2020 Mast Survey Report
Kentucky Department of Fish and Wildlife Resources

White oak (*Quercus alba*), a vital food source for wildlife. Photo: KDFWR.

Contents

Introduction

Our Agency

The Kentucky Department of Fish and Wildlife Resources (KDFWR) is an agency of the Kentucky Tourism, Arts & Heritage Cabinet. KDFWR is overseen by a commission of members nominated by Kentucky's sportsmen and women from 9 districts across the state and appointed by the Governor. KDFWR employs about 400 full-time staff, including conservation officers, wildlife and fisheries biologists, conservation educators, and specialists in information technology, public relations, and administrative services. KDFWR receives no money from the state's General Fund; rather, the agency is funded through the sale of hunting and fishing licenses, boating registration fees, and federal grants based on the number of hunting and fishing licenses sold in the state.

KDFWR's Wildlife Division is responsible for the conservation and management of wildlife populations in the state to provide opportunity for hunting and viewing wildlife. Each year, KDFWR staff and partners from other agencies, universities, and non-governmental organizations conduct a mast survey in an effort to summarize mast conditions and shed light on population and harvest trends of various wildlife species. The Grouse & Turkey Program and Small Game Program coordinate the survey and prepared this report of survey findings.

Importance of Mast to Wildlife

Mast refers to the fruit of woody vegetation, many types of which provide important foods for wildlife. "Hard mast" includes acorns, hickory nuts, beechnuts, walnuts, and hazelnuts, all of which are available to wildlife beginning in late summer through fall and winter. "Soft mast" includes the many types of soft fruits produced from late spring through the summer and early fall, such as serviceberries, wild plums, wild grapes, dogwood berries, and persimmons.

Both hard and soft mast are important for Kentucky's wildlife throughout the year, but fall and winter hard mast production is of primary concern for wildlife managers because of the great influence this food resource exerts on the movements, body condition, and thus population dynamics of many forest-dwelling wildlife species. Thus, the KDFWR Mast Survey focuses on surveying oak, hickory, and American beech trees.

Deer, bears, wild turkeys, ruffed grouse, squirrels, small mammals, and other species depend on nutritious hard mast to bulk up before winter and for sustenance during winter when few other foods are available. Research has shown that in years when acorn crops are large enough to be available in March and April, female ruffed grouse enter the nesting season in better condition. The same may be true for other species. Animal movement in fall and winter is related to the availability of high-energy hard mast foods. In years when little to no mast is available from oaks, hickories, or beech trees, wildlife may move more often and/or greater distances in search of limited food supplies. Higher rates of movement may lead to more encounters with wildlife, some positive (deer and turkeys using fields to a greater degree in search of waste grains) and some negative (bear nuisance activity may be higher).

Mast production may be highly variable year to year, especially among the many oak species in our forests. Harsh spring weather may hinder flowering and pollination, reducing the fall mast crop. However, weather does not explain all the variability in mast production and all factors influencing a given year's mast crop are unknown. Variability in production is buffered to some degree by having different hard mast species present in a forest stand, and most forests in Kentucky have multiple oak and hickory species. Some have walnuts and beech, as well.

Monitoring Mast Production: KDFWR's Mast Survey

Since 1982, KDFWR has conducted a statewide mast production survey of important producers of wildlife foods. The KDFWR Mast Survey evaluates 4 broad groups of trees of importance to Kentucky wildlife: red oaks, white oaks, hickories, and beech. By monitoring mast production annually, we can detect trends in wildlife food availability in our forests any given year. We may also compare these metrics to the number of animals harvested or observed in a given year to determine the relationship between mast and wildlife.

Past Method

Beginning in 1982 the Mast Survey took the form of a survey card sent out to area biologists for completion on 3 separate areas in their respective regions. The survey card had 4 categories for each tree and shrub group: Heavy, Moderate, Light, and None. These subjective categories reflected the surveyor's personal evaluation of the amount of hard or soft mast occurring on each group of trees and shrubs in September and October (**Figure 1**). The trends observed from these data cannot be assimilated in the current survey method, but are valuable metrics in a historical context (**Figure 2**).

ANNUAL MAST SURVEY CARD			G-PR(44)	
County_____ Observer _____ Year 2005				
	Heavy	Moderate	Light	None
The Hickories				
The Red Oaks				
The White Oaks				
Black Walnut				
American Beech				
Flowering Dogwood				
Other				

Figure 1. Old survey card method for mast assessment across Kentucky 1982 – 2007.

Overall Mast Production in Kentucky, 1982-2006

Figure 2a: Mast Survey results, 1982-2006.

Ratings are mast production index values averaged annually across all trees surveyed. Species survey included various white oak, red oak, and hickory species, American beech, black walnut, and flowering dogwood.
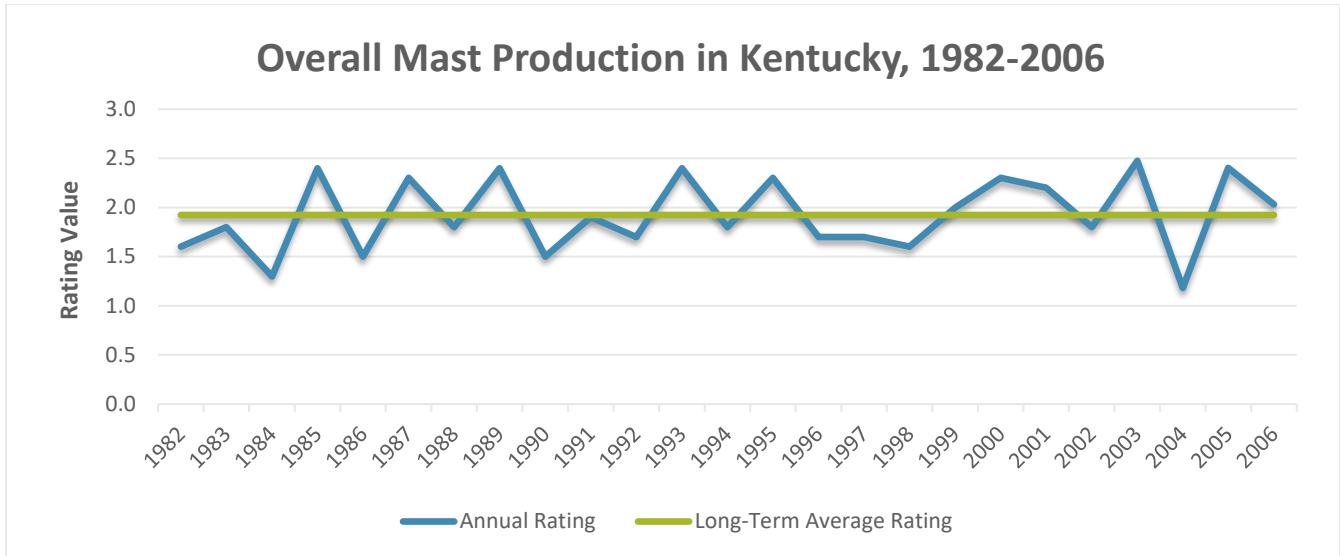
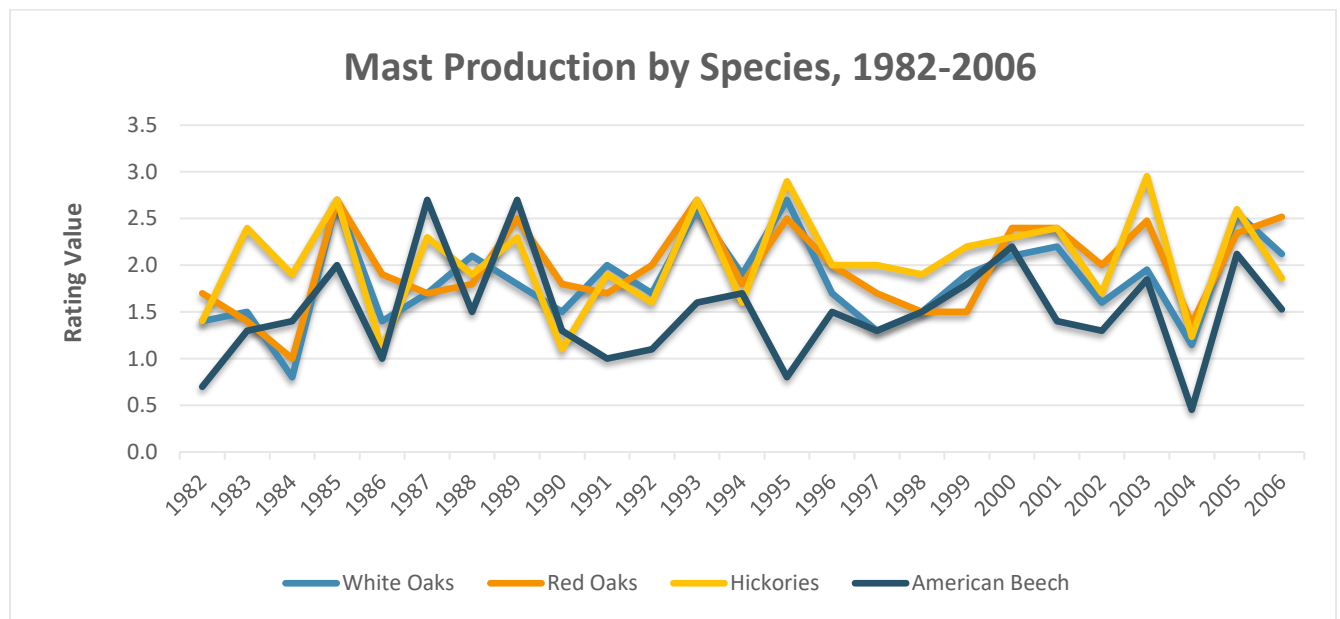**Mast Production by Species, 1982-2006**

Figure 2b: Mast Survey results by species group, 1982-2006.

Ratings are mast production index values averaged annually across all trees surveyed within each of 4 groups: white oak species, red oak species, hickory species, and American beech.

Current Method

Beginning in 2007 the Mast Survey changed to a more quantitative method of data collection. This change was motivated by the formation of a coordinated hard mast survey by several eastern states in 2007 based on recent research. The goal was to allow comparison of mast conditions regionally (**Figure 3**).

The current method requires individuals to scan the crown of each survey tree for 30 seconds and estimate the percentage of the crown bearing mast. This percentage, abbreviated as "PCA" (the "A" originally meant "acorns" but here denotes "any" mast) is quantitative, which is preferable to the old qualitative method. To alleviate concern that PCA is still subjective, we reclassify the PCA ratings more broadly based on presence or absence of any mast, abbreviated as "PBA". We group PBA ratings into categories: failure (0-19% PCA), poor (20-39% PCA), average (40-59% PCA), good (60-79% PCA), and bumper (80-100% PCA).
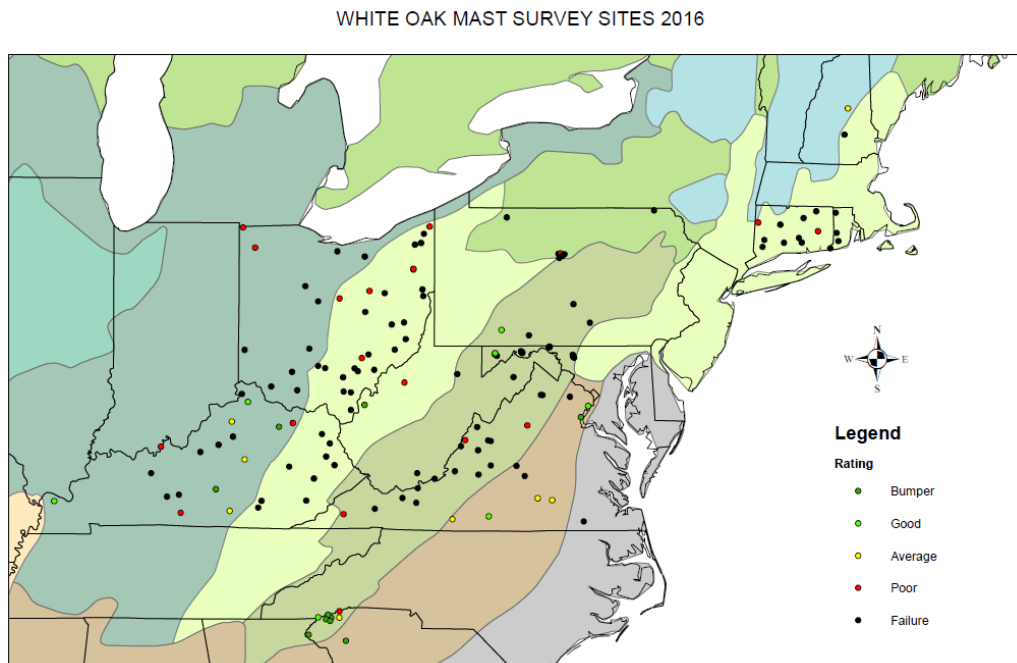
Figure 3. White oak mast survey locations for the regional mast survey consortium, 2016. Red oaks were also surveyed in all participating states, but hickory and beech surveys are unique to KY.

Surveyors

The Mast Survey in Kentucky takes place across the state. The number of surveys conducted each year has varied but typically has included about 25 individual survey routes. Most routes include 100 trees per route, with 25 each in the white oak group, red oak group, hickory group, and American beech. Historically, KDFWR biologists completed surveys but the list of surveyors now includes volunteers from other natural resource agencies, universities, and non-governmental organizations.

Mast Survey Results and Discussion

In 2020, surveys were completed along 40 individual routes in 35 counties (**Figure 4**). A total of 3,320 individual trees were sampled, including over 900 trees each in the white oak, red oak, and hickory groups, plus over 500 American beech trees (**Table 1**).

Across the state, in terms of the percentage of trees bearing mast (PBA), mast production by red oaks rated "good", white oaks and hickories rated "average", and beech rated "poor" (**Figure 5**). Regionally, red oak production rated "bumper" in the east and "good" in the west (**Figure 5**). White oak differed little between east and west, while hickory was poorer in the east than in the west. Beech was poor in both regions.

Red oak acorn crops were good to bumper at 12 of 15 (80%) eastern sites and 16 of 25 (64%) western sites (**Table 2**). White oak acorn crops were good to bumper at 4 of 15 (27%) eastern sites and 6 of 24 (25%) western sites (**Table 2**). Hickory nut crops were good to bumper at 2 of 15 (13%) eastern sites and 10 of 25 (40%) western sites (**Table 2**). Beechnut crops were good to bumper at 3 of 12 east sites (25%) and 2 of 11 west sites (18%). (Note however, beechnut production values are questionable because we do not check for viability via float tests.)

As is typical and confounding to managers, mast production varied highly at both region and site levels (**Figure 6, Table 2**). Across sites within each region, masting was more variable in the west compared to the east for white oaks (by 36%), red oaks (69%), and hickories (58%); this variance is based on the inter-quartile range, or width, of each box in **Figure 6**). As an example of how two nearby sites can vary, hickory mast rated failure at the Gilbert Tract of KY River WMA but rated average at Rich WMA. In contrast, Kaler Bottoms WMA in far western KY showed the same rating for hickory mast as Little Shepherd Trail in southeastern KY. With such variability, check the survey site nearest to your location (**Table 2**). Despite high variation, wildlife in Kentucky appear to have access to at least some mast in a majority of sites surveyed (**Figure 5**).

Long-term trends in PBA for each tree group show substantial fluctuations year-to-year at the statewide level (**Figure 7**). Based on 2019's results, we might have predicted that red oak and beech crops would decline and white oak and hickory crops would increase. Beech did decline, but red oak actually increased slightly while white oak and hickory were essentially unchanged. Causes of variability in mast production are not well understood, particularly at local levels.

The PBA values and ratings so far reported are a presence-absence metric. In some years PBA may over-estimate the amount of mast in Kentucky's forests. For example, the PBA value of a white oak with 1 acorn observed is the same as a white oak with 1,000 acorns observed. This year many trees had very little mast in their crowns. PBA and PCA are not related linearly, or 1 to 1 (**Figure 9**). At the site level, for all 4 tree groups, PBA values increase faster than PCA values, so slight changes in PCA can bump the PBA rating category (**Figure 9A**). At statewide and regional levels, the PBA-PCA relationship varies somewhat by tree group (**Figure 9B**). Furthermore, PCA values "averaged" across sites (actually, expressed here as the median, 8%) are much lower than PBA (median = 52%). In addition, at the site level PBA values were 3.5 times more than PCA values for PBA (IQR = 0.63) versus PCA (IQR = 0.17). Differences can be seen in PCA values grouped regionally (**Table 1, Figure 10**) and for each site (**Table 2, Figure 11**). So, despite the fairly widespread presence of mast,

sportspeople of the Commonwealth should expect animal behavior to reflect lower levels of mast production during Fall 2020-21 hunting seasons.

Table 1. Mast survey results, statewide and regionally, 2020.

Results for survey sites are summarized statewide and by region. PCA is the percentage of a tree's crown bearing mast (0 to 100%), averaged across all survey trees statewide or in the region. PBA is the percentage of trees bearing any mast (0 to 100%) out of all survey trees statewide or in the region. PBA Rating is the PBA value categorized into classes ("Failure" = 0 to 20%, "Poor" = 21 to 40%, "Average" = 41 to 60%, "Good" = 61 to 80%, "Bumper" = 81 to 100%).

Region	Tree Group	Trees Surveyed	PCA	PBA	PBA Rating
Statewide	White Oak	934	9.0	43.0	Average
Statewide	Red Oak	948	31.5	74.1	Good
Statewide	Hickory	931	11.8	43.9	Average
Statewide	Beech	507	8.3	30.2	Poor
East	White Oak	369	8.6	47.4	Average
East	Red Oak	363	34.0	81.5	Bumper
East	Hickory	376	6.0	36.2	Poor
East	Beech	293	6.0	29.7	Poor
West	White Oak	565	9.2	40.2	Average
West	Red Oak	585	29.9	69.4	Good
West	Hickory	555	15.7	49.2	Average
West	Beech	214	11.4	30.8	Poor

Table 2. Mast survey results by survey site, 2020.

Sites are ordered alphabetically within each region. Not all tree group were surveyed at each site (e.g., no beech at Cane Creek WMA).

Site	Region	White Oak	Red Oak	Hickory	Beech
Ashland WMA	East	Failure	Bumper	Failure	Failure
Cane Creek WMA	East	Good	Bumper	Average	
Dewey Lake WMA	East	Average	Bumper	Average	Failure
Fishtrap Lake WMA	East	Good	Good	Good	Failure
Fleming WMA	East	Poor	Bumper	Poor	Failure
Goodin Rdg Beaver Ck WMA	East	Average	Bumper	Good	Average
Grayson Lake	East	Good	Bumper	Average	Good
Kentucky Ridge SF	East	Average	Good	Failure	Poor
Knob State Forest	East	Failure	Average	Failure	Failure
Little Shepherd Trail	East	Failure	Bumper	Failure	
Maywoods	East	Poor	Average	Failure	
Paintsville	East	Average	Average	Average	Failure
Redbird WMA	East	Average	Bumper	Failure	Failure
Rock Creek	East	Poor	Good	Average	Bumper
Yatesville Lake	East	Good	Bumper	Average	Good
Adair WMA	West	Failure	Average	Failure	Good
Barren River State Park	West	Bumper	Bumper	Bumper	Bumper
Beechy Creek WMA	West	Poor	Poor	Failure	Failure
Big rivers	West	Average	Good	Good	
Bluegrass Army Depot	West	Failure	Good	Average	
Bugwood / Wayne	West	Bumper	Bumper	Bumper	Average
Central Kentucky WMA	West	Poor	Bumper	Good	
Clay WMA	West	Bumper	Bumper	Bumper	
Gilbert Tr KY Riv WMA	West	Failure	Bumper	Failure	
Green River WMA	West	Poor	Good	Good	Failure
Hancock Biol Stn	West	Bumper	Average	Bumper	
Kaler Bottoms WMA	West	Good	Poor	Failure	Failure
KDFWR HQ Salato	West	Average	Bumper	Average	
Kleber WMA	West	Failure	Bumper	Failure	
L. B. Davidson	West	Failure	Poor	Poor	Poor
Livingston Co WMA	West	Failure	Good	Failure	
Lloyd WMA	West	Poor	Bumper	Bumper	
Mammoth Cave	West	Average	Average	Average	Failure
Mullins WMA	West		Bumper	Good	
Rich WMA	West	Poor	Poor	Average	
Rolling Fork	West	Failure	Good	Failure	Failure
Shanty Hollow	West	Failure	Failure	Failure	Failure
Taylorsville Lake WMA	West	Poor	Bumper	Poor	
Tradewater WMA	West	Good	Bumper	Poor	
Yellowbank WMA	West	Average	Average	Good	Failure

Figure 4: Mast Survey sites, 2020.
East-West regional division based on the U.S. Forest Service ecological province classification.

Figure 5: Percentage of trees bearing mast (PBA), 2020.
This bar plot shows the distribution of PBA values when sampled trees are grouped by species group and survey site. PBA is presence or absence of mast derived from estimates of the percentage of tree crown area bearing mast (PCA) greater than 0, grouped statewide and by survey region.

Figure 6. Variation in percentage of trees bearing mast (PBA), 2020.
Distribution of PBA values summarized by tree species group and site. The horizontal line inside each box represents median PBA (50% of values across all sites in the region are below this value). The lower bound of each box is 25th percentile (25% of values below this value). The upper bound is the 75th percentile (75% of values below this value). The "whiskers" show maximum and minimum values, excluding outliers. Outliers, represented by individual dots, are 1.5 times greater than the upper quartile or lower than the lower quartile.
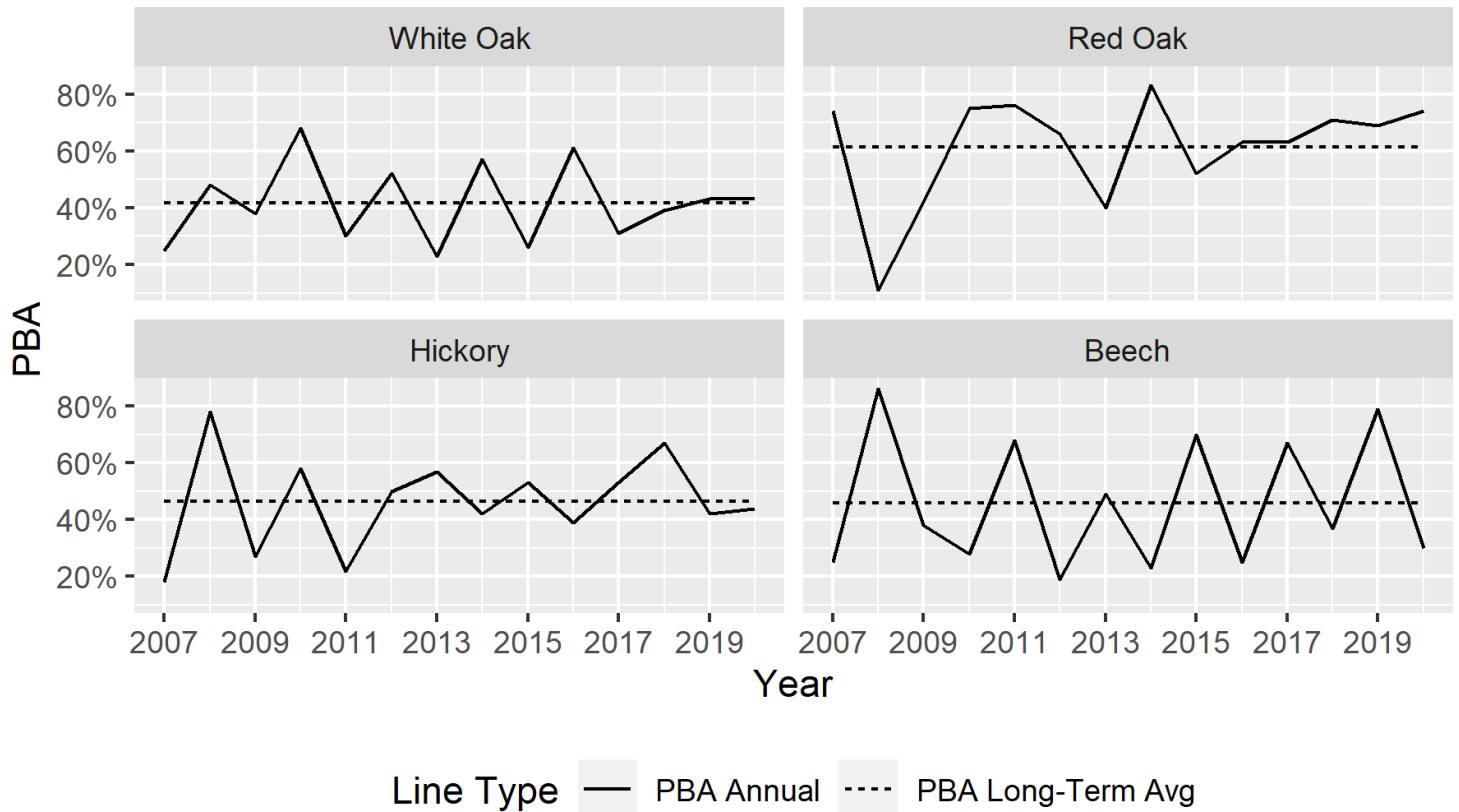
Figure 7: Trends in percentage of trees bearing mast (PBA) by species group, 2007-2020.
PBA is presence or absence of mast derived from estimates of the percentage of crown area bearing mast [PCA] greater than 0. NOTE: Percentages for beech are suspect because we do not routinely assess soundness of beechnuts by floating the nuts (sound nuts sink), which is important since beech mast is known to be highly irregular.
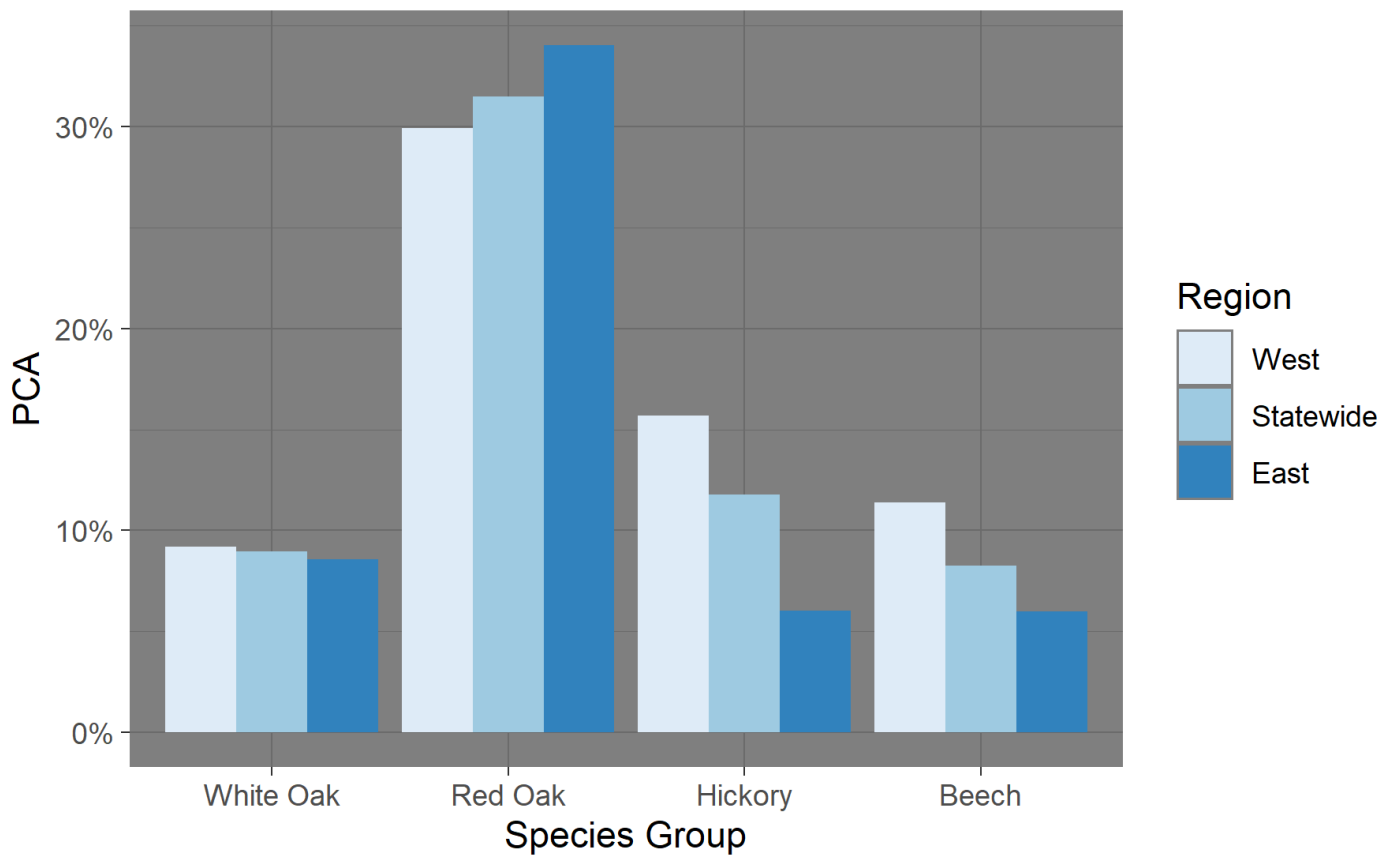
Figure 8. Percentage of tree crown area bearing mast (PCA), 2020.
This barplot shows PCA values of surveyed trees averaged statewide and in each of the 2 survey regions.
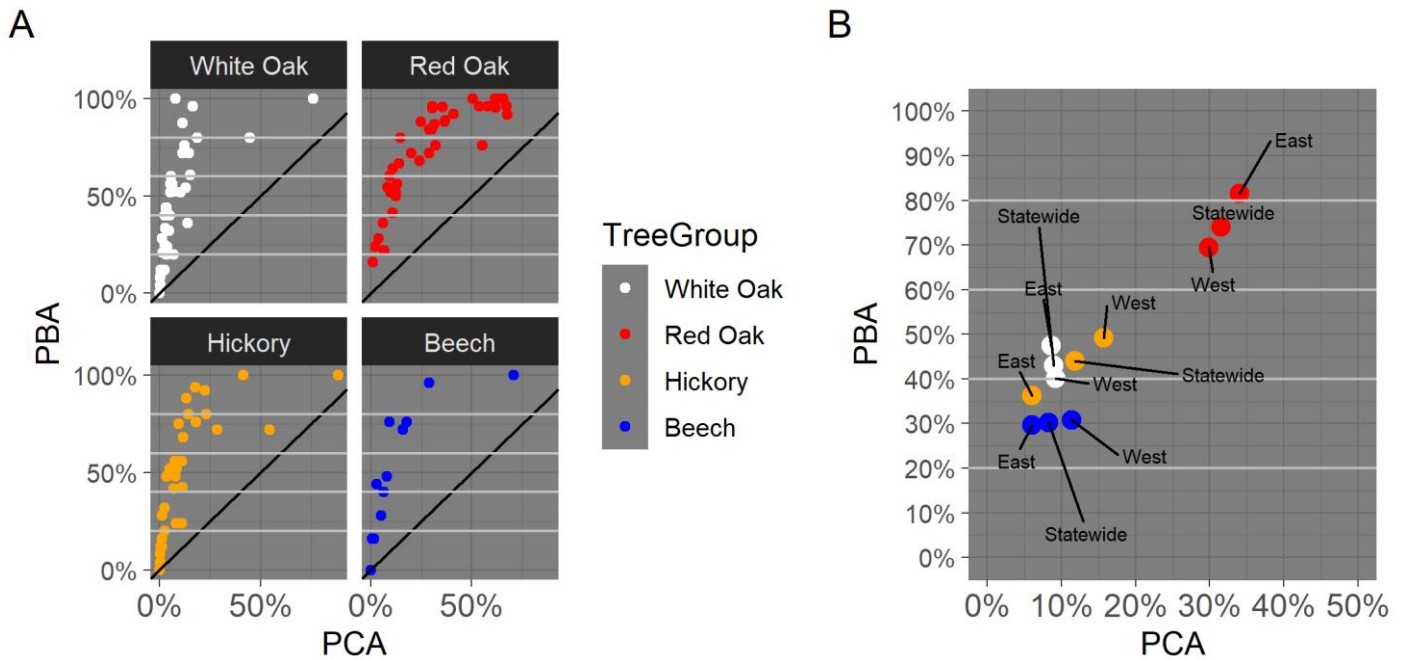
Figure 9. Relationship of PCA and PBA, 2020.

Plot (A) shows the correlation of PCA values with PBA values by tree group for each survey site. Each dot is a site and colors represent tree species groups. The black diagonal line in each subplot is a reference for what would be a perfectly linear relationship; however, for each tree group, the relationship is not linear, with PBA values being higher for a given PCA level. Plot (B) shows the PCA-PBA correlation summarized statewide and regionally. Colors represent tree groups and dots are statewide or regionally summarized values of PCA and PBA. For (A) and (B), the white horizontal lines denote the PBA ratings described above ("Failure" = 0 to 20%, "Poor" = 21 to 40%, "Average" = 41 to 60%, "Good" = 61 to 80%, "Bumper" = 81 to 100%).
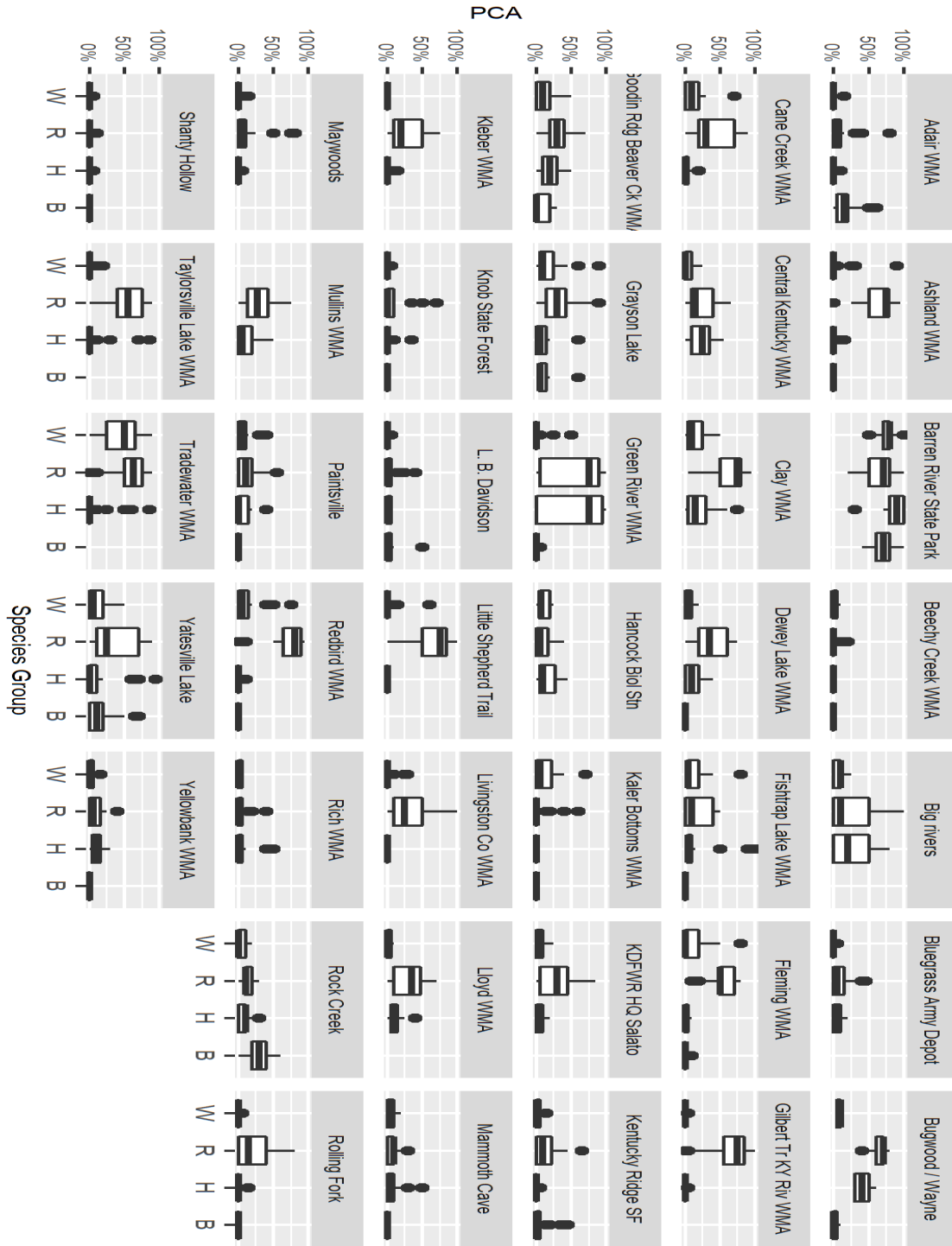
Figure 10. Percentage of tree crown area bearing mast (PCA) by site, 2020.

Plots show the distribution of PCA values among individual trees at each survey site. Tree species group are abbreviated (W = white oak, R = red oak, H = hickory, B = beech).
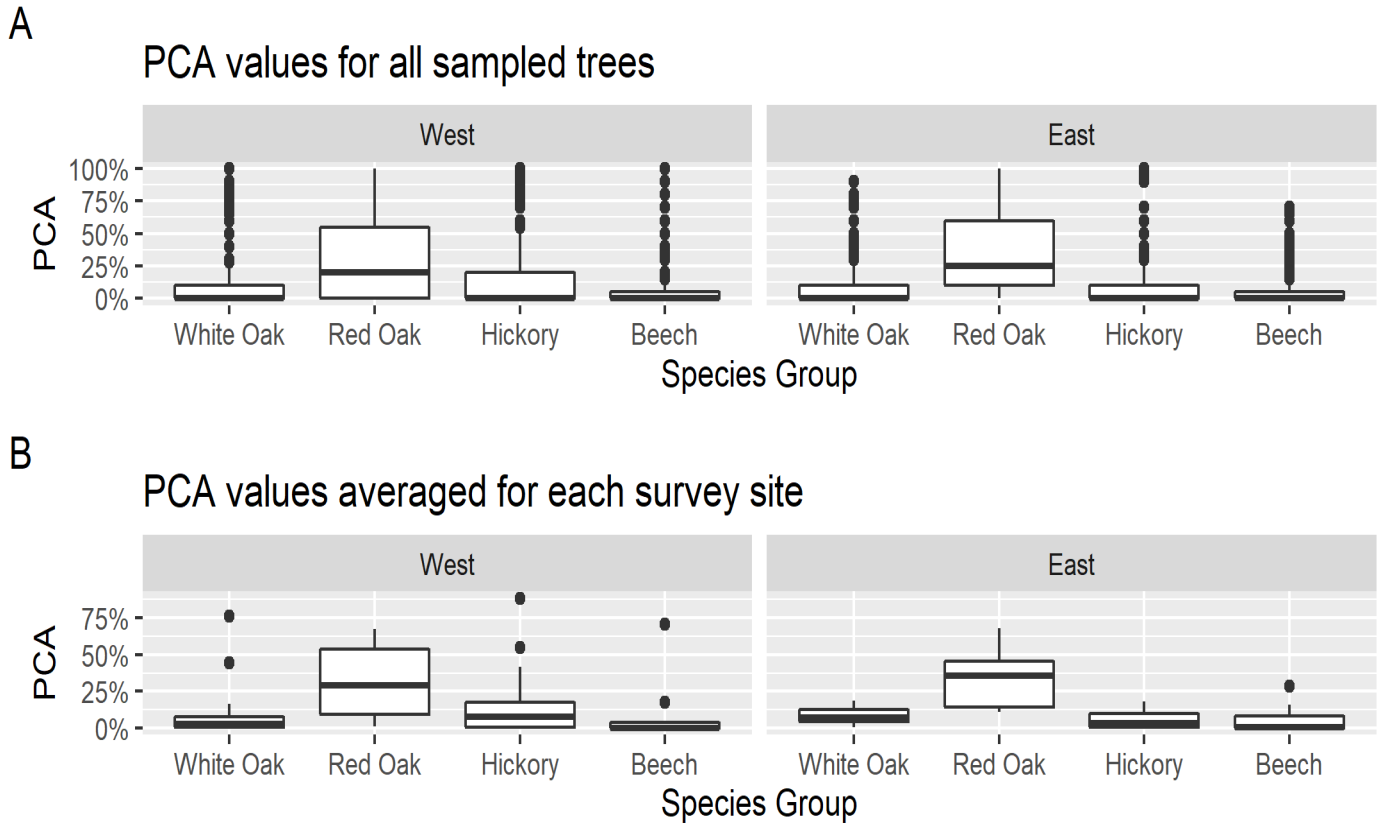
A

PCA values for all sampled trees

B

PCA values averaged for each survey site

Figure 11. Variation in percentage of tree crown bearing mast (PCA), 2020.

Boxplot A shows the distribution of PCA values among individual trees in each region. Boxplot B shows the distribution of PCA averages for survey sites in each region.

Closing

In addition to monitoring current mast production, wildlife and natural resource managers should be concerned with the ability of eastern forest ecosystems to produce hard mast, and thus to support the wildlife populations we manage and cherish. Future hard mast production, particularly of acorns, is in jeopardy due to changes in the composition (and structure) of our forests.

Analyses of forest inventory data collected by the U.S. Forest Service and state forestry agencies indicate that oaks are losing their foothold as a dominant species group. McShea and others (2007) found that most oaks are in the overstory (i.e., in dominant and co-dominant canopy classes) and the proportion of oak among the intermediate-aged trees in our forests has declined significantly since the late 1980s. Thus, a major concern is that there will not be sufficient young oaks to replace aging mature oaks. Also, the density of maple trees (all size classes) nearly doubled between 1989 and 2000 forest inventories; this is disconcerting because species like red maple do not produce quality food for forest wildlife. These changes have been perpetuated by poor forest management, such as high-grading (cutting only the best trees, often oaks, while leaving the rest) and a lack of pro-active management practices that reduce shade to allow sunlight to reach the young oaks in the forest understory. Examples of such practices include mid-story removal, crop-tree release, and commercial timber harvest design to thin or perpetuate oak.

Forest managers must work to keep quality mast trees in Kentucky forests. Our hope is that results of the Mast Survey can help them plan forest management practices (such as mid-story removal) that foster oak and hickory regeneration in our forests.

Acknowledgments

The Department of Fish and Wildlife Resources is funded through the sale of hunting and fishing licenses. It receives no general fund tax dollars.