

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.”⁶ 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.⁷ Forest health is a broad term encompassing the evaluation of the entire forest ecosystem and its interactions, both in urban and rural forests.

Maintaining forest health is directly tied to proper forest management. Examples include reducing wild fires and managing the numerous invasive species that impact our forests. Unfortunately, continued globalization and rapid worldwide movement of goods have led to increases in the importation of exotic pathogens, plants, and insects. Many of the exotic species that are invasive can alter forest ecosystems and threaten the health of Kentucky’s forests.⁶ Because Kentucky native forests have little or no resistance to invaders, areas not managed will certainly be negatively impacted. Active management, as opposed to passive neglect, is important to improve and sustain forest health.⁷ 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.⁶

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. According to the 2017 Kentucky Forest Sector Economic Contribution Report, the total direct economic contribution of Kentucky’s forests was equal to \$8.5 billion, while the total economic contribution was equal to \$13.5 billion with over 60,000 jobs in the forest sector.⁸ These economic benefits show that healthy forests are important monetary assets for Kentucky forest landowners.

2. Recreation and Aesthetics

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. 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 miles⁹, 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 wellbeing of people and communities and reduces processing costs.¹⁰

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.¹¹ 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 (CO₂), 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 CO₂, methane (CH₄) and nitrous oxide (N₂O). 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.¹² Increased greenhouse gas concentrations are predicted to raise the Earth's average temperature, and influence precipitation and storm patterns. Such changes could also alter 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 48%

of Kentucky is forested, nearly 680,000 acres of forest, primarily on private lands, were converted to other land uses in the last 15 years.⁷ This land area is significant, representing an area nearly as large as the entire Daniel Boone National Forest, which is over 708,000 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.¹¹

The Office of Kentucky Nature Preserves (OKNP) estimates that only 0.5% of Kentucky remains in a natural condition compared to what existed prior to European settlement.¹³ Only about 5,000 acres of old-growth forest remain in Kentucky.¹⁴ 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 the 554 acre 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.¹⁴

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.¹⁴

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.

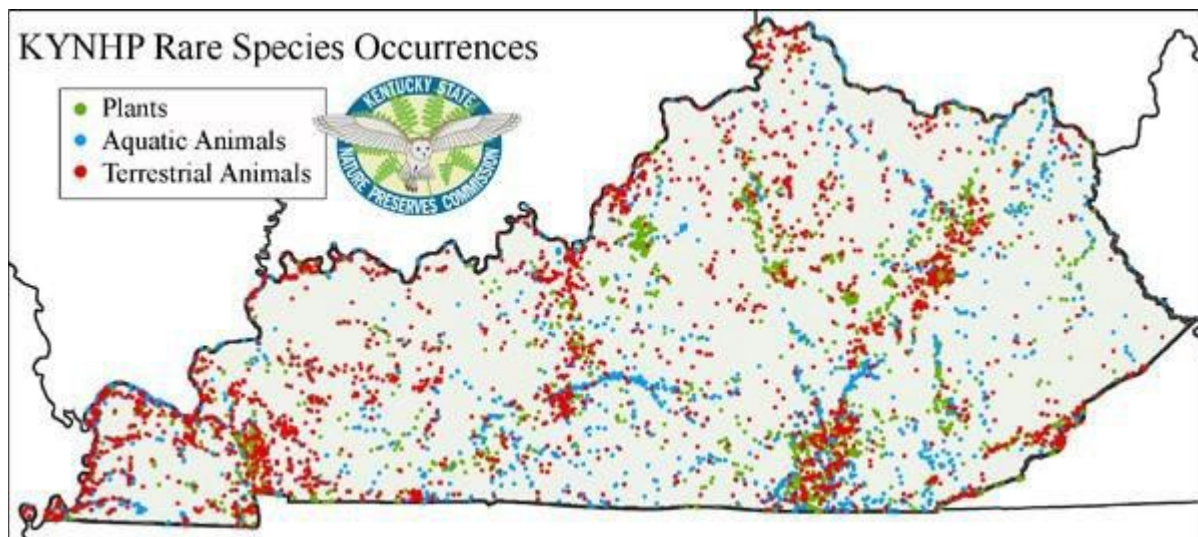
c. *Southern Floodplain Forest Region*

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. In addition, 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, 387 vascular plant and lesser taxa, and 347 animal taxa. 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. Thirty-six natural communities are also considered to be rare. Of these communities, several are forest communities 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 are examples.¹⁴



(Source: KSNPC)

FIGURE 3 – KENTUCKY NATURAL HERITAGE PROGRAM RARE SPECIES OCCURRENCES

3. Soils

Forest soils are substantial contributors to the forest ecosystem and forest health. The locations of soil types within Kentucky are shown in Figure 4. 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.¹¹ Limestone-derived soils tend to support more plant species and be more productive than sandstone soils.¹⁵ 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.¹¹

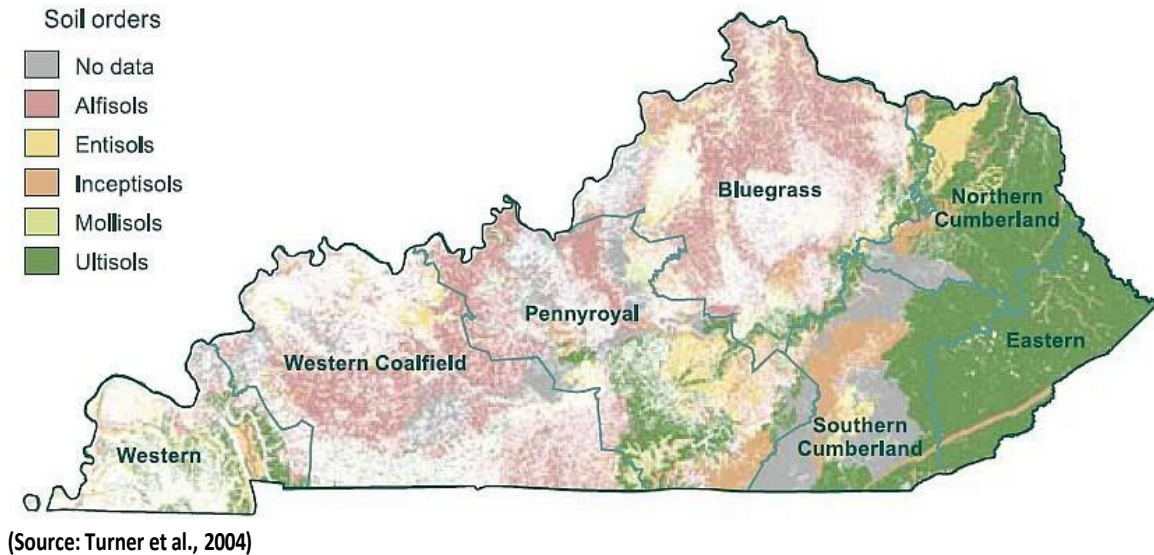


FIGURE 4 – SOIL ORDERS OF KENTUCKY FORESTS

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,¹⁶ while severe fire can cause significant losses of soil nitrogen that affect subsequent forest growth.¹⁷ Water content in non-forest soils is higher than in forest soils, as are stream flow and peak flows.¹⁸ Thus, differences in soil moisture levels have been found to affect the rate of soil nitrogen cycling,¹⁷ 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.”¹⁹ 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 Plan²⁰ 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 open 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 are key conditions 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, structure and diversity are also key conditions for healthy forests. Structure refers to the complexity of the vertical and horizontal forest as well as the success of successional processes creating this complexity. Diversity refers to different types of forest communities as well as numbers of species within forests. Complexity of the forest structure with overstory, understory, shrub, and herbaceous cover similarly provides increased protection and food supplies to forest animals. A high diversity of tree species and communities allows for more abundant and diverse wildlife populations due to increased food sources and habitats. When the structure or diversity 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

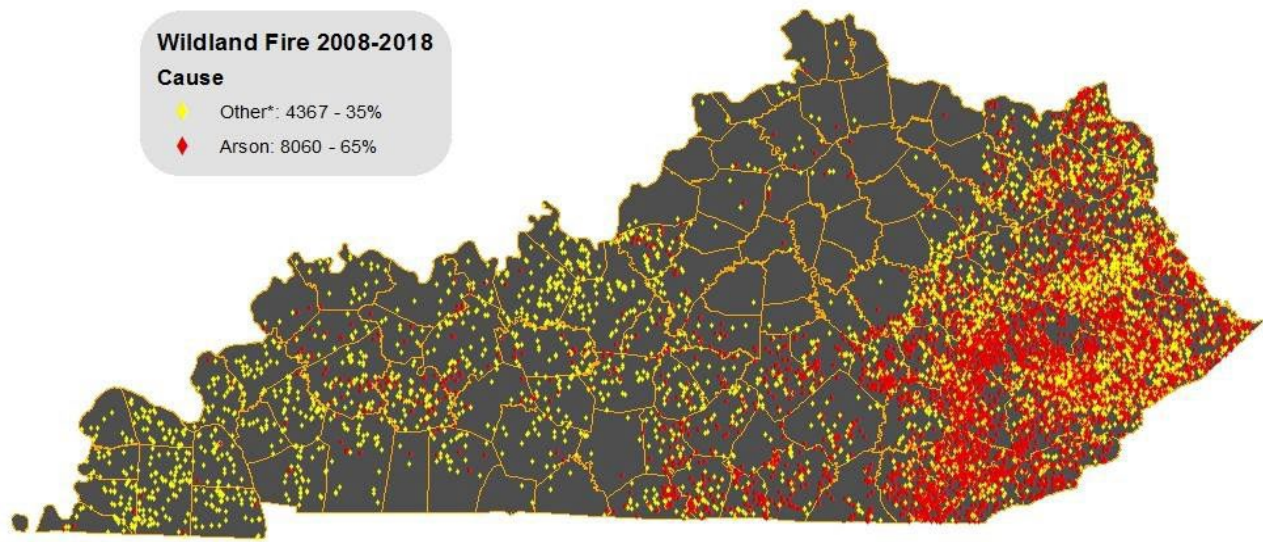
begins with the clearing of an entire site (removing all structure and diversity), and then creating ornamental landscapes with trees of similar ages and with a limited selection of species. However, by active planning to retain large portions of the existing vegetation, the impacts to the structure and diversity 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.

Previous research is showing that the Daniel Boone National Forest is more crowded due to fire suppression.²¹ In forests experiencing crowding 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 by lowering hazardous fuel loads, 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 OKNP, “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.”¹³

Uncontrolled wildfires can be extremely dangerous and costly, both in terms of forest health and in terms of 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. Data from the Kentucky Division of Forestry reported 12,422 wildland fires from 2008 to 2018 burned 371,782 acres of private land and cost over \$8.5 million in suppression costs. From 2008 through 2018, arsonists started 65% of the 10,942 fires in Kentucky, predominantly in the eastern Kentucky area, as shown in Figure 5. 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.



* Other causes include Lightning, Campfire, Smoking, Debris, Railroad, Equipment, Children, & Miscellaneous

FIGURE 5 – WILDFIRE AND ARSON FIRES RESPONDED TO BY KDF FROM 2008-2018

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 threats to Kentucky's forest health are 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 1, are discussed. Most of these threats are exotic with the exception of the native Southern Pine Beetle.

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 Aquatic and Terrestrial Nuisance Species Management Plans produced by the KDFWR and the Kentucky Invasive Plant Council website (www.se-eppc.org/ky/).

TABLE 1 – PROMINENT THREATS FROM INSECTS, PLANTS, AND DISEASES

INSECTS	PLANTS	DISEASES
Emerald Ash Borer Hemlock Woolly Adelgid Gypsy Moth Southern Pine Beetle	Bush Honeysuckle Kudzu Japanese Honeysuckle Tree of Heaven Japanese Privet Oriental Bittersweet	Laurel Wilt Disease Thousand Cankers Disease Sudden Oak Death Beech Bark Disease

a. *Emerald Ash Borer*

The Emerald Ash Borer (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 across much of the eastern United States. EAB was first confirmed in Kentucky in 2009. An EAB quarantine of 20 counties located in the region between Louisville, Lexington, and northern Kentucky was initially established. In the following years, additional EAB infestations were found in nearby counties and the state quarantine was expanded accordingly. In April of 2014, the county quarantine system was rescinded and the entire state was added to the Animal and Plant Health Inspection Service (APHIS) list of regulated areas. EAB has since continued its spread through Kentucky and as of October 2019 has been confirmed in 92 counties (Figure 6).

Ash trees are prevalent throughout Kentucky and are an important part of Kentucky’s forests. Because of the spread of EAB, many woodland owners and forest industries already are or will be impacted by this invasive insect. Based on current utilization rates for ash, it has been estimated that the EAB-induced ash disaster will cost landowners and forest industries nearly \$100 million annually.²³

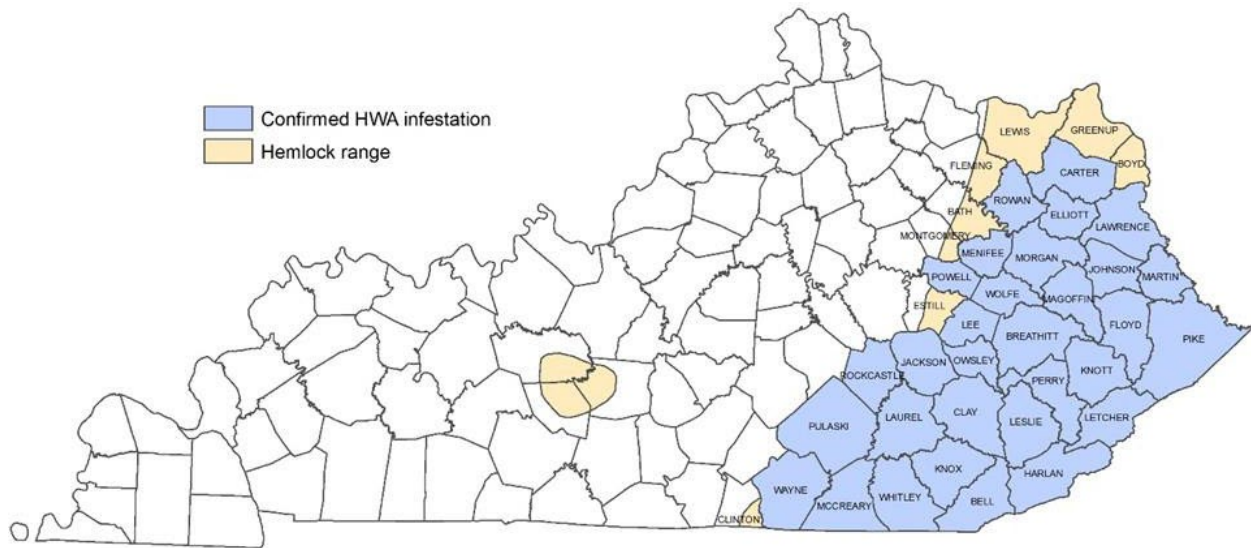


FIGURE 7 – HEMLOCK WOOLLY ADELGID DISTRIBUTION IN KENTUCKY

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.²⁵ 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.¹⁴ 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.²⁶ 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.²⁷

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.²⁸ Additionally, kudzu is a host for soybean rust, which further increases the importance of proper control.

e. *Japanese Honeysuckle*

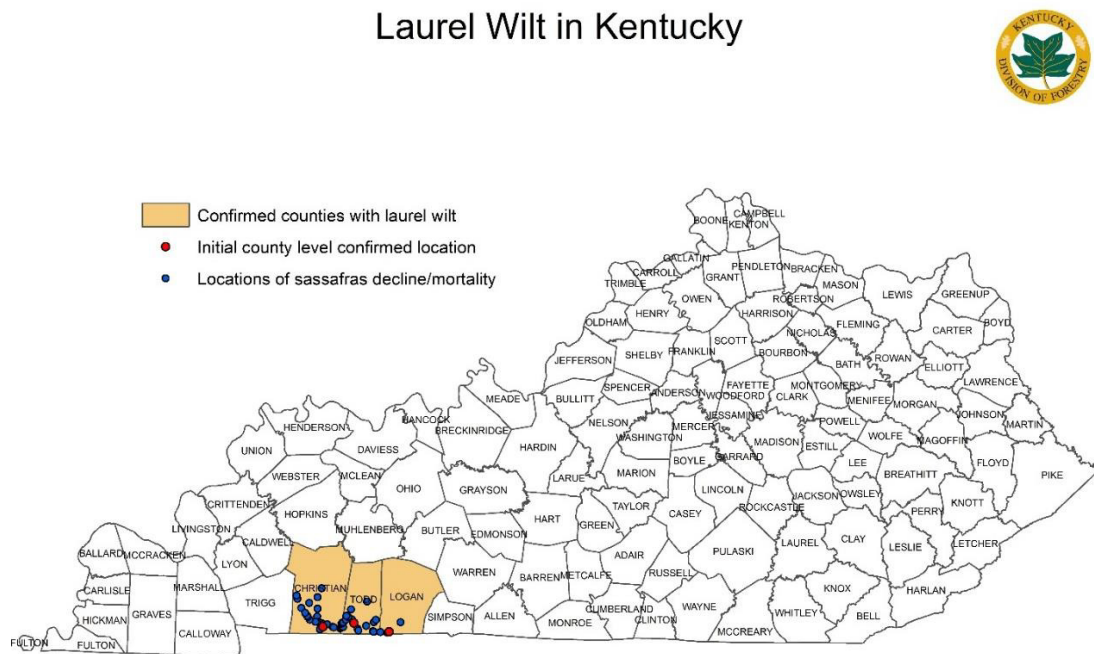
Japanese honeysuckle is also one of Kentucky's most important and widespread forest pests. It is a perennial, semi-evergreen twining vine native to Japan. It was brought to the U.S. in the early 1800s for use

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.²⁹ Selective control of this species without damaging the native vegetation on which it grows is often impossible.

f. Laurel Wilt Disease

Laurel wilt is a new disease that was confirmed in Kentucky in 2019. The disease is known to impact certain members of the laurel family (Lauraceae). Decline related to this disease was first documented in Georgia in 2002 where large numbers of coastal Redbay trees began dying. Research has found that the fungus *Raffaella lauricola* is responsible for tree death and that the non-native Redbay ambrosia beetle (*Xyleborus glabratus*) serves as the main vector for transmitting the disease to new trees.³⁰ As the Redbay ambrosia beetle bores into trees, it transmits the spores of the fungus to the tree. Over time, the fungus compromises the vascular system, which causes tree wilting and mortality.

Since 2002, laurel wilt has spread from coastal Georgia to 11 states across the southeastern US. In addition to range expansion, the disease has moved into a new host from the laurel family, sassafras. In 2019, pockets of sassafras decline were reported in southwestern Kentucky and lab tests soon confirmed laurel wilt in Christian, Todd and Logan counties (Figure 8). In Kentucky, sassafras will be the main species impacted but there is also potential for decline in spicebush, a common woodland shrub belonging to the laurel family. It can be expected that over time laurel wilt will move throughout the range of sassafras in Kentucky.



Last updated: August 14, 2019

FIGURE 8 – LAUREL WILT DISTRIBUTION IN KENTUCKY

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 Asian longhorned beetle is currently found in Ohio and would be a major pest of concern if it ever spread into Kentucky. Another pest not found in Kentucky but that is impacting nearby states is the spotted lanternfly. 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. Forest Loss and Fragmentation

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, and removes air and water quality benefits, as well as 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, power lines, 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. 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 April 2019, approximately 4.3% of Kentucky's eastern coalfields (370,808 acres) are permitted for mining. In Kentucky's western coalfields, a total of 40,673 acres are permitted for mining (approximately 1.4%)³¹
- The mountaintop removal mining acreage currently permitted is 1% of the total surface mining area permitted in the Commonwealth³¹
- On average, mountaintop removal mining acreage represents less than 15% 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 areas³¹
- Since 2001 there have only been three mining permits approved with a mountaintop removal mining component, the last being issued in 2006³¹

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 the past decade, 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.

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. The direct impact of potential changing climate on Kentucky forests is unknown, but certain species may not be as suited under future conditions as they are now.

F. 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 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.

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

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 to the U.S. by imported Asian chestnut trees around 1900.³² 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 11.³³ However, by 1950, the American chestnut had been all but eliminated, with other hardwoods (such as oaks) filling the areas where chestnuts used to grow.³⁴ The blight destroyed 3.5 billion trees in the greatest devastation of a species in recorded history.³⁵ Indeed, the USDA has deemed the American chestnut to be functionally extinct due to the extent of the loss.³⁶ Yet many stakeholders are working together to bring this tree back to our forests.

Three approaches to restoring the American chestnut to a place of ecological and economic importance have been advanced. Thus far, this includes breeding, biotechnology, and biocontrol. The American Chestnut Cooperators' Foundation (ACCF) is continuing the traditional method of breeding with all-American wild-types from various regions of the tree's native range to achieve blight resistance.³⁷ Whereas, the American Chestnut Foundation (TACF) is crossbreeding Chinese chestnuts, which are less susceptible to blight, with American chestnuts in order to improve resistance. These hybridized chestnuts are essentially 94% American, displaying all the characteristics of native wild-types, with the addition of Chinese blight resistance.

Currently, there are 17 seed orchards being operated by various state chapters, and starting in 2011, the offspring of these hybrids were put to the test in restoration trials across the region.³⁶ Additional resistance selection is also underway for *Phytophthora cinnamomi*, the agent of ink disease, which has already stalled restoration efforts in some orchards. Meanwhile, the biotechnological aspects of the program are progressing rapidly. Researchers with the State University of New York's College of Environmental Science and Forestry have found a gene (OxO) within wheat that enhances resistance through an oxalate detoxifying enzyme. This enzyme attacks and eradicates oxalic acid, the primary weapon employed by the *Cryphonectria* fungus. Transgenic innovation has made it possible for the OxO gene to be successfully incorporated into American chestnuts resulting in trees that are 99.999% the same as their wild counterparts. These genetically modified trees are awaiting federal approval before they will be ready for public distribution within the next five years.³⁸ The final route to restoration is through biocontrol and it presents itself through hypovirulence. Several strains of the fungus contain viruses which hinder the fatal progression throughout the tree, thus giving the tree a better chance to defend itself. In the future, these specific strains will be unified into the overall plan for restoration.³⁶

Here in our state 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.³⁹ Two new orchards were established in April 2008: the Meades Landing Orchard in Oldham County and the Wilkins Orchard in Shelby County.⁴⁰ The first chestnut grove was started in 2011 at Jefferson Memorial Forest, and likewise in 2011, a breeding orchard located in Robinson Forest was the first to inoculate trees to check for blight resistance. We also have a regional seed orchard on EKU's campus in Madison County, which began in 2016, and has had approximately 3,000 seedlings planted to date.³⁶

Successful planting efforts are also aiding in restoring the American chestnut. The Appalachian Regional Reforestation Initiative (ARRI), coal groups, and the KDF have worked with the TACF to incorporate American chestnut into surface mine reclamation efforts.^{39, 40} In 2008, ARRI began a program to reforest mine lands with American chestnut. Thus far, Operation Springboard has been very successful, with 142,500 trees planted in 2009 and 2010,⁴¹ and additional funding for 12 more sites on reclaimed mines, some of which are located in Kentucky.⁴² 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.

It is the goal of all the stakeholders involved to insure the restoration and reforestation of the American chestnut. Yet, this achievement demands collaboration from all counterparts, and will most likely necessitate synergistic approaches. Moving forward, the program will have to take other factors into consideration. Indeed, other forest health concerns such as ambrosia beetles and gall wasps will need special attention.

3. Small Woodlot Management

Many of the small woodlot landowners have no interest in harvesting timber, instead preferring to maintain their property for the aesthetic value, recreation, and wildlife. Opportunities exist for small forests to provide big benefits to all Kentuckians. It is extremely difficult to manage these properties for long-term forest sustainability.

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. Certification 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.

5. Kentucky Division of Forestry Tree Seedling 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 1-3 million seedlings annually, which are sold at a low cost to the public. Tree species include both hardwoods and pines.⁴³ 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.²² Strong preventative measures must continue to be enforced to discourage 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.²² Unfortunately, none of these recommendations were funded, so the arson problem persists. However in 2016, the KDF partnered with the KDFWR Law Enforcement Division to provide assistance to the KDF employees in investigating and prosecuting violations of burning laws. This partnership was made possible through a grant from the USFS.

Kentucky utilizes the Community Wildfire Protection Plan and Firewise USA® program to help reduce wildfire risk to communities. The Healthy Forests Restoration Act of 2003 authorized and defined CWPPs 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

Currently, 50 Kentucky communities and six counties have developed CWPPs, as shown in Figure 9. Since 2016, seven plans have been developed for communities at high risk of wildfires, and six more plans are expected to be completed by 2020. 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. CWPPs incorporate an education component to prioritize teaching residents about wildfire safety, prevention, and risk reduction.

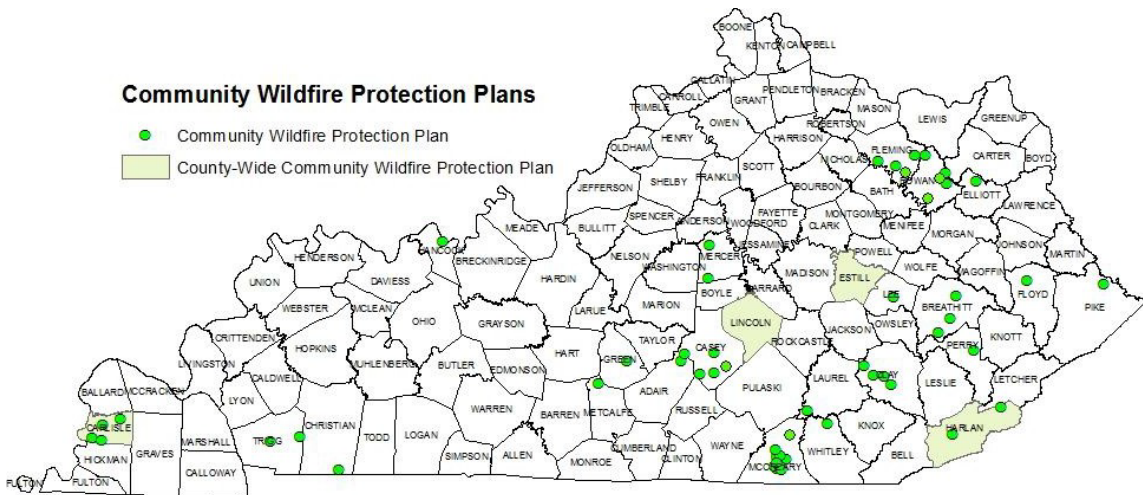


FIGURE 9 – KENTUCKY COMMUNITY WILDFIRE PROTECTION PLANS

Firewise USA® is a program that teaches residents actions they can accomplish to reduce wildfire risks around their homes and neighborhoods. It encourages communities to take ownership of their wildfire safety, and learn how to live harmoniously with wildfire. Developing a CWPP is a key component to Firewise USA® program in Kentucky. Kentucky currently has seven active Firewise Communities and nine that are working toward recognition.

Kentucky maintains a thriving Smokey Bear program, as well as other outreach activities, throughout the

year. Personnel across the state plan and participate in meetings, displays, classes, field days and other activities to educate the public about the many aspects of wildfire.

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.⁷ 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.⁴⁴

The Kentucky Division of Forestry (KDF) began participating in prescribed fire implementation during the spring of 2018. From that season through June 30, 2019, the KDF has assisted the USFS Daniel Boone National Forest, Office of Kentucky Nature Preserves, The Nature Conservancy, U. S. Fish and Wildlife, and the Kentucky Department of Fish and Wildlife Resources in implementing approximately 15,000 acres of fuel reduction and ecological diversity. The KDF is making strides to improve the prescribed fire program within the agency by encouraging personnel to attend the Kentucky Certified Burn Boss trainings, participating in prescribed fires management, and participating on the Kentucky Prescribed Fire Council either as a member of the executive board, or on individual committees. With these strides, the agency will be able to offer prescribed fire to private landowners to help with hazardous fuel reduction in areas of wildland urban interface, and enhancing ecosystems in critical habitats.