PART 1: FORESTRY ISSUES
ISSUE 1: FOREST HEALTH

A. Introduction

The Kentucky Forest Health Task Force (KFHTF) has defined healthy forests as ones that "have the capacity for renewal, for recovery from a wide range of disturbances, and for retention of their ecological resiliency, while meeting societal needs for uses, products and services."[10] Under this definition, forest health and tree health are distinct. Individual dead, dying, decaying, insect-infested, or otherwise unhealthy trees can be components of a perfectly healthy forest depending upon the forest type, age, size, numbers, and distribution of dead and dying trees as well as a variety of other factors.[11] Forest health is a broad term encompassing the evaluation of the entire forest ecosystem and its interactions, both in urban and rural forests.

Kentucky's forestland acreage has decreased during the last few years, which can be attributed to the conversion of the land to non-forest land use, including urban development and mining. However, trees are larger and more stems are present per acre. The solutions to maintaining and increasing Kentucky's forest health include proper forest management, reducing wildfires and eliminating invasive, exotic species from our forests.[11]

Continued globalization and rapid worldwide movement of goods have led to increases in the importation of exotic pathogens, plants and insects. Many of these exotic species that are invasive can alter forest ecosystems and threaten the health of Kentucky's forests.[10] Because Kentucky native forests have little or no resistance to foreign invaders, not managing the forests could result in losing our entire native forest ecosystem. Active management, as opposed to passive neglect, is important to improve and sustain forest health.[11] It is necessary to invest in Kentucky's forest health by conducting systematic aerial and ground surveys, detection surveys for invasive species, proper management, education of Kentucky's citizens, and restoration planting. Otherwise, the integrity of Kentucky's forests may be irreversibly altered.[10]

B. Public Benefits

Why is forest health important for Kentucky? Numerous public benefits from timber and non-timber related economies, recreational and aesthetic factors, air and water benefits, erosion control, and wildlife habitat are just a few of the many reasons why healthy forests are important to the citizens of Kentucky. For some of these benefits, an economic value can be quantified, but for many, the effect of healthy forests on the quality of life cannot be adequately priced.

1. Economics

While discussed more in depth in Issue 5, healthy forests provide more income to the economy than unhealthy forests. The USFS has estimated the total economic importance of Kentucky's forests at nearly $8.7 billion annually.[8] These economic benefits show that healthy forests are important monetary assets for Kentucky forest landowners.

2. Recreation and Aesthetics

According to the National Woodland Owners Survey, approximately 135,000 Kentucky family forest owners, who own 4.7 million acres, listed recreation as an activity occurring in the past five years on their forestland. Public recreation occurred on 1.2 million acres of family-owned forestland.[8] A healthy forest

provides the quality aesthetics that the public expects from our forests. Many Kentucky landowners give aesthetics as a reason for owning forestland.[8] Cities with increased greenspace and street trees, and neighborhoods with mature trees present a more desirable and welcoming façade than those lacking trees or where the urban forests arise solely on abandoned, unmanaged areas. Whether in urban or rural areas, many landowners desire healthy trees rather than trees suffering from the effects of disease or insect infestation.

3. Clean Air and Water

Forests are an important factor in providing both clean air and water. Trees help improve air quality in numerous ways. In one year, an acre of mature trees can absorb an equivalent amount of carbon dioxide as a car driving 26,000 miles[12], as well as absorbing other pollutants including ozone, particulate matter, sulfur dioxide, nitrogen monoxide, and carbon monoxide. The health of the surrounding forestlands is vital to the integrity of water-supply systems as well. Rainfall that passes through forests is cleaner than rainfall that drains from roads or disturbed lands, and groundwater that has passed through forested buffers is cleaner than water running directly off farm fields. Some of the forests' benefits to clean water include reducing pollution, erosion, and sedimentation. These benefits are examined more fully in Issue 2. Appropriate forest management improves the delivery of clean water and air, which in turn enhances the well being of people and communities and reduces processing costs.[13]

4. Soil Erosion Control

Soil erosion can have a huge impact on the health of Kentucky's forests. Soil erosion is the wearing away of the land surface by running water, wind, ice or other geological agents.[8] Soil compaction, disturbance, and wildfires can lead to decreased tree growth, increased water runoff, and soil erosion. When eroded soil accumulates in stream systems, the habitat for many aquatic species is covered, reducing the stream water quality. The increased duff layer and deep root system of a healthy forest limits erosion from all sources.

5. Wildlife Habitat

Healthy forests yield quality wildlife habitat and provide both shelter and food supply. Forests that are too dense and unmanaged can create uncommon stress on the trees and make them more susceptible to insect and disease outbreaks that threaten wildlife. Invasive exotic species often provide poor food supplies and dominate the landscape such that the diversity of habitats is reduced. Wildfires (unplanned and uncontrolled fires) are also a threat to the health of the forest and subsequently to the forest wildlife species due to the destruction of habitat and food sources.

6. Carbon Sequestration

Trees are "sinks" for carbon dioxide (CO_2), the most abundant greenhouse gas emitted by human activities. Healthy, well-managed forests can enhance carbon storage in trees and soils, preserve existing tree and soil carbon, and reduce emissions of CO_2, methane (CH_4) and nitrous oxide (N_2O). The United States Environmental Protection Agency (USEPA) predicts that greenhouse gas concentrations in the atmosphere will continue to increase during the next century unless emissions are substantially decreased and sinks are increased from present levels. Increased greenhouse gas concentrations are predicted to raise the Earth's average temperature and influence precipitation and storm patterns. Such changes could also change the ranges of flora and fauna species and expand the spread of invasive exotic species.

C. Forest Resources

Healthy forests are important, but are Kentucky's forests healthy? This question is more difficult to answer because we have no absolute standard by which to judge. While threats to forest health such as pests, diseases, and wildfire impacts can be monitored, most indicators of forest health are somewhat subjective in nature.

1. Current and Historical Forest Area

We can say with confidence that Kentucky's forests are changing, and at times quite rapidly. Although 47% of Kentucky is forested, nearly 780,000 acres of forest, primarily on private lands, were converted to other land uses in the last 15 years.[11] This land area is significant, representing an area larger than the entire Daniel Boone National Forest, which is over 707,000 acres. While great losses have occurred over this time, the remaining timber is larger and the trees per acre increased such that for every one tree removed there are 1.5 trees growing.[8]

The Kentucky State Nature Preserves Commission (KSNPC) estimates that only 0.5% of Kentucky remains in a natural condition comparable to what existed prior to European settlement.[14] Only about 5,000 acres of old-growth forest remain in Kentucky.[15] On federal lands, the Big Woods of Mammoth Cave National Park provides a remnant of upland tuliptree-oak-hickory forest, and the Rock Creek Research Natural Area in Laurel County displays a hemlock-mixed mesophytic forest. State-owned sites with significant old-growth forest include Lilley Cornett Woods, a registered national natural landmark, in Letcher County and the 2,350 acres in Blanton Forest in Harlan County, the largest stand of old-growth in the state. Another large stand (870 acres) of old-growth is found in the Letourneau Woods in the southwestern portion of the Obion Creek Wildlife Management Area (WMA) in Fulton County, Kentucky. Outside of these sites, the acreages of most other old-growth stands in Kentucky are relatively small with the Curtis Gates Lloyd WMA in Grant County amongst the largest.[15]

Kentucky has a rich diversity of plant species including numerous forest species. In comparison to states such as Pennsylvania and Ohio, Kentucky has similar numbers of native plant species, but has slightly lower numbers than Tennessee or Missouri, as shown in Table 1.[15] The number of non-native plant species in Kentucky is somewhat lower than in surrounding states, but even so a recent study indicated that an astonishing 24% of the woody plant species within Kentucky are non-native and at various stages of naturalization.[16]

TABLE 1 – PLANT SPECIES IN KENTUCKY AND THE SURROUNDING STATES

	PENNSYLVANIA	OHIO	KENTUCKY	TENNESSEE	MISSOURI
Native species*	2,076	2,019	2,030	2,267	2,382
Non-native species*	1,242	979	570	518	820
Total species*	3,318	2,998	2,600	2,785	3,202

*Includes lesser taxa

The forest regions of Kentucky have traditionally been divided into three regions associated with physiographic features: the Mixed Mesophytic Forest Region of the Appalachian Plateau, the Oak-Hickory Forest Region of the Interior Low Plateaus and eastern uplands of the Mississippi Embayment, and the small Southern Floodplain Forest Region along the Mississippi Bottoms of the Mississippi Embayment. The following discussion, from Jones 2005, gives a general overview of the dominant and common forest species in these regions.[15]

a. Mixed Mesophytic Forest Region

The Mixed Mesophytic Forest Region, which includes the eastern third of Kentucky, is characterized by a rich overstory dominated with deciduous tree species including American beech, cucumber magnolia, oaks (northern red and white), sugar maple, yellow-poplar, white ash, and the evergreen eastern hemlock. Big-leaf and umbrella magnolias are often present in the understory. White basswood and yellow buckeye serve as indicators of this forest type due to their consistent presence. The shrub and herbaceous layers are renowned for their diversity as one of the most biologically rich areas in the United States.

b. Oak-Hickory Forest Region

The Oak-Hickory Forest Region includes the greater part of Kentucky from the Appalachian Plateau in the east to the uplands of the Jackson Purchase. The forests are characterized by a wide number of overstory species, especially oaks (black, northern red, southern red, and white) and hickories (bitternut, pignut, and shagbark), but also American elm, American basswood, black cherry, black walnut, and white ash. Because of the limestone present in this area, species such as bur oak, chinkapin oak, Kentucky coffeetree, and rock elm are found in this forest type.

c. Southern Floodplain Forest Region

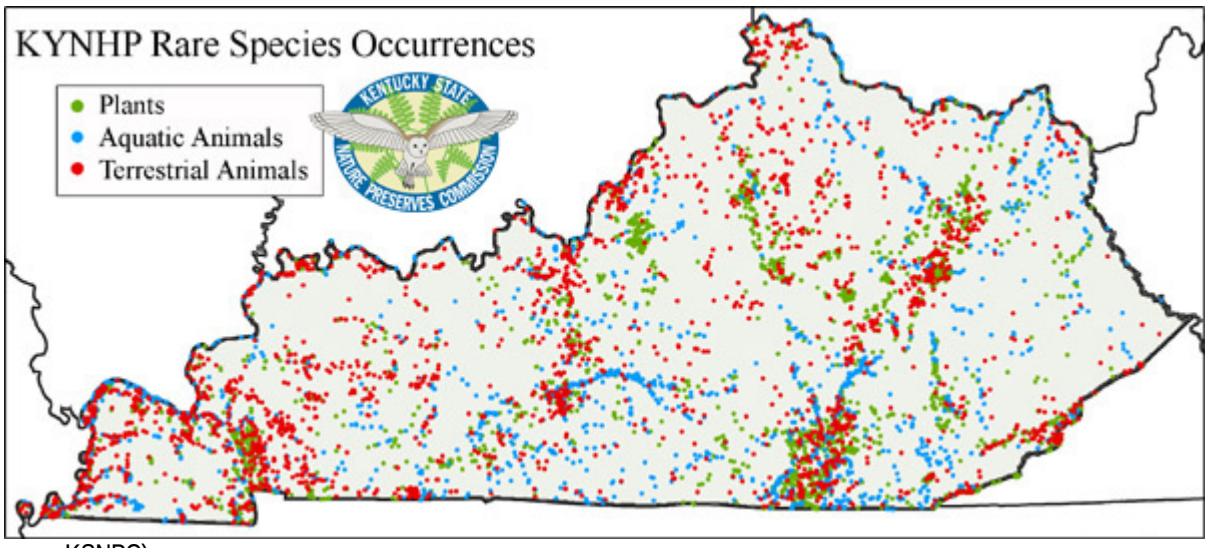
The Southern Floodplain Forest Region occupies only the small region along the floodplains of the Mississippi River and its tributaries. Amidst the few extensive forests in this region, bottomland hardwoods including oaks (cherrybark, overcup, swamp chestnut, and willow), sugarberry, and sweetgum are common. Scattered swamp communities dominated by bald-cypress and water tupelo are found in this region.

Although the ranges and divisions of these forest regions in Kentucky have been similarly classified since the late 1940s and early 1950s, the relative species composition of these forests has changed over that time. For example, yellow-poplar composed 6% of the total growing stock volume in 1952 but today represents 13% of the total volume. The high number of exotic species and the shift in species dominance indicate that Kentucky's forest communities have changed and are continuing to change. The effect of these changes on forest health may be debatable.

Other attributes of forests, such as the biodiversity, changes in the numbers of rare species, forest age, down woody material, and soil type can be used to evaluate the health of Kentucky's forests.

2. Biodiversity

The occurrences of rare or endangered biota of Kentucky are shown in Figure 3. The current Kentucky list of rare and extirpated biota names one lichen, 390 plants, and 317 animals as rare and 6 plants and 49 animals as extirpated from Kentucky or extinct.[17] The loss of so many species through Kentucky's history shows obvious impacts to all environments in Kentucky's past. However, the recent changes in these communities indicate that forest health, as well as the health of other habitats, continues to be impacted. From 2002 to 2008, 43 of these rare species declined by becoming rarer while only 24 improved in rank.[14] Several forest communities themselves are also listed as rare in Kentucky including the Appalachian pine-oak forest, Bluegrass mesophytic cane forest of the Inner Bluegrass, Cumberland Highlands forest of Black Mountain, and bald-cypress and bottomland hardwood swamps of the Mississippi Embayment area to name a few.[15]

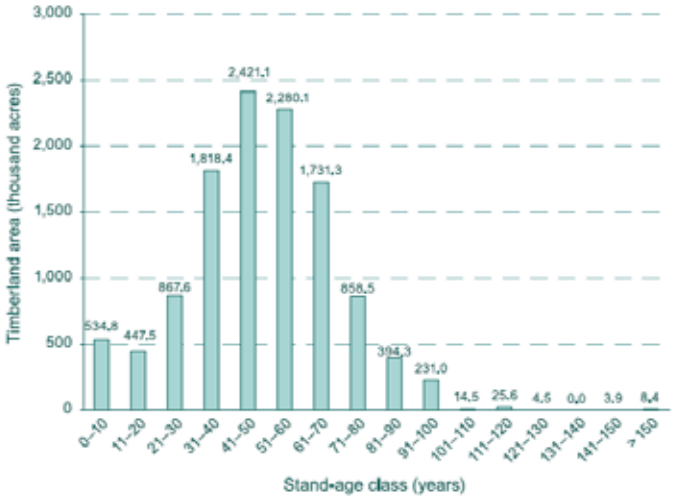


(Source: KSNPC)

FIGURE 3 – KENTUCKY NATURAL HERITAGE PROGRAM RARE SPECIES OCCURRENCES

3. Forest Age and Crown Condition

As of 2004, most forest stands were found to be greater than 40 years old with stands between 41 and 50 years old being the most abundant age class, as shown in Figure 4. [8] As forests age, they generally become more susceptible to health problems such as disease, insect invasion, and environmental stresses. By comparing the average stand ages in Kentucky to the average and range of typical life spans for common eastern tree species in Table 2[18], it is apparent that mortality will be increasingly common in the future for some short to mid-lived species. Individual trees may live much longer than these ages and forests as a whole can maintain health over long periods of time, as shown by the remnants of old-growth in Kentucky. However, the aging of Kentucky's forests is a factor to consider when evaluating the forest health.



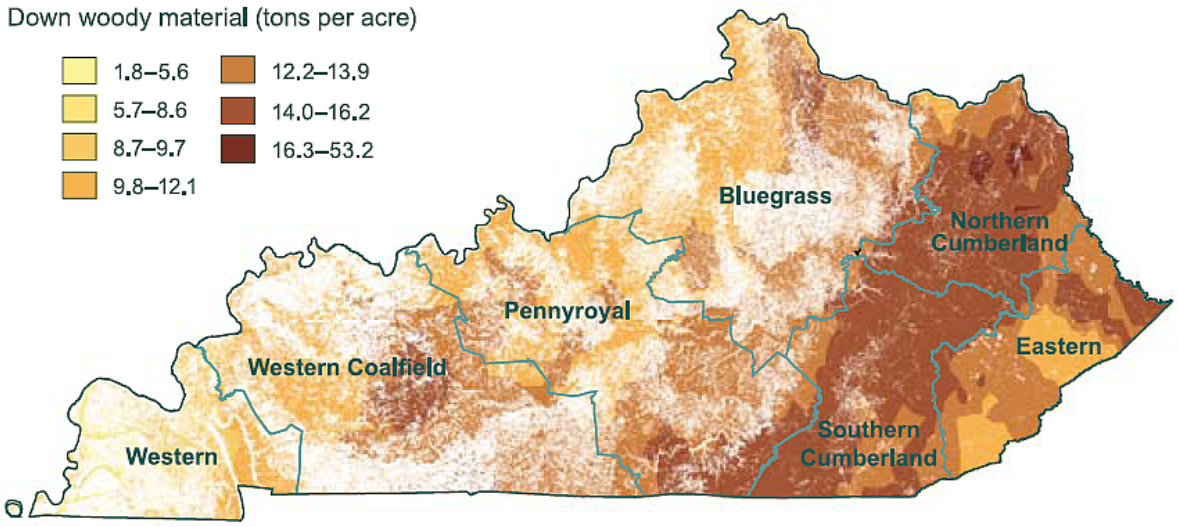
(Source: Turner et al., 2004)

FIGURE 4 – KENTUCKY TIMBERLAND AREA BY STAND-AGE

The tree crown condition can be used to track forest health, because trees in poor health often show signs of reduced growth and dieback. While some trees have been known to live to long ages with broken crowns, often such damage causes mortality. In Kentucky, average tree crown conditions were found to be within the expected range for trees in the south.[8]

TABLE 2 – AVERAGE AND RANGE OF TYPICAL LIFESPANS FOR COMMON EASTERN TREE SPECIES

COMMON NAME	AVERAGE AGE	AGE RANGE	COMMON NAME	AVERAGE AGE	AGE RANGE
Bald-cypress	264	150-500	Southern white oak	127	80-150
White oak	194	90-250	Nuttall's oak	125	80-163
Bur oak	181	125-250	Water tupelo	123	90-175
American beech	168	100-250	Pignut hickory	117	50-175
Sugar maple	162	90-200	Pecan	117	60-200
Swamp white oak	157	100-200	Blackgum	116	80-150
Northern red oak	151	90-200	Pin oak	116	80-170
Chestnut oak	141	75-200	Black cherry	115	70-175
Cherrybark oak	139	90-200	Sweetgum	112	80-125
Shagbark hickory	137	75-225	Shortleaf pine	110	75-200
Post oak	137	70-190	Pitch pine	110	75-200
Yellow-poplar	136	80-300	Red maple	106	50-175
Overcup oak	135	80-165	Scarlet oak	105	65-150
Bitternut hickory	133	80-200	Green ash	98	60-150
Black walnut	131	75-200	Cottonwood	79	50-100
Water oak	130	80-200	Silver maple	78	50-100
White ash	129	80-150	Virginia pine	76	40-125
Black oak	129	75-200	Sassafras	69	30-175
Eastern white pine	-	75-200	Black locust	-	15-150
Mockernut hickory	127	60-200	Black willow	65	40-100



(Source: Turner et al., 2004)

FIGURE 5 – DOWN WOODY MATERIAL ABUNDANCE

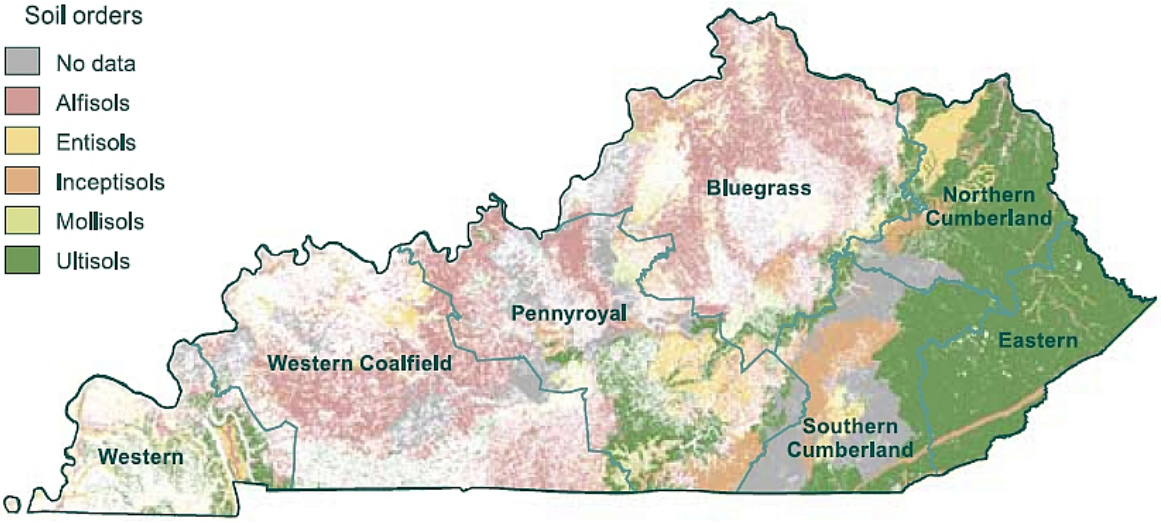
4. Organic Material

Deadwood, including standing snags and fallen woody debris, benefits forest ecosystems by improving the soil and providing habitat and food for plants and animals. However, if deadwood is too abundant, it can sustain damaging wildfires. Therefore, managers must maintain a balance between too much and too little deadwood. Down woody debris, used as an indicator of deadwood, is most abundant in the Northern and Southern Cumberland regions and in small areas of the Western Coalfield region as shown in Figure 5.

Most of the coarse woody debris sampled in Kentucky was moderately decayed and of relatively small diameter. Prior to the catastrophic ice damage of 2009, the greatest quantities of down woody debris were found in loblolly-shortleaf pine, oak-pine, and oak-hickory forest-type groups.[8]

5. Soils

Forest soils are substantial contributors to the forest ecosystem and forest health. The locations of soil types within Kentucky are shown in Figure 6. Soils in southern and eastern forests of Kentucky are primarily classified as Ultisols, which are often too nutrient poor to sustain agricultural production but are well suited for forestry because of the leaf litter and woody detritus nutrient input. Alfisols are the primary soils in the northern and western forests of Kentucky. They are highly fertile, naturally forested soils that are often cultivated for agriculture but also support broadleaf deciduous and mixed evergreen forests. The ability of the soil to hold nutrients tends to be greatest in the Bluegrass and Pennyroyal regions and lowest in the Western and Western Coalfield regions.[8] Limestone-derived soils tend to support more plant species and be more productive than sandstone soils.[19] Most soils in Kentucky are fairly compacted indicating that root growth and exchange of water and air may be difficult in much of the state.[8]



(Source: Turner et al., 2004)

FIGURE 6 – SOIL ORDERS OF KENTUCKY FORESTS

Because the forest ecosystem consists of aboveground and belowground components, the relationship between soil health and forest health is interactive. Trees depend on the soil for stability, nutrient cycling and intake, and water. Soils are composed of numerous components including organic and inorganic materials, microorganisms such as bacteria and fungi, insects, and burrowing animals which are all affected by the growth of roots, organic inputs, and the transpiration of water associated with the surface vegetation. As such, changes to the forest surface have effects on the soil and the soils have long-term effects on the forests above. For instance, dormant season fires in hardwood forests have been found to affect root growth and microbial activity,[20] while severe fire can cause significant losses of soil nitrogen that effects subsequent forest growth.[21] Water content in non-forest soils is higher than in forest soils, as are stream flow and peak flows.[22] Thus, difference in soil moisture levels has been found to affect the rate of soil nitrogen cycling,[21] and thus the productivity of the site. Therefore, soil health is an important factor to consider when evaluating forest health.

D. Key Conditions

1. Native Species

One key condition to forest health is a prevalence of native species. The forest communities of Kentucky are complex ecosystems, with interdependent food webs involving trees, shrubs, and herbaceous plants as well as birds, insects, amphibians, reptiles, mammals, and other wildlife. Native communities of both plants and animals that have adapted to the local conditions and have not been impacted by invasive exotic species are more stable than impacted communities. Native species are also a natural heritage of the state.

Maintaining native forest species involves both encouraging the growth of native species and limiting the growth of invasive species. The USFS defines an invasive species as one "that is non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health." [23] Many exotic (non-native) species have been deliberately introduced as erosion control (kudzu), agricultural crops (Johnson grass), and ornamental plants (purple loosestrife, burning bush) while others have been introduced accidentally (emerald ash borer). Although most invasive species are exotic, native species, such as the southern pine beetle or the eastern tent caterpillar, can also be defined as invasive when they spread rapidly and cause extensive damage.

The Kentucky Terrestrial Nuisance Species Management Plan[24] lists some of the biological, socio-economic, and aesthetic impacts of invasive species as follows:

- Disruption of balanced food webs and nutrient cycling
- Degradation of native habitats
- Reduced abundance of native organisms due to increased competition
- Almost half of the federally threatened or endangered species in the U.S. are impacted by invasive species
- Decreased biodiversity
- Alteration of natural disturbance regimes
- Depletion of limited management resources
- Lost tourism dollars when recreational experiences such as hunting and hiking are no longer possible or pleasant
- Reduced property values resulting from invasive overgrowth and "smothering" of forests and opens spaces
- Decrease productivity and increase costs when terrestrial nuisance species interfere with commercial logging and agricultural operations
- Interference with transportation right-of-ways
- Annual damage and control costs of more than $138 billion in the U.S.
- Unquantifiable loss of aesthetic benefits

Thus, the preservation of native species and control of invasive species is a key condition for forest health.

2. Forest Structure and Diversity

When large areas are simplified into a few species, ages, or structural stages (as further discussed in Issue 3), disturbance has a greater likelihood of causing a widespread problem.

In relation to the importance of native species, diversity and structure are also key conditions for healthy forests. Diversity refers to different types of forest communities as well as numbers of species within

forests. Structure refers to the complexity of the vertical and horizontal forest as well as the success of successional processes creating this complexity. A high diversity of tree species and communities allows for more abundant and diverse wildlife populations due to increased food sources and habitats. Complexity of the forest structure with overstory, understory, shrub, and herbaceous cover similarly provides increased protection and food supplies to forest animals. When the diversity or structure of a forest is decreased, it loses some of its function and, in many cases, could be considered less healthy.

Maintaining forest structure and diversity often requires management. The relationship between active management and healthy forests is strong, as detailed in Issue 4. For example, subdivision construction often begins with the clearing of an entire site (removing all diversity and structure), and then creating ornamental landscapes with trees of similar ages and with a limited selection of species. However, by active planning to retain large portions of the existing vegetation, the impacts to the diversity and structure can be reduced. Active management in urban as well as rural environments must be practiced to retain or enhance the structure and diversity if we are to sustain healthy forests.

3. Fire Occurrence

Fire is a key condition because of its positive and negative effects on the forest resources of Kentucky. Beginning in the 1930s, fire suppression was initiated as a control measure to limit the negative impacts of fire on forest stands. Although seemingly necessary at the time, recent evidence suggests some negative effects on forest stand structure and species composition resulting from this policy of fire suppression.

Current research is showing that the Daniel Boone National Forest is more crowded due to fire suppression.[25] In forests crowded in the midstory and understory, species that can tolerate more shade, such as red maples, can out compete oaks and other species that require more sun. Although the effects and benefits of fire are still under research, prescribed fire may be used to reduce forest density and promote the growth of shade intolerant species. It can also reduce the potential of catastrophic and destructive wildfires, control invasive species, and reduce the incidence of disease and insect damage to forests. Prescribed fire releases nutrients, removes excess leaf litter that inhibits vegetative growth, releases seed for germination, and increases species diversity. According to the KSNPC, "loss of diversity, in both number of species and varieties of habitat, is also caused by the virtual elimination of wildfire as a normal event in natural environments where it traditionally occurred... Without periodic fire, the special fire-adapted communities of plants and their associated fauna will cease to exist as part of our landscape. Fire exclusion is also a cause in the decline of oak reproduction, which is changing the nature of the forest and reducing a hard mast food source that is critical for wildlife."[14]

Uncontrolled wildfires can be extremely dangerous and costly, both in terms of forest health and socioeconomic impacts. In regard to forest health, wildfires occurring in dry environments with large fuel sources, such as those created by the recent ice storms, can consume large quantities of timber resources and eliminate habitat for protected species. Kentucky has the highest rate of deliberately set wildland fires in the southern U.S. The Wildland Arson Task Force reported 8,628 wildland fires from 2000 to 2005. These fires burned 411,441 acres of private land and cost over $20 million in suppression costs.[26] From 2004-2009, arsonists started 60% of the 4,461 fires in Kentucky, predominantly in the eastern Kentucky area, as shown in Figure 7. The costs associated with arson fires are much greater than just dollars spent on suppression efforts. There are costs to the timber resource, the economy, the forest industry, the health of Kentucky citizens, and the personal costs to residents and firefighters dealing with the risks associated with smoke and fire.

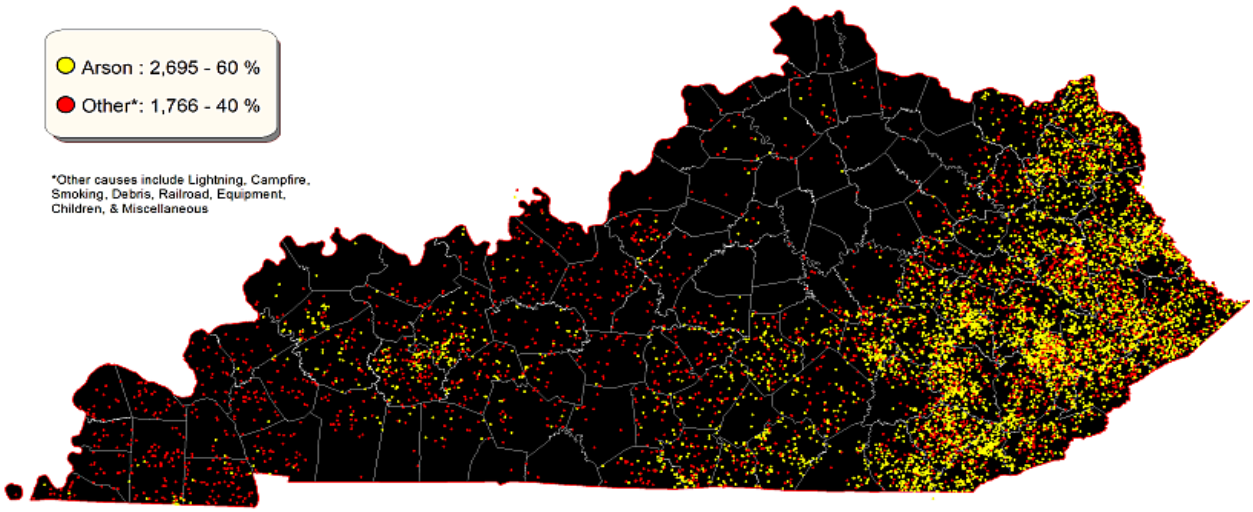


FIGURE 7 – WILDFIRE AND ARSON FIRES RESPONDED TO BY KDF FROM 2004 – 2009

Kentucky has identified communities at risk (CARS) in order to help ensure the protection of people and property from wildfires. The most recent CARS assessment was generated during the Southern Wildfire Risk Assessment. The Southern Wildfire Risk Assessment used population density and a wildfire susceptibility index to determine the CARS ratings of low, medium, high, and very high. The wildfire susceptibility index is calculated using the factors of probability of fire occurrence, estimated fire behavior, and fire suppression effectiveness. This assessment found over 800 CARS at high or very high risk from wildfires, all of which are located in the eastern part of the state. This is due to the wildfire susceptibility index factors of fire occurrence, estimated fire behavior, and fire suppression effectiveness.

E. Direct Threats

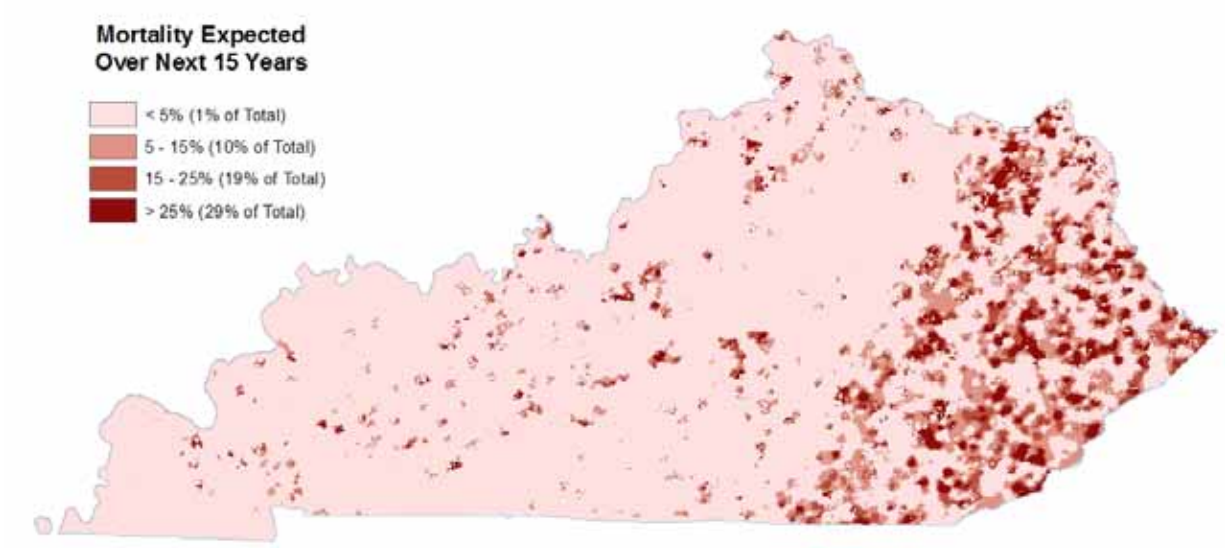
After forest loss, the most direct and extensive threat to Kentucky's forest health is invasive insects, plants, and diseases. However, a variety of factors can cause unhealthy forest conditions including weather pattern changes, pollution, landscaping practices, recreation, mismanagement, and coal mining. An overview of the ways in which these conditions impact forest health follows.

1. Threats from Insects, Plants, and Diseases

The threats to Kentucky's forests from invasive insects, plants, and diseases are numerous and threaten the health of forest communities regardless of the desired use. Although the complete list of invasive species threatening our forests is much longer than can be detailed in this document, some of the worst threats, summarized in Table 3, are discussed. Most of these threats are exotic with the exception of the native Southern pine beetle. The cumulative effect of these invasive species is expected to be devastating, particularly in the forests of eastern Kentucky. The *Southern Forest Land Assessment* predicted that, over the next 15 years, mortality is expected to be over 25% in many areas throughout the state, as shown in Figure 8.[27]

Because of the negative effects of invasive species, integrated pest management programs that set action thresholds, monitor and identify key pests, prevent invasion, and indicate control measures are important to maintain forest health and limit the influence of these species. For further analysis of invasive species in Kentucky, readers should consult the Terrestrial and Aquatic Nuisance Species Management Plans

produced by the KDFWR, the KFHTF Annual Report (www.kyforesthealth.org), and the Kentucky Exotic Pest Plant Council Web site (www.se-eppc.org/ky/list.htm).



(Source: Southern Forest Land Assessment, 2008)

FIGURE 8 – MORTALITY DUE TO INSECTS AND DISEASE

TABLE 3 – PROMINENT THREATS FROM INSECTS, PLANTS, AND DISEASES

INSECTS	PLANTS	DISEASES
Emerald ash borer	Bush honeysuckle	Chestnut blight
Hemlock woolly adelgid	Kudzu	Sudden oak death
Gypsy moth	Japanese honeysuckle	Thousand cankers disease
Southern pine beetle	Tree of heaven	Beech bark disease
	Japanese privet	
	Oriental bittersweet	

a. Emerald Ash Borer

The emerald ash borer (EAB) is expected to be one of the most destructive pests to affect Kentucky. As of October 2009, the EAB was confirmed in Campbell, Fayette, Franklin, Greenup, Henry, Jefferson, Jessamine, Kenton, Oldham, Owen, and Shelby counties in Kentucky. Considering that white ash and green ash rank 11th and 14th respectively in terms of total standing volume in Kentucky[8], the EAB may significantly impact Kentucky's timber production and economy.

The EAB, an invasive insect native to Asia, was discovered in southeast Michigan in 2002. Since then, it has destroyed tens of millions of ash trees in urban, rural, and forested settings in 13 states and two Canadian provinces. Currently, the entire states of Michigan, West Virginia, Illinois, Indiana, and Ohio are under federal quarantines that restrict the movement of ash trees, branches, logs, and firewood out of those states. Kentucky is cooperating with the Animal and Plant Health Inspection Service to enforce a quarantine for specific areas of the state. Kentucky has quarantined counties 1) where EAB has been identified, 2) close to an infestation site, and 3) containing a high density of ash trees adjacent to infested counties. The 20 counties that have been quarantined include Boone, Bourbon, Campbell, Carroll, Fayette,

Franklin, Gallatin, Grant, Harrison, Henry, Jefferson, Jessamine, Kenton, Oldham, Owen, Pendleton, Scott, Shelby, Trimble and Woodford counties, as shown in Figure 9.[28,29] Survey efforts will continue in following years.

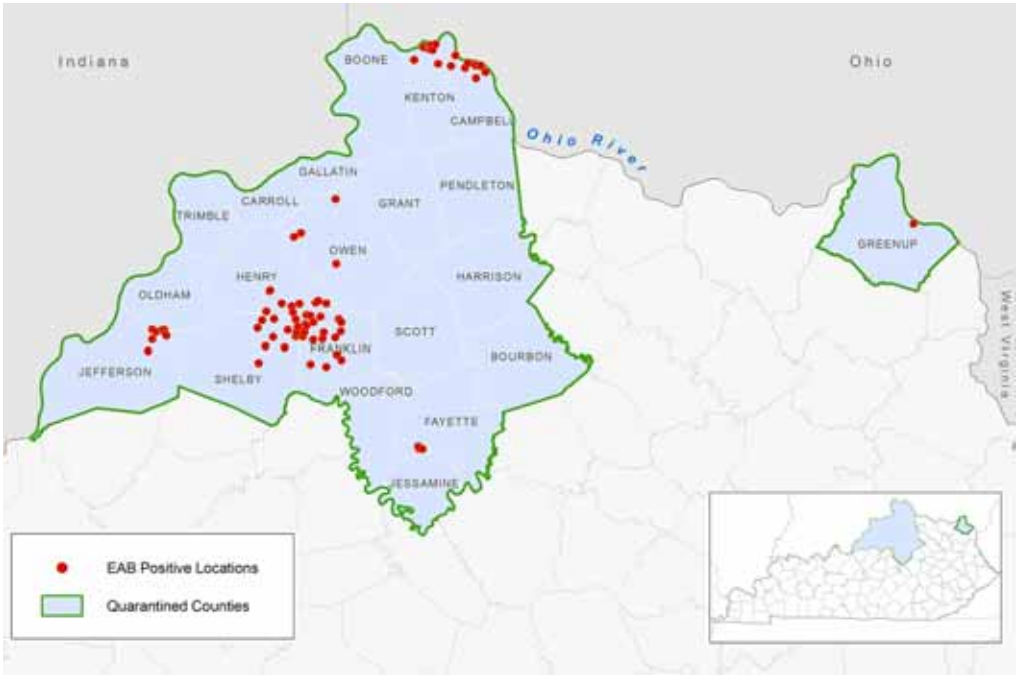


FIGURE 9 – EMERALD ASH BORER DISTRIBUTION AS OF NOVEMBER 2, 2009

Firewood movement has been a major factor in the spread of EAB; thus, the Kentucky Department of Parks has banned all non-certified firewood regardless of the source. The KFHTF produced a firewood poster that is displayed at all state and federal parks, campgrounds, and various other sites across the state.[29]

b. Hemlock Woolly Adelgid

The hemlock woolly adelgid (HWA) is one of Kentucky's most significant ecological threats. It is a small, soft-bodied insect that feeds on hemlock trees by removing fluids from the needles. Originating in Japan, it was first reported in the eastern U.S. in 1951 near Richmond, Virginia.[30] In March 2006, the first occurrence in Kentucky was documented in Harlan County.[10] This insect attacks and kills eastern hemlocks of all ages, sizes, and conditions. The hallmark of a HWA infestation is the presence of white, cottony masses on the underside of hemlock needles. The adelgids conceal themselves and their eggs under these cottony masses. In addition to Kentucky, HWA is currently in 17 states.[31] In areas of other Appalachian states, hemlock death is approximately 80%.[14] The potential loss of hemlocks in Kentucky will have major ecological and environmental effects on forest health including soil erosion, water quality, and biodiversity.[10]

In Kentucky, surveys have located HWA throughout many of the counties along the Kentucky-Virginia border and scattered distribution elsewhere in the state. Occurrences have been reported from Bell, Clay, Grayson, Harlan, Laurel, Leslie, Letcher, McCreary, Oldham, Powell, Pike, and Whitley counties as shown in Figure 10. All nine of the state nature preserves in Bell, Harlan, and Letcher counties, including the state's largest old growth forest, are infested. The infestations in Grayson and Oldham counties were fairly isolated and were eradicated by the landowners. One of the most recent infestations was found in Powell County near Gray's Arch in the Red River Gorge.[32] In 2008, state and federal agencies joined with

individuals and non-profit organizations to pool resources, prioritize treatment areas, and inform the public by forming the *Save Kentucky's Hemlocks* organization.[14]

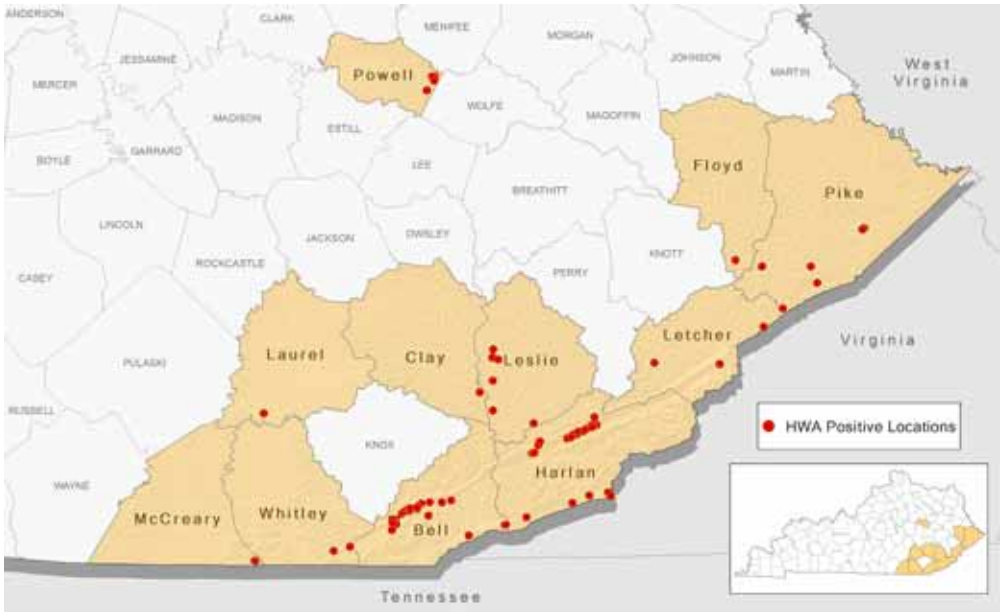


FIGURE 10 – HEMLOCK WOOLLY ADELGID DISTRIBUTION IN KENTUCKY

c. Bush Honeysuckle

Bush honeysuckle, an Asian native, was introduced to the U.S. in 1897. Escapes from ornamental plantings were recorded in the 1920s. Until the 1970s, the plant was promoted for conservation and wildlife uses.[33] It is currently widely distributed throughout Kentucky and the eastern U.S.

Although there are several species of bush honeysuckle, Amur honeysuckle is probably the single greatest invasive plant threat to forest biodiversity in Kentucky.[15] Amur honeysuckle is found throughout the northern, central, and western portions of the state, but is particularly abundant in the Bluegrass Region. It is known for its appeal as a backyard-landscaping shrub. It can establish itself practically anywhere the soil has been disturbed and is typically spread by birds. It competes especially well in canopy gaps and forestland edges and is moderately shade tolerant.[34] It rapidly colonizes these areas forming a dense shrub layer which can out-compete native species due to its prolonged growing season and suspected chemical inhibition of growth in other species.[35]

d. Kudzu

Kudzu is one of Kentucky's most important forest pests. It is a vine native to Japan and China and was first introduced to the U.S. in the late 1800s as an ornamental. It was later grown as a forage crop and promoted for erosion control. It is found throughout the southeastern U.S. and Kentucky. Kudzu can grow as much as a foot per day, and 60 feet per year, blanketing native vegetation with a thick mat that prevents photosynthesis. Its taproot can reach over six feet in length, seven inches in diameter, and weigh up to 400 pounds.[36] Additionally, kudzu is a host for soybean rust, which further increases the importance of proper control.

e. Japanese Honeysuckle

Japanese honeysuckle is also one of Kentucky's most important and widespread forest pests. It is a perennial, semi-evergreen twining vine native to Japan. It was brought to the U.S. in the early 1800s for use as a groundcover and is still sold at garden centers. Because Japanese honeysuckle is shade tolerant, the plant can creep along the ground surface at moderate growth rates, but when forest openings occur, it aggressively expands, blocking sunlight with its thick growth and girdling trees as it tightly climbs up and over their canopies. It typically dominates disturbed habitats including roadsides, old fields, forest edges, bottomlands, and floodplains. Evidence also suggests that this species is allelopathic, inhibiting the growth of other plants.[37] Selective control of this species without damaging the native vegetation on which it grows is often impossible.

f. Chestnut Blight

Chestnut blight has caused some of the most destructive impacts to Kentucky's forests. It is caused by the fungus *Cryphonectria parasitica*, which was introduced into the U.S. by Asian chestnut trees around 1900.[38] The American chestnut tree was an essential component of the forested ecosystems of the eastern U.S. At one time it composed 25% of the hardwood tree population within much of its range in the southern Appalachian Mountains, as shown in Figure 11.[39] By 1950 however, American chestnut had been all but eliminated, with other hardwoods (such as oaks) filling the areas where chestnuts used to grow.[40] The blight destroyed 3.5 billion trees in the greatest devastation of a species in recorded history.[41]

The blight fungus attacks chestnut trees by forming cankers, or localized areas of dead tissue, on their stems. Chestnut trees are killed by blight when a canker completely encircles the stem, preventing the transport of water and sugars. Trees can have multiple cankers, and each one is capable of encircling the stem.[42] Researchers are currently investigating methods to increase disease resistance in an attempt to restore the species.

(Source: *www.acf.org*)

FIGURE 11 – NATURAL RANGE OF AMERICAN CHESTNUT PRIOR TO CHESTNUT BLIGHT

g. Other Important Invasive Threats

In addition to these most prominent threats, numerous other invasive plants, insects, and diseases could be listed. In the event gypsy moth becomes established in Kentucky, it will be a significant pest based on the destruction it has caused in other states. The native southern pine beetle caused so much damage during its last outbreak that much of the host material (pines) was killed. Another future outbreak would not be expected for another 12 to 17 years. Tree of heaven, Japanese privet, Japanese stiltgrass, and Oriental bittersweet are all expanding their ranges and impacts. Diseases such as sudden oak death, thousand cankers disease, and beech bark disease have caused significant losses outside of Kentucky and are potential threats.

2. Fragmentation and Forest Loss

Forest loss by conversion to another land use and forest fragmentation, the division of forest blocks into smaller units, are two distinct but interrelated phenomena. While both issues are discussed in depth in Issue 3, habitat loss is the most significant threat to forest health in Kentucky. Forest loss eliminates or decreases habitat for wildlife and protected species, removes air and water quality benefits, and many other benefits provided by forests.

Fragmentation can lead to further forest loss or general decreases in forest health. The pressures of connecting or expanding human services by roadways, powerlines, and pipelines often fragment rural forests. New corridors through forestlands are often less expensive than reconstructing existing corridors. While construction of such corridors results in the loss of some forest area, the impact is larger than just the loss. Soil is disturbed, the opportunity for the spread of invasives is increased, and wildlife populations are divided. Fragmentation creates smaller forest blocks with more edge habitat, which is beneficial to some wildlife such as deer, but it decreases habitat for populations of interior forest species.

3. Mismanagement of Forest

Forest health can suffer both from a lack of management as well as from active, but improper, management techniques. As discussed in Issue 4, the lack of management plans or activity amongst privately owned forests indicates potential for trees to become weak, unhealthy, and susceptible to disease and insect invasion. Further complicating the problem, the threat of invasive exotic species increases in these unmanaged or mismanaged forests. Even when the desired objective is preserving a forest ecosystem, such as an old-growth forest, active management including invasive species monitoring and resources inventories are important steps in planning how to preserve an area.

However, in an effort to protect, enhance, or restore forests, managers can unwittingly cause more problems than they solve. For example, the historic suppression of fires in the Daniel Boone National Forest is thought to have contributed to the severity of the southern pine beetle outbreak in 1999 to 2002.[11] Mowers, construction equipment, and herbicide applicators can move invasive plant seeds to new locations. Similarly, other active management techniques such as timber harvesting in an area with extensive invasive plant coverage or seeding exotic invasive species for erosion control can lead to the decline of forests rather than their improvement.

4. Coal Mining

Because of the continuous need for low-cost electrical energy, coal mining is a valuable industry of Kentucky. However, surface mining removes the forests growing on top of the mountain to reach the coal supply. The forest impacts through loss and fragmentation are addressed through regulations, including

the Surface Mining Control and Reclamation Act of 1977, which requires reclamation of mining sites after projects have been completed. However, in the lag between the restoration and the impacts the forest benefits are lost. The reclaimed forests may also be of a different species composition and structure than the pre-mining forest. Invasive plants often invade reclaimed forests. The following data show the extent of the impact mining has had on Kentucky's forests:

- As of 2010, approximately 4.7% of Kentucky's eastern coalfields (339,599 acres) are permitted for mining. In Kentucky's western coalfields, a total of 46,160 acres are permitted for mining (less than 1%)[43]
- The mountaintop removal mining acreage currently permitted is less than 1% of the total surface mining area permitted in the Commonwealth[43]
- On average, mountaintop removal mining acreage represents less than 18% of the approved permit area on those mine sites where this type of reclamation is approved. Other types of mining such as area, contour, and finger-ridge removal mining, are also used on mountain areas [43]
- Since 2001 there have only been three mining permits approved with a mountaintop removal mining component, the last being issued in 2006 [43]
- From 1987 to 2001, approximately 600,000 acres previously impacted have been reclaimed [44]
- As of 2001, 80,000 to 150,000 acres still required reclamation[44]

Kentucky's coal reserves and forests are each important natural resources, and the balance between managing both of these resources to their fullest extent will remain a challenge.

5. Recreation/Aesthetics and Other Human Activities

Humans are perhaps the main contributor to the accelerated spread of insects, diseases, and invasive plant species, often due to recreational activities or aesthetic desires. Although recreation is an integral use of Kentucky's forests, frequent human travel into forests can increase the risk of carrying invasive plant seeds, insects such as gypsy moth, or other invasives into unaffected environments by their boats, trailers, cars, and trucks. For example, many are either unaware or ignore the firewood transportation restrictions, which allowed EAB to enter Kentucky. It is suspected that hikers or rock climbers may have brought HWA to the Red River Gorge. Airports and river ports can also be points of entry for invasive species, as was the case with the EAB. Kentuckians also continue to plant, likely without understanding the impacts, non-native invasive species on their landscapes. Many nurseries even encourage the planting of non-native invasive species (such as burning bush) because customers prefer their fall coloration and appearance.

Recreation activities can also negatively impact forests in other ways. All-terrain vehicle activities can cause erosion, injuries to trees, soil compaction, and the increased possibility of wildfires. Additionally, poorly designed hiking and horse trails can lead to significant erosion and impacts on plant and animal communities. Recreational activities must be available to the public, but with protective restrictions.

6. Weather and Climate Change

Weather plays a very important role in forest health. Weather events include but are not limited to drought, straight-line winds, ice and snow damage, and flooding. In recent years, Kentucky's forests have suffered considerable damage from straight-line winds and ice damage. The damage has resulted in lost revenues from potential timber sales as well as losses in recreation and aesthetics. As a result of the damage, more light can reach the forest floor, which greatly increases the risk of non-native plants becoming established in the affected environments. Additionally, the stresses resulting from damage and drought can make trees

more susceptible to insects and pathogens. As a result, there is dieback among upland species, particularly oak.

Future weather patterns may also pose an emerging threat to Kentucky's forests as the mean global surface temperature has increased approximately one degree since the mid 1970s.[45] If changes in the temperature and weather patterns continue to increase, the hardiness zones and natural ranges of the plant species around the globe may also change. Some predictions suggest that increased temperatures might improve diversity and mast production in oak-hickory forests. However, some of Kentucky's forest species may not be as competitive as those adapted to future conditions, which may lead to negative changes in the forest communities.

7. Air Pollution

Ozone, which provides protection from ultraviolet rays in the upper atmosphere, also affects the growth and development of forest vegetation by directly injuring the foliage of sensitive species when abundant in the troposphere. In Kentucky, black cherry, sassafras, yellow poplar, spreading dogbane, milkweed, bigleaf aster, white ash, sweetgum, pin cherry, and blackberry are bioindicators of ozone damage. Statewide, approximately 2% of these plants exhibited signs of ozone-related injury but the damage usually only affected less than 5% of the plant.[8] Ambient ozone exposures tend to be lowest where Kentucky's forested acreage is highest.[8]

G. Opportunities

Although the threats to Kentucky's forest health are many and diverse, the opportunities for addressing these threats and improving health in other ways are also numerous and diverse. Bright spots such as the reintroduction of the American chestnut, the tree nurseries of Kentucky, heightened concern about wildfires, increased management use of prescribed fire, and the increased awareness of invasive exotic species indicate that much can be done to improve forest health.

1. Public Awareness

Outreach and education play a vital role in disseminating ecological and environmental information to landowners to promote sound forest management practices on private lands. Healthy forests play an important role in meeting the diverse cultural, recreational, and economic needs of the people of Kentucky. It is important to continue to develop innovative ways of communicating with the general public and Kentucky's forest owners to help them to understand why and how insects, diseases, and non-native invasive plant species must be controlled. Otherwise, the current health and composition of Kentucky's forests could be irreversibly altered.

Increased public awareness of the effect of exotic invasive species may reduce the purchase of such species for ornamental planting, erosion control, or wildlife use. Also, public campaigns, such as stopping the spread of the EAB through firewood movement, may increase proactive management and prevention of the spread of invasive species.

KDF promotes multiple educational programs for schools, clubs, and organizations including Project Learning Tree, Kentucky Envirothon, forestry-related units of study for teachers, and Woodland Owner Short Courses for adults. They also produce three issues of the *Kentucky Woodlands Magazine* each year and four issues of the *Tree Line* newsletter. These programs, as well as others, are advancing the

education of the Kentucky public on forestry-related issues. Other agencies, non-profits, and local governments have public awareness campaigns that may also be utilized to increase local awareness.

2. Reintroduction of American Chestnut

Two approaches to restoring the chestnut to a place of ecological and economic importance have been advanced. The American Chestnut Cooperators' Foundation (ACCF) is conducting breeding amongst native American chestnuts that are resistant to the chestnut blight, while The American Chestnut Foundation (TACF) is intercrossing Chinese chestnuts with American chestnuts in order to improve resistance. As of April 2009, the ACCF boasted that 188,849 seedlings and seed nuts of the all-American chestnuts had been planted.[41] TACF has also achieved much success, producing hybrid chestnuts that are essentially 15/16 American chestnut and 1/16 Chinese chestnut in character. Further breeding will produce pure-breeding blight resistant chestnuts that display many of the American chestnut's growth characteristics while retaining the blight resistance of Chinese chestnuts.

The Kentucky Chapter of TACF has developed mother tree orchards in Adair, Carter, and Morgan counties. These mother tree orchards contain sprouts that were dug from the forest and transported to a location where they could be cared for and eventually pollinated and incorporated into TACF's breeding program. This will help to preserve more of the American chestnut's genetic diversity. The TACF hopes to establish mother tree orchards with trees from every region where chestnuts were present.[46] Two new orchards were established in April 2008: the Meades Landing Orchard in Oldham County and the Wilkins Orchard in Shelby County.[47]

Successful planting efforts are also aiding in restoring the American chestnut. The Appalachian Regional Reforestation Initiative, coal groups, and the KDF have worked with the TACF to incorporate American chestnut into surface mine reclamation efforts.[46,47] It is hoped that similar restoration opportunities will continue to be pursued. The American chestnut is still considered endangered in Kentucky based on Kentucky Revised Statute (KRS) 146.610(2)(a) and 400 KAR 3:020, Section 3. Under KRS 149.015, the Energy and Environment Cabinet is required to establish and maintain propagation of blight resistant chestnut tree seedlings within their nurseries and provide them to landowners at reasonable cost.

3. Small Woodlot Management

Seventy-five percent of Kentucky forest landowners own 10 acres or less. This translates to approximately 702,000 acres of family-owned forests of a size considered to be unavailable for sustained timber production.[8] Although many of the small landowners have no interest in harvesting timber, preferring to maintain their property for the aesthetic value, recreation, and wildlife, opportunities exist for small forests to provide big benefits to all Kentuckians. Because only 1% of the 423,000 private landowners in 2004 had a written management plan, education and outreach targeting this sector may provide large dividends.[8]

4. Certification

Forest certification, covered in more detail in Issue 4, is the process of determining if forest management on a given property meets predetermined environmental, economic, and social standards of good management. It may be accomplished through the Sustainable Forestry Initiative® (SFI), American Tree Farm System® (ATFS), or the Forest Stewardship Council (FSC). Forest certification provides credentials for the timber products grown on certified forests in an effort to promote sustainable forestry practices. There is a chain of custody process that tracks the products from the forest to the end use. Ensuring market access for certified wood products and improving forest management are the two primary objectives

of forest certification. With these objectives, forest certification should provide forest owners a competitive advantage and increase wood profit over time. Certified forest products are produced in a manner that promotes environmental, social, and economic sustainability.

According to the Kentucky Woodland Owner's Association, there are currently very few certified forests due to the costs associated with third party audits under the FSC system. However, hopes are that the ATFS certification system will gain increased recognition and prominence to the advantage of Kentucky forest landowners.[48]

5. Kentucky Division of Forestry Nurseries

Kentucky's interest in reforestation began in 1914 when the General Assembly authorized the establishment of two small nurseries, which were located in Frankfort and Louisville.

The KDF now operates two tree seedling nurseries:

- John P. Rhody Nursery located near Gilbertsville in western Kentucky, established in 1956
- Morgan County Nursery located near West Liberty in eastern Kentucky, established in 1960

The two nurseries grow 3-4 million seedlings annually, which are sold at a low cost to the public. Tree species include both hardwoods and pines.[49] The nurseries are important means of providing stock for afforestation and reforestation of the rural and urban areas of Kentucky.

6. Fire Prevention

As discussed earlier, Kentucky has the highest rate of deliberately set wildfires in the southern U.S.[26] Strong preventative measures must continue to be enforced to discourage the arsonists. The Wildland Arson Task Force recommended a two-fold approach to address this problem. First, establish a KDF law enforcement unit with proper positions, funding, and equipment to investigate and prosecute wildland arson with increased penalties for offenders. Second, increase KDF funding to initiate a comprehensive media campaign, to increase the education of officials, and to develop a strong fire prevention program in Kentucky's schools.[26] Unfortunately, none of these recommendations was funded, so the arson problem remains.

The main tool available to reduce the wildfire risk to communities is the Community Wildfire Protection Plan (CWPP). The Healthy Forests Restoration Act of 2003 authorized and defined CWPP's and outlined how they relate to hazardous fuel reduction funding. Key points for the CWPP include:

- Plans are generally developed by local government with assistance from state and federal agencies and other interested partners
- Plans can take a variety of forms and may be as simple or complex as necessary, based on the specific needs and desires of the local community or county
- Plans do not need to be complicated but they should effectively address local forest and range conditions, values-at-risk, and priorities for action

Thirty-eight of Kentucky communities have developed CWPPs, as shown in Figure 12. Local, state, and federal officials, as appropriate, collaboratively developed these plans. They identify and prioritize areas for hazardous fuel reduction treatments to reduce the wildfire risk, and recommend measures that communities can take to reduce the ignitability of structures in the community. Because most of these CWPPs are not located in communities (CARS) at high or very high risk, there are many opportunities to

increase wildfire protection in Kentucky. For example, no CWPPs have been developed in Perry County, which has the highest number of CARS in the state.

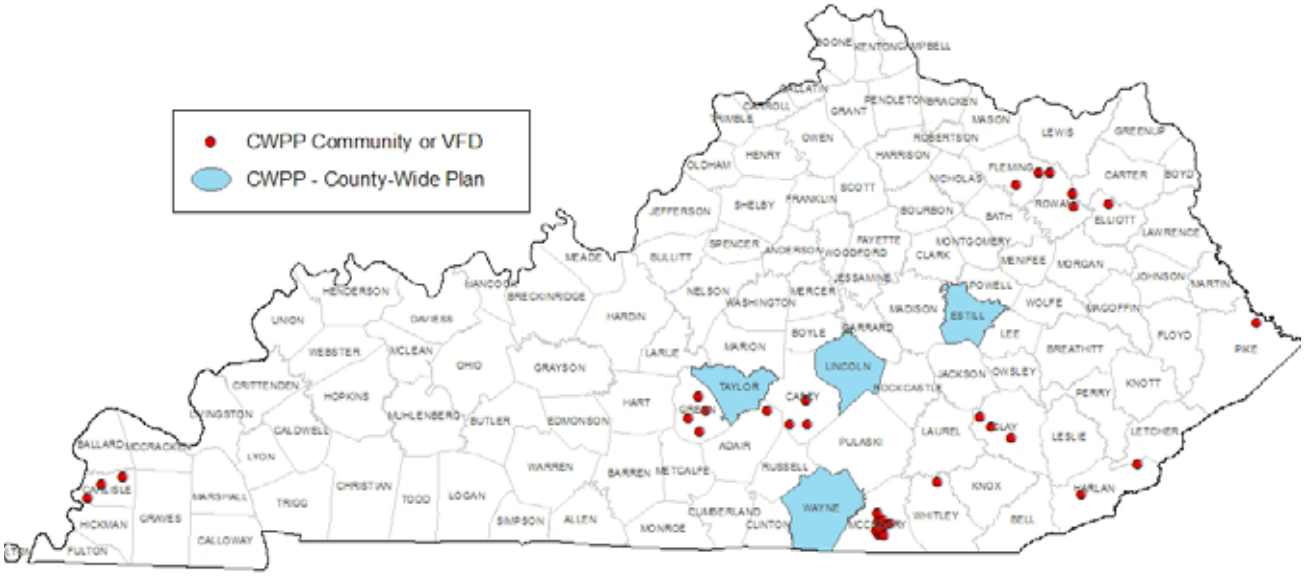


FIGURE 12 – KENTUCKY COMMUNITY WILDFIRE PROTECTION PLANS

Kentucky has excellent outreach programs and has held numerous meetings in different parts of the state in an effort to educate the general public about the serious impacts of wildfire. Although not a fire prevention program, the Firewise USA Communities program encourages small communities and associations to take action to minimize home loss to wildfire. Kentucky currently has 29 Firewise USA Communities.[50]

7. Prescribed Fire

Ongoing research throughout Kentucky is directed at understanding the potential for prescribed fire to accomplish forest management goals, which include the reduction in fire-sensitive species and tree density.[11] Fire has been an important disturbance agent in our forests for thousands of years and is thought to have been integral to the long-term development of upland oak forests in the Appalachian region. Managers responsible for maintaining the diversity and productivity of southern Appalachian forests are increasingly turning to prescribed fire as a management tool in oak-dominated forests.[51] On March 12, 2007, prescribed fire was used to restore open wildlife habitat on Taylorsville Lake WMA. At 1,100 acres in size, it was the largest prescribed fire in the Kentucky Department of Fish and Wildlife Resources (KDFWR) history.[52]

In addition to the KDFWR, many other forest management groups such as the KSNPC, USFS Land Between the Lakes National Recreational Area, and the USFS Daniel Boone National Forest, are utilizing prescribed fire as a management tool. The Kentucky Prescribed Fire Council is a large and diverse organization involved in many aspects of prescribed fire including education, training, and collaboration. Its mission is to promote understanding and enhance collaboration for the use of ecologically based prescribed fire in the Commonwealth of Kentucky.