## ISSUE 2: WATER QUALITY AND QUANTITY

Kentucky's forests are a vital resource in and of themselves, but they also play a key role in protecting another major resource – water. Forests provide many helpful physical, chemical, and biological functions that improve the water quality and quantity in streams, rivers, lakes, and even the karst waterways of the Commonwealth. Some of these benefits include bank stabilization, reduction of sedimentation and undesirable nutrients, shading of streams, slowing the water velocity, and providing habitat and food for aquatic organisms.

These benefits are crucial considering the current status of Kentucky's waterways. Of the assessed streams and rivers, 62% were found to be impaired.[53] Most impairment was due to habitat-related changes.[53] In particular, impacts to the forested area bordering streams and rivers, called the riparian zone, were frequently the direct or indirect cause of stream impairment. Thus, the loss of forested resources has significantly impacted Kentucky's streams.

Threats to forest resources are numerous, including human as well as natural factors. In order to maintain or increase the beneficial effects of forest resources upon the waters of Kentucky, the retention and expansion of forested areas in riparian zones, wetlands, lake and pond borders, and above extensive karst features are key. Although threats to these resources remain, opportunities for conservation and restoration of these areas are increasing with increased public awareness of the beneficial influence of forests on water resources.

### *A. Current Status of Waters in Kentucky*

Kentucky is home to over 49,000 miles of streams and rivers and over one million acres of lakes, ponds, and reservoirs, including some of the largest man-made lakes in the nation. These waterbodies provide boating, fishing, and swimming recreation, they support industry, generate energy, provide drinking water, and support numerous aquatic species. The karst groundwater system of Kentucky has formed the world's longest cave system at Mammoth Cave National Park. The waters of Kentucky are one of its most valuable resources.

Kentuckians withdraw waters for a variety of uses. According to a 2005 data, 4,343 million gallons per day (MGD) of water are withdrawn from Kentucky waterways, with 3,430 MGD used for thermoelectric power, 558 MGD for public water supply, and 186 MGD for industrial use.[54] A large number of Kentuckians also withdraw from the abundant groundwater present in the karst topography underlying 55% of Kentucky's lands. Groundwater is used for drinking water by an estimated 400,000 private landowners and over 1.2 million Kentuckians through public groundwater systems.[55]

The waters of Kentucky are also home to a vast, interconnected web of life including mayflies and crayfish, trout, darters, bass, river otter, kingfishers, red-eared sliders, and mudpuppies. Of the 37 federally threatened and endangered species in Kentucky, 20 are strictly aquatic and three require aquatic-related habitats. Some of these species are found nowhere else in the world. The aquatic wildlife is important biologically, but it is also important economically. According to a 2006 survey, the total hunting and fishing economy of Kentucky brought in $1.9 billion dollars with $855 million in revenues due to fishing alone.[56] Canoeing, kayaking, boating, swimming, and other recreational uses of Kentucky's lakes and rivers also bring important economic revenues to the state. For example, the city of Somerset is widely known as the "houseboat capital of the world," with several large houseboat manufacturing plants, an industry that arose from nearby Lake Cumberland.

Despite the importance of water as a resource, both water quality and quantity have become a concern in many areas throughout Kentucky. Although only 12% or 10,553 of the 90,961 miles of Kentucky's streams and rivers had been assessed as of 2008, 6,562 miles or 62% were found to be impaired.[53] These impaired waterbodies are shown in Figure 13. The leading causes of water pollution in Kentucky are 1) sedimentation, 2) pathogens, 3) nutrient/eutrophication biological indicators, 4) habitat disturbance, and 5) unknown causes. The leading sources of impairment are 1) habitat-related sources, 2) agriculture, 3) urban or municipal sources, 4) unknown sources, and 5) mining. Specifically, loss of riparian habitat, the forested area bordering streams and rivers, is the most common source of impairment, cited as the probable source of 1,334 miles or 21% of the listed impairments. Indirectly, loss of riparian habitat occurs frequently in impairments listed for agriculture, urban, municipal, and mining sources. Silviculture practices were cited on only 6% of impaired streams. The impairment of Kentucky streams also has implications for downstream waterbodies, such as the Gulf of Mexico.[57]

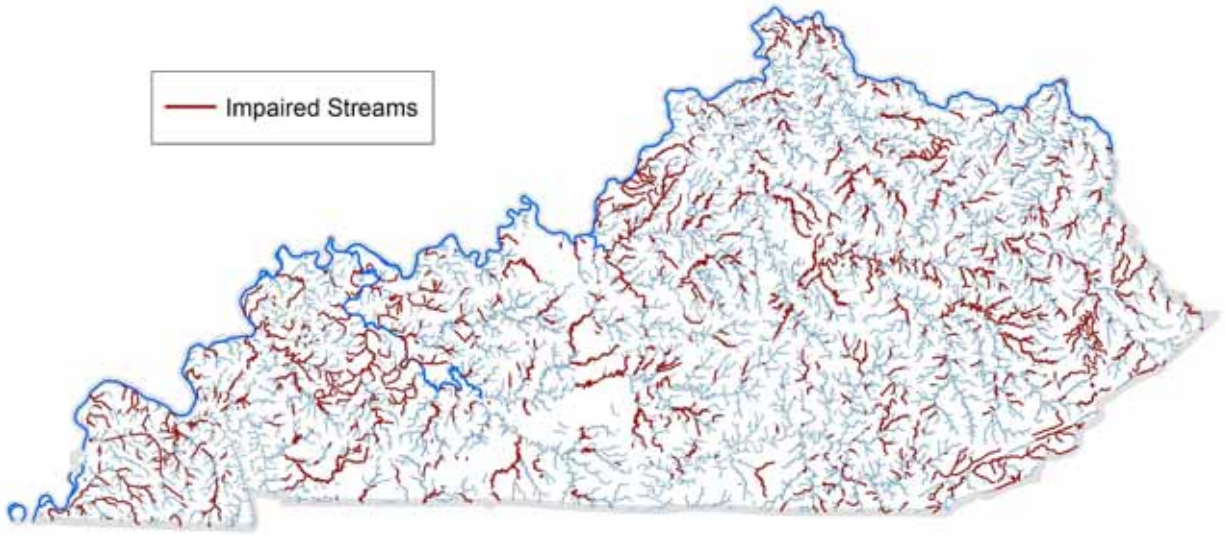



FIGURE 13 – IMPAIRED STREAMS OF KENTUCKY

Although 42% of Kentucky's lakes, ponds, and reservoirs by number and 27% by area show impairment, the causes and sources of impairment show much less correlation to forest resources. In these lakes, ponds, and reservoirs, methylmercury and mercury in fish tissue are by far the greatest causes of impairment according to the Kentucky Division of Water (KDOW).[53] The most common sources of impairment for ponds, lakes, and reservoirs are listed as 1) atmospheric deposition of toxics, 2) unknown sources, 3) upstream sources, 4) agriculture, and 5) industrial point source discharge.[53]

While many waterbodies are impaired, others with excellent water quality in the state are afforded various levels of special protection. Seven categories of "Special Use Waters" are identified under Kentucky Administration Regulations for such protection. These Special Use Waters include Cold Water Aquatic Habitat (CAH), Exceptional Waters, Reference Reach Waters, Outstanding State Resource Waters, Outstanding National Resource Waters (ONRW), State Wild Rivers, and Federal Wild and Scenic Rivers. These designations are due to the ability to support trout populations, uniqueness, exceptional water quality, and representativeness of primitive conditions. Specifically, the CAH designation indicates surface waters and associated substrate that will support indigenous aquatic life, or self-sustaining or reproducing trout populations, on a year-round basis (401 KAR 10:031, Section 4). The OSRW surface waters are designated by the cabinet pursuant to 401 KAR 10:031, Section 8, and includes certain unique waters of

the Commonwealth. As shown in Figure 14 below, the watersheds surrounding the ONRW and CAH waters have a mean percent forested area of 65% with some areas having as much as 97.7% forested areas. Much of the watersheds with less than 25% forested area are located in the Lower Cumberland Basin, which was historically prairie. Although each of these waterbodies is protected for different reasons, the high quality waters of Kentucky consistently feature watersheds with large areas of forestland.

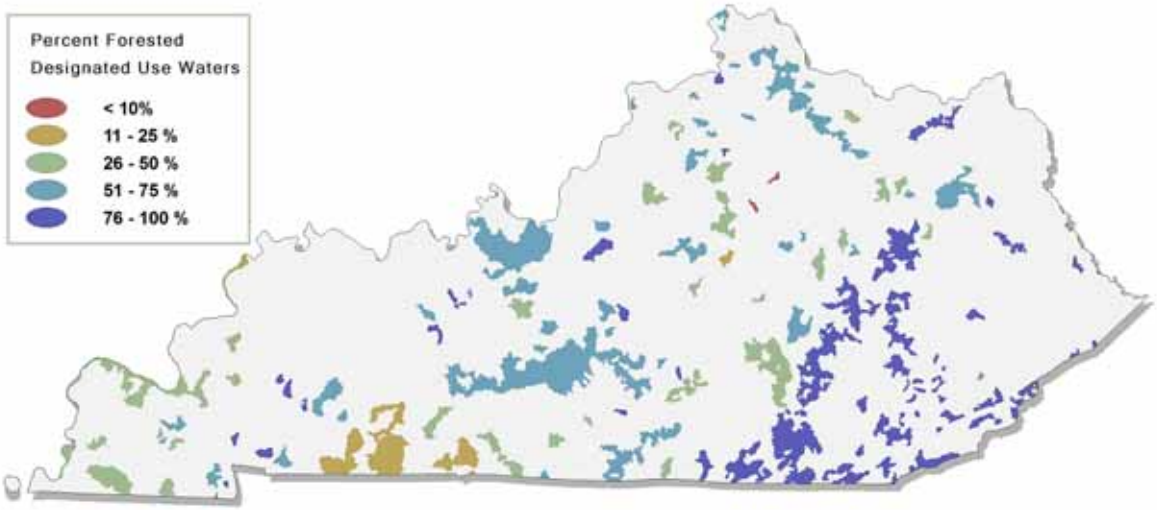



FIGURE 14 – PERCENT FORESTED COVERAGE OF OUTSTANDING NATIONAL RESOURCE WATERS AND COLD WATER AQUATIC HABITAT WATERSHEDS

While impairment is a problem with streams and rivers, loss is a problem associated with the state's wetlands. From the 1780s to the 1980s it is estimated that the 1,566,000 acres of wetland in Kentucky were reduced to 300,000 acres, an 81% reduction.[58] According to most recent estimates, of the 404,500 acres of wetland in Kentucky (National Wetland Inventory mapping) 85%, or almost 346,000 acres, are forested (based on overlays of Forest Class from the 2001 National Land Cover Dataset). The location of these wetlands is shown in Figure 15. Performing critical flood control, water storage, erosion reduction, and nutrient filtration functions, the loss of these wetland areas, particularly the forested wetlands, has been detrimental to the overall water quality of the Commonwealth.

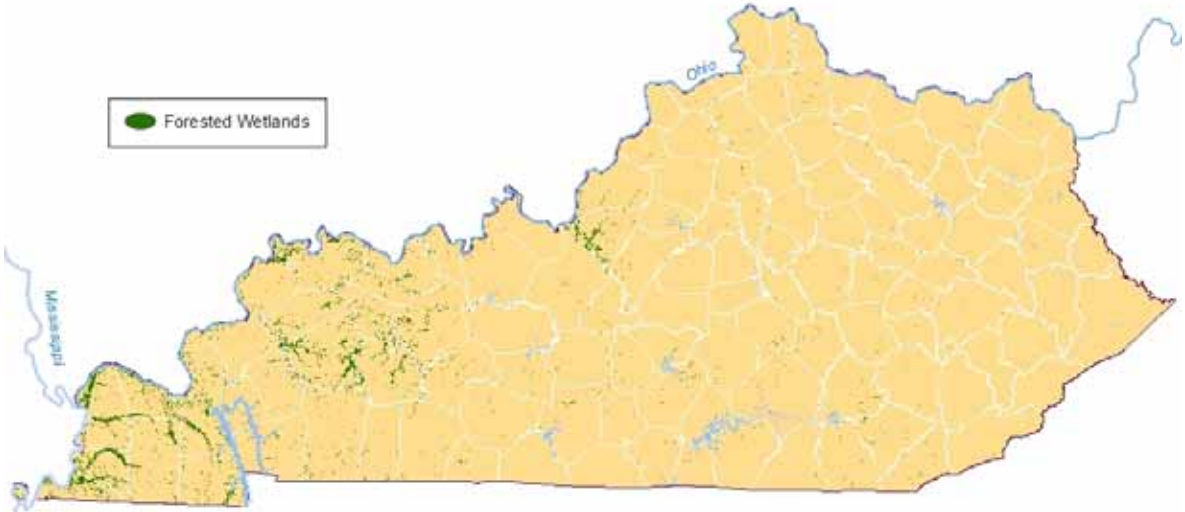



FIGURE 15 – FORESTED WETLANDS OF KENTUCKY

Thus, water quality assessments have found that impairments are often due to a lack of forest resources, while Special Use Waters consistently feature dense forest resources, which indicates a strong correlation between forestland and clean water. While natural occurrences such as tree falls can cause water quality impacts such as erosion or sedimentation, these impacts are typically short-lived and less extensive than impacts from other land uses.[59] Also, forest resources purify water and stabilize streambanks and aquatic habitat as well as the volume of water entering the stream system.

### *B. Forest Resource*

Each individual tree is capable of providing important water quality and quantity benefits. One of the primary benefits is the reduction of nonpoint source pollution. Unlike water pollution from the end of a pipe, nonpoint source pollution comes from many sources such as polluted runoff and is the most common type of pollution.

Whether in an urban or rural setting, trees reduce nonpoint source pollution by decreasing runoff. They also increase groundwater flows by increasing infiltration and subsurface storage. Trees reduce sediment loads from landscape and channel erosion, reduce thermal shocks to streams through their cooling effects, and aid in cloud formation due to evapotranspiration. The organic matter in leaves serves as a food source to stream ecosystems and trees reduce pollution by root absorption of nutrients and chemicals. A tree in any area is capable of producing these benefits, but the greatest benefits are provided from riparian zones, forested wetlands, and large forested blocks.

#### *1. Riparian Zones*

Riparian zones are forested lands bordering streams and rivers that provide numerous water quality benefits. The canopy coverage provided by trees in riparian zones shades the stream, decreasing the water temperature. The shading also suppresses algal blooms, and the fish kills often associated with them, in areas where nutrient levels are high.

Exposed riparian tree roots provide a home for aquatic species and armor to stream banks against erosion and sedimentation impairments. Increased root depth, density, and surface cover decrease the amount of bank loss from erosion. When forest riparian vegetation is removed without proper Best Management Practice (BMP) implementation or reforestation, streambanks often collapse and channels widen and/or deepen. Sequestration of nutrients such as nitrogen and phosphorus are also provided by riparian vegetation. Undeveloped riparian lands remove 50-95% of nutrients and pesticides, 60-96% of pathogens, and 75-95% of sediment approaching rivers or streams. These processes vary by the width of the riparian zone, its slope, its soil type, and the amount, density, and type of vegetation in the zone.[60]

#### *2. Forested Wetlands*

The effect of wetlands on water quality and quantity depends on location, elevation, vegetation abundance and type, soil type, root structure, and the local climate among other factors. In general, wetlands provide benefits such as flood storage and stormwater surge reduction, alterations of precipitation and evaporation levels, maintenance of water quality, and erosion reduction. Forested wetlands are particularly important due to the large volumes of water that the root systems are capable of uptaking and storing.

Acting as natural sponges, wetlands absorb water and slowly release it back into the stream or groundwater system. One estimate indicates than an acre of wetland can store as much as 1 - 1.5 million gallons of floodwater.[61] Historically, when bottomland hardwood wetland forests were more prevalent along

the Mississippi River, they were capable of storing 60 days of floodwater, but now can store only 12 days, resulting in more frequent flooding damage.[62] This absorptive capacity of wetlands reduces flood heights as well as water velocity. Wetlands also stabilize temperatures and affect weather patterns due to the moisture retention.

The water quality functions of wetlands are diverse. In streamside wetlands, vegetation slows the water velocity and allows sediments to settle, reducing siltation impacts to the stream. Biogeochemical reactions involving microbes, soils, and vegetation root systems can provide the benefits of lowered concentration of heavy metals, sulfur, nitrogen, and phosphorus. Wetlands have been found to remove 82% of sediment, 61% of total nitrogen, 62% of phosphorous, and 79% of metals (e.g., lead, zinc, iron) from the waters that flow into them.[60] The ability of wetlands to filter and transform nutrients and other constituents has resulted in the construction and use of artificial wetlands in the U.S. and other countries to treat wastewater and acid mine drainage.[63]

Lastly, the vegetation in wetlands, as in riparian areas, can decrease erosion and suspended sediment levels. The decreased water velocity in vegetated wetlands allows sediments from upstream sources to settle out instead of flowing downstream.

#### *3. Large Standing Forest Blocks*

Groundwater is water that is found underneath the soil surface. Most groundwater originates as rainfall that is absorbed into the soil and continues downward until it reaches a saturated zone called the water table. This groundwater typically moves towards surface waters, such as lakes, streams, and wetlands, recharging these areas in times of drought. However, when surface water levels are high the groundwater levels are also increased in what is called "groundwater recharge." In karst areas (areas containing caves, sinkholes, springs, or disappearing streams), surface water can quickly become groundwater, so groundwater is highly susceptible to pollution in these areas.

Forested land provides important benefits to both groundwater and surface water. Forested land absorbs rain, traps and filters pollutants, recharges groundwater, slows storm runoff, sustains late season flows, reduces flooding, maintains watershed stability and resilience, and provides critical habitat for fish and wildlife. Studies show that the percentage of forested land in a source water area is one of the most important factors in determining water quality. The more forested land in a source area, the better the water quality and lower the treatment costs. Watersheds with less forested land have higher water temperatures and also higher levels of fecal coliform, turbidity, and nutrients.[60]

Reduction of forest cover increases water yield while establishment of forest cover decreases yield. Water yield is the amount of surface water and groundwater leaving a watershed. On average, removal of 10% of forest cover was found to increase water yield by 40 millimeters in conifers, 25 millimeters in deciduous hardwoods, and by 10 millimeters in brush and grasslands.[64] While simply removing forest increases the water yield, placing an impervious barrier such as pavement, roofing, or exposed rocks from mining further increases these yields.

### *C. Public Benefit*

Forests and trees, whether urban or rural, should be utilized for the water quality benefits because no other land use can provide the widespread benefits that forest resources can. One national study found that the quality of water draining from forests is typically the best in the nation whether the land is managed or unmanaged. [65] Trees also provide a recreational and aesthetic enhancement to the water resources,

provide habitat for wildlife, increase the water supply, reduce runoff, and reduce the costs of treating polluted water.

### *1. Recreational and Aesthetic Water Benefits*

The combination of forested canopy with clean waterways enhances the recreational value of waterways. In urban areas, these forested waterways can provide park-like areas with bike trails and walkways while on rural lands these areas may be used for hunting or wildlife observation. Often the aesthetic value of riparian corridors can increase real estate value and aesthetic quality, especially when showy, flowering tree species are present.

### *2. Wildlife Habitat Benefits*

Riparian corridors and forested wetlands provide both aquatic and terrestrial habitat and food supply. Falling leaves and twigs are the energy supply for numerous aquatic macroinvertebrates, fish, bacteria, and aquatic fungi. Root wads and large fallen branches provide aquatic habitat. Nesting songbirds, kingfishers, wood ducks, herons, and bats inhabit the branches or protected stream corridors of riparian trees while small mammals, deer, fox, coyote, woodcock, and other animals utilize the terrestrial habitat for travel corridors or den and nesting sites. Fruits and flowers provide food for terrestrial insects and animals. Muskrats and beavers feed directly on riparian vegetation.

The importance of forests in providing aquatic wildlife habitat can be demonstrated through the objectives of the Southeastern Aquatic Habitat Plan.[66] The stated overall goal of this long-term, regional plan for the southeastern U.S., including Kentucky, is "to maintain, restore, and conserve the quantity and quality of freshwater, estuarine, and marine habitats to support healthy, sustainable fish and aquatic communities, and to sustain public use of water resources for the benefit of the citizens of the southeast region and the entire nation." The plan identifies eight primary objectives to accomplish this goal. Of these eight, five can be obtained either directly or indirectly by utilizing Kentucky's forest resources, including:

- Establish, improve, and maintain riparian zones
- Improve or maintain water quality
- Improve or maintain appropriate hydrologic conditions for the support of biota in aquatic systems
- Establish, improve, or maintain appropriate sediment flows
- Maintain and restore physical habitat in freshwater systems

Specific targets of this plan include ensuring "adequate rural/agricultural riparian habitat exists on at least 85% of the lands near rivers and streams" and reducing "the number of acres of freshwater wetlands drained or converted through development annually in the Southeast." The plan also recommends that communities maintain forests because "they save communities millions of dollars in stormwater treatment costs, air pollution, and energy costs."

Kentucky's State Wildlife Action Plan also indicates that forest resources are important for maintaining aquatic habitat. Forestry-related water quality action items in this plan include "Encourage and assist in using, developing, and implementing BMPs, including revision and evaluation as applied to aquatic systems" (Priority Conservation Action #159) and "Identify and implement shoreline and riparian zone habitat restoration projects (planting bottomland hardwood species, establishing riparian buffers)" (Priority Conservation Action #32).[67] Thus, forest resources provide key wildlife resources for the public benefit.

### *3. Stabilize Water Supply Benefit*

Water and forest resources have always shown a strong relationship, recognized even by early settlers. The pioneer botanist F.A. Michaux accounted that in the dense forests of early Kentucky "… thick beds of leaves … [are] speedily converted into mold by the humidity that reigns in these forests."[1] In 1864, George Perkins Marsh wrote, "For when the earth was covered with the forest, perennial springs gushed from the foot of every hill; brooks flowed down the bed of every valley."[68] In 1911, the Weeks Act authorized the purchase of forestlands in the headwaters of navigable streams for the purpose of conserving forests and water supplies.[69] The relationship between forestland and a stable water supply remains clear today. The USFS indicates that 53% of the nation's current water supply originates on forestland versus 26% from agricultural land and 21% from all other land uses, despite the fact that forests occupy only 29% of the surface area.[65] Statistics for Kentucky's water supply origins are not available. As the need for water supply increases, so should the value of forest resources in providing this benefit.

### *4. Benefit of Reduced Stormwater Runoff*

One nationwide study found that impervious cover reduces infiltration of groundwater (*i.e.,* recharge of aquifers) by 6.2 billion to 132.8 billion gallons of water annually per major metropolitan area. While a forestland would absorb this water, on impervious surfaces water moves as runoff at a rapid velocity toward stream channels. One study found that impervious surfaces multiply discharge rates by two to five times. This high velocity water discharge results in flash flooding and water surges, increasing flood damage and erosional scarring of streams. Research shows that a stream becomes "impacted" when only 10% of the land in its watershed is covered by impervious surfaces; it becomes "degraded" (and therefore non-supporting of aquatic life and hydrologic functions) at 25% impervious cover in the watershed and severely degraded at 60% impervious cover.[60] Forestland use has the greatest rainfall absorption capacity of any land use. Thus, the increase in forest cover will decrease the amount of stormwater runoff.

### *5. Water Quality Benefits and Reduced Treatment Costs*

Costs of treating wastewater and stormwater in cities throughout the Commonwealth are escalating as the population increases. Forest-related water treatment options are often overlooked and undervalued as water utility managers focus on infrastructure-related treatment options. However, the value of forest resources as cost-effective water treatment options has been shown throughout the nation. One study estimated that the Congaree Bottomland Hardwood Swamp in South Carolina provided the equivalent filtration of a $5 million wastewater treatment plant.[62] The Southeast Watershed Forum[12] indicates that a 50% urban tree loss in Chattanooga, Tennessee resulted in a 17% increase of stormwater at a cost of $279 million while a 44% loss in Chamblee, Georgia resulted in $129 million in expenses. Tree canopy losses in Atlanta resulted in $240 million in sewer improvement expenses.

In northern Kentucky, a large-scale study in 2009 by Sanitation District No.1 examined water treatment alternatives to correct stream degradation due to sewer overflows. Their analysis compared traditional gray controls, such as water treatment plants, storage facilities, and pipe replacement, to green infrastructure and watershed controls, such as retention facilities, wetlands, riparian buffers, reforestation, tree boxes, and rain gardens among other methods. According to their findings, a model combining a low level of gray controls "with a moderate implementation of green and watershed controls yields greater overall benefits as compared to a gray-only program at a higher level of overflow control." They also concluded "green and watershed controls can provide substantial improvements in water quality relative to their cost."[70]

According to the American Water Works Association, a watershed with only 10% forest has an average annual cost to treat drinking water sources of $923,450. This cost drops to $746,790 if the watershed has

20% forest, to $586,190 if the watershed has 30% forest, to $465,740 if the watershed has 40% forest, to $369,380 if the watershed has 50% forest, and to $297,110 if the watershed has 60% forest. The costs of treating contaminated groundwater supplies average 30-40 times greater than the costs of preventing their contamination, and can be up to 200 times greater.[60] Thus, forests can provide both measurable economic value to water quality and quantity as well as providing indirect and immeasurable benefits in recreation, aesthetics, and wildlife habitat.

### *D. Key Conditions*

In an effort to protect water resources, national and statewide environmental laws have been enacted. Sections 401 and 404 of the Clean Water Act make it necessary to obtain permits from KDOW and the USACAE, prior to beginning most projects that affect streams and wetlands in the U.S. Kentucky's floodplain laws (under KRS 151) are intended to provide proper floodplain management and reduce damages from flooding. Kentucky's Agricultural Water Quality Act was passed in 1994 in order to protect surface and groundwater resources from pollution as a result of agriculture and silviculture (forestry) activities. It applies to all landowners with 10 or more acres and requires that they have a written plan specifying silviculture and agricultural BMPs to be used on their property. The Kentucky Forest Conservation Act (KFCA) applies primarily to commercial timber-harvesting operators and BMP practices to be used in timber cut for commercial purposes. Together, these laws are intended to address some of the most direct threats to water quality and quantity in Kentucky.

However, many of the forest resources that provide the water quality benefits are not covered under jurisdictional law. If Kentucky's citizens value the benefits provided by forest resources on water quality and quantity, additional protection, management, or restoration measures should be taken to improve the conditions under which forest resources provide these benefits. Incentives for forest landowners could be offset by the savings realized in water treatment.

#### *1. Riparian Areas*

Although riparian zones produce many water quality benefits, these benefits are dependent on the width of the riparian area, the size of the stream that it borders, vegetative structure, and density.

Stream ordination is a system applied to designate the size and location of stream systems. One method of stream ordination, as shown in Figure 16, assigns all headwater perennial streams with an order of one, and increases the order at the confluence of streams of equal order. Thus, when two third-order streams combine, a fourth-order stream is produced. As shown in Figure 17, the water quality functions provided by the riparian zone vary by stream order. Riparian corridors on first- and second-order streams, which comprise the majority of Kentucky streams, provide the maximum nutrient removal, shading, and bank stabilization benefits.[71] Fish habitat and aquatic ecosystem benefits are typically greatest for third- and fourth-order streams while flood mitigation benefits of riparian corridors increase as the stream order increases. Sediment control benefits remain relatively constant for all stream orders.

FIGURE 16 – STREAM ORDER DIAGRAM[72]

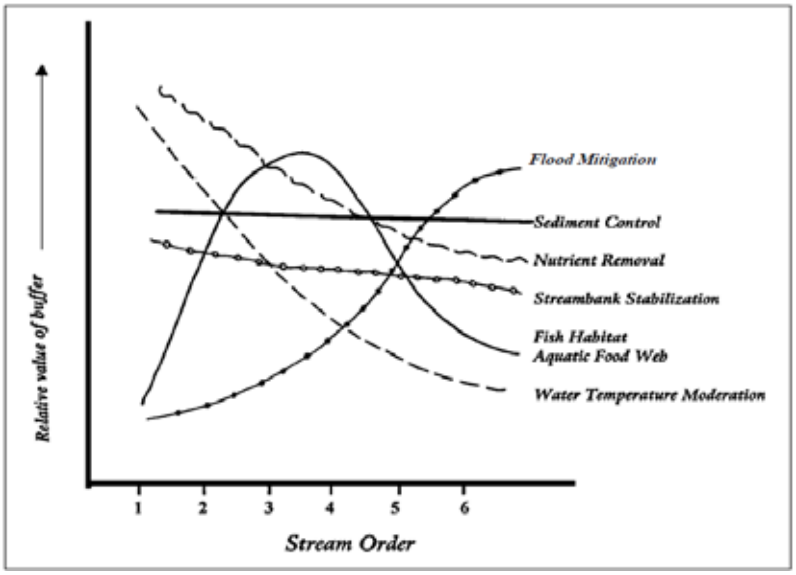



FIGURE 17 – GENERALIZED EFFECT OF STREAM ORDER ON FUNCTIONS IN THE RIPARIAN BUFFER [71]

The width of the riparian zone necessary to achieve these benefits varies depending on the desired use. According to USACE research[73], streambank stabilization, organic inputs (such as twigs and leaves as a habitat and food source), and water quality benefits may be achieved with relatively narrow riparian widths (typically 10-60 feet), while flood mitigation and habitat require much larger widths, usually greater than 100 feet. The minimum riparian width for some functions is summarized in Figure 18.

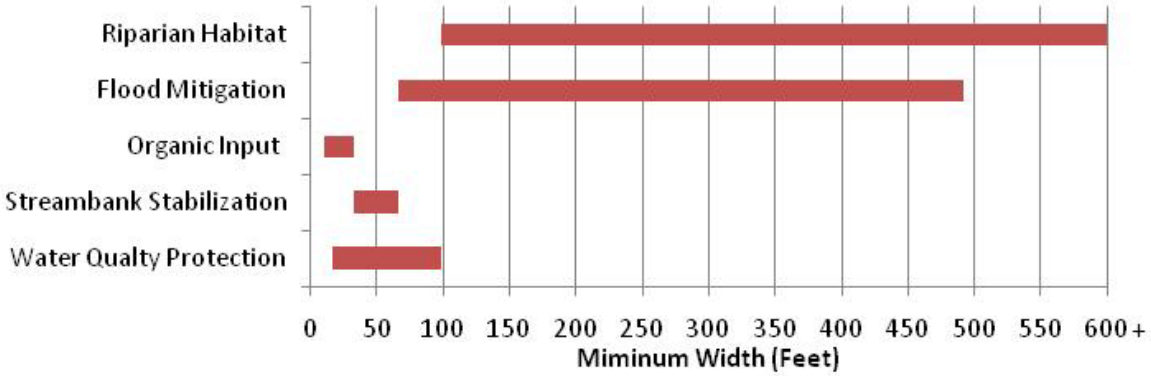



FIGURE 18 – MINIMUM RIPARIAN WIDTH BY DESIRED BENEFIT[73]

The structure of these riparian forested communities also has a lot to do with their functionality. Forest structure refers to the spatial organization of differing sizes, species, and communities of plants, both horizontally and vertically. For instance, mature trees with established root systems near streambanks provide greater stabilization than small trees or trees further from the streambank. Likewise, complex and diverse systems of overstory and understory trees, shrubs, and groundcover of differing heights, densities, and species can provide for far more wildlife habitat than just simple tree canopy cover.

Perhaps the most important region for riparian zone protection would be in the mountainous areas of eastern Kentucky, where the flat bottomlands of stream valleys are treasured for urban development. Riparian zones are a key factor for ensuring water quality benefits from forestlands.

### *2. Forested Wetlands*

Forested wetlands of Kentucky are also critical to water quality and quantity benefits. KDFWR developed species "guilds" which relate wildlife species to particular habitat types. Forty-two species are grouped in the "forest wetland" habitat guild, which is more than the upland forest guild, despite the much smaller area occupied by forested wetland habitat.[67] Forested wetland habitats, such habitats as cypress swamps, tupelo swamps, bottomland hardwood communities and green ash swamps, can be found throughout Kentucky but are most common in western and central Kentucky. The larger river systems (Mississippi, Ohio, and Green Rivers and their tributaries) harbor the most complex and extensive tracts of forested wetlands, but smaller tracts can be found even in the Appalachian corridors. KDFWR indicates that forested wetlands are one of the most severely impacted and endangered community types in Kentucky.[67] Increasing bottomland hardwood forest areas, protecting unique habitats, and minimizing impacts from mining and urban sprawl are some of the objectives for forested wetlands.

The importance of these areas for wildlife habitat is demonstrated by the number of WMAs established on these lands. Particularly in western Kentucky, the majority of WMAs target forested wetlands for protection as shown in Figure 19. Other WMAs tend to surround lakes or streams in which wetland habitats would also often be present.

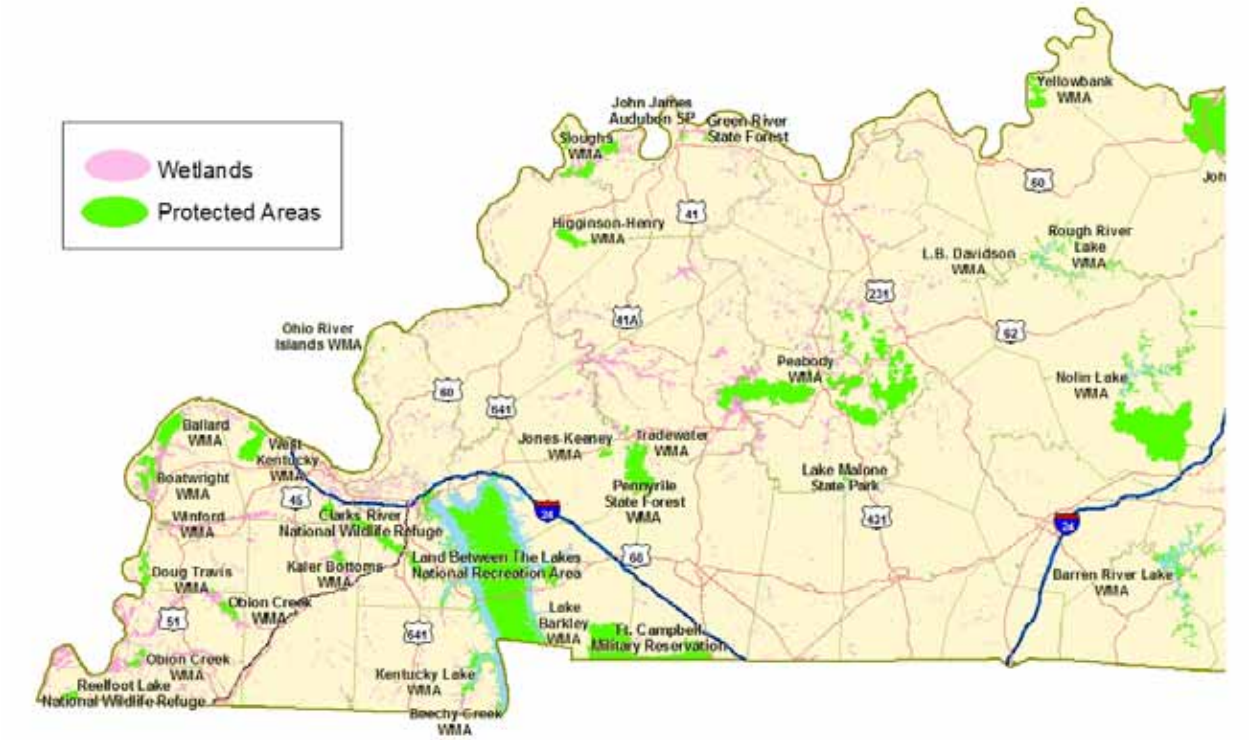



FIGURE 19 – PROTECTED AREAS AND WETLANDS IN WESTERN KENTUCKY

Particularly along the Mississippi and Ohio rivers, bottomland forest wetlands provide much needed protection against flooding. However, throughout the state they also provide important water filtration and supply stabilization benefits. Because the creation of forested wetlands in areas where they did not

previously exist is extremely difficult, retention of the remaining wetlands is essential to maintaining their public benefit.

### *3. Urban Trees and Forests*

Urban trees and forests are important for water benefits because of their value in reducing stormwater runoff, uptaking nutrients, aesthetic features and other benefits. Small, planted trees with restricted root systems and surrounded by pavement are clearly not as valuable as mature trees with extensive root systems located along an urban stream or beside a rain garden.

The urban tree cover determines the amount of rainfall intercepted from falling on impervious surface, and thus the stormwater runoff reduction. While the urban tree cover in Kentucky was found to be 33.4%[74], overall goals of urban tree cover in the Kentucky typically exceed 40%.[75] The Northern Kentucky Urban and Community Forestry Council analyzed the forest canopy coverage in Boone, Kenton, and Campbell counties providing comprehensive urban tree cover information. In Boone County, for example, forested cover was only 36%, indicating room for public improvement.[76]

Soil compaction or paving can limit the amount of filtration and uptake by tree root systems, so maximizing the amount of growing space and understory vegetation around a tree maximizes the benefits. Also, trees planted in elevated, isolated parking lots, medians, or inserted into otherwise paved streetscapes provide very little water treatment when compared to trees in depressed stormwater catchments.

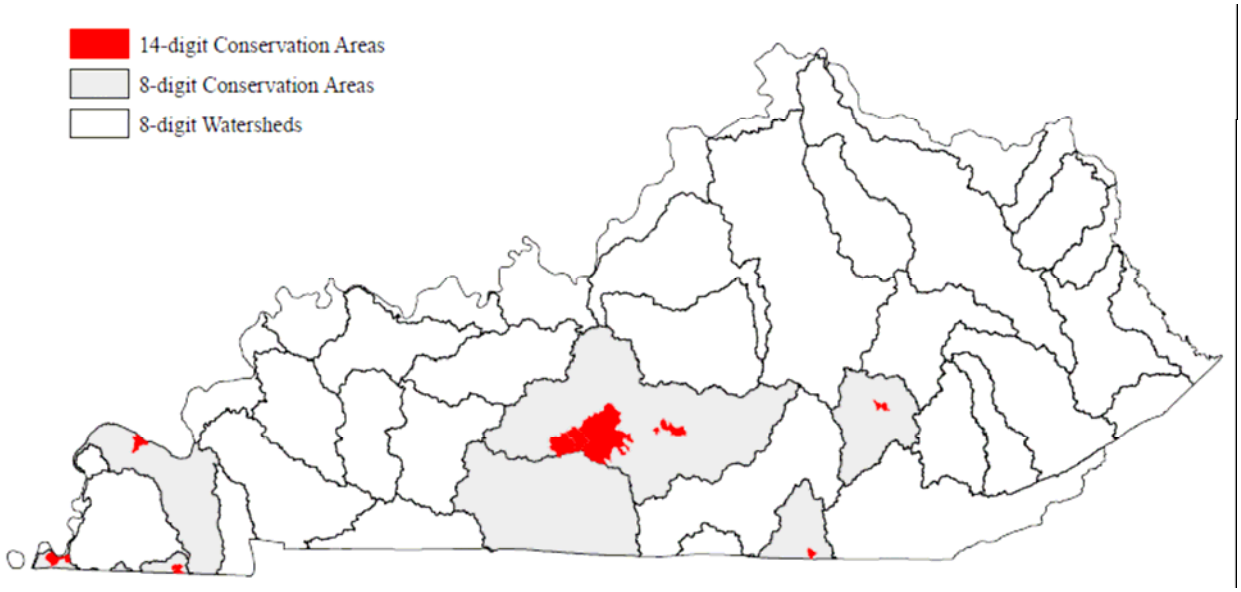
### *4. Key Geographic Areas*

While riparian buffers, forested wetlands, and urban trees identify general areas throughout the state, certain geographic areas are also critical for maintaining water benefits.

From a water quality perspective, retention of the high density of forested areas surrounding the "Special Use" waters of Kentucky is essential to preserving the excellent water quality in these areas. Because many of these locations have remained Outstanding Waters because of the lack of disturbance to the forested landscape, preserving these waters is also dependent on retaining this forest coverage.

From an aquatic wildlife perspective, six 8-digit HUC watersheds have been identified as the highest priority conservation areas for the aquatic group of organisms including mussels, fish, and lampreys based on richness of species with greatest conservation need. These critical conservation areas are shown in Figure 20 and include, from west to east, Obion Creek, Lower Tennessee and Lower Ohio Rivers, Barren River, Upper Green River, South Fork Cumberland, and the Rockcastle River.[67]

Another geographic area of importance is the karst region of Kentucky. Because groundwater resources are often used directly by private landowners without a municipal water treatment system, the protection provided by forest resources in areas in which domestic groundwater wells are abundant is critical. Figure 21 shows the relationship between groundwater wells (shown by black dots) and the hydrogeologic sensitivity rating, a measure of the ease and speed with which pollutants can move into and within a groundwater system with 1 indicating low sensitivity and 5 high. The risk of groundwater contamination is highest along the Mississippi Plateau region in western and south central Kentucky and in the Inner Bluegrass region of the state where karst is most abundant. Additional forested cover in these areas would aid in water filtration and improve the drinking water supply of well users. Well users with high risk for groundwater pollution are particularly abundant in north central Kentucky.




(Source: KDFWR, 2005)

FIGURE 20 – CRITICAL AQUATIC CONSERVATION AREAS

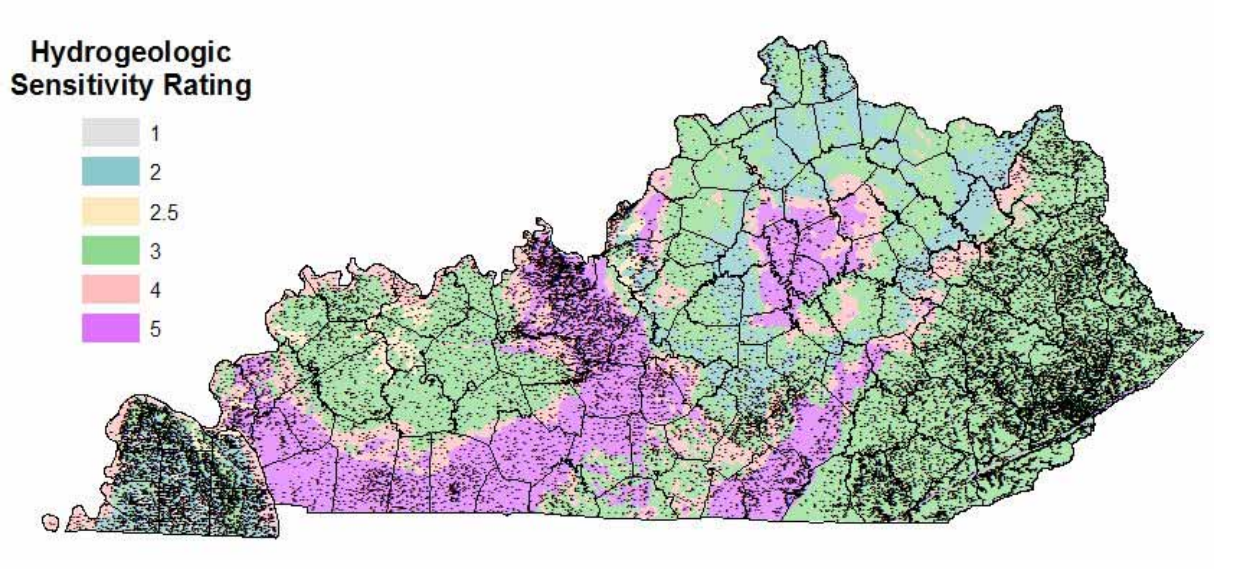



FIGURE 21 – GROUNDWATER SENSITIVITY AND DOMESTIC WELL LOCATIONS

Because Mammoth Cave National Park is a national treasure, the groundwater quality in this area is of particular importance. Forest resources outside the park boundaries should also be protected to preserve this resource.

### *E. Direct Threats and Contributing Factors*

Loss or disturbance of forest resources, whether due to land use conversion or impacts from wildfire or disease, is a direct threat to the quality and quantity of water resources available to Kentuckians. Once key forest resources are disturbed or lost, restoration of these benefits can take years and in some cases is impossible because of the impact of the land alteration.

### *1. Forestland Conversion or Loss*

While discussed more in depth in Issue 3, impacts of water quality and quantity benefits are also due to the increase in parcelization, urban land use expansion, and a growing human population. Of the 12 counties that averaged at least 1,000 people per square mile of forestland, only Campbell, Kenton, and Boone remained at least 30% forested in 2004.[8] Although most urban land use expansion by 2020 was predicted to occur at the expense of agricultural land use, every county is expected to increase in urban land use with some effects on forestland. Forestland is not forecasted to increase by more than 2% in any county, and in the 31 counties in which losses are predicted they are typically between 1 and 5%.[8]

The high percentages of impervious surfaces in urban lands or in surface mining can cause increased water yield and higher velocity surface runoff. Especially during active surface disturbance, the potential for water quality impacts are the greatest since sedimentation and erosion are increased during soil disturbance. Sites cleared of vegetation and replanted after development typically take years to redevelop and usually the community structure is vastly different than the original plant community.

Although little net change in the forestland of the mountains of eastern Kentucky is predicted, the direct threat of urban development on water quality is often particularly severe in this area because the expansion of urban development and agriculture typically occurs in the flat riparian corridors and bottomlands that are crucial for water quality benefits.

Also, as the urban population expands, the demand for water supplies also increases. This increased demand could cause impacts on aquatic ecosystems and water quality based on increased water withdrawals. The increased withdrawal demand could be compounded if the drought conditions experienced in recent years continue in the future. Some models predict temperatures to increase to levels currently found in Florida within the next 20 to 30 years. Drought conditions would not only decrease the available water supply but would also increase the likelihood of wildfires, compounding losses to the water supply from burning of the forest resources.

### *2. BMP Implementation During Commercial Timber Harvesting*

In accordance with the Kentucky Forest Conservation Act of 1998, timber harvesting operators are required to use appropriate BMPs, and a Kentucky Master Logger must be on site and in charge of all commercial logging operations. The KDF is required to inspect all logging operations for compliance with both provisions and to follow a series of enforcement actions to deal with noncompliance. When necessary, a special order or emergency order can be issued to shut down a logging operation until compliance is achieved.

However, a recent study[77] indicated that overall silvicultural BMP implementation was only 56% in 2004 to 2005 but improved to 68% in 2006 to 2008, as shown in Figure 22. The survey also indicated that the KDF inspected approximately half of the timber harvesting operations being conducted during these respective time periods, as shown in Figure 23. The most frequent implementation problems identified were removal of tree tops from intermittent stream channels, revegetation of eroded or high erodible areas, improper implementation of water control structures, and improper spacing of the control structures.

While this survey documents BMP implementation under the KFCA, no data are available on the rates of proper implementation of forestry BMPs for landowners under the Agricultural Water Quality Act or landowners physically cutting and harvesting their own timber. Funding constraints have resulted in the reduction in the number of KDF forest ranger technicians inspecting timber harvesting operations to ensure

appropriate use of BMPs. Without funding and staff to inspect harvest sites, increase logger education, and pursue enforcement actions, BMP use is not likely to improve.

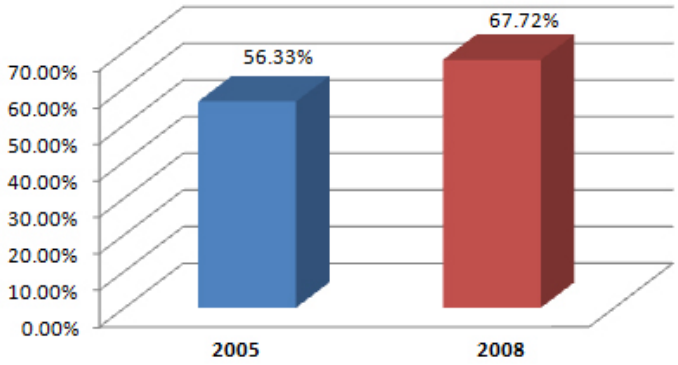



FIGURE 22 – TIMBER HARVEST MONITORING STUDY PERCENTAGE OF SITES WITH BMPS INSTALLED

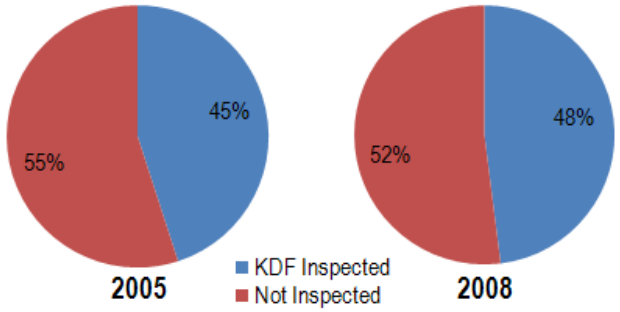



FIGURE 23 – TIMBER HARVEST MONITORING STUDY PERCENTAGE OF SURVEYED SITES INSPECTED BY THE KENTUCKY DIVISION OF FORESTRY

### *3. Hemlock Woolly Adelgid*

Because the eastern hemlock is a dominant riparian species in the forests of eastern Kentucky, the HWA, discussed fully in Issue 1, is a particularly potent threat to the water quality benefits. Eastern hemlock is the most shade-tolerant tree species in the eastern U.S. and is able to survive in the understory with as little as 5% full sunlight, making it a unique species for wildlife habitat and water quality benefits. Hemlock-shaded streams have been found to have lower summer temperatures and are less likely to become dry.[78] As the infestation kills these streamside trees, the shading, nutrient and sediment uptake, and other benefits will be lost, impacting the entire aquatic ecosystem to an unknown extent.

### *4. Chemical Treatment in Riparian Corridor*

Because stream corridors are one of the main avenues for the spread of invasive species, attempts to control the spread of these species is often focused on riparian areas. The most cost effective method for controlling these species is chemical control through the use of herbicides, but the attempted control can sometimes have a negative impact on water quality.

The control of HWA by pesticide is a perfect illustration of this threat. Imidacloprid, the pesticide that protects against HWA infestations, is highly toxic to aquatic invertebrates and should never be applied directly to water. However, because eastern hemlocks are dominant along stream riparian areas, this substance may affect stream water quality due to drift, runoff, or other mechanisms.

Herbicides may also affect stream health in a similar manner. Approved aquatic use herbicides, such as Rodeo™, are available on the market, but the degree to which these aquatic approved herbicides are used as opposed to aquatic restricted herbicides such as hexazinone, picloram, atrazine, or even gasoline is unknown. An applicator may not intend for an herbicide to reach the water resource, but unintended drift, runoff, or leaching may cause unintended stream impairment. Also, although aquatic insects and fishes seem to be unaffected by approved aquatic use herbicide formulations, other aquatic life such as diatoms are still likely to be affected.[71]

#### *5. Wood Biomass Harvesting*

Woody biomass harvesting for energy needs involves the extraction of woody materials including the wood, bark, and debris that remain from a commercial timber harvesting as well as the harvesting of low quality timber not suitable for timber and plantation forests established for biomass production. As energy demands increase, non-sustainable or improper woody biomass extraction may threaten water quality and quantity as well as forest resources. Particularly on the steep slopes in eastern Kentucky and other areas of the state where soil instability is an issue, extraction of these resources may disturb the soil layer and cause significant erosion and sedimentation problems.[79] These water quality impacts may be long-term as reestablishment of vegetation on these slopes would be a challenge. The potential for a robust woody biomass market may increase the likelihood of clearcutting trees greater than 3 to 4 inches in diameter regardless of location. The habitat, nutrient removal, aesthetic, and water supply impacts of such removals are obvious, suggesting the need for consideration of additional protection of riparian areas through biomass harvesting BMPs or regulatory oversight.

### *F. Opportunities*

Opportunities for the restoration, conservation, and protection of forest resources and their water quality benefits are numerous and diverse. In general, as public awareness about the economic value of forest resources for water quality and quantity benefits increases, opportunities for better management and expansion of forest resources improve. Also, as water quality and quantity become more of a state and federal issue, the cooperation between governmental agencies becomes increasingly important.

Through watershed based planning and increased enforcement actions, forest resources are increasingly being spotlighted as the most cost-effective features for improving water quality. Urban forestry programs are recognizing the public benefits of this resource, and tools are available for improved planning for incorporation of tree cover into urban settings. Multiple cost-share programs, mitigation funds, restoration groups, and even innovative funding sources such as water quality trading are offering ever more diverse opportunities for improving the water quality benefits of Kentucky's forests.

#### *1. Watershed Based Plans*

The collaborative efforts necessary to assemble watershed based plans throughout the state provide opportunities for better agency cooperation for utilizing forest resources to improve water quality and quantity. A statewide Watershed Steering Committee meets regularly to provide guidance, oversight, and communication to interagency/organizational activities. This committee includes state and federal agencies,

universities, nonprofit advocacy groups, trade associations, and local government associations offering opportunities for watershed collaboration.

In many areas of the state, community organizations have developed watershed based plans to focus remedial efforts in these watersheds. Riparian and forested wetland restorations are frequently recommended in these reports. Approved Clean Water Act Section 319(h)-funded watershed plans in Kentucky include Pleasant Run in the Green River Basin; Ten Mile Creek of Eagle Creek, Hanging Fork, and Clarks Run in Kentucky River Basin; and Corbin City Reservoir and Rock Creek in the Upper Cumberland River Basin. Multiple other plans are currently in development throughout the state.

### *2. Urban Forestry Programs*

The *Reforest the Bluegrass* program, established in 1999, has been an extremely successful program through joint efforts of the Lexington-Fayette Urban County Government, commercial sponsor funding, and volunteer support. Using less than $105,000 in local government funds and $75,000 in private fund raising, and over 5,000 volunteers, the program has restored more than 150 acres of floodplain by planting over 130,000 tree seedlings with approximately 75% first year survival.[80] Similarly, the Northern Kentucky Urban and Community Forestry Council celebrated its third *Reforest Northern Kentucky* program in 2009, and the City of Frankfort began the *Reforest Frankfort* program. During these three events, volunteers planted over 12,000 seedlings in 2009. Such successful models of urban forestry should be encouraged throughout the state.

Urban forestry programs, such as these, could be linked with geographic information system (GIS)-based analyses in order to determine the ecosystem benefits of urban tree planting and to set goals for reforestation percentages in key areas. Urban tree canopy studies through CITYgreen or i-Tree, discussed more fully in Issue 4, can calculate the environmental benefits of urban trees. Future applications under development include i-Tree Hydro, which is designed to quantify and illustrate hourly and total changes in stream flow and water quality associated with community forests. Such tools could be utilized to promote the use of urban forests for water quality benefits as well as other ecosystem services.

### *3. Agroforestry*

Agroforestry presents a unique opportunity to expand forestlands while maintaining agricultural uses. Some of goals of techniques such as alley cropping, forest farming, silvopasture, and windbreaks include improving the soil and water quality, reducing erosion and flooding, and enhancing aquatic habitat. Using agroforestry techniques, the riparian buffer is improved by the landowner in a "series of zones of native trees, shrubs, and grasses a) to protect the temperature and clarity of moving water and b) to prevent agricultural chemicals and soil from eroding directly into stream water."[81]

### *4. Cost-Share Programs*

Many cost-share programs are available as an economic incentive to encourage protection and restoration of forest habitat. Federal cost-share programs include the Natural Resources Conservation Service (NRCS) Conservation Reserve Program (CRP), Environmental Quality Incentives Program (EQIP), the Wetlands Reserve Program (WRP), Wildlife Habitat Improvement Program (WHIP), Healthy Forest Reserve Program, Farm and Ranch Lands Protection Program, and the Kentucky Soil Erosion and Water Quality Cost-Share Program. Each of these programs specializes in funding for particular habitat restoration types, and is further described in Issue 4. The WRP program, for instance, offers private landowners an opportunity to protect and restore wetland habitats on their lands. Since 1995, the program

has proven successful, gaining easements on over 17,000 acres and restoring over 7,800 acres of wetland.[82] Figure 24 demonstrates that the majority of the acreage protected has been in the key western Kentucky region.

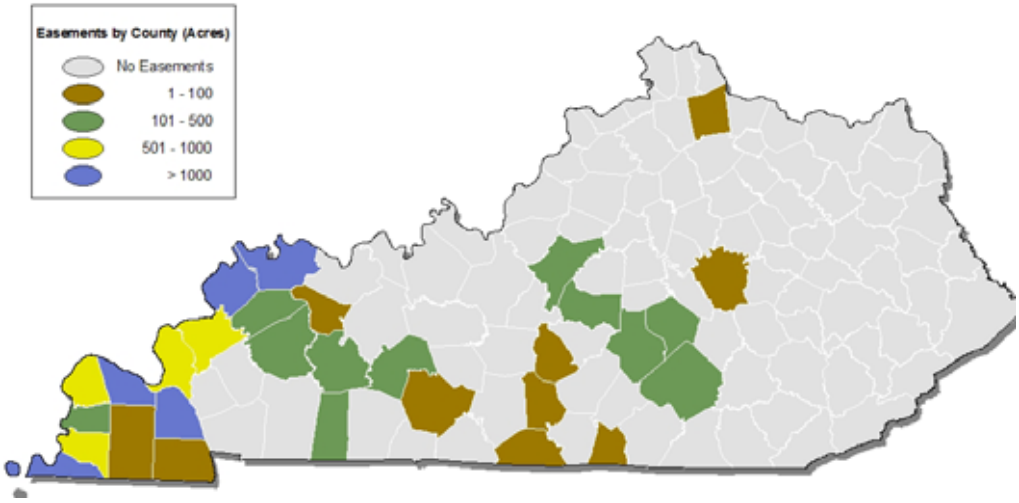



FIGURE 24 – WETLAND RESERVE PROGRAM EASEMENT ACREAGE BY COUNTY

The award winning Green River Conservation Reserve Enhancement Program (CREP) is another example of a successful cost-share program. The goal of this effort is to reduce the sediment, pesticides, and nutrients entering the Green River and Mammoth Cave System by 10% at an expected cost of over $105 million. [83] Other programs are similarly available to protect other forest-related water quality benefits.

The Mississippi River Basin Healthy Watersheds Initiative looks to address nutrient loading through conservation practices that avoid, control, or trap nutrients and improve water quality. In fiscal years 2010 through 2013, $80 million dollars will be set aside annually for projects in focused watersheds with the twelve-state area, which includes Kentucky. The focused watersheds in Kentucky are the Licking River, Lower Green River, Bayou De Chien-Mayfield, Obion, and Red River watersheds, as shown in Figure 25.[84]

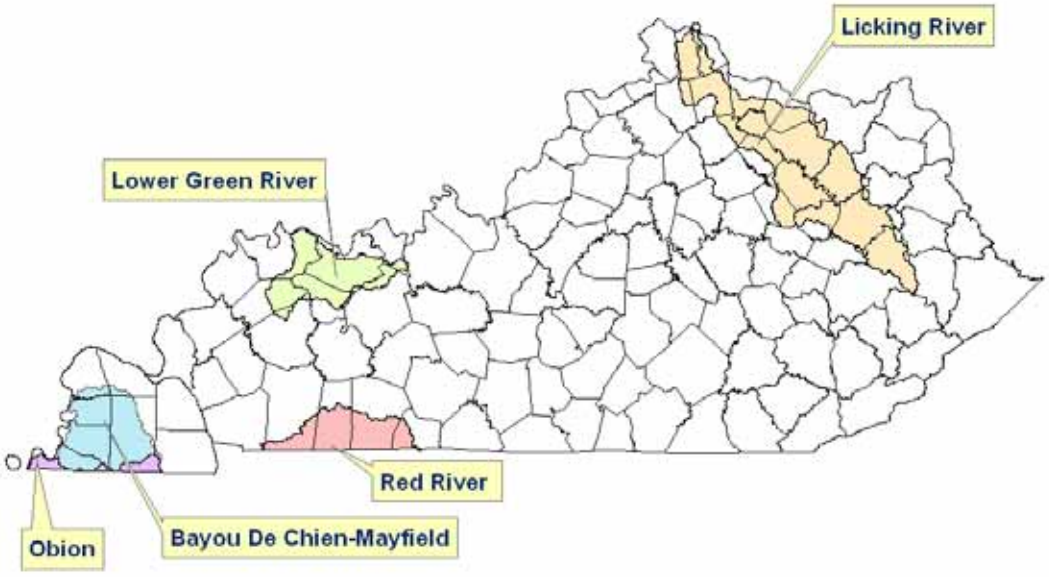



FIGURE 25 – MISSISSIPPI RIVER BASIN INITIATIVE FOCUSED WATERSHEDS IN KENTUCKY

### *5. Coal Mining Reclamation*

In 2004, the Appalachian Regional Reforestation Initiative (ARRI) was established as a coalition of citizens, the coal industry, government, and other groups dedicated to restoring forests on coal mined lands in the eastern U.S. Using a technique known as the Forestry Reclamation Approach, one of the major objectives of the ARRI is to convert reclaimed mined land to highly productive forestland through tree planting and improved proper coal mining reclamation techniques.[85] ARRI and similar organizations present numerous opportunities for water quality improvements in coal regions of the state.

### *6. Wetland and Stream Mitigation Funds*

Established in 2000 under KRS 150.255, the Kentucky Wetland and Stream Mitigation Fund provides opportunities for conservation and restoration through the KDFWR. Activities that permanently impact wetlands or streams require mitigation of some form under the requirements of USACE 404 permit and KDOW 401 Water Quality Certification. The Kentucky Wetland and Stream Mitigation Fund receives funding from entities who pay a fee in-lieu of implementing the mitigation themselves in what is called "fee in-lieu of" mitigation.

All KFDWR in-lieu fee projects are permanently protected through easements or ownership, so either landowners must be willing to donate a permanent conservation easement or the land must be available for purchase. Typical easements include a minimum of 50 feet on either side of the stream bank, and stream projects at least 1,000 feet in length are preferred.[86] Such projects often involve riparian buffer restoration.

### *7. Water Quality Trading*

One innovative opportunity for increasing the water quality benefits of forest resources is water quality trading. Currently, the University of Kentucky is among the ten finalists for a $3.7 million grant from the US EPA to "focus on water quality trading or other market-based water quality projects to reduce nitrogen, phosphorus, sediment, or other pollutant loadings that cause low oxygen levels." "The University of Kentucky's water quality trading market feasibility assessment will target two Kentucky sub-basins: the Green River and Kentucky River Watershed both located within the Ohio River Basin. The main pollutants of study are nitrogen, phosphorus, and sediment."[87] Such studies may present future models for market-based opportunities for forest restoration for water benefits.