CONCLUSION

The passenger pigeon and some other forms of wildlife disappeared while conservation was still in its infancy. The conservationists who came before us crusaded for the protection of the buffalo, the antelope, and the other varieties of our vanishing herds of big game. They also helped awaken a boisterous and greedy America to the values inherent in the wild and natural environment. The conservationists who came before us were not always successful, but they achieved some marvelous accomplishments in the establishment of our National Forests and Refuges and in the preservation of some of our parks and scenic wonders.

Now, it is our turn. It is our turn and the challenges before us which overshadow all others are those that pertain to the quality of the environment. It is our generation of conservationists which will win or lose important battles against pollution. It is, also, our generation of conservationists which is destined to preserve some, and possibly a great many, cypress brakes, patches of timber, and at least significant portions of our once vast wilderness domain which remains in the overflow bottoms.

FOREST SOILS AND GAME NUTRITION

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ABSTRACT

Early writings indicated that high soil fertility levels increased both quantity and quality of some wildlife species. More recent work has shown that factors other than soil fertility are also related to quality range for wildlife. Soils apparently have not been a limiting factor to turkey distribution in Missouri, since transplanted populations have done well on many soil types, even prairie soils. Weights of fawn white-tailed deer ranged from high in north Missouri to low in south Missouri, presumably reflecting a poorer quality of range in the Ozarks. However, chemical analyses of preferred deer foods collected from three soil areas did not reveal consistent differences which could be related to soil type or physical development of deer. Most native foods were of low quality. The increased physical development of deer in northern Missouri apparently resulted more from supplemental feeding on cultivated crops than from soil fertility. Digestibility of foods needs to be determined to more completely evaluate their worth. Several other studies have indicated that nutritive values of plants are not directly correlated with soil fertility but are influenced by many other factors. The major influence of soil fertility is expressed by the manner in which it influences the thinking of land managers.

"As our soil goes—so goes wildlife." (Crawford—1949). This theme has been reiterated in different phraseology by wildlife workers in Missouri since the 1940's (Denny, 1944 and Crawford, 1946). The basic idea for this theme probably originated with University of Missouri soil scientist, Dr. William Albrecht, who preached "Quality not quantity"—"protein not bulk". Dr. Albrecht (1949) believed that all life is the end product of the soil and that the distribution, health and survival of wildlife was related to the soil and its fertility.

Studies of several wildlife species in Missouri added support to Dr. Albrecht's statements (Crawford—1950). The body weights of 8,180 raccoons collected from 95 Missouri counties showed a direct relationship to soil fertility ratings for the various counties. The number of raccoons harvested also was related to the soil fertility. The lowest harvest was taken from soils of relatively high fertility but not high enough to encourage intensive land use which reduced woody cover. Harvests from the most fertile soils were slightly reduced because of intensive land use.

The size and quality of opossum pelts was related to soil fertility of the area where the animals were taken. The largest pelts of best quality were taken on good (Union) soils. Intermediate pelts came from moderately fertile (Clarksville) soils. The poorest pelts came from low fertility (Hanceville and Lebanon) soils.

Muskrat pelts from streams ranking highest in fertility were larger and of better quality than pelts from streams with low fertility.

The most intensive study involved the cottontail rabbit. Body weights of 175,861 rabbits from 14 widely scattered areas of Missouri showed a direct relationship between quality of the soil and size of rabbits. This observation lead to more intensive study in which approximately 450 rabbits were collected from 38 soil regions. Femur bones of rabbits on better soils were up to 12 percent larger (length, diameter and thickness of walls) than femurs from rabbits on less fertile soils. Breaking strength of femur bones from rabbits collected on soils of high fertility was 37% greater than femur bones from rabbits collected on soils of low fertility. Calcium and phosphorus content of rabbit femurs decreased as soil fertility decreased. Forest soils (Clarksville Stoney Loam, Clarksville Gravelly Loam and Ashe Stoney Loam) produced rabbits with the lowest measurements.

Soil types were a major factor in delineating Zoogeographic Regions and Game Range Types by Bennitt and Nagel (1937). These regions are outlined in Map 1. Soils affect wildlife in many different ways. Soils plus climate determine plant succession and climax vegetation on any given area. The vegetation on an area determines the food and cover available to wildlife. Quantity, quality, and variety of food are affected by the soil.

Soil also affects wildlife through socio-economic factors. Intensive agriculture on soils of high fertility usually results in decreased cover with lower carrying capacity for wildlife. Agriculture on infertile soils results in soil depletion with reduction of food and cover usually accompanied by soil erosion. On soils unsuited for agriculture, livestock may be serious competitors for wildlife food. Attempts to convert sub-marginal soils to pasture by timber removal or annual burning also affect wildlife. Poor soils result in lower economic and social levels and poaching of wildlife is usually of greater importance in poor soil areas than in fertile soil areas.

White-tailed deer *(Odocoileus virginiana)*, turkey *(Meleagris gallopavo silvestris)* and squirrels *(Sciurus niger* and *S. carolinesis)* are the major forest game species in Missouri. Ruffled grouse *(Bonasa umbellus)* are being stocked in an effort to restore them to Missouri but are of limited distribution at the present time.

TURKEYS

Dalke, Leopold and Spencer (1946) thought that soil type and fertility were major factors affecting distribution and population densities of turkeys. One soil type, Clarksville stoney loam, supported 79% of Missouri's turkey population in 1942. Clarksville gravelly loam supported 15% of the turkeys. Ashe stoney loam and Hanceville loam together supported 3% of the turkeys.

The Western Ozarks had the highest turkey populations in 1942. Populations declined between 1942 and 1957 (Lewis—1961), but have increased since 1957. The Eastern Ozarks turkey population declined 60% between 1947 and 1952 but also increased since 1957.

The fertile soils of the Mississippi Lowlands once supported good turkey population but drainage, land-clearing and intensive agriculture eliminated turkeys from the region.

Present distribution of turkey populations has less relation to soils than in 1942. Lewis (1967) said, "any basic relationship between soil fertility and number of turkeys seems to have been over-ridden in more recent years by a number of sociological and land-use factors." Markley (1967) said, "the edaphic relationship between turkey distribution and soil types are largely obscured by other factors, certainly turkey populations are dependent upon land use, which is a product of both soils and region economics."

A trapping and transplanting program which began in 1954 resulted in turkey populations in many new areas, with many soil types, even the prairie soils of northern Missouri. Success of the Ste. Genevieve county release (Menfro and Union soil types) illustrated the success of turkeys on other than Ozark forest soils. Twenty-two birds released in 1955-56 increased to an estimated population of 300 birds by 1960. During the 1967 hunting season, 141 gobblers were killed in Ste. Genevieve county. Turkeys killed in Ste. Cenevieve county were slightly heavier than birds from Douglas County, where they originated.

Adair county in north-central Missouri is even further removed from the forest soils of the Ozarks. Turkeys have become well established since the stocking in 1961-62 and 35 gobblers were killed during the 1967 season.

The fact that turkeys have become established and are flourishing on many soil types indicates that soils were not the basic factor limiting turkey distribution in 1942.

Nutritional requirements of wild turkeys have not been established but probably are about the same as requirements of domestic turkeys which require feed relatively high in protein and energy. Wild turkeys supply these needs by eating mast and seeds, insects in season and green grass (Korschgen—1967).

SQUIRRELS

The relationship of squirrels to soil is even harder to define than for turkeys. Squirrels occur on most major soil types in Missouri. In general, fox squirrels are usually found on prairie soils and gray squirrels on forest soils. This distribution is related to food and cover on the two types of soils. Fox squirrels prefer a relatively open habitat with scattered trees, preferably near a cornfield. Gray squirrels prefer more solid stands of timber with a relatively dense understory.

A fertile soil may not necessarily produce good squirrel habitat. Brown and Yeager (1945) in Illinois stated, "An environment without a variety of staples may be of little value, and may actually be uninhabitable, except when auxillary foods prevail. River bottom forests of pure elm and maple or extensive cottonwood-willow flats are seldom occupied by squirrels, even with adjacent cornfields." Bottomland soils are generally very fertile so we can conclude that soil does not determine squirrel populations.

In a study of fox squirrels in Michigan (Allen—1943), harvest data indicated that the lowland, clay plains were the poorest squirrel range. Areas of predominately sand and clay uplands with a high percentage of moraine and outwash soils were most productive of fox squirrels. Soil affected squirrel range by determining forest cover and agricultural use.

All of the studies which were reviewed stressed the importance of variety in the diet of squirrels. However, staple foods consisted of only about a half dozen items, hickories (including pecans), acorns, walnuts, elm fruits, mulberry and corn (Brown and Yeager—1945).

Nutritional requirements of squirrels have not been determined. However, because their diet consists for a large part of mast or seeds (Nixon, Worley and McClain—1968) their nutrition is probably less affected by soil fertility than is the nutrition of a herbivore, such as deer. Several studies (Spinner and Bishop—1950, Korschgen—1964, Hart, Guillbert, and Goss—1932, Wainio and Forbes—1941), indicated that chemical composition of seeds and fruits from different soil areas were essentially the same.

DEER

During the past 25 years there have been many reports of studies relating effects of inadequate nutrition on physical growth and productivity of deer (Dietz—1965, Goodrum and Reid—1962). The majority of these reports dealt with overpopulations of deer which had overbrowsed the range thus reducing quantities of food available and eliminating the most preferred (and assumedly most nutritious) foods. Numerous studies have reported that chemical composition of forage correlated with thrift of deer herds but few of these studies tried to correlate quantity or quality of forage with soil fertility.

Hundley (1959) determined seasonal composition of 5 browse species from 4 different soils in Virginia. Nutritional content of twigs showed no consistent differences between soil types. However, the soil types themselves were quite similar. Different plant species had quite different composition when growing on the same soil type. Some affect of soils was apparent on moisture and protein content of browse.

Thorsland (1966) compared chemical analysis of soils and forage from six areas in South Carolina. The most nutritious forage and largest deer came from an area with the highest mineral content in the soil. Less nutritious forage and smaller deer came from an area with lower mineral content in the soil.

The white-tailed deer in Missouri occurs in all parts of the state. The population in the Mississippi Lowlands, however, is very low because of intensive land use. Biologists have weighed and measured over 25,000 deer in various regions of the state during the past 15 years. These measurements indicate distinct differences in range quality within the state. Body weight of fawns directly reflects nutritive levels (Murphy and Coates—1966). When body weights of fawns are superimposed on a soil map of the state, they do not necessarily correspond to soil type. The fawn weights fall into three general classes corresponding to southern, central and northern Missouri. Fawns from the prairie soils of northern Missouri are much heavier than fawns from the other two areas. Antler development of males and productivity of females follows the same pattern. These data indicate that the poorest deer range occurs in the southern part of the state, with a range of intermediate quality in the central part of the state and the best range north of the Missouri River.

In an attempt to correlate quality of native browse with observed differences in physical development of deer, samples of preferred deer foods were collected from four widely separated areas south of the Missouri River. The samples represented at least three different soil areas. Chemical analyses of the forage samples (Tables 1 and 2) did not reveal consistent differences which could be related to soil type or to physical development of deer. The study did show that most of the native forage species were of relatively low nutritive quality. Before any true evaluation can be made, however, we need to determine the digestibility of the different foods. Several animal nutritionists have published warning against trying to apply chemical analysis of forage to nutritive levels without knowing true feed values (Swift—1957, Bissell—1958, Short—1966). As an example, chemical analyses show that acorns have about the same crude protein content as corn (7-8 percent), however, acorns have practically no digestable protein (Morrison—1956).

Food habits studies (Korschgen—1962) indicate that the observed differences in range quality may be related to the relative amounts of different foods composing the diets of deer. The diet of deer in southern Missouri is composed mainly of native forage which our chemical analyses indicate to be of poor quality. Deer in central Missouri supplement their diet with corn and other cultivated crops. Agricultural crops make up more than one-third of the diet of deer in northern Missouri.

The amount of crude protein in deer forage has received considerable attention because protein is probably the most essential nutritional element. Several studies have shown that browse from recently burned areas had higher protein content than browse from unburned areas (Einarsen—1946, Lay—1957). Other studies have indicated that deer prefer and can select plants with higher protein content (Swift—1948). Increased utilization of dogwood following heavy fertilization with nitrogen was reported by Mitchell and Hosley (1936). Percent of utilization correlated with increased nitrogen content of dogwood but correlated more closely with the amount of reducing sugars. Several studies showed seasonal differences in protein content of browse (Lay—1956, Spinner and Bishop—1950, Dietz—1965, Bissell and Strong—1955 and Einarsen—1946).

Other factors than soil fertility, however, affect the nutritive value of forage. One author (Sheets—1946) stated "Soil fertility is only one of many factors affecting nutritive value of plants. Other factors, climate, growing season etc., may be more important than soil fertility." In a review of the literature on Influence of Environment on the Chemical Composition of Plants (Anon.—1954), the authors concluded that plant composition and nutritive value are dependent, within certain limits, on a complex interrelationship between many chemical, physical and biological factors associated with environment.

In summary, poor soils have poor potential for wildlife production. The best soils have the best potential but land-use prevents wildlife from reaching this potential. As Durwood Allen stated in his book, Our Wildlife Legacy, "A fertile soil will not guarantee heavy game populations, but large game populations seldom develop on poor soils."

Soils definitely influence the thinking of land managers. It is this influence, as it affects land management practices, that will have the greatest effect on forest game.

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MAP 1. MISSOURI
ZOOGEOGRAPHIC REGIONS

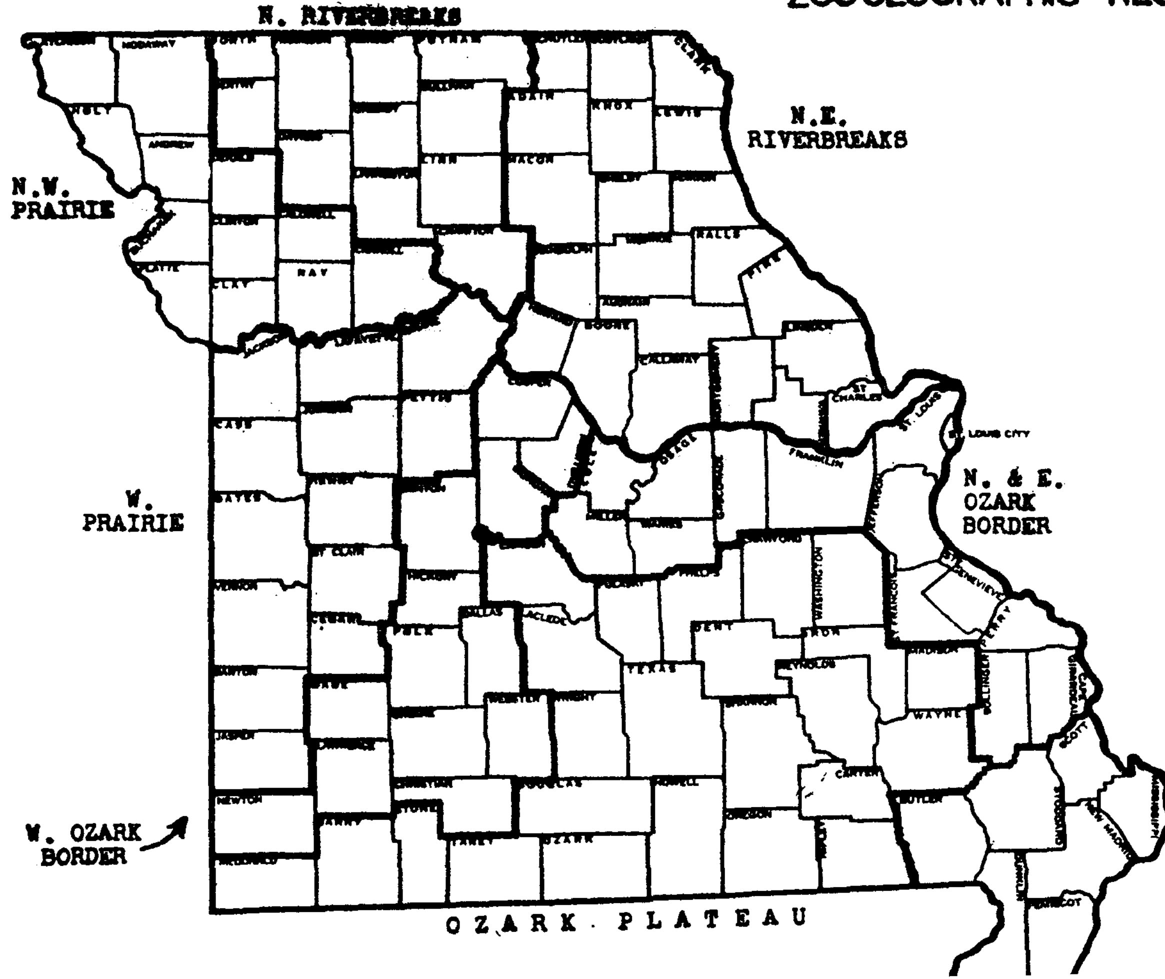

TABLE 1. Chemical Composition of Preferred Summer Browse Plants [1]

SPECIES	Region	% Crude Protein	% Fat	% Ash	% Water	% Fiber	% Calcium	% Potassium	% Phos.
Rose	S. W.	6.50	2.49	5.05	9.91	16.23	1.26	0.77	0.12
	S. E.	6.87	2.56	4.68	10.23	15.62	1.34	0.74	0.10
	Cent.	7.37	2.70	5.86	10.66	16.28	1.23	1.00	0.14
Desmodium	S. W.	13.87	1.60	5.45	9.56	21.83	0.93	1.29	0.16
	S. E.	14.12	1.88	5.28	9.48	22.99	0.76	1.31	0.14
	Cent.	15.50	1.96	6.41	9.25	23.29	0.95	1.47	0.16
Sunflower	S. W.	8.69	3.05	13.75	11.78	13.13	2.62	2.79	0.15
	S. E.	8.31	3.24	12.17	10.93	16.31	1.95	2.53	0.12
	Cent.	8.69	2.77	13.64	10.64	16.21	1.88	2.94	0.14
Aster	S. W.	8.00	1.02	7.77	9.57	22.29	0.93	2.50	0.24
	S. E.	8.44	1.12	8.08	9.61	22.69	0.94	2.55	0.18
	Cent.	8.37	1.20	8.41	9.89	23.04	0.91	2.58	0.19
Goldenrod	S. W.	7.75	5.12	7.41	8.93	17.32	0.87	2.27	0.17
	S. E.	8.00	2.45	7.74	8.96	17.93	0.90	2.36	0.18
	Cent.	8.50	3.77	8.31	8.99	18.97	0.88	2.31	0.17
New Jersey Tea	S. W.	12.87	1.85	4.22	10.11	16.75	1.11	0.78	0.12
	S. E.	12.44	2.00	3.84	9.60	19.70	0.83	0.79	0.12
	Cent.	12.87	1.47	4.56	9.69	19.29	0.87	1.06	0.12
Grape	S. W.	10.50	3.82	8.07	10.39	10.54	1.90	1.38	0.17
	S. E.	11.94	3.53	8.42	10.75	12.65	1.95	1.33	0.18
	Cent.	13.12	2.82	8.18	10.91	17.05	1.54	1.72	0.21
Greenbrier	S. W.	9.25	2.95	5.85	8.48	29.63	1.12	1.34	0.14
	S. E.	14.25	2.43	6.30	8.40	29.48	0.75	1.86	0.22

TABLE 2. Chemical Composition of Winter Browse Plants [1]

	% Crude Protein	Fat	% Fiber	% Ash	% Calcium	% Phosphorus	% Potassium
Red Cedar							
I Taney Co.	6.50	10.08	24.13	4.04	1.35	0.12	0.50
II Carter Co.	7.19	10.44	25.48	3.68	1.19	0.13	0.51
III Camden Co.	6.81	12.35	23.48	3.54	1.09	0.12	0.48
IV Gasconade Co.	7.81	11.23	24.62	3.54	1.05	0.13	0.50
Dwarf Sumac							
I Taney Co.	4.50	7.35	27.47	4.34	1.48	0.11	0.64
II Carter Co.	4.56	7.75	27.87	4.02	1.46	0.09	0.57
III Camden Co.	4.37	7.05	27.15	4.04	1.45	0.10	0.54
IV Gasconade Co.	4.56	7.97	26.92	3.82	1.32	0.11	0.58
Fragrant Sumac							
I Taney Co.	5.00	3.96	33.53	3.60	0.75	0.11	1.09
II Carter Co.	4.94	3.80	32.52	3.16	0.69	0.09	0.88
III Camden Co.	5.75	4.48	31.32	3.66	0.77	0.13	1.05
IV Gasconade Co.	5.75	3.88	31.89	3.42	0.63	0.11	1.05
Low Blueberry							
I Taney Co.	4.12	4.20	37.04	2.27	0.69	0.09	0.37
II Carter Co.	4.69	4.14	36.69	2.16	0.69	0.08	0.37
III Camden Co.	4.44	4.06	35.99	2.33	0.70	0.09	0.34
IV Gasconade Co.	4.31	4.26	36.95	2.29	0.68	0.09	0.32
Smooth Sumac							
I Taney Co.	4.50	8.54	26.36	5.17	1.82	0.15	0.89
II Carter Co.	5.25	9.00	24.05	4.68	1.50	0.15	0.93
III Camden Co.	4.50	9.48	25.12	4.86	1.69	0.12	0.86
IV Gasconade Co.	4.62	8.08	25.47	4.92	1.73	0.13	0.93
Sassafras							
I Taney Co.	5.06	3.41	35.77	1.85	0.55	0.09	0.32
II Carter Co.	5.44	3.27	36.37	1.91	0.57	0.09	0.32
III Camden Co.	4.81	3.47	36.91	1.79	0.51	0.09	0.29
IV Gasconade Co.	5.06	3.51	35.74	1.80	0.52	0.09	0.29
Pine							
I Taney Co.	6.25	6.65	24.13	2.55	0.32	0.12	0.41
II Carter Co.	7.12	7.31	22.97	2.26	0.22	0.12	0.41

1 Chemical analyses done by University of Missouri College of Agriculture Experiment Station Chemical Laboratories.