse species composition, complex structure, windward and leeward shrub row, and herbaceous vegetation




b. Longitudinal section of single-row windbreak and cross section of the same single-row windbreak

In multiple-row woody corridors, more complex vertical and horizontal structure is possible. Structural diversity can be achieved in the following ways:

- Plant a core of tall deciduous and evergreen trees, tapered to small trees and shrubs on either side.
- Plant a mixture of grasses, forbs, and low shrubs to form a diverse understory after trees and shrubs are established.
- Add one or more shrub rows approximately 30 feet to either side of windbreaks.
- Add a wide band of herbaceous vegetation on either side of the windbreak outside the shrub row.
- Clump groups of shrubs on the lee side of woody corridors. Edge, cover, and food will be increased.
- Add vines to the planting. Choose species that do not harm the plants on which they climb.

Single row corridors, such as field windbreaks and hedgerows, typically have a simple structure. The structural diversity of these types of corridors can be enhanced in several ways:

- Alternate tree species within the row.
- Alternate deciduous and coniferous species within the row (consider alternating clusters).
- Alternate different forms (vase shaped, oval, or pyramidal) of trees within the row.
- Add a low row of shrubs beneath the tree row.
- Add a band of herbaceous vegetation beneath and on either side of the tree row out to the drip line after trees and shrubs are established.
- Add vines to the planting. Choose species that do not harm the plants on which they climb.
- Match growth rates of deciduous and evergreen trees.

**Keep wildlife needs in mind in the design phase.** Specific habitat components of corridors must be a deliberate design consideration.

- Provide food and cover over all seasons, especially during the winter months. Place herbaceous food plots or fruit bearing shrubs in the lee of a windbreak in areas with severe winters.
- Generally, native plant species should be used instead of introduced species. Occasionally, introduced species with high value to wildlife are appropriate. Always select species that provide food and/or cover for wildlife, but keep in mind that some introduced species highly valued by wildlife, such as Russian Olive (*Elaeagnus angustifolia*) may be targeted by State and local governments for removal. Special efforts should be made to ensure that recommendations for introduced or adapted species are not in conflict with local regulations.
- The design should not cause snow to fill the entire windbreak. Snow covers food and habitat. Living snow fences planted 50 feet windward can prevent excessive snow accumulation within the windbreak.
- Perimeter and length are more important than area. Given limited available land, a long, narrow windbreak is preferable to a short, blocky one.
- Consider adding nest boxes and supplemental winter-feeding stations.

**Manage vegetation to promote plant vigor and longevity.**

- Habitat quality increases dramatically with age. Stress longevity in the management of woody corridors.
- Manage livestock grazing within the windbreak. Grazing animals can severely damage ground vegetation as well as the trunks and lower branches of trees and shrubs. However, when managed properly, grazing can improve wildlife habitat within the windbreak by maintaining the desired plant community structure.
- Leave snags for cavity nesting birds and bats and insect-eating species. If necessary, snags can be topped at about 20 to 25 feet to allow more light penetration for understory plant growth.

**Manage the matrix as a complement to woody corridors.** Adjacent habitat and food resources are important. Minimum-till cropland provides sources of food and cover, while heavily grazed rangeland has little to offer most wildlife species. Fall plowing of croplands diminishes wildlife food and cover resources and should be avoided. Late spring mowing of forage crops can destroy nests and kill adults of ground-nesting species, such as the ring-neck pheasant. Techniques, such as leaving turn rows adjacent to woody cover or unmowed strips adjacent to corridors, can benefit wildlife.

**Strive for connectivity.** Where possible and appropriate, connect the windbreak to other conservation practices or natural habitats. The benefits of connectivity are described thoroughly in section 613.01.

### (4) Stream/riparian corridors

Riparian corridors are composed of streams and the vegetation on either side of them. Undisturbed, they normally include the entire flood plain and a portion of the upland at the edge of the flood plain. Width is extremely variable, depending on the width of the stream, flow characteristics, and topography.

Many riparian corridors naturally have large amounts of woody vegetation. Introduced riparian corridors in the form of riparian forest buffers should be heavily planted to woody species as well.

***(i) Purposes***—Riparian corridors are perhaps the most valuable type of wildlife corridor per unit area. Most of the resources needed for a species to survive are located in and adjacent to the corridor. NRCS practice standards for riparian forest buffers state the following purposes:

- Create shade to lower water temperatures and improve habitat for aquatic organisms.
- Provide a source of detritus and large woody debris for aquatic organisms and habitat for wildlife.
- Reduce excess sediment, organic material, nutrients and pesticides in surface runoff, and excess nutrients and other chemicals in shallow groundwater flow.

***(ii) Traditional design criteria***—NRCS specifications for three-zone riparian forest buffers provide an excellent framework for quality wildlife corridors (fig. 613–51). Research conducted in Iowa by Schultz and colleagues (1995) supports these specifications and adds some detail:

**Zone 1** is closest to the water and consists of water-loving tree and shrub species. Willows are used frequently because of their fast growth and tendency to sprout from the roots.

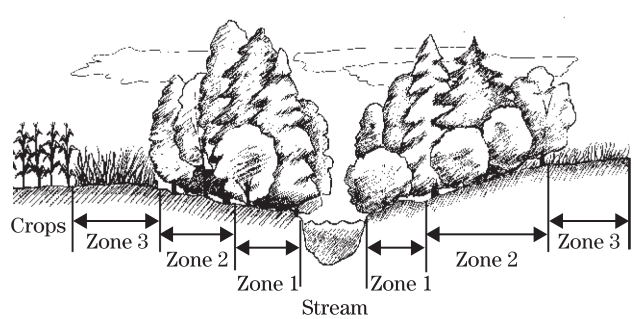
**Zone 2** starts at the edge of zone 1 and extends further upland. It is planted with slower-growing hardwood tree species interspersed with shrubs.

**Zone 3** is essentially a grass filter strip on the upland side of zone 2 and must conform to NRCS conservation practice specifications. Schultz and colleagues recommend that this zone be dominated by tall residual grasses, such as switchgrass (*Panicum virgatum*), though other grass and forb species can be included. This zone is essential for agricultural settings (crops next to streams). It may also be important in forested or urban settings.

See Conservation Practice Standard 391, Riparian Forest Buffer (USDA NRCS, 2003) for further information.

***(iii) Recommendations***—Because most riparian corridors are composed mainly of woody vegetation, most of the recommendations cited in section (3), Introduced woody corridors, will apply to riparian corridors as well. However, riparian corridors also require periodic flooding to maintain stand viability. Likewise, the recommendations in section (1), Planted grass/forb corridors, will apply to the grass zone on the outer edge of riparian buffer strips. For specific management directions, reference the Federal interagency publication *Stream Corridor Restoration: Principles, Processes, and Practices.*

**Figure 613–51** Cross section of a three-zone riparian forest buffer



Riparian corridors are highly vulnerable to adverse impacts caused by upland management practices. The best place to address these impacts is not at the edge of the riparian corridor, but at the point of origin (in the uplands).

Conservation practices that reduce the amounts of sediment, fertilizers, and other pollutants leaving the field in runoff and erosion support healthy riparian corridors. They vary by region and land use, but generally include the following recommendations:

- Cease cultivation of highly erodible soils on steep slopes.
- Use contour farming, stripcropping, and other such practices to reduce erosion on long slopes.
- Be flexible with crop choices, match the crop with a suitable soil type.
- Employ minimum tillage systems; i.e., no-till, mulch-till, ridge-till.
- Practice crop rotation.
- Use rest-and-rotation grazing systems.
- Promote selective logging.
- Use effective waste management practices.

## (e) Summary

Several planning concepts and principles are appropriate for use in wildlife corridor planning projects. They can be broken down into wildlife planning principles for patches, corridors, and matrices, and can be interpreted and used differently at different scales. In addition, design of NRCS conservation practices can be modified slightly to enhance wildlife habitat. High levels of connectivity, diverse vegetative structure, proper management and maintenance, and use of native plant species are key components of agricultural landscapes highly valuable to wildlife.

# 613.05 Areawide planning process

## (a) Introduction

Landscapes are complex assemblages of interactive patches, corridors, and matrices. They are continually being modified by humans to produce goods and services to meet social demands. The ecological and social dimensions of landscape function, structure, and change require an interdisciplinary approach to planning at an areawide scale. The terms areawide and watershed are used interchangeably when referring to planning scales larger than a site, farm, or ranch.

Planning at a landscape or watershed scale is not new in the United States. Pioneering theorists included planners, geographers, landscape architects, and wildlife biologists; prominent individuals included Warren Manning *The Greater Birmingham District* (1919), Jens Jensen *A Greater Westside Park System* (1920), Benton MacKay *The New Exploration: A Philosophy of Regional Planning* (1928), and Aldo Leopold *Game Management* (1933). Contemporary theorists include Philip Lewis *Quality Corridors for Wisconsin* (1964), Ian McHarg *Design with Nature* (1969), Carl Steinitz, Richard Toth, and colleagues *Honeyhill* (1969), Michael Soule and B.A. Wilcox *Conservation Biology* (1979), Richard Forman and Michel Godron *Landscape Ecology* (1986), Thomas Edwards and others *Gap Analysis: A Geographic Approach for Assessing Biological Diversity* (1993), and Daniel Smith and Paul Hellmund *Ecology of Greenways* (1993). Landscape planning methodologies have evolved from these efforts.

The NRCS planning process, a product of that evolution, as described in the *National Planning Procedures Handbook* (NPPH) affirms Hugh Hammond Bennett's 1947 soil and water conservation principles:

- Consider the needs and capabilities of each acre within the plan.
- Consider the farmer's facilities, machinery, and economic situation.
- Incorporate the farmer's willingness to try new practices.
- Consider the land's relationship to the entire farm, ranch, or watershed.
- Ensure the conservationist's presence out on the land.

Bennett's principles acknowledged a need to understand natural ecosystems and cultural activities at areawide and conservation plan scales. The vast majority of conservation projects are at the farm, ranch, or community plan scale. However, conservation issues also need to be considered on a watershed and ecoregion planning scale. A watershed is typically larger than 5,000 acres and smaller than 1 million acres.

Conservationists become involved in large-scale, areawide planning efforts, often referred to as the Coordinated Resource Management Process, in several ways:

- Partnering with other Federal agencies that have authorization to initiate watershed planning; for example, the Army Corps of Engineers, U.S. Forest Service, or U.S. Fish and Wildlife Service.
- Partnering with various State agencies, soil and water conservation districts, regional planning commissions, counties, or other governmental entities that have legal authority to plan at large scales.
- Partnering with private conservation organizations or land trusts, such as Ducks Unlimited or The Nature Conservancy.
- Providing information and technical assistance to planning agencies and private consultants involved in large scale planning.
- Facilitating the planning process for developing watershed plans for individual landowners, groups of landowners, communities, watershed councils, or similar groups who request technical assistance.

## (b) Planning process

Coordinating planning projects at the conservation plan scale and watershed scale requires a flexible planning process. The NRCS planning process described in the NPPH provides a useful framework for guiding the planning process at large and small scales.

The iterative planning process identifies nine steps carried out in three phases. In the NPPH, each step specifies a planning standard, list of inputs, and a list of products. The planning standard sets the minimum quality level for each step. The list of inputs recommends information sources while the list of products describes the outputs of each step.

The areawide planning process diagram (fig. 613–52) demonstrates how the planning process can be used for wildlife conservation at the areawide planning scale. Because the focus of this publication is on wildlife, wildlife concerns are emphasized in each planning step. The existing NPPH standards, inputs, and products for each of the planning steps are referenced; however, the primary focus is on providing information necessary for applying this process to wildlife conservation.

## (c) Getting started

### (1) Preplanning: areawide/watershed scale

The NPPH outlines how to proceed with preplanning activities at an areawide scale. The *National Watershed Planning Manual* is also a useful reference. In addition, the planning facilitator should

- understand preconditions that can lead to watershed planning,
- identify stakeholders,
- generate local support for watershed planning,
- establish trust among stakeholders, and
- organize an interdisciplinary, interagency, public/private planning team.

***(i) Preconditions***—Sociologists identified several preconditions that can lead to planning projects. Some of the more common preconditions include crisis, mandate, incentives, and leadership.

*Crisis* is often the factor that initiates conservation planning. In the Midwest, the devastating floods of the mid-1990s created a public awareness of the role that wetlands play in reducing flooding. This new insight prompted numerous watershed-scale efforts to restore natural hydrological functions. Plans proposed that filled and tiled wetlands be restored and conservation easements be acquired on flood plains.

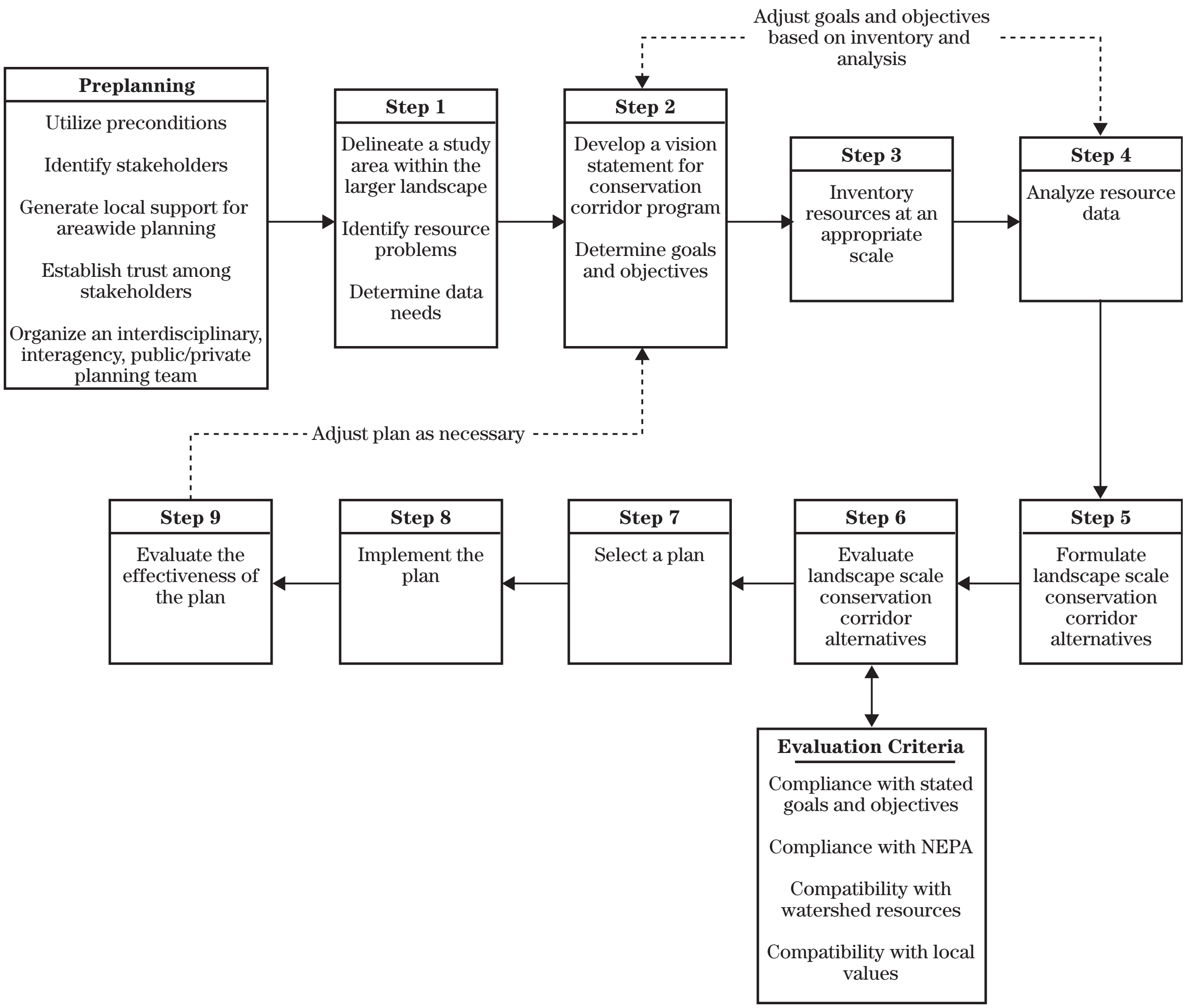
*Mandates*, typically regulatory, require watershed- or project-scale planning to address specific issues or problems. For instance, water quality standards mandated by another Federal agency may require farmers to address confined animal waste problems. NRCS field conservationists often use such mandates as an opportunity to create support for a comprehensive planning approach addressing water quality issues at a watershed scale.

*Incentives* are used extensively by the NRCS to promote the voluntary adoption of conservation practices. In a recent survey, NRCS biologists ranked incentives as the most important factor influencing a landowner's decision to participate in a conservation program. The USDA Wildlife Habitat Incentives Program (WHIP) provides cost-share assistance for private landowners to implement wildlife habitat development plans. Incentive programs are a useful tool for encouraging planning projects.

*Leadership* can come from public agencies, private citizens, influential landowners, or conservation organizations. Areawide planning may be promoted by a strong leader whose energy, personality, and vision can mobilize others to participate. In many cases local conservationists provide technical support to qualified leaders in other agencies or groups spearheading conservation planning in the watershed. In some cases the conservationist serves in this leadership role. District or NRCS conservationists are often effective leaders because they have established trust with many of the stakeholders in the watershed.

A combination of preconditions often creates the necessary climate for watershed conservation corridor planning. As preconditions become more conducive to watershed planning, the potential partners should take a proactive role by initiating a comprehensive planning effort.

**Figure 613–52** Areawide planning process



***(ii) Identify stakeholders***—Successful wildlife conservation planning at the areawide scale depends upon bringing together interested stakeholders to form a collaborative-based planning group. Collaboration-based planning is simply people pooling their resources to solve problems they could not address individually. A collaborative planning approach offers several benefits (Gray 1989):

- Relationships among stakeholders are improved.
- Broad analysis of the problem improves the quality of the solution.
- Parties retain ownership in the solutions.
- Participation enhances acceptance of the solutions and willingness to implement.
- Risk of impasse is minimized.
- Cost-effectiveness is improved.
- Potential for innovative solutions is increased.

Successful areawide planning and implementation often depends on voluntary participation and cooperation, thus initial identification, recruitment, and involvement of the stakeholders is critical. Care must be taken not to overlook potential participants. Overlooking a particular stakeholder group can create animosity and eliminate some of the support necessary for plan approval and implementation.

Stakeholder groups, which may be involved in watershed planning, include:

- Landowners
- State conservation agencies
- Federal land agencies
- State wildlife/fish and game agencies
- U.S. Fish and Wildlife Service
- Farm Bureau
- Resource conservation and development councils
- Conservation and environmental groups
- State extension service
- County commissioners
- Native American tribes
- Local citizens
- Municipal and county planning agencies
- Soil and water conservation districts
- Recreation groups
- Developers and realtors

Identifying and recruiting stakeholders is an ongoing process. The initial group of stakeholders can help recruit other parties that should be involved in the planning effort.

***(iii) Generate local support for watershed planning***—The leader of a watershed planning effort needs to build a foundation of local support. He or she should visit key representatives of each stakeholder group to generate support. Several aspects of the watershed scale planning process should be ensured during each visit:

- It is a locally driven collaboration-based process.
- It improves cost-effectiveness through partnering.
- It produces multiple benefits (see section 613.03).
- It is a proactive approach to problems and opportunities.

*Local control* of the planning process is the fundamental underlying concept. General support for planning is enhanced when it is clear that the process will be locally driven and collaborative in nature and that all stakeholders will be involved in helping shape plan alternatives.

*Cost effectiveness* is another benefit of collaborative planning. Limited financial and personnel resources can be leveraged by partnering with other agencies and conservation groups.

Promoting the *variety of benefits* that areawide planning in general and conservation corridors in particular provide increases support for watershed planning (see section 613.03). Different sets of benefits are important to different stakeholders. Explain the plant and wildlife conservation benefits that a watershed plan could provide to conservation groups and the increased crop yields and reduced soil erosion to landowners.

Potential participants in a planning effort should also understand that planning is a *proactive approach* that can be used to manage the impacts of current and future human development on watershed resources, wildlife populations in particular. More importantly, proactive watershed planning can optimize the conservation of natural, cultural, social, and economic resources in the watershed.

***(iv) Establishing trust***—Skepticism and distrust among various stakeholders with differing values are commonly the result of stereotyping or previous negative experiences. Stakeholders must trust each other if the planning process is to move forward. Conservationists should consider using a qualified facilitator to bring divergent groups together to negotiate a plan in good faith. Facilitators can increase trust among the stakeholders by

- being a good listener,
- being respectful of other's concerns,
- avoiding the use of unnecessary jargon, and
- allowing each participant to share concerns and issues.

The conservationist, whether facilitator or not, must be a good listener and respectful of all stakeholders' concerns. Good communication is essential to building trust. The conservationist should encourage stakeholders to use common terms in their presentations and discussions. The introduction of technical terms or jargon may confuse or alienate participants and should be avoided.

Trust among the various parties can also be developed during the planning process. All stakeholders should be encouraged to discuss their concerns in a group setting. This process can dissolve misleading stereotypes and build greater trust.

***(v) Organizing the planning effort***—The project leader's next task is to prepare for the initial planning meeting. Several key items need to be considered for organizing an effective planning effort.

- Meeting time and location
- Agenda
- Formalizing the planning effort
- Group structure
- Ground rules for meetings

*Meeting time and location.* Select a time for planning meetings that allows the largest number of stakeholders an opportunity to attend. Ask each stakeholder about the dates and times most convenient for him or her. Match schedules and determine the best day and time. Typically, meetings are held in the evening.

The meeting location should be easily accessible for all participants. Agency offices should be avoided as meeting sites in areas where wildlife or other resource issues are controversial. A neutral meeting location, such as a library or school facility, is usually a good alternative.

*Agenda.* A printed agenda, handed out to the participants at the beginning of the meeting is probably the most important tool for facilitating efficient meetings. An agenda helps keep the meeting focused and suggests to the participants that their valuable time will not be wasted. When participants feel that the process is unorganized, enthusiasm fades quickly.

In developing the agenda, the leader should have a clear understanding of what needs to be accomplished as well as realistic expectations of what can be achieved. It is often a good idea to establish time limits to keep the meeting duration to a reasonable length. As a rule of thumb, initial meetings should not exceed 2 hours.

*Formalizing the planning effort.* Research on collaborative planning efforts suggests effective groups typically adopt some formal structure. A formal charter is not necessary, but the group should have a clear mission statement that outlines the broad purpose of the group. In many cases a memorandum of understanding (MOU) outlining roles and responsibilities of the participating groups is appropriate. The group should have an identifying title, such as the Willow Creek Watershed Planning Committee. One or two official points of contact should be determined so that the public knows whom to call if there are questions about the planning group. This helps prevent miscommunication. Groups may wish to develop ways of reporting progress. Newsletters, mail-out brochures, and Web sites are examples of successfully used media.

Formalizing the planning process serves several purposes:

- It demonstrates to the general public that this is an organized group of stakeholders with a specific function.
- It generates a sense of responsibility and commitment to the planning process; such that participants tend to feel an obligation to accomplish objectives.
- It is often necessary to acquire grants and other sources of funding.

*Group structure.* Various models exist for structuring partnerships, but the following are common elements of watershed planning groups:

**Coordinator**—Serves as the leader of the planning effort and as a point of contact for the public. Responsible for the day-to-day administrative functions including funding coordination.

**Facilitator**—Assists planning efforts where some issues are highly controversial and helps remove barriers of mistrust among the stakeholders. Should be skilled in planning and guiding meetings.

**Steering committee**—Individuals and organizations representing the range of viewpoints of those residing in the watershed. Provides the main direction for the group.

**Technical advisory committee**—Government representatives, private individuals, and organizations with the technical expertise to advise the steering committee and answer technical questions.

**Task groups**—Responsible for efforts that involve several resources or many stakeholders; for example, assigned to address wildlife, water quality, agricultural resources, or other specific issues.

In some situations, it is useful to build upon existing planning structures and institutions. As an example, existing resource conservation and development councils offer an effective structure for watershed planning. Where local perception of existing institutions is negative, it may be advisable to begin with a new, independent organization. Whatever approach is taken, an effective group structure should be open, flexible, stable, and credible.

*Ground rules for meetings*—Areawide planning invariably touches on some sensitive and controversial issues, and ground rules for meetings are frequently needed to guide participant conduct. Ground rules promote honest, but diplomatic dialogue that does not threaten stakeholder relationships. Different lists of ground rules are used by facilitators in conducting meetings. The project leader should be familiar with *Robert's Rules of Order* and should have a copy on hand at each meeting. They are needed when formal decisions are made. For general meetings and working sessions, keep the rules simple so they promote the free exchange of information and ideas.

### (2) Summary

Activities in the preplanning phase are important steps for laying a solid foundation in the watershed planning process. The NPPH offers some guidance on working with individuals and groups.

In addition, the NRCS Social Sciences Institute is currently producing a series of publications to assist conservationists involved in planning partnerships. The series entitled *People, Partnerships, and Communities* includes information sheets on listening skills, running effective public meetings, conflict management, and community leadership. These information sheets are available at

**http://www.ssi.nrcs.usda.gov/publications/**

Other potentially useful resources:

**Pulling Together: A Land Use and Development Consensus Building Manual.** 1994. Published by Program for Community Problem Solving, (202) 783-2961.

**Facilitator's Guide to Participatory Decision-Making.** 1996. S. Kaner, et al. Published by New Society Publishers, (800) 567-6772.

## (d) Phase 1 Collection and analysis at watershed scale

Phase 1 involves:

- Identifying problems and opportunities
- Determining objectives
- Inventorying resources
- Analyzing resources

In phase 1, the planning group works to reach consensus on the problems, opportunities, and objectives for the watershed plan. Frequently, a watershed planning project produces potentially significant environmental or social impacts affecting an endangered species. In these cases planning falls under the purview of the National Environmental Policy Act (NEPA). It is beyond the scope of this handbook to discuss NEPA; however, numerous references are available.

The following information applies to those areawide-planning projects that do not require an environmental assessment (EA) or environmental impact statement

(EIS). However, becoming familiar with the material in this section will help the conservationists and planning team prepare an EA or EIS for a watershed plan if it is needed.

## Step 1 Identify problems and opportunities

**Planning standard**—The stakeholders' wildlife and wildlife habitat problems, opportunities, and concerns are identified and documented.

The NPPH provides an outline for identifying problems and opportunities at a watershed scale. This section focuses on several of the key tasks:

- Delineating a planning area
- Creating a base map
- Identifying wildlife and wildlife habitat problems and opportunities in the planning area

### (1) Delineate planning area

Numerous criteria can be used to delineate a planning area. Each criterion has its advantages and disadvantages for wildlife conservation planning.

**Political or resource administrative criteria**

***Advantages***

Political boundaries

- Familiar boundaries for landowners; they suggest local control.
- Reflect how many land-use decisions are made.
- Define regulations and regulatory procedures.
- May include functioning planning agencies and adopted plans.

Water district boundaries

- Familiar boundaries for landowners; they suggest local control.
- Reflect how many water-use decisions are made.
- May include active planning committees and adopted plans.

Conservation district boundaries

- Familiar boundaries for NRCS.
- Familiar boundaries for landowners and suggest local control.
- Include active planning committees and adopted plans.

***Disadvantages***

- Do not relate to physical landscape structure or ecological function.
- Habitats may not conform to political or resource administrative boundaries.
- Wildlife home ranges, migration, and dispersal do not conform to political or resource administrative boundaries.
- Existing plans and regulations may not have adequately considered wildlife and wildlife habitat.

**Biological or geographic criteria**

***Advantages***

Wildlife species ranges

- Reflect wildlife use of the landscape.
- Critical for planning for wide-ranging species, such as cougars and bears.
- Emphasize values of landscape level planning for wildlife.

Watersheds

- Define hydrological processes within the boundary.
- Management practices are reflected throughout the watershed.
- Define the location of critical riparian corridors.
- State wildlife management units are often based on watersheds.

***Disadvantages***

- Watersheds may cross several political boundaries.
- Home ranges of many species are not well known and would be time consuming and expensive to generate.
- Home ranges of some species may include several watersheds.

- Single planning, administrative, or regulatory mechanism is seldom operative.
- Necessary planning, administrative, and regulatory mechanism could be complex, cumbersome, and conflicting.
- Boundaries could be unfamiliar and confusing to landowners.
- Suggest regional or state control; an unpopular concept with most landowners

The planning team needs to determine which type of planning boundary is most appropriate for their areawide project. In many cases watersheds are the most practical planning unit and are being used to delineate many planning boundaries. In Virginia, for example, NRCS delineated approximately 500 watersheds averaging 53,000 acres for planning purposes.

Whatever criteria are used to establish the planning boundary, the planning area should be large enough to include the home ranges of all but the most wide-ranging wildlife species. The study area occasionally needs to be expanded to include the home ranges of important wide-ranging species.

### (2) Create a base map

***(i) Scale***—During the process of delineating a planning project boundary, a base map should be prepared to help participants visualize the planning area. USGS 7.5-minute quadrangles at 1:24,000 are often an appropriate scale for watershed planning projects. Large watersheds require splicing together several maps. It should be noted that some quadrangle maps do not reflect current conditions, particularly in rapidly urbanizing areas, and may need to be updated.

***(ii) Context***—The NPPH provides some guidance for preparing a base map. Key elements to include on the base map are

- topography,
- hydrology,
- political boundaries,
- transportation and utilities, and
- general land ownership (public/private).

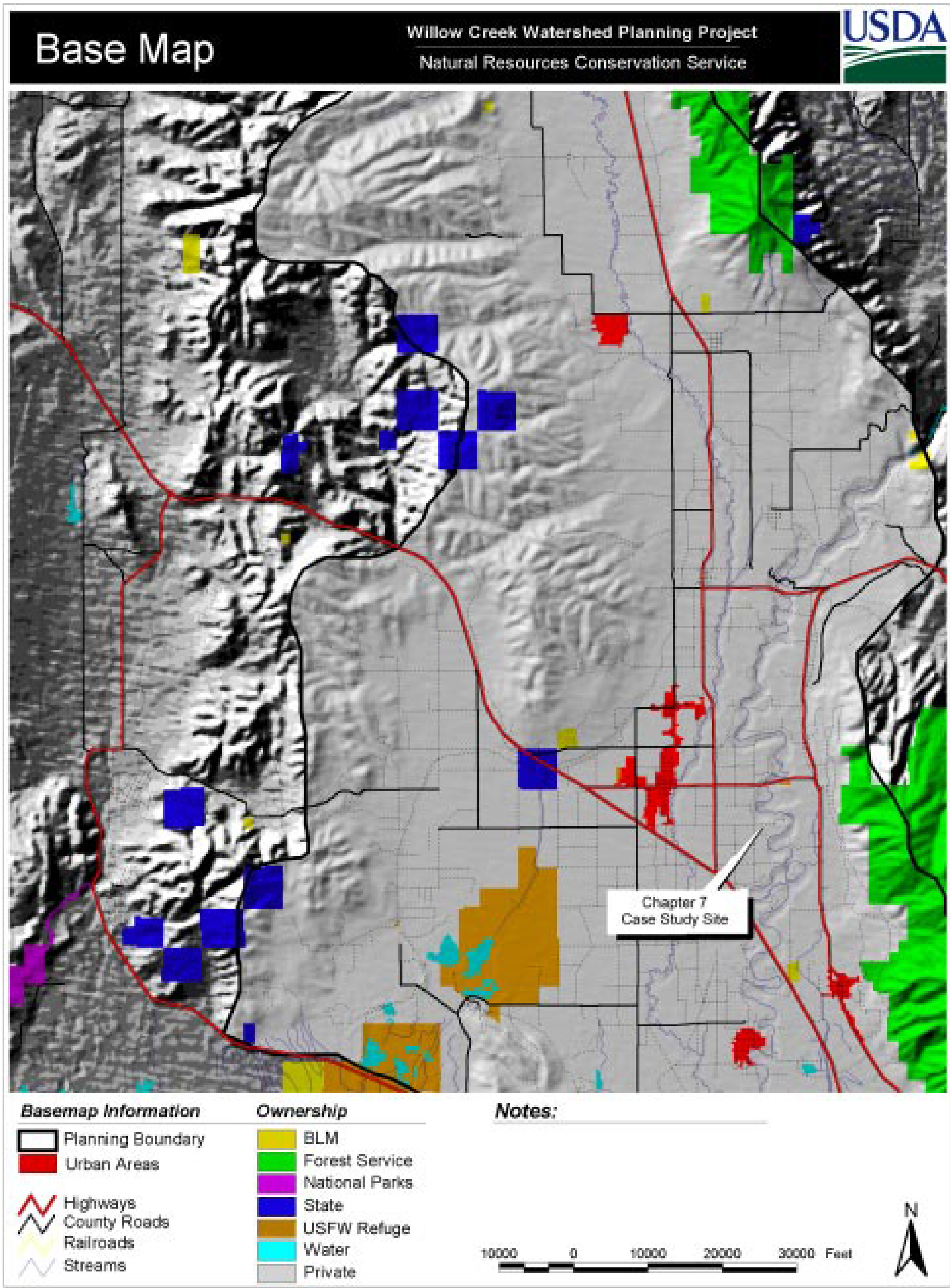
These elements should be displayed in simple graphic form maintaining clarity even when additional information is added or overlaid later during inventory and plan preparation steps. Figure 613–53 provides an example of a watershed base map. The planning boundary follows a watershed boundary except at the upper and lower ends where political boundaries were used. This was necessary because two counties in the study area chose not to participate in the planning project, a common problem in many watershed planning efforts.

The team needs to decide if it will produce hand drawn or computer-generated base maps to record inventory information and prepare plans. This decision depends on resources available, such as personnel, funding, and computer hardware and software.

Computers are a useful tool for large-scale planning because of their capabilities for storing, manipulating, and displaying large quantities of data. A Geographic Information System (GIS) is a particularly valuable computer tool for watershed planning. GIS is a collection of computer hardware and software designed to efficiently store, update, manipulate, analyze, and display all forms of geographically referenced information. It can be used to organize information in layers, such as hydrology, topography, wildlife distribution patterns, and critical habitat areas. Unlike manual mapping systems, the drawing scale can be adjusted and data layers can be easily updated. The example base map in figure 613–53 was completed using GIS. Although the base map was printed on an 8.5- by 11-inch sheet, it could be printed on a larger sheet format to facilitate the placement of additional information. In many states existing resource data are being converted to GIS formats. Planning team members from resource agencies should check availability of existing GIS data. For instance, the Automated Geographic Reference Center (AGRC) in Utah is consolidating data from various State and Federal agencies and is organizing it into a GIS format. GIS maps are then made available to the public for planning purposes.

If computer resources are not available, it will be necessary to prepare the base maps by hand. Hand drawn maps should be prepared using indelible ink on durable Mylar or drawing film, so that blueprints or large-format photocopies can be made and used during the planning process.

**Figure 613–53** Base map made using GIS



### (3) Problem and opportunity identification

The NPPH outlines a general process for identifying problems and opportunities. The key steps in this process include

- scoping,
- reviewing existing data,
- gathering preliminary expert opinion,
- verifying field data,
- making recommendations for studies (if necessary), and
- documenting of problems and opportunities.

***(i) Scoping***—Scoping involves direct communication with various publics and dialogue among planning team members. The purpose of scoping is the preliminary identification of problems and opportunities for wildlife conservation in the watershed. During scoping, it may become evident that the planning project warrants further environmental evaluation as required by NEPA. Other references should be consulted for preparing NEPA documents using proper procedures and formats.

Wildlife conservation at a watershed scale is complex and involves many interrelated resource issues. Consequently, identification of problems and opportunities requires an *interdisciplinary approach* that addresses ecological, cultural, social, and economic issues. Wildlife issues must be addressed by a knowledgeable team with backgrounds in wildlife biology, terrestrial and aquatic ecology, and conservation biology. Together, they can identify the problems and opportunities of greatest significance to the wildlife resource. However, biologists and ecologists must interact with other team members; interdisciplinary planning is effective only when all participants work across disciplines to achieve a plan that is directed toward the conservation of desired resources. It is the planning coordinator's responsibility to keep the group focused on problem identification and not on premature solutions.

During scoping meetings, the public and different stakeholders are given an opportunity to *identify problems* and opportunities from their perspective. This includes listening to experts, long-time residents, the public, and various stakeholders. Scoping is an important time to interact with each other, identify issues of concern, and to build solid working relationships.

Public involvement from stakeholder groups that may seem reluctant to directly participate on the planning team must be nurtured. Input from these groups and the public may be gained through surveys, informal one-on-one meetings, meetings with special interest groups, and open public meetings. Often perceived problems are identified in this process. These problems are real to the stakeholder and must be addressed. Research reports, studies, and expert testimony are tools that can be used to clarify the facts surrounding many of these concerns.

In addition to identifying problems, the group should take a proactive approach and *identify opportunities* to enhance wildlife habitat and biodiversity. Unlike problems, opportunities do not place blame on any particular group within the watershed. Sometimes, an opportunity becomes the factor that rallies and sustains group support for a project. The group should reference section 613.04 for ideas on identifying opportunities for improving conservation of wildlife in the watershed.

A *watershed tour* is a valuable scoping tool for identifying problems and opportunities. It provides an opportunity for team members to discuss perceptions of problems and possibilities in the watershed. It is best to schedule the tour after the initial planning meeting so that the public's concerns identified during scoping can also be addressed in the field.

The NRCS Social Science Institute developed Rapid Resource Appraisal (RRA), a format for a daylong field trip and a set of activities that planning groups can use to quickly learn about the problems and opportunities in a watershed. The RRA (USDA NRCS 1997), which can be specifically tailored for wildlife issues, should be done shortly after scoping so all participants become familiar with the issues and their complexity. Field notes, photos, videos, and other such information should be compiled during the tour to record conditions for future reference. A useful brochure on RRA is available from the NRCS Social Sciences Institute Web page described previously.

***(ii) Review existing data***—The planning team should reference any previous work done in the watershed, such as environmental impact statements, environmental assessments, planning reports, wildlife research projects, and thesis. Reference librarians can assist in locating these resources. In some states GAP analysis data (as described in section 613.04) may be available and should be used in identifying problems and opportunities.

***(iii) Preliminary expert opinion***—Biologists and ecologists on the planning team are responsible for identifying the wildlife-related problems and opportunities inherent in the pattern of patches, corridors, and matrix in the watershed. Although the pattern of these landscape features is different in each watershed, there are relationships and land use practices common to most watersheds that should be identified.

- How do wildlife utilize the pattern of landscape elements? Note in particular, patches with high biodiversity and corridors important for dispersal or migration.
- What existing patches or corridors are being managed for biodiversity?
- What land uses or management practices may be adversely impacting the habitat or conduit functions of existing patches and corridors?
- What land uses or management practices may be limiting wildlife species diversity or abundance?
- What patches could be linked with corridors to enhance biodiversity?
- What locations in the watershed have the potential to be restored as patches or corridors?

Biologists and ecologists should consolidate the information gathered during the scoping process and watershed tour and prepare a preliminary report of their findings.

***(iv) In-field verification***—The planning team should schedule additional field trips to verify problems and opportunities identified in the preliminary expert opinion report. This provides another opportunity to refine the group's findings.

***(v) Recommendations for studies—***In many cases existing data on wildlife populations and habitat for a particular watershed are limited. Field studies may be required before the team can begin preliminary documentation of the problems and opportunities. Additional data may be collected during the inventory step of this phase. Problems and opportunities will not be finalized until the resource data are analyzed in planning step 4.

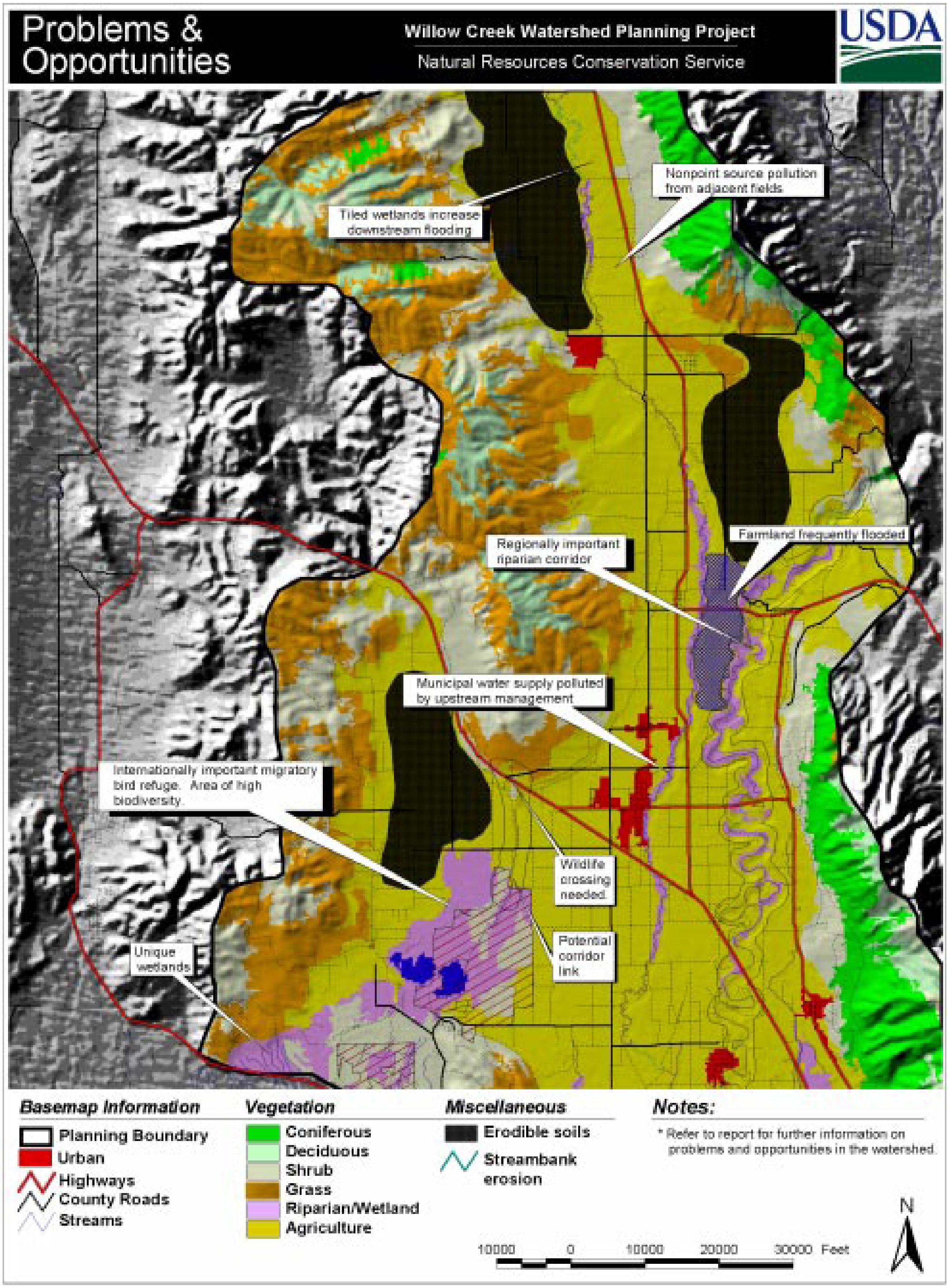
### (4) Documentation

After problems and opportunities have been identified, they should be documented on the base map (fig. 613–54). The value of mapping the results is that it ties issues to specific locations within the planning area. Short reports should be prepared to supplement mapped data. The team should also document problem and opportunity areas with photographs for future reference. Photographs of the existing condition can also be valuable in evaluating the implemented plan.

### (5) Products

- Mapping format, scale, precision, and role of technology
- Base map with planning boundary
- Preliminary identification of wildlife and wildlife habitat problems and opportunities documented on base maps and short reports

**Figure 613–54** Base map showing problems and opportunities



## Step 2 Determine objectives

**Planning standard**—The planning group's objectives are clearly stated and documented.

The NPPH provides an outline of how to determine objectives at a watershed scale. In addition, the planning group should develop a vision statement and establish objectives (desired future condition) for wildlife conservation and biodiversity.

### (1) Develop a vision statement

The main reason that stakeholders initiate watershed planning is because they wish to change the existing conditions in the watershed to some desired future condition. The desired future condition defines the focus for the inventory, the benchmark for the analysis of existing conditions, criteria for formulating and evaluating alternatives, and guidance for what conditions to evaluate and monitor. Often the planning team develops a vision statement; a short description of what they believe the future condition should be for the watershed. This vision must be shared among all stakeholders and agreed upon by everyone in the planning effort.

The vision statement may be a general statement for all resources in the watershed, or the group may decide to craft individual statements for each resource. A specific statement would then be prepared for the wildlife resource. A vision statement should clearly define the final destination of the planning effort. It will be the touchstone throughout the planning process. The vision statement for wildlife conservation from the Edisto River Basin Project in South Carolina (Beasely et al. 1996, p. 186) is an example.

**A Vision for Wildlife in the Edisto River Basin**

*Wildlife and wildlife habitat are important to enhancing the quality of life of people both inside and outside of the basin area. Because there is an abundance of good quality habitat, the committee sees that conservation of natural habitats and prevention of degradation is a significant opportunity within the Edisto Basin….Connectivity is believed to be essential for the long-term viability of a number of native species. For these reasons, maintaining and enhancing both large blocks of habitat and connectivity among habitats are important for sustaining regional wildlife diversity.*

### (2) Determine objectives

Objectives are road maps to desired future conditions expressed in the vision statement. They are specific statements describing how the desired future will be achieved. The following are common attributes of an objective:

- Start with an action verb.
- Specify a specific outcome.
- Specify a timeframe to reach the desired outcome.
- Frame objectives in positive terms.
- Make objectives specific and measurable for later evaluation.
- Phrase objectives in a way that describes what is desired without prescribing a specific solution.

Objectives for wildlife should respond to the wildlife conservation problems and opportunities identified in step 1. They may be revised as new information is generated during the inventory and analysis steps. The planning group should be aware of any Federal, State, or local laws related to wildlife that could affect the plan concepts and objectives.

When developing objectives, the principles described in section 613.04 should be consulted. In addition, the following list of categories can serve as a guide for the development of a comprehensive set of objectives. The planning team may want to develop objectives for each category.

**Habitat**
Matrix
Patch
Corridor

**Wildlife**
Non-game
Game
Vulnerable

**Other**
Educational
Policy

Short- and long-term objectives need to be developed. To maintain stakeholder commitment to watershed planning efforts, some tangible objectives need to be achieved in a short time as well as results that may be realized 10 to 20 years in the future.

#### (3) Documentation

The vision statement and objectives for the planning project should be recorded in a short report. A brochure with highlighted objective statements, photographs, drawings, charts, and other graphics depicting the desired future condition of the watershed may be useful. The brochure can be used for promotional and educational purposes.

#### (4) Products

- Vision statement (desired future condition)
- Measurable objectives for wildlife and wildlife habitat

## Step 3 Inventory resources

**Planning standard**—Sufficient data and information are gathered to analyze and understand wildlife and wildlife habitat conditions in the planning area.

The general intent of the resource inventory is to describe existing (benchmark) conditions within the project planning boundary. The wildlife resource section of an inventory should include a wildlife species component and a habitat component. When watershed plans require preparation of an EIS or EA, NEPA guidelines must be followed for inventorying wildlife. The wildlife resource inventory at a watershed scale should

- investigate in greater detail each problem and opportunity identified in step 1,
- collect additional data as necessary in response to the vision statement and specific objectives established in step 2,
- describe wildlife resources including species diversity and abundance, threatened or endangered species, and vulnerable populations,
- describe wildlife use of existing patches, corridors, and the matrix, and
- describe general habitat conditions in patches, corridors, and the matrix.

Information generated in the watershed inventory is useful for further defining the problems and opportunities identified in step 1. Inventory information may also suggest the group's objectives need to be altered to more accurately reflect conditions within the project boundary.

#### (1) Inventory responsibilities

In many instances, the technical advisory committee or a similar subgroup of the planning effort is responsible for the wildlife and wildlife habitat inventory. Participants on these committees generally have the best access to wildlife resource data since many are biologists or other resource professionals. However, it is also important to involve other stakeholders when possible in the inventory process. Many long-term residents, local biology teachers, birdwatchers, or environmental groups can offer valuable insight. Involving all of the stakeholders creates a sense of ownership in the process, leads to better input of information, and establishes a better group understanding of the wildlife resource.

#### (2) Data collection

The NPPH provides a general outline for inventorying resources at a watershed scale. Ecologists and biologists in consultation with other team members will specify the kinds of data required to adequately plan for the wildlife resource. Each watershed is unique; hence, most data requirements will be watershed or area specific. However, the following basic data needs relate to most watershed scale projects.

Wildlife species data needs:

- Wildlife present in the planning area
  - > Non-game species
  - > Game species
  - > Threatened and endangered species (Federal and State listed species)
- GAP data (where available)
- Vulnerable populations of a species
- Historical species (once present, but no longer reside in the watershed)
- Population characteristics for species of concern
- Culturally important species (especially those tied to Native Americans or valuable to limited income groups for subsistence)

Wildlife habitat data needs:

- GAP data (where available)
- Existing vegetation
- Historical vegetation

- Wildlife species/plant communities relationships
- Land cover types
- Land ownership
- Habitat features
  - > Patches with high biodiversity
  - > Patches with vulnerable populations
  - > Migration and dispersal corridors
  - > Special areas (e.g., calving sites)
- Potential habitats
- Species ranges for species of concern
- Water availability and historical hydrology

The goals of the inventory process for watershed planning are to identify the most important elements of wildlife habitat at the landscape scale and determine the level to which they are protected. These key elements form the basic structure of the conservation plan alternatives developed in later steps. A GAP analysis (described in section 613.04) is useful for this purpose. The GAP map identifies areas with high levels of biodiversity that are currently not being managed for wildlife conservation (fig. 613–55).

### (3) Documentation

All inventory data should be mapped at the same scale as the base map (fig. 613–56). This may require enlarging or reducing mapped information from different sources. For a watershed inventory, a convenient mapping scale is the 1:24,000 USGS quadrangle map. It should also be noted that some data features, such as corridors, need to be exaggerated in scale to be visible on the base map.

The biologists and resource specialists on the planning team should determine the specific types of inventory maps needed to depict the wildlife resource in the watershed. The categories and level of detail on the maps vary depending on the regional context. A short report summarizing inventory results may also be appropriate.

### (4) Products

- Detailed inventories of the planning unit
- Information on human considerations
- Identification of other ecological concerns, including wildlife issues
- Identification of cultural resources
- Identification of infrastructure physical features, such as roads, houses, fences, power lines, and other utilities
- Benchmark data for the planning area

## Step 4 Analyze resources

**Planning standard**—The benchmark condition for the planning area is documented. Results are displayed in easily understood formats depicting current natural resource conditions, physical characteristics of the planning unit, and comparisons between existing and potential conditions. The causes of any resource problems are identified.

The planning group must now interpret the inventory data for the watershed planning area. The NPPH outlines the basic procedures for step 4 analysis. The professional expertise of team members and consultants (where necessary), discipline manuals, and inventory worksheets are critical resources in the analysis process at the watershed scale. Each resource inventoried in step 3 will be analyzed in detail. The reports and maps prepared specifically for wildlife in the analysis step should

- depict the current condition of wildlife and habitat resources in the planning area,
- compare existing conditions with potential conditions, and
- identify the causes of resource problems.

Analysis of resources at the watershed scale is complex. An interdisciplinary team approach is necessary to conduct a thorough analysis that describes the interrelationships among resources. Biologists, ecologists, and other resource specialists should provide specific guidance for analysis of wildlife and wildlife habitat. Again, all stakeholders should be involved in the analysis process to the extent possible. Group involvement promotes better understanding of the wildlife resources, which facilitates development of plan alternatives in step 5.

Results of the analysis may suggest that some previously defined objectives may need to be eliminated or modified; some new objectives may be added. At the completion of step 4 and phase I, the planning group

**Figure 613–55** Gap map identifying areas of high biodiversity

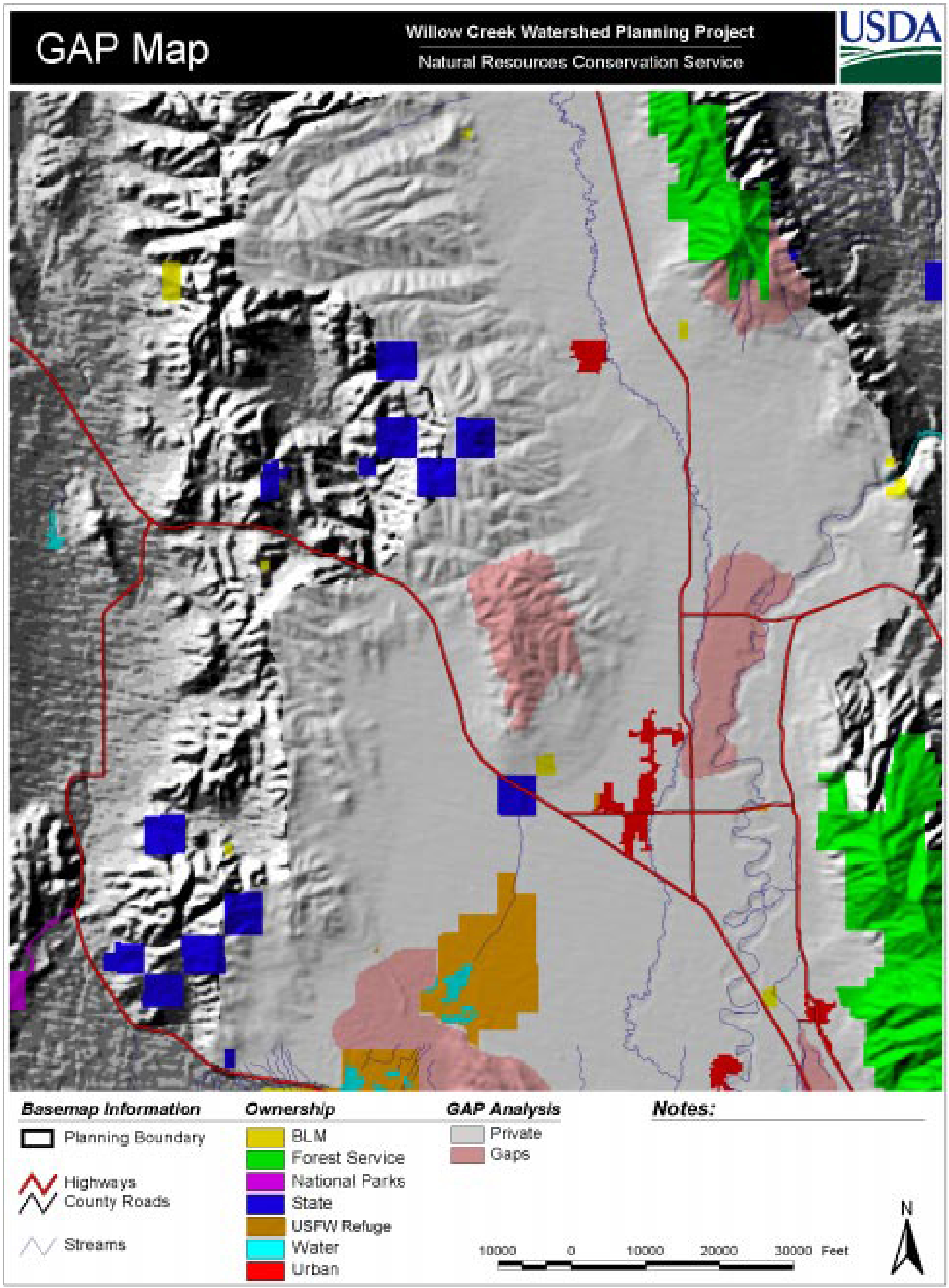
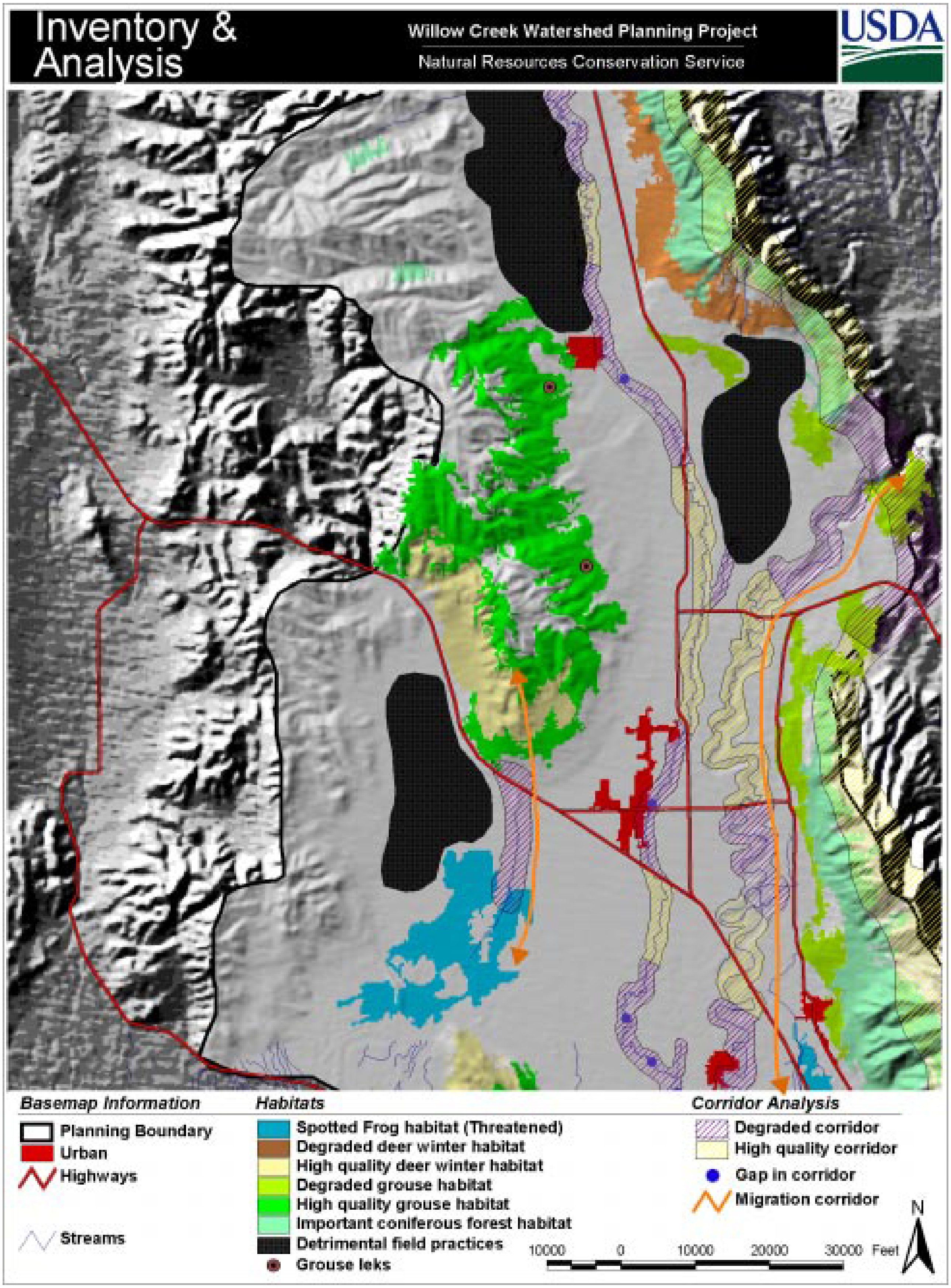


**Figure 613–56** Base map showing inventory data



should agree on problems, opportunities, and objectives for the watershed plan.

The analysis of watershed wildlife resources focuses on the community level. Major issues include wildlife species diversity and abundance, critical habitat reserves/patches, linkages between major corridors and reserves/patches, and attributes of the matrix detrimental or beneficial to wildlife.

The intent of the analysis of wildlife resources at the watershed level is to

- locate key reserves/patches, corridors, and special areas with high levels of species diversity,
- describe the general status of wildlife populations or metapopulations of species of concern,
- describe the general factors limiting species diversity or species abundance,
- identify gaps in key corridors,
- identify which reserves/patches or corridors may be at risk,
- describe factors creating at-risk conditions, and
- identify other wildlife-related issues based on project objectives

### (1) Analysis questions

The analysis of wildlife-related resources should answer the following key questions. Additional specific questions may be developed by the planning team based on objectives established by the group.

Wildlife species component:

- What factors are limiting game and non-game wildlife species diversity and abundance?
- What wildlife populations are vulnerable to local extinction? What are the limiting factors for these vulnerable populations?
- Are there any threatened or endangered species? What are the limiting factors for these species?

Wildlife habitat component

- Which reserves/patches have the greatest species diversity?
- Which reserves/patches that have the greatest species diversity are in public ownership?
- Which corridors are essential to species migration or dispersal?
- Where are gaps in corridors that limit migration/dispersal?
- What existing corridors are at risk and for what reasons?
- Where should new corridors be placed?
- Where are potential habitats?
- What attributes of the matrix management or land use are detrimental or beneficial to wildlife? Where are they located?
- What natural disturbance factors have been altered (fire, grazing, insect control)?

### (2) Documentation

The answers to the analysis questions should be documented in a short analysis report and on a composite map. The analysis information needs to be synthesized into concise, accurate, and easy to understand tables, graphs, and maps. A concise presentation of information facilitates group discussion.

The composite map would document the habitat condition for significant reserves/patches, corridors, and the matrix in the watershed. It would also locate the following:

- Reserves/patches with threatened and endangered species or vulnerable populations
- Reserves/patches, corridors, special areas and special features at risk
- Potential habitats for restoration
- Reserve/patches with high biodiversity not presently being managed to preserve or enhance biodiversity (GAPS)
- Corridors used by wildlife for migration and dispersal
- Gaps in existing corridors
- Potential corridor locations that could facilitate dispersal between patches
- Special sites and features
- Field management practices detrimental or beneficial to wildlife

Figure 613–56 is an example of a watershed composite analysis map. The value of mapping the results of the analysis is that it ties the conclusions to specific locations within the planning area. The participants can see direct links to the inventory, analysis, and real resources, which will facilitate Step 5, Formulating alternatives.

### (3) Products

- A complete statement of objectives
- An analysis of the benchmark condition of the planning unit and related areas
- A complete analysis of all resources inventoried
- Environmental evaluation
- Cultural resources evaluation
- Other program and legal evaluations
- Identification of the causes or conditions that resulted in the resource problems
- A complete definition of problems, opportunities, and concerns

## (e) Phase 2 Decision support at the watershed scale

Phase 2 involves the following steps:

- Formulate alternatives
- Evaluate alternatives
- Make decisions

In phase 2, the planning team's task is to develop a range of plan alternatives that addresses the problems, opportunities, and objectives identified in phase 1. At the completion of phase 2, the planning group will select a watershed plan that will be presented for public review.

### Step 5 Formulate alternatives

**Planning standard**—Alternative plans (treatments) are developed to meet quality criteria and objectives of the watershed planning team.

The NPPH outlines a general process for formulating watershed scale plan alternatives. The purpose of this section is to provide guidance for formulating alternatives that address wildlife conservation. The wildlife component of the watershed plan should be prepared by the entire planning team. It is assembled as a series of map overlays or layers. The base layer is the composite analysis map, which depicts existing habitat resources in the watershed. Subsequent layers illustrating proposed solutions to specific problems or opportunities are overlaid on the analysis composite base maps. Layers typically include the following information:

**Existing habitat resources**—This base is a copy of the composite analysis map prepared in step 4.

**Function**—This layer delineates the location of functional issues that need to be addressed by the watershed plan (i.e., wildlife habitat, flood plain management, erosion control, water quality issues).

**Existing habitat resource management**—This layer delineates recommendations for preservation, enhancement, or restoration of existing habitat resources.

**Potential habitat and new wildlife plantings**—This layer delineates major sites in the watershed that could be developed into wildlife habitat (new plantings for wildlife are shown on this layer).

**Synthesis**—This layer uses the concepts and principles described in section 613.04 to integrate the three previous layers into an ecologically sound wildlife plan that responds to the unique resources of the watershed and the planning team's objectives.

### (1) First layer—function

Many references on planning theory recommend that initial planning studies focus on functional issues. Functional issues at the watershed scale usually include flooding, erosion control, and air and water quality protection; rarely do projects focus on wildlife resources alone. Typically, functional issues are what motivated landowners and communities within a watershed to initiate the project. The problems and opportunities identified in steps 1 through 4 reflect the issues of concern. The recommended process for addressing functional issues follows:

- Review the group's objectives related to flood control, erosion control, air and water quality protection, and other functional issues.
- Identify the ecological functions of corridors or other conservation practices or combinations of practices that can be used to solve the problem or capitalize on the opportunity.
- Identify existing corridors that could be preserved, enhanced, or restored to meet program objectives, solve functional problems, or capitalize on opportunities.

- Select new corridor types or management practices or combination of practices that provide necessary functions to meet objectives, solve problems, or realize opportunities not addressed by existing corridors.
- Locate and map new corridor types and management practices or combinations of practices on the watershed base map.
- Repeat this procedure for each objective, functional problem, or opportunity.

When all the conservation practices and systems of practices necessary to meet the group's objectives have been located on the base map, a preliminary functional plan has been completed (fig. 613–57). Starting plan development by addressing functional issues does not mean that wildlife issues are any less important; they are simply addressed more completely later in the process. Often wildlife habitat and corridor recommendations explored in layers 3 to 5 will suggest necessary changes to the functional plan. The planning team will resolve potential conflicts by working toward compromise.

### (2) Second layer—Existing habitat resource recommendations

The general condition of critical patches, corridors, potential patches, and special areas and features was documented in the watershed analysis. The causes of the conditions were also identified. Both conditions and causes should be addressed in each plan. The following procedure for addressing habitat quality issues is suggested:

- Review the current condition of each patch, corridor, special area, or special feature as described in the analysis.
- Review the wildlife analysis report to identify factors degrading these habitats or limiting species diversity or abundance.
- Recommend ways to alleviate the cause or causes of habitat degradation or other factors limiting species diversity or abundance.

General recommendations to preserve, enhance, or restore patches, corridors, or other habitat resources should be noted on the base map and linked directly to that resource (fig. 613–58). Specific management techniques for meeting these objectives should be keyed to the habitat resources on the map and described in detail in the implementation report (step 8).

### (3) Third layer—Potential habitats and new wildlife plantings

The planning team should review the areas of potential habitat delineated on the analysis map and assess the possibilities of enhancing or restoring these areas. Consider the function that these areas could perform in addition to habitat. For example, farming on flood plains is common in many regions of the country. During wet years, crop production in these areas is marginal. Many farmers are either voluntarily selling these marginal lands to conservation organizations or participating in easement programs that return these sites to wildlife habitat. (See Iowa River case study at end of this section.) Not only have these practices restored habitat for wildlife, they have also restored other hydrological functions that help mitigate downstream flooding.

Easement corridors for railroads, highways, power lines, pipelines, and other utilities provide real possibilities to link patches and other corridors across the watershed. If properly planted and managed, easement corridors can provide excellent habitat for many species. Similar habitat and linkage potential can reside on steep slopes, damaged soils, waste areas, and disturbed sites. Locate potential habitats worthy of development on the areawide/watershed base map (fig. 613–59).

New wildlife corridor plantings at any areawide scale should emphasize reconnecting reserves/patches within the watershed that were historically linked. They often are located in riparian or upland corridors or areas that have been degraded over time. Occasionally, large wildlife corridor plantings are proposed in areas previously devoid of corridors to provide habitat or facilitate wildlife migration or dispersal. Plantings of this type are increasingly important because agriculture and urbanization have drastically altered the presettlement landscape pattern. (See the Iowa River and Tensas case studies for examples.) All new plantings should be based on the principles described in section 613.04. Care should be exercised so that new plantings are compatible with normal farming or ranching practices. Locate all proposed new plantings on this layer.

### (4) Fourth layer—synthesis

Synthesis involves combining the mapped information from all three layers. The pattern that emerges from overlaying all layers is often disconnected. It is a

**Figure 613–57** Completed function plan map

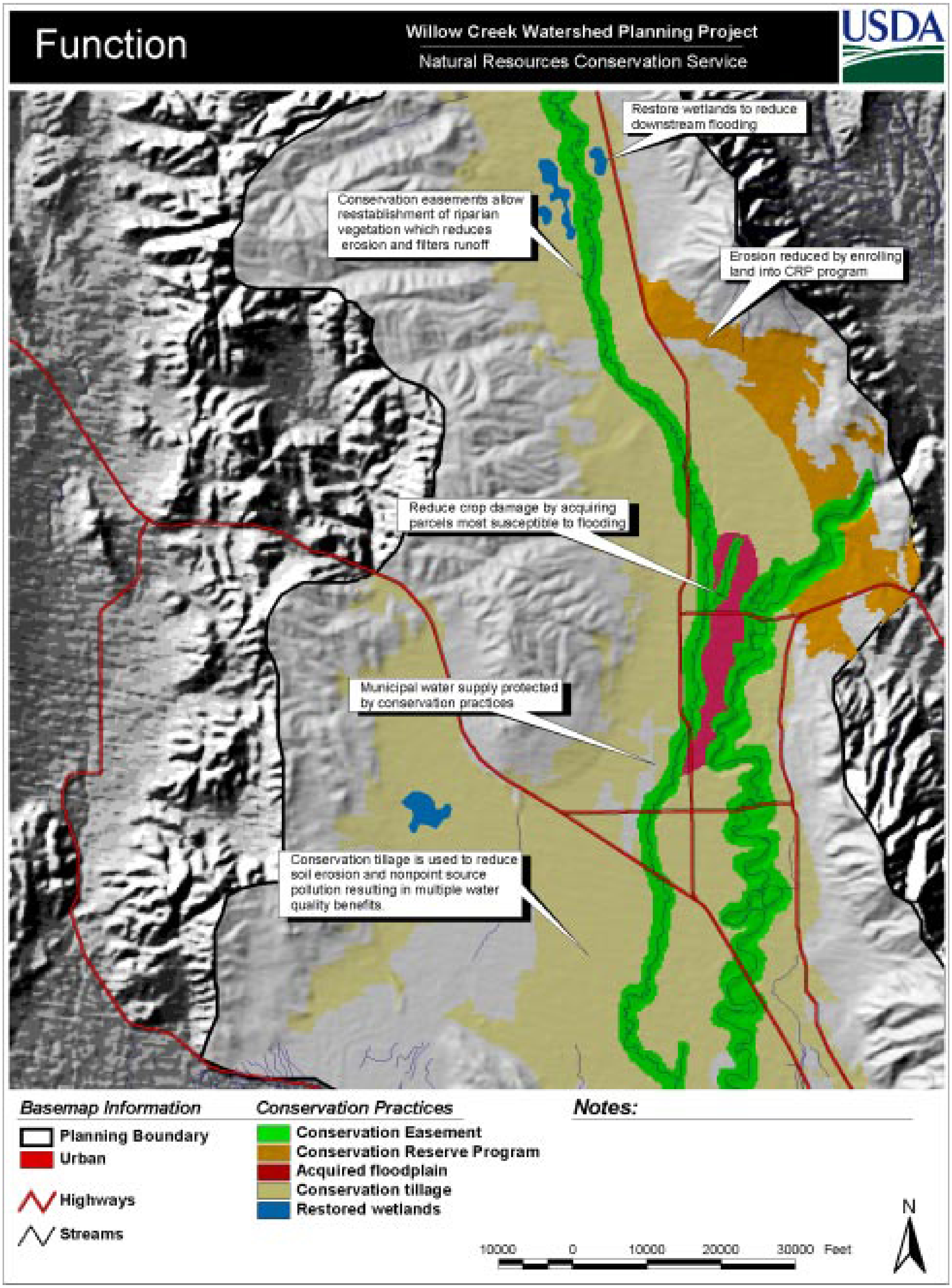


**Figure 613–58** Base map with layer showing resource recommendations

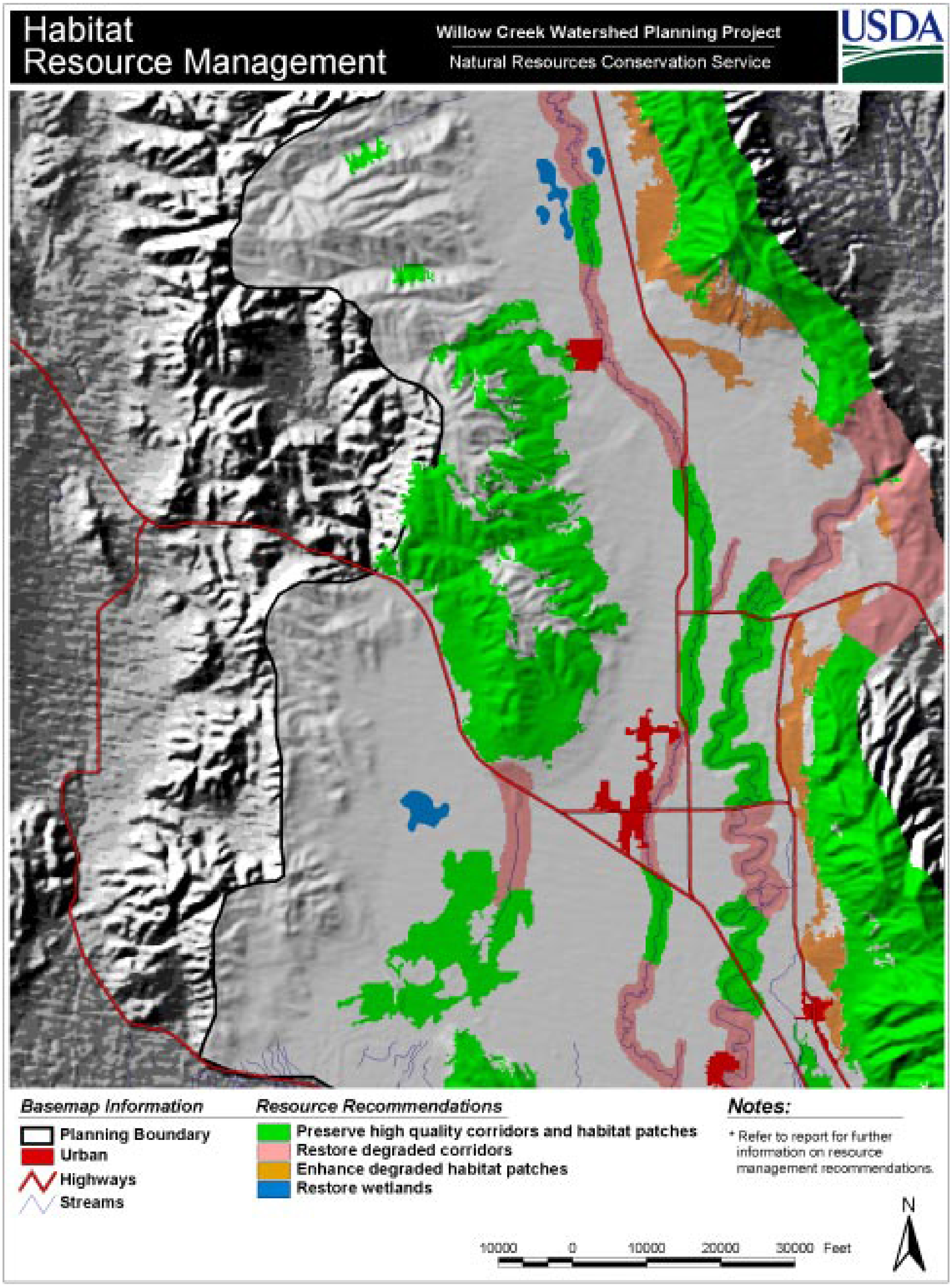
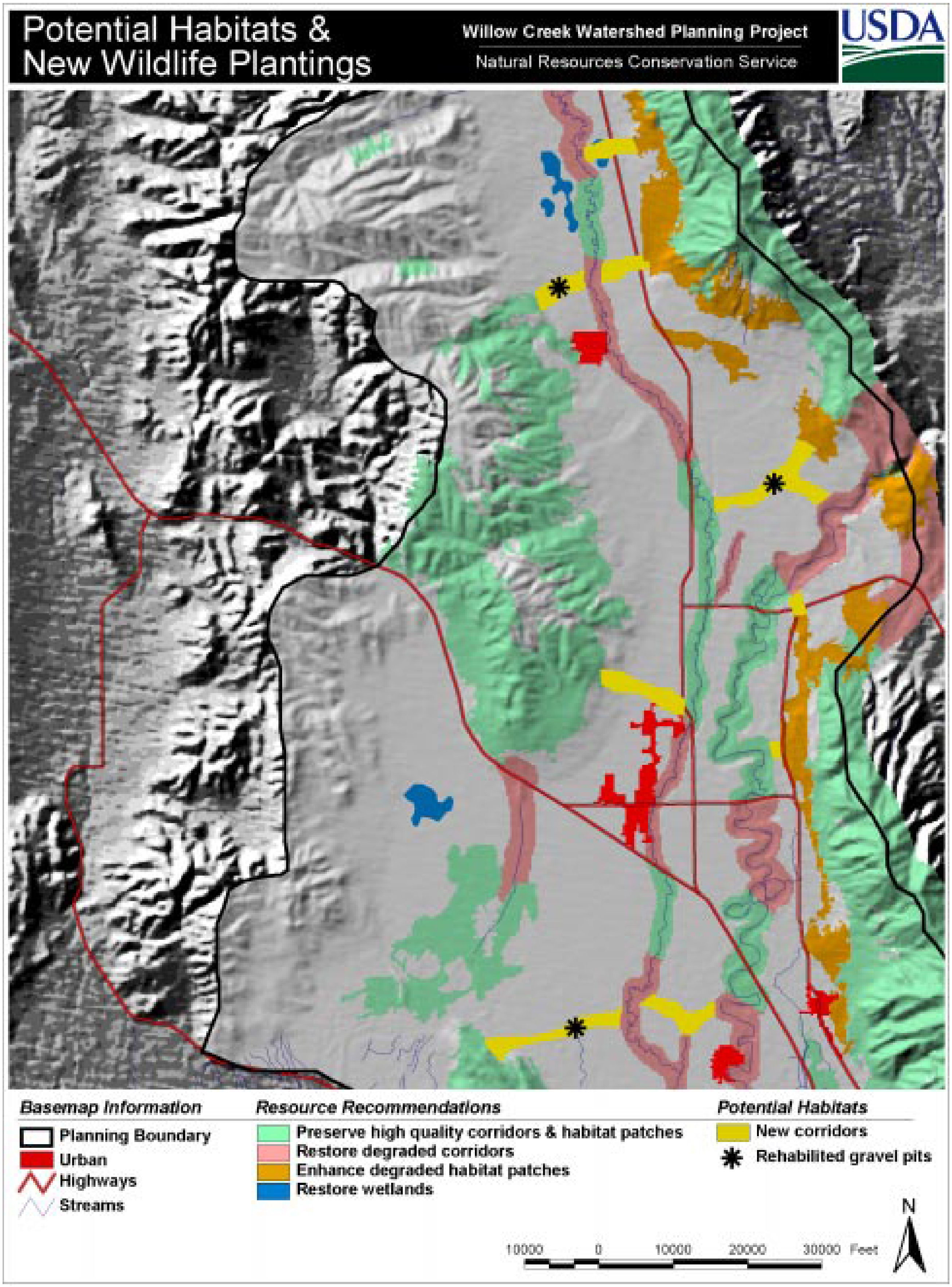


**Figure 613–59** Base map with layer showing potential habitat and new wildlife plantings



collection of implementation strategies, conservation practices and management recommendations, not yet a plan. The challenge for the planning team is to convert this collection of recommendations into a plan. The team needs to identify practical opportunities to connect reserves/patches, corridors, potential habitat patches, special areas, and special features into an integrated pattern. The intent is to optimize the value-added benefits of connectivity. The planning team should reference these concepts and principles to help guide the plan development process.

In some instances, a reserve/patch or corridor cannot be linked in a practical way. They will remain disconnected from the overall structure of the conservation plan, but are still valuable as habitat.

The wildlife component of the areawide plan that emerges from this synthesis should optimize habitat resources in the watershed.

***(i) Planning habitat concepts and principles***—The concepts and principles described in section 613.04 are guidelines that the planning team can use to synthesize the three previous layers into an integrated wildlife habitat plan. They suggest locations, configurations, and linkages for corridors and patches in the watershed that would provide the greatest benefit for wildlife. The concepts and principles are applicable regardless of project scale and have been rephrased as planning directives to use in this phase of the process.

Patches

- Preserve all large reserves/patches or introduce new large patches where practical.
- Connect all reserves/patches, large or small, that were historically connected.
- Do not subdivide existing reserves/patches.
- Preserve clusters of small patches.
- Preserve reserves/patches that are near each other.
- Introduce new patches in areas devoid of habitat.

Corridors

- Preserve continuous corridors; plant gaps in discontinuous corridors.
- Preserve existing corridors that connect existing patches; pay particular attention to migration and dispersal corridors.
- Introduce, where practical, corridor plantings to connect reserves/patches that were historically connected.
- Preserve or introduce multiple corridor or steppingstone connections between reserves/patches that were historically connected.
- Design new corridors to be as wide as practical; widen existing corridors where practical.

Special areas and features

- Preserve all reserves/patches, corridors, and special areas or special features inhabited by threatened and endangered species or vulnerable populations.
- Preserve other special areas and features.

Potential habitats

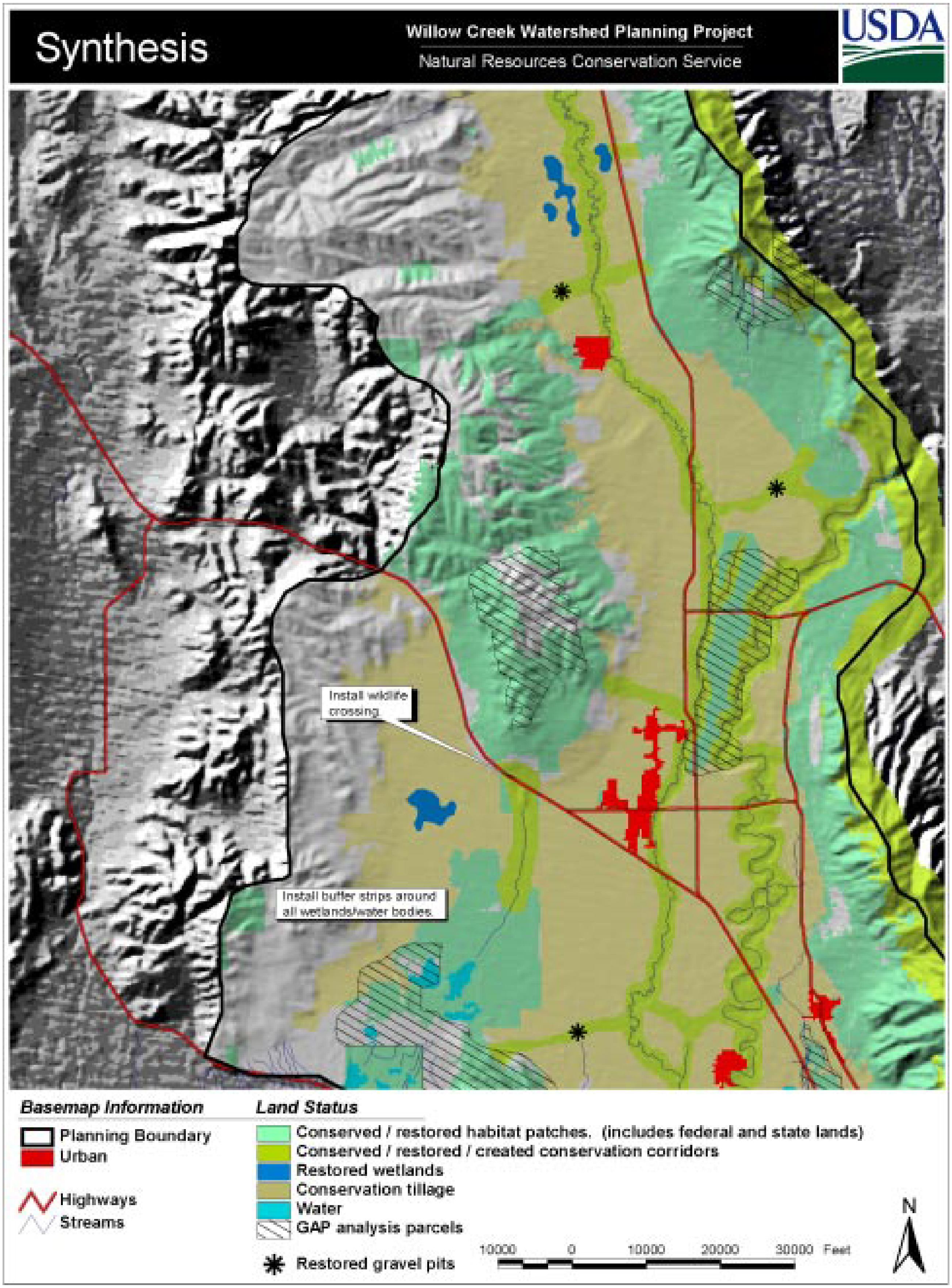
- Develop potential habitats where practical.
- Consider artificial structures to provide habitat when natural habitat has been degraded or destroyed (a watershed-wide bluebird nest box or bat house program, for example).

Other principles

- Address key impacts that create at-risk conditions for habitat in the watershed.
- Recommend matrix management principles that benefit wildlife.
- Recommend structural diversity in reserve/patch and corridor plant communities.
- Recommend native plant communities.

The planning team should adapt concepts and principles as necessary to meet project resource conditions and needs of specific wildlife species. This provides a framework for the combining of conservation practices. The planning team should take the preliminary plan into the field and review the general recommendations and patterns of patches and corridors. Adjustments to the plan should be made as necessary. The team should draw up the final base plan once all adjustments have been made (fig. 613–60).

**Figure 613–60** Final map with combined information from the three layers



### (5) Develop alternatives

The team is responsible for considering various alternatives. Alternatives should focus on conservation functions, wildlife (diversity or target species), or other corridor benefits. However, each alternative must meet the objectives identified in phase I. Some examples of alternatives follow:

- A plan alternative or several alternatives using various conservation implementation strategies, management practices, and recommendations to address functional problems and opportunities.
- A plan alternative to optimize for wildlife species diversity.
- A plan alternative to increase populations of a particular species, guild, or suite of species.
- A plan alternative to optimize recreation, economic, or other corridor benefits.
- A no-action alternative (required by NEPA).

Wildlife and conservation biologists and other resource specialists on the planning team should play key roles in assuring that each plan alternative addresses wildlife issues.

Some alternatives may emphasize wildlife. For instance, a wildlife biodiversity alternative may emphasize the preservation, enhancement, and restoration of habitats for all species native to the watershed. Other plans may choose to optimize a particular species. For example, one alternative could emphasize bobwhite quail. Such a plan would focus on factors limiting quail populations and would propose landscape scale habitat modifications to reduce limiting factors. Caution is required in preparing single species plans or other single focus alternatives. Without careful consideration of the entire plant and animal community in the watershed, implementing a single species plan could jeopardize overall biodiversity.

The NPPH requires that a no-action plan alternative be considered. The purpose of this plan is to estimate the future condition of the watershed if no action is taken to conserve resources. New corridors would be planted and existing corridors would be removed at current rates. Trends in the condition of corridors and habitat patches would be assumed to continue. Construction of roads, bridges, community development, and other landscape modification would be assumed. This alternative often depicts the worst-case scenario for wildlife (fig. 613–61).

The planning team must agree that each alternative meets the group's objectives with the exception of the no-action alternative. In addition, each alternative must comply with all relevant Federal, State, and local regulations.

### (6) Documentation

Any plan recommendations that can be shown graphically should be drawn on the watershed base map. Include other recommendations in a brief report. At least two alternatives for the wildlife component of the plan should address wildlife and wildlife habitat problems and opportunities identified in the analysis. Each wildlife alternative must meet the goals and objectives specified in step 2.

### (7) Products

- A range of alternative plans developed by the planning team
- A short report summarizing the different plans

## Step 6 Evaluate alternatives

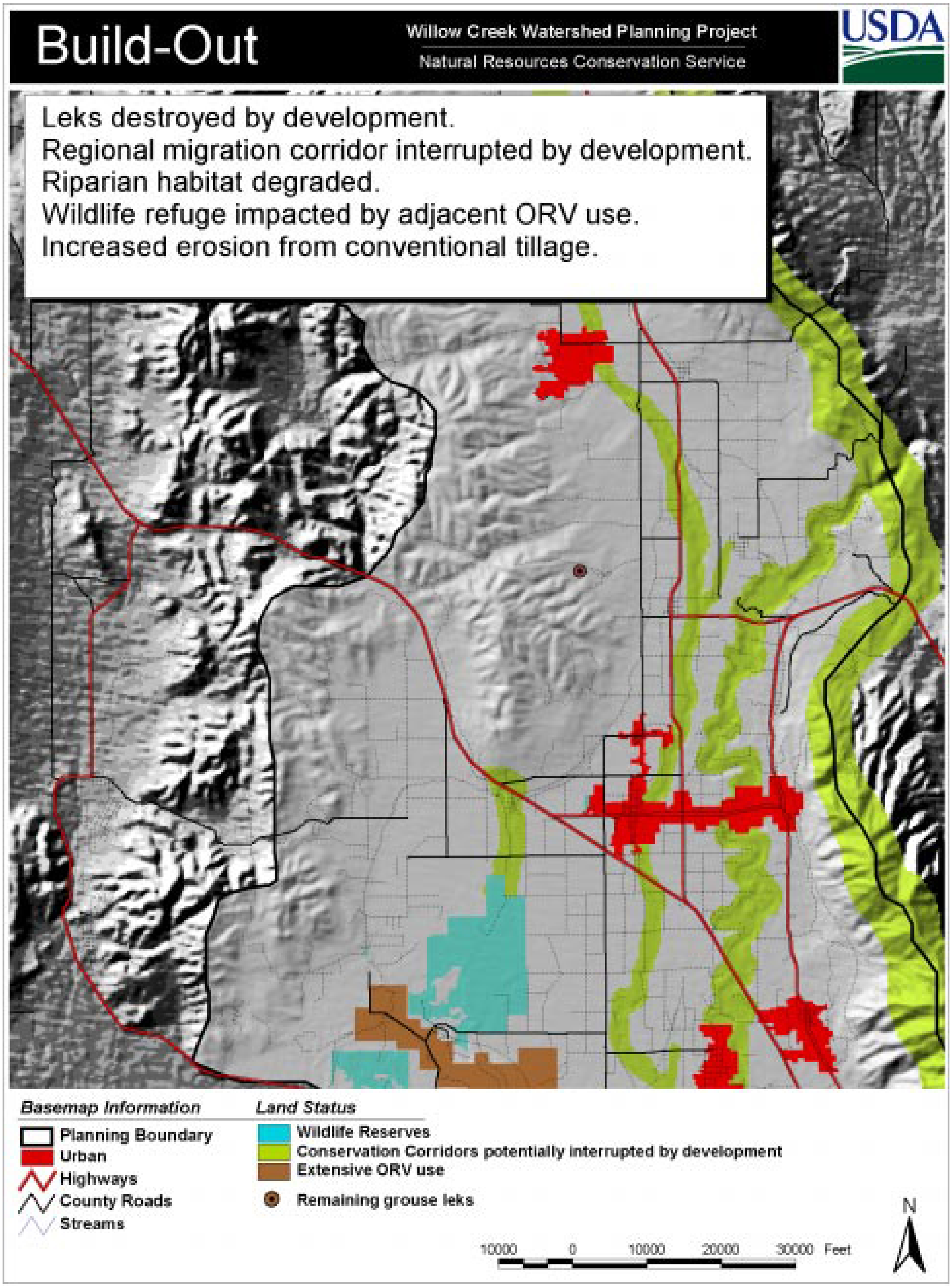
**Planning standard**—The effects of each alternative are evaluated, and impacts are described. The alternatives are compared to benchmark conditions to evaluate their ability to solve problems, meet quality criteria, and meet the stakeholders' objectives.

The planning team must now evaluate the watershed plan alternatives developed in step 5. The NPPH outlines the basic procedures for evaluating alternatives.

Often, watershed planning projects address a variety of resource issues, such as flooding, water quality, and soil erosion, as well as wildlife conservation. Resource experts on the planning team develop criteria to evaluate each resource issue for each of the plan alternatives. The purpose of this step is to focus on evaluating alternatives for the wildlife component of the watershed plan. This done as follows:

- Compare the wildlife component of the watershed plan alternatives against the habitat benchmark conditions as described in the analysis.
- Compare the effectiveness of each alternative in meeting the stakeholders' wildlife related objectives.

**Figure 613–61** Map showing results of no-action plan alternative



- Verify compliance with Federal, State, and local statutes regulating wildlife or wildlife habitat.

### (1) Evaluation procedure

An example watershed alternative plan evaluation worksheet that can be used for quantifying the potential impacts of each alternative on wildlife and wildlife habitat is included on the following page. The Alternative Evaluation Worksheet A is similar in concept to the conservation effects for decisionmaking (CED) worksheet used by the NRCS to evaluate conservation plans. Worksheet A is based on principles and recommendations outlined in section 613.04. Biologists and ecologists on the planning team can add other evaluation criteria as necessary to examine the unique wildlife aspects of each watershed. Results of the evaluation should be illustrated with graphs and matrices so the entire planning group can understand evaluation results and participate in the evaluation process.

***(i) Habitat***—The length and area of habitat patches and corridors in each plan are approximated and compared against the existing benchmark condition in the watershed. Linkages between patches and corridors are also evaluated. Plans that preserve, enhance, restore, or create the most lineal feet of corridors, area of reserves/patches, and number of on- and off-site linkages in the planning area would be ranked the highest for wildlife conservation.

***(ii) Wildlife***—Estimating the effects of habitat change on species diversity and abundance requires input from wildlife and conservation biologists on the planning team. A rough estimate of species abundance may be made by selecting a species as an indicator for each general habitat type (grassland, woodland). Using the home range of indicator species as a unit of measure, abundance for this particular species can be roughly estimated. The area of patches and corridors that correlate to the species required habitat type is divided by the home range size to determine the potential population of the species in the watershed. Species diversity can be assessed by using the GAP analysis process described in section 613.04. Plans that provide the greatest abundance and diversity of wildlife are given a higher ranking for wildlife conservation. Although these approaches do not take into account the quality of the habitat, they can provide a coarse assessment of the alternatives at a watershed scale.

After each alternative is evaluated, they can be compared against each other using the Alternative Evaluation Worksheet B, which follows on the page after worksheet A. Worksheet B allows the group to quickly assess and discuss the strengths and weaknesses of each plan alternative. In planning projects that involve other resources, an overall evaluation matrix can be created that includes other ecological, social, and economic criteria in addition to wildlife.

### (2) Documentation

Documentation of step 6 should include the evaluation matrices and a short report summarizing advantages and disadvantages of each alternative for wildlife conservation.

### (3) Products

- Set of practical plan alternatives compatible with planning group's objectives
- Graphs and matrices displaying the effects and impacts of various plan alternatives

## Step 7 Make decision

**Planning standard**—A watershed plan alternative is selected based on the planning group's clear understanding of the impacts of each alternative.

Decisionmaking at the watershed planning level may be the responsibility of a particular stakeholder or agency or the group as a whole. Those responsible for selecting an alternative for the area or watershed often depend on who initiated the planning process. In some cases the group funding the project retains final decisionmaking authority. In other cases mandates or laws require a certain agency to select the preferred alternative; for example, the U.S. Fish and Wildlife Service (USFWS) is responsible for alternative selection and approval where federally listed threatened and endangered species are involved.

The decisionmaking responsibility is sometimes shared by the planning group as a whole. A group decision is particularly common in planning projects that do not have regulatory requirements. The only way these types of plans are implemented is if a majority of stakeholders support the selected plan.

# Areawide/Watershed Plan
# Alternative Comparison Worksheet B

Completing this form will provide a general evaluation of the impact of each alternative on wildlife habitat and wildlife populations.

**INSTRUCTIONS**: Enter the alternative name or number in the space provided. Using a scale, measure the length or calculate the area for each criteria and record them in the matrix. Where requested check whether these figures have increased, remained the same, or decreased relative to the existing condition (benchmark). The last two criteria require the planning team to estimate the alternative's impact on wildlife. Each state is encouraged to develop criteria for making these estimates.

NAME OF PLANNING TEAM: ________________________

PLANNING AREA LOCATION: ________________________

PLANNING COORDINATOR: ________________________

**ALTERNATIVE NAME :** ________________

**EVALUATION**

| **Criteria *** | | Increase | No Change | Decrease | Acres | Length | Number | Not Applicable |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| Total area of corridors in watershed | | | | | | | | |
| Number of linkages to adjacent patches or corridors | | | | | | | | |
| Total length of corridors in watershed | | | | | | | | |
| Length of existing corridors in watershed | | | | | | | | |
| | Preserved | | | | | | | |
| | Enhanced | | | | | | | |
| | Restored | | | | | | | |
| | Removed | | | | | | | |
| Total area of patches by plant community in watershed | | | | | | | | |
| | Grass | | | | | | | |
| | Grass shrub | | | | | | | |
| | Riparian wooded | | | | | | | |
| | Riparian shrub | | | | | | | |
| | Riparian grass | | | | | | | |
| | Upland wooded (natural) | | | | | | | |
| | Upland wooded (introduced) | | | | | | | |
| | Wetland | | | | | | | |
| Special areas preserved | | | | | | | | |
| Other conservation measures (Specify) | | | | | | | | |
| Estimated effects on species diversity | | | | | | | | |
| Estimated effects on species abundance (Specify species) | | | | | | | | |

* Area and length measurements are approximate.

Comments: ________________________

# Areawide/Watershed Plan
# Alternative Comparison Worksheet B

Completing this evaluation form will provide a general comparison between alternatives.

**INSTRUCTIONS**: Review Evaluation Worksheet A for each alternative. Based on the review and discussion with team members, rate each of the first 9 criteria as excellent (green), good (blue), fair (yellow), or poor (red) for each alternative. The team needs to document the criteria used to develop the ratings. Place the appropriate color in the rectangle opposite the criteria and beneath each alternative. Repeat the process for the last 5 criteria - increase (green), remain the same (yellow), or decrease (red). States are encouraged to develop specific criteria for each of the general criteria categories on the worksheet. These criteria should accurately reflect habitat conditions in each state. In general, the alternative with the most green and blue rectangles will be the best overall alternative. Clearly, the relative importance of criteria will vary with each project. The planning team can proceed from this general evaluation to a more sophisticated and weighted numerical evaluation if sufficient quantifiable data are available.

NAME OF PLANNING TEAM: __________
PLANNING AREA LOCATION: __________
PLANNING COORDINATOR: __________

**EVALUATION**

| **Criteria *** | **Alternatives** | | |
|---|---|---|---|
| | Alt. A | Alt. B | Alt. C |
| Meeting project wildlife objectives | | | |
| Protection of patches with high levels of biodiversity | | | |
| Protection of migration or dispersal corridors | | | |
| Corridor connections between patches | | | |
| New patches planted | | | |
| Corridors preserved, enhanced, or restored | | | |
| Special areas and features protected | | | |
| Potential habitats developed | | | |
| Matrix management benefiting wildlife | | | |
| * Estimated effects on species richness | | | |
| * Estimated effects on species abundance | | | |
| * Protection of threatened or endangered species | | | |
| * Protection of vulnerable populations | | | |
| * Other area-wide/watershed specific wildlife objectives (specify) | | | |

**KEY**

| | | |
|---|---|---|
| Excellent | | Green |
| Good | | Blue |
| Fair | | Yellow |
| Poor | | Red |
| Not Applicable | NA | |

* Apply to last 5 categories

| | | |
|---|---|---|
| Increase | | Green |
| Remain the same | | Yellow |
| Decrease | | Red |
| Not Applicable | NA | |

Comments: __________

**Natural Resources Conservation Service - Conservation Corridor**

At the beginning of the watershed planning project, the entire planning team should agree upon which deci-sionmaking process will be used. This helps to avoid confusion and misunderstanding. Some watershed planning groups use a majority vote system to select final plans. This democratic form of decisionmaking is familiar and comfortable to many planning participants. Problems can arise, however, when a minority within the group is adamantly opposed to the plan selected. Often compromise and revisions to the preferred plan are required before an acceptable plan emerges.

More groups are exploring consensus-based decisionmaking. Consensus is reached when participants agree on a single alternative plan. The participants may not agree with all aspects of the plan, but they do not disagree enough to warrant opposition to the overall plan selected. Each party retains the right to veto a plan, but that party assumes a responsibility to provide alternative components for the plan.

The goal of consensus decisionmaking is to select a plan supported by everyone. This in turn increases the probability that the plan can be successfully implemented. Plan selection by consensus also has its share of problems—it can lead to a stalemate or result in a weak, compromised plan. Frequently, wildlife are given a low priority in a consensus plan because wildlife issues are often controversial and difficult to arbitrate.

#### (3) Documentation

The NPPH provides general guidance for preparing necessary products for this step. Documentation should include a short report with the final plan and a description of how the plan was selected. This report may also include potential program or implementation strategies. In cases where an EIS or EA is needed, formal NEPA documentation of the decisionmaking process is required.

#### (4) Products

- The plan document with the selected alternative, including potential program or implementation opportunities
- Schedule of plan implementation
- NEPA documentation (when required)

## (f) Phase 3 Application at the watershed scale

Phase 3 involves two steps:

- Implement plan
- Evaluate plan

In phase 3, the planning team, agencies, private conservation organizations, communities, and others individually or collectively may be involved in the implementation of the plan. They may also be involved in the ongoing evaluation of the implemented plan and, where necessary, propose adaptive management.

### Step 8 Implement plan

**Planning standard**—The planning team has adequate information and understanding to implement a watershed plan.

Strategies for implementing a watershed plan vary with each project. For example, planning projects initiated by a crisis often have substantial financial support from federal and state programs; implementation proceeds rapidly. The Iowa River Project is a good case in point. Within 1 year of a major flood, land parcels or conservation easements within the Iowa River flood plain were purchased to allow natural restoration of riparian wetlands.

However, watershed plans generally are implemented one farm, ranch, or community open space at a time. Frequently, the key to implementing large-scale farm, ranch, or community projects is outside assistance in the form of funding, materials, and volunteer help. The value of a watershed plan is that it offers coherent landscape structure and logical recommendations for integrating conservation plans at the landowner level. Over time, the watershed plan becomes reality with completion of numerous individual conservation plans. The NPPH and information in section 613.06 provide some guidance on how to proceed with the implementation process at the conservation plan scale.

#### (1) Options for implementation

The following options for implementing a watershed scale plan are described in this section.

- Land acquisition

- Conservation easements
- Federal and state programs
- Zoning
- Voluntary participation

***(i) Land acquisition***—Land acquisition is among the best tools for protecting critical habitat areas identified in the watershed plan. Land can be acquired by Federal and State agencies, private conservation organizations, and communities through programs, grants, and other sources of funding. The acquired parcels can then be managed for wildlife by either private conservation organizations or government agencies. This approach offers a high level of protection for wildlife resources and is especially valuable for protecting critical habitats that may not be protected by other means. However, adequate funding for acquisition and particularly for long-term management often limits this approach.

***(ii) Conservation easements***—Conservation easements involve purchase of development rights for land parcels with significant habitat value. To many landowners, easements are preferable over fee-simple sale of their land. With a conservation easement, the owner retains title to the land and can maintain previous land uses.

Some conservation easements are more restrictive and specify acceptable land uses and land management practices for the parcel. In exchange for not developing the land or for modifying land management practices, the owner receives cash payments and tax benefits. If the land is sold, the easement remains in place. For example, an easement along a riparian corridor may still allow the rancher to use the area; however, the corridor may never be developed into homes or other built structures. Purchasing easements may allow funding resources to be used more efficiently than outright acquisitions; however, management control over the area is usually reduced.

***(iii) Federal, State, and other incentive programs***—A wide range of Federal and State programs, such as the USFWS Partners in Wildlife Program, offer assistance for protection and restoration of wildlife habitat on private lands. This includes USDA programs, such as Wildlife Habitat Incentive Program, Wetland Reserve Program, and the Conservation Reserve Program. Many of these programs are directed at individual landowners and offer incentives, such as cost sharing. They are often cost effective ways of preserving, enhancing, and restoring habitat for wildlife. NRCS and personnel of other agencies should be consulted on programs available for wildlife conservation.

***(iv) Voluntary participation***—Voluntary participation in wildlife conservation projects should be a component of every implementation plan. The effectiveness of this approach depends upon demonstrating the benefits of conservation practices to landowners and communities. Demonstration projects and field tours are ways to demonstrate success and influence individuals to participate in conservation projects.

Two of the main purposes of a large-scale wildlife planning effort are to consolidate resources and to share responsibility for wildlife conservation. All stakeholders can participate in implementing the plan. Sharing responsibility also can lead to creative funding opportunities. Many private foundations base their funding on evidence the project has involved public participation and has broad-based support. Potential funding and assistance partners are covered in section 613.07.

***(v) Zoning***—Zoning controls location and management of land uses. It is a power given to local governments only. It can be a useful and cost-effective tool for protecting wildlife habitat over a large area. For instance, zoning may protect critical riparian habitat by restricting development on flood plains. An advantage of this approach is reduced costs for the county or community. Local governments are challenged to create publicly acceptable zoning plans. Coordinating zoning regulations across several political boundaries can be extremely difficult. Enforcement of regulations, particularly those related to resource management, can also be troublesome and expensive.

### (2) Documentation

Communication and coordination among stakeholders should be documented in a short report so all stakeholders clearly understand their responsibilities for implementing the plan. Funding sources should also be identified and secured.

### (3) Products

- Communication and coordination between the stakeholders
- A description of tasks to be completed by the various stakeholders
- Funding sources documented

## Step 9 Evaluate plan

**Planning standard—**The planning group determines if implementation results are meeting the ecological, economic, and social objectives and resolving conservation issues in a satisfactory manner. Resource impacts that are different from those predicted are fed back into the watershed planning process.

Evaluation of the implemented plan is an often overlooked, but necessary component of the watershed planning process. The purposes for evaluating the watershed plan as implemented are to

- ensure that wildlife habitat in the watershed is functioning as intended,
- estimate wildlife response to the watershed plan,
- disseminate evaluation data and inform stakeholders, and
- initiate adaptive management where resource responses are different from predicted.

Evaluation of the watershed plan occurs at two levels: the watershed and conservation plan levels. Many components of the watershed plan are implemented through individual conservation plans (see section 613.06). The cumulative evaluations of conservation plans provide a partial assessment of the watershed plan.

An evaluation at the watershed scale is necessary. This evaluation can provide a valuable overview of the condition of wildlife resources in the watershed. Otherwise, positive results from a few individual conservation plans may bias overall results if other watershed areas are experiencing significant negative impacts to wildlife. Evaluations of watershed and conservation plans provide the most realistic picture of the condition of wildlife resources.

### (1) Evaluation techniques

Evaluation strategies should be based on objectives established in step 2. In many cases the objectives include wildlife species and habitat components. Biologists on the team will be responsible for designing an evaluation scheme addressing these components. Habitat condition evaluation determines the ability of the resource to support wildlife. The planning team should develop specific techniques to evaluate different habitat types.

Biologists also should develop approaches for evaluating wildlife populations at a watershed scale. These techniques can be expensive, and it is best to take advantage of ongoing surveys. Federal and State wildlife agencies conduct game and non-game species inventories. Much of these data are collected based on wildlife management units (often watersheds are used for unit boundaries) that can be correlated directly to the project area. Participants on the planning team from these agencies can provide more information. Although these sources of data may not reflect specific responses to the plan, they can illustrate overall trends of different wildlife populations in the watershed.

Other long-term wildlife surveys often exist. For example, postal carriers in Kansas have voluntarily counted wildlife during 4 weeks every year for the past 30 years. The Audubon Society conducts an annual Christmas Day bird count, and high school students have successfully monitored invertebrate populations in streams. Other conservation organizations also conduct informal wildlife surveys.

### (2) Dissemination of evaluation data

Data collected in the evaluation can be used to educate the public about the value of planning at a watershed scale and the benefits to wildlife of implementing conservation practices. For example, a watershed planning group in Idaho holds an annual watershed conference and celebration open to the public. This event provides an excellent opportunity to inform the public about wildlife in the watershed and to demonstrate the value of conservation practices to the wildlife resource. Events like this can stimulate landowners to initiate wildlife conservation plans on their farm or ranch or in their community. It is important to report failures as well as successes and indicate what adaptive management practices are being employed to alleviate problems.

### (3) Adaptive management

Several years of evaluation data may indicate wildlife responses to the watershed plan are different from those predicted. Adjustments to the plan may be necessary. The planning team needs to emphasize that wildlife planning is an ongoing process and that modifications will be necessary. Once the plan has been implemented and evaluation procedures are in place, the planning group can probably meet on a less frequent basis. However, the group should continue to function so that adaptive management can be implemented as necessary. It also is important that the entire stakeholder group remain involved in the evaluation process. Not only does this reinforce ownership in the overall planning process, it lessens the chance stakeholders will disagree over results.

### (4) Documentation

Evaluation data should be compiled into a short report with most of the data presented in easy-to-understand graphs and charts. The final portion of the report should address any necessary adaptive management recommendations. The report should be distributed to the entire planning group and made available to the public.

### (5) Products

- Evaluation report summarizing results of the wildlife monitoring
- Recommendations for changes
- Updated areawide/watershed plan

## (g) Case studies

The Iowa River Corridor Project and the Texas Lower Rio Grande Valley Wildlife Corridor case studies that follow illustrate two of the corridor-planning principles:

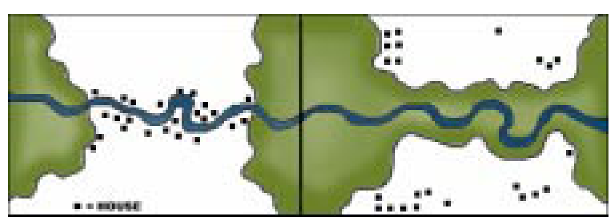
- Natural connectivity should be maintained or restored
- Continuous corridors are better than fragmented corridors

Case Study:

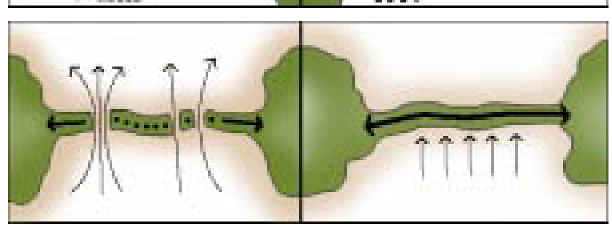
# IOWA RIVER CORRIDOR PROJECT

Corridor Planning Principles described in section 613.04 that are exhibited by this case study include:

**NATURAL CONNECTIVITY SHOULD BE MAINTAINED OR RESTORED.**



**CONTINUOUS CORRIDORS ARE BETTER THAN FRAGMENTED CORRIDORS.**



# Case Study: Iowa River Corridor Project


***Figure 1:*** *Flooding along the Iowa River during summer of 1993.*

*This project initiated by the NRCS illustrates the effectiveness of combining USDA programs and technical assistance with the expertise of diverse conservation partners. The planning team produced a conservation corridor plan that benefits wildlife and will dampen the adverse impacts of future flooding events.*

The Iowa River runs from north-central Iowa to southeastern Iowa where it joins the Mississippi River. Row crop agriculture and livestock production are the dominant land uses within the floodplain of the Iowa River. In 1993, unprecedented flooding occurred along many midwest rivers including the Iowa River (Figure 1). Damages to floodplain landowners were estimated at $6.9 million. Flooding is not a new problem for this area. On some of the farmland within the floodplain, landowners are lucky to harvest a crop 2 to 3 years out of 5. The estimated 10-year cost for disaster and subsidy payments along the Iowa River averaged between $750 and $1000 per acre. In many cases, the cumulative cost of repeated payments on agricultural land in the floodplains was greater than the land's value.

The Iowa River Corridor Project was initiated by the Natural Resources Conservation Service (NRCS) in 1993 at the request of landowners in the project area. Many landowners expressed dissatisfaction with traditional flood recovery methods (field and levee repair); they were interested in exploring other land use options. As a result, the Iowa River Corridor Project was formed as a partnership between landowners, private organizations, and local, state, and federal governments. The project's purpose was to develop and implement a plan of land use alternatives that represent sound floodplain management. The project area encompasses approximately 50,000 floodplain acres along nearly 50 miles of the Iowa River in central Iowa (Figure 2).

Partners in the project envisioned the floodplain corridor as *a mosaic of private and public land held together by the common thread of flood tolerant uses*. The NRCS Emergency Wetlands Reserve Program (EWRP) and Wetlands Reserve Program (WRP), which give landowners the option to restore damaged cropland to wetlands, were key to implementing the area-wide plan. Through EWRP and WRP, landowners with flood damaged cropland are offered a one time payment that is roughly equal to the value of their crop rights. In return, they grant a permanent easement and restore their cropland to its original wetland condition. The landowner maintains title and control of the land, holds the right to harvest timber, forage from the area, and use the land for recreational purposes (Figure 3).

In addition to providing economic benefits for area farmers, EWRP and WRP also benefit wildlife. The project area supports a variety of wildlife including two active bald eagle nesting sites, and the state listed sandhill crane and river otter. These species and others will benefit from the increase in habitat area and connectivity provided by restoration of floodplain wetlands (Figure 4).

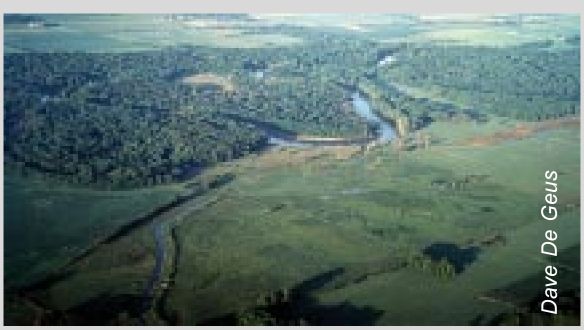



***Figure 2:*** *Aerial view of the Iowa River Corridor.*

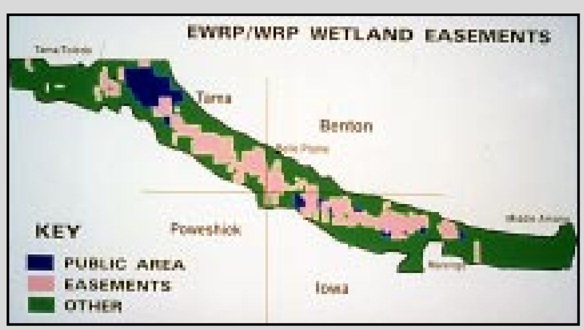



***Figure 3:*** *Wetland easements along the Iowa River Corridor.*

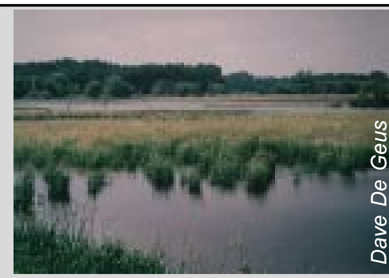
Many landowners in the project area looked forward to owning and managing easements for wildlife, timber, and recreation. However, others did not have a strong enough interest in owning wetland easements to justify the expense and time involved in managing such areas. This group of landowners approached NRCS officials and asked if they could sell all of their remaining land rights. Because the NRCS does not have the capability to own or manage land, they asked the U.S. Fish and Wildlife Service (USFWS) to consider assisting these landowners.

The USFWS evaluated the wildlife and recreational potential of the corridor and agreed to assist some landowners desiring a total buyout. The USFWS will also provide annual revenue sharing payments to county governments to offset most of the property tax revenues derived from lands formerly held by private landowners. Lands acquired by the USFWS will become part of the National Fish and Wildlife Refuge System and will be open to the public for a variety of outdoor recreational activities. The Nature Conservancy is assisting in the development of a GIS database system for the project area.

Accomplishments to date include:

- Ninety-one of 250 landowners have enrolled 11,600 acres in EWRP and WRP easement programs.
- Wetland restorations are underway. Earthwork is 75% complete and grass seedings should be completed in 1998.
- Thirty-five landowners have agreed to sell over 9,400 acres to the USFWS, making the Corridor Project the largest USFWS refuge in Iowa outside of the Upper Mississippi River NWR.
- The Soil and Water Conservation Districts and the project coordinator have formed a non-profit corporation to assist in wetland restoration and future conservation and development efforts.
- Over 25 project partners are assisting with project monitoring efforts, providing needed supplies, equipment, (e.g., GIS assistance, nesting structures, grain drills), and assistance in project planning.

***Figure 4:*** *Iowa County farm field after wetland restoration.*




As the floodplain wetlands are restored, the project should provide the following benefits:

- Improved water quality in the Iowa River for citizens using the river for drinking water and recreation
- Additional flood storage, thereby lowering flood peaks and damage
- Additional recreational/tourism opportunities for residents of central and eastern Iowa
- Increased habitat available for game and non-game wildlife
- Opportunities to stimulate economic development and tourism

The project partners realize floodplain management is an ongoing process and additional options should be available for landowners. The partners are sharing resources, ideas, and personnel to develop additional options for sustainable management of floodplain lands, including improved grazing systems, forage and timber management, and alternative crops such as crayfish, native grasses, flowers, and willows for baskets and furniture. The Iowa River Corridor Project clearly demonstrates a sustainable system of floodplain land use can achieve both economic and ecological goals.

*For more information on the project, contact:*

*Dave De Geus*
*Iowa River Corridor Project Office*
*Iowa County SWCD*
*435 N. Highland, Box 210*
*Williamsburg, Iowa 52361*
*Tel. (319) 668 – 2359*

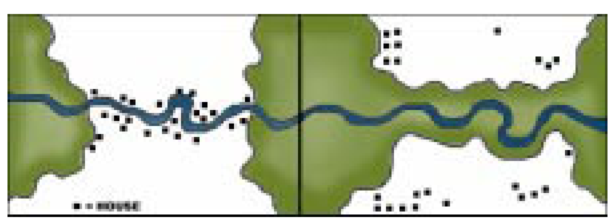
The information for this case study was abstracted with permission from the Iowa River Corridor Project Information Series, prepared by the Iowa River Corridor Project Partnership.

## Case Study:

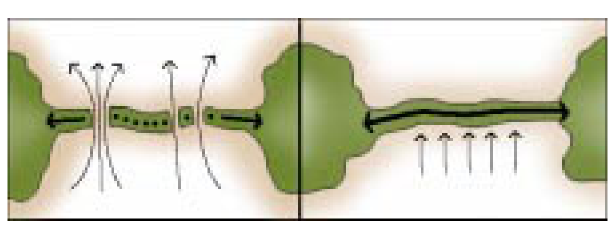
# LOWER RIO GRANDE VALLEY WILDLIFE CORRIDOR

Corridor Planning Principles described in section 613.04 that are exhibited by this case study include:

**NATURAL CONNECTIVITY SHOULD BE MAINTAINED OR RESTORED.**



**CONTINUOUS CORRIDORS ARE BETTER THAN FRAGMENTED CORRIDORS.**



# Case Study: Lower Rio Grande Valley Wildlife Corridor

*This case study illustrates how the NRCS in cooperation with other government agencies and private non-profit conservation organizations have collaborated to develop a 275-mile long conservation corridor plan. A variety of wildlife species including several threatened or endangered species will be some of the beneficiaries of this exciting project.*

The lower Rio Grande River from Falcon Dam to the Gulf of Mexico is the only source of drinking and irrigation water for more than 1 million people (Mexican and U.S. residents) and 0.5 million acres of U.S. agricultural land. Unfortunately, rapid human population growth and intensive development for international trade and agriculture on the lower 275 miles have severely degraded the riparian ecosystem.

The lower Rio Grande twists and turns; each river bend alternates from high, sloughing, vertical banks to gently sloping stretches with remnants of floodplain forests. Most of this stretch has banks, which have been severely damaged by intensive grazing or cleared for bridges, homesites and industrial parks. Refuse and sewage are dumped into the river in numerous locations.

Although less than 5% of the original habitat of the lower Rio Grande Delta remains, species diversity in the region continues to be high (1100 plants and 600 vertebrates). Habitat connectivity is critical for many of these species, including the federally listed endangered ocelot and jaguarundi.

To conserve this unique area, the U.S. Fish and Wildlife Service (USFWS) established the Lower Rio Grande Valley National Wildlife Refuge. The refuge's goal is to create a continuous wildlife corridor along the 275-mile stretch of river. In addition, the USFWS, Texas Parks and Wildlife Department (TPWD), National Audubon Society, and the Nature Conservancy of Texas (TNC) have acquired tracts for protection.

In 1996, the Natural Resources Conservation Service (NRCS), USFWS, and National Fish and Wildlife Foundation (NFWF) entered into an agreement to use funds from the USDA's Wetland Reserve Program (WRP) and a NFWF grant to purchase permanent easements along riparian areas and wetlands on private lands. These easements will link areas owned by public agencies and private conservation organizations.

Under WRP eligibility criteria, wetlands currently in agricultural production and riparian corridors up to 600 feet wide can be accepted. Cropland will be planted to species of trees and shrubs that USFWS, TPWD, and TNC are using in their restoration programs. Riparian areas already in desirable vegetation may only require fencing, or as a minimum, placement of WRP boundary signs.

The easement acquisition process is ongoing and expected to continue throughout the life of WRP. Land ownership patterns along the river dictate that several easements must be acquired in succession to link any two existing protected areas. All partners are attempting to identify interested landowners with eligible lands and encouraging them to participate in this program to increase and improve wildlife corridors along the Rio Grande River.

*For additional information contact:*

*Larry Ditto, Project Leader*
*Lower Rio Grande Valley NWR Complex*
*U.S. Fish and Wildlife Service*
*320 N. Main St., Rm 225*
*McAllen, TX 78501*
*(210) 630-4636*

This case study was written by Gary Valentine (NRCS) and has been included in this document with his permission.

# 613.06 Conservation planning process

## (a) Introduction

The NRCS has provided conservation planning, design, and implementation assistance to farmers, ranchers, and communities for decades. Thousands of conservation management practices have been installed across the country. The habitat created by these practices has been a significant factor in maintaining wildlife populations and species diversity in agriculturally dominated landscapes. However, more can be done to benefit wildlife. This section illustrates ways to integrate the concepts and principles described in section 613.04 into the conservation planning process to provide more, higher quality connected habitat for wildlife.

## (b) Planning process

The phases and steps outlined in the NPPH for preparing conservation plans are identical to those used in preparing a watershed plan (see fig. 613–52). The principal difference is more detailed site-specific information must be collected, analyzed, and synthesized for a conservation plan.

## (c) Getting started

### (1) Preplanning: conservation plan scale

The preconditions that initiate conservation planning on an individual farm, ranch, or community open space are often the same as those that trigger areawide planning efforts: crisis, mandate, incentives, or leadership. Planning may be recommended by the conservationist or NRCS assistance sought by a landowner or community. Regardless of who initiates the project, it is important to obtain basic information and assemble the necessary tools to start the planning process. The National Planning Procedures Handbook (NPPH) provides a detailed outline of how to proceed with preplanning activities.

In addition to the preplanning procedures, tools, and materials described in the NPPH, the conservationist should also have the following materials available:

- Areawide plan, if available
- Corridors In Our Landscape brochure
- This handbook
- USGS 7.5-minute quadrangle maps that include the client's property
- Copies of the NRCS 1:660 soil survey maps that include the client's property and immediately adjacent properties
- Any existing wildlife reports, research studies, Easement Assessment (EA) or Environmental Impact Study (EIS) reports or similar wildlife information specific to the watershed within which the client's property resides
- Photo prints, plans, or reports of completed projects within the conservation district that have preserved, created, enhanced, or restored wildlife habitat (consider developing a scrapbook of these materials to take into the field)

Having these materials available for the first formal client meeting will help the conservationist promote wildlife conservation as an integral part of the conservation plan. In addition, these materials will comprise a reference resource available when needed to answer client's questions.

## (d) Phase 1 Collection and analysis at the conservation plan scale

Phase 1 involves the following planning steps:

- Identification of problems and opportunities
- Determine objectives
- Inventory resources
- Analyze resources

In Phase 1, the client and conservationist work to reach agreement on the problems, opportunities, and objectives for the conservation plan.

## Step 1 Identify problems and opportunities

**Planning Standard**—The client's resource problems, opportunities, and concerns are identified and documented.

The first onsite visit with the client may be the most important step in the planning process at the farm, ranch, or community scale. Building trust begins with the first meeting. The client trusts the conservationist to provide the best advice and technical assistance possible in addressing his or her concerns. The conservationist trusts the client to properly implement recommended conservation practices and maintain them into the future. Both parties are committing time, money, and other resources necessary to successfully complete a conservation plan. Both parties understand that the conservation dividends resulting from their investment will accrue some time in the future.

### (1) Procedure

The first onsite meeting affords the conservationist an opportunity to listen to the client's concerns and see the problems and possibilities in the field. It also provides an opportunity to involve the client in the planning process. Asking questions about wildlife and wildlife habitat on the client's property can produce important insights. The conservationist can discuss wildlife habitat opportunities from an experienced perspective gained working throughout the surrounding landscape.

The NPPH provides a detailed outline on how to proceed with step 1 activities. In addition to these procedures, the conservationist should

- use the wildlife informational materials listed in the preplanning section as aids when discussing wildlife concerns, problems, and opportunities with the client,
- document wildlife and habitat related problems and opportunities that are on the client's property or on soil survey aerial photo maps,
- record these problems and opportunities with photographs,
- emphasize opportunities to link habitats on the client's property with habitats on adjacent property, and document these opportunities on maps and with photographs, and
- record on maps and with photographs large areas (>80 acres) devoid of habitat and discuss with the client new possibilities to provide wildlife habitat or enhance the habitat value of some other existing conservation management practices.

If the client's property is within the boundaries of an existing areawide plan, the following procedures should also be completed:

- Locate the client's property within the areawide plan and review the plan with the client. Emphasize wildlife habitat related elements of the plan that could affect the client's property and the immediate environs.
- Visit any locations on the client's property where habitat recommendations or other features have been delineated on the areawide plan.
- Discuss with the client the value-added benefits of incorporating these areawide wildlife habitat plan recommendations on their property. This handbook provides examples to share with the client.

Additional problems and possibilities invariably emerge later in the planning process. The inherent flexibility of the planning process accommodates new information when it emerges. Once the client and conservationist have identified all problems and opportunities, they have produced the products specified in the NPPH.

### (2) Documentation

Problems and opportunities are typically documented in a short report. This information can be recorded in Notes and Resource Inventory, a GIS database, or other agency tracking systems. The report should include field notes, photographs, and any sketch maps that were prepared.

### (3) Products

- Identification and documentation of wildlife and wildlife habitat problems, opportunities, and concerns in the case file
- Communication with the client

## Step 2 Determine objectives

**Planning standard**—The client's objectives are clearly stated and documented.

Clients initiate conservation projects because they wish to change existing conditions to some desired future condition. Often the project is intended to eliminate a particular problem, such as stabilize an eroding swale in a field, or explore some alternative resource use. The conservationist needs to understand fully the client's objectives and values related to resource management and can assist the process of determining objectives by offering advice and suggestions. Objectives can often be clarified by reviewing field notes from the first onsite meeting with the client. By working together, the client and conservationist can formalize meaningful and realistic objectives for the wildlife resource as well as other resources.

Objectives should be stated so they describe what is desired without prescribing a specific solution. This allows the client and conservationist opportunities to explore alternative plans in step 4 of the process.

### (1) Procedure

The NPPH includes an extensive list of items the client and conservationist should discuss and agree upon as part of the objective setting process. To ensure wildlife are fully considered in determining objectives, the conservationist should include the following in discussions with the client:

- Explain how the objectives may affect the site's resources and ecology and impact wildlife.
- Identify Federal, State, or local laws related to wildlife or other resources that could affect the client's objectives so that planning proceeds in a proactive way.
- Encourage consideration of an overall objective of preserving, enhancing, and restoring existing and potential (historical) habitats for diverse populations of desirable species.
- Encourage establishing as an objective linking habitats with those on adjacent properties, where applicable.
- Encourage considering as an objective new conservation practices for wildlife in large areas (>80 acres) devoid of habitat.
- Use the checklist in appendix 613B to get input on specific wildlife species important to the client; providing habitat for the client's preferred species can become an objective.
- If the property is within an existing areawide plan, review the plan with the client.
- Encourage the client to incorporate the areawide plan recommendations that apply to the property into the conservation plan objective statement.

When an agreement is reached on conservation plan objectives, the client and the conservationist will have produced the products described in the NPPH.

### (2) Documentation

Objectives are typically documented in a short report.

### (3) Products

- A list of the client's objectives including specific wildlife and wildlife habitat objectives as an objective note in the case file.

## Step 3 Inventory

**Planning standard**—Sufficient data and information are gathered to analyze and understand the natural resource conditions in the planning area.

The basic intent of the conservation plan inventory is to describe existing (benchmark) condition on the client's property. The wildlife resource section of the inventory has a wildlife species component and a habitat component. The specific intent of the wildlife resource inventory at the conservation plan scale is to

- identify wildlife species that do or could inhabit the client's property,
- map:
  - > plant community types
  - > wildlife species occurrence as associated with plant community types
  - > important corridors, habitat patches, and site features
  - > potential habitats
  - > general land cover types

- provide life history information for those species of special interest to the client, threatened or endangered species, or species of vulnerable populations, and
- emphasize inventory of wildlife resources related specifically to objectives of the individual landowner

The client's involvement in the inventory process is essential as they are knowledgeable of the property's history and resources. However, the conservationist should take every opportunity to educate the client about wildlife and habitat while they work together in the field. An informed landowner is more likely to make decisions benefiting the wildlife resource. Information generated in the inventory is useful for further defining problems and opportunities identified in step 1. It may also suggest that some original objectives be altered or eliminated or that new objectives be added.

### (1) Procedure

The NPPH provides a general outline of basic inventory inputs and describes the inventory tools and procedures needed to carry out this step of the planning process. Discipline handbooks are useful references and provide additional inventory procedures. The *Habitat Evaluation Procedure* (HEP) Handbook (USFWS 1996) is the recommended reference for evaluating the food, cover, and shelter components of wildlife habitat. In addition, a set of corridor inventory forms is included in appendix 613A.

### (2) Documentation

All inventory data should be mapped at a common scale. This may require enlarging or reducing mapped information from different sources. For conservation plan scale projects, a scale of 1 inch equal to 660 feet or the scale of NRCS aerial photo soil maps is the most convenient for planning purposes. The following maps, lists, and short reports should be prepared. Use aerial photos as a base for mapping (fig. 613–62 and 613–63).

**Wildlife species data needs**

- List of species observed or whose presence is inferred from indirect evidence on the site
- List of Federal or State listed threatened or endangered species (if any)
- List of species breeding on the site
- List of potential species (species typically associated with plant community types on the site), but not observed or inferred
- List of nuisance species (if any)
- Estimate of species abundance

**Wildlife habitat data needs**

Existing vegetation map

- Grass plant community type
- Grass shrub plant community type
- Riparian wooded plant community type
- Riparian shrub plant community type
- Riparian grass plant community type
- Upland wooded plant community type (natural)
- Upland wooded plant community type (introduced)
- Wetland type

Land use or cover type

- Cropland
- Pastureland
- Rangeland
- Conservation reserve (indicate type)
- Parks/open space
- Urban
- Wetland reserve program (WRP)
- Wildlife habitat incentive program (WHIP)

Habitat features map

*Special patches*

- Large remnant upland patches
- Large introduced patches

*Special corridors*

- Riparian corridors
- Migration corridors
- Dispersal corridors

*Special areas*

- Patches or corridors inhabited by threatened or endangered species or vulnerable populations
- Leks or other breeding sites
- Calving/birthing sites
- Winter range

**Figure 613–62** Base map showing planning boundary and 100-year flood plain

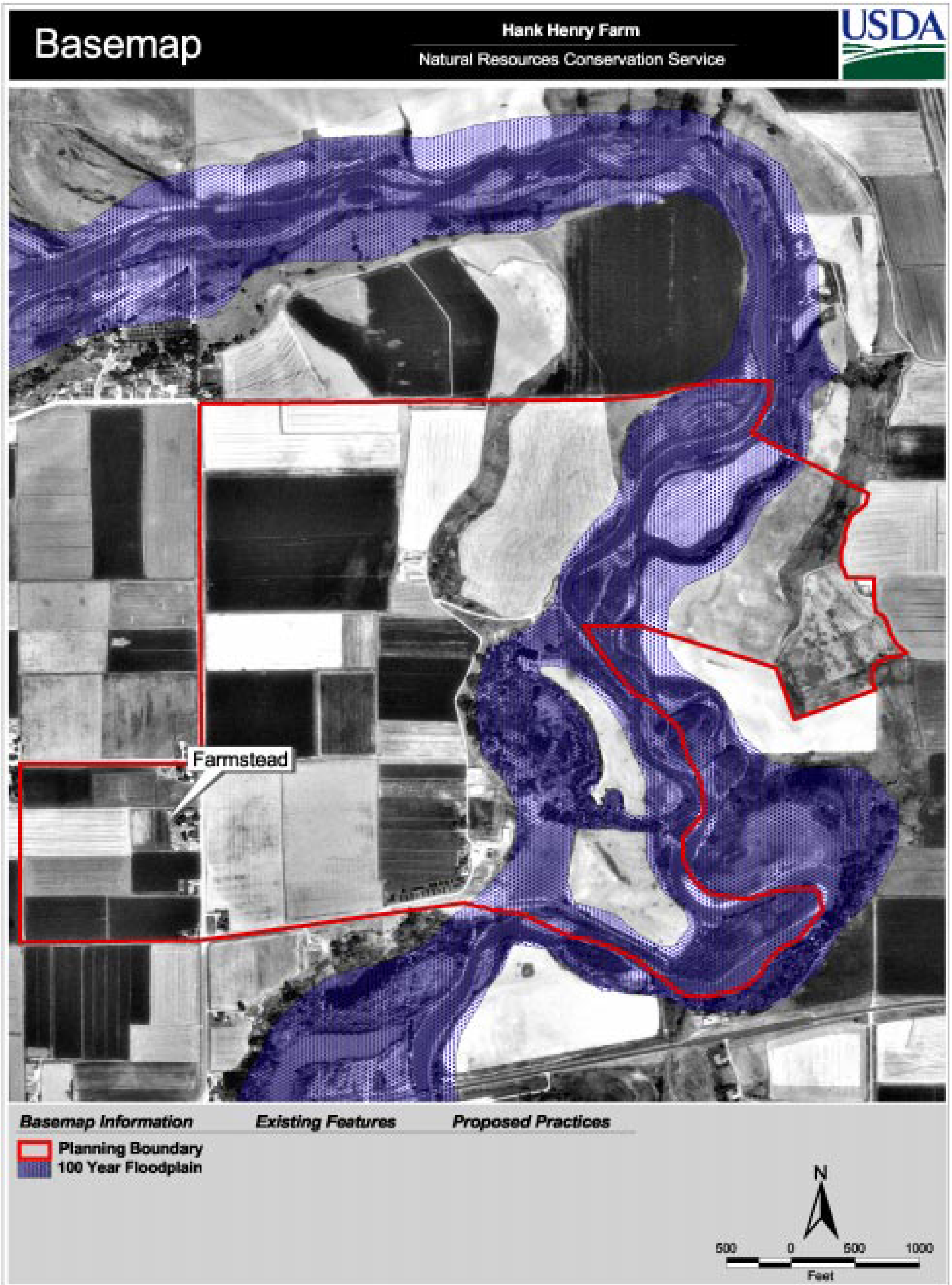
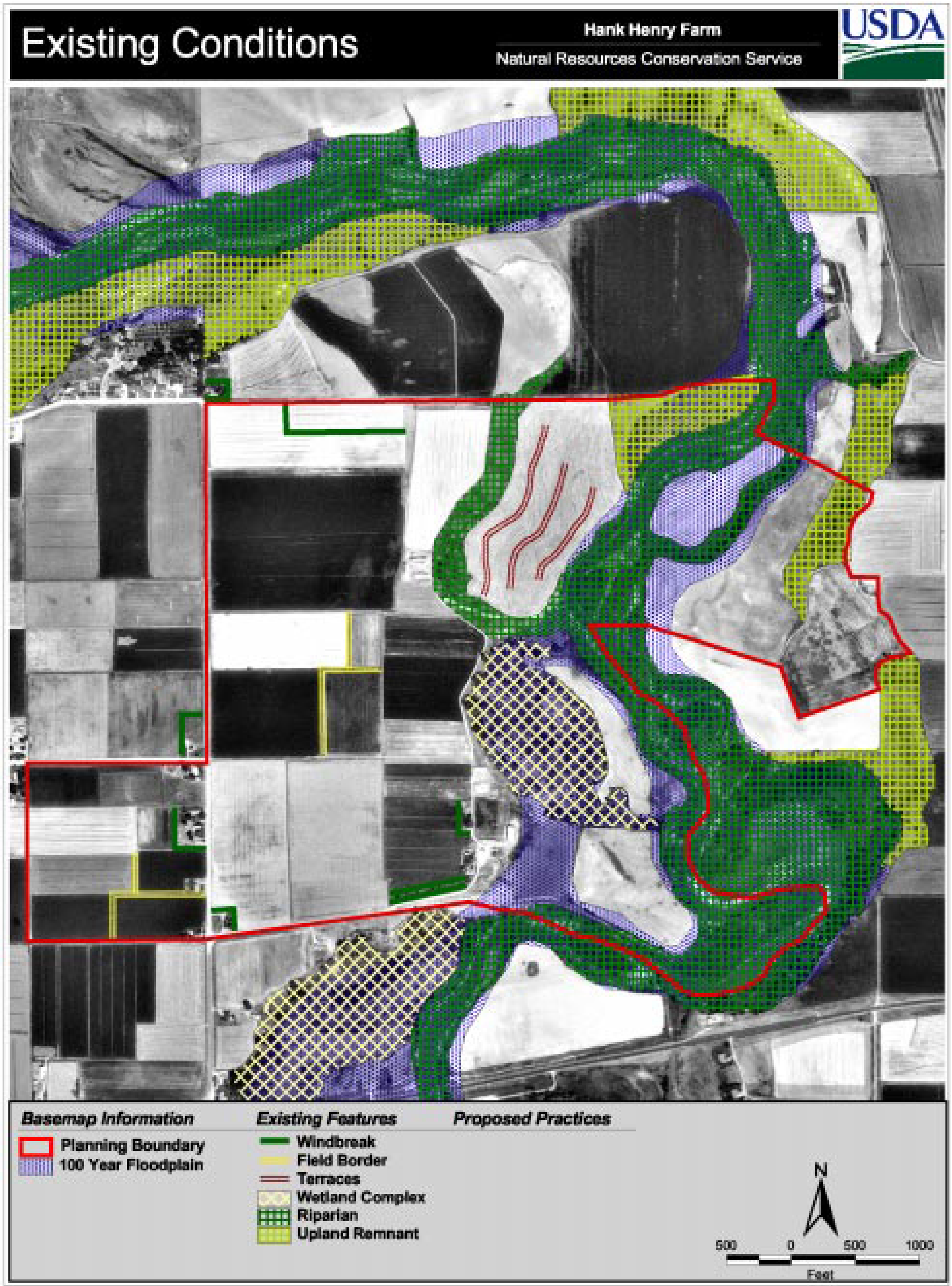


**Figure 613–63** Base map with existing conditions layer



- Winter cover
- Summer range
- Thermal cover
- Irreplaceable sources of food or water
- Other (specify)

*Special features*

- Snags
- Dens
- Burrows
- Talus or rock piles
- Cliffs
- Caves and abandoned mines
- Other (specify)

*Potential habitat maps*

- Steep slopes
- Poorly drained soils
- Damaged soils
- Disturbed sites (borrow pits, etc.)
- Easement corridors
- Waste areas
- Other (specify)

If the client's property is within an existing areawide plan boundary, many of these maps were completed at the scale of a USGS quad sheet 1:24,000. The information relevant to the client's property can be taken off the areawide plan, rescaled to 1:660, and drawn on the appropriate inventory sheet. Ground-truthing is required to verify the accuracy of conversion from one map scale to another, and additional detail may be required.

Other wildlife-related data needs vary depending on the client's objectives and the project site characteristics. Generally, this information does not need to be mapped; for example, life history information for threatened or endangered species, vulnerable species, or species of special interest to the client. When the inventory is completed, the client and the conservationist will have produced the products described in the NPPH.

### (3) Products

- List of wildlife species on the client's property with estimates of abundance and diversity
- Set of maps depicting the components of wildlife habitat on the client's property
- Short, wildlife-related reports where necessary to elaborate on the mapped information

## Step 4 Analyze resources

**Planning standard**—The benchmark condition for the planning area is documented. Results are displayed in easily understood formats depicting current natural resource conditions, physical characteristics of the planning unit, and comparisons between existing and potential conditions. The causes of the resource problems are identified.

The conservationist must now interpret the inventory data. Discipline handbooks, manuals, and inventory worksheets are critical references in the analysis process. Consulting with experts may be required; for example, when threatened or endangered species or locally vulnerable wildlife populations are issues.

The reports and maps prepared in the analysis phase should

- depict current wildlife and wildlife habitat conditions,
- compare current conditions with potential conditions, and
- identify causes of wildlife and wildlife habitat problems.

### (1) Procedures

The NPPH outlines the basic procedures for the analysis. Results of the analysis may suggest that some previously defined objectives be eliminated or modified; some new objectives may be added. At the completion of step 4 and phase 1, the conservationist and client should agree on problems, opportunities, and objectives for the conservation plan.

The wildlife component of the analysis should focus on wildlife and wildlife habitat, specifically species diversity, population dynamics, and habitat conditions, causes of conditions, and potential conditions in the patches, corridors, and matrix on the client's property. The analysis must draw cause-and-effect relationship between what occurs in the matrix and the condition of habitat in patches and corridors. It should also describe what if any effects patches and corridors exert on the matrix.

### (2) Analysis questions

Wildlife and wildlife habitat inventory information acquired in step 3 needs to be synthesized into concise, accurate, and easy to understand tables, graphs, and maps. Maps, either hand drawn or computer generated, are important in helping the client fully appreciate the wildlife-related problems and opportunities inherent on his/her property (fig. 613–64). The analysis of wildlife and wildlife habitat should answer the following questions:

***(i)Wildlife***

- What wildlife populations are vulnerable to local extinction? (Threatened and endangered species are a special case.)
- What are the principal causes of the populations' or species' vulnerable status?
- What is the potential condition of these vulnerable populations?
- What factors are limiting non-game species diversity or game species abundance?
- What factors enhance populations of nuisance or pest species?

Threatened and endangered (T&E) species listed under the Endangered Species Act are the responsibility of the U.S. Fish and Wildlife Service (USFWS). States may also have T&E species or species of concern lists. Any T&E species habitat on the client's property must be managed to comply with USFWS standards or State standards. Vulnerable populations, although not technically threatened or endangered, could experience local extinction. These populations are typically listed with the State Natural Heritage Program, which can specify a general area where a vulnerable species may be present. If the client's property falls within the general area, a survey should be conducted to determine the presence or absence of the species. If present, a biologist specializing in the species and a conservation biologist should be consulted to determine the causes of vulnerability and the potential of the population to persist.

Wildlife diversity is strongly influenced by plant community diversity, patch size, amount of edge, connectivity, and presence or absence of water. The conservationist can compare the habitat characteristics and wildlife species on that property to those of similar site locations in the watershed. The comparison may suggest general habitat characteristics limiting wildlife diversity on the client's property. The conservationist may request assistance and additional information from field biologists.

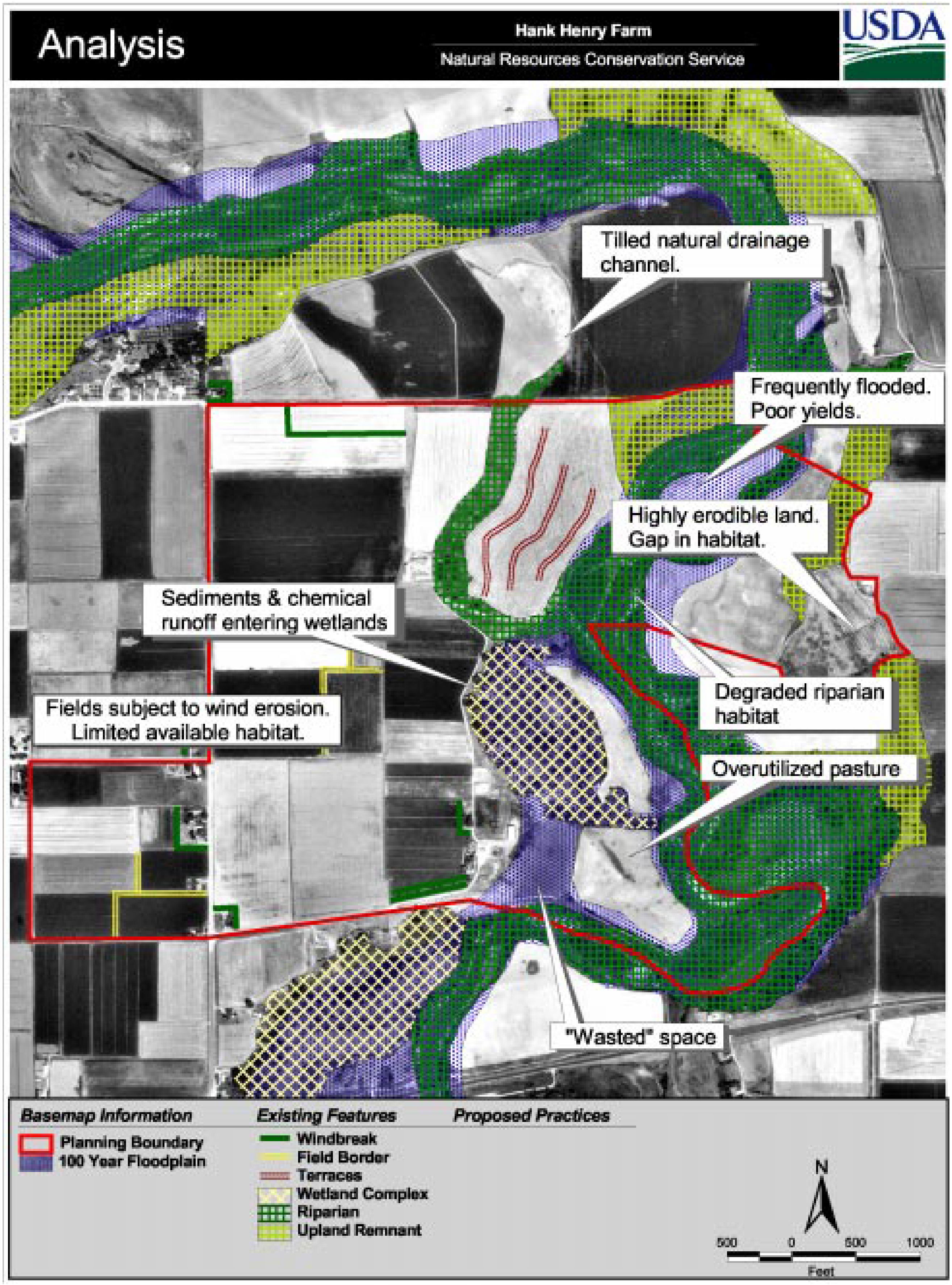
Most states have detailed models of the habitat requirements of game species. The USFWS also has Habitat Suitability Models for many game and non-game species. The conservationist can compare the habitat conditions described in the models with those identified in the inventory for a general idea of what factors may be limiting abundance or diversity. Unfortunately, information for many non-game species is limited. State or field biologists can provide more detailed information concerning limiting factors.

***(ii) Habitat***—Patches, corridors, potential patches, special areas, and special features

- What is the current condition of habitat in existing patches, corridors, potential patches, special areas, and special features?
- What causes these conditions?
- What is the habitat potential of existing patches, corridors, potential patches, special areas, and special features?
- What patches, corridors, potential patches, special areas, and special features are of greatest value or potential value to wildlife?

Patch habitat condition evaluations should be conducted using procedures outlined in discipline handbooks. Corridor condition evaluations should be completed using the corridor inventory forms in appendix 613A. The species present on the client's property are determined in the inventory phase. Several ways are used to determine what species were or could be present. Many states have species distribution maps showing what species would be expected on the client's site. The list of expected species can be compared with the inventory list. Conservationists may know what species could exist on the property based on experiences elsewhere in the watershed. Any EA or EIS done in the watershed will have a species list that can be used for comparative references.

**Figure 613–64** Analysis of current features



Determination of the habitat value of patches, corridors, and special areas should be based on existing wildlife species and habitat. Existing resources that have habitat potential, but are not presently being used by wildlife should be considered. The most valuable patches, corridors, special areas, and special features vary with each property, watershed, and region. However, the general habitat types and resources of high value listed below are in all watersheds and regions.

- Relatively undisturbed patches of remnant vegetation (large patches are particularly valuable)
- Stream/riparian corridors
- Migration and dispersal corridors
- Wetlands
- Lakes, ponds, springs, seeps, and other water features
- Irreplaceable sources of food, water, cover, or sites for reproduction

The conservationist can expand on this list to include habitats or resources considered most important in his or her region. Documentation of these important resources on the composite analysis map is critical to the next step in the planning process.

***(iii) At-risk habitats***

- What patches, corridors, special areas, or special features are at risk?
- What are the causes of risk to these habitat resources?
- What is the potential for mitigating or eliminating threats to wildlife or wildlife habitat?

A habitat component at risk is defined as a patch, corridor, special area or feature, or other wildlife resource whose continued ecological function is threatened by some internal or external factor. For example, an unbuffered wetland receiving excessive amounts of silt and agricultural chemicals would be classified at risk. At some point the level of pollutants causes eutrophication and significantly degrades the wetlands functional capabilities including habitat for wildlife. NRCS biologists reported matrix management practices, increasing field size, water development projects, and urbanization as primary factors in creating at-risk conditions in wildlife habitat. At-risk habitats should be delineated on the base map.

***(iv) Matrix***

- What current field management practices or other land use activities adversely impact wildlife or wildlife habitat?
- What specific attributes of management practices or land uses cause the adverse impacts?
- What potential wildlife or wildlife habitat benefits could be realized if field management practices or land uses were altered?

The condition and management of the matrix significantly impacts wildlife. The client and conservationist should evaluate both elements in the field. NRCS biologists reported in a recent survey that the timing of haying and mowing, fall plowing, spring ditchburning, spraying, and unmanaged grazing were among the more common management practices that adversely impact wildlife. Indirect adverse impacts on wildlife include soil erosion, sedimentation, and chemical-laden runoff. Matrix management practices adversely impacting wildlife should be delineated on the base map.

### (3) Documentation

All patches, corridors, and the matrix were mapped in Step 3, Inventory. Duplicate these maps and note the existing condition, causes of the condition, and potential condition. Relating this information to real locations on the property is useful for preparing alternatives. It is also important to note problems on the client's property, the causes of which originate off-site. These off-site problems are frequent in riparian corridors because of downstream flow.

Most of the analysis information will be recorded in short reports. However, it is also useful to develop a composite resource analysis map at the same scale as the inventory maps (1:660) (see fig. 613–64). This map documents the general habitat condition on the client's property and shows the location of the following features:

- Threatened or endangered species habitat
- Patches with vulnerable populations
- Condition of all patches, corridors, potential patches, special areas, and special features
- High value patches and corridors, special areas and features
- Gaps in corridor connectivity

- Potential corridor connections, both onsite and off-site
- Patches, corridors, special areas, and special features at risk
- Field management practices, both onsite and off-site, detrimental to wildlife
- Potential habitats

The value of mapping the analysis results is it ties the conclusions to specific locations on the client's property. The client can see direct links of the inventory, analysis, and resources. If other information is needed, the conservationist and client can refer to written reports documenting the analysis.

#### (4) Products

- Clear statement of the benchmark condition in the planning unit and related areas

## (e) Phase 2 Decision support at the conservation plan scale

Phase 2 involves three steps:

- Formulate alternatives
- Evaluate alternatives
- Make decisions

In phase 2, the client and conservationist develop a range of plan alternatives that address the problems, opportunities, and objectives identified in phase 1. At the completion of phase 2, they will select a conservation plan that best meets the objectives of the client and the needs of the natural resources.

### Step 5 Formulate alternatives

**Planning standard**—Alternative treatments are developed to meet quality criteria and the objectives of the client.

Two general conservation plan scales involve participation of the conservationist:

- Small-scale conservation plans that address one to several localized problems or opportunities; installing a grassed waterway, for example
- Large-scale, comprehensive farm/ranch or community conservation plans that could involve installation of numerous conservation practices or combinations of practices across the property

#### (1) Small-scale projects

Small-scale projects, one to several conservation practices on a farm or ranch, have historically comprised the majority of requests for assistance. Fortunately, each conservation practice has inherent potential to benefit wildlife in some way. The challenge for the conservationist is to enhance the habitat potential of each conservation practice (regardless of location), to design practices that produce habitat functional values greater than the practice itself, and to educate the client about increased benefits from planning on a broader scale. Reference section 613.04 for ways to enhance habitat value for each conservation practice. Before the project can proceed, all options to enhance habitat value must also meet the client's objectives for initiating the project.

#### (2) Large-scale projects

A large-scale, comprehensive conservation plan for an entire farm, ranch, or community open space presents a difficult challenge, but the benefits for wildlife can be significant if the challenge is met. The planning task is more challenging because it must address problems and opportunities on the entire property, not just a few specific locations. The opportunities to benefit wildlife are greater because the planning area is large; it may include a diversity of plant community types and ecosystems, and the number of opportunities to link patches and corridors with adjacent properties generally increases. There may also be greater flexibility in the location of conservation corridors and more opportunities to develop integrated systems of conservation practices onsite and off-site.

#### (3) Process

The wildlife component of the conservation plan is prepared in direct consultation with the client. The basic wildlife plan from which all alternatives are derived is assembled as a series of map overlays or layers (fig. 613–65). The base layer is the composite analysis map, prepared in step 4, which depicts existing habitat resources on the client's property. Subsequent layers illustrating proposed solutions to specific problems or opportunities are overlaid on the analysis composite base maps. The layers typically included are listed and described here.

**Existing habitat resources**—This base is a copy of the composite analysis map prepared in step 4 (see fig. 613–64).

**Function**—This layer delineates the location of conservation practices or systems of practices required to meet the client's objectives and comply with NRCS standards. Note: Wildlife functions are considered specifically in the potential habitat and new plantings layer and the synthesis layer.

**Existing habitat resource management**—This layer delineates recommendations for preservation, enhancement, or restoration of all existing habitat resources on the client's property.

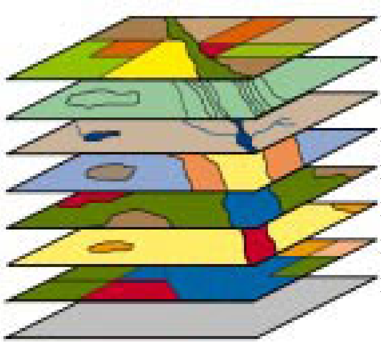
**Potential habitat and new plantings**—This layer delineates sites on the client's property that could be developed into wildlife habitat.

**Synthesis**—This layer uses the concepts and principles described in section 613.04 to integrate the three previous layers into an ecologically sound wildlife plan that responds to the resources of the client's property and program objectives.

***(i) First layer, Existing habitat resources***—The conservationist should make a copy of the composite analysis map that delineates the pattern of existing habitat components including:

- Threatened or endangered species habitat
- Patches with vulnerable populations
- The condition of all patches, corridors, potential patches, special areas, and special features

**Figure 613–65** Example of map overlays or layers




- High-value patches and corridors, special areas and features
- Gaps in corridor connectivity
- Potential corridor connections, both onsite and off-site
- Patches, corridors, special areas and special features at risk
- Field management practices, both onsite and off-site, detrimental to wildlife
- Potential habitats

***(ii) Second layer, Function***—Many conservation plan projects involve the location and design of new conservation corridors to solve functional problems. Clients have specific objectives in mind, often addressing a specific soil or water conservation problem. The location of the problem in the field dictates the location of the conservation practices or systems of practice. The recommended process for locating and designing new corridor plantings to achieve functional objectives should proceed as follows:

- Review the client's objectives related to field management practices, wildlife habitat, erosion control, and air/water quality protection.
- Identify which ecological functions of corridors or other conservation practices or combinations of practices could be used to solve the problem or capitalize on the opportunity.
- Consider possible solutions, such as fencing, grading, bioengineering, or modified management systems.
- Select corridor types or management practices or combination of practices that provide functions necessary to solve the problem or realize the opportunity, and are most beneficial to wildlife.
- Specify plant community structure and native plant species for the management practice, appropriate for wildlife species in the region (see section 613.04).
- Locate the corridor type, practice or combinations of practices where they would be installed in the field on the 1:600 base map.
- Repeat this procedure for each problem or opportunity.

When all conservation practices and systems of practices necessary to meet the client's objectives are located on the base map, a preliminary functional plan is completed. Starting plan development by addressing functional issues first does not mean wildlife issues are any less important; they are simply addressed later in the process. The final plan must integrate all objectives including wildlife objectives into an operational and ecologically unified whole (fig. 613–66).

***(iii) Third layer, Existing habitat resource management***—The condition of patches, corridors, potential patches, and special areas/features was documented in the analysis step 4. Causes of the conditions were also identified. Both conditions and causes should be addressed in the plan. The following procedure for addressing existing habitat resource issues is suggested:

- Review the current condition of each patch, corridor, special area, or special feature as described in the analysis.
- Review the wildlife analysis report to identify factors degrading these habitats or limiting species diversity or abundance.
- Recommend ways to alleviate the cause or causes of habitat degradation or other factors limiting species diversity or abundance.
- Include recommendations for problems or opportunities unique to the client's property.

General recommendations to preserve, enhance, or restore patches, corridors, or other habitat resources should be noted on the base map and linked directly to that resource (fig. 613–67). Specific management techniques for meeting these objectives should be keyed to habitat resources on the map and described in detail in the implementation report (step 8).

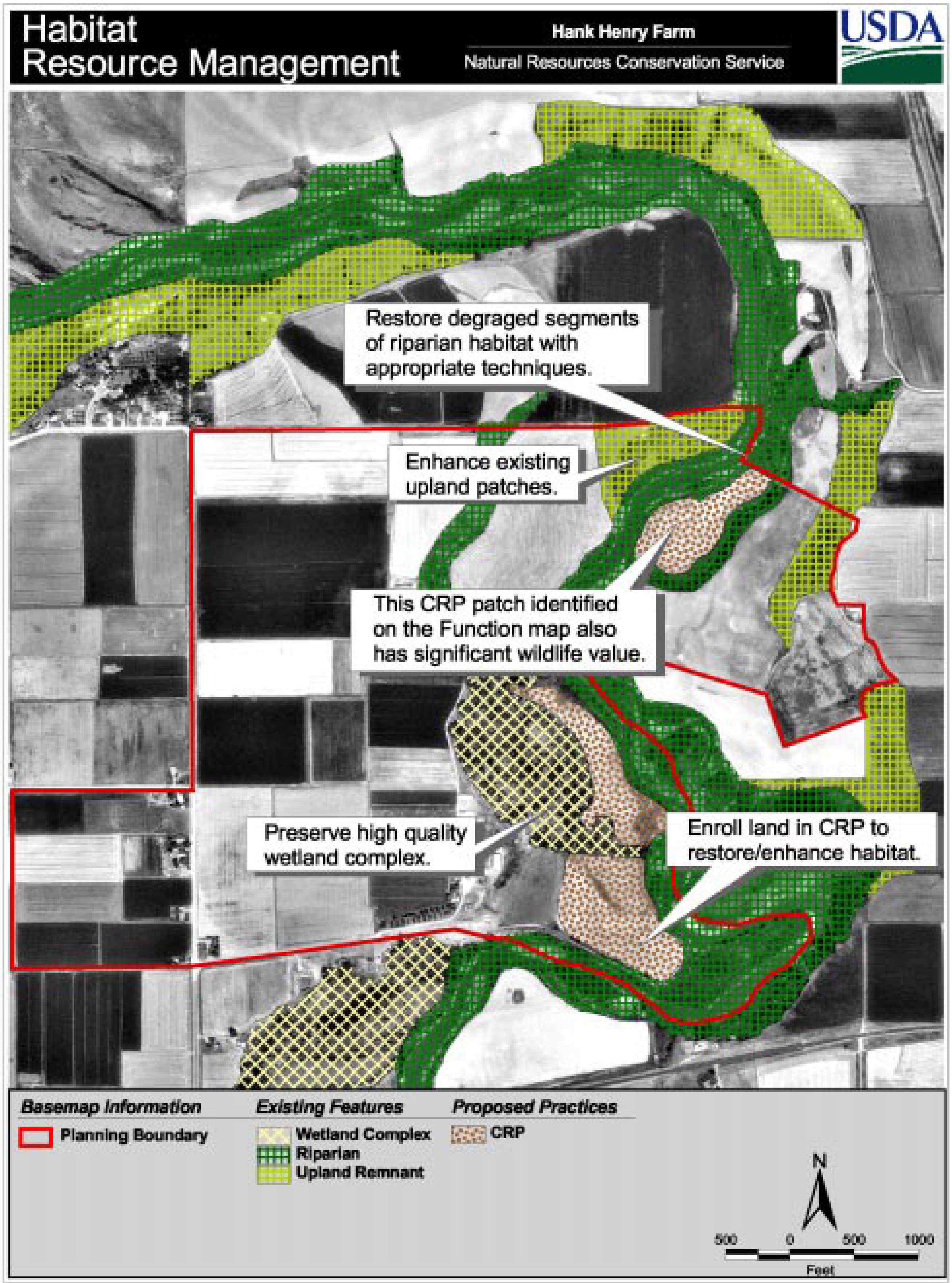
***(iv) Fourth layer, Potential habitats and new wildlife plantings***—The conservationist should review the areas of potential habitat delineated on the analysis map and assess possibilities of enhancing or restoring these areas. Consider the function these areas could perform in addition to habitat. For example, tiled wetlands are common in many regions of the country. During wet years, crop production in these areas is marginal. Many farmers are voluntarily crushing drain tiles, restoring these wetlands. Not only have these practices restored habitat for wildlife, they have also restored other wetland functions helping mitigate downstream flooding and reduce water pollution.

Easement corridors for power lines, pipelines, and other utilities provide real possibilities to link patches and other corridors across a site. If properly planted and managed, easements can provide excellent habitat for many species. Similar habitat and linkage potentially exist in steep slopes, damaged soils, waste areas, and disturbed sites. Locate potential habitats worthy of development on the base map.

New wildlife corridor plantings offer exciting opportunities (see the Hedgerow Farms case study at the end of this section). New wildlife corridor plantings should be located to provide other ecological functions in addition to habitat thus maximizing their utility. When appropriate, the conservationist should propose corridor locations that serve as major connecting structures for wildlife on the farm, ranch, or community. In many respects new plantings offer more design flexibility than any other plan activity. New plantings may include habitat patches as well as corridors. Look for opportunities to plant even small areas of new habitat within those large areas (>80 acres) outlined on the inventory map as being devoid of habitat.

**Figure 613–66** Map showing all proposed practices

**Figure 613–67** Map showing practices used to preserve, enhance, or restore patches, corridors, or other habitat resources



The conservationist needs to assure no proposed new plantings interfere with the client's normal farming or ranching operations. For example, an Iowa State University extension publication *Stewards of Our Streams—Buffer Strip Design, Establishment and Maintenance*, recommends streamside/riparian plantings to "square up" fields converting the area adjacent to stream meanders into habitat. If these recommendations were implemented, they would provide important riparian habitat and increase farm equipment operating efficiency (fig. 613–68). Locate all potential habitats proposed for enhancement or restoration and all new proposed plantings on this layer (fig. 613–69).

***(v) Fifth layer, Synthesis***—Synthesis involves combining the mapped information from all three previously developed layers. The pattern that emerges from overlaying all layers is often disconnected. It is a collection of conservation practices and management recommendations, not yet a plan. The challenge for the conservationist and the client is to convert this collection into a plan. They need to identify practical opportunities to connect patches, corridors, potential habitat patches, special areas, and special features into an integrated pattern. The intent is to optimize the value-added benefits of connectivity. The planning habitat concepts and principles in section 613.05 (page 613–88) can guide the plan development process.

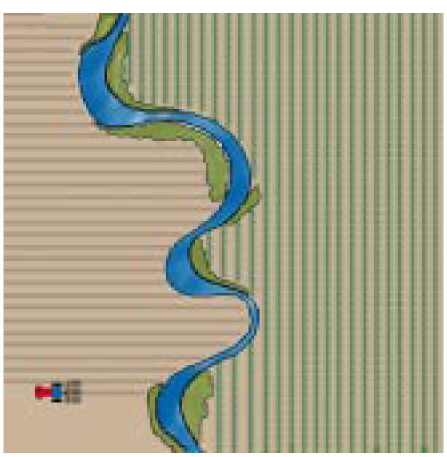
Optimizing connectivity and modifying the other plan elements in response to planning principles may involve

- extending a corridor,
- changing corridor location, width, or configuration, where practical,
- adding corridors or patches,
- proposing additional structural, mechanical, or management practices, and
- reintroducing natural mechanisms to manage vegetation.

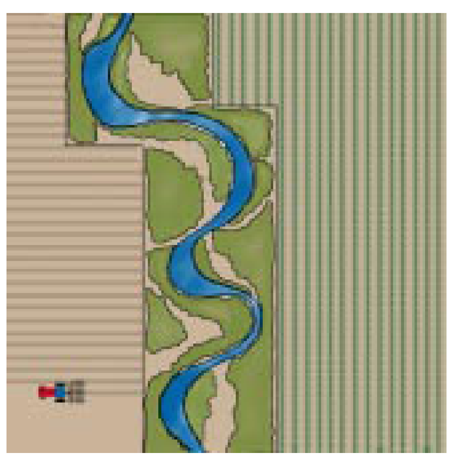
In some instances, patches or corridors cannot be linked in a practical way. They will remain disconnected from the overall structure of the conservation plan, but are still valuable as habitat.

The wildlife component of the conservation plan that emerges from the synthesis process should optimize habitat resources on the client's property. The conservationist and client should take the preliminary synthesis plan into the field and evaluate each recommendation on location. Adjustments to the plan should be made as necessary in response to onsite conditions. The conservationist will prepare a final plan once all adjustments have been made (fig. 613–70).

**Figure 613–68** Before and after streamside/riparian plantings to convert area into habitat



(a) Before squaring up fields, habitat is limited to small isolated patches



(b) After squaring up fields, habitat is increased fivefold and farming efficiency is enhanced

**Figure 613–69** Proposed practices and potential habitats

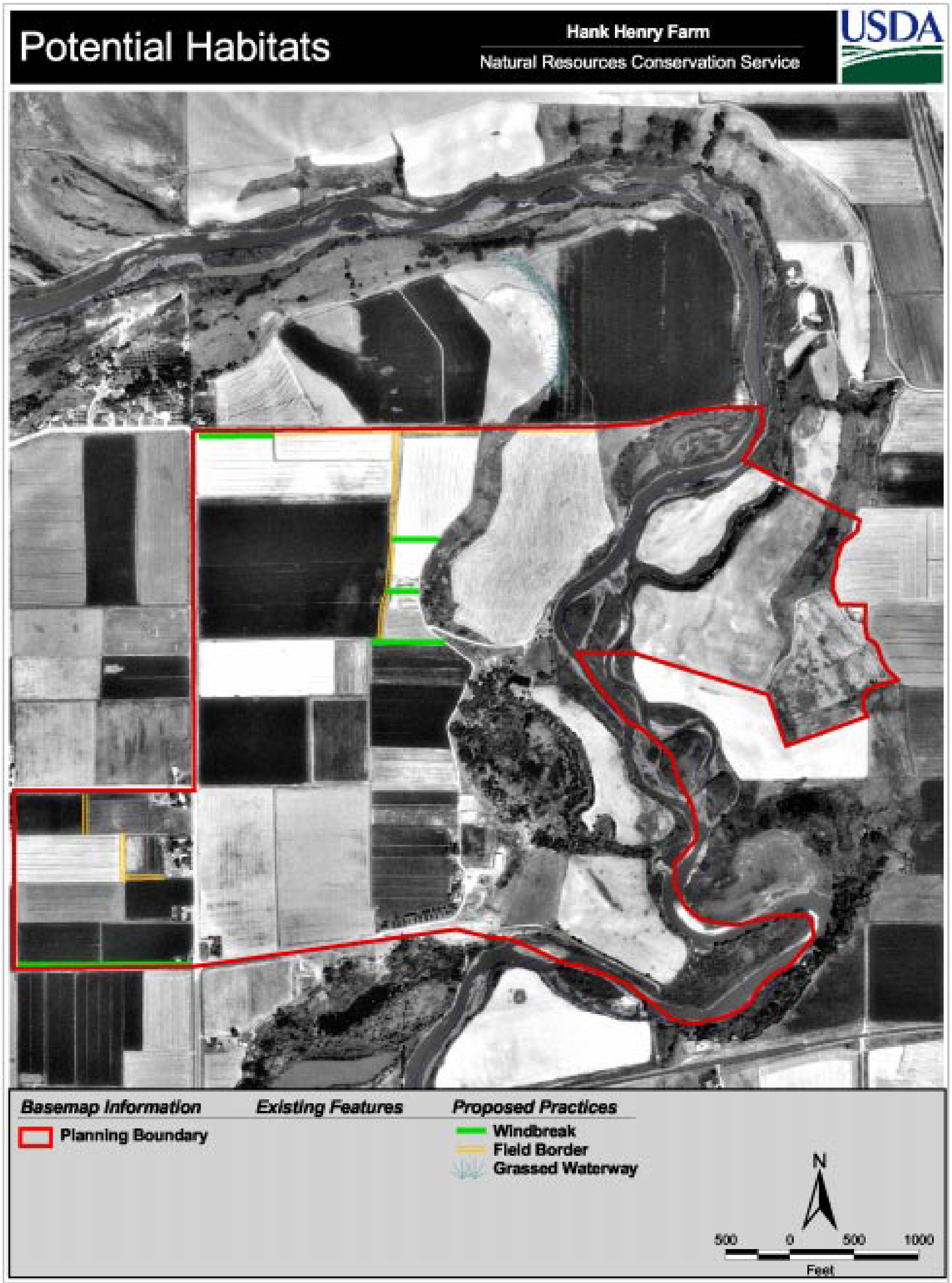
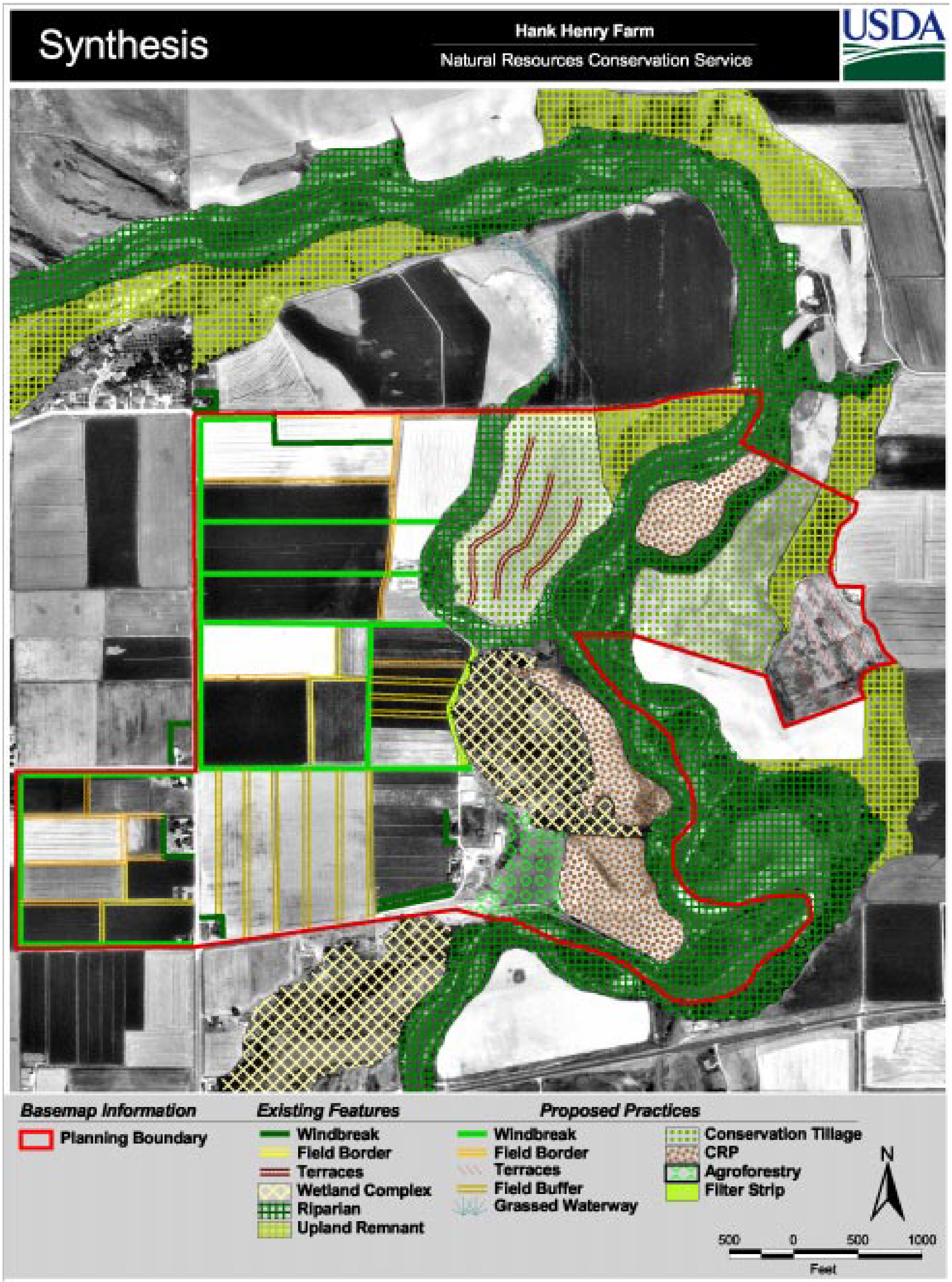


**Figure 613–70** The synthesis map shows all existing features and the proposed practices



### (4) Develop alternatives

The NPPH requires preparation of viable alternative conservation plans. There are several ways to develop alternatives to the base plan. Alternatives can focus on conservation function, wildlife (diversity or target species), or other corridor benefits. Some examples follow:

- Alternative plans using different management practices to address a particular soil or water conservation problem
- A plan to optimize wildlife species diversity
- A plan to increase populations of a particular species, guild, or suite of species
- A plan to optimize recreation, economic, or other corridor benefits
- A plan of conservation practices without enhancement for wildlife
- A no-action alternative (required)

The conservationist and client must agree that each alternative meets the client's objectives and NRCS standards. In addition, each alternative must comply with all relevant Federal, State, and local regulations.

### (5) Product

A description of wildlife habitat alternatives available to the client

## Step 6 Evaluate alternatives

**Planning standard**—The effects of each alternative are evaluated and impacts are described. Alternatives are compared to benchmark conditions to evaluate their ability to solve problems and meet quality criteria and the client's objectives.

The conservationist and client must evaluate the conservation plan alternatives developed in step 5. The NPPH outlines the basic procedures for evaluating alternatives. The intent of evaluating the wildlife habitat component of the conservation plan is to

- compare the wildlife habitat component of conservation plan alternatives against habitat benchmark conditions as described in the analysis,
- compare the wildlife habitat benefits of each alternative,
- compare the effectiveness of each alternative in meeting the client's objectives, and
- verify compliance with Federal, State, and local statutes regulating wildlife or wildlife habitat.

### (1) Procedure

The Conservation Plan Alternative Evaluation Worksheet provides a format for quantifiable comparisons between alternatives. Most of the data needed to fill out the form can be scaled from each plan alternative. However, estimated changes in species diversity require input from a biologist. Because state wildlife agencies and the USFWS manage wildlife populations, they should be invited to review plan alternatives and make recommendations.

Computer simulations constructed on oblique aerial photographs are effective in depicting what different alternatives would look like if implemented on the client's property (fig. 613–71). This valuable tool can help the client and conservationist visualize each alternative.

### (2) Products

- Set of practical conservation management system (CMS) alternatives compatible with client and NRCS objectives
- Conservation Effects for Decisionmaking Worksheet for each alternative displaying effects and impacts for the client to consider and use as a basis for making conservation decisions
- Technical assistance notes reflecting discussions between the planner and the client

# Areawide/Watershed Plan
# Alternative Comparison Worksheet B

Completing this form will provide a general evaluation of the impact of each alternative on wildlife habitat and wildlife populations.

**INSTRUCTIONS:** Enter the alternative name or number in the space provided. Using a scale, measure the length or calculate the area for each criterion and record them in the matrix. Where requested, check whether these figures have increased, remained the same, or decreased relative to the existing condition (benchmark). The last 2 criteria require the planning team to estimate the alternative's impact on wildlife. Each state is encouraged to develop criteria for making these estimates.

LOCATION
County: ____________
Township: ____________
Range: ____________
Section: ____________
Subsection: ____________

ADDRESS
Landowner: ______________________ *mailing*
______________________
______________________ *rural post*
______________________ *or fire code number*

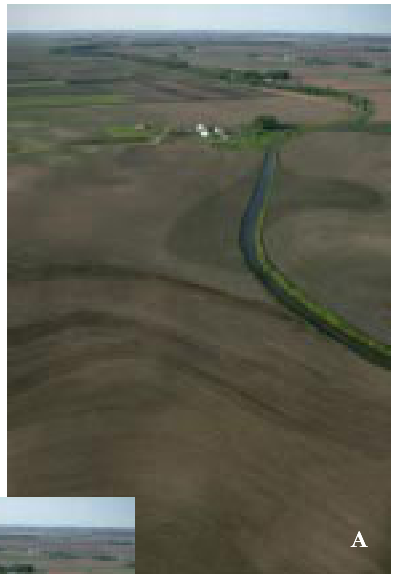
Phone # Day: ____________ Evening: ____________

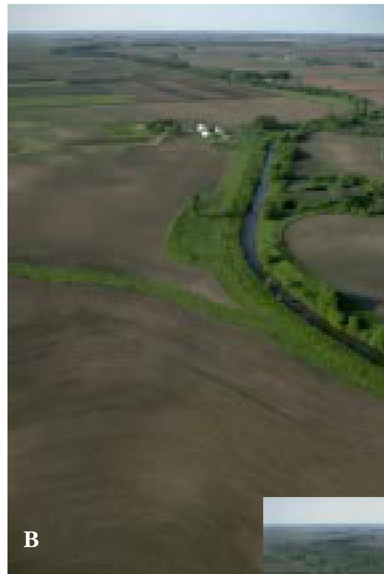
**ALTERNATIVE NAME:** ______________________
**EVALUATION**

| Criteria | | Increase | No Change | Decrease | Acres | Length | Number | Not Applicable |
|---|---|---|---|---|---|---|---|---|
| Total area of corridor | | | | | | | | |
| Linkage to adjacent patches or corridors | | | | | | | | |
| Total length of corridor | | | | | | | | |
| Length of existing corridor | | | | | | | | |
| | Preserved | | | | | | | |
| | Enhanced | | | | | | | |
| | Restored | | | | | | | |
| Total area of patches by plant community | | | | | | | | |
| | Grass | | | | | | | |
| | Grass shrub | | | | | | | |
| | Riparian wooded | | | | | | | |
| | Riparian shrub | | | | | | | |
| | Riparian grass | | | | | | | |
| | Upland wooded (natural) | | | | | | | |
| | Upland wooded (introduced) | | | | | | | |
| | Wetland | | | | | | | |
| Acres of farm or ranch land managed in ways that benefit wildlife | | | | | | | | |
| Acres of farm or ranch land taken out of production | | | | | | | | |
| Special areas preserved | | | | | | | | |
| Special features preserved | | | | | | | | |
| Other conservation measures (Specify) | | | | | | | | |
| Estimated effects on species diversity | | | | | | | | |
| Estimated effects on species abundance (Specify species) | | | | | | | | |

**Figure 613–71** Computer simulations (prepared by Gary Wells, U.S. Forest Service)

A. Depicts existing conditions on the farm. Note the engineered stream channel and dark gray wet soils adjacent to the stream.

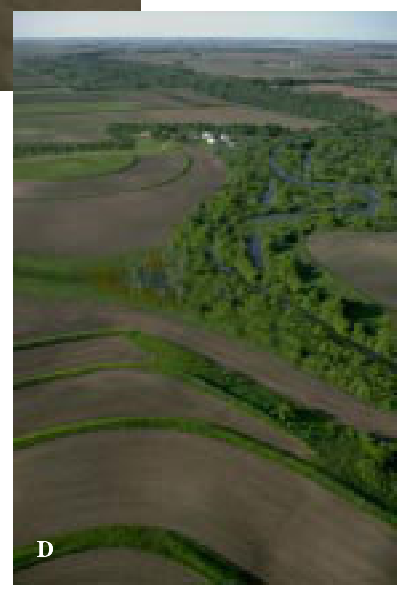


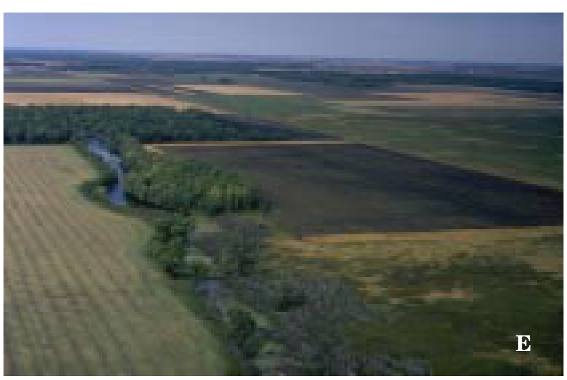


B. Installation of a shelterbelt around the farm buildings, a grassed waterway, riparian buffer along the stream and a wooded patch on the wet soils.

C. Grassed terraces have been installed and the riparian buffer widened in several locations. Terraces are connected to riparian buffers and grassed waterways.

D. The stream has been allowed to meander naturally within the flood plain and many flood plain functions are restored. This fully integrated set of conservation practices maximizes wildlife habitat benefits.





E. Existing conditions are depicted. Note the lack of connectivity between the wetland and wooded patch and the larger landscape.

F. Shelterbelts installed in this simulation link wetlands, riparian woodlands, and wooded patches, providing wildlife corridors and habitat across a large area.

## Step 7 Make decisions

> **Planning standard**—A conservation management system is selected based on the client's clear understanding of the impacts of each alternative. The selected alternative is recorded in the client's plan.

The conservationist assists the client to understand his or her options in selecting an alternative.

### (1) Procedure

The NPPH provides general guidelines for helping the client consider plan alternatives. It is important to review objectives established in step 2 at this point in the decisionmaking process. They should be basic criteria upon which the final decision is made. Also review the 1:660 scale drawings of each alternative using the Plan Alternative Evaluation Worksheets to compare habitat advantages and disadvantages of each alternative. A rigorous evaluation of each plan alternative will help the client understand the advantages and disadvantages for the wildlife resource and make an informed decision.

The conservationist prepares the final plan document once the client has selected an alternative. General guidance for preparing plan documents is provided in the NPPH.

Once the conservation plan is completed, it is delivered to the client and a date is set for followup or application assistance to coordinate funding and activities with State agencies, conservation groups, or others involved in plan implementation.

### (2) Products

- Plan document with the selected alternative, including potential program or implementation opportunities, and operation and maintenance
- Schedule of conservation system and practice implementation
- NEPA documentation (if required)
- Revised CED worksheet for a conservation plan

## (f) Phase 3 Application at the conservation plan scale

Phase 3 involves:

- Implement plan
- Evaluate plan

In Phase 3 the client and the conservationist cooperate in implementing the conservation plan. Installed management practices are evaluated, and adaptive management is applied where necessary.

## Step 8 Implement plan

> **Planning standard**—The client has adequate information and understanding to implement, operate, and maintain the planned conservation systems. Practices implemented with NRCS technical assistance will be installed according to Agency standards and specifications.

Implementing a conservation plan is the process of installing practices that make up the planned conservation management system. The plan may be implemented by the client with or without NRCS technical assistance. Implementation also includes operation and maintenance after installation to ensure proper future functioning. Wildlife benefit only after habitat enhancing conservation corridors and practices are installed. Wildlife continue to benefit as long as the corridors are maintained with their needs in mind.

### (1) Procedure

The NPPH provides detailed instructions on how to proceed with the implementation process. One area that requires additional information for wildlife-focused plans is permitting. A number of wildlife, wildlife habitat, and water quality related resources are regulated by Federal, State, or local law. Conservationists should be familiar with the types of required permits and permitting agencies. All necessary permits must be acquired before the plan can be implemented.

One of the most critical aspects of implementation is funding, particularly where wildlife habitat is concerned. Clients, for good reason, pursue the most cost-effective solution to a particular soil or water conservation problem. For example, in the upper Midwest, smooth brome (*Bromus inermis*) is the most common species planted in grassed waterways. Farmers and ranchers prefer smooth brome because it is easy to establish and provides good, inexpensive erosion control. However, pure stands of smooth brome have limited value as habitat for wildlife. Alternative grass/forb seed mixes that produce high quality habitat are more expensive and difficult to establish. Fortunately, numerous private conservation organizations in the upper Midwest and other regions are seeking partnership opportunities with landowners to enhance the habitat value of grassed waterways and other conservation practices. They have programs that contribute funds, native seed mixes, trees, shrubs, seeding and planting equipment, and labor. Support of this kind makes it possible for landowners to install appropriate conservation practices beneficial to wildlife at no additional cost. The reduced long-term costs of managing native plant communities are an additional benefit for the landowner.

Partnerships of this type result in enhanced wildlife habitat and a strengthened social structure in rural communities. Partnering with Federal and State agencies and county and local governmental departments can produce similar results. The next section in this part of the handbook is devoted to the topic of implementation.

### (2) Products

- Conservation practices applied
- Conservation management systems applied
- Communication with the clients
- Updated plan document
- Conservation plan revision notes
- Technical assistance notes
- Conservation contract, where applicable

## Step 9 Evaluate plan

**Planning standard**—The planner maintains contact with the client to determine whether the implementation results are meeting ecological, economic, and social objectives and solving conservation problems in a manner satisfactory to the client and beneficial to the resources. Resource impacts different from those predicted are fed back into the planning process, and adaptive management strategies employed.

The purposes for evaluating wildlife and wildlife habitat components of the conservation plan as implemented are to

- ensure wildlife habitat is functioning as intended,
- estimate wildlife response to conservation practices, and
- initiate adaptive management where wildlife responses are different from those predicted.

### (1) Procedure

Evaluation of the implemented plan effects on wildlife is an onsite activity. The client, conservationist, and NRCS biologist should work together to observe, measure, discuss, and record the wildlife and wildlife habitat data. The conservationist should use the plan evaluation step as an opportunity to discuss the results with the client. Habitat benefits of the conservation practices implemented and the importance of vegetation management in the perpetuation of those benefits should be emphasized. The NPPH outlines the general procedures necessary to complete a plan evaluation.

Evaluating (estimating) the effects of the conservation plan on wildlife can be a difficult task. The very nature and behavior of some species afford little opportunity for assessment. In addition, the effects of conservation practices are immediate. Plants take time to grow, and the results of fencing may require several years to be reflected in rejuvenated plant communities. The wildlife that inhabits these changing plant communities will also change over time in response to changing plant structure. Further, local and regional populations of wildlife are affected annually by weather and other natural factors. Consequently, changes in species abundance from year to year may not be responses to implemented management practices, but rather responses to other external factors.

Nevertheless, conducting a wildlife inventory over a period of years is worthwhile because it does illustrate trends. Inventories should be coordinated with state wildlife agencies and the USFWS. The types of information generated from a wildlife inventory that reflect the effects of the implemented conservation practice include the following:

- A list of species observed on the site
- A list of species that breed on the site
- Species abundance, estimated number of individuals present on the site
- Diversity, estimated number of species present on the site

Annual wildlife inventory information collected after implementation can be compared with data collected in the inventory, step 3. The data can be recorded on a simple bar graph to illustrate trends.

Several well-established inventory and monitoring techniques are in the wildlife biology literature. NRCS biologists and state wildlife agencies are well versed in these techniques, which include:

- Trapping
- Fecal pellet counts
- Call counts
- Harvest data (game species)
- Flush counts
- Roadside counts
- Number of artifacts (nests, burrows, tracks)
- Aerial counts

In addition, numerous species-specific inventory and monitoring techniques can be used as needed. It is beyond the scope of this handbook to detail each technique. The *Research and Management Techniques for Wildlife and Habitat* (The Wildlife Society 1994) is a useful reference. If threatened or endangered species or a vulnerable population is an issue, it may be necessary to enlist the help of other wildlife and conservation biologists in conducting an evaluation.

### (2) Adaptive management

Several years of evaluation data may indicate that a particular wildlife species or population is not responding as predicted to the implemented conservation practices. The plan should be reviewed by the conservationist and a biologist to determine the nature of the problem. Conservation practices should be modified as necessary to rectify the problem. In some cases additional practices need to be installed or species populations management employed.

### (3) Products

- Operation and management reports
- Outline of maintenance needs or other changes
- A decision to update or revise the plan, if needed
- Technical assistance notes indicating the effectiveness of the plan
- Case studies, if appropriate, following the guidance provided in the Field Office Technical Guide (FOTG), section V.
- Recommendations for changes in practice designs or specifications
- Recommendations for changes in FOTG materials
- A decision to revise or expand implementation strategies
- Updated conservation plan effects

## (g) Case study

The Hedgerow Farms, Winters, California, case study that follows illustrates four of the corridor-planning principles described in section 613.04:

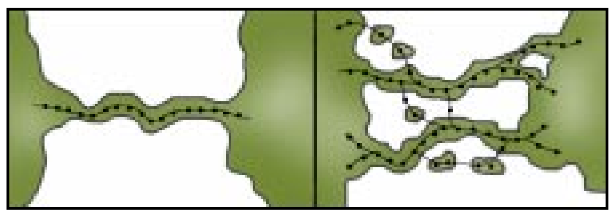
- Two or more corridor connections between patches are better than one
- Manage the matrix with wildlife in mind
- Native species are better than introduced species
- Structurally diverse patches and corridors are better than simple structure

## Case Study:

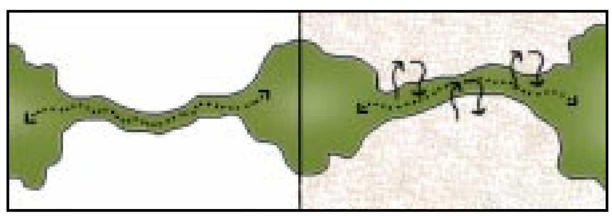
# Hedgerow farms

Corridor Planning Principles described in section 613.04 that are exhibited by this case study include:

**Two Or More Corridor Connections Between Patches Are Better Than One.**

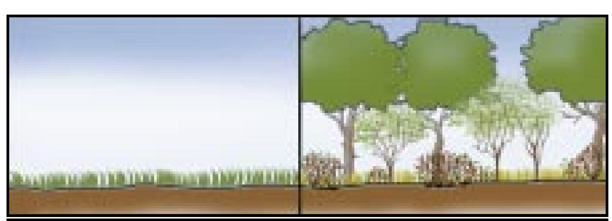


**Manage The Matrix With Wildlife In Mind.**



**Native Species Are Better Than Introduced Species.**

**Structurally Diverse Patches And Corridors Are Better Than Simple Structure.**



Vertical Structure

# Case Study: Hedgerow Farms

*This case study illustrates how a private landowner partnering with federal, state and local agencies and groups can develop an effective conservation plan at the farm or ranch scale. Conservation corridors form the essence of the plan and function both as habitat and conduit for the 110 species that have been recorded on the property. Hedgerow Farms is also a teaching and research facility for farmers and ranchers in the region.*


***Figure 1:** Aerial view of Hedgerow Farms.*

Hedgerow Farms, owned and operated by John Anderson and family, is a 600 acre row crop and grass seed production facility located 20 miles northwest of Davis, CA in the southern Sacramento Valley. Nestled in a 200,000-acre watershed at the base of the Vaca Hills, the farm is surrounded by other row crop farms and orchards. For the past 18 years, Hedgerow Farms has been pioneering methods for restoring and revegetating field borders, canal edges and berms, drainage ditches and riparian corridors with native California vegetation.

Intensive farming practices in the Sacramento Valley have essentially eliminated wildlife habitat and ecosystem functions on the majority of farmland. Most farmers routinely keep nonfarmed areas devoid of vegetation through a costly and labor-intensive combination of tillage and herbicides. Most of the major drainages that served historically as riparian corridors for wildlife have been channelized and stripped of vegetation.


***Figure 2:** A well designed windbreak with dense understory vegetation provides habitat for many species.*

In addition to eliminating wildlife habitat and biodiversity, this so-called “clean farming” has exacerbated soil erosion, sediment deposition, and flooding. It also locks farmers into a never-ending cycle of seasonal weed abatement. Left alone for even a short period, traditionally clean-farmed areas become a complex of non-native invasive weeds unacceptable to farmers that can choke water delivery systems.

The owners of Hedgerow Farms have developed and demonstrated the use of on-farm vegetation practices that completely reverse the concept of “clean farming.” Rather than eliminating vegetation, they have restored and cultivated native California vegetation on roadsides, irrigation canals, drainage ditches, field borders, and along a natural riparian corridor. Every non-farmed area is a complex of native plants (including perennial grasses, sedges, rushes, forbs, shrubs, vines and trees) competitively suppressing invasive weeds while providing a biologically diverse community of plants and animals.

Today, Hedgerow Farms supports multiple, interconnected corridors that have eliminated erosion, reduced the need for tillage and herbicides, and may even be assimilating agricultural nutrient run-off. The benefits to wildlife are tremendous. Over 110 species of birds have been recorded on the property. Game species are now regularly harvested and include dove, pheasant, quail, turkey, wood ducks, and mallards. Reptile and amphibian populations have made dramatic recoveries. A myriad beneficial insects and spiders inhabit the


**Figure 3:** *The grassed banks of this irrigation canal reduces bank erosion and provides habitat.*

The success and innovation of Hedgerow Farms has heightened local awareness and interest in conservation practices on farmland. The farm hosts an average of two tours each month attended by other farmers, agency representatives, and conservationists eager to learn more about farmland ecosystem management. The Yolo County Resource Conservation District together with NRCS works with Hedgerow Farms to provide education and outreach to expand these and similar programs throughout the watershed.

diverse vegetation complexes. The federally listed endangered Valley elderberry longhorn beetle has recently taken up residence in elderberry shrubs planted in 1986. This boon to wildlife has not compromised farm productivity: adjacent fields of corn, wheat, sunflowers, safflower, alfalfa, and tomatoes have not been negatively impacted and may even benefit from the beneficial insects and abundant predators associated with the restored habitat.

The owners of Hedgerow Farms have found that cooperation and partnerships with local agencies have been both essential and rewarding. Installing roadside habitat required the support and participation of the Yolo County public works agency. Restoring riparian habitat and revegetating canal banks depended on a close working relationship with the Yolo County Flood Control and Water Conservation District. The owners also relied upon multiple cost share programs to fund the projects, including USDA ACP funds, the U.S. Fish and Wildlife Service's "Partners for Wildlife" program, and EPA 319 funds through the Yolo County Resource Conservation District. Finally, on-going monitoring and research involves the State Water Resources Control Board, the University of California at Davis, and the University of California Cooperative Extension.

*For additional information, contact:*

*John H. Anderson*
*Hedgerow Farms*
*21740 Co. Rd. 88*
*Winters, CA 95616*

This case study was written by John Anderson and Jeannie Wirka and is printed in this document with their permission.

United States
Department of
Agriculture

**Natural
Resources
Conservation
Service**

National Biology Handbook

Subpart B—Conservation Planning

# Part 614 Stream Visual Assessment Protocol Version 2


(190–VI–NBH, Amend. 3, December 2009)

Issued December 2009

For additional information contact:

Fisheries Biologist
West National Technology Support Center
1201 NE Lloyd Blvd., Suite 1000
Portland, OR 97232
(503) 273–2400

# Preface

This document presents a revised and updated NRCS Stream Visual Assessment Protocol Version 2 (SVAP2) for use by conservation planners, field office personnel, and private landowners. Like its predecessor, it is a relatively easy-to-use tool for qualitatively evaluating the condition of aquatic ecosystems associated with wadeable streams, that is, those shallow enough to be sampled without use of a boat. Such wadeable streams include those modified to improve drainage on agricultural lands, especially if these systems are part of an ecologically functional stream and/or river network. While the protocol does not require users to be experts in aquatic ecology, it does require they read the protocol's user guidance thoroughly before beginning an assessment. The SVAP and SVAP2 are tools that work best when users first identify local stream reference conditions that can effectively provide a standard for comparison. State offices are encouraged to refine the protocol based on the physical settings, stream conditions, and life history requirements of aquatic fauna found in their specific locales. Additional guidance on how to make State modifications is provided in appendix C.

Both versions of the SVAP provide a relatively basic level of ecological assessment based on qualitative descriptions. Each is designed to give a snapshot of wadeable stream ecosystem conditions that allows planners and conservationists to assist landowners with determining the quality of stream habitats located on their property. SVAP2 was developed to provide more comprehensive descriptions of several scoring elements, namely, channel condition, hydrological alteration, riparian area conditions, and fish habitat complexity. Field conservationists are encouraged to use SVAP2 in those situations where more detail is needed to critically score these elements and their relative contribution to the condition of the stream. This version lends itself to tracking trends in stream conditions over time, as well as identifying resource concerns and their potential causes. The original SVAP is designed to be conducted with the landowner. SVAP2 can be completed with a landowner or conservation planning team. Background information relevant to ecological processes and functions of stream/riparian ecosystems is incorporated into both versions of the SVAP.

# Acknowledgments

This version of the Stream Visual Assessment Protocol (SVAP) was developed by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) under the leadership of **Kathryn Boyer**, fish biologist, West National Technology Support Center, Portland, OR. The SVAP Revision Workgroup members provided substantial assistance in revision of the overall protocol and specific scoring elements.

**Jenny Adkins**, water quality specialist, NRCS, Nashville, TN

**Kale Gullett**, fisheries biologist, East National Technology Support Center, Greensboro, NC

**Edward Neilson**, resource conservationist, NRCS, Grand Junction, CO

**Barry Southerland**, fluvial geomorphologist, West National Technology Support Center, Portland, OR

**Billy Teels** (retired), Central National Technology Support Center, Fort Worth, TX

**Deborah Virgovic**, fisheries biologist, NRCS, Mount Vernon, WA

**Kip Yasumiishi**, civil engineer, West National Technology Support Center, Portland, OR

Formal technical reviews of an earlier draft of the protocol were completed by the following people whose assistance is much appreciated.

**Greg Kidd**, biologist, NRCS, Madison, WI

**Julie Hawkins**, biologist, NRCS, Richmond, VA

**Robert Weihrouch**, biologist, NRCS, Madison, WI

**Mitch Cummings**, fisheries biologist, NRCS, Tillamook, OR

**Todd Bobowick**, soil conservationist (fisheries), NRCS, Torrington, CT

**Erin Myers**, biologist, NRCS, Gainesville, FL

**Romy Myszka**, biologist, NRCS, Fort Worth, TX

**Jennifer Anderson-Cruz**, biologist, NRCS, Des Moines, IA

**Stephen Brady**, wildlife biologist, NRCS, Fort Worth, TX

**Chet Hadley**, biological science technician, NRCS, Heppner, OR

**Andrew Lipsky**, biologist, NRCS, Warwick, RI

**Daniel Thompson**, wildlife biologist, NRCS, Grand Junction, CO

**National Riparian Service Team**, Bureau of Land Management, Prineville, OR

# Part 614 Stream Visual Assessment Protocol Version 2

Contents:

## Tables



## Figures

## 614.00 Introduction

The Stream Visual Assessment Protocol (SVAP) is a national protocol that provides an initial evaluation of the overall condition of wadeable streams, their riparian zones, and their instream habitats. The majority of the Nation's streams and rivers are small, often with intermittent flows and, yet, they constitute a close multidimensional linkage between land and water management. These smaller streams and rivers are increasingly a focus of Natural Resources Conservation Service (NRCS) assistance to landowners. This protocol is developed for relatively small streams, be they perennial or intermittent. If the stream can be sampled during low flow or seasonally wet periods of the year without a boat, it can be assessed using the SVAP. Although this protocol has been developed for use nationwide, its authors recognize the importance of regional differences in influencing stream conditions. The NRCS thus encourages modification and calibration of the national protocol's scoring elements, if needed, to achieve greater sensitivity to resource conditions at State and regional levels. Thus, version 2 (SVAP2) can be viewed as a national framework for States to revise or amend, if necessary, to better assess local stream and riparian conditions. Guidance for such modifications is provided in appendix C.

The SVAP2 protocol can be successfully applied by conservationists with limited training in biology, geomorphology, or hydrology. Since publication of the initial version of the SVAP, the protocol has taken on broader applications as a tool to evaluate quality criteria for conservation planning, establish eligibility for Farm Bill programs, identify potential resource concerns, and assess trends in stream and riparian conditions over time. Consequently, NRCS State Offices have played a large role in modifying the protocol, updating training materials, and transferring SVAP2 technology to the field. States should continue with such efforts and also pay close attention to achieving consistency in how the protocol is applied within their States and in adjacent States. It is less critical that a particular assessment discern between a score of 5 or 6 with subtle subjective differences than it is that the protocol be interpreted and applied consistently, year-to-year by multiple users. Consistency, efficiency, and effectiveness can be gained by collaborating closely with local users and those in other States within the region. NRCS State Offices are encouraged to contact appropriate National Technology Support Center (NTSC) specialists regarding refinement of this SVAP2's scoring criteria to more accurately reflect local conditions. NTSC specialists can also assist with coordinating regional training to improve understanding of the methodology and consistency in use of the SVAP2.

The SVAP2 is a preliminary qualitative assessment tool to evaluate features that affect overall stream conditions at the property level. The tool assesses visually apparent physical, chemical, and biological features within a specified reach of a stream corridor. Because of its qualitative nature, the protocol may not detect all causes of resource concerns, especially if such causes are a result of land use actions in other parts of the watershed. It does provide a means to assess site conditions in the context of the larger watershed. A synthesis of information gathered during the preliminary assessment and field assessment portions of the protocol can be used to provide general guidance to landowners on how watershed features and practices they employ are reflected in the quality of their stream ecosystems.

# 614.01 What is a healthy stream?

A stream's watershed captures precipitation, filters and stores water, and regulates its release through the stream channel network and eventually into a lake, another watershed, or an estuary and the ocean. Watersheds are characterized by different climates, geomorphic features, soil types, vegetation, and land uses. Their upland features control the quantity and timing of water and materials that make their way overland and into a stream system. The environmental conditions of a stream or river corridor (such as water quantity and quality, riparian and flood plain function, and habitat quality) are thus linked to the entire watershed. These linkages affect stream processes that act vertically, laterally, longitudinally, and over time. Land managers may have little control of watershed management beyond their property lines or jurisdictional boundaries. Nevertheless, activities that occur in many individual farm fields, rangelands, or pastures can have cumulative impacts on the condition of an individual landowner's stream and those downstream. Sound watershed and stream corridor management are important for maintaining stream conditions that allow the stream to be resilient and resistant to natural disturbance and human-caused perturbations. The natural resilience of a stream to recover from floods, fire, and drought is an indicator that it is healthy (Meyer 1997).

Streams, their flood plains, and adjacent riparian areas are complex ecosystems where numerous biological, physical, and chemical processes interact (Cushing and Allen 2001). Changes in any one feature or process in a stream ecosystem have cascading effects throughout the stream as it flows downstream and as its flows change with seasonal shifts in precipitation. Stream processes are interconnected, and these connections maintain a balance of materials that are transported and deposited by the stream, including sediment, water, wood, and nutrients. If conditions change, these processes must readjust to keep the stream resilient and functional for energy and material transport and aquatic fauna and flora. The conditions of a stream reflect current and past land uses and management actions. As such, they can also help predict future trends of watershed land use and conditions.

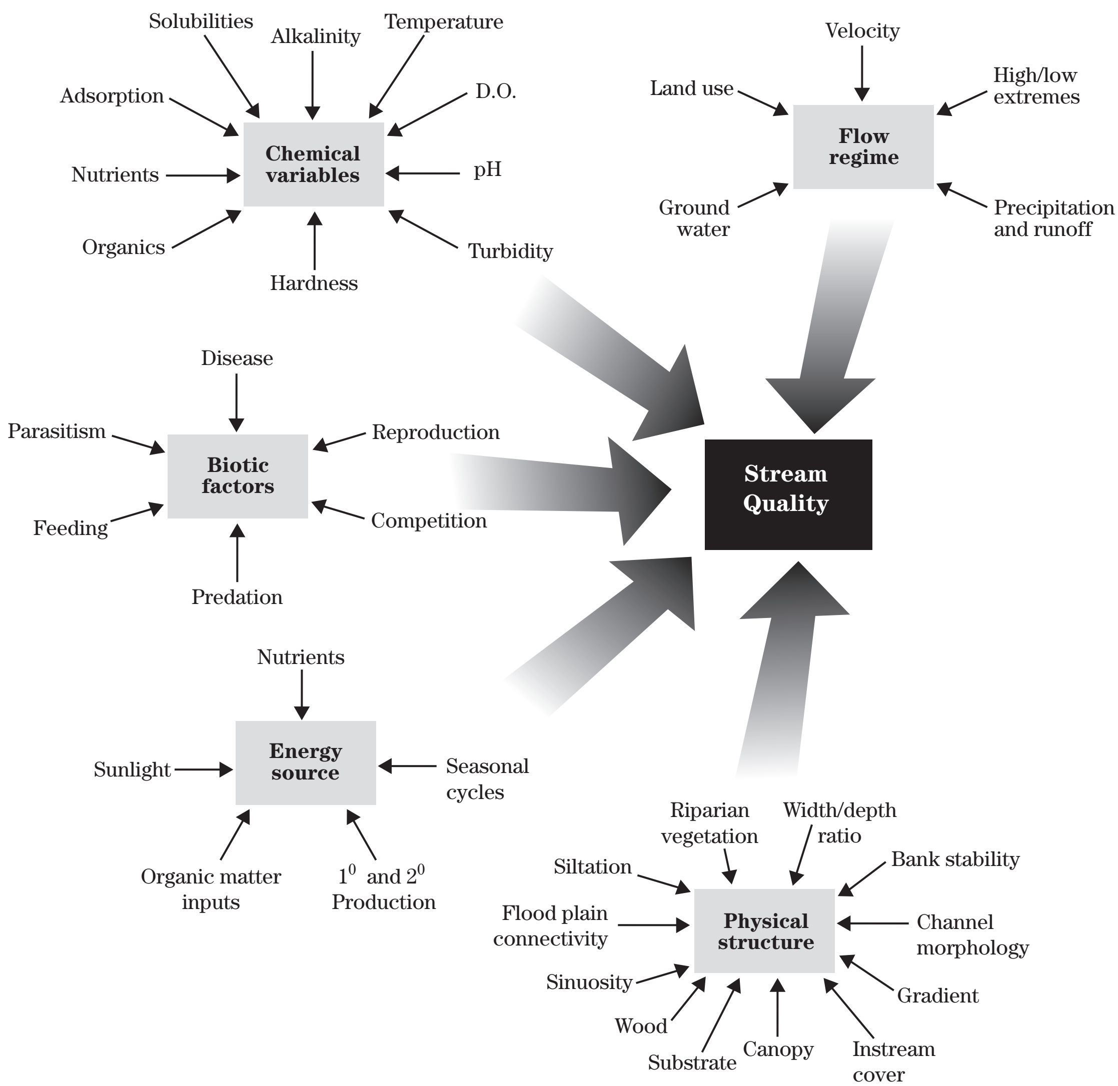
Multiple factors affect stream conditions and, therefore, stream quality (fig. 1). For example, increased nutrient loads alone may not cause a visual change to a forested stream, but when combined with tree removal and channel widening, the result may shift the energy dynamics from a community based on leaf litter inputs to one based on algae and aquatic plants. The resulting chemical changes caused by photosynthesis and respiration of aquatic plants coupled with temperature increases due to loss of canopy cover will alter the aquatic community.

Many stream processes are in delicate balance. For example, the force of the streamflow, amount of sediment, and stream features that slow or hasten flow must be in relative balance to prevent channel incision or bank erosion. Increases in sediment loads beyond the capacity of the stream to transport them downstream can lead to extensive deposition of sediments and channel widening.

Lastly, the biological community of a stream also affects its overall condition. As indicators of biological integrity fish, aquatic invertebrates, and all other members of a stream's community portray a pattern of stream condition that further enhances our ability to detect concerns. For example, the prevalence of exotic species in a fish assemblage of a particular stream often indicates deterioration in stream function or quality. While beyond the scope of the SVAP2, such indices of biological integrity provide an even more comprehensive picture of a stream ecosystem's condition (Giller and Malmqvist 1998; Matthews 1998).

Stream corridors benefit from complex and diverse physical structure. Such complexity increases channel roughness that dissipates the energy of water and reduces its erosive power. Structural complexity is provided by channel form (meanders, pools, riffles, backwaters, wetlands), profile (stream gradient, width, and depth), materials that have fallen into the channel (trees and bank material), overhanging vegetation, roots extending into the flow, and streambed materials (sand, gravel, rocks, and boulders). The movement of these materials and the path of flow form pools, riffles, backwaters, side channels, flood plain wetlands, and many other types of habitats. Thus, streams with complex flood plains and a diversity of structural features generally support a higher diversity of aquatic species

**Figure 1** Factors that influence the quality or condition of streams (modified from Karr et al. (1986))



(Schlosser 1982; Pearsons et al. 1992; Gurnell et al. 1995).

Chemical pollution of streams and rivers diminishes stream health and harms aquatic species. The major categories of chemical pollutants are oxygen-depleting sources such as manure, ammonia, and organic wastes; nutrients such as nitrogen and phosphorus from both fertilizers and animal wastes; acids from mining or industrial effluents; and contaminants such as pesticides, salts, metals, and pharmaceuticals. It is important to note that the effects of many chemicals depend on multiple factors. For example, an increase in the pH caused by excessive algal plant growth may cause an otherwise safe concentration of ammonia to become toxic.

Finally, it is important to recognize that healthy, resilient streams, riparian areas, and flood plains operate as a connected stream corridor system. Lateral exchange of water and materials between a stream and its flood plain is the driving force for nutrient dynamics in the stream corridor community. Primary productivity of flood plain habitats is closely tied to hydroperiod, or the length of time the flood plain is inundated or saturated with water. Productivity is greatest in wetlands with pulsed flooding (periodic inundation and drying) and high nutrient input and lower in drained or permanently flooded conditions. Flood plains and their associated wetlands play a critical role in the health of the stream itself. An example would be the removal of nitrogen (denitrification) in floodwaters by flood plain wetlands (Forshay and Stanley 2005).

Riparian wetlands may also influence stream channel morphology and flows, buffering the stream channel against the physical effects of high flows by dissipating energy as waters spread out onto the flood plain. In many instances, these flood plains provide refuge habitat for aquatic species, especially during flood events. As streamflows recede, riparian wetlands provide water storage, slowly releasing water and aquatic organisms back to the stream through surface and subsurface transport, thereby influencing stream baseflows during drier times of the year.

In summary, physical, chemical, and biological elements that influence stream conditions also provide indicators of how well a stream is functioning and responding to natural disturbances (floods) or human actions (land clearing). A stream corridor that maintains key ecological and physical functions over time is a healthy, resilient ecosystem that can support diverse communities of aquatic species.

# 614.02 Stream classification

A healthy stream will look and function differently depending on its location or ecological setting. A mountain stream that flows through a narrow valley over a shale bedrock bottom is very different from a stream that flows through a wide valley over alluvial deposits. Similarly, coastal streams are different from piedmont streams and desert canyon streams. Accurately classifying the type of stream in an area of interest is important to assessing the current condition, or health, of that particular stream. Stream classification is a way to account for the effects of natural variation in streams and helps avoid comparing the conditions of streams of different classes. A stream's classification provides a point of reference for subsequent assessments that may occur at the site. Ideally, a separate SVAP modification should be developed for each stream class, but realistically, this is not possible. At best, States should identify only as many stream classes as are necessary to account for natural variation in streams caused by the prevailing environmental influences of their region. Some important factors to consider are major land resource areas (MLRA) or ecoregion, drainage area, and gradient. Ecoregions are geographic areas in which ecosystems are expected to be similar. Drainage area is the size of the area of a watershed (catchment or basin). Gradient is the slope of a stream. For example, an SVAP2 modification may be warranted for low gradient, wadeable streams of the northern Piedmont of North Carolina. References regarding stream classification can be found in appendix A.

NRCS State Offices are responsible for SVAP2 modifications. Because there are many stream classification systems, States should select the one most suitable to their ecoregion and decide the scale at which their SVAP2 will be modified or refined (for all stream classes within the State, for all stream classes within an ecoregion of the State, or for several stream classes within an ecoregion). Enough up-front work should be done by State Offices in tailoring the protocol to permit field offices to use it without further modification. This includes refining and evaluating the protocol, modifying the element criteria and scoring to reflect local conditions, and delineating the geographic boundaries for its intended use.

# 614.03 Reference sites

One of the most difficult challenges associated with evaluating a stream's quality or existing condition is the determination of historic and potential conditions. An accurate assessment of the stream requires a benchmark of, or reference to, what a healthy stream in the targeted ecoregions should look like. It is often assumed that historic conditions of streams were healthy or resilient after disturbances. However, it is unrealistic to expect that all stream systems can potentially be as resilient as they were prior to extensive land use activity. In such cases, land managers often identify a benchmark condition that reflects the least impaired conditions of the ecoregion. Under this scenario, the SVAP2 would be adapted to reflect the stream corridor conditions to which managers are aspiring to.

Reference sites represent the range of conditions that potentially exist for a particular class of stream. Least impaired reference sites represent the best conditions attainable, and most impaired reference sites the worst. One challenge in selecting least impaired reference sites is that there are few streams left, especially in agricultural landscapes, that have not been influenced by human actions. Accessible, least impaired reference sites are important not only because they define a benchmark for attainable conditions, but they also serve as demonstration areas for field staff to observe the characteristics of the region's best streams that would result in the highest possible SVAP2 scores. A common pitfall in reference site selection is the failure to survey a wide enough area to find sites that are truly least impaired and are representative of an entire class of stream. Another common problem, particularly in highly altered landscapes, is the failure to identify sites that are most impaired. In addition to setting the lower bar of the stream health gradient, most impaired sites provide a clear illustration of how streams are not supposed to look and serve as models for improvement actions. Remember, reference sites should represent an entire stream class and thus may be located in another county or State. Therefore, it helps if they can be identified at a State or higher level and with the help of State agencies that may have already established reference sites that represent a full range of human perturbations for a given class of stream.

# 614.04 Using this protocol

This protocol is intended for use in the field with the landowner. Conducting the assessment with the landowner provides an opportunity to discuss natural resource concerns and conservation opportunities. Before leaving the office to assess a stream, a preliminary assessment of watershed features should be conducted in the field office. The Stream Visual Assessment Summary Sheet (exhibit 1) provides a standardized form for recording information and data collected during both the preliminary and field portions of the assessment.

## (a) Preliminary assessment of the stream's watershed

- *Become familiar with watershed conditions* before going to the assessment site. Stream conditions are influenced by the entire watershed including uplands that surround the assessment site. Changes in upland conditions can change the discharge, timing, or duration of streamflow events that affect stream conditions. Aerial photographs, topographic maps, stream gages, and any other source of data available can be used to obtain information about watershed conditions before conducting the SVAP2 on a stream. State agencies, watershed groups, local landowners, and Federal land managers are likely to already have documented relevant information about watershed conditions. Ecoregion descriptions, size of the watershed (drainage area) and upland practices often explain conditions at the assessment site and are helpful for addressing some of the elements in SVAP2.
- *Gather land use information about the watershed* to provide a context for the stream to be assessed and a better understanding of the conditions at the site. For example, road crossings and water control structures may prevent movement of aquatic species. Mining, agriculture, and urbanization all influence water quality and quantity, as well as stream corridor condition.
- *Review available water resource information* for the watershed and stream reach. Water control structures and/or activities outside of the assessment reach may be affecting streamflow. Ask the landowner if he or she is aware of upstream withdrawals (surface diversions or pump stations), drains, or any features that affect the amount of instream flow during the year. The U.S. Environmental Protection Agency's (EPA) Surf Your Watershed Web site (http://www.epa.gov/surf) is also a good source of information.
- *Consult the State fish and wildlife agency* regarding stream and riparian species likely to be present in the reach and whether fish passage to or from the area is limited.
- *Become familiar with potential riparian plant species* and community types appropriate to the area to be assessed.

## (b) Delineating the assessment reach

Assess one or more representative reaches, evaluate conditions on both sides of the stream, and indicate left and right bank conditions looking downstream. A reach is a length of stream with relatively consistent gradient and channel form. *An assessment reach for this protocol is, at a minimum, a length of stream equal to 12 times the bankfull channel width.* Longer reaches may be appropriate, depending on the objectives of the assessment.

Bankfull channel width is the stream width at the bankfull discharge, or flow rate that forms and controls the shape and size of the active channel. Bankfull discharge or bankfull flow is the flow rate at which the stream begins to move onto its active flood plain, if one is present. On average, the bankfull discharge occurs every 1.5 to 2 years, depending on local stream channel and weather conditions. Figure 2 illustrates the relationship between baseflow (low flow), bankfull flow, and the flood plain.

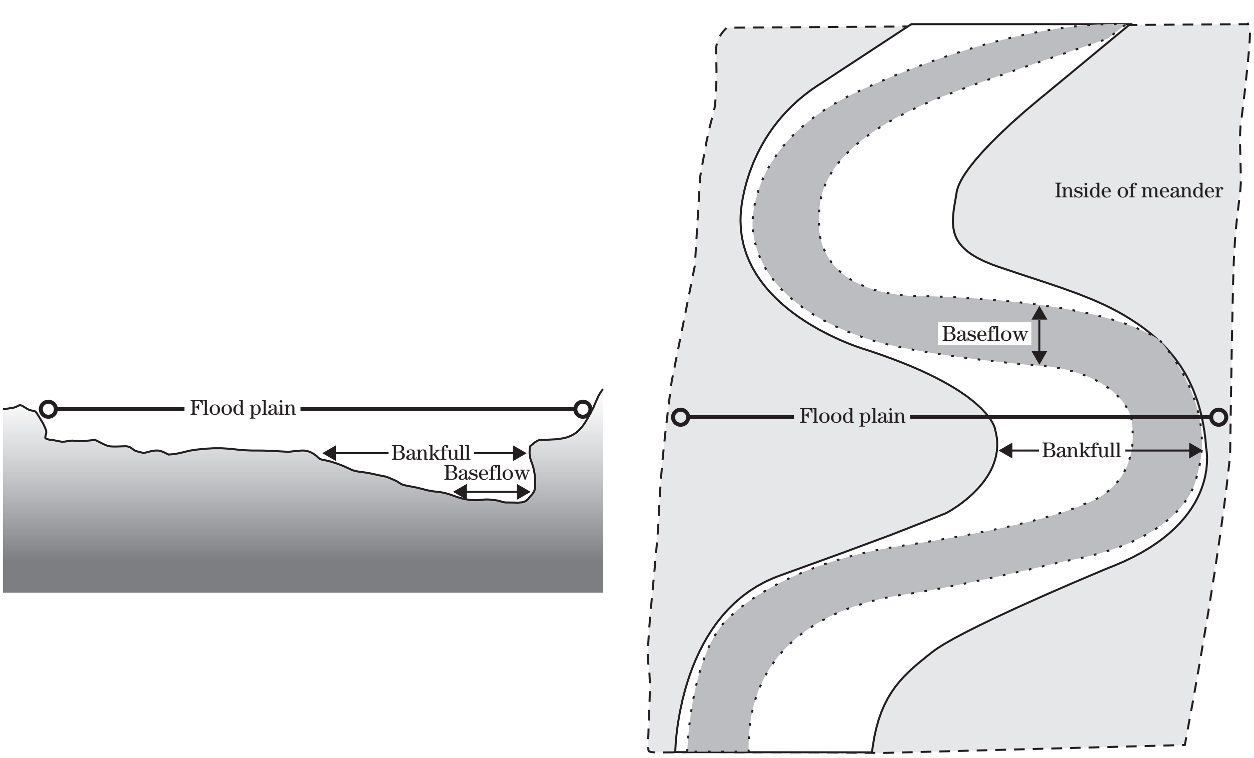
Bankfull width is determined by locating the first flat depositional surface occurring above the bed of the stream. The lowest elevation at which the bankfull surface could occur is at the top of the point bars or other sediment deposits in the channel bed. These generally occur on the inside of the meanders (white part of the figure 2). Other indicators of bankfull elevation include a break in slope on the bank, vegetation changes or exposed roots, a change in the particle size of bank material, and wood or small debris left from high waters. In temperate areas of the country, vegetation can grow into depositional bars below some bankfull indicators. Therefore, look for signs of well-established vegetation at the elevation level with the top of point bars to help identify bankfull stage.

The following videos and documents are resources to assist field personnel in identifying bankfull discharge indicators across the coterminous United States. They can be downloaded from: http://www.stream.fs.fed.us. Click on "Publications and Products."

- A Guide to Field Identification of Bankfull Stage in the Western United States, principally narrated by Luna B. Leopold.
- Identifying Bankfull Stage in Forested Streams of the Eastern United States, principally narrated by M. Gordon Wolman.
- Guide to Identification of Bankfull Stage in the Northeastern United States. USDA General Technical Report (RMRS–GTR–133–CD). Fort Collins, CO.
- Harrelson, C., L. Rawlins, and J.P. Potyondy (1994). Stream Channel Reference Sites: An Illustrated Guide to Field Technique. USDA General Technical Report (RM–245): 61.

Often the stream length within the landowner's property boundaries is shorter than the minimum length needed to adequately determine conditions using the SVAP2. If permission is received to cross property boundaries, it is appropriate to do so to evaluate an adequate length of the stream. If crossing property boundaries is not an option, the assessment reach length will be the length that is within the property boundaries. When large sections of stream are to be assessed and there are constraints that prohibit assessing the entire stream length, representative reaches of the stream on the property should be subsampled. Using aerial photographs, topographic maps, and various stream classification methods, streams can be stratified into smaller units (stream reaches) that share common physical characteristics such as stream gradient and average bankfull width. The degree of

**Figure 2** Baseflow, bankfull, and flood plain locations (Rosgen 1996)



stratification will depend on the reason for assessing the stream. If simply providing an opportunity for the landowner to learn about the general conditions of the stream, perhaps only one reach is assessed. If the SVAP2 is being conducted to identify potential improvement actions, the entire stream within the property should be assessed. SVAP2 scores can then be used as a preliminary and qualitative evaluation of conditions. Low scores likely indicate more quantitative assessments of geomorphic, hydrological, and biological features of the stream corridor are needed to determine what stressors are causing the problems identified. Quantitative assessments should only be completed by trained specialists (stream ecologists, hydrologists, geomorphologists, hydraulic engineers) to assure the complex features influencing stream conditions are being evaluated as accurately as possible. If there are several stream types (reaches) within the property, multiple stream visual assessments should be completed, one for each reach. Regardless of the situation, the SVAP2 requires field personnel to score four elements based upon the entire length of the stream that is within a single landowner's property. These are: riparian area quantity, riparian area quality, canopy cover, and barriers to aquatic species movement.

## (c) Scoring the elements of the Stream Visual Assessment Protocol

The SVAP2 ideally should be completed during baseflows when habitat feature limitations are likely to be most visible. Each assessment element is scored with a value of zero to 10. Some of the 16 elements, for example, salinity, may not be relevant to the stream being assessed. Score only those elements appropriate to the ecological setting of the stream. Livestock or human waste should be scored in all reach assessments.

Background information is provided for each assessment element, as well as a description of what to look for. Using Part 2B of the Stream Visual Assessment Protocol Summary Sheet, record the score that best fits the observations made in the assessment reach. Base observations on the descriptions in the matrix provided for each element assessed. Assign a score that applies to the conditions observed in the assessment reach. If the conditions of the stream fit descriptions that occur in more than one column of the matrix, score the element based on the lower valued descriptions. For example, when scoring the element hydrological alteration, if bankfull flows occur according to the natural flow regime (score 10–9 column), but there is a water control structure present (score 8–7 column), assign the score based on the lowest scoring indicator present within the reach, which in this case would be an 8 or 7. Again, evaluate conditions on both sides of the stream, and note left bank and right bank conditions while looking downstream.

The complete assessment is recorded on the summary sheet, which consists of two principal sections: Preliminary Watershed Assessment and Field Assessment.

Section 1 records basic information about the watershed and reach such as drainage area, location, and land uses. Space is provided for a description of the reach, which may be useful to locate the reach or illustrate problem areas. On the worksheet, indicate tributaries, presence of drainage ditches, and irrigation ditches; note springs and ponds that drain to the stream; include road crossings, and note whether they are fords, culverts, or bridges.

Section 2 is used to record the scores for up to 16 assessment elements. Score an element by comparing the observations to the descriptions provided. If matching descriptions is difficult, try to compare what is being observed to the conditions at reference sites for the area. Again, some of the elements may not be applicable to the site and, therefore, should not be included in the assessment. The overall assessment score is determined by adding the values for each element and dividing by the number of elements assessed. For example, if the scores add up to 76 and 12 assessment elements were used, the overall assessment value would be 6.3, which is classified as FAIR. This value provides a numerical score of the environmental condition of the stream reach. This value can be used as a general statement about the state of the environment of the stream or (over time) as an indicator of trends in condition.

# 614.05 Stream assessment elements

## (a) Element 1—Channel condition

### Description and rationale for assessing channel condition

The shape of a stream channel changes constantly, imperceptibly, or dramatically, depending on the condition of the stream corridor (channel, riparian area, and flood plain) and how it transports water and materials. Channel condition is a description of the geomorphic stage of the channel as it adjusts its shape relative to its flood plain. Channel adjustments resulting in a dramatic drop in streambed elevation (incision or degradation) or excessive deposition of bedload that raises the bed elevation (aggradation) affect the degree of bank shear and often decrease stream channel stability. Such channel adjustments can have substantial effects on the condition of streams, adjacent riparian areas, associated habitats, and their biota. For example, the greater the incision in a channel, the more it is separated from its flood plain, both physically and ecologically. Conversely, the greater the aggradation, the wider and shallower a stream becomes, which can affect riparian vegetation, surface water temperatures, and stream and riparian habitat features.

Conceptual models of how a channel evolves or adjusts over time illustrate the sequence of geomorphic changes in a stream that result from disturbances in the watershed. Such sequences are useful for evaluating trends in channel condition. The stages of the Schumm Channel Evolution Model (CEM), as shown in figure 3, provide a visual orientation of the pattern of streambed adjustment in an incising stream, its gradual detachment from the existing flood plain, and eventual formation of a new flood plain at a lower elevation. A similar model by Simon (1989) is also described in the Stream Corridor Restoration Handbook (FISRWG 1998) available in most NRCS field offices.

Stage I channels are generally stable and have frequent interaction with their flood plains. The relative stability of the streambed and banks is due to the fact that the stream and its flood plain are connected, and flooding occurs at regular intervals ($Q_2$). Consequently, the stream's banks and flood plain are well vegetated. Depositional areas (bars), if present, form a gradual transition into the active flood plain, as shown by the arrow in figure 4.

**Figure 3** Channel Evolution Model, after Schumm, Harvey and Watson (1984). $Q_2$ indicates a flood interval of 2 years; $Q_{10}$ indicates an interval of 10 years

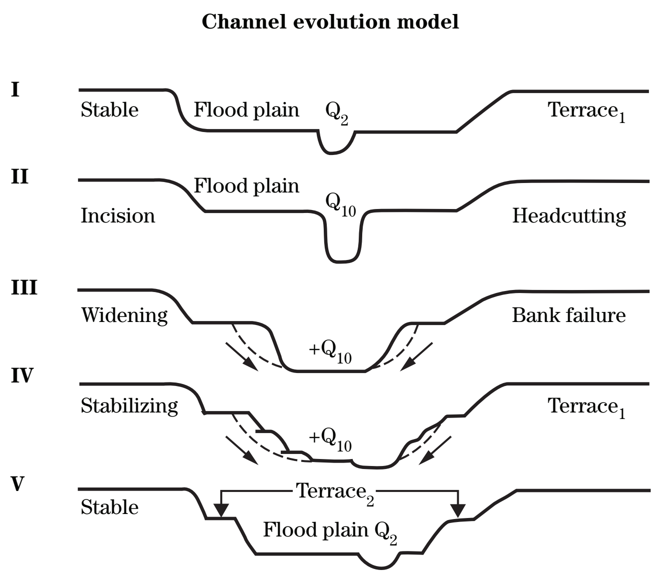



**Figure 4** CEM stage I. Typically excellent channel condition with natural bank protection

Land use activities that increase runoff, such as land-clearing, paving, or channel straightening, often result in channel incision processes characteristic of stage II in channel evolution. The height of the banks increases due to downcutting of the channel, and the stream and flood plain have less frequent interaction. Bank vegetation becomes stressed, and banks are prone to failure. Once failures begin, the channel widening of stage III begins. A stage II channel is typically narrower at the bed relative to the depth (often referred to as low width-to-depth ratio) than a stage III channel. A stage II channel is in an active downward trend in condition and active headcuts are often present (fig. 5).

During stage III, bank failures increase the formation of bars located next to the now relatively vertical banks. In stage III, alternating point bars are typically forming on opposite banks adjacent to vertical banks (fig. 6). Channel widening continues until the stream bed is wide enough to disperse streamflows and slow the water, beginning stage IV in channel evolution. Bank vegetation loss continues.

During stage IV, sediments begin to build up in the channel instead of moving downstream, aggrading the bed. Eventually, vegetation begins to establish in the sediment deposited along the edge of the stream, creating channel roughness and further slowing the flow. An early stage IV channel indicates relatively poor conditions, while a late stage IV channel indicates an improving trend in channel condition. At this stage, the stream has become more sinuous. Alternating bar features are apparent.

Stage V begins when a new flood plain begins to form. Early in stage V, bank vegetation may not be fully established, and some bank erosion is likely. In a late stage V, the original active flood plain from stage I is now a high terrace, and the evolution of a stage I channel begins, with a new flood plain developing at a lower elevation than the terrace (fig. 7).

**Figure 5** CEM stage II. Poor channel condition, headcuts common

**Figure 6** CEM stage III, with bars adjacent to vertical banks

**Figure 7** CEM Stage V channel, with developing flood plain (left) and abandoned flood plain, now a terrace, behind trees on right side of stream

The reader should keep this conceptual channel evolution model in mind as he or she visually assesses the characteristics of the stream. In areas where heavy vegetation occurs naturally due to higher annual precipitation, eroded banks and slightly incised channels may be masked and consequently harder to observe. In these areas, try to observe bank features from a location near the channel bed. In using the scoring matrix, note that a channel that is either incising or aggrading cannot score higher than an 8. Use the upper right portion of the matrix to score incising or incised channel reaches. Use the lower right portion of the matrix to score aggrading channel reaches.

**Element 1** Channel condition

<table>
<tr><th>Natural, stable channel with established bank vegetation</th><th colspan="3">If channel is incising (appears to be downcutting or degrading), score this element based on the descriptions in the upper section of the matrix</th></tr>
<tr><td rowspan="4">No discernible signs of incision (such as vertical banks) or aggradation (such as very shallow multiple channels)<br><br>Active channel and flood plain are connected throughout reach, and flooded at natural intervals<br><br>Streambanks low with few or no bank failures<br><br>Stage I : Score 10<br>Stage V: Score 9 (if terrace is visible)<br><br>No more than 1 bar forming in channel</td><td>Evidence of past incision and some recovery; some bank erosion possible<br><br>Active channel and flood plain are connected in most areas, inundated seasonally<br><br>Streambanks may be low or appear to be steepening<br><br>Top of point bars are below active flood plain<br><br>Stage I: Score 8<br>Stage V: Score 7–8<br>Stage IV: Score 6</td><td>Active incision evident; plants are stressed, dying or falling in channel<br><br>Active channel appears to be disconnected from the flood plain, with infrequent or no inundation<br><br>Steep banks, bank failures evident or imminent<br><br>Point bars located adjacent to steep banks<br><br>Stage IV: Score 5<br>Stage III: Score 4<br>Stage II: Score 3</td><td>Headcuts or surface cracks on banks; active incision; vegetation very sparse<br><br>Little or no connection between flood plain and stream channel and no inundation<br><br>Steep streambanks and failures prominent<br><br>Point bars, if present, located adjacent to steep banks<br><br>Stage II or III, scores ranging from 2 to 0, depending on severity</td></tr>
<tr><td>8 7 6</td><td>5 4 3</td><td>2 1 0</td></tr>
<tr><td colspan="3">If channel is aggrading (appears to be filling in and is relatively wide and shallow), score this element based on the descriptions in the lower section of the matrix</td></tr>
<tr><td>Minimal lateral migration and bank erosion<br><br>A few shallow places in reach, due to sediment deposits<br><br>Minimal bar formation (less than 3)</td><td>Moderate lateral migration and bank erosion<br><br>Deposition of sediments causing channel to be very shallow in places<br><br>3–4 bars in channel</td><td>Severe lateral channel migration, and bank erosion<br><br>Deposition of sediments causing channel to be very shallow in reach<br><br>Braided channels (5 or more bars in channel)</td></tr>
<tr><td>10 9</td><td>8 7 6</td><td>5 4 3</td><td>2 1 0</td></tr>
</table>

**What to look for**

State Offices are encouraged to develop photo series appropriate to their particular area. Figures shown are from all regions of the United States.

- **Channel is not incising or aggrading**. A score of 10 is appropriate for a stage I channel (fig. 8) with a frequently inundated flood plain that often covers the width of the valley. A late stage V channel with a lower active (frequently flooded) flood plain, well-established vegetation on the banks, and a higher terrace (abandoned flood plain) from previous channel evolutions would score 9 (fig. 9).
- **Channel appears to be incising.** Scores of 8, 7, or 6 indicate degrees of observable detachment between the active bankfull channel and the flood plain. The top of the point bars are below the elevation of the flood plain. A stage I or V channel that has an active, but less frequent, out-of-bank flow into the flood plain would score an 8 (figs. 10 and 11).

**Figure 8** CEM stage I. Score: 10

**Figure 10** CEM stage I. Point bars below bank. Score: 8

**Figure 9** CEM stage V. Score: 9

**Figure 11** CEM stage V. Slight flood plain detachment. Score: 8

- **Channel is incising.** If active channel erosion is apparent on the outside of meanders of a stage V and it is forming a new flood plain and out-of-bank flows still occur, lower the score to a 7 (fig. 12 ).
- **Channel is incising**. Active bank erosion is causing sediment build up in channel, forming depositional features of a stage IV channel. The channel is still adjusting its width. If top of bars are below active flood plain, score a 6 (fig. 13). Lower score to 5 if top of bars of the stage IV channel are adjacent to steep banks as shown by the arrow in figure 14.
- **Channel is incising**. There is disconnect between the flood plain and the bankfull channel (fig. 15), with riparian vegetation compromised by lack of seasonal flooding and lowered water table. Channel appears to be widening in areas of sediment build-up, typical of stage III channels (score 4).

**Figure 13** CEM stage IV, Score: 6

**Figure 12** CEM stage V. Score: 7

**Figure 14** CEM stage IV. Score: 5

**Figure 15** CEM stage III. Score: 4. Note point bar adjacent to steep bank (where person is standing)

- **Channel is incising** with no connection between the active flood plain and the vegetation. Tensile cracks or headcuts often present in a Stage II channel; score would be a 3 (fig. 16).

- **Channel is deeply incised** and completely disconnected from flood plain, usually characteristic of a stage II or III, depending on whether channel widening has begun. Scores range from 2 to 0 (table 1) depending on observed conditions (figs. 17 and 18).

**Figure 16** CEM stage II. Score: 3


**Figure 18** CEM stage II. Score: 1 or 0

**Figure 17** CEM stage III, with active point bars forming. Score: 2 or 1

**Table 1** Guide to figure ratings and CEM stage

| Figure no. | CEM stage | SVAP score |
|---|---|---|
| 4 | I | 10 |
| 5 | II | 0–1 |
| 6 | III | 4 |
| 7 | V | 9 |
| 8 | I | 10 |
| 9 | V | 9 |
| 10 | I | 8 |
| 11 | V | 8 |
| 12 | V | 7 |
| 13 | IV | 6 |
| 14 | IV | 5 |
| 15 | III | 4 |
| 16 | II | 3 |
| 17 | III | 1–2 |
| 18 | II | 0–1 |

**What to look for (aggrading channels)**
The removal of willows and other kinds of riparian vegetation will decrease bank stability and contribute to streambank failure. Excessive streambank failure and lateral migration (the process of a stream shifting from side to side within a valley or other confinement) often result in wider and shallower channels unable to transport sediments downstream. Excessive channel filling occurs when a stream channel can no longer transport both the size and load of sediments associated with the watershed runoff conditions. Streams with no pools that previously had pools and riffles are most likely aggraded. Stream segments that are excessively wide and shallow with multiple center bars are often aggraded. Streams that once maintained single- or dual-threaded channel patterns, but have converted to a braided system (three or more channels at bankfull discharge), are typically aggraded. Excessively aggraded systems are unstable and channel adjustments from side to side can be rapid.

- **Channel is aggrading.** The streambed appears to be filling with sediment faster than it can be transported downstream. Deposits appear oversteepened and unstable, as in figure 21. Channel appears to be wider and shallower than in other reaches of stream. Some bank erosion is evident. Some mid-channel bars may be forming or present. Bed features such as pools and riffles appear to be less discernible or segregated. Lateral migration of channel is apparent. Point bar(s) may be separated from their flood plain. Scores range from 8 to 6 depending on degree of impairment from stable reference conditions (figs. 19, 20, and 21).

**Figure 20** Aggrading channel with shallow areas in reach. Score: 6–7

**Figure 19** Aggrading channel with point bar separated from flood plain. Score: 8

**Figure 21** Aggrading channel, downward trend with lateral migration evident. Score: 5

- **Channel is aggrading.** Channel is wide and shallow, and the banks are actively eroding. Extensive deposition such as center bars and side bars are present. The streambed appears to have less pool-riffle features with a more consistent riffle-plane bed. Bank vegetation is sparse. Pools that would have typically formed in the meander bend portion are shallow and featureless. Scores range from 5 to 3 (fig. 22).
- **Channel is aggrading.** Channel is extremely wide and shallow with interconnected channels (figs. 23 and 24). Streambanks are typically unstable and highly eroded with sparse vegetation. Excessive deposition is common throughout the active channel. Multiple bars, both center and side bars, are located throughout the active channel. Lateral migration is common.

**Figure 22** Multiple aggraded wide and shallow channels, with actively eroding streambanks. Score: 4

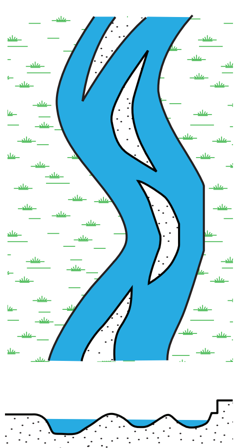


**Figure 23** Aggraded channel. Score: 2

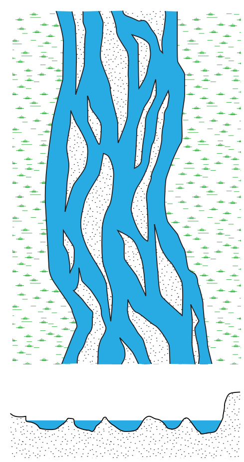


**Figure 24** Aggraded channel. Score: 1–0

In concluding the assessment of this element of SVAP, remember that **channel condition** is of critical importance to overall stream health, yet difficult to visually assess accurately. Scores of less than 5 for channel condition may indicate substantial channel adjustments are occurring and a quantitative assessment by well-trained specialists is warranted.

## (b) Element 2—Hydrologic alteration

**Description and rationale for assessing hydrologic alteration**

Hydrologic alteration is the degree to which hydrology and streamflow conditions differ from natural, unregulated flow patterns. Streamflow regime affects the distribution and abundance of stream species and influences the health of streams through several physical and chemical processes (Allan 1995; Poff et al. 1997). Naturally occurring daily and annual flow variations provide ecological benefits to flood plain ecosystems and the aquatic and terrestrial organisms that depend upon them (Poff and Ward 1989). With respect to fish, natural streamflow variations provide cues for spawning, egg hatching, rearing, and swimming to off-channel flood plain habitats for feeding or reproduction and upstream or downstream migration (Junk et al. 1989).

The full range of streamflow at any point in a given watershed is essential in maintaining the complex physical and biological structures and functions of a stream corridor. The geometry, composition, and appearance of a stream channel and its adjacent flood plain are largely the result of fluvial processes that govern a dynamic equilibrium between streamflow, the materials it carries, and riparian vegetation (Lane 1955; Leopold et al. 1964). Bankfull and higher flows are important factors that control stream channel shape and function and maintain physical habitat for animals and plants (Wolman and Miller 1960). Generally, bankfull flow occurs every 1 to 2 years in unregulated alluvial rivers (Wolman and Leopold 1957) and lasts for only a few days each year. However, numerous researchers have recorded bankfull flow return intervals greater than 2 years (Williams 1978), especially in arid and semiarid settings such as in the southwestern United States (Wolman and Gerson 1978). Conversely, in regions dominated by frequent, prolonged rainfall, bankfull flow can occur once or twice yearly. Consequently, the 2-year event should be considered as only a coarse estimate of bankfull flow. The reader is encouraged to seek additional assistance when working in streams where streamflow is generated by monsoonal precipitation or other extreme climatic events or affected by significant flow regulation because of upstream reservoirs, pump plants, or diversions.

Water and land management practices that alter the timing, duration, magnitude, frequency, or rate of change of streamflow patterns can substantially alter riparian and instream habitat along regulated stream reaches (Calow and Petts 1994). Water withdrawals, watershed and flood plain development, agricultural or wastewater effluents, and practices that change surface runoff (dikes and levees) or subsurface drainage (tile drainage systems) affect the amount and quality of water in a stream channel across the water year. The effects of water withdrawals on aquatic resources and stream condition can usually be readily observed (especially during low-flow periods). However, augmenting streamflow with irrigation runoff or stormwater from municipal areas also often results in adverse physical and biological impacts. For example, the total runoff volume from a 1-acre parking lot is about 16 times that produced by an undeveloped acre of meadow (Schueler 1994). Additionally, peak discharge, velocity, and time of concentration also increase significantly when natural landscapes are replaced by impervious surfaces (Booth 1990). Further, runoff introduces pollutants to waterways and often results in rapid physical deterioration and aquatic community changes (Booth and Jackson 1997). Finally, heavy grazing and clearcutting often have similar, although typically less severe, effects (Platts 1991; Jones and Grant 1996).

**Element 2** Hydrologic alteration

| | | | |
|---|---|---|---|
| Bankfull or higher flows occur according to the flow regime that is characteristic of the site, generally every 1 to 2 years **and** No dams, dikes, or development in the flood plain[1/], or water control structures are present **and** natural flow regime[2/] prevails | Bankfull or higher flows occur only once every 3 to 5 years or less often than the local natural flow regime<br><br>Developments in the flood plain, stream water withdrawals, flow augmentation, or water control structures may be present, but do not significantly alter the natural flow regime[2/] | Bankfull or higher flows occur only once every 6 to 10 years, or less often than the local natural flow regime<br><br>Developments in the flood plain, stream water withdrawals, flow augmentation, or water control structures alter the natural flow regime[2/] | Bankfull or higher flows rarely occur<br><br>Stream water withdrawals completely dewater channel; and/or flow augmentation, stormwater, or urban runoff discharges directly into stream and severely alters the natural flow regime[2/] |
| **10 9** | **8 7 6** | **5 4 3** | **2 1 0** |

1/ Development in the flood plain refers to transportation infrastructure ( roads, railways), commercial or residential development, land conversion for agriculture or other uses, and similar activities that alter the timing, concentration, and delivery of precipitation as surface runoff or subsurface drainage.

2/ As used here, "natural flow regime" refers to streamflow patterns unaffected by water withdrawals, flood plain development, agricultural or wastewater effluents, and practices that change surface runoff (dikes and levees) or subsurface drainage (tile drainage systems).

## What to look for

- Ask the landowner about the frequency of bankfull, overbank, and low flows, referring to figure 2 as needed. Be cautious—water in an adjacent field does not necessarily indicate natural flooding. The water may have flowed overland from a low spot in the bank outside the assessment reach or be an artifact of irrigation or drainage management.
- Look for indicators that help identify bankfull stage (refer to channel condition element). If there is newly deposited debris (leaves and branches) or unvegetated mineral sediments (mud lines, sands, and silts) near the edge of the active channel, it is very likely that bankfull or higher flows have occurred in recent months.
- If channel bars are present, inspect the type and general age of vegetation. A vegetative commu-

nity dominated by invasive species or seedlings less than 2 years old is a good indicator that bankfull or higher flows have occurred in the last 2 years, or with some regularity. An absence of vegetation on bars could be interpreted in the same manner, unless the stream is braided (three or more channels with excessive sand, gravel and/or cobble substrates and a notable lack of permanent vegetation) and/or streamflow is significantly regulated.

- Evidence of flooding includes high water marks, such as water stain lines, sediment deposits, or stream debris, well above the stream channel. Look for these on streambanks, trees, rocks, or other structures such as bridge pilings or culverts.
- Water control structures are any feature that alters streamflow. Examples commonly include stream surface intakes (pump stations, flashboard or full-round risers, drop pipes, stop log structures, screw or flap gate structures), streamside infiltration galleries or ring wells, diversions, dikes, or dams (both temporary and permanent). Any water control structures that divert water directly out of a stream should be suitably screened to prevent entrapment or capture of fish.

## (c) Element 3—Bank condition

**Description and rationale for assessing bank condition**

Stable streambanks are essential components of functional physical habitat and unimpaired biological communities. An excess of fine sediment in streams impacts aquatic species assemblages (Waters 1995) and results in significant water quality impacts with severe economic consequences (Pons 2003). Simon et al. (2000) found that unstable streambanks can contribute as much as 85 percent of the total sediment yield in an entire watershed. Severely unstable streambanks can result in the loss of valuable farmland, force changes in water tables, and endanger transportation infrastructure and other flood plain features.

Bank erosion is a natural mechanism in alluvial rivers, cannot be totally eradicated and provides important physical and ecological functions to the evolution of stream channels and flood plains (Wolman and Leopold 1957; Hooke and Redmond 1992). Excessive bank erosion usually occurs where riparian areas are degraded or when a stream is unstable because of changes in land management practices, hydrology, sediment dynamics, or isolation from its flood plain. Bank failures are generally attributed to the interaction of fluvial and gravitational forces (Thorne 1982)—high, steep banks with undercutting occurring at the base of the slopes are very prone to erosion or collapse.

A healthy riparian corridor with a well-vegetated flood plain contributes to bank stability. The roots of some perennial grasses, sedges, and woody vegetation can help hold bank soils together and physically protect the bank from scour during bankfull and higher flow events. Therefore, the type of vegetation covering streambanks is an important component of bank stability. For example, many trees, shrubs, sedges, and rushes have the type of root masses capable of withstanding high streamflow events, while Kentucky bluegrass does not. Further, native riparian vegetation generally provides better erosion resistance and bank stability than invasive species (Tickner et al. 2001). Finally, surface and subsurface soil types also influence bank stability. For example, banks with a thin soil cover over gravel or sand are more prone to collapse than are banks with deep, cohesive soil layers.
Score each bank individually and average the total to report a single, composite bank condition score.

**Element 3** Bank condition

| | | | | |
|---|---|---|---|---|
| Banks are stable; protected by roots of natural vegetation, wood, and rock [1/]<br><br>No fabricated structures present on bank<br><br>No excessive erosion or bank failures [2/]<br>No recreational or livestock access | | Banks are moderately stable, protected by roots of natural vegetation, wood, or rock or a combination of materials<br><br>Limited number of structures present on bank<br><br>Evidence of erosion or bank failures, some with reestablishment of vegetation<br><br>Recreational use and/or grazing do not negatively impact bank condition | Banks are moderately unstable; very little protection of banks by roots of natural wood, vegetation, or rock<br><br>Fabricated structures cover more than half of reach or entire bank<br><br>Excessive bank erosion or active bank failures<br><br>Recreational and/or livestock use are contributing to bank instability | Banks are unstable; no bank protection with roots, wood, rock, or vegetation<br><br>Riprap and/or other structures dominate banks<br><br>Numerous active bank failures<br><br>Recreational and/or livestock use are contributing to bank instability |
| **Right bank** | **10 9** | **8 7 6** | **5 4 3** | **2 1 0** |
| **Left bank** | **10 9** | **8 7 6** | **5 4 3** | **2 1 0** |

1/ Natural wood and rock does not mean riprap, gabions, log cribs, or other fabricated revetments.
2/ Bank failure refers to a section of streambank that collapses and falls into the stream, usually because of slope instability.

### What to look for

- Evaluate the entire length of all banks along the assessment reach, and then consider the proportion of unstable to stable banks. Obviously, if a quantifiable portion of the reach shows signs of accelerated erosion or bank failures, bank stability is a problem and should be scored as such. Conversely, if the majority of the reach shows minimal erosion and no signs of bank failure, bank stability is likely good. Finally, it is best to score this element during the summer or whenever flows in the assessment reach are low.
- Signs of erosion and possible bank stability problems include unvegetated stretches, exposed tree roots, and scalloped edges (sections of eroded bank between relatively intact sections).
- When observing banks from within the active channel or below bankfull elevation, look for piping holes, rills, and or gullies. Each of these concentrated flow paths is associated with eventual bank stability problems or outright failures.
- Look for tension cracks while walking along streambanks. Tension cracks will appear as vertical fissures or crevices running along the top of the streambank roughly parallel to the flow.
- Evidence of construction, vehicular, or animal paths near banks or grazing areas leading directly to the water's edge suggest conditions that may lead to bank collapse.
- Sections of streambank lying instream adjacent to existing banks are a telltale sign of active bank erosion and instability.

## (d) Elements 4 and 5—Riparian area quantity and quality

**Description and rationale for assessing riparian area conditions**

Riparian areas are the vegetated areas adjacent to stream channels that function as transitional areas between the stream and uplands. Riparian vegetation thrives on the moisture provided by streamflow and ground water associated with the stream corridor. Riparian areas may or may not include flood plains and associated wetlands, depending on the valley form of the stream corridor. For example, steep mountainous streams in narrow V-shaped valleys often do not have obvious flood plains. Riparian areas are among the most biologically diverse habitats of landscapes and are sources of wood, leaves, and organic matter for the stream. These areas provide important habitat and travel corridors for numerous plants, insects, amphibians, birds, and mammals.

Ecological processes that occur in the stream corridor are linked to those in uplands via intact riparian areas and flood plains, if present. Riparian areas themselves also provide valuable functions that maintain or improve stream and flood plain conditions. The capacity for riparian areas to sustain these functions depends in part on the quality and quantity of the riparian vegetation and how it interacts with the stream ecosystem. The quality of the riparian area increases with the width, complexity, and linear extent of its vegetation along a stream. A complex riparian community consists of diverse plant species native to the site or functioning similarly to native species, with multiple age-classes providing vertical structural diversity suitable for the site. As explained previously, the quality of riparian areas is influenced by the hydrological features of the stream, as well as upland and bank conditions. Well-established and connected riparian areas perform critical functions for maintaining healthy, resilient stream ecosystems by providing:

- a vegetative filter for surface runoff, reducing pollutants and sediment entering streams, and no concentrated flow from upland areas
- roughness that slows water and the erosive effects of floodwater
- root systems that bind soil, protect streambank integrity, and build flood plain surfaces
- moisture, soil conditions, surface macrotopography and microtopography, and microclimates for a diversity of riparian plants, animals, and microorganisms
- structurally diverse habitat for migratory songbirds, as well as resident species of wildlife that are especially dependent on woody riparian vegetation for reproduction and feeding
- shade or overhanging vegetation to maintain cooler water temperatures for aquatic species
- large wood to forested stream channels, which offers instream cover, creates pools, traps sediments, and provides habitat for stream biota
- organic material (leaves, twigs, grass) and insects for stream and riparian food chains
- undercut banks important to fish for hiding and resting
- diverse, complex off-channel habitats, such as backwaters, wetlands, and side channels formed by the interaction of streamflow, riparian vegetation, and often large wood. These areas of slower water provide critical refuge during floods for a variety of aquatic species and serve as rearing areas for juvenile fish
- a diversity of plant species of multiple age classes, adapted to the site and providing critical habitat for both resident and migratory birds and other riparian wildlife species

Well-established riparian areas are critical for stream health and fish and wildlife habitat. For this reason, it is important to evaluate both the quantity (Element 4) and the quality (Element 5) of the riparian area, and score the riparian conditions of the entire stream within a property boundary. Visually score the entire stream, if possible. If the stream is too extensive to score using SVAP2, score only the assessment reach visually, and use recent aerial photos (less than 2 years old) to score those riparian areas of the stream outside of the assessment reach.

**Element 4** Riparian area quantity

| | | | | | |
|---|---|---|---|---|---|
| Natural plant community extends at least two bankfull widths or more than the entire active flood plain and is generally contiguous throughout property | | Natural plant community extends at least one bankfull width or more than 1/2 to 2/3 of active flood plain and is generally contiguous throughout property<br>Vegetation gaps do not exceed 10% of the estimated length of the stream on the property | Natural plant community extends at least 1/2 of the bankfull width or more than at least 1/2 of active flood plain<br>Vegetation gaps do not exceed 30% of the estimated length of the stream on the property | Natural plant community extends at least 1/3 of the bankfull width or more than 1/4 of active flood plain<br>Vegetation gaps exceed 30% of the estimated length of the stream on the property | Natural plant community extends less than 1/3 of the bankfull width or less than 1/4 of active flood plain<br>Vegetation gaps exceed 30% of the estimated length of the stream on the property |
| **Right bank** | **10 9** | **8 7** | **6 5** | **4 3 2** | **1 0** |
| **Left bank** | **10 9** | **8 7** | **6 5** | **4 3 2** | **1 0** |

**Note:** Score each bank separately. Scores should represent the entire stream riparian area within the property. Score for this element = left bank score plus right bank score divided by 2. If the score of one bank is 7 or greater and the score of the other bank is 4 or less, subtract 2 points from final score.

### Riparian area quantity: what to look for

- This element rates the extent of the riparian area on the property (length × width). Estimate the width of the vegetation area from the edge of the active channel outward to where natural riparian vegetation ends and other land use/land cover begins.
- Vegetation gaps are lengths of streamside with no natural vegetation ecologically suitable for the site and at a density and spacing uncharacteristic of the plant community being assessed. Estimate gap percentage by dividing the total length of gaps by the total length of the stream within the property boundary multiplied by 100.
- For this element, natural plant community means one with species native to the site or introduced species that have become naturalized and function similarly to native species of designated reference sites, growing at densities characteristic of the site. Regional plant guidebooks are useful to have in the field for scoring this element.
- Compare the width of the riparian area to the bankfull channel width. In steep, V-shaped valley forms, there may not be enough room for a flood plain riparian area to extend as far as one or two active channel widths. In this case, a score may be adjusted to a higher value based on reference site conditions.

**Element 5** Riparian area quality

| | | | | |
|---|---|---|---|---|
| | Natural and diverse riparian vegetation with composition, density and age structure appropriate for the site | Natural and diverse riparian vegetation with composition, density and age structure appropriate for the site: Little or no evidence of concentrated flows through area | Natural vegetation compromised | Little or no natural vegetation |
| | No invasive species or concentrated flows through area | Invasive species present in small numbers (20% cover or less) | Evidence of concentrated flows running through the riparian area<br>Invasive species common (>20% <50% cover) | Evidence of concentrated flows running through the riparian area<br>Invasive species widespread (>50% cover) |
| **Right bank** | **10 9** | **8 7 6** | **5 4 3** | **2 1 0** |
| **Left bank** | **10 9** | **8 7 6** | **5 4 3** | **2 1 0** |

**Notes:** Score should represent the entire stream riparian area within the property.
Score for this element = left bank score plus right bank score divided by 2.

### Riparian area quality: what to look for

- Plant species should be native or naturalized and consist of multiple structural layers (grasses and forbs, shrubs, and/or trees if suitable for the site). Forested sites should also have a diverse mix of shrubs, understory trees, and new shrub and tree regeneration. Early successional sites (recently disturbed by fire, tree harvesting, grazing, land clearing) should have representative native species (typically herbaceous, woody, and tree seedlings). Continually disturbed sites usually have only a few species, and often these include nonnative invasive species. As early vegetation matures, the structure of the plant community becomes more diverse with a multilayer canopy. Finally, the plant community reaches a mature stage with regeneration, growth, and mortality occurring in all layers. In forested streams, mature trees with potential for falling into the stream are present. Regional plant guidebooks are useful for scoring this element.
- Vigorously growing vegetation in the riparian area on both sides of the stream is important for healthy stream and riparian conditions. In doing the assessment, examine both sides of the stream, and note on the site diagram which side of the stream has problems. For the highest ratings, there should be no evidence of concentrated flows through the riparian area that are not adequately buffered or intended to short-circuit the riparian area or buffer and no nonnative invasive species.
- The type, timing, intensity, and extent of activities in riparian areas are critical in determining the impact on these areas. Note these in the Summary Sheet. Riparian areas that have roads, agricultural activities, residential or commercial structures, excessive animal use, or significant areas of bare soils have reduced functional value for the stream and its watershed.

## (e) Element 6—Canopy cover

### Description and rationale for assessing canopy cover

In forested riparian areas, shading of the stream is important because it helps maintain cool water temperatures and limits algal growth. Cool water has a greater oxygen holding capacity than warm water. In many cases, when streamside trees are removed, the stream is exposed to the warming effects of the sun, causing the water temperature to increase for longer periods during the daylight hours and for more days during the year. This shift in light intensity and temperature often causes a decline in the numbers of certain species of fish, insects, and other invertebrates and some aquatic plants. They may be replaced altogether by other species that are more tolerant of increased light intensity, lower dissolved oxygen, and warmer water temperature. For example, trout and salmon require cool, oxygen-rich water and may rely on food organisms produced by detritus-based food chains. Loss of streamside vegetation that causes increased water temperature and decreased oxygen levels contributes to the decrease in abundance of trout and salmon from many streams that historically supported these species. Warm-water species also benefit from canopy cover to keep streams from exceeding optimal temperatures. Increased light and the warmer water also promote excessive growth of submerged macrophytes (vascular plants) and algae that can cause a shift from a detritus-based to an algae-based food chain, thus altering the biotic community of the stream. Although some stream food webs are detritus-based, others (especially some warm-water streams) are algae-based and require a certain amount of light to be naturally productive. *Therefore, this element is particularly sensitive to the type of stream (stream class) and fish community that is being assessed and calibration of scoring may be necessary.* Remember that many of the features of this element are influenced by the degree of upstream shading in addition to flow volume, degree of flow alterations, channel type, and other factors. Therefore, the element is assessed for canopy over the entire property rather than at a single assessment reach. Choose the matrix appropriate for the stream and its native fauna. For example, if the stream is a trout stream, use the matrix for cold-water streams. If the stream is naturally warmer than 70 degrees Fahrenheit, use the matrix for warm-water streams. Lastly, percentages in the scoring matrix should be modified according to the site's potential for plant communities that will provide shade to the stream.

**Element 6** Canopy cover

(a) Cold-water streams

| >75% of water surface shaded within the length of the stream in landowner's property | 75–50% of water surface shaded within the length of the stream in landowner's property | 49–20% of water surface shaded within the length of the stream in landowner's property | <20% of water surface shaded within the length of the stream in landowner's property |
|---|---|---|---|
| **10 9** | **8 7 6** | **5 4 3** | **2 1 0** |

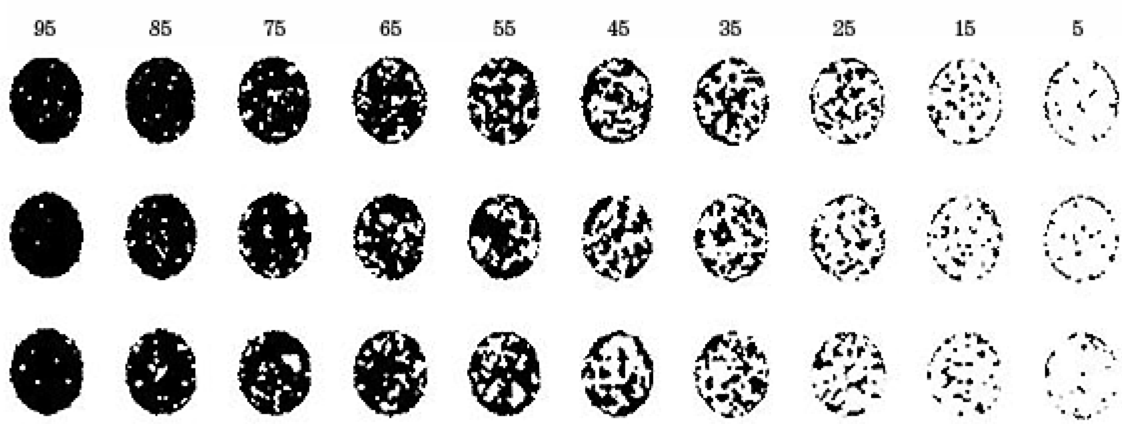
(b) Warm-water streams

| 50–75% of water surface shaded within the length of the stream in landowner's property | >75% of water surface shaded within the length of the stream in landowner's property | 49–20% of water surface shaded within the length of the stream in landowner's property | <20% of water surface shaded within the length of the stream in landowner's property |
|---|---|---|---|
| **10 9** | **8 7 6** | **5 4 3** | **2 1 0** |

## What to look for

- Estimate the percent of the stream surface area that is shaded over the entire property. This may require cover estimates at several points within and outside the assessment reach. Time of the year, time of the day, and weather can affect the observation of shading. Therefore, the relative amount of shade is estimated by assuming that the sun is directly overhead and the vegetation is in full leaf-out. To enhance accuracy of the assessment, aerial photographs taken during full leaf-out should be used to supplement visual assessments. Figure 25 may be used as a guide for both visual and aerial estimates.

**Figure 25** Percent canopy cover. Numbers above the ovals refer to the percent black (= shade/cover). (USDA Forest Service FIA Manual, http://www.fia.fs.fed.us/library/)



## (f) Element 7—Water appearance

### Description and rationale for assessing water appearance

The water appearance assessment element compares turbidity, color, and other visual characteristics of the water with those of a reference stream. The assessment of turbidity is the depth to which an object can be clearly seen. Clear water indicates low turbidity. Cloudy or opaque water indicates high turbidity. Turbidity is caused mostly by particles of soil and organic and inorganic matter suspended in the water column.

Streams often show some turbidity after a storm event because of soil and organic particles carried by runoff into the stream or suspended by turbulence. Intrinsic characteristics of a watershed, such as geology and soils unaffected by human activities, should be considered in reference conditions and assessment. For example, glacial flour creates high turbidity and is considered a natural process of erosion in glacial streams. Tea-colored water due to tannins from a natural process in bogs and wetlands may also affect clarity in some streams. Altered clarity due to natural processes would not receive low ratings.

**Element 7** Water appearance

| | | | |
|---|---|---|---|
| Water is very clear, or clarity appropriate to site; submerged features in stream (rocks, wood) are visible at depths of 3 to 6 feet<br>No motor oil sheen on surface; no evidence of metal precipitates in streams | Water is slightly turbid, especially after storm event, but clears after weather clears; submerged features in stream (rocks, wood) are only visible at depths of 1.5 to 3 feet<br>No motor oil sheen on surface or evidence of metal precipitates in stream | Water is turbid most of the time; submerged features in stream (rocks, wood) are visible at depths of only .5 to 1.5 feet<br>**and/or**<br>Motor oil sheen is present on water surface or areas of slackwater<br>**and/or**<br>There is evidence of metal precipitates in stream | Very very turbid water most of the time; submerged features in stream (rocks, wood) are visible only within .5 feet below surface<br>**and/or**<br>Motor oil sheen is present on the water surface or areas of slackwater |
| **10 9 8** | **7 6 5** | **4 3 2** | **1 0** |

### What to look for

- Clarity of the water is an obvious and easy feature to assess. The deeper an object in the water can be seen, the lower the amount of turbidity. This measure should be taken after a stream has had the opportunity to settle down following a storm event.
- A stream should not smell like oil or have pronounced motor oil sheen on its surface.
- Use the depth that objects are visible only if the stream is deep enough to evaluate turbidity using this approach. For example, if the water is clear, but only 1 foot deep, do not rate it as if an object became obscured at a depth of 1 foot.

| | |
|---|---|
| Clear visibility | 3–6 ft |
| Slightly turbid | 1–5-3 ft |
| Turbid | 0.5–1.5 ft |
| High turbidity | <0.5 |

## (g) Element 8—Nutrient enrichment

### Description and rationale for assessing nutrient enrichment

Nutrients are necessary for stream food webs by promoting algal and aquatic plant growth, which provide habitat and food for aquatic organisms. However, an excessive amount of algal and plant growth is detrimental to stream ecosystems. High levels of nutrients (especially phosphorus and nitrogen) lead to increased growth of algae and aquatic plants. Subsequently, respiration and decomposition of plant organic matter consume dissolved oxygen in the water, lowering the concentration of oxygen available to aquatic organisms and possibly contributing to significant die-offs. A landowner may have seen fish gulping for air at the water surface during warm weather, indicating a lack of dissolved oxygen. Streams respond differently to nutrient loading. The presence of algal blooms—thick mats of algae and an overabundance of aquatic plants (macrophytes)—are often indicators that nutrients are high. However, the absence of such blooms may not always be indicative of nutrient concentrations. Stream velocity, light availability, temperature, and types of stable substrate present in a stream are important factors that affect algal and plant abundances. Water quality problems that arise from excess turbidity, herbicides, or salinity will also affect the abundance or absence of algae or macrophytes. If there is little or no algal growth, assess the factors described in the *What to look for* section, and summarize the findings accordingly. Nutrient enrichment is difficult to assess visually. If a score of less than 5 is determined, a simple quantitative assessment, such as water quality testing for total phosphorus, may be warranted.

**Element 8** Nutrient enrichment

| | | | |
|---|---|---|---|
| Clear water along entire reach<br>Little algal growth present | Fairly clear or slightly greenish water<br>Moderate algal growth on substrates | Greenish water particularly in slow sections<br>Abundant algal growth, especially during warmer months<br>**and/or**<br>Slight odor of ammonia or rotten eggs<br>**and/or**<br>Sporadic growth of aquatic plants within slack water areas | Pea green color present; thick algal mats dominating stream<br>**and/or**<br>Strong odor of ammonia or rotten eggs<br>**and/or**<br>Dense stands of aquatic plants widely dispersed |
| **10 9** | **8 7 6** | **5 4 3** | **2 1 0** |

### What to look for

- Streams with high velocity greater than .33 foot per second and high concentrations of nutrients are typically not dominated by filamentous algae. Thus, the water may appear very clear, yet still have high nutrient concentrations.
- If light is a limiting factor due to shading from riparian vegetation, look for algal growth on rocks and boulders in reaches exposed to light.
- Most algae grow more rapidly at higher temperatures. Within a range of 32 to 77 degrees Fahrenheit, increasing temperature by 18 degrees Fahrenheit typically doubles the rate of algal growth.
- Low complexity of substrate reduces filamentous algal growth.
- The presence of dense stands of aquatic macrophytes may be an indicator of nutrient availability. Diversity with the aquatic plant community should be noted and considered. Some species typically associated with springs, such as watercress, may not be associated with heavy nutrient loading. Clear water and a diverse, dispersed aquatic plant community are optimal for this characteristic.

## (h) Element 9—Manure or human waste presence

### Description and rationale for assessing manure or human waste presence

Manure and human waste increase nutrients and biochemical oxygen demand in streams, which alter food webs and nutrient cycles of stream/riparian ecosystems. Ask the property manager if and when livestock have access to the stream. Manure from livestock contaminates water if livestock have direct access to the stream or runoff from corrals, pastures, or paddocks is not diverted away from the stream. Similarly, wastewater piped or diverted directly to a stream is a health risk to aquatic species and humans. *Score this element on the entire property and all properties where SVAP2 is completed.*

**Element 9** Manure or human waste presence

| | | | |
|---|---|---|---|
| Livestock do not have access to stream<br>No pipes or concentrated flows discharging animal waste or sewage directly into stream | Livestock access to stream is controlled and/or limited to small watering or crossing areas<br>No pipes or concentrated flows discharging animal waste or sewage directly into stream | Livestock have unlimited access to stream during some portion of the year<br>Manure is noticeable in stream<br>**and/or**<br>Pipes or concentrated flows discharge treated animal waste or sewage directly into stream | Livestock have unlimited access to stream during entire year<br>Manure is noticeable in stream<br>**and/or**<br>Pipes or concentrated flows discharge untreated animal waste or sewage directly into stream |
| **10 9** | **8 7 6** | **5 4 3** | **2 1 0** |

### What to look for

- Indications of livestock droppings in or adjacent to the stream channel
- Features such as fences, water gaps, and hardened crossings that limit livestock access to stream
- Areas with slow moving water and sunlight with unusually dense vegetation or algal blooms
- Pipes or concentrated flow areas that may be dumping livestock or human waste directly into the stream

## (i) Element 10—Pools

**Description and rationale for assessing pools**
Regardless of the stream channel type, pools are important resting, hiding, and feeding habitat for fish. Streams with a mix of shallow and deep pools offer diverse habitat for different species of fish and other aquatic species. In fish-bearing streams, a general rule of thumb to distinguish deep pools from shallow pools is this: a deep pool is 2 times deeper than the maximum depth of its upstream riffle, while a shallow pool is less than 2 times deeper than the maximum depth of its upstream riffle. This general rule may not apply to extremely high-gradient streams dominated by cascades, however. Continuous pools (those not separated by riffles, wood jams, rock steps, or fast-water) provide less diverse habitat and are indicative of poor stream structure and should not be considered for scoring in the first three boxes (only the last). Fish use such cover to rest, hide from predators, catch food items in the swirling currents that occur around submerged structures, and avoid territorial conflicts. Isolated pools occur when streamflows are so low that portions of the stream are essentially dewatered temporarily. If deep enough, these isolated pools serve as refuges for stranded fish and other aquatic species until rains restore continuous flow in the system and reconnect the pools to their previously dry riffles.

Fish habitat is often limited by the amount of available cover, such as submerged logs, boulders, tree roots, and undercut banks, in pools. Stream alteration often reduces the amount and complexity of pools, thus degrading fish habitat. On the other hand, beavers often create pools in streams, which may add habitat diversity and enhance pool habitats; however, their effects may also inundate riffles and other shallow water habitats. Thus, it is important to assess SVAP stream reaches in the correct context, that is, in relation to local reference conditions. States are encouraged to modify scoring of this element according to local pool-to-riffle ratios generally present in reference stream reaches. Remember, representative reaches of streams throughout the area are being assessed, and if conditions should change dramatically within the property due to alteration or other influences affecting the structure and function of the stream, additional reaches should be assessed.

**Only one pool morphology type (low gradient or high gradient) should be used per assessment reach.**

**Element 10** Pools: Low-gradient streams (<2%) scoring matrix

| | | | |
|---|---|---|---|
| More than two deep pools separated by riffles, each with greater than 30% of the pool bottom obscured by depth, wood, or other cover<br>Shallow pools also present | One or two deep pools separated by riffles, each with greater than 30% of the pool bottom obscured by depth wood, or other cover<br>At least one shallow pool present | Pools present but shallow (<2 times maximum depth of the upstream riffle)<br>Only 10–30% of pool bottoms are obscured due to depth or wood cover | Pools absent, but some slow water habitat is available<br>No cover discernible<br>**or**<br>Reach is dominated by shallow continuous pools or slow water |
| **10 9** | **8 7 6** | **5 4 3** | **2 1 0** |

**Element 10** Pools: high-gradient streams (>2%) scoring matrix

| | | | |
|---|---|---|---|
| More than three deep pools separated by boulders or wood, each with greater than 30% of the pool bottom obscured by depth, wood, or other cover.<br>For small streams, pool bottoms may not be completely obscured by depth, but pools are deep enough to provide adequate cover for resident fish<br>Shallow pools also present | Two to three deep pools, each with greater than 30% of the pool bottom obscured by depth wood or other cover; at least one shallow pool present.<br>For small streams, pool bottoms may not be completely obscured by depth, but pools are deep enough to provide some cover for resident fish<br>At least one shallow pool also present | Pools present but relatively shallow, with only 10–30% of pool bottoms obscured by depth or wood cover.<br>For small streams, pool bottoms may not be completely obscured by depth, but pools are deep enough to provide minimal cover for resident fish<br>No shallow pools present | Pools absent |
| **10 9** | **8 7 6** | **5 4 3** | **2 1 0** |

### What to look for (low-gradient streams)

- The number of pools per assessment reach is estimated based on walking the stream or probing from the streambank with a stick or pole. You should find deep pools on the outside of meander bends. Pools are typically separated by riffles or other shallow water habitats. In drier climates, deep pools may be temporarily isolated from their riffles, yet still provide important refuge habitat. Pools are formed by obstructions in the stream channel such as fallen trees, accumulations of wood (jams), beaver dams, boulders, root wads, rock outcrops, beaver dams, and accumulated plant debris.
- Assess pool cover by estimating the percent of the pool bottom that is obscured by cover features or depth, assuming one is positioned directly over the feature looking straight down at the stream bottom. In shallow, clear streams a visual inspection may provide an accurate estimate.

### What to look for (high-gradient streams)

- In high-gradient streams, energy is dissipated by alternating slow and fast water conditions with step-pools and rapids/scour pools. Step-pools operate similar to stair steps with water dropping vertically over nearly complete channel obstructions (often a large rock and/or large wood) scouring out small depressions or plunge pools (Hunter 1991). Streams with step-pool conditions usually have gradients greater than 4 percent and pools are spaced at one pool every 1.5 to 4 bankfull channel widths. Pool spacing decreases as gradient increases (Rosgen 1996).
- Streams with gradients between 2 and 4 percent are often rapids and lateral scour pool dominated. Scour pool spacing is typically one pool every 4 to 5 bankfull channel widths and is created by channel confinements and wood or sediments.
- Plunge pools and scour pools are important aquatic habitat features providing resting and hiding cover for fish and aquatic species. With these pools, turbulence, large rock, wood, and the depth of water all contribute hiding cover for fish.

## (j) Element 11—Barriers to aquatic species movement

**Description and rationale for assessing barriers to aquatic species movement**

Most aquatic organisms move around their habitats or undertake daily, seasonal, or annual migrations. For example, anadromous trout and salmon spawn and rear in freshwater, move to marine environments to grow to adulthood, and return to freshwater after a period of months or years to reproduce and die (Groot and Margolis 1991). Other fish commonly use estuaries, river mouths, and the lower reaches of rivers within a span of a few days for feeding, sheltering, or as refuge from predators (Gross et al. 1988). Others use headwater streams for spawning and downstream lakes or rivers for feeding as they mature. Consequently, barriers that block the movement of fish or other aquatic organisms are important components of stream assessment.

Instream features or water management practices can create barriers that limit or prohibit the passage of aquatic organisms either seasonally or annually. Passage barriers may prevent the movement or migration of fish, deny access to important breeding or foraging habitats, and isolate populations of fish and other aquatic animals. Both natural and fabricated barriers occur within river and stream systems, and natural physical barriers include waterfalls, cascades, and large rapids. Common fabricated physical barriers include dams, diversions, culverts, weirs, excessively high-grade control structures or buried sills with broad crests. Chemical and biological barriers, such as water quality and quantity (temperature and low stream flows) and predation from nonnative species, also exist in many rivers across the United States. However, these types of passage problems are often seasonal and can be difficult to identify with limited field time and site-specific data.

Passage barriers are typically categorized by characteristics such as water velocity, water depth, and barrier height in relation to the passage requirements of a given species and/or life stage.

Three commonly used barrier classes are:

- *Partial*—impassable to some species or certain age classes all or most of the time
- *Temporary*—impassable during some times to all or most species and/or age classes (e.g., during low flow conditions)
- *Complete*— impassable to all fish at all times

For example, a poorly designed or damaged culvert may be a temporary barrier to upstream migrating adults when flows are high because velocities within the culvert barrel exceed their natural swimming capabilities. Some highly migratory fishes like Pacific salmonids can leap 6 feet or more to bypass a waterfall, whereas shad in the same river will be faced with a complete barrier (Bell 1990; Haro and Kynard 1997). Many State and Federal agencies have laws that are applicable to this element. Conservationists should become familiar with State-applicable regulations as part of the preliminary assessment.

When addressing this element, assess a length of stream at least 12 times the bankfull width or the entire stream length on the landowner's property, whichever is greater. Be sure to detail in the notes the species and life stages of aquatic organisms for which barriers are being evaluated.

**Element 11** Barriers to aquatic species movement scoring matrix

| No artificial barriers that prohibit movement of aquatic organisms during any time of the year | Physical structures, water withdrawals and/or water quality seasonally restrict movement of aquatic species | Physical structures, water withdrawals and/or water quality restrict movement of aquatic species throughout the year | Physical structures, water withdrawals and/or water quality prohibit movement of aquatic species |
|---|---|---|---|
| **10** | **9 8 7** | **6 5 4 3** | **2 1 0** |

**What to look for**

- Ask the landowner about any dams or other barriers that may be present 3 to 5 miles upstream or downstream of his or her property.
- Note the presence of natural barriers along the assessment reach, their size.
- Beaver dams generally do not prevent fish migration and should not be identified as passage barriers unless supporting information exists.
- Livestock and/or equipment/vehicle crossings can be passage barriers if water flows fast and shallow (less than 6 in) across smooth or uniform surfaces at least half as wide (from upstream to downstream) as the bankfull width. For example, a 12-foot-wide hardened vehicle ford that crosses a stream with a bankfull width of 20 feet is likely a temporary passage barrier.
- Low-head dams are most likely temporary or complete barriers, especially if outfitted with a concrete apron that covers the streambed along the entire downstream face.
- Culverts can be especially problematic to migratory aquatic organisms. Unless specifically designed with passage purposes in mind, most culverts are partial upstream passage barriers for the smallest life stages of native fish. Culverts should be scored as temporary or complete passage barriers if the culvert:
  - alignment does not match the stream
  - width is less than bankfull width
  - slope is greater than channel slope
  - is not countersunk
  - is perched (elevated) above the outlet pool
  - inlet is plugged with debris
  - inlet or outlet shows sign of erosion or instability

## (k) Element 12—Fish habitat complexity

**Description and rationale for assessing fish habitat complexity**

The dynamic features of stream corridors create diverse habitat types and conditions for fish and other aquatic species. Quality fish habitat is a mosaic of different types of habitats created by various combinations of water quality and quantity, water depth, velocity, wood, boulders, riparian vegetation, and the species that inhabit stream corridors. The greater the variety of habitat features, the more likely a stream is to support a diversity of aquatic species. Fish require these complex habitats with diverse types of hiding, resting, and feeding cover in parts of the stream and variable flow features. For example, deep pools (with slower currents) provide cover, thermal refuge, and a place to rest. Riffles (with faster currents) provide benthic invertebrates to prey on. Fast water is well aerated, providing more oxygen to the stream ecosystem. The more types of different structural features, the more resilient the habitat is to natural disturbances (such as floods), as well as human perturbations (such as water withdrawals). The dynamic nature of instream habitat features assures fish and other species are able to find suitable areas to rear, feed, grow, hide, and reproduce during the course of their life histories. Because fish habitat needs and types vary considerably from species to species and throughout the country, States should adjust scoring of this element to reflect reference conditions and species habitat features characteristic of their region.

**Element 12** Fish habitat complexity scoring matrix

| Ten or more habitat features available, at least one of which is considered optimal in reference sites (large wood in forested streams) | | Eight to nine habitat features available | | Six to seven habitat features available | | Four to five habitat features available | | Less than four habitat features available | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **10** | **9** | **8** | **7** | **6** | **5** | **4** | **3** | **2** | **1** | **0** |

**Note:** Fish habitat features: logs/large wood, deep pools, other pools (scour, plunge, shallow, pocket) overhanging vegetation, boulders, cobble, riffles, undercut banks, thick root mats, dense macrophyte beds, backwater pools, and other off-channel habitats

**What to look for**

Within the entire assessment reach, observe the number of different habitat features that provide diverse and complex habitats for fish. Each habitat feature must be present in appreciable amounts to score (as compared to suitable reference sites). Features include:

- **Logs, large wood—**fallen trees or parts of trees that are submerged in the water and large enough to remain in the assessment reach during normal flows. **Minimum 2/reach; #/reach:** _____
- **Small wood accumulations—**submerged accumulations of small wood pieces, twigs, branches, leaves, and roots. Though likely to be temporary components of stream habitats, their pieces will continue to provide structural complexity as the debris moves within the reach. **Minimum 1/reach; #/reach:** _____
- **Deep pools—**areas of slow water with smooth surface and deep enough to provide protective cover for fish species likely to be present in the stream. **Minimum 2/reach; #/reach:** _____
- **Secondary pools** (scour, plunge, pocket pools) —pools formed by boulders or wood that divert water and scour depressions below turbulent flows. **Minimum 4/reach; #/reach:** _____
- **Overhanging vegetation—**tree branches, shrub branches, or perennial herbaceous vegetation growing along the streambank and extending outward over the stream's surface, providing shade and cover. **Minimum 3/reach; #/reach:** _____
- **Large boulders**—submerged or partially submerged large rocks (>20 inches in diameter). **Minimum 3/reach if no wood. Minimum 2/reach if wood present; #/reach:** _____
- **Small boulder clusters—**groups of 2 or more smaller rocks (>10 and <20 inches in diameter) interspersed relatively close together in the channel. **Minimum 3/reach; #/reach:** _____
- **Cobble riffles—**fast, bubbly water flowing amongst and over small rocks between 2 and 10 inches in diameter. **Minimum 2/reach; #/reach:** _____
- **Undercut banks—**water-scoured areas extending horizontally beneath the surface of the bank, forming underwater pockets used by fish for hiding and thermal cover. **Minimum 3/reach or 25 percent of bank area; #/reach:** _____
- **Thick root mats—**mats of roots and rootlets, generally from trees but sometimes from mature dense shrubs at or beneath the water surface. **Minimum 3/reach; #/reach:** _____
- **Macrophyte beds—**beds of emergent, submerged, or floating leaf aquatic plants thick enough to serve as cover. **Minimum 1/reach; #/reach:** _____
- **Off-channel habitats—**side channels, flood plain wetlands, backwaters, alcoves. **Minimum 2/reach; #/reach:** _____
- **Other locally important habitat features (describe)** _____

## (l) Element 13—Aquatic invertebrate habitat

**Description and rationale for assessing aquatic invertebrate habitat**

Four functional groups characterize the feeding functions of most aquatic invertebrates: shredders, collectors, grazers, and predators. Some species can be placed in more than one functional feeding group. The groups are typically present in all streams, although the dominance of groups will vary from headwater streams to larger streams and rivers. These functional feeding groups help predict the location and diverse substrate needs of specific invertebrates within the stream. Substrates are materials that provide a base for invertebrates to live and colonize. In a healthy stream, substrates are varied, free of sediment, abundant, and in place long enough to allow colonization by invertebrates. High stream velocities, high sediment loads, and frequent flooding may deplete substrate or cause it to be unsuitable habitat, at least temporarily until recolonization occurs.

Wood and riffle areas with boulders/cobbles support the bulk of the invertebrate community in temperate streams (Benke et al. 1984). Wood typically supports a more diverse invertebrate community, while boulders and cobble within riffles typically support higher numbers (abundance) of species. High numbers of habitat types for fish often equate to high invertebrate habitat types. The scale of habitat assessment is necessarily much smaller for invertebrates because their range of mobility limits the size of their habitat, or microhabitat. Therefore, an array of different types of habitat should be found within a smaller area of the reach. Assess the number of different types of habitat within a representative subsection of the assessment reach that is equivalent in length to five times the active channel width. To score, habitat types should be present in appreciable amounts (as expected in reference conditions or least impaired conditions).

**Element 13** Aquatic invertebrate habitat scoring matrix

| | | | | |
|---|---|---|---|---|
| At least 9 types of habitat present<br>A combination of wood with riffles should be present and suitable in addition to other types of habitat<br>(If nonforested stream, consider reference site's optimal habitat type needed for this high score) | 8 to 6 types of habitat<br>Site may be in need of more wood or reference habitat features and stable wood-riffle sections | 5 to 4 types of habitat present | 3 to 2 types of habitat present | None to 1 type of habitat present |
| **10 9** | **8 7 6** | **5 4** | **3 2** | **1 0** |

**Note: Aquatic invertebrate habitat types, in order of importance:** Logs/large wood, cobble within riffles, boulders within riffles. Additional habitat features should include: leaf packs, fine woody debris, overhanging vegetation, aquatic vegetation, undercut banks, pools, and root mats.

## What to look for

- **Logs, large wood—**fallen trees or parts of trees that are submerged or partially submerged in the water and large enough to remain in the assessment reach during normal flows. **Minimum 2/subreach; #/subreach: _____**
- **Large boulders within riffles**—submerged or partially submerged large rocks (>20 inches in diameter); **Minimum 2/subreach if no wood; minimum 1/subreach if wood present; #/subreach: _____**
- **Small boulders in riffles clusters—**groups of two or more smaller rocks (>10 and <20 inches in diameter) interspersed relatively close together in the channel. **Minimum 2/subreach; #/subreach: _____**
- **Fine woody debris—**accumulations of twigs, branches, leaves, and roots. Though likely to be temporary components of stream habitats, their pieces will continue to provide structural complexity and substrate for invertebrates as the debris moves within the reach. **Minimum 2/subreach**; **#/subreach: _____**
- **Overhanging vegetation—**tree branches, shrub branches, or perennial herbaceous vegetation growing along the streambank and extending outward over the stream's surface, providing shade, cover and food. **Minimum 1/subreach; #/subreach: _____**
- C**obble riffles—**fast, "bubbly" water flowing amongst and over small rocks between 2 and 10 inches in diameter. **Minimum 1/subreach; #/subreach: _____**
- **Undercut banks—**water-scoured areas extending horizontally beneath the surface of the bank, forming underwater pockets used by aquatic insects for resting and feeding. **Minimum 1/subreach or 25 percent of bank area; #/subreach: _____**
- **Pools**—slow water, deeper than riffles. **No minimum subreach; #/subreach: _____**
- **Thick root mats—**mats of roots and rootlets, generally from trees but sometimes from mature dense shrubs at or beneath the water surface. **Minimum 1/subreach; #/subreach: _____**
- **Macrophyte beds—**emergent submerged, or floating leaf aquatic plants thick enough to serve as cover. **Minimum 1/subreach; #/subreach: _____**
- **Other locally important habitat features (describe) ____________________________**

## (m) Element 14—Aquatic invertebrate community

### Description and rationale for assessing aquatic invertebrate community

This important element reflects the ability of the stream to support aquatic invertebrates such as crayfish, mussels, dragonflies, and caddisflies. However, successful assessments require knowledge of the life cycles of some aquatic insects and other macroinvertebrates and the ability to identify them. For this reason, this is an optional element.

Aquatic invertebrates include crustaceans (such as crayfish), mollusks (such as snails), spiders, and aquatic insects. These organisms are important to aquatic food webs. To better understand aquatic invertebrate functions, habitat needs and interrelationships within the food web, ecologists have categorized these organisms into four major functional feeding groups:

- ***Shredders*** process leaves, sticks, and twigs. Their habitats are distinguished by areas that trap and retain organic matter (leaf packs). They are generally found in headwater streams.
- ***Collectors*** are made up of two types of aquatic invertebrates, also generally found in headwater streams:
  - ***Filterers*** process smaller organic matter, suspended in the water. Their habitats are large stable rock or logs.
  - ***Gatherers*** actively collect their food, plant and animal material. Their habitat is usually medium to large rocks.
- ***Grazers*** feed on algae in areas of streams receiving sunlight. Like gatherers, their habitat is medium to large rocks.
- ***Predators*** feed on other animals. Their habitats include logs, medium to large rocks, water column, pools, and leaf litter.

The presence of a diversity of intolerant macroinvertebrate species (pollution sensitive) indicates healthy, resilient stream conditions. Macroinvertebrates, such as stoneflies, mayflies, and caddisflies, are sensitive to pollution and do not tolerate polluted water. These intolerant orders of insects comprise group I. Group II macroinvertebrates are facultative, meaning they can tolerate limited pollution. This group includes damselflies, aquatic sowbugs, and crayfish. The dominant presence of group III macroinvertebrates, including midges, craneflies and leeches, without the presence of group I suggests the water is significantly polluted. The presence and abundance of only one or two species from group I species in a reach community does not generally indicate diversity is good. As with all elements in the SVAP, comparison with reference conditions or those found in least impaired streams in the area are encouraged.

**Element 14** Aquatic invertebrate community scoring matrix

| | | | |
|---|---|---|---|
| Invertebrate community is diverse and well represented by group I or intolerant species<br>One or two species do not dominate | Invertebrate community is well represented by group II or facultative species, and group I species are also present<br>One or two species do not dominate | Invertebrate community is composed mainly of groups II and III<br>**and/or**<br>One or two species of any group may dominate | Invertebrate community composition is predominantly group III species<br>**and/or**<br>only one or two species of any group is present and abundance is low |
| **10 9 8** | **7 6 5** | **4 3 2** | **1 0** |

## What to look for

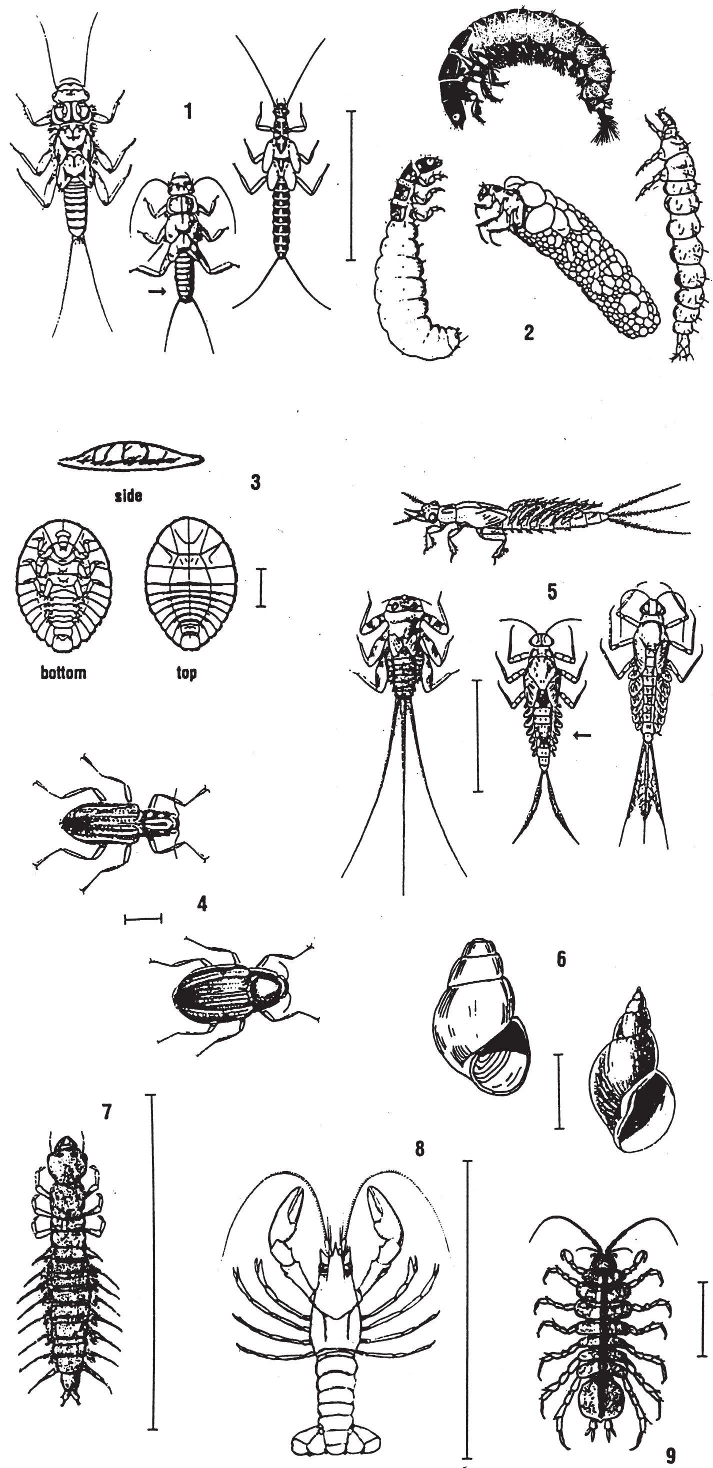
Figure 26 shows illustrations for each of the three groups of macroinvertebrates with the listing of invertebrate taxonomic order. This rating is qualitative and therefore potential biases should be avoided to provide accurate representation of each site.

- Collect macroinvertebrates by picking up cobbles, gravel, leaf packs, silt, fine woody debris, and other submerged objects in the water. Sample all types of potential insect habitat (refer to insect/invertebrate habitat element) for an equal amount of time to reduce biases and improve accuracy.
- A healthy and stable invertebrate community will be consistent in its proportional representation (evenness) of species, though individual species abundance may vary in magnitude. Note the kinds of macroinvertebrates (group type), approximate number of each species, and relative abundance of each species sampled. Determine if one or two species dominate the aquatic invertebrate community. An abundance of an individual species, such as caddisflies or snails, is often equated to a tolerance of stress, such as poor water quality, and lower diversity.

**Element 15** Riffle embeddedness scoring matrix

| Gravel or cobble substrates are <10% embedded | Gravel or cobble substrates are 10–20% embedded | Gravel or cobble substrates are 21–30% embedded | Gravel or cobble substrates are 31—0% embedded | Gravel or cobble substrates are >40% embedded |
|---|---|---|---|---|
| **10 9** | **8 7** | **6 5** | **4 3** | **2 1 0** |

**Figure 26** Stream invertebrates (Source: Izaak Walton League of America)




Bar lines indicate relative size

**Group I Taxa: Pollution-sensitive taxa found in good quality water.**

**1** Stonefly: Order Plecoptera. .5 to 1.5 inches, six legs with hooked antenna, two hair-line tails. Smooth (no gills) on lower half of body (see arrow).

2 Caddisfly: Order Trichoptera. Up to 1 inch, six hooked legs on upper third of body, two hooks at back end. May be in a stick, rock, or leaf case with head sticking out. May have fluffy gill tufts on underside.

3 Water Penny: Order Coleoptera. 1/4 inch, flat saucer-shaped body with a raised bump on one side and six tiny legs and fluffy gills on the other side. Immature beetle.

4 Riffle Beetle: Order Coleoptera. 1/4 inch, oval body covered with tiny hairs, six legs, antennae. Walks underwater. Swims beneath surface.

5 Mayfly: Order Ephemeroptera. 1/4 to 1 inch, brown, moving, plate-like or feathery gills on sides of lower body (see arrow), six large hooked legs, antennae, two to three long hair-like tails that may be webbed together.

**6** Gilled Snail: Class Gastropoda. Shell opening covered by thin plate called operculum. When opening is facing you, shell usually opens on right.

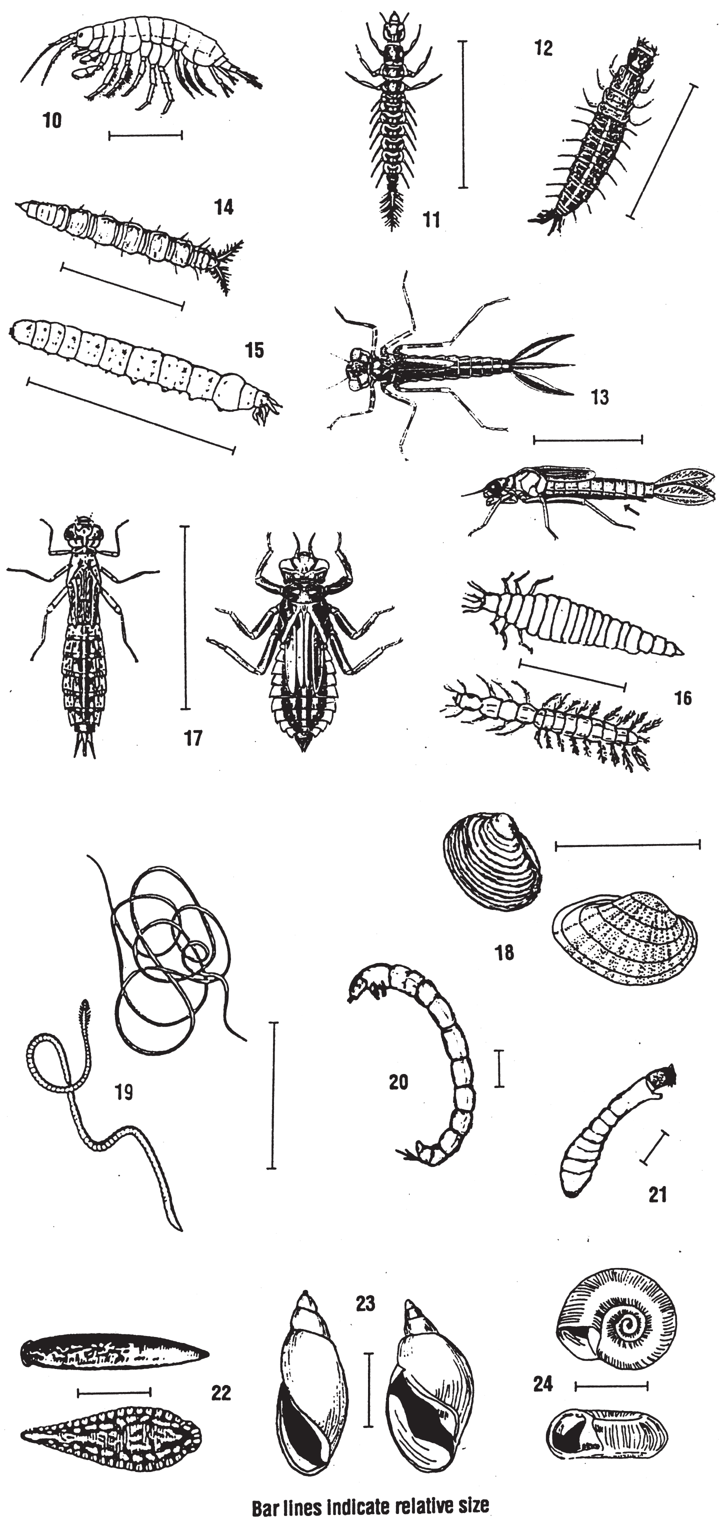
**7** Dobsonfly (hellgrammite): Family Corydalidae. 3/4 to 4 inches, dark-colored, six legs, large pinching jaws, eight pair of feelers on lower half of body with paired cotton-like gill tufts along underside, short antennae, two tails, and two pair of hooks at end.

**Group II Taxa: Somewhat pollution tolerant taxa found in good or fair quality water.**

**8** Crayfish: Order Decapoda. Up to 6 inches, 1 large claw, eight legs, resembles lobster.

**9** Sowbug: Order Isopoda. 1/4 to 3/4 inch, gray oblong body wider than it is high, more than six legs, and long antennae.

**Figure 26** Stream invertebrates (Source: Izaak Walton League of America)—Continued




**10** Scud: Order Amphipoda. 1/4 inch, white to gray, body higher than it is wide, swims sideways, more than six legs, resembles small shrimp.

**11** Alderfly Larva: Family Sialidae. 1 inch long. Looks like small hellgrammite, but has long, thin, branched tail at back end (no hooks), no gill tufts below.

**12** Fishfly Larva: Family Cordalidae. Up to 1 1/2 inch long. Looks like small hellgrammite, but often light reddish-tan color or with yellowish streaks. No gill tufts underneath.

**13** Damselfly: Suborder Zygoptera. 1/2 to 1 inch, large eyes, six thin hooked legs, three broad, oar-shaped tails, positioned like a tripod. Smooth (no gills) on sides of lower half of body (arrow).

**14** Watersnipe Fly Larva: Family Athericidae (Atherix). 1/4 to 1 inch, pale to green, tapered body, many caterpillar-like legs, conical head, feathery "horns" at back end.

**15** Crane Fly: Suborder Nematocera. 1/3 to 2 inches, milky, green, or light brown, plump caterpillar-like segmented body, four finger-like lobes at back end.

**16** Beetle Larva: Order Coleoptera. 1/4 to 1 inch, light colored, six legs on upper half of body, feelers, antennae.

**17** Dragon Fly: Suborder Anisoptera. 1/2 to 2 inches, large eyes, six hooked legs. Wide, oval to round abdomen.

**18** Clam: Class Bivalvia.

**Group III Taxa: Pollution-tolerant organisms can be in any quality of water.**

**19** Aquatic Worm: Class Oligochaeta, 1/4 to 2 inches, can be tiny, thin, worm-like body.

**20** Midge Fly Larva: Suborder Nematocera. Up to 1/4 inch, dark head, worm-like segmented body, two legs on each side.

**21** Blackfly Larva: Family Simulidae. Up to 1/4 inch, one end of body wider. Black head, suction pad on other end.

**22** Leech: Order Hirudinea. 1/4 to 2 inches, brown, slimy body, end with suction pads.

**23** Pouch Snail and Pond Snails: Class Gastropoda. No operculum. Breathe air. When opening is facing you, shell usually open to left.

**24** Other Snails: Class Gastropoda. No operculum. Breaths air. Snail shell coils in one plane.

## (n) Element 15—Riffle embeddedness

### Description and rationale for assessing riffle embeddedness

Embeddedness measures the degree to which gravel and cobble substrates in riffles are surrounded by fine sediment. It relates directly to the suitability of the stream substrate as habitat for macroinvertebrates, fish spawning, and egg incubation. Riffles are areas, often downstream of a pool, where the water is breaking over rocks, cobbles, gravel, or other substrate material on the bed of a stream, causing surface agitation. In coastal areas, riffles can be created by shoals and submerged objects. Riffles are critical for maintaining high species diversity and abundance of insects for most streams and for serving as spawning and feeding grounds for some fish species. This element is sensitive to regional landscape differences and should therefore be related to locally established reference conditions.

Do not assess this element unless riffles or swift-flowing water and coarse substrates are present or a natural feature that should be present.

**Element 15** Riffle embeddedness scoring matrix

| Gravel or cobble substrates are <10% embedded | Gravel or cobble substrates are 10–20% embedded | Gravel or cobble substrates are 21–30% embedded | Gravel or cobble substrates are 31—0% embedded | Gravel or cobble substrates are >40% embedded |
|---|---|---|---|---|
| **10 9** | **8 7** | **6 5** | **4 3** | **2 1 0** |

### What to look for

- This element should be assessed only in streams where riffles are a natural feature.
- The measure is the depth to which objects are buried by sediment. This assessment is made by picking up particles of gravel or cobble with fingertips at the fine sediment layer. Pull the particle out of the bed, and estimate what percent of the particle was buried.
- Some streams have been so smothered by fine sediment that the original stream bottom is not visible. Test for complete burial of a streambed by probing with a measuring stick. Does substrate move easily when the substrate is moved around with one's feet? If not, substrate material is likely greater than 40 percent embedded.

## (o) Element 16—Salinity (if applicable)

### Description and rationale for assessing salinity

The origin of elevated salinity levels in streams is often associated with irrigation of salt-laden soils, dryland crop/fallow systems that produce saline seeps, oil and gas well operations, and animal waste. Salt accumulation in streambanks can cause break down of soil structure, decreased infiltration of water, and toxicity. High salinity in streams affects aquatic vegetation, macroinvertebrates, and fish. If observed impacts of salt are a product of natural weathering processes of soil and geologic material uninfluenced by humans, this element should not be scored.

**Element 16** Salinity scoring matrix

| | | | |
|---|---|---|---|
| No wilting, bleaching, leaf burn, or stunting of riparian vegetation<br>No streamside salt-tolerant vegetation present | Minimal wilting, bleaching, leaf burn, or stunting of riparian vegetation<br>Some salt-tolerant streamside vegetation | Riparian vegetation may show significant wilting, bleaching, leaf burn, or stunting<br>Dominance of salt-tolerant streamside vegetation | Severe wilting, bleaching, leaf burn, or stunting; presence of only salt tolerant riparian vegetation<br>Most streamside vegetation is salt tolerant |
| **10 9 8** | **7 6 5** | **4 3** | **2 1 0** |

**Note:** Do not assess this element unless elevated salinity levels caused by people are suspected.

### What to look for

- High salinity levels can cause a burning or bleaching of riparian vegetation. Wilting, loss of plant color, decreased productivity, and stunted growth are visible signs.
- Other indicators include whitish salt accumulations on streambanks and displacement of salt intolerant vegetation by more tolerant species.

# 614.06 References

Allan, J.D. 1995. Stream ecology: structure and function of running waters. Chapman and Hall, Inc. New York, NY.

Bell, M.C. 1990. Fisheries handbook of engineering requirements and biological criteria. Fish Passage Development and Evaluation Program, U.S. Army Corps of Engineers, North Pacific Division. Portland, OR. 290 pp.

Benke, A.C., T.C. Van Arsdall, Jr., D.M. Gillespie, and F.K. Parrish. 1984. Invertebrate productivity in a subtropical blackwater river: the importance of habitat and life history. Ecological Monographs 54:25–63.

Booth, D.B. 1990. Stream-channel incision following drainage-basin urbanization. Water Resources Bulletin 26:407–417.

Booth, D.B., and C.R. Jackson. 1997. Urbanization of aquatic systems-degradation thresholds, stormwater detention, and limits of mitigation: Journal of American Water Resources Association 33:1077–1090.

Calow, P., and G.E. Petts. 1994. The rivers handbook: hydrological and ecological principles, volumes One and Two. Blackwell Scientific Publications, Oxford, UK.

Forshay, K.J., and E.H. Stanley. 2005. Rapid nitrate loss and denitrification in a temperate river flood plain. Biogeochemistry 75:43–64.

Giller, P.S., and B. Malmqvist. 1998. The biology of streams and rivers. Oxford University Press, Oxford, UK. 296 pp.

Groot, C., and L. Margolis. 1991. Pacific salmon life histories. University of British Columbia Press, Vancouver, BC.

Gross, M.R., R.M Coleman, and R.M. McDowall. 1988. Aquatic productivity and the evolution of diadromous fish migration. Science 239:1291–1293.

Gurnell, A.M., K.J. Gregory, and G.E. Petts. 1995. The role of coarse woody debris in forest aquatic habitats: implications for management. Aquatic Conservation 5:143–166.

Haro, A., and B. Kynard. 1997. Video evaluation of passage efficiency of American shad and sea lamprey in a modified Ice Harbor fishway. North American Journal of Fisheries Management 17:981–987.

Hooke, J.M., and C.E. Redmond. 1992. Causes and nature of river planform change. *In* Dynamics of gravel bed rivers. P. Billi, et al. (eds). John Wiley & Sons, New York, NY. pp 559–571.

Hunter, C.J. 1991. Better trout habitat, a guide to stream restoration and management. Island Press, Washington DC. 320 pp.

Jones, J.A., and G.E. Grant. 1996. Long-term stormflow responses to clearcutting and roads in small and large basins, western Cascades, Oregon. Water Resources Research 32: 959–974.

Junk, W.J., P.B. Bayley, and R.E. Sparks. 1989. The flood pulse concept in river-flood plain systems. *In* Proceedings of the International Large River Symposium. D.P. Dodge (ed.). Canadian Special Publication in Fisheries and Aquatic Science 106: 110–127.

Karr, J.R., K.D. Fausch, P.L. Angermier, P.R. Yant, and I.J. Schlosser. 1986. Assessing biological integrity in running waters: a method and its rationale. Illinois Naural History Survey Special Publication 5. Champaign, IL. 28 pp.

Lane, E.W. 1955. The importance of fluvial geomorphology in hydraulic engineering. Proceedings of the American Society of Civil Engineers 81:1–17.

Leopold, L.B. 1994. A view of the river. Harvard University Press, Cambridge, MA. 298 pp.

Leopold, L.B., M.G. Wolman, and J.P. Miller. 1964. Fluvial processes in geomorphology. W.H. Freeman and Company, San Francisco, CA.

Matthews, W.J. 1998. Patterns in freshwater fish ecology. Chapman and Hall, International Thompson Publishing, New York, NY.

Maxwell, J.R., C.J. Edwards, M.E. Jenson, S.J. Paustiam, H. Parrott, and D.M. Hill. 1995. A hierarchical framework of aquatic ecological units in North America (Nearctic Zone). Forest Service, General Technical Report NC–176, North Central Forest Experiment Station, MN. 72 pp.

Meyer, J.L. 1997. Stream health: Incorporating the human dimension to advance stream ecology. Journal of the North American Benthological Society 16: New Concepts in Stream Ecology: Proceedings of a Symposium. pp. 439–447.

Montgomery, D.R., and J.R. Buffington. 1993. Channel classification, prediction of channel response, and assessment of channel condition. Report TFW–SH10–93–002 prepared for the SHAMW committee of the Washington State Timber/Fish/Wildlife Agreement. 84 pp.

Pearsons, T.N., H.W. Li, and G.A. Lamberti. 1992. Influence of habitat complexity on resistance to flooding and resilience of stream fish assemblages. Transactions of the American Fisheries Society 121:427–436.

Platts, W.S. 1991. Livestock grazing. *In* Influences of Forest and rangeland management on salmonid fishes and their habitats. W.R. Meehan (ed.). American Fisheries Society Special Pub. 19:389–423. Bethesda, MD.

Poff, N.L., and J.V. Ward. 1989. Implications of streamflow variability and predictability for lotic community structure: A regional analysis of streamflow patterns. Canadian Journal of Fisheries and Aquatic Sciences 46:1805–1817.

Poff, N.L., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg. 1997. The natural flow regime: A paradigm for river conservation and restoration. BioScience 47:769–784.

Pons, L. 2003. Helping states slow sediment movement: a high-tech approach to Clean Water Act sediment requirements. Agriculture Research 51: 12–14.

Rosgen, D.L. 1994. A classification of natural rivers. Catena. 22:169–199.

Rosgen, D. 1996. Applied river morphology. Wildland Hydrology, Pagosa Springs, CO. 352 pp.

Schlosser, I. J.1982. Fish community structure and function along two habitat gradients in a headwater stream. Ecological Monographs 52:395–414.

Schueler, T.R. 1994. The importance of imperviousness. Watershed Protection Techniques. 1(3):100–111.

Schumm, S.A., Harvey, M.D., and Watson, C.C. 1984. Incised channels: morphology, dynamics, and control. Water Resource Publications, Littleton, CO.

Simon, A., A. Curini, S.E. Darby, and E.J. Langendoen. 2000. Bank and near-bank processes in an incised channel. Geomorphology 35:193–217.

Thorne, C.R. 1982. Processes and mechanisms of river bank erosion. *In* Gravel-Bed Rivers. R.D. Hey, J.C. Bathurst, and C.R. Thorne (eds.). John Wiley & Sons. New York, NY. pp 227–259.

Tickner, D.P., P.G. Angold, A.M. Gurnell, and J.O. Mountford. 2001. Riparian plant invasions: hydrogeomorphological control and ecological impacts. Progress in Physical Geography 25: 22–52.

U.S. Environmental Protection Agency (EPA). 2003. Level III ecoregions of the Continental United States (revision of Omernik, 1987): Corvallis, Oregon, USEPA National Health and Environmental Effects Research Laboratory, Map M–1, various scales.

Waters, T.F. 1995. Sediment in streams: Sources, biological effects and controls. American Fisheries Society Monograph 7. Bethesda, MD.

Williams, G.P. 1978. Bankfull discharge of rivers. Water Resources Research 14:1141–1154.

Wolman, M.G., and L.B. Leopold. 1957. River flood plains: Some observations on their formation. USGS Professional Paper 282–C. U.S. Geological Survey. Washington, DC.

Wolman, M.G., and J.P. Miller. 1960. Magnitude and frequency of forces in geomorphic processes. Journal of Geology 68:54–74.

Wolman, M.G., and R. Gerson. 1978. Relative scales of time and effectiveness of climate in watershed geomorphology. Earth Surface Processes and Landforms 3:189–208.

## Stream Visual Assessment Protocol 2 Summary Sheet

Owner's name ___________________________ Evaluator's name_______________________________

Stream name ____________________________ Tributary to: __________________________HUC: ____

## 1. Preliminary Assessment

### A. Watershed Description

Ecoregion or MLRA___________________ Watershed Drainage area (acres or mi$^2$ )_______________

Watershed management structures: (no.): dams___ water controls _____ irrigation diversions___

No. of miles of contiguous riparian cover/mile of entire stream in watershed (estimated)__________

Land use within watershed (%): cropland _____ hayland _____ grazing/pasture _____ forest ____

urban _____ industrial ______ other (specify) _____

Agronomic practices in uplands include: _________________________________________________

Confined animal feeding operations (no.) ______ Conservation (acres) ______industrial(acres) _______

Number of stream miles on property_________________ Number of total stream miles____________

Stream hydrology: _____intermittent; months of year wetted : __________________

_____perennial; months of year at baseflow:__________________

**B. Stream/Reach Description**:

Stream Gage Location/Discharge: ___________________________/____________ft$^3$/s

Applicable Reference Stream: ____________________ Reference Stream Location: ____/_____

Information Sources:

## 2. Field Assessment

### A. Preliminary Field Data

Date of assessment_______________ Weather conditions today_________________________
(ambient temp.\ % cloud cover)

Weather conditions over past 2 to 5 days: _____________________________________________.
(No. of days precip/average daytime temp.)

Reach location (UTM or Lat./Long.) _______/_______ Channel type/classification scheme_______/_______

Riparian Cover Type(s): Tree____ % Shrub____% Herbaceous ____% Bare ____%

Bank Profile: Stratified___ Homogeneous____ Cohesive Soil___ Noncohesive Soil ____

Gradient (√ one): Low (0-2%)___ Moderate (>2<4%)___ High (>4%) ___

Bankfull channel width ______ft Reach length _______ft Flood plain width_______ft

Average riparian zone width_______ ft Method used (e.g., Range finder): ______________________

Average height of woody shrubs _______ Method used (e.g., Range finder): ______________________

Flood plain wetlands, if present ________ acres/reach

Dominant substrate (%): boulder ____ cobble ____ gravel ____ sand____ fine sediments ____
(> 250 mm) (60-250mm) (2-60 mm) (2-.06 mm) ( < .06 mm)

Photo Point Locations and Descriptions:

| Photo Pt. # | GPS Coordinates/Waypoints | Description |
|---|---|---|
| | | |
| 1 | | |
| 2 | | |
| 3 | | |

SVAP Start Time/Water Temp: ________/________SVAP End Time/Water Temp: _____/________

Notes:

**B. Element Scores**

| Element | Score | Element | Score |
|---|---|---|---|
| 1. Channel Condition | | 14. Aquatic Invertebrate Community | |
| 2. Hydrologic Alteration | | 15. Riffle Embeddedness | |
| 3. Bank Condition | | 16. Salinity | |
| 4. Riparian Area Quantity | | **A. Sum of all elements scored** | |
| 5. Riparian Area Quality | | **B. Number of elements scored** | |
| 6. Canopy Cover | | | |
| 7. Water Appearance | | **Overall score: A/B** ________ | |
| 8. Nutrient Enrichment | | 1 to 2.9 Severely Degraded | |
| 9. Manure or Human Waste | | 3 to 4.9 Poor | |
| 10. Pools | | 5 to 6.9 Fair<br>7 to 8.9 Good | |
| 11. Barriers to Movement | | 9 to 10 Excellent | |
| 12. Fish Habitat Complexity | | | |
| 13. Aquatic Invertebrate Habitat | | | |

Suspected causes of SVAP scores less than 5 (does not meet quality criteria for stream species)

___

___

___

Recommendations for further assessment or actions:

___

___

___

Riparian wildlife habitat recommendations:

___

___

___

C. Site Diagram: indicate approximate scale, major features, resource concerns, etc.

**1 to 2.9 Severely Degraded**
**3 to 4.9 Poor**

**Provide notes related to each element scored on back of site diagram, as needed.**

# Appendix A Additional References for Further Reading

## Watershed health and assessment


Collins, B.D., D.R. Montgomery, A.J. Sheikh. 2002. Reconstructing the historical riverine landscape of the Puget lowland. *In* Restoration of Puget Sound Rivers. D.R. Montgomery, S. Bolton, D.B. Booth, and L. Wall (eds.). University of Washington Press, Seattle, WA.

Cushing, B., and J. Allen. 2001. Streams: their ecology and life. Academic Press, San Diego, CA.

Karr, J.R. 1999. Defining and measuring river health. Fresh Water Biology 41:221–234.

Kondolf, G.M., and P.W. Downs. 1996. Catchment approach to planning river channel restoration. *In* River Channel Restoration. A. Brookes and F.D. Shields., Jr. (eds.). John Wiley & Sons, Chichester, UK. pp 129–148.

Naiman, R.J., T.J. Beechie, L.E. Benda, D.R. Berg, P.A. Bisson, L.H. MacDonald, M.D. O'Connor, P.L. Olson, and E.A. Steel. 1992. Fundamental elements of ecologically healthy watersheds in the Pacific Northwest Coastal Ecoregion. *In* Watershed management: balancing sustainability and environmental change. R.J. Naiman (ed). Springer-Verlag, New York, NY. pp.127–188.

National Research Council. 1992. Restoration of Aquatic Ecosystems. National Academy Press, Washington, DC.

National Research Council. 2002. The Missouri River Ecosystem: exploring the prospects for recovery. National Academy Press, Washington, DC.

Stanford, J.A., and J.V. Ward. 1992. Management of aquatic resources in large catchments: recognizing interactions between ecosystem connectivity and environmental disturbance. *In* Watershed Management. R.J. Naiman (ed.). Springer-Verlag, New York, NY. pp 91–124.

Wang, L., J. Lyons, P. Kanehl, and R. Gatti. 1997. Influences of watershed land use on habitat quality and biotic integrity in Wisconsin streams. Fisheries 22:6–12.

Wang, L., J. Lyons, P. Kanehl, and R. Bannerman. 2001. Impacts of urbanization on stream habitat and fish across multiple spatial scales. Environmental Management. 28:255–266.

Ward, J.V., and J.A. Stanford. 1995. Ecological connectivity in alluvial river ecosystems and its disruption by flow regulation. Regulated Rivers 11:105–119.

Ward, J.V., K. Tockner, U. Uehlinger, and F. Malard. 2001. Understanding Natural Patterns and Processes in River Corridors as the Basis for Effective River Restoration. Regulated Rivers: Research and Management. 17:311–323.


## Stream classification


Bryce, S.A., and S.E. Clarke. 1996. Landscape-level ecological regions: linking state-level ecoregion frameworks with stream habitat classifications. Environmental Management 20:297–311

Frissell, C.A., W.J. Liss, C.E. Warren, and M.D. Hurley. 1986. A hierarchical framework for stream habitat classification: viewing streams in a watershed context. Environmental Management 10:199–214.

Hawkes, H.A. 1975. River zonation and classification. *In* River ecology. B.A. Whitton (ed.). University of California Press, Berkeley, CA. pp. 312–374.

Kondolf, G.M. 1995. Geomorphological stream channel classification in aquatic habitat restoration: uses and limitations. Aquatic Conservation: Marine and Freshwater Ecosystems 5:127–141.

Montgomery, D.R., and J.M. Buffington. 1993. Channel classification, prediction of channel response, and assessment of channel condition. Washington State Timber, Fish, and Wildlife. p. 67.

Rosgen, D.L. 1994. A classification of natural rivers. Catena 22:169–199

Thorne, C.R. 1997. Channel types and morphological classification. Applied Fluvial Geomorphology for River Engineering and Management. John Wiley & Sons, Chichester, UK. pp.176–222.

## Reference conditions

Hughes, R.M., D.P. Larsen, and J.M. Omernik. 1986. Regional reference sites: a method for assessing stream potentials. Environmental Management 10:629–635.

Hughes, R.M. 1995. Defining acceptable biological status by comparing with reference conditions. *In* Biological Assessment and Criteria: Tools for Water Resource Planning. W.S. Davis, and T.P. Simon (eds.). Lewis Publishers, Boca Raton, FL. 31–47.

Reynoldson, T.B., R.H. Norris, V.H. Resh, K.E. Day, and D.M. Rosenberg. 1997. The reference condition: a comparison of multimetric and multivariate approaches to assess water-quality impairment using benthic macroinvertebrates. Journal of the North American Benthological Society. 16:833–852

## Channel condition

Leopold, L.B. 1994. A View of the River. Harvard University Press, Cambridge, MA.

Leopold, L.B., M.G. Wolman., and J.P. Miller. 1964. Fluvial processes in geomorphology. W.H. Freeman and Company, San Francisco, CA.

Schumm, S.A., M.D. Harvey, and C.C. Watson. 1984. Incised Channels: Morphology, Dynamics and Control. Water Resources Publications, Littleton, CO. 200 p.

## Hydrologic alteration

Andrews, E.D. 1984. Bed-material entrainment and hydraulic geometry of gravel-bed rivers in Colorado. Geological Society of America Bulletin 95:371–378.

Dunne, T., and L.B. Leopold. 1978. Water in environmental planning. W.H. Freeman and Company, New York, NY. 818 pp.

Gore, J.A. and G.E. Petts. 1989. Alternatives in regulated river management. CRC Press, Inc., Boca Raton, FL.

Gregory, S.V., F.J. Swanson, W.A. McKee, and K.W. Cummins. 1991. An ecosystem perspective of riparian areas. Bioscience 41:540–551.

Hill, M.T., W.S. Platts, and R.L. Beschta. 1991. Ecological and geomorphological concepts for instream and out-of-channel flow requirements. Rivers 2: 198–210.

Hynes, H.B.N. 1975. The stream and its valley. Verhandlungen, Internationale Vereinigung fur theoretische und Aufewandte Limnologie 19:1–15.

Jackson, W.L., and R.L. Beschta. 1992. Instream flows for rivers: maintaining stream form and function as a basis for protecting dependent uses. *In* Interdisciplinary approaches in hydrology and hydrogeology. M.E. Jones, and A. Laeanen (eds.) St. Paul, MN. American Institute of Hydrology. pp. 524–53.

Ligon, F.K., W.E. Dietrich, and W.J. Trush. 1995. Downstream ecological effects of dams. BioScience 45:183–192.

Middleton, B.A. 2002. Flood pulsing in wetlands: restoring the natural hydrological balance. John Wiley & Sons, New York, NY.

Molles, M.C., C.S. Crawford, L.M. Ellis, H.M. Valett, and C.N. Dahm. 1998. Managed flooding for riparian ecosystem restoration. BioScience 48:749–756.

Montgomery, W.L., S.D. McCormick, R.J. Naiman, F.G. Whoriskey, and G.A. Black. 1983. Spring migratory synchrony of salmonid, catastomid, and cyprinid fishes in Riviere je la Truite, Quebec. Canadian Journal of Zoology 61:2495–2502.

Naesje T., B. Jonsson, and J. Skurdal. 1995. Spring floods: a primary cue for hatching of river spawning Coregoninae. Canadian Journal of Fisheries and Aquatic Sciences 52: 2190–2196.

Nesler, T.P., R.T. Muth, and A.F. Wasowicz. 1988. Evidence for baseline flow spikes as spawning cues for Colorado Squawfish in the Yampa River, Colorado. American Fisheries Society Symposium 5:68–79.

Platts, W.S., and R.L. Nelson. 1985. Impacts of rest-rotation grazing on stream banks in forested watersheds in Idaho. North American Journal of Fisheries Management 5:547–556.

Power, M.E., A. Sun, G. Parker, W.E. Dietrich, and J.T. Wootton. 1995. Hydraulic food chain models. BioScience 45:159–167.

Resh, V.H., A.V. Brown, A.P. Covich, M.E. Gurtz, H.W. Li, G.W. Minshall, S.R. Reice, A.L. Sheldon, J.B Wallace, and R. Wissmar. 1988. The role of disturbance in stream ecology. Journal of the North American Benthological Society 7:433–455.

Richter, B.D., J.V. Baumgartner, J. Powell, and D.P. Braun. 1996. A method for assessing hydrologic alteration within ecosystems. Conservation Biology 10: 1163–1174.

Schlosser, I.J. 1985. Flow regime, juvenile abundance, and the assemblage structure of stream fishes. Ecology 66:1484-1490.

Schmidt, L.J., J.P. Potyondy. 2004. Quantifying channel maintenance instream flows: an approach for gravel-bed streams in the Western United States. General Technical Report RMRS–GTR–128. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Fort Collins, CO. 33 pp.

Seegrist, D.W. and R. Gard. 1972. Effects of floods on trout in Sagehen Creek, California. Transactions of the American Fisheries Society 10:478–482.

Simon, A. 1989. A model of channel response in distributed alluvial channels. Earth Surface Processes and Landforms 14:11–26.

Sparks, R.E. 1995. Need for ecosystem management of large rivers and their flood plains. Bioscience 45:168–182.

Stanford, J.A., J.V. Ward, W.J. Liss, C.A. Frissell, R.N. Williams, J.A. Lichatowich, and C.C. Coutant. 1996. A general protocol for restoration of regulated rivers. Regulated Rivers 12:391–413.

Trepanier S., M.A. Rodriguez, and P. Magnan. 1996. Spawning migrations in landlocked Atlantic salmon: time series modeling of river discharge and water temperature effects. Journal of Fish Biology 48:925–936.

Troendle, C.A. and R.M. King. 1987. The effect of partial cutting and clearcutting on the Deadhorse Creek watershed. Journal of Hydrology 90:145–157.

Ward J.V., and J.A. Stanford (eds.). 1979. The Ecology of Regulated Streams. Plenum Press, New York, NY. 398 pp.

Welcomme, R.L. 1992. River conservation: Future prospects. *In* River Conservation and Management. P.J. Boon, R. Calow, and G. E. Petts (eds). John Wiley & Sons, New York, NY. pp. 454–462

Whiting, P.J. 2002. Streamflow necessary for environmental maintenance. Annual Reviews of Earth and Planetary Science 30:181-206.

Wilcock, P.R., G.M. Kondolf, W.V.G. Matthews, and A.F. Barta. 1996. Specification of sediment maintenance flows for a large gravel-bed river. Water Resources Research 32:2911–2921.

Williams, G.P., and M.G. Wolman. 1984. Downstream effects of dams on alluvial rivers. U.S. Geological Survey Professional Paper No. 286.

## Bank condition

Belsky, A.J., A. Matzke, and S. Uselman. 1999. Survey of livestock influences on stream and riparian ecosystems in the Western United States. Journal of Soil Water Conservation 54:419–431.

Clary, W.P., and J. W. Kinney. 2002. Streambank and vegetation response to simulated cattle grazing. Wetlands 22:139–148.

Hooke, J.M. 1979. An analysis of the processes of river bank erosion. Journal of Hydrology 42:39–62.

Hooke, J.M. 1980. Magnitude and distribution of rates of river bank erosion. Earth Surfaces and Processes. 5:143–157.

Knox, J.C. 2001. Agricultural influence on landscape sensitivity in the Upper Mississippi River Valley Catena 42:193–224

Kauffman, J.B., and W.C. Krueger. 1984. Livestock impacts on riparian ecosystems and streamside management implications—a review. Journal of Range Management 37:430–438.

Lawler, D.M. 1993. The measurement of river bank erosion and lateral channel change: a review. Earth Surface Processes and Landforms 18:777–821.

Odgaard, A.J. 1987. Streambank erosion along two rivers in Iowa. Water Resources Research 23:1225–1236.

Schmetterling, D.A., C.G. Clancy, and T.M. Brandt. 2001. Effects of rip-rap bank reinforcement on stream salmonids in the Western United States. Fisheries 26:6-13.

Simon, A. and M. Rinaldi. 2000. Channel instability in the loess area of the Midwestern United States. Journal of the American Water Resources Association 36:133–150.

Trimble, S.W. 1997. Contribution of stream channel erosion to sediment yield from an urbanizing watershed. Science 278:1442–1444.

Waters, T.F. 1995. Sediment in streams: sources, biological effects, and control. American Fisheries Society Monograph 7. Bethesda, MD.

## Barriers to aquatic species movement

Clay, C.H. 1995. Design of fishways and other fish Facilities. Second Edition. CRC Press, Inc., Boca Raton, FL. 248 pp.

Graf, W.L. 1999. Dam nation: a geographic census of American dams and their large-scale hydrologic impacts. Water Resources Research 35:1305–1311.

Groot C., L. Margolis, and W. C. Clarke (eds.). 1995. Physiological ecology of Pacific salmon. University of. British Columbia Press, Vancouver, BC.

Gross, M.R., R.M Coleman, and R.M. McDowall. 1988. Aquatic productivity and the evolution of diadromous fish migration. Science 239:1291–1293.

Jungwirth, M., S. Schmutz, and S. Weiss (eds.). 1998. Fish Migration and Fish Bypasses. Fishing News Books, Oxford, UK. 438 pp.

Lang, M., M. Love, and W. Trush. 2004. Improving fish passage at road crossings. Final report to the National Marine Fisheries Service, produced in cooperation with Humboldt State University Foundation under NMFS contract 50ABNF800082. Arcata, CA. 128 pp.

Monk, B., D. Weaver, C. Thompson, and F. Ossiander. 1989. Effects of flow and weir design on the passage behavior of American shad and salmonids in an experimental fish ladder. North American Journal of Fisheries Management 9:60–67.

Taylor, R.N. and M. Love. 2003. Fish passage evaluation at stream crossings. Part IX *in* California Stream Habitat Restoration Manual, 3rd edition, 1998. Prepared by G. Flosi, S. Downie, J. Hopelain, M. Bird, R. Coey, and B. Collins. Sacramento, CA. 100 electronic pp.

U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS). 2006. Fish passage and screening designs. Technical Supplement 14–N to NEH 654, Stream Restoration Design Handbook. Washington, DC.

Washington Department of Fish and Wildlife. 2000. Fishway guidelines for Washington State. Olympia, WA. 57 pp.

Washington Department of Fish and Wildlife. 2000. Fish passage barrier and surface water diversion screening and prioritization manual. WDFW Habitat Program, Environmental Restoration Division, Salmon Screening, Habitat Enhancement and Restoration Section, Olympia, WA. 158 pp.

Washington Department of Fish and Wildlife. 2003. Design of road culverts for fish passage. Olympia, WA. 110 pp.

## Aquatic invertebrates and habitat

Benke, A.C., and J.B. Wallace. 2003. Influence of wood on invertebrate communities in streams and rivers. *In* The Ecology and Management of Wood in World Rivers. S.V. Gregory, K.L. Boyer, and A. Gurnell (eds.). American Fisheries Society. Bethesda, MD. pp. 149–177

Gregory, B.M. 2005. Microhabitat Preferences by Aquatic invertebrates Influence Bioassessment Metrics in Piedmont Streams of Georgia and Alabama. Proceedings of the 2005 Georgia Water Resources Conference.

Taylor, C.A., M.L. Warren, J.F. Fitzpatrick, H.H. Hobbs, R.F. Jezerinac, W.L. Pflieger, and H.W. Robison. 1996. Conservation status of crayfishes of the United States and Canada. Fisheries 21:25–38.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The River Continuum Concept. Canadian Journal of Fisheries and Aquatic Sciences. 37:130–137

## Fish habitat complexity

Allan, J.D., and A.S. Flecker. 1993. Biodiversity conservation in running waters. BioScience 43:32–43

Bayley, P.B. 1991. The flood pulse advantage and the restoration of river-flood plain systems. Regulated Rivers: Research and Management. 6:75–86

Dolloff, C.A. and M.L. Warren, Jr. 2003. Fish relationships with large wood in small streams. *In* The Ecology and Management of Wood in World Rivers. S.V. Gregory, K.L. Boyer, and A. Gurnell (eds.). American Fisheries Society. Bethesda, MD. pp. 179–193

Beechie, T., and S. Bolton. 1999. An approach to restoring salmonid habitat-forming processes in Pacific Northwest watersheds. Fisheries 24:6–15.

Fausch, K.D., C.L. Hawkes, and M.G. Parsons. 1988. Models that predict standing crop of stream fish from habitat variables: 1950–85. Gen. Tech. Rept. PNWGTR–213. U.S. Dept. Agriculture, Forest Service, Pacific Northwest Research Station. Portland, OR. 52 p.

Fausch, K.D., C.E. Torgerson, C.V. Baxter, and H.W. Li. 2002. Landscapes to riverscapes: bridging the gap between research and conservation of stream fishes. BioScience 52:483–498.

Federal Interagency Stream Restoration Working Group (FISRWG). 1998. Stream corridor restoration: principles, processes and practices. National Technical Information Service, U.S. Department of Commerce, Springfield, VA. Also published as U.S. Department of Agriculture Natural Resources Conservation Service (1998) Stream corridor restoration: principles, processes, and practices. National Engineering Handbook (NEH), Part 653. Washington, DC.

Frissell, C.A., and R.K. Nawa. 1992. Incidence and causes of physical failure of artificial habitat structures in streams of western Oregon and Washington. North America Journal of Fisheries Management 12:182–197.

Gregory, S.V., K.L. Boyer, and A. Gurnell. 2003. The ecology and management of wood in world rivers. American Fisheries Society. Bethesda, MD.

Hawkins, C.P., R.H. Norris, J.N. Hogue, and J.W. Feminella. 2000. Development and evaluation of predictive models for measuring the biological integrity of streams. Ecological Applications 10:1456–1477.

Junk, W.J., P.B. Bayley, and R.E. Sparks. 1989. The flood pulse concept in river-flood plain systems. *In* Proceedings of International Large River Symposium (LARS), Toronto, Ontario, September 14–21, 1986. D.P. Dodge(ed.). Canadian Special Publication of Fisheries and Aquatic Sciences. pp. 110–127

Karr, J. R., K.D. Fausch, P.L. Angermeier, P.R. Yant, and I.J. Schlosser. 1986. Assessing biological integrity in running waters: a method and its rationale. Special Publication 5. Illinois Natural History Survey. Champaign, IL.

Maser, C., and J.R. Sedell. 1994. From the forest to the sea: the ecology of wood in streams, rivers, estuaries, and oceans. St. Lucie Press, Delray Beach, FL.

Poff, N.L., and J.V. Ward. 1990. Physical habitat template of lotic systems: recovery in the context of historical pattern of spatiotemporal heterogeneity. Environmental Management. 14:629–645.

Poff, L.N., J.D. Allan, M.B. Bain, J.R. Karr, K.L. Prestegaard, B.D. Richter, R.E. Sparks, and J.C. Stromberg. 1997. The natural flow regime: a paradigm for river conservation and restoration. BioScience 47:769–784.

Reich, M., J.L. Kershner, and R.C. Wildman. 2003. Restoring streams with large wood: a synthesis. *In* The Ecology and Management of Wood in World Rivers. S.V. Gregory, K.L. Boyer and A. Gurnell (eds.). American Fisheries Society. Bethesda, MD. pp. 355–366

Schlosser, I.J. 1987. A conceptual framework for fish communities in small warmwater streams. *In* Community and Evolutionary Ecology of North American Stream Fishes. W. J. Matthews and D. C. Heins (eds.). University of Oklahoma. Norman, Oklahoma, and London, UK.

Sedell, J.R., G.H. Reeves, F.R. Hauer, J.A. Stanford, and C.P. Hawkins. 1990. Role of refugia in recovery from disturbances: modern fragmented and disconnected river systems. Environmental Management 14:711–724.

Shields, F.D., Jr., and R.T. Milhous. 1992. Sediment and aquatic habitat in river systems. Final Report, American Society of Civil Engineers Task Committee on Sediment Transport and Aquatic Habitat. Journal of Hydraulic Engineering 118:669–687.

Shields, F. D., Jr., S.S. Knight, and C.M. Cooper. 1998. Rehabilitation of aquatic habitats in warmwater streams damaged by channel incision in Mississippi. Hydrobiologia 382:63–86.

Townsend, C.R. 1989. The patch dynamics concept of stream community ecology. Journal of the North American Benthological Society 8:36–50.

U.S. Environmental Protection Agency (USEPA). 2000. Water quality conditions in the United States: The 1998 National Water Quality Inventory Report to Congress. Report No. EPA841–R–00–001, USEPA, Washington, DC.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The river continuum concept. Canadian Journal of Fisheries and Aquatic Sciences 37:130–137.

Wang, L., and J. Lyons. 2003. Fish and benthic macroinvertebrate assemblages as indicators of stream degradation in urbanizing watersheds. *In* Biological response signatures: indicator patterns using aquatic communities. T.P. Simon (ed.). Regulated Rivers: Research and Management. 17:311–323.

Ward, J.V., and J.A. Stanford. 1983. The intermediate disturbance hypothesis: an explanation for biotic diversity patterns in lotic ecosystems. *In* Dynamics of lotic ecosystems. T.D. Fontaine, and S.M. Bartell, (eds.). Ann Arbor Press, Ann Arbor, MI. pp. 347–356.

White, D.S. 1993. Perspectives on defining and delineating hyporheic areas. Journal of the North American Benthological Society 12:61–69.

Williams, J.E., J.E. Johnson, D.A. Hendrickson, S. Contreras-Balderas, J.D. Williams, M. Navarro-Mendoza, D.E. McAllister, and J.E. Deacon. 1989. Fishes of North America endangered, threatened, or of special concern. Fisheries 14:3–20.

Williams, J.D., M.L. Warren Jr., K.S. Cummings, J.L. Harris, and R.J. Neves. 1993. Conservation status of freshwater mussels of the United States and Canada. Fisheries 18:6–22.

Yount, J.D., and G.J. Niemi. 1990. Recovery of lotic communities and ecosystems from disturbance—a narrative review of case studies. Environmental Management 14:547–569.

## Riparian areas

Baker, M.B., Jr., P.F. Ffolliott, L.F. DeBano, and D.G. Neary. 2004. Riparian areas of the Southwestern United States: hydrology, ecology, and management. Lewis Publishers, CRC Press, Boca Raton, FL. 408 pp.

Baxter, C.V., K.D. Fausch, and W.C. Saunders. 2005. Tangled webs: reciprocal flows of invertebrate prey link streams and riparian areas. Freshwater Biology 50: 201–220

Bolton, S.M. and J. Shellberg. 2001. Ecological issues in flood plains and riparian corridors. Final White Paper prepared for Washington State Transportation.

Boyer, K.L., D.R. Berg, and S.V. Gregory. 2003. Riparian management for wood in rivers. *In* The Ecology and Management of Wood in World Rivers. S.V. Gregory, K.L. Boyer, and A. Gurnell (eds.). American Fisheries Society, Bethesda, MD. pp. 407–420.

Briggs, M.K. 1996. Riparian Ecosystem Recovery in Arid Lands: Strategies and References. The University of Arizona Press, Tucson, AZ. 159 pp.

Chambers, J.C., and J.R. Miller (eds). 2004. Great Basin Riparian Ecosystems—Ecology, Management and Restoration. Island Press, Covelo, CA. 303 pp.

Cooke, H.A., and S. Zack. In Press. Use of standardized visual assessments of riparian and stream condition to manage riparian bird habitat in eastern Oregon. Environmental Management.

Gregory, S.V., F.J. Swanson, A. McKee, and K.W. Cummins. 1991. Ecosystem perspectives of riparian areas. Bioscience 41:540–551.

Huggenberger, P., E Hoehn, R. Beschta, and W. Woessner. 1998. Abiotic aspects of channels and flood plains in riparian ecology. Freshwater Biology 40: 407–425.

Malanson, G.P. 1993. Riparian landscapes. Cambridge University Press, Cambridge, UK. 296 pp.

Naiman, R.J., and H. Decamps, 1997. The ecology of interfaces: riparian areas. Annual Review of Ecology and Systematics 28:621–658.

Naiman, R.J., H. Decamps, and M.E. McClain, 2005. Riparia: ecology, conservation, and management of streamside communities. Elsevier, Inc., London, UK. 430 pp.

National Research Council (NRC). 2002. Riparian Areas: Functions and Strategies for Management. National Academy Press, Washington, DC.

Stromberg, J.C. 2001. Restoration of riparian vegetation in the southwestern United States: importance of flow regimes and fluvial dynamism. Journal of Arid Environments 49:17–34.

Verry, E.S., J.W. Hornbeck, and C.A. Dolloff. 2000. Riparian management in forests of the Continental Eastern United States. Lewis Publishers, CRC Press, Boca Raton, FL.

Ward, J.V., K. Tockner, and F. Schiemer. 1999. Biodiversity of flood plain river ecosystems: ecotones and connectivity. Regulated Rivers: Research and Management 15:125–139

Wichert, G A., and D.J. Rapport. 1998. Fish community structure as a measure of degradation and rehabilitation of riparian systems in an agricultural drainage basin. Environmental Management 22:425–443.

Winward, A.H. 2000. Monitoring the vegetation resources in riparian areas. General Technical Report. RMRS–GTR–47. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. Fort Collins, CO.

## Water appearance

Stevenson, R.J., and J.P. Smol. 2002. Use of algae in environmental assessments. *In* Freshwater Algae in North America: Classification and Ecology. J.D. Wehr, and R.G. Sheath (eds.). Academic Press, San Diego, CA.

Digital Keys to Aquatic Insects
http://www.waterbugkey.vcsu.edu/

## Riparian plant guidebooks

Common Arizona Riparian Plants
http://www.plant-materials.nrcs.usda.gov/pubs/azpmstn7363.pdf

Field Guide for Identification and Use of Common Riparian Woody Plants of the Intermountain West and Pacific Northwest Regions
http://www.plant-materials.nrcs.usda.gov/pubs/idpmcpu7428.pdf

# Appendix B Glossary

**Active channel width** The width of the stream at the bankfull discharge. Permanent vegetation generally does not become established in the active channel.

**Active flood plain** That part of a flood plain that is frequently inundated with water.

**Aggradation** Geologic process by which a stream bottom or flood plain is raised in elevation by the deposition of material.

**Alluvial** Deposited by running water, such as sediments.

**Bankfull discharge** The stream discharge (flow rate, such as cubic feet per second) that forms and controls the shape and size of the active channel and creates the flood plain. This discharge generally occurs once every 1.5 years on average.

**Bankfull flow** Discharge where water just begins to leave the stream channel and spread onto the flood plain. Bankfull flow is roughly equivalent to channel-forming (conceptual) and effective (calculated) discharge for alluvial streams in equilibrium, and generally occurs every 1 to 2 years (on average).

**Bankfull stage** The stage at which water starts to flow over the flood plain; the elevation of the water surface at bankfull discharge

**Baseflow** The portion of streamflow that is derived from natural storage of precipitation that percolates to ground water and moves slowly through substrate before reaching the channel. Baseflow sustains streamflow during periods of little or no precipitation and is the average stream discharge during low flow conditions.

**Benthos** Bottom-dwelling or substrate-oriented organisms.

**Boulders** Large rocks measuring more than 10 inches across.

**Channel** With respect to streams, a channel is a natural depression of perceptible extent that periodically or continuously contains moving water. It has a definite bed and banks that serve to confine the stream's water.

**Channel form** The morphology of the channel is typically described by thread (single or multiple channels in valley floor), and sinuosity (amount of curvature in the channel).

**Channel roughness** Physical elements of a stream channel upon which flow energy is expended including coarseness and texture of bed material, the curvature of the channel, and variation in the longitudinal profile.

**Channelization** Straightening of a stream channel to make water move faster.

**Cobbles** Medium-sized rocks that measure 2.5 to 10 inches across.

**Confined channel** A channel that does not have access to a flood plain.

**Concentrated flow** Undispersed flow, usually flowing directly from an unbuffered area of overland flow; concentrated flow generally contains sediments and/or contaminants from areas beyond the stream corridor.

**Degradation** Geologic process by which a stream bottom is lowered in elevation due to the net loss of substrate material. Often called downcutting.

**Detritus** Materials such as leaves, twigs, or branches that enter a stream from the uplands or riparian area.

**Downcutting** See Degradation.

**Ecoregion** A geographic area defined by similarity of climate, landform, soil, potential natural vegetation, hydrology, or other ecologically relevant variables.

**Embeddedness** The degree to which an object is buried in steam sediment.

**Emergent plants** Aquatic plants that extend out of the water.

**Ephemeral stream** A stream with a channel that is above the water table at all times and carries water only during and immediately after a rain event.

**Flood plain** The level area of land near a stream channel, constructed by the stream in the present climate, and overflowed during moderate flow events (after Leopold 1994).

**Flow augmentation** Artificially adding water to a stream channel with timing and magnitude that disrupts the natural flow regime. Examples include irrigation deliveries, trans-basin diversions, or wastewater from irrigated lands, treatment plants, or commercial facilities.

**Fluvial** A feature of or pertaining to the action of moving water.

**Forb** Any broad-leaved herbaceous plant other than those in the Gramineae (Poceae), Cyperacea, and Juncaceae families (Society for Range Management1989).

**Gabions** A wire basket filled with rocks; used to stabilize streambanks and control erosion.

**Geomorphology** The study of the evolution, process, and configuration of landforms.

**Glide** A fast water habitat type that has low to moderate velocities, no surface agitation, and a U-shaped, smooth, wide bottom.

**Gradient** Slope calculated as the amount of vertical rise over horizontal run expressed as feet per foot or as percent (ft/ft × 100).

**Grass** An annual to perennial herb, generally with round erect stems and swollen nodes; leaves are alternate and two-ranked; flowers are in spikelets each subtended by two bracts.

**Gravel** Small rocks measuring 0.825 to 2.5 inches across.

**Habitat** The area or environment in which an organism lives.

**Herbaceous** Plants with nonwoody stems.

**Hydrology** The study of the properties, distribution, and effects of water on the Earth's surface, soil, and atmosphere.

**Hyporheic** Below the surface of the streambed, including interstitial spaces.

**Incised channel** A channel with a streambed lower in elevation than its historic elevation in relation to the flood plain.

**Intermittent stream** A stream that flows only certain times of the year, such as when it receives water from springs, ground water, or surface runoff.

**Lateral migration** The adjustment of a stream channel from side to side often involving the recession of a streambank. In a braided river system, both streambanks may be recessing due to excessive channel filling and limited bedload transport capabilities (see fig. 18).

**Macrophyte bed** A dense mat of aquatic plants.

**Macrotopography** Depositional features within a flood plain developed by water flow and greater than 6 inches than the average land surface of the flood plain.

**Microtopography** Features within a flood plain developed by water flow and less than 6 inches than the average land surface of the flood plain.

**Meander** A winding section of stream with many bends that is at least 1.2 times longer, following the channel, than its straight-line distance. A single meander generally comprises two complete opposing bends, starting from the relatively straight section of the channel just before the first bend to the relatively straight section just after the second bend.

**Macroinvertebrate** A spineless animal visible to the naked eye or larger than 0.5 millimeters.

**Natural flow regime** The full range of daily, monthly, and annual streamflows critical to sustaining native biodiversity and integrity in a freshwater ecosystem. Important flow regime characteristics include natural variations in streamflow magnitude, timing, duration, frequency, and rates of change (see Poff et al. 1997 for further detail).

**Nickpoint** The point where a stream is actively eroding (downcutting) to a new base elevation. Nickpoints migrate upstream (through a process called headcutting).

**Oligotrophic** Having little or no nutrients and, thus, low primary production.

**Perennial stream** A steam that typically flows continuously throughout the year.

**Point bar** A gravel or sand deposit on the inside of a meander; actively mobile deposits.

**Pool** Deeper area of a stream with slow-moving water.

**Reach** A section of stream (defined in a variety of ways, such as the section between tributaries or a section with consistent characteristics).

**Riffle** A shallow section in a stream where water is breaking over rocks, wood, or other partly submerged debris and producing surface agitation.

**Riparian areas** Riparian areas are transitional areas between terrestrial and aquatic ecosystems and are distinguished by gradients in biophysical conditions, ecological processes, and biota. They are areas through which surface and subsurface hydrology connect waterbodies with their adjacent uplands. They include those portions of terrestrial ecosystems that significantly influence exchanges of energy and matter with aquatic ecosystems.

**Riprap** Rock material of varying size used to stabilize streambanks and other slopes.

**Run** A fast-moving section of a stream with a defined thalweg and little surface agitation.

**Scouring** The erosive removal of material from the stream bottom and banks.

**Sedge** A grass-like, fibrous-rooted herb with a triangular to round stem and leaves that are mostly three-ranked and with close sheaths; flowers are in spikes or spikelets.

**Stormwater runoff** Overland runoff from a precipitation event not absorbed by soil, vegetation, or other natural means.

**Substrate** The mineral or organic material that forms the bed of the stream; the surface on which aquatic organisms live.

**Surface fines** That portion of streambed surface consisting of sand/silt (less than 6 mm).

**Thalweg** The line followed by most of the streamflow. The line that connects the lowest or deepest points along the streambed.

**Turbidity** Murkiness of water caused by particles such as fine sediment and algae.

**Water control structures** Any physical feature located in or adjacent to a stream used to control the direction, magnitude, timing, and frequency of water for instream or out-of-stream uses. Examples include dams, pumps, water treatment or power plant outfalls, gated culverts, standpipes, subsurface drains, and ring wells.

**Watershed** A ridge of high land dividing two areas that are drained by different river systems. The land area draining to a waterbody or point in a river system; catchment area, drainage basin, drainage area.

# Appendix C Technical Information to Support Implementation of the Stream Visual Assessment Protocol Version 2

Appendix C provides documentation to support the use of the Stream Visual Assessment Protocol Version 2 (SVAP2). The topics covered in this section include a summary of changes from Stream Visual Assessment Protocol Version 1 (SVAP) and development of SVAP2, context for use with other methods of stream assessment, summary of results of a validation study of the SVAP2, and instructions for modifying the protocol.

## Summary of changes in SVAP2

Applications and uses of the SVAP evolved as more NRCS personnel became familiar with it. Most importantly, field and State Office personnel were asked to utilize SVAP for determination of eligibility for fish and wildlife resource conservation in Farm Bill programs, evaluation of the level at which aquatic habitat is being achieved in an RMS, preliminary evaluation of streams where restoration actions were being considered, and documentation of trends after stream and riparian project implementation. The uses for the protocol thus expanded beyond the original intent of the SVAP. Revisions are now made to allow field personnel to assess conditions relatively quickly and with a reasonable degree of accuracy and repeatability. Because SVAP Version 1 was designed for landowners to learn about streams with assistance from field office personnel, the cadre of specialists retained this objective in the development of SVAP2.

The following concerns of field users of SVAP Version 1 were addressed in the revision and are reflected in SVAP2:

- Revise SVAP to be congruent with existing wildlife habitat evaluation guides. A value of .5 is the threshold/difference between source and sink habitat for terrestrial wildlife. Using SVAP2, a score of 5 or above for a stream should be considered the threshold/difference between source and sink stream habitat for fish and wildlife.
- Revise wording and protocol elements to assure better consistency among and between States to allow repeat assessments over time.
- Revise critical scoring elements to better reflect the current state of the art and NRCS emphasis on stream corridor conservation. These elements are channel condition, hydrological alteration, riparian quality, riparian quantity, and bank condition.

The SVAP Version 1 and SVAP2 were developed by combining parts of several existing assessment procedures. Many of these sources are listed in the references section. Three drafts of SVAP2 were developed and reviewed by the workgroup and others between the fall of 2006 and the spring of 2008. During the summer of 2007, the workgroup conducted a field trial evaluation of the third draft. Subsequently, additional revisions were made, and the fourth draft was sent to all NRCS State Offices, selected Federal agencies, and other partners for review and comment during the spring of 2008. Comments were received from eight NRCS State Offices, Bureau of Land Management, and several NRCS national specialists. Comments were, for the most part, uniformly supportive of the need for user guidance and for the document as drafted. Many reviewers provided suggestions that improved explanatory text for the supporting descriptions accompanying the assessment elements. Most of the suggested revisions were incorporated into the final draft of the protocol.

## Context for use of SVAP2

The SVAP2, like its predecessor, is intended to be a relatively simple, yet comprehensive assessment of stream condition that maximizes ease of use. It is suitable as a *general approximation* of stream condition at the time in which the protocol is used. It can also be used to identify the need for more precise quantitative assessment methods that focus on a particular aspect of the aquatic system. These would include geomorphic analysis, quantitative habitat condition, and biological surveys. The SVAP2 is applicable nationwide because it utilizes ecological and physical factors that are least sensitive to regional differences. However, regional differences are a significant aspect of stream assessment, and therefore, the protocol's scoring elements are expected to be modified to reflect regional differences in physical landscape features and weather patterns. The national SVAP2 is viewed as a framework that will evolve over time to better reflect State or within-State regional differences. Instructions for modification are provided later in this document.

The SVAP2 is issued as a component of the National Biology Handbook. States are encouraged to incorporate it within the Field Office Technical Guide. The document may be modified by States. The electronic file for the document may be downloaded from the NRCS Web site.

## Summary of validation study of SVAP2

SVAP2 was field tested regionally and nationally, along with three alternative protocols designed to evaluate physical habitat condition of streams. The protocols evaluated were NRCS's SVAP2, the Ohio EPA's Qualitative Habitat Evaluation Index (QHEI), the EPA's Rapid Bioassessment Protocol (EPA–RBP), and a quantitative protocol developed by EPA's Environmental Monitoring and Assessment Program (EMAP–QTPH). The contractors sampled one site on each of 51 wadeable agricultural streams in the summer of 2007. Sites were distributed throughout the United States, except for the Deep South because of high waters, and they included 8 sites in California (Central Valley), 10 in Oregon (Willamette Valley), 4 in North Dakota (Northern Plains), 8 in South Dakota (Northern Plains), 4 in Nebraska (Western Corn Belt), 5 in Iowa (Western Corn Belt), 2 in Minnesota (Western Corn Belt), 6 in Pennsylvania (ridge and valley), 3 in Maryland (ridge and valley), and 1 in West Virginia (ridge and valley).

Precision was assessed through use of scatter plots, coefficients of variation, and a signal/noise test (among-site variance/within-site observer variance) for all four protocols. Results indicated high precision among field technicians for all qualitative protocols, but greater precision for the quantitative protocol. Overall, all four methods produced similar assessment precision results, although SVAP2 elements riffle embeddedness and nutrient enrichment demonstrated low observer precision. Depending on the purpose for completing the SVAP2, a simple quantitative assessment of these elements such as pebble counts or water quality testing for total phosphorus may be warranted if element scores are lower than 5. Salinity and macroinvertebrate elements were not included in the study.

Accuracy of SVAP2 was evaluated by comparing qualitative index scores against a quantitative physical habitat index (EMAP–QTPH), qualitative metric scores against quantitative (EMAP–QTPH) metric scores, and qualitative and quantitative habitat index scores against quantitative biological index scores (fish assemblage tolerance index, fish IBI, macroinvertebrate EPT, macroinvertebrate IBI). The results indicated acceptable levels of accuracy for all four habitat indices, but greater accuracy for the quantitative protocol. Also, comparisons between each of the four habitat indexes, and the biological indexes were only weakly correlated. These comparisons were likely confounded by other stressors, such as water quality or landscape-scale perturbances, and their effects on aquatic biota.

Four SVAP2 elements (channel condition, hydrological alteration, water appearance, and nutrient enrichment) were found to be less accurate in characterizing these stream features than the quantitative EMAP metrics. However, the EMAP metric used to make three of these comparisons (hydrological alteration, water appearance, nutrient enrichment) were only weakly comparable, which may explain some of the variation between the two methods. The comparison of the EMAP metric (bed stability) to the SVAP2 channel condition was relatively comparable, and so the lack of strong correlation between these two methods is likely due to the complexity of visually assessing these stream features (table C–1). This finding reinforces the need to complete a quantitative assessment of channel condition if SVAP2 scores for this element are lower than 5.

## Instructions for modification of SVAP2 to better reflect local conditions

The NRCS SVAP2 may be used in many locales without modification when the objective of the user is to learn about features that determine overall stream and riparian conditions. As its predecessor, SVAP2 was designed to use assessment elements that are the least sensitive to regional differences. Nonetheless, when using the tool to evaluate trends in stream corridor habitat conditions over time, the elements and scoring categories should be calibrated to reflect conditions characteristic of the geographic area. If narrative descriptions of scoring elements match local features and hydrologic regimes the SVAP2 will be:

- easier to use locally
- more responsive to changes in local stream condition over time
- more precise and accurate

Two parts of the SVAP2 may be modified—the individual elements and their narrative descriptions and the rating scale for assigning an overall condition rating. The simplest approach to modifying the SVAP2

**Table C–1** Correlations between qualitative SVAP metrics and quantitative EMAP metrics. Individual observers combined, n=102 (LRBS data were missing for 22 sites)

| SVAP metric | EMAP metric* | Pearson correlation | Spearman correlation |
|---|---|---|---|
| Channel Condition | LRBS (n=80) | 0.27 | 0.29 |
| Hydrologic Alteration | LRBS (n=80) | 0.16 | 0.13 |
| Bank Condition (Left/Right) | XGB | –0.50/–0.51 | –0.44 /–0.44 |
| Riparian Area Quantity (Left/Right) | XCMGW | 0.54 /0.64 | 0.48/0.52 |
| Riparian Area Quality (Left/Right) | XCMG | 0.52 /0.56 | 0.47/0.52 |
| Canopy Cover | XCDENMID | 0.76 | 0.74 |
| Water Appearance | XFCALG+XFCAQM | –0.14 | –0.05 |
| Nutrient Enrichment | Log10 Total P | –0.10 | –0.07 |
| Manure | W1H_PSTR | –0.73 | –0.60 |
| Pools | RPGT20 | 0.64 | 0.66 |
| Barriers | PCT_DRS | –0.48 | –0.43 |
| Invertebrate Habitat | PCT_FN | –0.61 | –0.66 |
| Fish Habitat | SDDEPTH | 0.61 | 0.55 |
| Embeddedness | PCT_FN | –0.61 | –0.69 |

*LRBS: $\log_{10}$ relative bed stability; XGB: sum of riparian bare ground cover
XCMGW: sum of woody canopy, mid-layer and ground vegetation cover
XCMG: sum of canopy, mid-layer and ground vegetation cover
XCDENMID: mean % canopy midstream
XFCALG+XFCAQM: % areal cover of filamentous algae and aquatic macrophytes
LOG10 TOTAL P: $\log_{10}$ of total phosphorus; W1H_PSTR: sum of riparian pasture, hay
RPGT20: number of residual pools >20 cm deep
PCT_DRS: % stream dry stream bed
PCT_FN: % silt, clay and muck; SDDEPTH: standard deviation of thalweg depth

is based on professional experience and judgment. Under this approach an interdisciplinary team should be assembled to develop proposed revisions. Revisions should then be evaluated by conducting comparison assessments at sites representing a range of conditions and evaluating accuracy (correlation between different assessment methods), precision (reproducibility among different users), and ease of use.

*Step 1* Decide on tentative number of versions.

Is the desire to develop a revised version for the State, for each ecoregion within the State, or for several stream classes within each ecoregion?

*Step 2* Develop a tentative stream classification.

If developing protocols by stream class, develop a tentative classification system. (If interested in a statewide or ecoregion protocol, go to step 3.) One might develop a classification system based on stream order, elevation, or landscape character. Do not create too many categories. The greater the number of categories, the more assessment work will be needed to modify the protocol, resulting in more accommodation of degradation within the evaluation system. As an extreme example of the latter problem, one would not want to create a stream class consisting of those streams that have bank-to-bank cropping and at least one sewage outfall.

*Step 3* Assess sites.

Assess a series of sites representing a range of conditions from highly impacted sites to least impacted sites. Try to have at least 10 sites in each tentative classes. Those sites should include several potential least impacted reference sites. Try to use sites that have been assessed by other assessment methods (such as sites assessed by State agencies or universities). As part of the assessments, be sure to record information on potential classification factors and if any particular elements are difficult to score. Take notes so that future revisions of the elements can be rescored without another site visit.

*Step 4* Rank the sites.

Begin the data analysis by ranking all the sites from most impacted to least impacted. Rank sites according to the independent assessment results (preferred) or by the SVAP scores. Initially, rank all of the sites in the State data set. Classifications will be tested in subsequent iterations.

*Step 5* Display scoring data.

Prepare a chart of the data from all sites in the State. The columns are the sites arranged by the ranking. The rows are the assessment elements, overall numerical score, and narrative rating. If independent assessment data is available, create a second chart by plotting the overall SVAP scores against the independent scores.

*Step 6* Evaluate responsiveness.

Does the SVAP score change in response to the condition gradient represented by the different sites? Are the individual element scores responding to key resource problems? Were users comfortable with all elements? If the answers are yes, do not change the elements and proceed to step 7. If the answers are no, isolate which elements are not responsive. Revise the narrative descriptions for those elements to better respond to the observable conditions. Conduct a desktop reassessment of the sites with the new descriptions, and return to step 4.

*Step 7* Evaluate the narrative rating breakpoints.

Do the breakpoints for the narrative rating correspond to other assessment results? The excellent range should encompass only reference sites. If not, reset the narrative rating breakpoints. Set the excellent breakpoint based on the least impacted reference sites. Use judgment to set the other breakpoints.

*Step 8* Evaluate tentative classification systems.

Go back to step 4 and display the data this time by the tentative classes (ecoregions or stream classes). In other words, analyze sites from each ecoregion or each stream class separately. Repeat steps 5 through 7. If the responsiveness is significantly different from the responsiveness of the State-wide data set or the breakpoints appear to be significantly different, adopt the classification system, and revise the protocol for each ecoregion or stream class. If not, a single statewide protocol is adequate. After the initial modification of the SVAP, the State may want to set up a process to consider future revisions. Field offices should be encouraged to locate and assess least impacted reference sites to build the database for interpretation and future revisions. Ancillary data should be collected to help evaluate whether a potential reference site should be considered a reference site. Caution should be exercised when considering future revisions. Revisions complicate comparing SVAP scores determined before and after the implementation of conservation practices if the protocol is substantially revised in the intervening period. Developing information to support refining the SVAP can be carried out by research partners working cooperatively with NRCS.