

# WILDLIFE HABITAT, FOREST RESOURCE, AND HYDROLOGIC CONDITION INVENTORY AT LAND BETWEEN THE LAKES

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On June 14, 1963, President John F. Kennedy announced that the Tennessee Valley Authority was to be given the mission of developing the Land Between the Lakes Project (LBL) to demonstrate how a large block of marginal land could furnish outdoor recreation and conservation-education opportunities and stimulate the economy of the surrounding area, the Tennessee Valley, and the Nation. The project was officially launched in January, 1964.

The 170,000-acre area, lying two-thirds in Kentucky and one-third in Tennessee, is a 40-mile-long strip of land separating TVA's Kentucky Lake and the U. S. Army Corps of Engineer's Lake Barkley. It is a rolling, predominantly forested area within the Highland Rim and Pennyroyal land resource region. LBL harbors such resident game as white-tailed and fallow deer, turkey, gray and fox squirrels, wood ducks, quail, and cottontail rabbits. Fall and winter migrants include Canada geese, mallards, black ducks, and a variety of other waterfowl.

TVA has set three specific objectives for achievement by 1975:

1. Native wildlife will be increased to optimum levels for hunting, youth and adult education, and for the pure enjoyment their presence brings the vacationing public.
2. The forest will be developed to provide improved wildlife habitat, to perpetuate an attractive setting for outdoor recreation and conservation education, and to improve timber quality.
3. Economically mature timber will be cut and used through a commercial timber harvesting and processing operation to show visitors that timber harvesting is compatible with recreation, game management, and watershed protection.

An approach toward objectives of such magnitude requires a systematic, scientific base measure of the total biota. Accordingly, a field inventory was conducted January 24-March 9, 1966, to measure current wildlife habitat, forest resources, and hydrologic condition at LBL. Results furnish a benchmark for future measurement of change and a basis for prudent planning and management of these resources.

Although surveys elsewhere have measured wildlife habitat, forests, and hydrology, few have been designed to assess these features *simultaneously*. The unique pooling of inventory techniques was a savings in time, personnel, and money.

This report predominantly covers the inventory phase which measured current wildlife habitat conditions at LBL.

## PROCEDURES

One hundred and fifty-seven permanently located plots were distributed systematically over the entire land area through a grid system which placed four plots per 2½ minute topographic subdivision. Plot centers were inked on quad sheets and air photos. Both were available for field work but air photos were preferred unless it was impossible to pick out well-defined features on the photo. Three plot sites fell on areas deemed unsuited for habitat analysis and were discarded (two at house lots, one on a paved highway). Two field crews, each consisting of a biologist, forester, and aide, took the data.

### *Forest Resources*

Concentric 1/5-, 1/20-, and 1/100-acre plots were used to gather sawtimber, poletimber, and forest reproduction data, respectively. Azimuths and distances from plot center were recorded for each tally tree. Species, diameter breast high, merchantable height, cull percent, tree

status, tree grade, growing stock class, and injury data were recorded also. From this, stocking, species composition, stand size class, volume, grade, and mortality of the forest resource was derived.

### Hydrologic Condition

Three soil pits were dug at each plot site to determine litter coverage, humus depth and texture, rockiness, and soil depth to texture change. Observations on cover and related land features including incidence and severity of erosion, fire, and grazing damage were noted.

### Wildlife Habitat Inventory

Wildlife resource data were recorded to furnish measures of present habitat conditions, range utilization, evidence of factors that could limit population increases (water, openings, foods, shelter) and records of the kinds of wildlife observed.

Wildlife observations were recorded while chaining the distance from starting points to plot centers. Openings and water sources encountered on these transects were tallied by distance from starting points.

Streams and drains, water holes, and ponds were recorded as permanent (wet) or intermittent (dry). Acreage of each opening was estimated.

Appraisals of habitat for seven game species were made using air photos and field reconnaissance. Conditions for deer (*Dama virginiana*), squirrel (*Sciurus carolinensis*), raccoon (*Procyon lotor*), wild turkey (*Meleagris gallopavo*), ruffed grouse (*Bonasa umbellus*), cottontail rabbit (*Sylvilagus floridanus*), and bobwhite quail (*Colinus virginianus*) were rated as good, average, poor, or none at each plot locality.

Table 1 outlines optimum habitat characteristics used to rate habitat on units varying in size to account for mobility in home range difference. Obvious factors limiting wildlife increases were judged including food and cover quality, interspersion, water, and den sites. These data were not intended to meet statistical interpretation requirements but to indicate qualitative features of the area surveyed.

TABLE 1

Wildlife Species	Deciduous Woodland	Brush-land	Grass-land	Crop or Open Land	Conifers	Evaluation Unit (acres)
	Percent total land area					
Deer	25-40	25-50		10-25	0-25	1,000
Squirrel	100	—	—	—	—	10
Raccoon	50-90	—	—	10-50	—	200
Turkey	50-80	10-25		10-25	0-10	1,000
Grouse	30	30	—	10	30	40
Rabbit	25	15-25	25	25	0-10	40
Quail	25	15-25	25	25	0-10	40

Species appraisal units were rated good if each of the types indicated in Table 1 were present within the proportions given. Average ratings were given where each of the types were present but in less favorable proportions. Poor habitat consisted of each type being present but with one or more of the types being scarce. Ratings of none included those units upon which one or more of the types were lacking.

Two parallel 50-foot line transects were established at each plot to measure species composition and density of the lesser vegetation. The permanent plot center pin was starting point for the first transect and a point 100 feet east of plot center was starting point for the second. Pins were set at the zero and 50-foot points. The eastern edge of a steel tape stretched from the starting point toward magnetic north was the line used to measure intercepts from six feet to ground level. Intercepts were measured to the nearest one-hundredth of a foot.

All plant species were measured following the technique given by

Canfield (1941). Browsing incidence was recorded by a circle for deer and a box for rabbits.

## RESULTS

Wildlife habitat, forest resources, and hydrologic data have been punched on cards to facilitate IBM 405 analysis. Hence, interrelationships and comparisons can be analyzed quickly. Although wildlife habitat results commanded prime interest in this paper, TVA will make available the use of any data and encourages further analysis where it might complement other studies.

### Water Sources

Not included in the present survey but obviously important as sources of free water are the two large impoundments—Kentucky Lake and Lake Barkley—which form the north, east, and west boundaries of LBL. No point in the area is more than four miles from one of these bodies of water. Together, these lakes offer 300 miles of shoreline border. And within the bounds of LBL lie four smaller lakes—Bard's Creek, Energy, Long Creek, and Hematite—which combined impound 1,000 surface acres.

Incidence of interior water sources, wildlife openings, and wildlife observations was analyzed from the total distance of transects laid out along known azimuths from starting points to plot centers. This furnished a sample of over 10 miles (54,800 feet).

Incidence of streams and drains, ponds, and waterholes encountered are listed in Table 2. The type most frequently crossed was intermittent streams and drains, which comprised 61 percent of all sources tallied. Inland permanent water is a scarce commodity. Although 35 percent of all sources encountered were classed as permanent—e.g., capable of holding water—over four-fifths (86 percent) were small waterholes, largely in intermittent stream channels. These quickly evaporate in dry weather. Hence, the frequency of truly permanent water sources (ponds and streams) averaged but one and one-fourth miles.

### Wildlife Openings

Forest openings 10 acres and above have been identified previously by TVA (1963) and included on a type map depicting present and potential forest-wildlife use at LBL.

TABLE 2  
INCIDENCE OF WATER SOURCES

Source	Number Tallied	Incidence * in Feet	Percent by Type
Streams, wet	7	7,800	4
Streams, dry	102	500	61
Waterholes, wet	50	1,000	30
Waterholes, dry	6	9,100	4
Ponds, wet	1	54,800	1
Ponds, dry	0	—	—
Total	166	300	100

\* Incidence equals total combined distance measured (54,800 feet) ÷ number tallied.

The present survey established incidence, by size classes, for openings below 10 acres. Table 3 provides these results.

Highway 68 divides LBL about equally north and south. These sections were used to determine whether incidence of openings differed. The northern part includes what was formerly Kentucky Woodlands National Wildlife Refuge, which presently harbors the highest population of turkey and deer, including fallow deer (*Dama dama*).

For the total LBL area, incidence averaged one opening per 4,000 feet. North of the highway incidence was one per 3,500 feet, as opposed

to one per 4,500 feet to the south. Little difference among size classes was evidenced between these two sections.

TABLE 3  
INCIDENCE OF WILDLIFE OPENINGS

Area	Size of Openings					Totals (0-10)
	1/8-1/2	1/2-1 acres	1-2	2-5	5-10	
	incidence (in feet)					
North U.S. 68 Number	1 20,900	0 —	1 20,900	1 20,900	3 7,000	5 3,500
South U.S. 68 Number	0 —	0 —	2 15,700	3 10,500	2 15,700	7 4,500
Total Area Number	1 52,300	0 —	3 17,400	4 13,100	5 10,500	13 4,000

*Wildlife Observed*

Table 4 presents the number and incidence of wildlife species observed during field work. These data were analyzed to determine the average distance traveled on foot for each species seen. No care was taken to reduce noise among crew members and observations were continued throughout the day. This was not intended to be a census but it does approximate conditions under which many visitors to LBL expect to see wildlife.

Average distances per sighting varied from one quail per half mile to one turkey per over 10 miles. Deer were seen once for every one and one-fourth miles walked, on the average.

TABLE 4  
WILDLIFE OBSERVED DURING FIELD WORK

Species	Number Seen	Average Distance per Observation (54,800 ÷ (1) )
	(1)	(2) feet
White-tailed deer	8	6,850
Gray squirrel	18	3,040
Fox squirrel	1	54,790
Turkey	1	54,790
Rabbit	2	27,400
Quail	19	2,880
Striped skunk	1	54,790
Gray fox	1	54,790
Red fox	1	54,790
Woodcock	2	27,400
Bald eagle	1	—
Great horned owl	2	—
Mourning dove	7	—
Canada goose	471	—
Wild ducks *	—	—

\* Includes mallards, black duck, teal, wood duck, gadwalls, and coots.

### Lesser Vegetation Studies

The 154 pairs of 50-foot line transects furnished a base sample of 15,400 linear feet to ascertain species composition and density (percent ground covered) of the living shrubs, vines, forest reproduction, grasses, and herbaceous forbs growing up to six feet above ground at LBL. Fifty-five woody and 19 herbaceous plant species (or genera) were tallied.

These data were analyzed by area, stand size classes, and topographic sites. Sampling errors increase substantially as overall data were broken down into these subgroups. Nevertheless, some direction and scope of variability in understory composition and density was attained. Data summaries are given in Table 5.

Overall, winter understory up to six feet was composed of 70 percent woody plants, 12 percent herbs, and 18 percent grasses. The three vegetation types covered 17 percent of the ground surface (woody, 12 percent; herbaceous, two percent; and grasses, three percent).

Woody composition was not affected significantly by area or stand size classes down to pole timber. Significant variation may have occurred in the seeds and saplings class and among topographic site classes.

Apparently, woody species density was influenced by stand size classes. In the two forest categories considered to contain best sunlight conditions—large sawtimber and seeds and saplings—woody density was the highest—17 percent and 16 percent, respectively.

TABLE 5  
SPECIES COMPOSITION AND DENSITY OF LESSER  
VEGETATION BY AREA, STAND SIZE CLASSES  
AND TOPOGRAPHIC SITE

Variables	Type of Vegetation							
	Woody			Forbs		Grasses		
	Compo- sition	Den- sity	SE*	Compo- sition	Den- sity	Compo- sition	Den- sity	SE*
percent								
<b>Area</b>								
Total LBL	70	12	11.2	12	2	18	3	14.7
North of 68	71	12	14.0	6	1	23	4	16.2
South of 68	70	11	12.4	17	3	14	3	15.4
<b>Stand Size</b>								
<b>Classes</b>								
Large sawtimber	90	17		6	1	4	1	
Small sawtimber	78	11		8	1	14	2	
Pole timber	87	12		11	2	2	tr.	
Seeds & saplings	61	16		7	2	32	8	
Open land	31	8		29	7	40	9	
<b>Topographic Site</b>								
Dry upland	76	12		11	2	13	2	
Moist upland	83	12		8	1	9	1	
Bottomland	52	20		1	tr.	47	18	

\* Sampling errors at one standard error of the mean. Grasses and forbs are combined.

Topographic site did not appear to influence composition or density greatly between dry upland and moist upland sites. Bottomland sites presented a different picture.

Although the woody component of the species composition was lower here (52 percent), density was greatest (20 percent). This was probably due to the better soil fertility and moisture conditions characteristic of bottomland sites.

## Browse Utilization

Records of animal use of vegetation for food were confined to deer and rabbit browsing. All woody plants intercepted by line transects which showed any winter browsing were tallied regardless of intensity of use per plant.

Deer use was recorded on the following in decreasing order: huckleberry (*Vaccinium* and *Gaylussacia*), strawberry bush (*Euonymus*), grape (*Vitis*), greenbriar (*Smilax*), sumac (*Rhus*), New Jersey tea (*Ceanothus*), sassafras (*Sassafras*), persimmon (*Diospyros*), and hard maple (*Acer*).

Browsing by rabbit was recorded for: greenbriar, huckleberry, winged elm (*Ulmus*), coralberry (*Symphoricarpos*), ironwood (*Ostrya*), grape, black cherry (*Prunus*), black gum (*Nyssa*), strawberry bush, honeysuckle (*Lonicera*), red elm, rose (*Rosa*), poison-oak (*Toxicodendron*), hazelnut (*Corylus*), serviceberry (*Amelanchier*), briars (*Rubus*), wild plum (*Prunus*), hard maple, hickories (*Carya*), sweet gum (*Liquidambar*), white oak group (*Quercus*), and red oak group (*Quercus*).

What was perhaps the heaviest acorn crop in years nullified significant winter browsing by deer. This study measured a browsing incidence of 0.4 percent for deer and 1.4 percent for rabbits.

## Food and Cover Production

The following analysis is an attempt to estimate annual growth production of lesser vegetation (in pounds per acre, air-dried, winter condition) in order to more completely appreciate this part of the wildlife habitat.

Previous work by the senior author on private land in north Georgia gave an opportunity to project a production estimate for LBL (Burbank, 1965). In the Georgia study, line transects were used to measure composition and density as per LBL inventory. Total woody understory production was estimated to be 12 pounds desirable deer browse per acre, and 23 pounds other woody vegetation.

In the LBL study, Barber's (1962) list of desirable deer browse in Kentucky was used to determine that component. Woody density was used to accommodate differences in range density between north Georgia study area and LBL (Georgia density was 32 percent, LBL 12 percent).

Desirable browse density in north Georgia was seven percent; on LBL it averaged four percent. Hence, annual production of this desirable component at LBL was estimated to be  $(4\% \div 7\% \times 12 \text{ lbs.})$  seven pounds per acre. Similarly, the other woody vegetation was estimated to be  $(8\% \div 25\% \times 23 \text{ lbs.})$  again seven pounds per acre for an overall production estimate of 14 pounds woody annual growth per acre at LBL.

Production per acre (Table 6) was highest in bottomland sites (27 pounds) and lowest in openland (nine pounds). Among stand size classes, production per acre was highest in seeds and saplings and heavy sawtimber (20 pounds) and lowest in small sawtimber (12 pounds).

**TABLE 6**  
**POUNDS PER ACRE OF WOODY DEER BROWSE PLANTS**  
**BY AREA, STAND SIZE CLASS, AND TOPOGRAPHIC SITE**

Variable	Production Estimates		
	Desirable Species	Undesirable Species	Total
	pounds per acre		
<b>Area</b>			
Total LBL	7	7	14
North of U. S. 68	7	7	14
South of U. S. 68	7	6	13
<b>Stand Size Class</b>			
Large sawtimber	9	11	20
Small sawtimber	5	7	12
Pole timber	5	8	13
Seedlings and saplings	10	10	20
Open land	5	4	9
<b>Topographic Site</b>			
Dry upland	7	7	14
Moist upland	7	7	14
Bottomland	17	10	27

Acorn production—an estimate of the pounds of acorns capable of being produced—was determined from basal area factor tables as given by the USFS (1959). Basal area data collected during the LBL inventory were grouped by DBH class to correspond to the USFS tables.

Total fresh acorn production capabilities amounted to 7,800,000 pounds (Table 7). White oaks comprised 54 percent (4,200,000 pounds).

**TABLE 7**  
**ACORN PRODUCTION ESTIMATES FOR LBL**

Oak Groups By Area	Basal Area Sq. Ft. Per Acre	Pounds/Acre Fresh Acorns (USFS Table 4)	Pounds Produced (in thousands)
<b>North U.S. 68</b>			
71,200 acres forested			
Red oaks			
9-14" DBH	10	23	1,600
15" +	4	14	1,000
White oaks			
9-14" DBH	10	18	1,200
15" +	4	11	800
		66	4,600
<b>South U.S. 68</b>			
74,400 acres forested			
Red oaks			
9-14" DBH	6	14	1,000
15" +	1	4	300
White oaks			
9-14" DBH	14	25	1,800
15" +	2	5	400
		48	3,500
<b>Total Area</b>			
145,600 acres forested			
Red oaks			
9-14" DBH	8	18	2,600
15" +	2	7	1,000
White oaks			
9-14" DBH	12	21	3,000
15" +	3	8	1,200
		54	7,800

### Wildlife Habitat Analysis

The following details describe forest and nonforest conditions which directly and indirectly influenced the qualitative ratings made in the field for each of the seven game species concerned.

Of the 170,000 acres comprising LBL, 145,600 acres (85 percent) is in forests. Most of the forest is hardwoods with upland hardwoods (oak-hickory) occupying 88 percent of the forest land. Other hardwood types—bottomland hardwoods and ridgetop blackjack oak—occupy eight percent in about equal amounts. Small areas of pine and cedar account for the remaining 6,400 acres. Over half of the forest area is sawtimber stands (54 percent) and about one-fourth (27 percent) is poletimber. Small sawtimber—trees less than 15 inches diameter—comprises 81 percent of all sawtimber stands. Red oaks comprise 33 percent of the sawtimber volume, white oaks (chiefly *Quercus alba*) 45 percent, hickory species 10 percent, sweet gum three percent, yellow-poplar two percent, and small amounts of others. Nonforest land accounts for 23,400 acres, half of which is cultivated or pastured. About nine-tenths of this is pastured. The rest is equally divided between land idle for two years or more and land devoted to other uses.

Appraisals of habitat are summarized in Table 8. Good habitat was rated from a high of 48 percent total land area for deer to one percent for ruffed grouse. Land classed poor or nonhabitable did not exceed 30 percent for deer, gray squirrel, raccoon, and turkey. With 85 percent of LBL in forest it is reasonable to expect total area classed average and better not to exceed the 34 percent and 24 percent so classed, respectively, for cottontail rabbit and quail.

TABLE 8  
WILDLIFE HABITAT EVALUATIONS FOR SEVEN GAME SPECIES

Wildlife Species	Percent Total Land Area			
	Good	Average	Poor	None
White-tailed deer	48	45	6	1
Gray squirrel	24	47	21	8
Raccoon	10	67	21	2
Wild turkey	19	64	14	3
Ruffed grouse	1	24	66	9
Cottontail rabbit	9	25	41	25
Bobwhite quail	4	20	47	29

Factors which could limit habitability of range were recorded at each plot site. These included presence of required vegetation types, interspersions, cover quality, travel lanes, food quality, water, and den sites. Results of this appraisal of limiting factors is given in Table 9. Since one or more factors often were present at the same site the percentages of land area as given are not additive.

Presence of required vegetation types loomed as the most significant deterrent, ranging from 18 percent total land area for raccoon to 83 percent for quail. Food quality appeared to be second, ranging from three percent total land area for grouse to 42 percent for raccoon.

TABLE 9  
FACTORS LIMITING GAME HABITAT

	White-tailed Deer	Gray Squirrel	Raccoon	Wild Turkey	Ruffed Grouse	Cottontail Rabbit	Bobwhite Quail
	percent total land area						
Presence required vegetation	36	43	18	38	78	76	83
Interspersion	16	X	3	6	7	2	3
Cover quality	18	X	2	16	12	11	3
Travel lanes	X	X	X	X	X	1	—
Food quality	28	20	42	29	3	10	11
Water	X	X	6	11	X	X	X
Den sites	X	34	29	X	X	X	X

X — not applicable.



## SUMMARY

The wildlife habitat, forest, and hydrologic conditions survey has measured many parts of the environment which exist at LBL. The information gained will influence TVA policy and management for years to come. But, this study does not represent an end; rather a beginning—a starting point from which more detailed information will be collected and used to improve management decisions.

These facts were uncovered:

- A shortage of free water appears to exist throughout the interior (one permanent source per 6,860 feet).
- Most openland occurs as large blocks in cleared creek bottoms (14 percent total land area).
- Small woodland openings are inadequate and need to be increased (one per 4,000 feet).
- Upland hardwoods occupy 88 percent of the forest land. Eight-tenths (81 percent) of all sawtimber stands is composed of trees less than 15 inches in diameter. Oaks comprise 78 percent of the sawtimber volume, with white oaks making up nearly half (45 percent) of that volume.
- Lesser vegetation in winter covers less than one-fifth (17 percent) of the land area. Woody browse comprises 70 percent of the species composition, grasses 18 percent, and forbs 12 percent.
- Browse production was estimated to be 14 pounds (air dried, winter) per acre, half in desirable deer foods.
- Acorn production capabilities amounted to 7.8 million pounds, or 54 pounds per forest acre.
- Winter browsing incidence was 0.4 percent for deer and 1.4 percent for rabbit.
- Habitat rated good ranged from 48 percent total land area for deer to one percent for ruffed grouse.
- Lack of required vegetation types loomed as the most significant factor limiting game, ranging from 18 percent total land area for raccoon to 83 percent for quail.

The survey has laid groundwork to be sure but more importantly has opened many doors for further study. Here are a few of the wildlife opportunities which need attention at LBL:

- Better methods to census wildlife.
- Local mast and lesser vegetation production studies.
- Summer and winter browse studies.
- Ecological studies—particularly white-tailed deer versus fallow deer, both deer versus turkey, and public recreation impact on all wildlife.

TVA hopes that investigations such as these can be conducted through cooperative arrangements with colleges, other federal agencies, state game and fish departments, and independent conservation organizations.

LBL will be a great outdoor recreation playground. But it is also destined to be a great outdoor laboratory where man can continue to explore, to analyze, to observe, and come to a better understanding of this "package of environment" called "Land Between the Lakes."

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