RIPARIAN METHODOLOGY

A Methodology for Defining and Assessing Riparian Areas in the Raritan River Basin

New Jersey Water Supply Authority, for the Raritan Basin Watershed Management Project

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METHODOLOGY FOR DEFINING AND ASSESSING RIPARIAN AREAS
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EXECUTIVE SUMMARY

Riparian areas that are maintained in their natural state serve a wide variety of functions that help protect streams, lakes, rivers and other waterways from environmental degradation. The destruction of riparian areas and the removal of riparian vegetation for urbanization and development projects can result in the deterioration of aquatic ecosystems and contribute to the impairment of healthy streams and waterways.

Stream channels with impaired riparian zones or those entirely without riparian areas do not receive protection from negative influences such as polluted surface water runoff or stream bank erosion. Riparian areas that have been damaged or replaced by impervious surfaces do not provide any benefits to the stream channel or its existing biota. The condition of vegetation along streams is a major component in determining the integrity of riparian ecosystems.

In an effort to assess the health and extent of riparian areas that exist within the Raritan River Basin, the New Jersey Water Supply Authority investigated available methodologies to define riparian areas in cooperation with the Raritan Basin Work Group and Project Team. Review of existing scientific literature has shown that no one specific method is practical for defining riparian areas in all areas due to the wide range of existing conditions across the landscape. This report defines riparian areas based on the specific ecological, hydrological, and economical benefits they provide throughout the Basin.

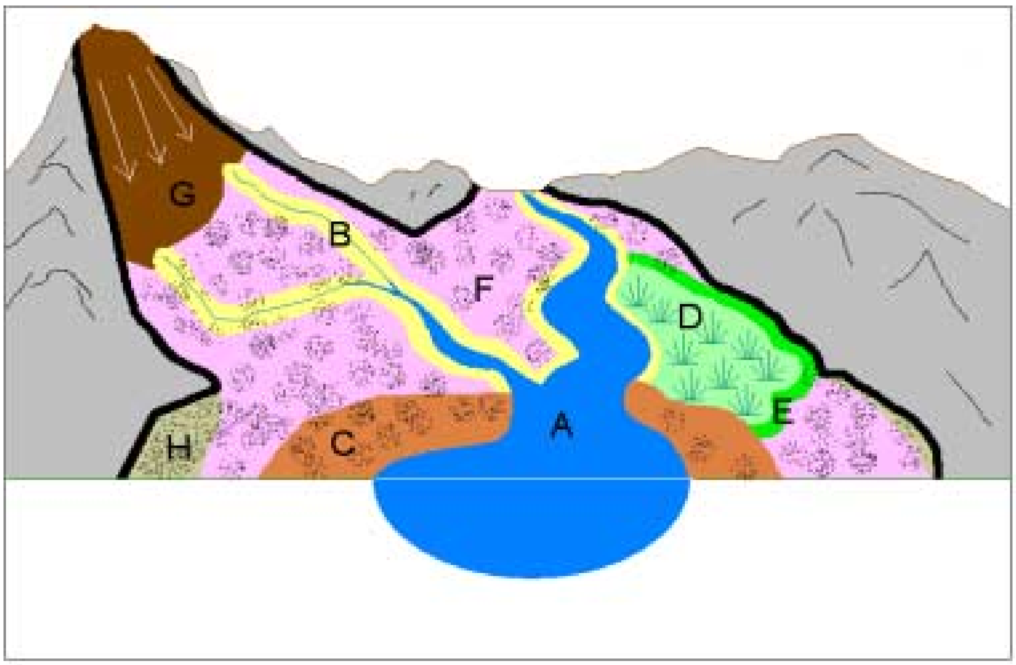
Riparian areas will be defined and mapped for the Raritan Basin project using all of the following parameters, with the total riparian area being the sum of the areas defined by the parameters:

- Wetlands directly adjacent to stream channels including:
    - o Wetlands larger than one acre
    - o Wetlands modified for agricultural or other purposes (whether such modified wetlands are ultimately included is dependent upon further research)
- Wetland transition areas for:
    - o Exceptional resource value (e.g., trout production or fresh water (FW) 1 waters) and intermediate resource value wetlands
- Wildlife passage corridors (undergoing scientific peer review)
- Floodplains including:
    - o 100-year floodplain
    - o Areas otherwise prone to flooding
- Steep slopes (slopes greater than 15%) that are directly adjacent to waterways or to a riparian feature associated with a waterway
- All hydric soils that are directly adjacent to surface waters within the Basin
- Soils with a seasonal high water table within 1.5 feet of the ground's surface that are directly adjacent to surface waters within the Basin
- Areas along streams that provide shade cover to the streams

- Specified widths necessary to remove pollutants from surface or ground water flow
- Barriers and alterations to stream flow including:
    - Dams
    - Road crossings
    - Managed streams

The health of riparian areas will be assessed by determining the extent to which the above areas are no longer in a natural (or fully functional) condition.

A conceptual diagram illustrating the approaches detailed in this methodology is presented below. The letters on the diagram represent specific parameters of the riparian area and are described beneath the graphic.



A. Trout Stream

B. Wildlife Passage Corridor (150 feet on each side of all 1st and 2nd Order streams)

C. Wildlife Passage Corridor (300 feet on each side of all streams 3rd Order and above)

D. Freshwater Wetlands (Areas 1-acre or larger and directly adjacent to streams)

E. Wetlands Transition Area (150 feet along wetlands of trout production and fresh water (FW) 1 streams; 50 feet along intermediate resource value wetlands)

F. 100 Year Floodplain

G. Steep Slope (Slopes greater than 15% that flow directly down to other riparian components of a waterway)

H. Soils (All hydric, alluvial or soils with a seasonal high water table within 1.5 feet of the ground's surface)

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- United States Geological Survey
- Upper Raritan Watershed Association

1.0 DEFINITION OF RIPARIAN AREAS

Riparian areas are "complex ecosystems that help provide optimum food and habitat for stream communities as well as aid in the control and mitigation of nonpoint source pollution."[1] Riparian areas facilitate the removal of excess nutrients and sediment from surface water runoff. They shade streams to optimize light and temperature conditions for aquatic plants and animals. Streamside riparian areas have been found to improve the quality of water resources by removing harmful pollutants in storm water runoff and increase the biological diversity and productivity of stream communities.[2]

Defining riparian areas is a difficult task due to the large number of influencing factors that require consideration, including soil characteristics, hydrology, and landscape features. Riparian areas vary in width, shape, and character and do not stop at any arbitrary, uniform distance away from a stream or watercourse.[3] Natural riparian areas are comprised of grasses, trees, or both types of vegetation and can exist within natural, agricultural, forested, suburban, and urban landscapes.[4]

Based on a review of existing literature, there is no universally accepted definition for riparian areas. Some definitions refer to the term riparian as "the ecosystems adjacent to a river." According to a scientific literature review on riparian buffers conducted by Seth Wenger of the University of Georgia, riparian areas are defined in two ways: (1) the area along streams and rivers that in its undisturbed state has a floral and faunal community distinct from surrounding upland areas, and (2) the area along streams and rivers which might benefit from some type of protection [including the impact of human land use activities such as farming and construction].[5]

Riparian areas are often referred to as an "ecotone," or the boundary that exists between ecosystems. Like many other ecotones, riparian areas are exceptionally rich in biodiversity and exhibit a greater variation in characteristics than either of the systems they connect, which makes them uniquely valuable. Riparian areas perform a wide range of functions with respect to stream health, wildlife uses, and the economic and social values of people. Functions and values of riparian areas include, but are not limited to the following:

- Maintaining habitat for fish and other aquatic organisms by moderating water temperatures and providing woody debris;
- Storing flood waters, thereby decreasing damage to property;
- Stabilizing stream banks and reducing channel erosion;
- Offering recreational and educational opportunities;
- Providing habitat for terrestrial organisms;
- Improving the aesthetics of stream corridors (which can increase property values);
- Trapping/removing sediment from runoff;
- Trapping/removing phosphorus, nitrogen, and other nutrients from runoff that can lead to eutrophication of aquatic ecosystems; and
- Trapping/removing other contaminants from runoff, such as pesticides.

In addition to maintaining all of the abovementioned "services," properly functioning, natural riparian areas help preserve land areas along streams, rivers and other water bodies that are frequently unsuitable or less suitable for other uses. The benefits of natural riparian areas relate to how the areas function to protect air, land, water quality and animal habitat. While the benefits of riparian areas can be grouped into broad categories, many interrelationships exist between them.[6] Examples of riparian benefits will be discussed in subsequent sections.

There are many definitions used by government agencies and the private sector to define riparian areas. Most definitions focus on either the functions of riparian areas or land use applications where an exact definition is not required. However, a riparian definition is vital for consistent and uniform identification and mapping.[7]

The United States Fish and Wildlife Service defines riparian areas as the plant communities that are contiguous to and affected by surface and subsurface hydrologic features of perennial or intermittent water bodies (rivers, streams, lakes, or drainage ways). According to the USFWS definition, riparian areas are usually transitional between wetland and upland areas and have one or both of the following characteristics: 1) distinctly different vegetative species than adjacent areas, and 2) species similar to adjacent areas but exhibiting more vigorous or robust growth forms.

The riparian mapping system utilized by the USFWS is in concert with the Cowardin et al. (1979) classification system used for wetland mapping. The Cowardin et al. system is the Federal standard for wetland mapping in the United States and is based on detailed photointerpretation, cartographic, and digitizing conventions that are ground checked for specific projects. Woody riparian areas associated with perennial or intermittent streams are the predominant feature of the USFWS's mapping effort, which facilitates a high degree of mapping accuracy. Emergent cover areas are also mapped if the imagery allows identification of these features. Aerial photographs are the primary data source used for riparian mapping, with field reviews, soil survey, topographic maps, and local inventories used secondarily. The procedure used by the USFWS to map riparian areas is currently used for resource inventory purposes only and does not have a relationship to a riparian regulatory program. Therefore, riparian mapping is done only to meet the requirements of cooperating agencies. A method to determine the integrity or health of riparian systems has not yet been developed.

As indicated above, riparian areas do not have sharply definable boundaries and are considered part of a broader landscape. For the purpose of this project, riparian areas will be defined using an eclectic approach that will focus on the specific functions and values of riparian areas and the benefits they provide. Items of specific discussion include the ecological, hydrological, soil dynamics and water quality benefits provided by riparian areas.

2.0 ECOLOGICAL FUNCTIONS AND VALUES OF RIPARIAN AREAS

2.1 Wetlands

<u>Discussion</u>

Riparian areas and associated wetlands provide a number of ecological benefits to aquatic ecosystems including protection of streams, rivers and lakes as well as providing habitat for an array of plant and animal species that are dependent on those aquatic ecosystems. Wetlands adjacent to streams afford treatment of the greatest possible drainage area and are very effective at removing pollutants from storm water runoff in the absence of concentrated flow. Concentrated flow consists of surface water runoff that is generally piped or channeled directly from a developed area to a stream channel. When runoff is discharged to a stream in this manner, the resulting concentrated flow bypasses the natural filtration system of the riparian area and therefore receives no pre-treatment or decrease in velocity prior to entering the stream. Bypassing the riparian area not only results in an increased pollutant load to the stream, but also increases the potential for stream bank erosion, sedimentation of the stream and degradation of overall stream health.

An important role of wetland vegetation is the uptake and long-term storage of nutrients. Wetland areas are more productive because of the nutrient and water subsidies provided by periodic flooding.[8] Further discussion of wetlands with respect to water quality filtration is discussed under the section on water quality and filter zones.

As mentioned above, wetlands provide numerous benefits to streams which makes it critical that these areas be protected and included in the riparian area mapping process. The study discussed below exemplifies the importance of protecting streamside riparian wetlands.

A Geographic Information System (GIS) analysis conducted by the University of New Hampshire Cooperative Extension to promote watershed based land use decisions in New Hampshire communities, recommended that a 100-foot buffer[9] be established to enhance the protection of wetlands associated with riparian areas. A larger buffer was recommended for sensitive wetlands (bogs[10], fens[11], white cedar swamps), prime wetlands, endangered or threatened species protection, and wildlife habitat areas. Implementing the 100-foot buffer was found to about double the protective acreage around streams and valuable wetland habitats.[12]

Through use of the University of New Hampshire Cooperative Extension Method, the Town of Deerfield, NH was able to evaluate the functional values of all of its major wetland areas and proposed some areas for designation as prime wetlands. A 200-foot buffer overlay was also created to visualize the impact and to discern whether the size chosen was adequate to serve both water quality and wildlife habitat concerns. The resulting analysis indicated that with the 200-foot buffer, some wetlands in the sample area would be connected to each other, but others would not. The GIS analysis indicated that other, perhaps nonregulatory, methods would be needed to establish habitat connections among all of the critically important wetlands.[13]

Methodology

For the purpose of this analysis, wetland areas located directly adjacent to or proximate to a stream channel will be mapped. This includes wetlands that have streams running from or through them or those that are directly adjacent to a stream channel.

Wetlands that have been modified for agricultural or other purposes and are adjacent to a stream or waterway are also being considered for inclusion in the mapping process. However, prior to including modified wetlands on the maps, technical advice is being sought from several agencies (including the United States Department of Agriculture's Natural Resources Conservation Service, the New Jersey Department of Environmental Protection (NJDEP) and a wetlands consultant) to determine the accuracy of the available GIS coverage.

Wetlands with less than a 1-acre threshold will not be mapped. Wetland transition area widths for trout production and fresh water (FW) 1 streams (150 feet) will be mapped as well as transition areas for intermediate resource value wetlands (50 feet).

2.2 Wildlife Passage Corridors

Discussion

Wetlands, riparian corridors, and adjacent lands are particularly valuable habitats for wildlife, which rely on access to rivers and streams for foraging. Vegetated riparian areas also function as corridors for wildlife movement by providing connectivity to a wide array of habitats which helps to maintain healthy wildlife populations. Therefore, it is key that riparian corridors be maintained in order to promote safe travel by land from one habitat to another. Loss of wildlife corridors results in habitat fragmentation, which in turn results in wildlife decline and extirpation (eventual loss of the species). It has been estimated that approximately 80% of all natural riparian communities within North America and Europe have been lost due to development.[14] Habitats that become isolated islands surrounded by development lose much of their ecological value even though the habitat is not directly impaired.[15]

It has been noted that the width of riparian areas designated for water quality and fisheries needs may not meet the habitat requirements of terrestrial wildlife. Most researchers advocate preserving as wide an area as possible that covers the floodplain and an additional upland area on at least one side of the stream channel.[16]

Review of existing literature indicates that while narrow riparian areas provide suitable habitat for some species, wider areas are required to support a greater diversity of species including those dependent on interior habitat types (e.g., those species requiring a significantly wider forested area). Seth Wenger of the University of Georgia recommends a conservative riparian area width of approximately 300 feet from the edge of the stream channel on each side of the stream to facilitate wildlife movement. Wenger recognizes that a 300-foot wide riparian area may not be practical on all streams in all locations, and recommends that water quality and aquatic habitat functions should be used to determine minimum riparian widths in most areas. Having at least a few wide (300-1,000 foot on each side of the stream) riparian areas along some streams would provide habitat for those species that rely on areas of interior forest.[17]

The Maryland Forest Service's recommendation for protecting species that rely on areas of interior forest ranges between 150 and 300 feet from the edge of the stream channel on each side of the stream (300 to 600 feet total). This recommendation helps facilitate the movement of neotropical-nearctic migrants as well as other species dependent on interior forest areas for nesting and foraging activities.

According to a study conducted by the Massachusetts Department of Fisheries, Wildlife and Environmental Law Enforcement, 300 feet is the generally accepted minimum width needed to provide adequate habitat and movement corridors for most wildlife species. The recommended 300 foot width can refer to either a 150 foot width or a 300 foot width on each side of the stream depending on the condition of the stream channel. For instance, if a stream channel were narrow enough that it did not represent a barrier to movement across it (i.e., an animal could cross over it on a fallen log, hop over on stones, wade through shallow water, or run across via branches in the canopy, etc.), then a total width of 300 feet (150 feet on each side of the stream) would suffice. Conversely, if the stream channel were so wide that crossing it would be difficult or if the stream has been disturbed in any way (e.g., extensive use of the river by motorized watercraft), than a 300 foot width would be required on each side of the stream.[18]

The Massachusetts Department of Fisheries, Wildlife and Environmental Law Enforcement also recommends that riparian forests be at least 330 feet wide to provide some nesting habitat for neotropical-nearctic songbird migrants.

The width required for an effective riparian corridor is dependent upon its length. Effective corridors may be narrow if they are short enough that dispersers[19] may pass through without foraging. The effectiveness of corridors will be affected by the type and extent of human activities and land use practices both within and adjacent to the corridor. Although the basic principles determining the effectiveness of corridors have been established, knowledge of the use of corridors for wildlife movement is extremely limited. Further research is required to determine dispersal patterns and the use of natural corridors before the movement of free-ranging mammals across landscapes can be determined.[20]

It has been determined that individual stream corridors exhibit similar increases in species richness as corridor width increases, but no single width has been established as being an appropriate corridor dimension for all stream types and all species. "Two conclusions have been suggested: 1) appropriate corridor width must be evaluated on a stream by stream basis, and 2) 'width' is an ineffective approach to conserving biological species. Variables which affect how the stream interfaces with the terrestrial landscape (e.g. elevation above stream, stream bank slope) may be better predictors of minimum corridor dimensions."[21] An assessment to determine minimum stream corridor width for biological conservation along mid-order streams in Vermont estimates that a minimum corridor width necessary to achieve 95% of species richness along third-order streams is a conservative estimate that ranges between 433 and 581 feet on each side of the stream.[22]

Stream order is a measure of stream size ranging from the smallest streams (first-order) to the largest streams (e.g., twelfth-order). As stream-order increases, streams increase in width, depth and the amount of water being discharged. Riparian areas along any stream (regardless of order) provide valuable habitat and foraging opportunities for wildlife species.

A series of habitat suitability index models published by the United States Fish and Wildlife Service for a variety of wildlife species including birds, mammals, reptiles and amphibians demonstrates a need for buffer widths between 10 and 350 feet on each side of the stream depending on the particular resource needs of individual species.[23]

Methodology

Although review of the scientific literature illustrates that there is no “ideal” width for all riparian areas, a common recommendation is that a width of at least 300 feet be preserved along both sides of all streams regardless of stream order. Although 300 feet is sometimes viewed as a relatively conservative estimate, it ensures adequate protection of habitat and movement corridors for a wide variety of wildlife species.

For this methodology, it is recommended that an unobstructed 300 foot width be used in the mapping process. In order to ensure the unobstructed width, it is recommended that 150 feet on each side of all first and second order perennial (meaning that they carry water all year long) streams, and 300 feet on each side of all third order streams and above, be designated for wildlife passage protection. However, prior to utilization of these widths in the mapping process, technical advice from several agencies (including the United States Fish and Wildlife Service, the NJDEP Endangered and Nongame Species Program and the United States Department of Agriculture – Natural Resource Conservation Service) is being sought to ensure that these recommendations are appropriate and justifiable.

3.0 HYDROLOGICAL FUNCTIONS AND VALUES OF RIPARIAN AREAS

3.1 Floodplains

Discussion

Vegetated riparian areas are valuable for floodwater storage and help minimize large magnitude floods. Riparian areas with undeveloped floodplains provide overbank storage for floodwaters, which slows the water velocity and thereby reduces the height and velocity of floodwaters downstream. The floodplain also serves as a natural reservoir, slowly releasing water into the stream to help reduce flood peaks downstream.[24] Natural riparian areas also reduce the potential for erosion of stream banks and adjoining floodplains, which helps in preventing sedimentation of the stream.[25] To protect again floods, Wenger recommends that the riparian area include the entire floodplain and be as wide as possible to include all adjacent wetlands.

Schueler[26] suggests that the riparian area should fully incorporate all lands within the 100-year floodplain, and be extended in other areas to include adjacent wetlands, steep slopes or critical habitat areas. Gregory and Ashkenas also recommend including the entire 100-year floodplain in order to provide adequate flood control during major flood events.[27]

According to the NJDEP Land Use Regulation Program for Stream Encroachment, a floodplain is defined as "the area adjacent to a stream, lake or pond, which is covered by floodwater when it rains. This area can shrink or expand depending on how much it rains. In general, the regulated floodplain is the area that would be covered by water during the '100 year storm' - a storm which has a 1 in 100 chance of occurring in any one year period. The NJDEP also regulates areas designated as floodways. A floodway is defined by the NJDEP as "the channel and portions of the flood plain adjoining the channel which are reasonably required to carry and discharge the regulatory flood. The floodway refers to both the delineated floodway on State Adopted Studies and the area between the encroachment lines located on both sides of a non-delineated watercourse."

Methodology

Review of existing literature indicates that the 100-year floodplain should be included in the definition of riparian areas. Review of existing literature did not indicate any studies which referenced inclusion of the 500-year floodplain. For the purpose of this study, the riparian area will include the 100-year floodplain, the designated floodway, and any areas otherwise prone to flooding.[28]

3.2 Steep Slopes

Discussion

"The slope of the land on either side of the stream may have the greatest influence on the effectiveness of a riparian area in trapping sediment and retaining nutrients. The steeper the slope, the higher the runoff velocity and the less time it takes nutrients and other contaminants to pass through the [area], whether attached to sediments or moving in subsurface flow. Slope is a variable in virtually all riparian models and should definitely be included in a formula for calculating [riparian area] width."[29]

Through his scientific literature review, Wenger found that any cutoff point for steep slopes will be somewhat arbitrary, but 25% appears to be reasonable given the range of slopes recommended by other researchers. Recommendations for classifying a slope as a steep slope ranged between 10% and 40%. Therefore, Wenger's recommendation was to increase the riparian area width (whatever that fixed width is determined to be) by 2 feet for each slope percent up to 25%. Slopes steeper than this are not credited toward the riparian area width.

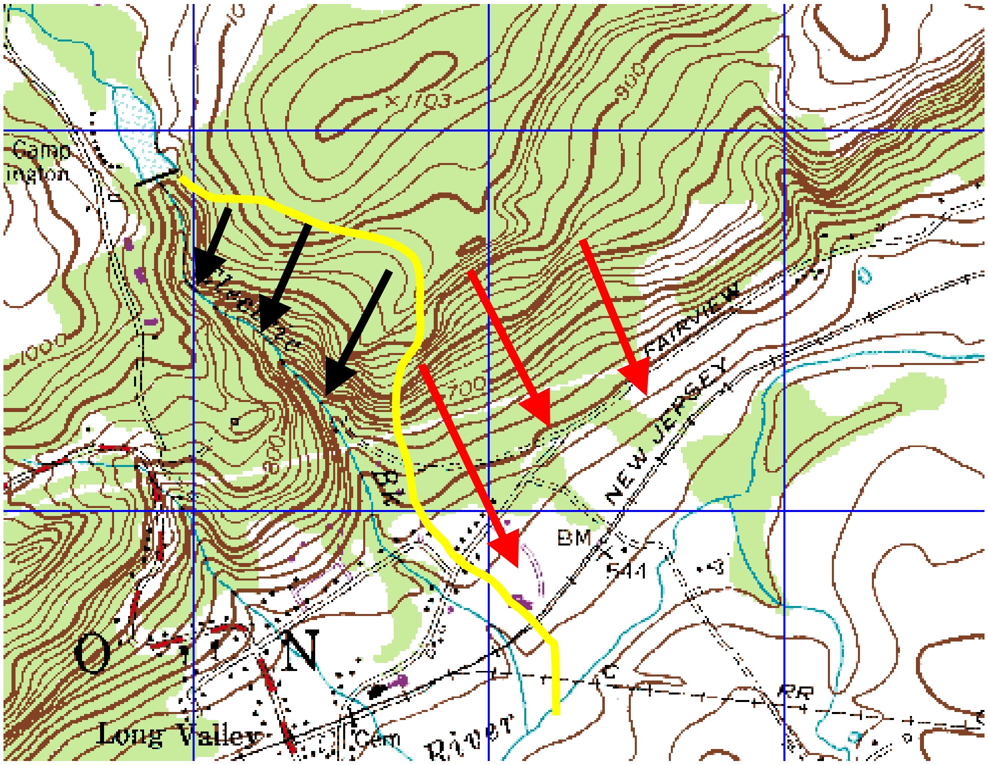
Wenger cites three options for determining riparian area widths for steep slopes. The first option is a very conservative approach, which includes a 100-foot width plus 2 feet for every 1% increase in slope. The second option includes a 50-foot width plus 2 feet for every 1% increase in slope, and the third option is a fixed width of 100 feet.

Other recommendations for calculating steep slopes include the Maryland Department of Natural Resources Forest Service's calculation which recommends a riparian area width of 50 feet for flat ground and an increase in width by an additional 4 feet for every 1% increase in slope. Schueler recommends adding an additional four feet for every one percent increase of slope above 5%.

Methodology

The slope percentages discussed above are based on a regulatory buffer concept used for the management of riparian areas. The purpose of this methodology however, is to characterize riparian areas, not manage them. Therefore, the percentages discussed above may be useful during the management phase of this project, but are not appropriate for use in this report. Therefore, a decision has been made to characterize steep slopes as 15% or greater, based on common use of this value in New Jersey ordinances for storm water management and zoning. According to the storm water ordinances, slopes of 15% or greater generally require additional storm water control measures to effectively filter and control storm water runoff.

Determination of riparian area width for the Basin will be dependent on a variety of factors and will not be based solely on slope steepness. For the purpose of this study, riparian steep slopes will be identified as any slope greater than 15% that directly impinges on a riparian area as defined by any other parameter. Downhill gradient lines will be examined through GIS analyses, and those slopes that do not directly flow to a riparian area will be excluded from the mapping process. Steep slopes that are directly adjacent to waterways or directly adjacent to any other riparian feature associated with the waterway will be mapped. An example of a steep slope that would be included in the riparian area definition is illustrated in the graphic below. The arrows indicate the direction of a flow from the top of the slope.



Yellow Line = Width of Riparian Area
Black Arrows = Steep Slopes included within Riparian Area
Red Arrows = Steep Slopes not included within Riparian Area

4.0 SOIL DYNAMICS OF RIPARIAN AREAS

Discussion

Soils consisting of silt or clay particles that have not been compacted are typically ideal for vegetative growth. Soils with granular or crumb-like consistencies promote percolation of water and air and help reduce erosion. Conversely, compacted soils slow or prevent surface water infiltration which is a limiting factor for plant growth, and in turn affects the amount of food and cover available for wildlife.[30]

According to Wenger, "[s]oil characteristics determine in large part whether or not overland flow occurs, how fast water and contaminants move to the stream [or ground water regime], and other factors relevant to the effectiveness of the riparian zone.

However, determining soil characteristics on a large scale can be somewhat problematic due to the inherent limitations of soil survey maps."[31] Wenger recommends that it is reasonable to consider very general soil characteristics, such as frequently flooded or hydric soils and the overall hydrology of an area.

Methodology

All soils classified as hydric soils and alluvial soils that are directly adjacent to surface waters within the Basin will be included in the riparian area definition. In addition to mapping the hydric soils, a query will be conducted using the metadata from the county soil surveys to identify all soils in the Basin with a seasonal high water table within 1.5 feet of the ground's surface.

5.0 WATER QUALITY/FILTER ZONE FUNCTIONS OF RIPARIAN ZONES

Discussion

Vegetated riparian areas and adjacent wetlands operate as filter zones that can prevent the direct flow of sediment, phosphorus and nitrogen into streams. Excessive nutrients such as phosphorus and nitrogen compounds cause explosive growth of algae and rooted aquatic vegetation, the death of which can deplete oxygen in the water and restrict the activity of aquatic organisms. This process can drastically change ecosystems.

Excessive phosphorus in a stream leads to an overgrowth of algae and other aquatic plants. This increase in algae is referred to as eutrophication which is a process that adversely affects water quality when algal growth interferes with the amount of sunlight reaching submerged aquatic plants. The lack or absence of sunlight prevents photosynthesis in submerged aquatic plants, which causes them to die. Since the bacteria that decompose the dying plants maintain a high oxygen demand, the dissolved oxygen levels in the stream drop abruptly, which causes fish and other aquatic life to die or relocate.

Other factors contributing to decreased oxygen levels in streams include the excessive deposits of silt, sediment and detritus (leaves, limbs and fruit that fall from streamside vegetation) contained in surface water runoff. Streams containing shallow areas with a rocky or gravelly substrate (i.e., riffles) generally are well oxygenated. However, when increased sediment loads enter the stream, the consistency of the substrate changes, which decreases dissolved oxygen levels and changes available instream habitats utilized by macroinvertebrates and other aquatic species.

Another factor affecting the amount of dissolved oxygen in a stream is water temperature. Cold water is able to hold more dissolved oxygen. Therefore, increases in water temperature are considered a form of thermal pollution because of the direct effect on aquatic life. Shading of the stream by a vegetated riparian corridor will help to keep the stream cool, which increases dissolved oxygen levels and lowers the stress on fish and aquatic macroinvertebrates. It is recommended that a 50-foot forested riparian area be preserved along stream channels to maintain proper stream temperature and provide woody debris inputs to the stream as food for aquatic species.

Riparian corridors also reduce the amount of nitrogen entering the stream directly or via shallow ground water flow. Nitrogen applied to farmland or lawns as fertilizer or found in animal waste is water-soluble and transforms to nitrate in runoff. Since nitrate does not attach to soil particles (as phosphorus does), it can leach into ground water and streams. Nitrogen is generally not considered a problematic nutrient in fresh waters; however, excessive nitrates in a stream can sometimes contribute to eutrophication. As a contaminant, nitrates can increase water treatment costs. A riparian corridor will impede and intercept runoff from rain events and shallow ground water flows. Once the runoff and shallow ground water flow enters the riparian corridor the nitrates can be transformed by bacteria for consumption by the corridor's vegetation.[32]

Sediment deposition is a natural process that takes place during storm events (periodic flooding). Accelerated upland erosion can increase sediment deposition in riparian and wetland areas because of downslope movement of dislodged soil material. Such deposition can change the soils, drainage, and vegetation associated with riparian or wetland areas. Riparian vegetation also reduces sediment and nutrient transport in a number of ways. Roots, especially those of woody vegetation, help stabilize stream banks by holding soil intact. Vegetation also increases hydraulic resistance to flow, thereby lowering flow velocities and causing sediment deposition.[33]

Finally, the trees and plants that make up the riparian area also contribute to the health of the stream by providing food to aquatic organisms. Detritus that accumulates on the bottom of streams provide food for bacteria, fungi, and macroinvertebrates (cumulatively called benthic detritivores), which form a basis of the aquatic food chain. Studies have found that native plant species may be more beneficial: replacing leaves from native species with leaves from foreign species has an adverse effect on the survival of leaf-eating mayfly larvae.[34]

A 100-foot riparian area width is generally recommended for reducing nitrate and phosphorus concentrations from surface and ground water runoff, while a 50-foot width has been determined to be sufficient under certain conditions.[35] Wetlands are also sites of high denitrification activity so the establishment of a fixed riparian area width for the passage of wildlife and the protection of wetland areas will provide adequate filtration of ground and surface water runoff within the Basin. A riparian area of 100 feet is also wide enough to trap sediments under most circumstances, although riparian areas should be extended for steeper slopes.[36]

Methodology

For the Raritan Basin, a riparian area of 100 feet on each side of all streams will be designated as the water quality filtration zone. Of the 200 foot wide area, 50 feet on each side of the stream will be considered important for stream shading and the maintenance of cooler instream temperatures. The area designated as the water quality filtration zone will be included within the designated wildlife passage area discussed above.

6.0 BARRIERS AND ALTERATIONS TO STREAM FLOW

6.1 Dams

Discussion

The fragmentation and alteration of streams by humans have dramatic effects on ecosystem integrity and biological diversity.[37] Human created barriers including dams fragment aquatic ecosystems by blocking access of migratory fish and the free movement of other aquatic species to upstream spawning areas. Instream fragmentation contributes to losses of aquatic species and the integrity of aquatic ecosystems. Water impoundments such as dams not only fragment habitats, but also contribute to local extirpation of species and losses in genetic diversity.

Methodology

"Dams" coverage available from the NJDEP will be used to map the location of stream flow obstructions that create barriers to the upstream movement of fish and other aquatic species.

6.2 Road Crossings

Discussion

Road crossings are perhaps one of the most potentially damaging barriers to riparian corridors due to the breaks they cause in streamside vegetative cover. The more fragmented a riparian area, the wider the area should be in order to perform its desired functions such as controlling stream flows and filtering surface and ground water runoff. The length or connectivity of the riparian corridor is as important as its width.[38]

Roads can be significant barriers to the movement of small vertebrates and invertebrates in terrestrial ecosystems as well as to aquatic life. Instream culverts constructed for road crossings can impede the passage of aquatic life.

Roads fragment large populations into smaller populations, thereby making them more susceptible to extinction. Wildlife species that attempt to cross highways are often struck and killed by automobiles – a large source of mortality for many species. In addition, culverts constructed as part of a road crossing also impede passage of aquatic life. Due to increased development along streams, individual species are less able to travel from one habitat to another.[39]

Methodology

According to a stream study conducted by May et al.[40], it was recommended that road crossings be limited to less than 2 crossings per kilometer (2 per 0.62 miles) of stream length, thereby maintaining a nearly continuous riparian corridor. For this methodology, road crossings will be evaluated and mapped using available GIS data. The number of crossings per linear mile will be counted and compared with the recommendation by May et al. in an effort to determine riparian integrity throughout the Basin.

6.3 Managed Streams

Discussion

Approximately 98% of all streams in the United States have been altered in some way, either by fragmentation due to dam construction or by water diversion projects.[41] Segments of streams throughout the Raritan Basin have been subject to managed flows, discharges and substantial water withdrawals. Specific streams with managed flows in the Basin include Spruce Run, South Branch of the Raritan River downstream of Spruce Run Reservoir, Rockaway Creek, the Lower Lamington River, North Branch of the Raritan River below the Lamington, the main stem of the Raritan River below the confluence of the North Branch and South Branch of the Raritan River, and the Delaware and Raritan Canal.

Methodology

For the purpose of this methodology, sections of streams with regulated flows will be identified using available data from the United States Geological Survey and the New Jersey Water Supply Authority and will be mapped as "flow managed segments." A comparison will then be made between managed and unmanaged streams to determine the number of "natural" streams that still exist within the Basin.

7.0 ASSESSING THE HEALTH OF RIPARIAN AREAS

Discussion

A healthy riparian area has a stable dimension, pattern, and profile that fits the natural geomorphology (land form) of the surrounding landscape. Stable natural channels tend to be winding and relatively narrow with little exposed or eroding stream bank, and access to an active floodplain.[42]

In a broad sense, the "health" or "integrity" of a riparian area may be defined as its ability to perform its normal functions. These functions include nutrient and sediment filtration, stream bank stabilization, water storage, aquifer recharge, habitat for fish and wildlife, protection against erosion, maintenance of proper stream temperature and dissolved oxygen content, and preservation of open space. Evaluating riparian integrity also requires consideration of upstream and adjacent land use areas.[43]

Conditions of vegetation along streams is a major component of the integrity of riparian ecosystems. Vegetation along streams help to protect stream banks from erosion during high flow events; influences bank morphology; and aids in the reduction of stream bank damage from natural elements such as ice, log debris and animal trampling. Vegetation along stream channels also creates shade cover over streams and helps maintain cooler water temperatures thereby preventing excessive temperatures, which can be harmful to macroinvertebrates and various fish species.[44]

The ability of riparian areas to filter out nutrients and improve water quality is also a factor in determining riparian integrity. Functional riparian areas control nonpoint source pollution from adjacent lands by trapping sediments and nutrients such as phosphorus and nitrogen in the soil that are carried by storm water during rain events.

Riparian areas also provide the availability of water, shade and foraging abilities for livestock. However, improper livestock use of riparian areas can affect the streamside environment by changing, reducing, or eliminating vegetation bordering the stream and resulting in soil compaction. Excessive livestock grazing results in alterations to channel morphology, volume of water flow, sedimentation and overall stream health.[45]

Stream channels with impaired riparian zones or those entirely without riparian areas suffer tremendously. Riparian areas that have been ecologically damaged, bisected with ditches or pipelines, or replaced by impervious surfaces including paved areas and parking lots do not provide any benefits to the stream channel or its existing biota. According to the Center for Watershed Protection, it has been estimated that sensitive stream elements are lost from a system when impervious cover amounts in a watershed reach 10%.[46] Impervious cover decreases infiltration rates which result in increased stormwater runoff amounts. The majority of landowners with streams and ponds within their property boundaries simply do not know the warning signs of a stressed riparian area or what can be done to improve the areas.

Indicators of a healthy stream ecosystem include evidence of both aquatic and terrestrial life; streams are cool, clean and oxygenated and are not cloudy or choked with sediment or algae; have vegetated floodplain areas and stream banks that do not appear to be eroded or undercut with exposed soil; and if left to their own accord, need little or no intervention. However, those streams showing signs of stress may need help and require little more than the control of invasive, non-native plants. Where severe erosion exists, however, more intense restoration activities may be warranted.[47]

Riparian areas have greater than normal soil moisture, are more productive than surrounding upland areas, and provide cover, nesting habitat, and water for wildlife species. The definition of a riparian area must therefore consider the importance and integrity of riparian and wetland communities and develop conservation strategies for these areas.

Methodology

Although riparian health is best determined through a series of field surveys and analyses, time restraints and lack of resources for the project will prevent field analyses for the 1,100 square mile basin. Integrity of the Basin's streams will therefore be assessed using a review of existing land use and land cover data published by the NJDEP for 1986 and 1995 respectively. The NJDEP data will allow for a comparative analysis of present riparian area conditions with riparian area conditions from approximately a decade ago when land development was at a high peak.

Land use/land cover data from the NJDEP will be used also to determine the percent "crown closure" and the percent impervious cover of riparian areas throughout the Basin. Generally, the greater the percent crown closure (10 to 50 percent or greater) and the lower the percentage of impervious cover, the higher the integrity of the riparian system.

This analysis will assist in determining specific locations throughout the Basin that have lost significant amounts of vegetated cover associated with riparian areas and stream channels. Data will also be used to assess areas of the Basin that require immediate attention with regard to maintaining and improving stream health. The assessment will allow for an identification of areas where riparian widths thought to be important (e.g., areas formerly containing hydric soils and wetlands in their natural state) have been reduced through land use changes. Available land use information from the past several decades will also be examined to help determine what percentage of the Basin has been developed, and to determine the integrity of remaining riparian areas.

The integrity of the Basin's riparian areas will be assessed using the following land use/land cover parameters:

- Adjacent wetlands (comparison of percent streamside wetlands in developed and undeveloped riparian areas);
- Wildlife passage corridors (determination of how much of the 300 foot riparian area width is intact throughout the Basin);
- Floodplains (determination of how much of the 100-year floodplain still exhibits natural vegetation [or is undeveloped] throughout the Basin)
- Steep slopes (percent of steep slopes in undeveloped condition throughout the Basin);
- Soils (percent of hydric soils in undeveloped condition);
- Dams (comparison of number of flow obstructions in developed and undeveloped riparian areas);
- Roads (number of crossings will be counted and compared with the recommendation of 2 crossings per 0.62 miles of stream length);
- Managed streams (comparison of the stream miles of managed and unmanaged streams to determine the number of unmanaged streams within the Basin);
- Percent crown closure (areas with 10-50% or greater);

- Percent impervious cover (comparison of % impervious cover in developed or disturbed areas with "natural" or undeveloped areas).

In order to compare the overall integrity of riparian areas throughout the Basin, an assessment will be made using a range of values for each of the parameters listed above. A quintile scoring system (i.e., 0-20, 21-40, 41-60, 61-80 and 81-100) will be used to rate the integrity of existing riparian areas. For example, a riparian area with a low percent crown closure, high percent impervious cover, and a large number of dams, road crossings and managed streams would receive a low rating which would be indicative of a highly stressed riparian system. The lower the rating, the lower the integrity of the area. A matrix will then be created to compare all of the Basin's riparian areas (minimum area of determination will be at the subwatershed [or HUC-14] level).

8.0 CONCLUSION

The methodologies discussed above represent a method for defining, characterizing and mapping the riparian areas of the Raritan Basin. Identifying the extent to which riparian areas exist is important for determining which areas of the Basin contain intact riparian areas, which areas are at risk for impairment, and which areas have been stripped of their natural vegetation and converted to impervious cover. The identification and characterization of the Basin's riparian areas will later be used to make recommendations for areas needing improvement or protection from further degradation. Table 1 below provides a summary of the methodologies for all of the parameters discussed above.

TABLE 1
SUMMARY OF METHODOLOGIES FOR DEFINING RIPARIAN AREAS

Parameter	Mapping Methodology
Wetlands	Areas 1-acre or larger and directly adjacent to streams.
Wetland Transition Areas	150 feet along wetlands of trout production and fresh water (FW) 1 streams; 50 feet along intermediate resource value wetlands.
Wildlife Passage Corridors	150 feet on each side of all 1st and 2nd order streams; 300 feet on each side of all streams 3rd order and above.
Floodplains	100-year floodplain; NJDEP designated floodways; and flood prone areas.
Steep Slopes	Slopes greater than 15% that flow directly down to other riparian components of a waterway.
Soils	All hydric soils and alluvial soils directly adjacent to a waterway. Soils with a seasonal high water table within 1.5 feet of the ground's surface will also be included.
Water Quality	100 feet adjacent to each side of all stream channels (included within the designated wildlife passage area).
Dams	All water obstructions included in NJDEP Dam Coverage Data.
Road Crossings	To be determined from NJDEP Land Use/Land Cover Data.
Managed Streams	Sections of flow managed by the USGS and NJWSA will be identified and mapped.
Riparian Health	To be determined from NJDEP Land Use/Land Cover Data.

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[6] Montgomery County Planning Commission, 1997
[7] USFWS, 1997
[8] Baker N., et al, 1997
[9] Buffer as it is referred to by the University of New Hampshire is considered to be *part of* the riparian area, not an add on to the riparian area.
[10] A bog is a peat-accumulating wetland consisting primarily of mosses that has no significant inflows or outflows (Mitsch and Gosselink, 1993).
[11] A fen is a peat-accumulating wetland that receives some drainage from surrounding mineral soil and usually supports marsh-like vegetation (Mitsch and Gosselink, 1993).
[12] Schloss, J.A. and F. Mitchell, 1996
[13] Schloss, J.A. and F. Mitchell, 1996
[14] Wenger, 1999
[15] MA Department of Fisheries, Wildlife and Environmental Law Enforcement, 1997
[16] Wenger, 1999
[17] Wenger, 1999
[18] Cohen, R., 2000
[19] Dispersers are species of wildlife that find and utilize specific corridors for movement patterns after birth to locate unoccupied areas with suitable habitat in which to maintain permanent populations. Dispersal patterns are strongly affected by the level of predation risk (Harrison, R.L., 1992).
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[28] Flood prone areas are defined as areas that are purported to be 100-year flood prone areas based on the NJDEP's definition (N.J.A.C. 7:13-1.2).
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