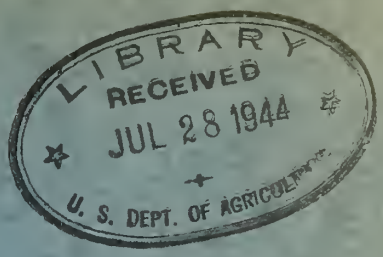
UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
WASHINGTON, D. C.




# WILDLIFE MANAGEMENT AS A PART OF SOIL CONSERVATION

By
Edward H. Graham
Biologist
Biology Division

Based on material presented as part of the course
in Wildlife Conservation given in the
Department of Agriculture Graduate School
Washington, D. C. 1940-41

SCS-MP-23
June 1941

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
WASHINGTON, D. C.
H. H. BENNETT, CHIEF

# WILDLIFE MANAGEMENT AS A PART OF SOIL CONSERVATION

by

Edward H. Graham

Biologist

Biology Division

Based on material presented as part of the course
in Wildlife Conservation given in the
Department of Agriculture Graduate School
Washington, D. C. 1940-41

No. SCS-MP-23
June, 1941

4866

# WILDLIFE MANAGEMENT AS A PART OF SOIL CONSERVATION

by

Edward H. Graham

Biologist

Biology Division

# WILDLIFE MANAGEMENT AS A PART OF SOIL CONSERVATION

## CONTENTS

## INTRODUCTION

Ten years ago a diligent search of the literature would not have disclosed a single reference to the relationship between wildlife management and soil conservation. Today it is not surprising to run across the reference that "soil and soil crops are the capital stock" with which wildlife managers deal and "wildlife is the interest on this capital" (Rush 1940) Neither is it unusual now to find in The Journal of Wildlife Management, the official publication of the recently organized professional Wildlife Society, an article which claims that "the success of pheasant stocking ... is very closely related to the average productivity of the soil. Increase of pheasants on the less productive soils can be brought about only by land management practices that will improve food and other habitat conditions" (Moss 1939). During the past decade the interest developed in wildlife as a product of the soil had as background much pertinent biological work in related fields plus a Nation's aroused concern with the conservation of soil and soil resources, among which wildlife is rightfully included.

It is the purpose of this treatment to show first, as a necessary prelude to the place of wildlife management in soil conservation, the development of America's interest in preserving soil from colonial days to the present, when such interest has found concrete expression in National, State, and local action. Following the general sketch of the soil conservation movement is a statement of the relationship of wildlife management to soil conservation, and, after this, a discussion of specific soil and water conservation practices and what they contribute to wildlife welfare on agricultural land. Finally, there are some concluding statements and a list of the references cited.

## THE SOIL CONSERVATION MOVEMENT

### Early Interest

Although widespread public interest in soil conservation and concerted National action against accelerated soil erosion in the United States is a very recent development, the depletion of soil resources accompanying our use of agricultural land is nothing new. In 1749 Peter Kalm, a Swedish botanist traveling in New Jersey, observed wasteful tillage methods and wrote that "the late rain had in many places washed away great pieces of the ground sown with wheat and rye" (Kalm 1937, v. 1, p. 264).

George Washington was troubled about soil erosion, for, in 1769, he experimented at Mount Vernon to determine "whether the land was not preserved more by harrowing than by lying in furrows." By the close of the eighteenth century, much of the previously productive cultivated land along the Potomac River had become practically worthless. Soon after the revolution Patrick Henry is said to have claimed that "since the achievement of our independence, he is the greatest patriot, who stops the most gullies." Thomas Jefferson, in 1817, wrote that "fields were no sooner cleared than washed," and two years later James Madison, in an address before the Agricultural Society of Albemarle, Virginia, stated that without soil-saving methods of cultivation, ownership of Piedmont farms was little more than a short-time lease (Hall 1937).

So, in the early history of the Nation, accelerated erosion was considered to be a very real problem. Progressive steps were taken, for Virginia farmers, more than 100 years ago, employed most of the principal methods of controlling erosion known today, including the

use of legumes and grasses to hold and improve the soil, green manuring, contour or horizontal plowing, terracing, and confinement of clean-tilled crops to the more flat lands. Even a type of strip cropping was used in which a strip of sod or alfalfa was maintained between rows of corn (Hall 1937; Hall 1940).

## Westward Expansion

The westward expansion of our Nation during the nineteenth century laid dormant an active public interest in erosion control, for new lands were ever available to those who, dissatisfied with worn-out fields, elected to move westward. Conservation was eclipsed by the opportunity of the moment, and not until the National pattern settled within circumscribed geographic limits did Americans once more look carefully to the use of the land.

During this period man-induced erosion had not diminished, of course, as attested by the notes of contemporary observers. For example, a Mississippi traveler, in 1835, deplored the destruction of soil by cotton cultivation without safeguards against erosion and the inevitable abandonment of the land (Ingraham 1835). Twenty years after this observer wrote, A. P. Calhoun (1855, pp. 266-267) stated that in spite of attempts to develop a soil-protecting grass cover in the South Carolina piedmont "the eye wanders over agricultural desolation ... a country that might be an Eden, repels the vision with its sedge fields, rotten fences, gullied hillsides, and undrained flats."

In 1864 George P. Marsh published the first edition of what was later to appear as the well known work, "The Earth as Modified by Human Action." Although not primarily interested in the erosion of agricultural land, Marsh nevertheless dramatically described in some detail the process of soil removal as it occurs on slopes denuded of forest cover. By 1894 F. H. King offered suggestions for the control of wind erosion on sandy soils of Wisconsin. The same year the U. S. Department of Agriculture published one of its earliest bulletins on soil conservation, entitled "Washed Soils: How to Prevent and Heal Them" (USDA 1894); it gave instructions on cultural methods of erosion control and stressed the importance of vegetation in holding soil on farm lands.

In the Yearbook of the Department of Agriculture for 1896, B. E. Fernow, botanist and forester, wrote about the relation of farm forests to erosion control. He considered it a necessity to plan the treatment not only of the farm woodland but of the entire farm in order to accomplish the best continued use of the land's resources, and his recommendations would do credit to modern farm planners. At that time, nearly a half century ago, the problem of soil wastage was believed by some to be so acute that N. S. Shaler, Harvard geologist, wrote (1896) that "it is now a question whether human culture, which rests upon the use of the soil, can devise and enforce ways of dealing with the earth which will preserve this source of life so that it may support the men of the ages to come."

## Renewed Interest

By the turn of the century many persons began to think about accelerated erosion. In 1904, J. W. Toumey stressed the importance of forests in preventing wind and water erosion; the same year Ten Eyck wrote of flood-damaged lands and how to renew them by revegetation. Articles on the waste from man-induced soil erosion began to appear in popular magazines (Ashe 1909), and, in 1909, the famed geologist T. C. Chamberlain stated before Congress that "When our soils are gone, we, too, must go, unless we shall find some way to feed on raw rock or its equivalent." In the same year, W. J. McGee pointed out to the First National Conservation Congress that through settlement and short-sighted agriculture erosion of the soil in the United States had become appalling, and two years later a U. S. Department of Agriculture bulletin on soil erosion appeared under his name (McGee 1911). In 1914, the Yearbook of the Department also carried an article on "Economic Waste from Soil Erosion" by R. C. B. Davis, in which methods of erosion prevention were given.

About this time F. H. H. Calhoun (1913) presented definite suggestions for controlling gullies in North Carolina, Maddox (1915) discussed West Tennessee gullied lands and their reclamation, and Baker (1916) wrote of terracing in North Carolina as a soil and water conservation measure. Brooks (1916) suggested the engineer's responsibility in erosion control, listing remedies; and in 1917 Dana further emphasized erosion as "one of the most serious dangers that threaten our farms." During this period there was also considerable attention directed toward the control and reclamation of drifting sand (Lamson-Scribner 1895, Hitchcock 1904, Baker 1906, Free and Westgate 1910).

Soil Conservation was deemed of sufficient National importance by 1911 that in an address that year before the National Conservation Conference at Kansas City the President of the United States, William Howard Taft, declared that "The first great step that has to be taken in reformed agriculture is the conservation of the soil. Under our present system the loss to the farmers of this country by the erosion of the soil is hardly to be calculated" (Taft 1911). Textbooks on soil management then began to give attention to the subject; that by F. H. King (1914) was one of the first to include specific recommendations for preventing soil washing.

The literature that appeared during the first and second decades of the present century shows well the impetus the soil conservation movement was gaining; the following decade may be said to have crystallized the movement. During this latter period, Leopold (1924), among the foresters, saw the importance of vegetation as an effective tool against erosion, and advocated vegetative as well as mechanical means of controlling silt movement in streams of the Southwest. Bates (1924), Munns (1923), and Zon (1927, 1932) further stressed the importance of forest cover in controlling erosion. By this time range men as well as foresters and agriculturists were considering accelerated erosion with respect to use of the land. Sampson and Weyl in 1918, for example, presented experimental evidence to show the relation between plant growth and erosion on western grazing land. Forsling (1928a, 1928b, 1931) also empnasized the importance of erosion control from the range ecologist's standpoint.

In 1928 H. H. Bennett and W. R. Chapline vividly described soil wastage in a Circular of the U. S. Department of Agriculture entitled

"Soil Erosion a National Menace." Figures were given to show soil losses and, in his part of the paper, Bennett stressed particularly the destruction of agricultural lands by accelerated erosion. In numerous subsequent articles Bennett continued to emphasize the serious consequences of the process throughout the United States and to declare the effect, not only upon agriculture, but upon the general socio-economic welfare of the Nation. Such presentation of the National situation was accentuated by intensive local studies, such as that by Bates and Zeasman (1930), who pointed out the gravity of the problem in west-central Wisconsin and made appropriate recommendations.

During the past ten years so many persons have contributed to soil and water conservation literature that this brief sketch cannot attempt to review the accomplishments of that period. It is sufficient to indicate that a recent annotated bibliography on soil erosion and soil and water conservation (Gaines 1938) includes 4,388 references, the great majority of which represent work of the past decade. Similarly, a bibliography on land utilization (Bercaw and Hannay 1938), for the years 1918 to 1936, contains more than 7,300 citations.

Recent attention to accelerated soil erosion and its control is not confined to writing about the subject, however, for, early in the present century, State agricultural experiment stations and the U. S. Department of Agriculture began to study erosion by field trial and experiment. By 1928 appropriations were authorized for the establishment throughout the United States of ten erosion experiment stations in order to learn more about erosion as a process affecting the land, to determine rates of infiltration as well as soil and water losses

under various types of plant cover, and to accumulate other information upon which a sound program of soil and water conservation might be based. Today such research is being conducted at 125 appropriately selected locations where important, useful data are being accumulated.

Previous to the inauguration of this National experimental program, some valuable watershed observations and experimental studies had already been undertaken. These included important work on run-off and erosion in the Appalachians (Glenn 1911); at Wagon Wheel Gap, Colorado (Bates and Henry 1922, 1928); in the Angeles National Forest, California (Munns 1920); and in the Manti National Forest, Utah (Barnes 1910; Reynolds 1911). Some significant experimental results had also been obtained at Holly Springs, Mississippi (Ames 1914); at Spur, Texas (Conner, Dickson and Scoates 1930; Dickson 1929); and in Missouri (Duley and Miller 1923).

## The Soil Conservation Service

Writing and research, however important, do not necessarily result in practical achievements; they alone could not accomplish the conservation of soil and soil resources. There was need for a National action program to apply what was already known about conserving soil and water, as well as to learn still more about practical methods for achieving that purpose. Such a program was initiated when, in September 1933, there was organized, in the Department of the Interior, an agency known as the Soil Erosion Service to conduct erosion-control work as a means of unemployment relief. It was believed that the control of erosion could be most widely accomplished through the example of actual farm demonstrations, and during the year and a half that the Soil

Erosion Service remained in the Department of the Interior, 41 demonstration projects were established, and approximately 50 C.C.C. camps were assigned to erosion-control work.

Shortly after its creation, the new Service conducted, in 1934, a Nation-wide erosion survey which showed that 282,000,000 acres of land, an area larger than the States of Texas and California combined, were so impoverished by erosion that they were no longer fit for farming or grazing. An additional 775,000,000 acres have been damaged to the extent that conservation measures must be applied to insure continued productivity. Thus more than half of the total land area of the United States has been shown to be seriously affected by accelerated erosion. These figures, furthermore, do not include rough mountainous areas and lands rendered useless to agriculture as a result of geological erosion, such as arid mesas and western badlands. Of our present cultivated land, about 60 percent is considered to be subject to continued erosion under current agricultural practices or so poor as not to return a satisfactory income at assumed price levels. In terms of reduced yields, abandoned acres, and loss of fertility, the estimated cost of erosion in the United States is $3,844,000,000 each year.

In March 1935 the Soil Erosion Service was transferred to the Department of Agriculture; the following month of the same year, April 1935, it became the Soil Conservation Service. A much broader program of demonstration in both projects and C.C.C. camp areas spread rapidly throughout the country, and the Soil Conservation Service undertook more extensive cooperation with land owners and operators in the application of soil and water conservation practices. Two basic requirements

were then as now considered essential to the successful accomplishment of sound conservation on farms and ranches. They were: (1) A complete farm plan, by which the use of each piece of land on the farm or ranch is planned according to its capability as determined by soil type, degree of erosion, slope, and other physical characteristics, and (2) coordinated attention to all of the aspects of farm operation and economy, including the properly balanced application of several technical fields such as soil science, agronomy, biology, range management, forestry, and engineering, wherever they contribute to the satisfactory development and execution of the farm or ranch plan.

In 1938 the Soil Conservation Service was assigned additional responsibilities, such as flood control work in cooperation with other agencies, action phases of the water facilities program in the 17 western States, the cooperative farm forestry program, drainage and irrigation work of the Department of Agriculture, and such land purchase as may contribute toward relief of social and economic ills in rural areas. The Soil Conservation Service has, therefore, evolved from an emergency erosion-control agency, in 1933, to a permanent Government bureau concerned with the whole broad problem of land use adjustment on the farm and range lands of the Nation.

## Soil Conservation Districts

National interest in soil and water conservation has culminated, not only in the establishment of a Federal agency charged with responsibility for conserving soil, but in the development of local units of government that are specifically organized for "the prevention and control of soil erosion and the conservation of soil and soil resources" -- soil conservation districts. Such districts are legally

constituted subdivisions of a State, usually operating over naturally bounded areas and organized in response to the petition and referendum of the farmers operating within their boundaries. During 1937, the Soil Conservation Service began to cooperate with soil conservation districts in several States. These districts have developed so rapidly since the close of 1937, when there were 14 embracing 8,619,000 acres, that in May 1941, only four years later, there were 501 districts embracing 306,099,469 acres in 38 States. Through soil conservation districts, soil and water conservation measures proven practical on demonstration projects can be extensively applied by farmers themselves.

It is apparent, therefore, that during the past few years the Nation's concern with the conservation of soil and soil resources has developed tremendously. This development has been shown by soil conservation work on the part of Federal and State agencies and by the people themselves through the passage of soil conservation districts laws in 41 States and the creation of hundreds of soil conservation districts through which farmers are democratically and cooperatively attacking the problem of man-induced soil erosion in America. The way is now clear, therefore, to coordinate local, State, and Federal efforts so effectively that widespread conservation of soil and soil resources ultimately may be achieved.

## WILDLIFE AND SOIL CONSERVATION

### The Relationship

Leopold (1933) and Darling (1934) were among the first to suggest the desirability of converting eroded areas into wildlife habitats. About the same time Holt (1934b) began to stress the importance of integrating wildlife conservation with soil conservation, and during the next few years won consideration for wildlife welfare in the rapidly developing Nation-wide program of soil conservation aimed by the Federal Government at better use of agricultural and range lands. Wildlife management is now accepted as an integral part of soil and water conservation operations.*

Beginning with the notion that by establishing vegetation to control erosion, habitats for game birds, such as quail, can be so developed on farms as to produce a marketable game surplus, ideas about the integration of soil and wildlife conservation have progressed until today attention is being given to all the biological phases of soil conservation. These include not only the production of game to supplement the usual crop production of a farm, but deal as well with rodent populations in relation to range vegetation and soil and water conservation structures, such as terraces and ponds, insects with respect to modern agricultural practices, such as strip cropping and winter cover crops, fish in farm ponds and streams, and other biological aspects of operations undertaken to conserve the Nation's agricultural resources.

---

* (See Bennett 1936, 1939; Holt, 1935b, 1936a, 1937, 1939b; Graham 1937; Van Dersal 1937a; annual reports of the Soil Conservation Service, Biology Division, to the U. S. House of Representatives Select Committee on the Conservation of Wildlife Resources, 1936 to date; U. S. Senate Report No. 1203; and the annual reports of the Chief of the Soil Conservation Service to the Secretary of Agriculture, 1935 to date.)

One of the first considerations of wildlife in relation to soil conservation appeared in a U. S. Department of Agriculture bulletin in 1934. Written by Wallace B. Grange and A. L. McAtee, it dealt with the improvement of the farm environment for wildlife and treated the value of thickets and other types of wildlife cover for checking erosion. Another treatment of game management on the farm (Darling, Sheldon, and Gabrielson 1936) that stressed the soil conservation implication appeared two years later. This was followed by practical suggestions for improving wildlife habitat as part of an erosion-control program in the Appalachian Piedmont, in a bulletin by A. O. Stevens (1937). More recently Edminster (1941) has produced a similar bulletin for the Northeast.** Even though it is such a young field of endeavor, wildlife conservation as a part of soil conservation has developed so rapidly that it is impossible here to cite all the articles on the subject that have appeared, many of them in farm, sport, and State conservation magazines. The interested reader is referred instead to two mimeographed lists of current literature, appearing periodically, that include most of the references on the subject, namely, "Wildlife Review," issued by the Fish and Wildlife Service, of the Department of the Interior, and "Soil Conservation Literature," compiled by the library staff of the Soil Conservation Service.

That wildlife management and soil conservation are complementary activities is due largely to the fact that vegetation established to

---

** Among others who have treated the subject are: Chase 1938; Darling 1935; Kenneth S. Davis 1936, 1938; Gabrielson 1938; Hill and Bradt 1940; Jenkins 1940; Kriebel 1938; Lehmann 1937; Migon 1940; Mershon 1936; Morton 1938; Rowalt 1938; Rule 1938; Terres 1936; Turner and Hatch 1938; Wallace 1937; Westveld and Bennitt 1936.

conserve soil and water can, if properly managed, provide food and shelter for wildlife. More and more it is becoming evident that vegetation is the primary tool with which erosion can be controlled, and wherever plants are to be used to check soil washing, whether in woodland, pasture, crop strips, terrace outlets, gullies, pond edges, or elsewhere, they can at the same time be made to contribute to the welfare of wildlife. This concept is a distinct advance over earlier thinking about wildlife and land use, which held that wildlife could best be encouraged on areas not suitable to any other use.

Although there is great need for large wildlife refuges, especially to preserve migratory waterfowl and vanishing species, progressive wildlife managers today recognize that there is very little land, whether it be strictly agricultural, range, or forest, which cannot, by modifications less detrimental than beneficial to the primary use of the land, sustain an especially adapted wildlife population. To maintain populations of mammals or birds on land not devoted primarily to their welfare is ecologically sound and has been stressed in recent articles by Holt (1939a) and McAtee (1939). In this connection, the importance of applying ecological principles to land use programs has been emphasized by Bennitt (1939), Clements (1935), Graham (1940), Hanson (1939), McAtee (1937), and Taylor (1934, 1935b).

The significance of improving conditions for wildlife on agricultural land is emphasized by the fact that 85 percent of all the land in the United States is used for agricultural purposes, including grazing. Furthermore, it has been estimated that 85 percent of all

hunting takes place on agricultural land, and that 70 percent of the wild fur crop is caught there, primarily by farm boys. It is therefore evident that unless it can be produced on areas primarily devoted to agriculture, the wildlife of our Nation must remain a small fraction of its real potential.

The Biology Division of the Soil Conservation Service

Just as public interest in soil and water conservation is reflected in the organization and history of the Soil Conservation Service, so interest in the biological phases of a National soil conservation program is indicated by the development of the Biology Division of that Service. The beginning of this part of the program was due, to a great extent, to the suggestions of Jay N. Darling and Aldo Leopold; its development has depended largely upon the foresight of H. H. Bennett, Chief of the Soil Conservation Service, and the direction of Ernest G. Holt, Chief of the Biology Division. A biologist was placed on the technical staff of the first soil conservation demonstration project, established in 1933. Shortly afterward, additional biologists were assigned to projects in various states throughout the East and Middle West. When, in 1935, the Soil Conservation Service was reorganized under the Department of Agriculture, there was authorized, in November of that year, a Section of Wildlife Management coordinate with other operating sections of the Service. The following month a small staff was set up in Washington to effect the organization of the new section. Since that time its work has expanded until, in all land use plans developed and operations conducted by the Service, consideration is being given to the needs of wildlife.

In June 1939, commensurate with a change in the status of all technical sections of the Soil Conservation Service, the Section of Wildlife Management became the Biology Division and, in line with increased responsibilities assumed by the Service, the functions of the Biology Division were enlarged. The Division now formulates the biological policies of the Service and collaborates with other divisions on surveys, planning, and procedures; it likewise supervises and coordinates the development, evaluation, improvement and application of the biological phases of Soil Conservation Service programs and practices to aid in the attainment of Service objectives. It furthermore approves work plans and procedures, inspects field operations to insure technical quality, adequacy of treatment, and adherence to policy; assembles and disseminates operating information pertinent to the biological phases of the Service programs; encourages application in the field of new, improved, or promising biological measures adaptable to Service programs; and maintains cooperative relations with the Fish and Wildlife Service, Department of the Interior, the Bureau of Entomology and Plant Quarantine, and other agencies concerned with biological problems. In brief, the biological work of the Soil Conservation Service now involves not only the integration of wildlife management with soil and water conservation, but also the application of biological principles and practices to programs aimed at better agricultural land use and permanent systems of farming.

## SOIL CONSERVATION PRACTICES BENEFICIAL TO WILDLIFE

One of the most significant things about the soil conservation program of the Nation is the change in land pattern which it is producing. Now, instead of square fields, there are strips of crops lying across the slope of the land, formerly bare gullies are clothed with vegetation and pastures and woodlands protect the steeper slopes. This new agriculture produces a pronounced change in habitat, and considerable attention is being directed toward effectively modifying the changing pattern for the benefit of wildlife.

To render agricultural land more useful to wildlife may require special types of vegetation or particular attention to those plants normally grown for crops, forage, and wood products. Within recent years the erosion-control and wildlife values of certain groups of plants have received definite consideration. McAtee (1936) prepared the first published list of plants valuable for wildlife utilization and erosion control. This was followed by an exhaustive treatment of the erosion-control and wildlife values of the native woody plants of the United States by Van Dersal (1938a), who has written shorter articles on special phases of the same subject (1938b, 1939, 1940). In the same vein, Musser (1939) has written of the usefulness of coralberry, and Graham (1939a, 1939b, 1941) has treated the erosion-control and wildlife values of legumes. The use of natural vegetation for the same purpose has been stressed by Whitaker (1937), Osborn and Whitaker (1936), and Osborn (1940).

Profits to the landowner from wildlife produced on the land, incidental to normal agricultural operations, have been discussed by Dambach and Good (1939), Towns (1939), and Edminster (1940). In

connection with payments for agricultural crop adjustments, the same subject has been treated by Sheldon (1935), Clark (1939), and Hill (1939). That erosion-control measures beneficial to wildlife are worth their cost, alone, in the soil conservation they accomplish has been attested by an economic study of wildlife as a supplementary farm enterprise, undertaken jointly by the Fish and Wildlife Service, Department of the Interior, and the Bureau of Agricultural Economics (Foster 1940). The investigators concluded that the most profitable objective of wildlife management on agricultural land is a "coordinated conservation program that will integrate wildlife production and utilization into all land-use and soil-conservation programs."

The relation of soil and water conservation practices to biological phenomena has captured the imagination of many who are not practically concerned with land use operations. For example, Wodehouse (1940) has claimed that a cure for hay fever is soil conservation, for when idle and eroding lands are clothed with appropriate erosion-control vegetation there will be little place for ragweed to persist. The relation of bee keeping to soil conservation has also been pointed out (Paddock 1937), for good seed and fruit production of many crop legumes and wildlife food plants useful in controlling erosion is dependent essentially upon pollination by bees.

## Strip Cropping, Crop Rotations, and Cover Crops

The practice of cultivating crops in contour strips has become widespread only recently in this country. The practice consists of alternating strips of close-growing vegetation, such as meadow, alfalfa, or small grain, with strips of clean-tilled row crops, such as corn,

cotton, or tobacco. Such strips are particularly effective in checking soil removal when they are placed across long gentle slopes, for they serve to interrupt the flow of water at regular intervals, thus reducing its erosive power. Although the change from large fields in single crops to fields in strips is theoretically helpful to wildlife because it produces, between the types of crops, an increase in "edge" and because it creates a greater diversity of food and cover, it was not until Dambach and Good (1940) censused the populations of breeding birds on some Ohio farms that strip cropping was determined to be definitely beneficial to wildlife. The study revealed that in fields consisting of strips of corn, small grain, and meadow, there were approximately twice the number of breeding, ground-nesting birds per acre as in comparable non-stripped fields (see also Dambach 1941). Further unpublished evidence by Edminster and others indicates that increased bird populations are characteristic of strip-cropped areas, due probably to the establishment of smaller acceptable territories within the limits of each strip than prevail in large fields of single crops, but additional studies must be undertaken to prove that this effect is universally true.

Another ecological interrelationship involved in strip cropping is the effect of the practice upon insect populations. As already pointed out by Bishopp (1938, 1939), Harris (1939), and Annand (1940), injurious insects may winter in permanent meadow strips used in strip cropping systems. Chinch bugs, for example, may thus be harbored near areas to be planted to corn the following spring. On the other hand, there is evidence to show that strip cropping may increase the effective

control exercised by predaceous insects upon harmful species (Marcovitch 1935), and it is possible that increased bird populations, due to strip cropping, may to some measure assist in controlling insects. Other insect-wildlife relationships have been pointed out by the authors just cited and by Strong (1938). Whatever they prove to be, however, the biological complexes resulting from soil conservation practices, once they are known, must be balanced against the actual effectiveness of the practice as an erosion control measure, because it has been shown that, in spite of possible disadvantages, properly applied strip cropping, for example, aids materially in the control of accelerated erosion.

The use of proper crop rotations is highly recommended as an erosion-control measure. Whether in solid fields or strips, crops are frequently rotated in such a manner that hay or meadow occupies a given piece of land for several consecutive years. This device for soil improvement and erosion control creates, in such fields, permanent, although perhaps rotating, habitats for ground-nesting birds. In such rotations the proximity of grain fields or strips to nesting areas likewise provides available wildlife food.

Although at first it may not be apparent, the practice of contour cultivation itself may be beneficial to wildlife. This is due largely to the reduction of muddy run-off, for thus much silt is excluded from streams. It is now believed, with some definite evidence at hand (Ellis 1936, 1937), that siltation may be generally as detrimental to aquatic organisms and aquatic habitats as industrial stream pollution.

Another soil and water conservation practice of benefit to wildlife is the use of cover crops. Permanent ground cover in orchards provides food and shelter for wildlife. Winter cover crops, many of them legumes

employed to improve and hold the soil during the months when erosion might otherwise be severe, frequently provide food for wildlife at a season when food is normally scarce. In the Southeast, for example, a winter cover crop of Augusta vetch (Vicia angustifolia) ripens its seeds early in the spring before other plants have matured. Complications may exist here too, however, for there is some question as to whether such leguminous winter cover crops may increase the insects injurious to cotton, such as the cotton root aphid.

In order eventually to arrive at a proper understanding of the entomological implications of such soil conservation practices as the use of winter cover crops and strip cropping, the Soil Conservation Service is cooperating with the Bureau of Entomology and Plant Quarantine and with State entomological agencies to learn more about the influence of soil and water conservation practices upon insect populations, and to properly adjust desirable conservation measures to possible attendant changes in insect populations.

## Terraces and Diversion Ditches

Terraces designed to conserve rainfall and dispose of excess run-off from cultivated fields may be retained in permanent vegetation that provides food and cover as well as protected lanes of travel for wildlife. Similar wildlife benefits are derived from diversion ditches that run across the slopes of cultivated fields to divert excess run-off, for not only is the ditch itself planted to a grass-legume mixture, but a wide desilting strip parallel to it on its upper side is also maintained in permanent vegetal cover. Such ditches and terraces must empty into well vegetated outlets which, in the Southeast at least, may be protected

with Bermuda grass sod in the bottom of the outlet channel and Lespedeza sericea on the channel berms. The lespedeza prevents the grass from encroaching on adjacent cultivated fields and the channels, thus flanked with borders of a tall herbaceous perennial, provide wildlife with excellent shelter and travel lanes.

## Field Borders and Roadsides

In the Gulf and Atlantic Coast States, particularly, there has long existed an erosion problem perplexing alike to the farmer, forester, and agronomist. This is the border of crop fields adjacent to woodland, where the shade and root competition from the trees prevent or stunt the growth of the crop. On such areas also, water accumulates from the crop rows and, coursing down the edge of the field, washes the soil and creates an unsightly and unproductive condition. The biologists interested in soil conservation saw in this area an opportunity not only to save soil but also to develop a strip of cover for wildlife on land otherwise useless. Although to create desirable cover on such a site some plant was needed that was at once an herbaceous perennial, able to grow in a depleted soil, and capable of competing with trees for sunlight and soil moisture, a satisfactory plant has been found. It is the introduced Asiatic Lespedeza sericea. As now established on thousands of farms in the Southeast, border strips of this plant effectively prevent erosion, afford turn rows for teams working the field, and furnish a useful habitat for wildlife.

The establishment of field border plantings has been eagerly adopted by the farmer and has been found equally acceptable to the agronomist and forester. Biologists have observed cottontail rabbits, bobwhites, and other birds in the border strips, and studies to determine

the effect of such strips upon populations of insects, birds, and mammals are being cooperatively arranged by the Soil Conservation Service and the Fish and Wildlife Service of the Department of the Interior. The use and establishment of these field borders, inaugurated by M. O. Stevens, has recently been described by Davison (1939a, 1939b), who is largely responsible for their widespread development. Davison (1940) has also made suggestions for the establishment of a strip of shrubs between the herbaceous lespedeza border and the trees, in order to produce a more satisfactory edge to the woodland and to provide a more beneficial cover and food supply for wildlife thus encouraged. Mulching as an aid in the establishment of field borders and in the development of vegetation on similarly eroded sites has been described by Franklin (1939a, 1939b).

Vegetation along roadsides in many cases may not provide particularly desirable wildlife habitats because of the proximity of traffic, but Davison (1941) has pointed out that in the Southeast widespread use of Lespedeza sericea, or other vegetation that prevents erosion, on road cuts and fills may contribute to the improvement of aquatic habitats by decreasing siltation in streams.

## Ponds, Reservoirs, Springs, Marshes and Swamps

The restoration of eroded land in the eastern States frequently requires the damming of gullies, resulting in ponds which, when planted and properly protected, as with a fence, become small wildlife refuges. Water for stock is made available in a tank or trough outside the protected pond area below the fence. Throughout the western States one of the ways of conservatively using the range and thus reducing soil loss by erosion is to provide well-distributed stock-watering ponds. In the

Great Plains larger impoundments of water are useful in retaining a supply of water during periods of drought. It is frequently impractical to completely fence these larger reservoirs, but if a fence is provided around the upper more shallow part where vegetation is encouraged to desilt inflowing water, ideal sanctuaries for waterfowl may be created. Ponds that are properly managed for fish are likewise a source of supplementary food for the farm family, and may contribute cash through fishing fees and the sale of bait minnows. The modification of eastern farm ponds for the benefit of wildlife has been described by Cecil N. Davis (1937, 1939a, 1939b), W. G. Davis (1939), Nagel and Clark (1937), and Osborn (1940); comparable use of western ponds has been discussed by Allan (1939). Allan andDavis (1941) now have in press a general bulletin treating the management of ponds for wildlife.

Springs, like ponds, may prove of distinct value to wildlife when their immediate environs are protected from grazing. In such instances water is made available to stock below an enclosing fence in tanks or troughs in which the water remains freer from contamination and cleaner for stock than in unprotected water holes. The water also remains purer as well as less hazardous to birds and mammals, if there are built into one side or end of the tank inclined steps up which wild animals may crawl to safety if they fall into the water, which they frequently do in areas where water is at a premium.

Gabrielson (1939) has pointed out that the "maintenance of small bodies of water, the more numerous the better, is one of the positive actions looking toward the creation of recreational facilities and wildlife values that can be made a part of any flood control program, and with the minimum of cost." Undoubtedly the establishment of numerous

protected ponds and reservoirs throughout the Central States, as part of a widespread soil and water conservation program, may do as much for waterfowl as larger, more widely scattered lakes. The smaller bodies of water present more "edge" or margin for nesting and feeding areas; also the spread of waterfowl diseases should be minimized where large concentrations of birds are avoided.

The experience of agriculturists has shown that it may be uneconomical to drain marshes and swamps, for the cost of drainage is frequently greater than the profit to be gained from the use of the drained land. It is fast becoming recognized that one of the best uses of a swamp or marsh is the production of wildlife, such as muskrats, thus programs designed to conserve soil and water incident to proper land use benefit desirable birds and mammals.

## Drainage and Irrigation

Much of the drainage work deemed essential to intensive agricultural operations in the East involves the construction of ditches to drain water from flat land productive only when properly drained. In the Southwest and the Pacific Coast, drainage ditches dispose of excess irrigation water, and there water is supplied to farmland by means of irrigation canals and ditches. These drainage and irrigation canals and ditches are most satisfactorily maintained in some kind of vegetative cover that checks weeds, prevents the banks from eroding, and does not choke the channels. Trials are being undertaken to determine the plant species, the most desirable perennial grasses, legumes, and shrubs, that will reduce ditch maintenance to a minimum, prevent erosion, and, at the same time, provide a home for wildlife. In intensively farmed areas,

where corn, small grain or some other seed crop usually is available adjacent to such vegetated ditches, agricultural land can produce wildlife, as shown by high pheasant populations in northwestern Ohio. In semi-arid areas such ditches, when properly managed, can likewise serve as unusually favorable wildlife habitats.

## Streams and Streambanks

The value of contour cultivation in preventing siltation of streams and thus improving habitats for fish and other aquatic life has been pointed out. Yet, so long as a watershed lacks the protection of adequate vegetation there will be erosion, silting, undercutting of streambanks, and drastic changes in habitat not only in the stream itself but on adjacent land areas. One need not look far to see bare streambanks cutting into fertile bottomland, and even though reasonable protection of the watershed is achieved, something should be done to expedite recovery of such raw, eroding areas. For this purpose fencing and the use of willows and other vegetation have proven successful (Fry 1938a, Morehead 1939, Stanek 1940). The willows not only stabilize the banks but transform previously bare areas into suitable habitats for many birds and small mammals.

As an erosion-control measure beavers have been stocked in streams of the western States, especially in forested headwaters where they can do no damage to crops or orchards. The dams built by these mammals have been highly effective in conserving water and retaining silt. In Washington, the value of one dam constructed by beavers, in less than two years time, was estimated by engineers at $2500 (Scheffer 1938). Beavers are soil and water conservationists of long experience (Fox 1940), and the occurrence of many natural meadows throughout the western

States is now recognized to have been the result of beaver activity (Finley 1937). In fact, the reintroduction of beavers to western regions, where they were once common, has caused mountain meadows once more to produce a natural hay crop as a result of the increased moisture retained by beaver dams.

## Woodland

In planning the best use of his land, the farmer frequently finds some areas too steep or potentially unproductive for crops or pasture. Such land can profitably be maintained in trees, for a good farm forest is the source of useful wood products. Whatever its primary purpose, a farm woodland can be so managed as to be of distinct benefit to wildlife. The integration of wildlife, woodland, and erosion control has been emphasized by Holt (1934a, 1935a), McIntyre (1936), Bode (1938), and Edminster (1939a). In order to save soil and to maintain natural reproduction of the trees, grazing and fire is excluded from the well-managed farm forest. This, in itself, is of the utmost importance to woodland wildlife, for it makes possible much more shelter and food than exists in a grazed, burned woodland. In Ohio the studies of Dambach and Good (1940) showed that ungrazed woodland supported more than twice as many pairs of breeding birds as comparable grazed woods. Strikingly analagous results were shown by similar studies of Mayall (1938) in Ontario. Hawbecker (1940) has also written of the greatly increased use by both birds and mammals of a 120-acre weedy tract in central California three years after it had been planted to trees and shrubs.

The preservation of den trees and an occasional piling of slash from cuttings will also make the woodlot more suitable to wildlife.

Other conservation practices, such as selective cutting for sustained yield, are highly beneficial to woodland wildlife, for they maintain a comparatively open and stable woodland habitat. A woodland management measure of interest to the forester and biologist alike is the development of the woodland edge. It is well known that in the ecotone or "edge" between two types of vegetation there usually exist more animal species and individuals than are characteristic of either vegetation type alone. Lay (1938) found in margins of woodland clearings in eastern Texas approximately twice the average number of birds that occurred within the woodland itself. More species as well as individual birds were also represented in the thicket of the woodland edge. To each new woodland established as part of a coordinated farm conservation plan, a few rows of shrubs are recommended for the periphery of the woodlot in order to simulate to some degree a natural woodland edge (Van Dersal 1937b). Such a border of shrubs not only provides food and cover for wildlife but also excludes desiccating winds from the forest interior and checks windthrows by deflecting wind above the trees.

Much has been written within recent years about woodland management practices that are beneficial to wildlife. The present discussion, however, attempts to adhere primarily to soil and related wildlife conservation measures, and for strictly woodland-wildlife practices the reader is referred to a recent Selected Bibliography of North American Forestry (Munns 1940).

## Hedgerows, Windbreaks, and Buffer Strips

Every quail hunter knows enough to look for birds along old rail fences overgrown with shrubs, briers, and vines. Many farmers, on the other hand, believe that overgrown fence-rows harbor harmful insects

and are a source of weed seeds; as a result they have become devotees of "clean" farming. The type of fence-row or hedge that may be desirable from a wildlife and erosion-control standpoint, however, is not an unattended growth of volunteer vegetation, but a planned and managed stand of selected plant species. Furthermore, entomologists are fairly well agreed today that many other factors, in addition to the protection that may be afforded by fence-row cover, play important parts in determining insect populations.

That a farm fence or hedge can usefully serve as a wildlife habitat and, if placed on the contour, as a barrier to soil erosion, has been emphasized particularly by Edminster (1938a, 1938b, 1939b, 1939c), and Enlow (1939). Practical suggestions for the establishment and management of shrubs in hedges, as well as in other situations, have also been made by Davison (1940). Certainly hedgerows, tracing a diverse pattern across a countryside, mean a great deal in the way of travel lanes, food, and nesting cover to wildlife, and they help greatly in creating, on the farm, an environment pleasing to man. Numerous field studies are being made in various parts of the country to determine the insect, bird, and mammal populations of hedges and fence-rows, so that we may some day be able to properly evaluate the part they should play in the most desirable agricultural pattern for American farms.

Just as hedgerows in the East may help to hold soil when they are established across the slope, so in the Great Plains windbreaks and buffer strips may act as effective barriers in reducing wind erosion and retaining snowfall. Whether in the form of a narrow windbreak, a shelter belt composed of several rows of trees flanked with shrubs (O'Connell 1938), or a buffer strip of a single row of shrubs, such plantings may

perform the dual role of controlling wind erosion and creating on semi-arid agricultural land a habitat more suitable to wildlife.

Wildlife food patches of crop plants have been given considerable attention (Fry 1938b) and under certain conditions may prove useful. In the Great Plains, however, food patches fit best into agriculture in the form of herbaceous buffers (Harper 1937, Fox 1939) of sunflower, corn, or other tall plants that effectively protect major crops from the wind and control wind erosion. In fact, buffers, windbreaks, and hedgerows, like other measures useful both for erosion control and wildlife, are best employed when they are established as integral and permanent parts of the farm pattern.

## Pastures and Meadowland

Although at first thought it may seem that pastures do not matter much to wildlife, nevertheless, when they are maintained in grass-legume mixtures designed for sustained forage yield and maximum erosion control, pastures may supply much in the way of both food and nesting cover for wildlife. Rotating pasture systems, using two or more kinds of pasture to provide a maximum of good forage throughout the grazing season, may provide undisturbed areas for ground nesting birds. Where deferred grazing is practiced as a forage-conservation measure, attention to nesting dates can provide time enough for birds to raise a brood before grazing is permitted. Meadows of permanent hay, frequently recommended as part of a strip cropping system or otherwise as part of a soil conservation farm plan, provide benefits to wildlife similar to those furnished by well-managed pastures.

There is another significant wildlife benefit to be derived from the establishment of pastures as part of a balanced conservation farm plan. By converting steep eroding areas to pasture as an erosion-control measure, livestock grazing may be limited to areas more specifically adapted to that use. Thus stock may be kept out of fields and woodlots that are thereby rendered more suitable wildlife habitats, as previously pointed out.

## Range Land

The proper management of range land is of inestimable benefit to wildlife because it creates shelter, food and water for many wild birds and mammals. There also is considerable evidence to show that jack rabbits and rodents are less troublesome on well-vegetated range. Antelope, sage hen, prairie chicken, and other animals of the Great Plains and the inter-montane West can better be conserved by maintaining an environment as natural as proper range use will permit. The relation between wildlife welfare and conservation practices on range land has been pointed out by Ligon (1938) and Compton (1939), and unpublished studies by Gale Monson indicate that the number of wild animals on moderately-grazed range is approximately twice that on comparable overgrazed areas. In addition to better food and cover resulting from the adoption of good range management, the development of well-distributed stock ponds may be highly beneficial to range wildlife. On semi-arid range lands of the western States, water-spreading and water-retention devices, such as contour furrows, produce a heavier stand of grass that is useful to livestock for forage and to wildlife for food and shelter.

The intimate relationship between range conservation and soil conservation has long been emphasized by far-sighted persons. Likewise, wildlife benefits are known to accrue by proper range-management methods just as they do by adequate attention to other conservation measures designed to accomplish good land use. The numerous publications on management of western ranges, livestock, and wildlife in relation to soil conservation cannot be discussed fully here, but a recent bibliography (Renner et al 1938) on the subject includes more than 8,000 references, with a large number on wildlife.

## Submarginal Land, Gullies and Odd Spots

In the past, many large tracts of land unsuited to agriculture have been settled and farmed in vain attempts to gain a livelihood from the soil. It is now realized, however, that submarginal areas are more wisely managed when utilized for their forest, wildlife, or recreational values. The conversion of submarginal land to uses other than crop production usually brings great advantages to wildlife and the management of such land now includes attention to the wildlife resource (Peterson 1939). Numerous submarginal areas scattered throughout the Nation have now been readjusted to non-agricultural use and many of them are proving to be refuges for range, woodland, and marshland wildlife.

Just as large tracts once misused by man can profitably be converted to wiser and less intensive use that is beneficial to wildlife, so small severely-eroded sites may be made to serve wildlife also. The revegetation of gullies, galled spots, and similar eroded areas with plants useful to wildlife has been so widespread that many persons think

of gully planting as the chief erosion-control wildlife-management endeavor. Adapted trees, shrubs, and herbaceous plants have been variously used in clothing such areas with protective vegetation suitable for food and cover, and although few counts are at hand, such rehabilitated sites are known to be much used by many kinds of wildlife. From the standpoint of the wildlife manager, the use of vegetation for controlling gullies has been described by Stevens (1937) and Nesbit (1940). Many others, to whom reference has been made, have offered suggestions useful for the same purpose.

On almost every farm there are small eroding areas standing within pastures or cropland that are too small to be effectively managed as woodland. There are rocky outcrops and small corners of fields which, for one reason or another, are not adapted to crop, pasture, or woodland use. Slight attention, perhaps only the prevention of burning and protection from grazing, transforms these areas into island refuges highly important to wildlife, for they increase the interspersion of convenient cover and food throughout the farm.

In planning the best use of his land a farmer may want to confine his cropland to the least erodible parts of the farm; this frequently necessitates the conversion of former cropland to pasture, woodland, or wildlife areas. As with larger submarginal tracts, proper attention to the wildlife benefits involved in this conversion of small areas upon individual farms can accomplish much for wildlife.

## CONCLUSION

### Wildlife and Agricultural Land Use

The management of wildlife in this country is a comparatively recent endeavor and wildlife management as an integral part of land use programs has only begun to take definite shape. Already, however, we know that much can be accomplished for the benefit of wildlife by agricultural operations. The farmer, soil conservationist, and wildlife manager together must determine the practices that jointly meet their objective -- the best sustained use of the land. Perhaps the most significant development in the coordination of soil and wildlife conservation is the fact that it has become apparent that a plan of wildlife management need not be superimposed upon a program of farm management. The two can be wholly integrated and a sound program of soil and water conservation can serve at the same time as an acceptable wildlife management program for the farm. One plan can answer both needs, and many of the ways in which both objectives are attained by the same operations have been described above.

### The Need for Research

Notwithstanding the substantial progress that is being made in wildlife management, we need to know much more about animal populations, even of common species, particularly as they relate to conservation operations. This is a field of study practically untouched in this country. Many conservation practices now recommended for their known erosion-control values must be evaluated in terms of their effect upon animal populations, both harmful and beneficial, before we can know the true importance of those practices to agriculture. For example, what is the effect of strip cropping upon populations of birds, mammals, and

insects? We must know whether winter legumes harbor insects injurious to the crops which follow them; likewise whether hedgerows by harboring insects are detrimental or by sheltering birds are helpful in reducing injurious insect populations. Knowledge of these interrelationships is accumulating and when we know whether or not such conservation practices are biologically advantageous, we will be in a position to recommend modifications beneficial to crop production.

Throughout the Great Plains one of the most notorious enemies of agriculture is the grasshopper. Although much effort is expended to solve the problem by such methods as poisoning, perhaps further study of grasshopper populations, their behavior and their natural relation to the land may help us to work with, rather than against, these insects. Much is known about grasshoppers, but not enough. The damage caused by unusually large animal populations may be handled more intelligently when we know more about population behavior. Such knowledge may aid materially in the use of cultural or "naturalistic" methods of control, not only of grasshoppers but of many other harmful species.

The relation of predators and rodents to the proper management of western range lands is a biological problem that is associated so intimately with the use of the range that wild animals are often blamed, to the exclusion of other influences, for the deterioration of range land. Burrowing rodents are frequently charged with causing erosion and breaks in terraces. These animals undoubtedly are associated with such damage, but they may frequently be more a symptom of poor land management, "animal weeds," than causes of the ailment. Bond and Borell (1939) have stated some of the problems involved in such rodent-range

relationships, and others have recently written objectively on the subject of soil and animal interdependence (Bond 1941, Holt 1936b, Taylor 1935a, Van Dersal 1937c, and Vorhies 1936a, 1936b).

There are other biological matters about which the agriculturist needs further practical information, but little reference can be made to them here. Suffice it to state that they are as divergent as the proper stocking and fertilizing of farm ponds for the production of food fish, the controlled burning of southern pine lands as a quail and forest management device, and the use of stubble mulch as a wind erosion control measure in dry farming areas with respect to its effect upon injurious insects.

In brief, there is distinct need for research on biological phenomena as they relate to soil and water conservation practices, for as yet there is only scant knowledge of biological processes with respect to land planning and management. It will be a long time before our knowledge is adequate, but those who use the land cannot afford to lose sight of the biological implications that result from their efforts (Taylor 1938). Whatever else the future holds for us, it may be said that insofar as the success of conservation and man's future happiness are concerned, two things must come to pass -- first, we must command a broader knowledge of natural phenomena than we now possess and, secondly, we must apply that knowledge to land use operations as well as to other human endeavors if we are to cope successfully with the complicated world in which we live.

## LITERATURE CITED

Allan, Philip F.
1939. Development of ponds for wildlife in the southern High Plains. Trans. 4th North American Wildlife Conf.: 339-342.

_____, and Davis, Cecil N.
1941. Ponds for wildlife. U. S. Dept. Agr. Farm. Bul. 1879. In press.

Ames, C. T.
1914. Soil erosion. Miss. Agr. Expt. Sta. Bul. 165: 3-12, illus.

Annand, P. N.
1940. Recent changes in agriculture and their effect on insect problems. Jour. Econ. Entom. 33: 493-498.

Ashe, W. W.
1909. The waste from soil erosion in the South. Review of Reviews 39: 439-443.

Baker, F. R.
1916. The prevention and control of erosion in North Carolina, with special reference to terracing. N. C. Agr. Expt. Sta. Bul. 236, 27 pp.

Baker, H. P.
1906. The holding and reclamation of sand dunes and sand wastes. Forestry Quart. 4: 282-288.

Barnes, W. C.
1910. The story of Manti: a study in cause and effect. Amer. Forestry 16: 532-534, illus.

Bates, C. G.
1924. The erosion problem. Jour. Forestry 22: 498-505.

_____, and Henry, A. J.
1922. Streamflow experiment at Wagon Wheel Gap, Colorado: preliminary report on termination of first stage of experiment. U. S. Monthly Weather Rev. Sup. 17, 55 pp., illus.

_____
1928. Forest and streamflow experiment at Wagon Wheel Gap, Colorado. U. S. Monthly Weather Rev. Sup. 30, 79 pp., illus.

Bates, C. G., and Zeasman, O. R.
1930. Soil erosion - a local and national problem. Wisc. Agr. Expt. Sta. Res. Bul. 99, 100 pp., illus.

Bennett, H. H.
1936. Wildlife and erosion control. Bird-Lore 38: 115-121, illus.

_____
1939. Soil conservation. McGraw Hill Co., N. Y. 993 pp., illus. Chapt. 28, Wildlife and Soil Conservation, pp. 568-595.

_____, and Chapline, W. R.
1928. Soil erosion a national menace. U. S. Dept. Agr. Circ. 33.

Bennitt, Rudolf
1939. Ecology in wildlife management. Outdoor Amer. 4: 4-6, 9, illus.

Bercaw, Louise O., and Hannay, Annie M.
1938. Bibliography on land utilization, 1918-36. U. S. Dept. Agr. Misc. Pub. 284, 1508 pp.

Bishopp, F. C.
1938. Entomology in relation to conservation. Jour. Econ. Entom. 31: 1-11.

_____
1939. Insects and conservation. Soil Conservation 4: 293-295.

Bode, I. T.
1938. The extension forester and wildlife conservation. Jour. Forestry 36: 283-287.

Bond, Richard M.
1941. Rodentless rodent erosion. Soil Conservation 6: 269.

_____, and Borell, Adrey E.
1939. Rodents and soil conservation. Soil Conservation 4: 220-223.

Brooks, Benj.
1916. Erosion of watersheds and its prevention. Jour. Amer. Water Works Assoc. 3: 409-414.

Calhoun, Andrew P.
1855. Address delivered before the Pendleton (South Carolina) Farmers' Society, October 13, 1855. Farmer and Planter 6: 266-272.

Calhoun, F. H. H.
1913. Gullying and its prevention. S. C. Agr. Expt. Sta. Circ. 20, 36 pp., illus.

Chamberlin, T. C.
1909. Soil wastage. 60th Cong., 3d sess., H. Doc. 1425, pp. 75-83.

Chase, Warren W.
1938. Soil and wildlife conservation. Minn. Conserv. 60: 14-15, 30, illus.

Clark, Arthur L.
1939. Cash for aiding wildlife. Mo. Ruralist 80: 5, 18.

Clements, Frederic E.
1935. Experimental ecology in the public service. Ecology 16: 342-363.

Compton, Lawrence V.
1939. Wildlife and the range. Soil Conserv. 4: 215-217.

Conner, A. B., Dickson, R. E., and Scoates, D.
1930. Factors influencing run-off and soil erosion. Tex. Agr. Expt. Sta. Bul. 411, 50 pp., illus.

Dambach, Charles A.
1941. The effect of land-use adjustments on wildlife populations in the Ohio Valley region. Trans. 5th North Amer. Wildlife Conf., pp. 331-337.

_____, and Good, E. E.
1939. Profits for the farmer. Soil Conserv. 4: 227-228.

_____
1940. The effect of certain land use practices on populations of breeding birds in southwestern Ohio. Jour. Wildlife Mangt. 4: 63-76, illus.

Dana, S. T.
1917. Farms, forests and erosion. U. S. Dept. Agr. Yearbook 1916: 107-134, illus.

Darling, J. N.
1934. Statement of Hon. Jay N. Darling, Chief, Bureau of Biological Survey, Department of Agriculture (May 8, 1934). To Spec. Comm. on Conserv. of Wildlife, House of Representatives, 73d Cong., pp. 1-18, 101-118, 153-158.

_____
1935. Conserving our wildlife. Recreation 28: 469, 471.

_____, Sheldon, H. P., and Gabrielson, I. N.
1936. Game management on the farm. U. S. Dept. Agr. Farm. Bul. 1759, 22 pp., illus.

Davis, Cecil N.
1937. Wildlife-saving farm ponds of Missouri. Soil Conserv. 2: 153-155, 159, illus.

_____
1939a. Utilizing farm ponds for wildlife. Soil Conserv. 4: 230-232.

_____
1939b. Development of ponds as wildlife areas in Missouri. Trans. 4th North Amer. Wildlife Conf.: 519-524.

Davis, Kenneth S.
1936. Protecting fin, fur, and feather in Coon Valley (Wisconsin). Soil Conserv. 2(6): 109-113.

_____
1938. Game fits in - to a system of soil-saving, money-making farming, and affords a Minnesota neighborhood real enjoyment in the bargain. Successful Farming 36: 9, 40-43, illus.

Davis, R. O. E.
1914. Economic waste from soil erosion. U. S. Dept. Agr. Yearbook 1913: 207-220, illus.

Davis, William G.
1939. Wildlife will come where it is invited. Mo. Wildlife 2(5): 7, 11, illus.

Davison, Verne E.
1939a. Putting eroded field borders to good use. Soil Conserv. 4: 224-225.

_____
1939b. Protecting field borders. U. S. Dept. Agr. Leafl. 188, 8 pp., illus.

_____
1940. Shrubs for wildlife on farms in the Southeast. U. S. Dept. Agr. Leafl. 200, 8 pp., illus.

_____
1941. Lespedeza sericea for road cuts and fills. Soil Conserv. 6: 186-188, illus.

Dickson, R. E.
1929. Results and significance of the Spur (Texas) runoff and erosion experiments. Jour. Amer. Soc. Agron. 21: 415-422.

Duley, F. L., and Miller, M. F.
1923. Erosion and surface runoff under different soil conditions. Mo. Agr. Expt. Sta. Res. Bul. 63, 55 pp., illus.

Edminster, Frank C.
1938a. The farm fence in wildlife. Amer. Wildlife 27: 38-39, 45-46, illus.

_____
1938b. Woody vegetation for fence rows. Soil Conserv. 4: 99-101, illus.

_____
1939a. Improving farm woodland for wildlife. Soil Conserv. 4: 212-214, 223.

Edminster, Frank C.
1939b. Hedge plantings for erosion control and wildlife management. Trans. 4th North Amer. Wildlife Conf.: 534-541.

1939c. The farm fence in wildlife management and erosion control. Pa. Game News 9(10): 10-13, illus.

1940. Is wildlife management worth while to the farmer? Pa. Game News 11: 6-7, 29, illus.

1941. Wildlife management through soil conservation in the Northeast. U. S. Dept. Agr. Farm. Bul. 1868, 54 pp., illus.

Ellis, M. M.
1936. Erosion silt as a factor in aquatic environments. Ecology 17: 29-42, illus.

1937. Pollution and aquatic life. Amer. Wildlife 26: 38, 45-46, illus.

Enlow, C. R.
1939. Hedges conserve soil and wildlife. Soil Conserv. 4: 209, 223.

Fernow, B. E.
1896. The relation of forests to farms. U. S. Dept. Agr. Yearbook 1895: 333-340, illus.

Finley, William L.
1937. The beaver - conserver of soil and water. Trans. 2d North Amer. Wildlife Conf. 295-297.

Forsling, C. L.
1928a. The soil protection problem. Jour. Forestry 26: 994-997.

1928b. Grazing control is needed for proper watershed protection. U. S. Dept. Agr. Yearbook 1927: 350-351.

1931. A study of the influence of herbaceous plant cover on surface run-off and soil erosion in relation to grazing on the Wasatch Plateau in Utah. U. S. Dept. Agr. Tech. Bul. 220, 72 pp., illus.

Foster, E. A.
1940. Statement of E. A. Foster, Division of State and Local Planning, Bureau of Agricultural Economics. Hearings before Select Comm. on Conserv. of Wildlife Resources, House of Representatives, pp. 237-255.

Fox, A. C.
1939. Annual crop buffer windbreaks. Natural wildlife feeding stations beneficial to birds. Dakota Farmer 59: 96-97, illus.

1940. Beavers as water conservationists. N. Dak. Outdoors 2: 5-6.

Franklin, Sydney
1939a. Mulching to establish vegetation for wildlife and erosion control. Trans. 4th North Amer. Wildlife Conf: 508-513.

1939b. Mulching to establish vegetation on eroded areas of the Southeast. U. S. Dept. Agr. Leafl. 190, 8 pp., illus.

Free, E. E., and Westgate, J. M.
1910. The control of blowing soils. U. S. Dept. Agr. Farm. Bul. 421, 23 pp., illus.

Fry, J. R., Jr.
1938a. Willows for streambank control. Soil Conserv. 4: 109-111, 128.

1938b. Wildlife food patches: Results of four years of observations in southwestern Wisconsin. Trans. 3d North Amer. Wildlife Conf. 730-735.

Gabrielson, Ira N.
1938. The land and the perpetuation of wildlife. Soil Conserv. 4(2): 56-57.

1939. The correlation of water conservation and wildlife conservation. Ill. Conserv. 4(1): 12-13.

Gaines, Stanley H.
1938. Bibliography on soil erosion and soil and water conservation. U. S. Dept. Agr. Misc. Publ. 312, 651 pp.

Glenn, L. C.
1911. Denudation and erosion in the Southern Appalachian region and the Monongahela Basin. U. S. Geol. Survey Prof. Paper 72.

Graham, Edward H.
1937. The Siamese twins of conservation. Amer. Wildlife 26: 88-89, illus.

1939a. Legumes for erosion control and wildlife. Soil Conserv. 4: 210-211.

1939b. Legumes for soil and wildlife conservation. Trans. 4th North Amer. Wildlife Conf. 501-507.

Graham, Edward H.
1940. Ecology and land use. Soil Conserv. 6: 123-128.

_____
1941. Legumes for erosion control and wildlife. U. S. Dept. Agr. Misc. Pub. 412, 153 pp., illus. In press.

Grange, Wallace B., and McAtee, W. L.
1934. Improving the farm environment for wild life. U. S. Dept. Agr. Farm. Bul. 1719, 62 pp., illus.

Hall, A. R.
1937. Early erosion-control practices in Virginia. U. S. Dept. Agr. Misc. Pub. 256, 31 pp., illus.

_____
1940. The story of soil conservation in the South Carolina Piedmont 1800-1860. U. S. Dept. Agr. Misc. Pub. 407, 36 pp., illus.

Hanson, Herbert C.
1939. Ecology in agriculture. Ecology 20: 111-117.

Harper, Frank B.
1937. Wide-row plantings of annuals. Soil Conserv. 3: 163-164, illus.

Harris, K. L.
1939. Soil conservation versus insect control. Ent. Soc. Wash. Proc. 41(1): 20-26.

Hawbecker, A. C.
1940. Planting for California wildlife. Calif. Fish and Game 26(3): 271-277, illus.

Hill, R. G.
1939. Farmers receive payment by following soil building practices favoring wildlife. Mich. Conserv. 8: 4-5, illus.

_____, and Bradt, G. W.
1940. Producing wildlife by good farm land use. Mich. State Col. Ext. Bul. 218, 33 pp., illus.

Hitchcock, A. S.
1904. Methods used for controlling and reclaiming sand dunes. U. S. Bur. Plant Indus. Bul. 57, 36 pp., illus.

Holt, Ernest G.
1934a. Integrating forestry and game management in erosion control. Jour. Forestry 32.

_____
1934b. Erosion control and game development. Trans. 20th Amer. Game Conf.: 177-181.

Holt, Ernest G.
1935a. Woodland conservation and wildlife preservation. The Land, Today and Tomorrow 2: 18-21.

_____
1935b. The Soil Erosion Service and wildlife. Trans. 21st Amer. Game Conf.: 319-325.

_____
1936a. Soil conservation means wildlife conservation. Proc. 1st North Amer. Wildlife Conf.: 239-243.

_____
1936b. Wildlife in soil and water conservation - animal life is an important factor in soil porosity and water retention. Amer. Wildlife 25: 86, illus.

_____
1937. Soil and wildlife conservation - a report of progress. Proc. 2d North Amer. Wildlife Conf.: 78-82.

_____
1939a. What is a biologically balanced farm? Soil Conserv. 4: 206-208.

_____
1939b. Birds and beasts aid erosion control. Amer. Wildlife 28: 79-86, illus.

Ingraham, J. H.
1835. The Southwest by a Yankee. Harper Bros., New York.

Jenkins, Hal.
1940. Conservation farming benefits wildlife. Outdoor Amer. 5: 4-5, illus.

Kalm, Peter
1937. Travels in North America. Transl. by A. B. Benson, 796 pp., illus.

King, F. H.
1894. Destructive effects of winds on sandy soils and light sandy loams, with methods of protection. Misc. Agr. Expt. Sta. Bul. 42, 29 pp., illus.

_____
1914. Soil management. 311 pp., illus. Orange Judd Co., New York and London.

Kriebel, Ralph M.
1938. Wildlife conservation in Indiana through erosion control. Ind. Audubon Yearbook 16: 67-77, illus.

Lamson-Scribner, F.
1895. Grasses as sand and soil binders. U. S. Dept. Agr. Yearbook 1894: 421-436, 580, illus.

Lay, Daniel W.
1938. How valuable are woodland clearings to wildlife? Wilson Bul. 50: 254-256.

Lehmann, V. W.
1937. Increase quail by improving their habitat. Tex. State Game, Fish and Oyster Comm., 44 pp., illus.

Leopold, Aldo
1924. Grass, brush, timber, and fire in southern Arizona. Jour. Forestry 22: 1-10.

_____
1933. Game management. 481 pp., illus. Charles Scribner's Sons, New York.

Ligon, J. Stokley
1938. Wildlife and modern land-use policies in the Southwest. Cattleman 25(6): 45-48.

Ligon, Rose
1940. Bringing back our upland game birds. Soil conservation program giving impetus to restoration of wildlife. Cattleman 26: 17, 19, illus.

McAtee, W. L.
1936. Groups of plants valuable for wildlife utilization and erosion control. U. S. Dept. Agr. Circ. 412, 12 pp., illus.

_____
1937. Wildlife in land planning. Pa. Game News 8(3): 4,5,26, illus.

_____
1939. Biologic balance on the farm. Soil Conserv. 5: 97-99.

McGee, W. J.
1909. The relation among the resources. 1st Natl. Conserv. Cong. Addresses and Proc., 96-102.

_____
1911. Soil erosion. U. S. Dept. Agr. Bul. 71, 60 pp., illus.

McIntyre, Arthur C.
1936. Revegetating eroding hillsides. Pa. Game News 7(9): 9, 16.

Maddox, R. S.
1915. West Tennessee gullied lands and their reclamation. Resources Tenn. 5: 8-22.

Marcovitch, S.
1935. Experimental evidence on the value of strip farming as a method for the natural control of injurious insects with special reference to plant lice. Jour. Econ. Entom. 28: 62-70.

Marsh, George P.
1864. Man and nature; or, physical geography as modified by human action. 560 pp., London.

Mayall, K. M.
1938. Natural resources of King Township, Ontario. Privately published.

Mershon, Ralph
1936. Wildlife, a new farm crop. South Agr. 67: 6, 27, illus.

Morehead, L. B.
1939. Willow mats halt streambank erosion. Soil Conserv. 5: 127, 131, illus.

Morton, J. N.
1938. Wildlife in the farm program. Pa. Game Comm. Bul. 16, 40 pp., illus.

Moss, A. E.
1939. Relation between take of upland game and agricultural land uses in Connecticut. Jour. Wildlife Mangt. 3: 269-278.

Munns, E. N.
1920. Chaparral cover, run-off, and erosion. Jour. Forestry 18: 806-814.

_____
1923. Erosion and flood problems in California. Calif. State Bd. Forestry Rept. to Leg. on Senate Concurrent Resolution 27, 165 pp., illus.

_____
1940. A selected bibliography of North American forestry. U. S. Dept. Agr. Misc. Pub. 364, 1142 pp., 2 vols.

Musser, Glenn E.
1939. Coralberry. Its value in erosion control. Pa. Game News 10: 5, illus.

Nagel, W. O., and Clark, M. W.
1937. Improvement of farm ponds and watersheds for erosion control and wildlife production. Mo. Agr. Ext. Serv. Circ. 361, 11 pp., illus.

Nesbit, R. J.
1940. Living dams control gullies. That fence-row washout can do damage. Ohio Farmer 185: 11, illus.

O'Connell, F. B.
1938. Shelter belts for wildlife. Outdoor America 4: 4-5, illus.

Osborn, Ben
1940. Native plants stabilize pond shores. Soil Conserv. 6: 144-145.

_____, and Whitaker, H. L.
1936. Significance of natural vegetation in planning erosion control and wildlife management. Soil Conserv. 2(6): 126-129.

Paddock, F. B.
1937. Relation of beekeeping to wildlife conservation. Amer. Bee Jour. 77: 519-520, 549.

Peterson, W. A.
1939. Wildlife in the land utilization program. Soil Conserv. 4: 229.

Renner, F. G., et al.
1938. A selected bibliography on management of western ranges, livestock, and wildlife. U. S. Dept. Agr. Misc. Pub. 281, 468 pp.

Reynolds, A. V. R.
1911. Grazing and floods: A study of conditions in the Manti National Forest, Utah. U. S. Forest Serv. Bul. 91, 16 pp., illus.

Rowalt, E. M.
1938. Soil defense in the South. U. S. Dept. Agr. Farm. Bul. 1809, 64 pp., illus.

Rule, Glenn K.
1938. Soil defense in the Northeast. U. S. Dept. Agr. Farm. Bul. 1810, 70 pp., illus.

Rush, W. M.
1940. Wildlife management and our big game animals. Nature Mag. 33: 29-36, illus.

Sampson, A. W., and Weyl, L. H.
1918. Range preservation and its relation to erosion control on western grazing lands. U. S. Dept. Agr. Bul. 675, 35 pp., illus.

Scheffer, Paul M.
1938. The beaver as an upstream engineer. Soil Conserv. 3: 178-181, illus.

Shaler, N. S.
1896. The economic aspects of soil erosion. Natl. Geogr. Mag. 7: 328-338, 368-377.

Sheldon, H. P.
1935. Game as a farm crop emphasized by agricultural adjustment. U. S. Dept. Agr. Yearbook 1935: 220-221.

Stanek, George R.
1940. Willow mats halt streambank erosion. The Ohio Conserv. Bul. 4(2): 17.

Stevens, R. O.
1937. Wildlife conservation through erosion control in the Piedmont. U. S. Dept. Agr. Farm. Bul. 1788, 25 pp., illus.

Strong, Lee A.
1938. Insect and pest control in relation to wildlife. Trans. 3d North Amer. Wildlife Conf.: 543-547.

Taft, W. H.
1911. Conservation of the soil. U. S. Dept. Agr. Off. Sec. Circ. 38, 8 pp.

Taylor, Walter P.
1934. Some animal aspects of reforestation and erosion control. Jour. Forestry 32: 8-10.

_____
1935a. Some animal relations to soils. Ecology 16: 127-136.

_____
1935b. Man and nature--a contemporary view. Sci. Monthly 41: 350-362.

_____
1938. Value of wildlife research for proper land-use management. Amer. Wildlife 27: 72-73, 77, illus.

Ten Eyck, A. M.
1904. Treatment and utilization of flood-damaged lands: Renewing washed and sanded lands. Kans. Agr. Expt. Sta. Bul. 121: 133-138.

Terres, J. K.
1936. The wildlife program of the Soil Conservation Service. Pa. Acad. Sci. 10: 19-25.

Toumey, J. W.
1904. Relation of forests to streamflow. U. S. Dept. Agr. Yearbook 1903: 279-288.

Towns, Homer G.
1939. Cash in the rancher's pocket. Soil Conserv. 4: 226-232.

Turner, L. T., and Hatch, A. B.
1938. The influence of soil conservation practices on upland game birds on Idaho farms. Univ. of Idaho Bul. 33(22): 67-69.

United States Department of Agriculture, Division of Chemistry, Soils, Forestry, and Botany.
1894. Washed soils: How to prevent and reclaim them. U. S. Dept. Agr. Farm. Bul. 20, 22 pp., illus.

United States House of Representatives.
1936-1941. Hearings before the Select Committee on the conservation of wildlife resources.

United States Senate.
1940. Report of the wildlife conservation work of the Soil Conservation Service. Rpt. of Special Comm. on the Conserv. of Wildlife Resources, 76th Cong. 3d sess. Rpt. No. 1203: 381-399.

United States Soil Conservation Service.
1935-1940. Report of the Chief of the Soil Conservation Service to the Secretary of Agriculture.

Van Dersal, William R.
1937a. Wildlife management. Soil Conserv. 3: 73-75, illus.

1937b. A border for the woods. Soil Conserv. 3: 99-101, illus.

1937c. The dependence of soils on animal life. Proc. North Amer. Wildlife Conf.: 458-467.

1938a. Native woody plants of the United States. Their erosion-control and wildlife values. U. S. Dept. Agr. Misc. Pub. 303, 362 pp., illus.

1938b. Utilization of woody plants as food by wildlife. Trans. 3d North Amer. Wildlife Conf.: 768-775.

1939. Some important timber trees and wildlife. Soil Conserv. 5: 103-107, illus.

1940. Utilization of oaks by birds and mammals. Jour. Wildlife Mangt. 4: 404-428.

Vorhies, Charles T.
1936a. Wildlife aspects of range renabilitation. Hoofs and Horns 5(8): 6-7, 5(9): 10-11.

_____
1936b. Rodents and conservation. Nature Mag. 28: 363-365, 379, illus.

Wallace, H. A.
1937. A product of the soil. As such, wildlife restoration is a problem of land management. Amer. Wildlife 26: 21, 27-28, illus.

Westveld, R. N., and Bennitt, R.
1936. Improving food and cover for wildlife on Missouri farms. Mo. Agr. Ext. Sta. Circ. 348, 8 pp.

Whitaker, H. L.
1937. Natural vegetation in soil conservation and wildlife management. Proc. North Amer. Wildlife Conf.: 468-475.

Wodehouse, R. P.
1940. Hold that sneeze. Rotarian 57(1): 43-44, illus.

Zon, R.
1927. Forests and water in the light of scientific investigations. U. S. Forest Service (unnumbered pub.) 106 pp., illus. (Reprinted with revised bibliography from 62d Cong., 2d sess., S. Doc.469, App. V. of the Final Report of the National Waterways Commission, pp. 203-302, 1912.)

_____
1932. Control of erosion by means of reforestation. Natl. Drain. Conserv. and Flood Control Cong. Proc. 21: 81-85.