8-15-1915

The Prairie Dog and Its Control

Myron Harmon Swenk
University of Nebraska at Lincoln

BULLETIN NO. 154.

THE UNIVERSITY OF NEBRASKA.

BULLETIN

OF THE

AGRICULTURAL EXPERIMENT STATION

OF

NEBRASKA.

VOLUME XXVIII, ARTICLE II.

THE PRAIRIE DOG AND ITS CONTROL.

BY M. H. SWENK.

DISTRIBUTED AUGUST 15, 1915.

A PRAIRIE DOG.

LINCOLN, NEBRASKA
U. S. A.

AGRICULTURAL EXPERIMENT STATION OF NEBRASKA.

THE GOVERNING BOARD.

(THE REGENTS OF THE UNIVERSITY.)

HONORABLE WILLIAM G. WHITMORE, *President*, Valley.
HONORABLE PHILIP L. HALL, Lincoln.
HONORABLE VICTOR G. LYFORD, Falls City.
HONORABLE FRANK L. HALLER, Omaha.
HONORABLE EDWARD P. BROWN, Davey.
HONORABLE JOHN E. MILLER, Lincoln.

THE STATION OFFICERS.

SAMUEL AVERY, PH. D., LL. D., *Chancellor*, ex officio.
E. A. BURNETT, B. SC., *Director; Animal Husbandry.*
C. W. PUGSLEY, B. SC., *Director of Extension Service.*
J. S. DALES, M. PH., *Financial Secretary.*
FRANK C. DEAN, A. B., *Bulletin Editor.*

THE WORKING STAFF.

E. MEAD WILCOX, PH. D., *Agricultural Botany.*
F. W. UPSON, PH. D., *Agricultural Chemistry.*
L. W. CHASE, M. E., A. E., *Agricultural Engineering.*
J. H. GAIN, M. D. C., *Animal Pathology.*
J. H. FRANDSEN, M. S. A., *Dairy Husbandry.*
LAWRENCE BRUNER, B. SC., *Entomology.*
T. A. KIESSELBACH, A. M., *Experimental Agronomy.*
H. C. FILLEY, A. M., *Farm Management.*
*W. J. MORRILL, M. FOR., *Forestry.*
R. F. HOWARD, A. M., *Horticulture.*
G. A. LOVELAND, A. M., *Meteorology.*
W. P. SNYDER, M. S., *Supt. of Experimental Substation*, North Platte.
C. B. LEE, A. M., *Associate in Animal Husbandry.*
HOWARD J. GRAMLICH, B. SC., *Associate in Animal Husbandry.*
M. H. SWENK, A. M., *Associate in Entomology.*
GEORGE K. K. LINK, A. M., *Assistant in Agricultural Botany.*
H. A. MCCOMB, B. SC., *Horticulturist of Experimental Substation*, North Platte.
W. M. OSBORN, B. SC., *Assistant in Dry Land Agriculture, U. S. Department of Agriculture*, North Platte.
J. W. CALVIN, B. SC., *Assistant in Agricultural Chemistry.*
P. B. BARKER, A. M., *Assistant in Agronomy (Soils).*
ERWIN HOPT, B. SC., *Assistant in Agronomy (Crops).*
J. A. RATCLIFF, A. M., *Assistant in Experimental Agronomy.*
L. B. STURDEVANT, A. M., M. D., *Assistant in Animal Pathology.*
E. G. WOODWARD, A. M., *Assistant in Dairy Husbandry.*
J. R. COOPER, B. SC., *Assistant in Horticulture.*
C. A. HELM, A. M., *Assistant in Experimental Agronomy.*
FLORENCE A. MCCORMICK, PH. D., *Assistant in Agricultural Botany.*
H. E. VASEY, A. M., *Assistant in Agricultural Botany.*
JAMES COWAN, M. E., *Superintendent Experimental Substation*, Valentine.
FRITZ KNORR, B. SC., *Superintendent Experimental Substation*, Mitchell.
H. L. NYE, *Foreman Demonstration Farm*, Culbertson.

*Resigned.

CONTENTS.

THE PRAIRIE DOG AND ITS CONTROL.

BY M. H. SWENK.

INTRODUCTION.

About a century ago, as the early explorers crossed this western country, their attention was particularly drawn to numerous animals about the size of the ordinary cottontail rabbit which lived in colonies on the plains, and which when disturbed began a sharp and vigorous chattering or barking that often was continued after the approach of the observer had caused the animals to rush into their underground burrows. Lewis and Clarke appropriately dubbed this interesting animal the "barking squirrel," and later the naturalist Thomas Say called it the "Louisiana marmot," at the same time remarking that the name "prairie dog," which had been given to the animal "from a fancied resemblance of its warning cry to the hurried barking of a small dog," was inappropriate and absurd. Nevertheless, this real or fancied resemblance of the excited chatter of these animals to a dog's barking caused them to be generally called "prairie dogs," and this name has persisted over the possibly more correct ones, which have long since become obsolete.

This prairie dog of the plains is one of the most characteristic mammals of the dry, nearly treeless, interior country of the United States. From the eastern half of Montana and the southwestern part of North Dakota, it ranges southward thru eastern Wyoming and Colorado, western South Dakota, Nebraska and Kansas, most of Oklahoma and New Mexico, and western Texas into north-central Mexico. It is, apparently, confined to regions of dry, sunshiny climatic conditions. In the more western and mountainous States it occurs only at the lower elevations, that is, up to about 6,000 feet. Its present distribution in Nebraska includes practically the whole of the State west of the 98th meridian, tho over most of the extreme eastern part of this range its numbers are small and declining, being represented by only a few, scattered, weak colonies. Formerly prairie dogs occurred eastwardly nearly to the Missouri River. Up to about 1880 there used to be an 80-acre colony as far east as Plum Creek, near Beemer, in Cuming County, and another about one-half as large on Clark Creek, near Fontanelle, in Washington County, but these are now extirpated. As recently as 1902 the prairie

dog extended east along the Niobrara River to the point of its junction with the Missouri.

Proceeding westwardly in the State, however, the number of prairie dogs rapidly increases, and soon many large, strong colonies are to be found. Over at least one-half of the area of the State prairie dogs are abundant enough to be a distinct hindrance to agriculture, and in many localities the animals are important pests. Moreover, the evidence is conclusive that most of the colonies of these animals are rapidly increasing in extent and population, especially during recent years, wherever no determined effort has been made to reduce them. The accompanying map (fig. 1) shows the present distribution of the plains prairie dog in Nebraska, its approximate former distribution, and the general area and principal localities from which reports of injury have been received at the Agricultural Experiment Station during the past few years.

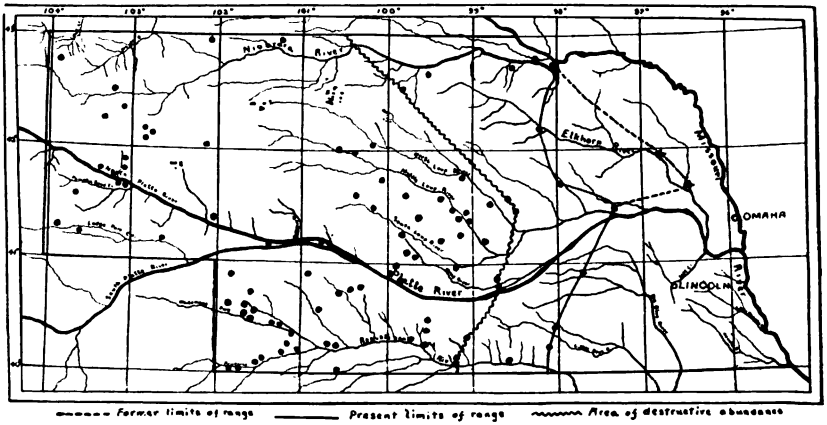

Fig. 1.—Distribution of the plains prairie dog in Nebraska.

INJURY.

The actual injury to Nebraska agriculture thru the ravages of prairie dogs has probably been underestimated, except perhaps by the men having large colonies of the animals on their ranches or farms. The chief damage by prairie dogs has been, and yet is, the extensive consuming or destroying of pasture grasses, especially in the valley lands of the ranges. But recently, with the increasing alfalfa acreage, the animals have come to quickly extend their colonies or establish new ones in alfalfa

fields, where their depredations soon become very serious and rival the injury to pastures. Moreover, because of the abundance of succulent green food supplied by the alfalfa plants, the prairie dogs are exceedingly difficult to destroy in such situations by the use of poisoned baits. Fields of wheat and other small grains, as well as fields of cane, kafir, and other sorghums, form attractive foraging grounds, and are to some extent utilized as places for the locating of colonies. If burrows are located in such fields the animals will clear a space for 10 or 12 feet around each burrow, thus destroying vastly more than they can actually consume. Prairie dogs are also proving something of a nuisance at places in the western irrigated districts by forming their burrows in the ditch banks, thereby sometimes causing washouts and making necessary the relocation of a ditch to stop water loss. Finally, the stepping into the open prairie dog burrows by horses and cattle has been the cause of many broken legs.

It is a very difficult matter to estimate, even approximately, the loss caused by prairie dogs in this State, owing to the scattered condition and variable size of their colonies, or "towns," and the varying density of their population, as well as the differences caused by contiguity or remoteness of the colonies in relation to cultivated fields. Colonies vary in size from a few dozen occupied burrows which cover an acre or two, to large colonies containing thousands of animals and covering several hundred acres. Nebraska colonies of size usually cover from 80 to 160 acres of pasture land, tho frequently as much as a half section is involved. In Texas, according to Merriam (5),* there is an enormous colony covering about 25,000 square miles.

As the area included in the "town" proper is usually kept largely or quite free from vegetation the value of the occupied areas as a foraging ground for live stock is largely lost. According to Merriam (5) on pasture lands 32 prairie dogs will eat as much as a sheep, and 256 as much as a cow, and the productive capacity of the invaded land is reduced from 50 to 75 per cent. Payne (8) in 1903 estimated that in eastern Colorado 2 per cent of the land was in dog "towns" and that this meant a loss of about 412 square miles of pasture land, or $50,000 worth of forage. Lantz (6, 12) in 1903 and 1904 estimated on the basis of personal observations and reports from over 518 townships out of 1,015 infested townships, that two to two and one-half million acres of Kansas land were occupied by prairie dog "towns," mostly pasture lands on which the injury was about 50 per cent, making a loss of about $80,000 to $100,000 annually, and this not includ-

*Numbers in parentheses following authors' names refer to the bibliography at the end of the bulletin.

ing alfalfa and wheat lands or losses of these crops. Certainly the total loss in Nebraska cannot fall much short of this, and it would probably be conservative to estimate the annual loss thru prairie dog injury in this State at $80,000.

APPEARANCE AND HISTORY.

The fully grown prairie dog of the plains (*Cynomys ludovicianus*) is a stout-bodied mammal about a foot in total length, with a short, full fur that in summer is a reddish brown above mixed with gray and black on the back and yellowish white below, and in winter is a grizzled buffy mixed with black above and pale buff below. The tail is short and flat, about three and a half inches long, and usually more or less black at the tip. The ears are very small, the cheeks have shallow pouches, or "pockets," the teeth are heavy and of the gnawing type, and the claws are long and well fitted for digging. The animal is really a specialized member of the squirrel family, most closely related to the woodchucks (*Marmota*) and ground squirrels (*Citellus*), and, needless to say, has nothing much in common with the dog.

The plains prairie dog was first scientifically named in 1815[1] from the plains of the upper Missouri, and two years later a special genus was formed for it.[2] Altho the plains prairie dog is the commonest and widest ranging species of the genus it is not the only one. In the higher parts of Colorado, New Mexico, and Arizona occurs the Gunnison prairie dog (*C. gunnisoni*), which is smaller and darker than the plains prairie dog, and which has a white-tipped tail. Farther west, in western Colorado, western Wyoming, and Utah, occurs the white-tailed prairie dog (*C. leucurus*), which has the tail two-thirds white and a black face patch. Four other species, *C. parvidens* from Utah, *C. arizonensis* from Arizona, *C. mexicanus* from northern Mexico, and *C. pyrrotrichus* from Oklahoma, are known. None of these, however, occur in Nebraska.

THE PRAIRIE DOG HOME.

Prairie dogs make their homes in burrows in the ground, the entrances of which are marked with circular mounds of earth from 3 or 4 to as much as 8 or 10 feet across and a foot or more in height, according to the length of the period of occupancy of

[1] Ord, Guthrie's Geography, 2d Amer. ed., ii, pp. 292 and 302 (*Arctomys ludovicianus*).

[2] Rafinesque, Amer. Month. Mag., ii, p. 45 (*Cynomys*).

the burrow (fig. 2). The value of these high mounds seems to be to keep the water out of the burrows during the floods accompanying sudden and heavy rains (for unlike the pocket gopher's mound the entrances of the prairie dog burrows are kept fully open by the animals) and to serve as a vantage point to sit upon and observe the surroundings. These mounds rapidly narrow to the diameter of the burrow proper, which is 4 to 5 inches, thus forming a funnel-shaped crater in the top of each mound.

Fig. 2.—A prairie dog burrow. Haigler, Nebraska.

From time to time, as necessary, soil is scraped from just outside of the mound and the mound itself is repaired or enlarged, the animal pressing the dirt into position with its nose. In doing this the ground around each burrow is kept bare of vegetation, so that in crowded colonies the soil of the whole "town" is bare, smooth, and hard, and often remains free from vegetation for some years after the extermination of a colony. Only by persistent cultivation can such areas be quickly reclaimed.

The burrow proper first usually slopes at a moderate angle for about a foot and a half and then usually goes downward at a very steep angle, sometimes nearly straight down into the ground, for a depth of 12 to 16 feet. At the end of this vertical descent the burrow turns at right angles, continuing horizontally for several feet, and in ascending side extensions or in the end of this horizontal portion the nests of the animals may be found.

A burrow dug out by Mr. W. H. Osgood at Alma, Nebraska, and described by Merriam (5) went down nearly vertically for 14½ feet, turned abruptly and then continued horizontally for 13½ feet, the occupied nest being in an elevated lateral extension of this horizontal portion. The nests do not always thus drop vertically, however, as two dug out by Mr. J. T. Zimmer at Comstock, Nebraska, exemplify. One of these, dug out on November 1, 1913, was a mere winding burrow 5 inches in diameter which dropped 4 feet into the ground in a horizontal distance of 6⅓ feet, the end ascending 10 inches in the terminal 2⅔ feet of its length. This burrow had no pockets of any kind and the nest was in the elevated end. The total length of the burrow, in all of its windings, was 9⅓ feet.

Another burrow, dug out December 3, 1913, was 4 inches in diameter and dropped obliquely 3 feet into the ground in a horizontal distance of 5 feet, then turned sharply to the left and enlarged to a diameter of 8 inches for about a foot when it narrowed again to the usual diameter and continued at the same angle for 11 feet before the terminal rise began. Undoubtedly the depth and form of prairie dog burrows varies greatly with different individuals, and probably also with the local soil conditions. Sometimes, also, a secondary burrow, which is often closed with soil, leads off from near the nest and reaches the surface at some distance from the main entrance mound, and these are usually used by the young prairie dogs until they are nearly grown.

HABITS.

The nest cavity in the burrow is heavily lined with buffalo grass and other fine grasses. Young prairie dogs appear but once a year, being born early in the spring, that is, late in March or early in April, and the normal number is said to be four. However, Mr. L. M. Gates saw an old prairie dog with six quarter grown young at a burrow near Haigler, May 19, 1914, indicating that the litter may sometimes exceed four in number. Other observers have given the maximum number at eight (8, 17). In May the young animals appear above ground and soon look after themselves. By the following spring they are fully grown.

Midsummer is utilized by the paired animals in the energetic digging of new burrows and in the cleaning out and repairing of the old ones. During the fall the animals become fat and quite sleepy. As cold weather approaches, during November, they decline in activity even more, and finally go into a partial hibernation within their burrows, tho they occasionally come out on fine, warm days even during midwinter. During the winter

the animals are usually to be found inhabiting burrows in groups of two to six pairs, probably for the conserving of warmth. With the growth of new vegetation in the spring they separate into single pairs to the burrow and resume their normal activity.

The periods of greatest activity in the prairie dog "town" are in the early morning and again in the evening. However, as a rule we have found very few dogs about before sunrise. During the hot part of the day they mostly stay in their burrows. Always a number of the animals may be seen standing erect on their burrow mounds, as sentinels to warn their feeding brethren of the approach of danger in any form. Whenever these sentinels give several sharp cries and disappear into their burrows with a characteristic flip of the tail, there is a general scurrying of the foraging animals to the protection of the burrows. They are able to live without drinking water, like some other mammals of arid regions, obtaining the necessary moisture for existence from the plants and seeds upon which they feed. The popular idea that the dogs dig to water is disproved by the fact that in some prairie dog towns artesian well borings have been sunk to a depth of hundreds of feet without striking water.

The prairie dog colony does not continually occupy the same limits but shifts more or less from year to year. As the animals do not have a wide foraging range, new burrows are continually extended toward areas of better food conditions in order to relieve the pressure of an increasing congestion of the population. Old burrows, too remote from the food supply, are eventually abandoned except as temporary places of refuge, and often considerable areas of the colony are thus left practically untenanted.

NATURAL ENEMIES.

In spite of the fact that prairie dogs do not wander far from their burrows, even when foraging, they are, naturally, greatly subject to control by natural enemies. And, aside from the favoring influence of increased food supply with the advent of cultivated fields, the chief reason for the recent increasing abundance of prairie dogs has been the removal of these enemies thru the activities of men, either directly or indirectly. In other words, it is the result of a constant and indiscriminating warfare waged by man against all carnivorous mammals and birds of prey.

Of course, some of this warfare is justifiable. The coyote (*Canis nebrascensis*) has too bad a record as a destroyer of live stock and poultry to be spared for the sake of the rather goodly number of prairie dogs that it stalks and destroys. The sharp-

shinned hawk (*Accipiter velox*), the Cooper hawk (*Accipiter cooperi*), and the western horned owl (*Bubo virginianus occidentalis*) have a bad record as destroyers of poultry, game, and song birds, and their destruction is good economic practice, even tho they may destroy a few prairie dogs. Nor would anyone advise the conservation of rattlesnakes (*Crotalus confluentus*), in spite of the fact that the chief food of these reptiles is young prairie dogs. But aside from these, all of the natural enemies of prairie dogs do so much more good than harm that they should be spared or protected, except possibly occasional individuals which have acquired bad habits.

Among the carnivorous mammals, both the long-tailed weasel (*Mustela longicauda*) and the black-footed ferret (*Mustela nigripes*) follow the prairie dogs relentlessly thru the most tortuous of their burrows until they catch and kill them. The badger (*Taxidea taxus*) feeds mostly on prairie dogs which it corners in their burrows and laboriously digs out and destroys. The northern plains skunk (*Mephitis hudsonica*), the long-tailed skunk (*Mephitis mesomelas varians*), and the prairie spotted skunk (*Spilogale interrupta*) are all highly important enemies of prairie dogs. All of these animals should be fully protected about prairie dog "towns."

Among the birds of prey, the ferruginous rough-legged hawk (*Archibuteo ferrugineus*) is found commonly about prairie dog "towns" and its food is largely, sometimes wholly, composed of these animals. The prairie falcon (*Falco mexicanus*), tho less common, is individually scarcely less valuable. The little burrowing owls (*Speotyto cunicularia hypogaea*) live in deserted prairie dog burrows and devour large numbers of the young dogs. The Krider and western red-tailed hawks (*Buteo borealis krideri* and *B. b. calurus*), the Swainson hawk (*Buteo swainsoni*), the marsh hawk (*Circus hudsonius*), and the short-eared owl (*Asio accipitrinus*) are all valuable destroyers of prairie dogs and should be protected instead of killed at every possible opportunity. The bull snakes about prairie dog towns, also, should never be killed, as they devour many of the young animals.

GENERAL CONTROL.

Considering, then, the generally obnoxious character of prairie dogs, when present in large and flourishing colonies and seriously injuring pastures and cultivated fields, it becomes an important and practical question as to how such aggressive colonies can be exterminated. Individual effort, tho helpful if sufficiently extensive, will not bring permanent relief if the rodents can restock

the colony by migrating in from other colonies in the vicinity. The organization of a general community warfare for a season or two is highly desirable, and will accomplish much more than many years of desultory and independent fighting. It is, in fact, essential for thoroly satisfactory results.

Two lines of attack on the prairie dog have suggested themselves as wholly feasible, and each has been rather fully investigated. These are, (a) the use of poisoned baits and (b) fumigating the burrows with asphyxiating gases.

USE OF POISONED BAITS.

In general, poisoned baits used against prairie dogs are one of two kinds: Freshly cut alfalfa or alfalfa hay poisoned and placed about the burrows, or else grain treated with some poisonous mixture. Tests of various deadly poisons by experimenters in the past have shown the general superiority, in safety of use, efficiency, stability, and economy, of strychnine (sulfate or alkaloid) as the poisonous element, and this was the only poison used in our experimental work. Powdered strychnine (not crystals) should always be used. Of course, in the preparation and handling of any strychnine-poisoned bait great care should be taken, since with the least carelessness serious results might come. However, most farmers and ranchmen fully realize the necessity of careful handling of strychnine and will take the necessary precautions. After preparing a batch of poisoned bait the utensils should be very thoroly cleaned. No residues of poisoned baits should be kept about the premises unless carefully guarded, labeled, and kept away from children. If, in spite of their small cost, it is preferred not to use poisoned baits, the carbon bisulfid treatment can always be resorted to.

The poisoned alfalfa bait is theoretically preferable to poisoned grain baits because it would not be attractive to small birds. Usually it is made by chopping about thirty pounds of the green plants into short lengths, and sprinkling until thoroly wet with a strychnine water prepared by dissolving an ounce of strychnia sulfate in a half gallon of boiling water, using a metal tub as a mixing vessel. If alfalfa hay is used, about 20 pounds of hay is required with the ounce of strychnine, which is dissolved in 3 or 4 gallons of water, the whole being thoroly mixed in the metal tub (15, 18).

In our experiments the use of alfalfa hay was wholly unsatisfactory. As an instance, 16 pounds of alfalfa hay was sprinkled with 5 gallons of water in which an ounce of strychnia sulfate had been dissolved, and this poisoned hay placed at prairie dog burrows at Comstock, Nebraska, November 19, 1912. When

these burrows were examined on November 21, there was no indication that the bait had been touched by the animals, and none had been killed, altho elsewhere poisoned grain was being readily taken at the same time and the animals were succumbing to it. Green alfalfa is procurable only at such seasons as green food is abundant and the dogs are difficult to poison with any bait whatever. Moreover, our observations showed that when poisoned grain is carefully applied the mortality to small birds is very slight. Consequently our efforts were directed mainly along the line of determining the best poisoned grain formula.

By using grain as a bait we have a food which the prairie dogs will take readily at any time that green food is not available. During the summer months when these animals feed almost wholly upon green food they are very difficult to poison, but after the grasses and roots have become dried and frozen they will take poisoned grain with alacrity. Therefore, for the beginning of poisoning operations late fall or early winter is the most propitious time, beginning usually in October or early November. The whole colony should be thoroly gone over at that time and usually a large percentage of the prairie dogs will be destroyed. The mere carrying of poisoned grain in the cheek pouches will kill the animals, even if they do not swallow any of it. A week or 10 days later a second application should be made to occupied burrows, and usually about one-half of the remaining animals will succumb to this treatment.

The operations had then best be suspended until the very early spring, when, if necessary, a third application should be made to occupied burrows. These two or three applications will destroy 75 to 90 per cent or more of the animals in the colony. The remaining animals can then be most thoroly and economically destroyed by fumigation. In mixing the grain and poison, the use of a galvanized fire shovel with five large holes drilled in it has been recommended (23). In distributing the poisoned grain the usual practice is to carry it in a sack and cover a strip 75 or 100 feet wide. A tablespoonful is usually placed about 18 inches from the mouth of each occupied burrow, and this was the amount used in our experiments, altho some use only one-half or even one-quarter of that amount (17). Of course, during the period that poisoned grain is about the burrows it is safest if live stock is excluded from that part of the range, altho it has been repeatedly used in pastures on which stock continued to graze without any fatalities. The grain can be dropped inside the burrow in the interests of perfect safety, but so much of it is lost by that method that the results are not nearly so satisfactory.

One cannot judge of the success of a poison application by the number of dead animals found within the colony, because the great majority of them die within their burrows and most of these that do die outside are carried away by coyotes within a few hours. Consequently one should not be discouraged because of a fewness of dead dogs to be found. Usually a little approximate census over portions of the colony a few days after the putting out of the poison as contrasted with a similar census taken before the application will reveal the true value of the treatment.

Peters and Avery (10) give the number of burrows per acre in a Nebraska prairie dog colony at 25 to 125, while Merriam (5) gives the number at Alma, Nebraska, as from 35 to 64. The average number over the whole of the large range pasture at Comstock, where our experiments were carried on, was a little over 30 to the acre, but in the more populous portion of the "town" it was 65 to 75 to the acre. Lantz (4, 6) states that in using poisoned grain at the rate of one tablespoonful to the burrow, a bushel will poison 1,000 to 1,200 burrows. This would be enough to cover 30 to 40 acres, on the average, if every burrow is treated, but as it is only necessary that the occupied burrows be treated that amount should cover 100 acres or more (100-160 acres according to Lantz). According to our experiments it requires a couple of hours to prepare the poisoned grain and a little over 20 hours of work for a man to carefully distribute a bushel of it to burrows determined as probably occupied. Valuing wheat at 85 cents a bushel, strychnine at 80 cents an ounce, and labor at $2 a day, we find that it costs slightly over three-fourths of a cent to treat a burrow, and to treat every burrow in a "town" would cost from 19 to 25 cents an acre. But, as only the occupied burrows need be treated, even at the first application, the cost of an application is reduced to only 5 to 8 cents an acre. In other words, with a bushel or two of poisoned grain a couple of men can properly treat any ordinary prairie dog "town" in a day or two, at a cost for labor and materials of less than 10 cents an acre.

In order to determine the best manner to prepare the poisoned grain so as to obtain the maximum results in economy and efficiency, it was decided to test in competition with each other under similar conditions the efficiency of several currently recommended formulae for poisoning prairie dogs. Both fall poisoning and spring poisoning were included in these experiments, and ten of the formulae in most current use or most recommended were tested. In this way it is hoped that our ranchmen will be enabled to adopt the best methods of prairie dog eradication by poisons

from the start, rather than to use formulae of inferior efficiency.

Arrangements were made by the writer with Mr. J. J. Westcott of the firm of Westcott and Gibbons of Comstock, Custer County, to conduct the planned series of experiments on the ranch of Mr. Gibbons near Comstock, where there was a small, somewhat isolated colony suitable for the experiments and a large "town" containing thousands of dogs in the main range pasture. Mr. J. T. Zimmer was entrusted with the task of carrying out the experiments, and spent the period from October 22, 1912, to December 12, 1912, at this ranch, making the experiments in fall poisoning, while the spring poisoning was done by him between February 12, 1913, and April 15, 1913, each period thus covering about two months of work.

COMPETITIVE EXPERIMENTS IN FALL POISONING.

As a preliminary experiment, unpoisoned grain was placed near a number of dog burrows October 25, and later in the day this was found to be all gone wherever dogs had been seen to enter the holes. The grain remained untouched near holes where no dog had been seen to enter. This indicated that the animals would probably take poisoned bait readily when it was placed near occupied burrows.

The plan of operation was to test each of the ten formulae by placing some of the poisoned grain at each of 100 apparently occupied burrows, and subsequently noting and comparing the results. The original criterion for determining occupied burrows was to watch for the dogs to appear and then to mark such burrows with a stake. On October 26 and 27 about fifty such occupied burrows were noted and marked. This method, however, was found to consume too much time if rigidly adhered to, for every time a stake was so driven to mark an occupied burrow all of the animals for some distance around were frightened into their burrows, and would not venture forth again until some time had elapsed. Furthermore, some of the dogs are so wary that they will rarely appear above ground at all when a person is in sight, and this would inevitably lead to many unmarked and therefore unpoisoned, tho certainly occupied, burrows among the marked ones, while the marked burrows made according to this criterion proved to be scattered too much to fairly represent a unit group. Accordingly, the original criterion was modified so that all burrows which on examination showed signs of recent occupancy were staked along with those at which the animals were actually seen, so as to form 100 apparently occupied burrows in a compact group.

The plan further contemplated the placing of the poison on a favorable day, and a week was to be given the animals to take it. During this week the number of dogs found dead in the poisoned area would be noted, altho as most of them would die in their burrows these data could have no final value in determining the actual efficiency of the poison. At the end of the week all of the 100 apparently occupied and treated holes would be plugged with soil and then watched to ascertain how many were dug out from within, care being taken not to count burrows which had been dug open from without by other dogs, as at this time the animals were moving about thru the "town" considerably, tho not enough to seriously vitiate the value of the experiments. In cases of doubt a burrow was to be replugged. The compact nature of the 100 marked burrows would tend to minimize the disturbing factor of extraneous opening of the burrows.

Formula 1.—This formula was recommended by A. T. Peters of this Station in 1900 (1). It is prepared as follows:

Dissolve completely 3 ounces of strychnia sulfate and one-half pound of potassium cyanide in 1 quart of boiling water. Add 2 quarts of molasses and 1 teaspoonful of oil of anise, and stir until thoroly mixed. Pour this mixture over a bushel of wheat in a tight receptacle, stirring well, and at the same time sprinkling in 4 pounds of finely ground corn meal. The molasses is to render the liquid adhesive so that it will cling to the grains of wheat, while the corn meal absorbs the superfluous liquid and thus enables the grains of wheat to carry more of the poison. For the best results use this poisoned grain while fresh, placing it about every burrow, or, if there are grazing animals in the "town," in the entrance of the burrow.

The 100 apparently occupied burrows were staked November 2. November 6 promised to be a fine day so the formula was made up and the poisoned grain placed. On November 7 live dogs were seen, but they were perhaps not so abundant as before. November 8 the poison was seen to be disappearing gradually, and, altho only a few live dogs were seen, no dead ones were found out of the burrows. November 9 one dead dog was found and only a few live ones seen. November 13, one week after placing the poison, all of the 100 burrows were plugged, but live dogs were seen in three of these burrows at the time of plugging. No more dead dogs were found. November 16 two more of the plugged burrows were opened from within and on November 18 five additional burrows were open. On December 6 ten of the 100 treated burrows were shown to be occupied, making the total effectiveness of the treatment presumably 90 per cent.

Formula 2.—In 1902 D. E. Lantz modified the Peters formula as follows (4):

Dissolve 1½ ounces of strychnia sulfate in 1 quart of hot water. Add a quart of syrup—sorghum, molasses, or thick sugar and water—and a teaspoonful of oil of anise. Thoroly heat and mix the liquid. While hot pour it over a bushel of clean wheat and mix completely. Then stir in 2 or more pounds of fine corn meal, the quantity needed depending upon the amount of extra moisture present. There should be enough to wet every grain of the wheat and no more. Let the poisoned grain stand over night and on the morning of a bright day distribute to each occupied burrow, putting it near the mouth of the burrow.

One hundred apparently occupied burrows were staked November 5. The above formula was made up on the evening of November 6 and the poisoned grain placed the following morning. On November 13 one dead dog was found. November 14, one week after the poison had been placed, all the 100 burrows were plugged. On November 16 three of these holes were opened from within, and no more were subsequently opened from within. The check on December 6 showed the probable effectiveness of the treatment to be 97 per cent.

Formula 3.—At the same time Lantz (4) further modified the Peters formula, not only reducing the strychnine and syrup but substituting coffee berries and white of egg for oil of anise, as follows:

Dissolve 1½ ounces of strychnia sulfate in 1 quart of hot water. Add a quart of syrup—molasses, sorghum, or thick sugar and water. Previously soak 2 ounces of green coffee berries in the whites of 3 eggs and let this stand for 12 hours. Add the liquid of this to the poisoned syrup, thoroly heat and mix. While hot pour it over a bushel of clean wheat and mix completely. Then stir in 2 or more pounds of corn meal, according to the amount of superfluous moisture present. Use as formula 2.

The 100 holes were marked November 18. The formula was made up on the evening of November 19, and the poisoned grain distributed November 21. On November 25 the poisoned grain had scarcely been disturbed and there were numerous live dogs. At the end of the week following the distribution of the poison (November 29) the burrows were plugged. November 30 two of the plugged holes had been opened from within. A doubtfully opened hole was replugged and was again opened, from within, December 4. The efficiency December 6 was apparently the same as that of formula 2 (97 per cent), three burrows showing occupancy.

Formula 4.—C. H. Merriam in an important article on the prairie dog published in 1902 (5) recommended the following formula, which also omits the oil of anise, but without a substitute:

Dissolve 1½ ounces of strychnia sulfate in warm water. Soak 1 bushel of wheat in this for 24 to 36 hours, until all is absorbed. Stir in a quart of molasses and sprinkle with enough corn meal to prevent sticking.

November 18 the 100 burrows were marked and that evening the above formula was made up. The grain was placed on the morning of November 19. Six days later (November 25) the poison had hardly been touched and there were numerous live dogs, so the plugging was delayed until November 29, 10 days after placing the poison. One hole was opened from within November 30, and later three others, apparently opened from within, were found. These were replugged and not subsequently reopened. On December 6 the presumed efficiency of this treatment was 96 per cent.

Formula 5.—Along with the preceding formula Merriam (5) suggested the following one, which does not allow for soaking the wheat and which was presented in the following definite form by J. E. Payne (8) in 1903:

Dissolve two ounces of strychnia sulfate in warm water. Add one quart of molasses and thoroly mix this with one bushel of wheat. After all of the liquid is absorbed add enough corn meal to prevent the grains sticking together.

The 100 burrows were marked October 27, but on October 29 the weather turned cold and the dogs remained in their burrows so that the poisoned grain was not put out until November 4. On November 5 one dead dog was found, but the poison did not seem to have been taken at many of the burrows, and live dogs were seen in numerous burrows. November 6 was a clear fine day with the dogs active, and one sick dog was just able to crawl into its burrow before it could be reached. On November 7 live dogs, tho yet present, were not so numerous as previously, and one nearly dead dog was found. Only a few dogs were seen November 9. On November 11, one week after the poison had been placed, the 100 burrows were plugged. November 12 five were opened from within, and several others were partly or wholly opened, apparently from without, so were replugged. November 13 a replugged burrow was found reopened, and a very sick dog found. On November 14 three live dogs were seen digging at plugged burrows from the outside, but they ran to unstaked burrows when disturbed; also a dead animal was found near one of these unmarked burrows. November 15 another

replugged burrow was reopened, and on November 18 another dead dog was found at an unmarked burrow. The record on December 6 showed seven burrows occupied, giving an efficiency of 93 per cent for this treatment.

Formula 6.—In 1908 Merriam (14) revised his formula of six years previously to the following one, chiefly by omitting the molasses and corn meal and simmering the poisoned solution and grain together:

Dissolve 1½ ounces of strychnia sulfate in 2½ gallons of water by heating in a covered receptacle. After the poison is thoroly dissolved add 1 bushel of grain (wheat), and allow the mixture to simmer in a closed vessel, stirring occasionally, until the moisture is taken up by the grain; or, the mixture may be allowed to stand over night to absorb the free moisture.

For this formula 100 apparently occupied holes were marked with stakes November 2. On November 6 the above formula was prepared and the poisoned grain distributed. Live dogs were present November 7, tho perhaps not so numerously as before. November 8 the poison was noted to be gradually disappearing and only a few live dogs were seen. November 9 a few live dogs were seen. The first dead dog was found November 13 and live dogs were seen in one burrow. At the end of the customary week, November 13, all the burrows were plugged. November 14 one burrow was opened from within; November 16 two more burrows had been opened; November 18 three more burrows had been opened, making in all seven burrows occupied at the checking on December 6 which gave an apparent efficiency of 93 per cent.

Formula 7.—In 1909 Lantz (15) proposed the following formula, which is about the same as formula 5, only there is less strychnine, and sugar syrup is used instead of molasses:

Dissolve 1½ ounces of strychnia sulfate in a quart of boiling water and add a quart or more of thick sugar syrup. Pour this mixture over a bushel of wheat in a clean metal vessel and stir until all of the wheat is wet. Stir in corn meal to take up any surplus moisture, if the poison is to be used immediately (or add more water and leave the wheat to absorb the strychnine over night if not to be used immediately).

The 100 burrows were staked October 28, but cold weather came and they were not treated until November 4. In the morning of November 5 one dead dog was found and later in the day one very sick dog was seen. Many burrows had the poison apparently untouched, however, and there were numerous living, if not healthy, dogs in the marked area. On November 6 two dogs died outside of their burrows. November 7 live dogs were

still present but not so numerous. November 8 the poisoned grain was disappearing, and, altho there were no dead dogs found, the living ones were few. November 9 only a few dogs were seen. At the end of the week (November 11) the burrows were all plugged. November 12 three were opened from within and were replugged. November 16 these three replugged holes were found reopened from within. The apparent efficiency of the treatment, as checked December 6, was 97 per cent.

Formula 8.—In 1901 the Kansas Agricultural Experiment Station purchased for use in that State from Mr. D. W. Staples, then of Quanah, Texas, a patented formula claimed to be effective at any season, and which seems to have given the best results in Kansas. The patent to this formula expired July 28, 1908. It is given by Scheffer in 1909 (16) as follows:

Mix 1 ounce of green coffee berries with the white of 1 egg and allow to stand at least 14 hours. Dissolve 1 ounce of powdered strychnia sulfate in one-half pint of boiling water. Dissolve 1 ounce of potassium cyanide in a quarter of a pint of hot water and allow it to cool. Add a little warm water to the mixture of coffee and eggs and mix it with the potassium cyanide. Then strain this mixture thru a coarse sieve into the mixing vessel and add one pint of syrup. Mix 1½ ounces of alcohol with the hot solution of strychnine and add it to the other mixture. Stir all thoroly, and use 2 quarts to each bushel of wheat, pouring it over the grain and stirring until every grain is wet with the poison. Stir in 2 or 3 pounds of fine corn meal to take up the extra moisture. Allow to stand over night and place some at the outside of each burrow.

One hundred burrows were staked November 18. The above formula was made up in the evening of November 19 and the poisoned grain distributed November 21. On November 25 the poisoned grain had hardly been touched and there were numerous live dogs. The burrows were plugged after eight days (November 29). November 30 no holes were opened. Later a hole was opened, replugged, and reopened from within December 4. The presumed efficiency December 6 was 99 per cent.

Formula 9.—The following formula, perfected by the Bureau of Biological Survey in 1910 for use against ground squirrels (*Citellus* spp.)[1] is recommended also by R. E. Clark in 1912 (17) as very effective against the prairie dog:

Dissolve one-half teacupful of ordinary laundry or gloss starch in a little cold water and add a pint and a half of boiling water, making a rather thick solution. While hot, stir in 1 ounce

[1] Merriam, Circular 76, Bureau of Biological Survey, p. 10.

of ground or powdered strychnia sulfate and mix until free from lumps. Add 1 teaspoonful of saccharine and beat thoroly. Pour the poisoned starch over 20 quarts of clean grain (barley or wheat) in a galvanized iron washtub and stir rapidly until the poison is evenly distributed. Then allow the grain to dry and it will keep indefinitely without deterioration.

One hundred burrows were marked November 13. The above formula was prepared in the evening of November 13 and the poisoned grain put out the following day. The burrows were plugged a week later, November 21. Several were opened. No dead dogs were found. Apparent efficiency on December 6, 94 per cent.

Formula 10.—Mr. S. A. Johnson in 1912 (19) recommended the following as having given the best results in Colorado (Colorado formula 6):

Dissolve 1 ounce of powdered strychnine alkaloid (for which we substituted strychnia sulfate), one-half teacup of starch and 1 teaspoonful of saccharine in 1 quart of boiling water. Pour it over 12 quarts of grain (barley, wheat, or oats) which is held in a tight vessel, as a galvanized iron tub (which should subsequently be scrubbed clean). Stir the mixture very thoroly until every grain receives a thoro coating, then spread the grain out to dry. It will keep indefinitely. Sprinkle on the mounds of the occupied burrows.

The burrows were selected and staked November 18, and in that evening the above formula was prepared, except that strychnia sulfate was substituted for the strychnine alkaloid, because of its greater solubility in water and less cost. Early the next morning the poisoned grain was distributed, and a week later (November 26) the burrows were all plugged. One burrow was seen to be occupied when plugged. November 27 an opened burrow seemed to have been opened from the outside but was replugged. November 29 no new burrows were opened. Three burrows opened from the outside were later replugged. On December 4 one dead dog was found. On December 6 no new plugged or replugged burrows were open, showing an apparent efficiency of 99 per cent.

Summarizing, the apparent efficiency of the 10 poisons, made according to the original formulae, was as follows:

FORMULA	PER CENT	FORMULA	PER CENT
1	90	6	93
2	97	7	97
3	97	8	99
4	96	9	94
5	93	10	99

But this is presuming that each of the 100 selected burrows was actually occupied, for as we have seen, burrows were selected which *seemed* to be occupied, as well as those which the dogs were actually seen to enter. In order to check this source of error, and reduce the above relative efficiency percentages to their approximate actual percentages, 100 burrows were selected in the same way as the other 10 sets of 100 burrows and marked December 9. On December 12 they were all plugged. At the same time 34 additional burrows at which dogs were *seen* to enter were plugged. On the next morning 4 of these 34 burrows were open and on December 16, 31 of them were open, while the next day (December 17) all were open. It is thus obvious that an occupied plugged burrow will be opened within a week. On December 16, 37 of the hundred burrows plugged December 12 were open. This proportion is without doubt small, as in formula 5 at least one-half of the burrows were *known* to be occupied since they were marked where the animals were seen to enter. But assuming that only 37 per cent of the selected burrows were occupied, we yet have a probable actual efficiency as follows, the relative efficiency remaining the same:

FORMULA	PER CENT	FORMULA	PER CENT
1	73	6	81
2	92	7	92
3	92	8	97
4	89	9	84
5	81	10	97

Obviously, formulae 8 and 10, which have given the best results in Kansas and Colorado, respectively, are the most efficient poisons in these experiments. Of the two, formula 10 is the more easily and quickly prepared, and the conclusion is reached that it is the most generally satisfactory formula to use.

The Colorado investigators have recently (20-23) proposed a new formula (Colorado formula 15) as a substitute for foregoing formula 10 (Colorado formula 6) which they state is more readily taken by the animals. It is prepared by dissolving 1 ounce of powdered strychnine alkaloid and 1 teaspoonful of saccharine in 1½ or 2 pints of water, adding three-fourths of a pint of flour and one-half pint of fine salt, mixing the whole thoroly with a Dover eggbeater, putting the mixture over a fire in a granite stewpan and bringing it to the boiling point, or heating until the flour begins to thicken, stirring constantly. Pour the poisoned mixture over 12 quarts of wheat or barley and thoroly mix, then spread and dry the grain. We have not tried this formula, but

it can hardly be more economical or effective than formula 10 above described, and seems to be somewhat more troublesome to prepare.

COMPETITIVE EXPERIMENTS IN SPRING POISONING.

In the spring poisoning it was decided to test still further five of the formulae used the preceding fall, including the two which had given the best results: viz, formulae 2, 6, 8, 10, and a modification of 10 to be designated as 10a. In these experiments, with fewer burrows to mark by stakes, the original criterion for determining occupied burrows was to be rigidly adhered to in spite of the difficulties encountered, and only those burrows into which the dogs were actually seen to enter were to be marked and treated.

The earlier work in the spring was much interrupted by inclement weather. From the date of the return to Comstock, February 12, 1913, until February 17, the weather was so unfavorable for the purposes of the experiments that the work was confined to making observations and to selecting favorable sections of the valleys for the work to be done later. February 17, however, was a fine bright day with nearly every dog out, and 375 burrows were noted as occupied, and properly marked. A period of cold, snowy weather from February 18 to March 3 kept the animals in their burrows, and until the 8th only a few ventured out, these mostly on March 4 and 7. March 8 and 9 were very fine days and formulae 2 and 6 were then placed. March 10 was unfavorable and caused a day's delay, the 11th was cloudy and windy but warm, while from the 12th to 16th was a period of storms and blizzards. March 18 opened unfavorably but grew pleasant later in the day, about as on February 17, but this day was succeeded by cold, cloudy, and stormy weather from the 19th to the 26th, again interrupting the work, as only a very few dogs were observed during this period. On March 27 the stormy weather began to abate and the experiments were not again seriously interrupted, except on March 30, April 3 and 8 to 11, which were days too stormy for successful work.

Formula 2.—On February 17, which was a fine, bright day with almost every dog out and active, 100 burrows, known to be occupied by the actual observation of the animals entering them, were marked. February 18 to March 7 was a period of almost continuously cold, stormy weather with much snow, so that prairie dogs appeared above ground only at intervals (e. g. March 4) and then only a short time and in very small numbers. As a result the treating of these burrows was postponed until March 9, when the finest weather of the spring up to that time

was experienced. The poisoned grain was prepared in the evening of March 8 and distributed the following day to the 100 burrows selected February 17. On March 10 two dead dogs were found and about 25 live ones were seen, but the poisoned grain had disappeared from only a few of the burrows, being apparently untouched at most of them. March 12-16 was stormy, with the dogs keeping in their burrows, but on March 18 the day turned pleasant and the dogs came out, 30 being noted at the marked burrows.

On the morning of March 31 a second application was made using oats as the grain instead of wheat. On April 12, a clear, fine day, suitable for making a final check count, as almost every dog was out, it was found that there were still 25 live dogs in the 100 burrows.

Formula 6.—On February 17, at the same time that the 100 occupied burrows were selected for formula 2, 75 occupied burrows were selected in the same way for another test of formula 6. March 8 was the first bright day suitable for distributing poisoned grain, so early on that day this formula was prepared and the grain was put out at the 75 burrows, the dogs beginning to appear just as the distribution was finished. On March 10 3 dead dogs were found and 30 live ones noted; much of the poison had not been taken, altho in a few cases it was all gone. On March 18, following 5 or 6 days of stormy weather, the dogs reappeared above ground and 35 were noted at the marked burrows.

On the early morning of March 29 a second application was made using oats as the grain instead of wheat. On April 12, a bright day with the dogs out in force, a careful check showed that there were still 26 live dogs in the 75 burrows.

Formula 8.—Also on February 17, 100 burrows known to be occupied were selected and marked for a further test of this formula. On the evening of March 9 the formula was made up with the expectation of placing it the next day, but unfavorable weather postponed its placing until March 11, when the dogs came out abundantly in the afternoon, altho the day was cloudy and windy. The following day and the next five days were stormy, but on the 18th the dogs came out, and a check showed 36 live dogs in the marked burrows.

On the morning of April 1 a second application was made using oats as the grain instead of wheat. The final check count on April 12 showed 26 live dogs in the marked burrows.

Formula 10.—At 100 burrows marked as occupied on February 17, grain poisoned according to the Colorado formula 6 with the same modification as was used the preceding fall, i. e., the sub-

stitution of strychnia sulfate for strychnine alkaloid, was placed on the morning of March 28. On April 1 in the middle of the day a check of those burrows showed 23 live dogs.

On the morning of April 2 a second application was made, using oats as the grain instead of wheat. When a final check was made on April 12, 23 live dogs were again found in the 100 burrows.

Formula 10a.—On March 18, 100 burrows into which dogs were seen to go were marked as occupied. On March 28 these were treated with grain poisoned according to the original Colorado formula 6, using strychnine alkaloid instead of strychnia sulfate. On April 1 in the middle of the day a check of these burrows showed 24 live dogs.

On the early morning of April 4, which was a clear, warm day, a second application was made using oats as the grain instead of wheat. The final checking on April 12 showed 24 live dogs, the same as on April 1.

Summarizing, the efficiency of the five poisons used in the spring poisoning experiments was as follows:

TABLE 1.—*Efficiency of five poisons used in the spring poisoning experiments.*

Formula	Original number of dogs in burrows	Number of dogs after 1st application (with wheat)	Number of dogs after 2d application (with oats)	Efficiency of 1st application	Efficiency of 2d application
				Per cent	*Per cent*
2	100	30	25	70	17—
6	75	35	26	53+	26—
8	100	36	26	64	28—
10	100	23	23	77	0
10a	100	24	24	76	0

It will thus be seen that the first application (with wheat) was quite satisfactorily effective, the formulae ranking in effectiveness as 10, 10a, 2, 8, and 6, the same as in the fall experiments except that 10a was not used in the fall and that 8 and 2 exchanged places in rank. There is apparently little difference in effectiveness whether strychnia sulfate (10) or strychnine alkaloid (10a) is used in formula 10, tho in the above experiment the former seems to give slightly better results. The keeping qualities and ease in handling of grain poisoned by this formula were excellent.

More dogs were destroyed with the first application of this poison than with both applications of any of the others. The second application was largely a failure, partly due to the lateness of the season when it was put out (March 29 to April 4), as a rather large amount of green food was available and being utilized by the dogs, and partly because of the fact that oats is a poor grain to use in poisoning prairie dogs. The lowered general percentages of efficiency would indicate the superiority of fall poisoning over spring poisoning, as the weather is more regular and dependable, and the dogs are more active and more eager to eat the poisoned grain.

One reason for the unsatisfactory showing of oats as compared to wheat is that the animals are likely to shell off the outer coat of the grain, thus discarding most or all of the poison, so that the grain can be eaten without poisoning them. The shelled hulls of the oats could be found commonly about the burrows. Moreover the lightness of the oats grains caused them to blow about more readily than wheat, both when being put out and later. Altogether wheat was seen to be a much more suitable grain for poisoning with strychnine than the available oats, and probably a more economical one to use in spite of the difference in cost. However, the Biological Survey used oats poisoned according to formula 9 in the National Forests of Colorado and New Mexico with success. Naked barley may probably be used with satisfactory results wherever available.

DEMONSTRATION POISONING EXPERIMENTS.

When the comparative superiority of formula 10 was ascertained by the checking of the results of the competitive fall tests of the 10 formulae just outlined, on December 6, it was decided to test this formula further, on a larger scale and under the most unfavorable conditions. Accordingly, on December 7, 18 quarts of poisoned wheat was prepared according to formula 10 (requiring 1½ hours to prepare), was well dried the next day, and on December 10 part of it was placed in a heavily infested alfalfa field where fresh food (alfalfa roots) was available. It required two men an hour to place grain enough to treat this field. On December 11 the poisoned grain was apparently yet untouched, and all subsequent checks, beginning December 12 and continuing to December 17, failed to show any dead dogs in this alfalfa field, or any indication that their number had been seriously reduced.

On December 13 and 14 the remainder of the eighteen quarts was distributed about burrows on the range pasture where fresh

food was scarce. It required two men four hours to place this grain. The area covered was about eighty acres and contained about 2,500 burrows. By actual count the concentrated part of this "town" contained from 130 to 150 burrows in an area 100 yards square containing 10,000 square yards. On December 14 2 dead dogs were found; on December 15, 15 dead dogs were found and the animals were obviously much less abundant than previously in the treated area; December 17, 3 more dead dogs were found and only 7 live dogs were noted in the field, while only 4 burrows showed signs of occupancy; December 18, 3 more dead dogs were found; and on December 20 a very sick dog was seen. Altogether the mortality following this latter application was exceedingly heavy, in striking contrast to the failure of the contemporaneous application in the alfalfa field. Clearly, this demonstrated the futility of trying to destroy prairie dogs with poisoned grain when the animals can get an adequate supply of fresh food. But on range pastures during the late fall, winter, and early spring poisoned grain is a very effective treatment.

As a further test in the spring the big range pasture was completely gone over and all of the burrows were treated with formula 10 March 28 and April 14. In doing this work 83 quarts of wheat and 24 quarts of oats were used, and it required 47½ hours of time to distribute these 107 quarts of poisoned grain. The exact time and material used was as follows:

TABLE 2.—*Time required and material used in an extensive application of formula 10.*

Date	Time	No. of men	Total hrs.	Grain used	Quantity of grain	
					Wheat	Oats
	P. M.				*Quarts*	*Quarts*
March 28	3-5	5	10.0	Oats	..	20
March 29	3-5	4	8.0	Oats and Wheat	12	4
March 31	3-4:30	3	4.5	Wheat	15	..
April 1	3-5	5	12.0	Wheat	24	..
April 5	3-4	5	5.0	Wheat	12	..
April 14	3-5	4	8.0	Wheat	20	..

From April 8 to 11, after most of the range pasture had been treated, a close survey of the area showed that the number of dogs had materially decreased, altho the small number seen might in part be accounted for by the fact that the period was a stormy one, which would tend to keep the animals in their burrows.

The application on April 14 included the infested alfalfa field unsuccessfully poisoned the preceding fall. On April 15, when the final check was made, it was estimated that 75 to 80 per cent of the prairie dogs on the range had succumbed to this extensive application of formula 10.

Other demonstration tests were made with other formulae both in the fall and spring. An application of formula 3 at unstaked burrows on November 21 showed dead animals on November 26 and an application of formula 4 at unstaked burrows on November 21 showed six dead dogs and a very sick one on November 22, and two more dead dogs November 21, but neither of these showed results as satisfactory as those following the use of formula 10.

EFFECT OF POISONING ON OTHER ANIMALS.

One point of especial observation was the result of the application of poisoned grain about the prairie dog burrows on the bird and mammal life of the region. Our observations, as well as those of others (17, 23), indicate that very few birds are killed by the exposure of this poisoned grain. In the fall experiments three Desert Horned Larks (*Otocoris alpestris leucolaema*) were found dead because of having eaten poisoned grain, one on November 16, 22, and 25, respectively. A dead white-footed mouse (*Peromyscus maniculatus osgoodi*) was found December 14 and another the following day. Coyotes carried away most of the dogs which died above ground; of the 15 dead dogs seen in the pasture December 15 following the application of formula 10 all had been carried away by December 17.

FUMIGATION OF BURROWS.

Several gases have been tried out as a means of destroying prairie dogs by asphyxiating them in their burrows, but carbon bisulfid has apparently given the most uniformly successful results. The use of Pintsch oil was first recommended as the result of experiments made by the Nebraska Station (10) and the success of this method, if the oil is of good quality and used under wet soil conditions, has been corroborated by Colorado experimenters (22). If purchased in barrel lots (50 gallons) this oil is considerably less expensive than carbon bisulfid, even tho twice as much of it as of carbon bisulfid should be used; but when purchased in ordinary lots (at 35 cents a gallon) the saving is not great. It seems to be true, however, that the Pintsch oil does not run even, and that while one lot may be used with success another lot may prove a failure, so that carbon

bisulfid is probably more economical because of its dependability and in spite of its somewhat greater cost. Pintsch oil is used just as described below for carbon bisulfid. The use of sulfur fumes is said to be effective and the cost of sulfur is low, but it requires a machine to force these fumes into the burrow, and, considering the cost of such a machine ($30), the tendency for it to wear out quickly, and the slowness and labor of its use, probably nothing is to be gained with sulfur fumes over the use of carbon bisulfid (6).

Carbon bisulfid (CS_2) is a colorless liquid which evaporates very quickly, forming a vapor heavier than air and which therefore naturally sinks to the bottom of a prairie dog burrow. This vapor has a very disagreeable odor, but unless breathed in considerable quantities has no injurious effects. It can be handled out-of-doors by carrying it in a spouted kerosene or oil can, and no special precautions need be taken except that no fire may be brought near the liquid or vapor as it is highly inflammable and somewhat explosive. For this reason it must not be handled by a man who is smoking, nor opened near a fire of any sort. It is usually used by pouring about an ounce on some porous material, such as dried horse droppings, dropping this into the burrow and then plugging the opening of the burrow with soil. It should be kept in perfectly tight cans which should always be corked when not in actual use.

The chief objection to carbon bisulfid as a destroyer of prairie dogs has not been a lack of effectiveness on its part, but that the expense of the material is high, two or three times that of a poisoned grain application, and the labor of applying it considerable. This high cost of an application (20 to 60 cents an acre) practically bars its extended use as a primary method, that is, as a destroying agent in the first "going over" of a colony. But after the prairie dogs have been greatly reduced in number by the use of poisoned grain and only the wary old dogs which steadfastly refuse to take poisoned food remain, this small but important residue of the colony can be destroyed with celerity by the carbon bisulfid treatment, and on this reduced scale its use is neither prohibitively expensive nor excessively laborious. Its use should be confined to burrows known or strongly suspected to be occupied by one or more of the animals, and it usually gives the best results if used after a rain when the interspaces in the soil are more or less clogged with water, so as to retard the diffusion of the vapor thru the soil. Also, in alfalfa and grain fields, or in colonies supplied with an abundance of green food, it seems to be the best way of getting rid of the animals.

FUMIGATION EXPERIMENTS.

In the fumigation experiments carbon bisulfid was the only fumigant used, altho a series of experiments using different dilutions of the carbon bisulfid with gasoline as recommended by Lantz (4, 6) was also carried out for purposes of comparison. The object was to determine the minimum effective dosage and the best means of applying the chemical.

The first fumigation experiments were made by J. T. Zimmer at Comstock in March and April of 1913, but the data obtained

Fig. 3.—An occupied prairie dog burrow just after treating with carbon bisulfid (above); a burrow after it was treated, plugged, and marked (below). Haigler, Nebraska.

by him were incomplete and not conclusive. Mr. L. M. Gates completed these experiments in the spring of 1914 (May 23-31) on the ranches of Messrs. Casey and Green, respectively one and four miles east of Haigler, Nebraska.

The plan of the experiments with carbon bisulfid was essentially the same as those with poisons. A burrow into which a prairie dog was seen to enter, and which was therefore known to be occupied, was selected and treated. The treated burrow was then plugged or sodded tightly and marked with a stake (fig. 3). For several days subsequent to the treatment the burrow was examined and its condition noted. If any one of the burrows was opened from the inside it was, of course, assumed that the treatment of that burrow was unsuccessful, but if it was not opened from the inside within a week it was assumed that the occupant had been killed by the fumigation. To make more certain that burrows opened from the inside were really occupied, such burrows were promptly reclosed. One hundred burrows were thus marked and treated, the amount of carbon bisulfid and the method of application being varied in 10 different ways so that sets of 10 burrows were treated exactly alike. The results follow:

1. On May 25, 10 burrows (1-10) on the Casey ranch were treated with one-half of a fluid ounce (about 1 tablespoonful) of carbon bisulfid, applied by soaking dry horse manure balls (5 burrows) or dry cow chips (5 burrows) with the chemical and dropping them into the burrows. The next day burrows 3, 4, and 8 were open from within, and these were reclosed. No more were open May 27 or 28. On May 29 burrow 5 was open and this was also reclosed, while on May 30 burrow 9 had been opened, and when closed was reopened May 31. Thus, five of the ten burrows showed that they contained live occupants within a week after the treatment, or that the treatment did not result in a mortality of over 50 per cent.

2. On the same day ten adjacent burrows (11-20) were treated with 1 ounce of carbon bisulfid applied on dry horse manure balls. These were examined every day from May 26 to 31 and only one was opened, that being burrow 15 on May 27, tho burrows 11 and 12 were dug into from the outside but not opened. Apparent mortality, 90 per cent.

3. On May 23 and 24, 10 burrows (21-30) in a wheat field on the Green ranch were treated with 1½ ounces of carbon bisulfid on dry horse manure balls. On May 24 one of the burrows treated the preceding day (21) was open, and on May 27 another (30) was open. Both were reclosed and not subsequently reopened. May 31 burrows 23 and 25 had been opened apparently

from the outside, tho burrow 25 was well opened. Apparent mortality, 80 per cent.

4. On the same days, 10 additional burrows (31-40) in the same "town" were similarly treated except that 2 ounces of carbon bisulfid were used to each burrow. Examination each day (except May 29) showed that no burrows were opened from within. Apparent mortality, 100 per cent.

5. On May 23, 10 burrows (41-50) mostly in a wheat field on the Green ranch were treated with 2½ ounces of carbon bisulfid applied on dry horse manure balls. On May 27 burrow 48 was open and when immediately replugged was reopened May 31. Apparent mortality, 90 per cent.

6. On May 23, 10 burrows (51-60) on the Green ranch were each treated with 1 ounce of carbon bisulfid applied on dry corn cobs. Altho examined every day (except May 29) for the next eight days none of these burrows were opened except that on May 26 burrow 52 was opened from the outside. Apparent mortality, 100 per cent.

7. On the same day 10 burrows (61-70) on the Green ranch were each treated with two ounces of carbon bisulfid applied on dry corn cobs. These likewise were examined every day (except May 29) until May 31 and none were found opened. Apparent mortality, 100 per cent.

8. On May 25, 10 burrows (71-80) on the Casey ranch were each treated with 1 ounce of carbon bisulfid applied on cotton rags. On May 26 burrow 75 was open and on May 28 burrow 74 was open. On the latter date burrows 71 and 77 were also more or less open; 71 was not fully opened, but the hole was barely large enough for an adult dog to force its way thru and escape, while 77 had only a very small opening and no work had been done about the burrow. On May 30 burrow 74 was reopened with a similar small hole. It is considered improbable that any of these last three openings were made by the adult dog seen to enter the burrow before the treatment. Apparent mortality, 80 per cent.

9. On the same day 10 burrows (81-90) on the Casey ranch were each treated with 2 ounces of carbon bisulfid applied on cotton rags. On May 29 burrows 83 and 90 were open, as was also burrow 86 but the opening in the latter was very small and not made by the prairie dog. Apparent mortality, 80 per cent.

10. On the same day each of 10 burrows (91-100) on the Casey ranch had one ounce of carbon bisulfid carefully poured down into the hole. The ground was quite moist at the time from rains of the preceding week so that maximum efficiency from this method could be expected. Altho examined every day

for the next six days none of these burrows were opened. Apparent mortality, 100 per cent.

From the above experiments one may conclude that one-half of a fluid ounce of carbon bisulfid is insufficient for the dosage of the average prairie dog burrow, because not over one-half of the animals succumb to such a treatment, but that 1 ounce is a sufficient dosage to kill 80 to 100 per cent of the animals. An increase in dosage to 1½, 2, or 2½ ounces does not consistently add to the effectiveness of the fumigation. When the soil is moist from recent rains good results will follow the simple careful pouring of the ounce of carbon bisulfid into the burrow, but probably the most consistently satisfactory results will follow the use of the chemical on dry corn cobs. Good results will also follow the use of the carbon bisulfid on dry horse manure balls, but cotton rags or waste as a medium have in these experiments not been so effective.

If carbon bisulfid is used at the rate of 1 fluid ounce (2 tablespoonfuls) to the burrow, and if it is purchased for small colonies by the pound in lots of 5 pounds or more, when it can usually be obtained for about 15 cents per avoirdupois pound even in villages, one pound making between 14 and 15 fluid ounces, the cost of the material is about 1 cent a burrow. If purchased in 5 gallon cans (at about $1 a gallon) as it would be for large colonies, the cost per burrow is reduced to about four-fifths of a cent. The average time of application and plugging for one man in the above experiments was about 4½ minutes to the burrow, varying from 3 minutes to the burrow in experiments 2 and 10 to 6 minutes in experiment 6, but where the work is being done with only approximate accuracy a man would probably be able to treat and plug at least 200 burrows in a day, at a cost of about $1.50 to $2 for material, making the total cost for material and labor (at $2 a day) about 2 cents a burrow.

In diluting carbon bisulfid with gasoline, 2 ounces of a mixture of 1 part of the carbon bisulfid with 4, 3, 2, and 1 parts of gasoline, respectively, were tried out on the Casey ranch, using dry horse manure balls as the medium; also one ounce of the equal mixture of the two was used. The results follow:

11. Ten burrows (101-110) treated and plugged May 25 with 2 ounces of carbon bisulfid diluted with gasoline, 1 part to 4 of gasoline, on dry horse manure balls, showed 1 burrow (105) reopened May 26, again May 29 and 30, and a fourth time May 31. Burrow 108 was opened May 28. Apparent mortality, 80 per cent.

12. Ten burrows (111-120) similarly treated May 25 with a dilution of 1 part to 3 of gasoline, showed two burrows (111 and

118) open May 29, one of them (111) from the outside, but this burrow when replugged was reopened from the inside May 31. Burrow 115 had caved in May 26, apparently without a dog having emerged or entered, but was also fully open May 29. Burrow 116 was dug into from the outside but not opened May 29. Apparent mortality, 80 per cent.

13. Ten burrows (121-130) similarly treated May 26 with a dilution of 1 part to 2 of gasoline, showed burrow 127 dug into from the outside but not opened May 29, open May 30, and reopened May 31, when burrow 130 was also open. Apparent mortality, 80 per cent.

14. Ten burrows (131-140) similarly treated May 26 with 2 ounces of carbon bisulfid and gasoline in equal parts showed burrows 133, 139, and 140 open on May 29, while 140 was reopened May 31. Burrows 131 and 135 were partly open May 27 and 28, respectively, obviously from the outside. Apparent mortality, 70 per cent.

15. Ten burrows (141-150) similarly treated May 26 and 27 with carbon bisulfid and gasoline in equal parts, but using only 1 ounce to the burrow, showed 141 reopened on May 27, 28, and 29, and burrow 145 reopened on May 29 and 31. Apparent mortality, 80 per cent.

As a check on the preceding 15 experiments, on May 27 10 occupied burrows (1-10) were plugged without treatment. May 28 burrows 1, 4, 6, 7, 8, 9, and 10 were all open, May 29 burrows 1, 6, 7, and 8 were reopened and 5 had a small opening, May 30 burrows 1, 6, 7, and 8 were again reopened, May 31 burrows 4, 5, 6, 7, 8, and 10 were open and burrow 2 was dug into from the outside. Thus within four days after plugging all but two of the burrows (2 and 3) had been opened, three of them (6, 7, and 8) four times, one (1) three times, two (4 and 10) twice, and two (5 and 9) once. Probably the others would have been opened within a week after the plugging.

In the fumigation experiments conducted by Mr. Zimmer at Comstock in March and April, 1913, the results with the more diluted carbon bisulfid were not so successful as in the Haigler experiments, possibly due to differences in soil conditions. The 1 to 4 dilution was used on 12 burrows March 4, on 15 March 7, on 10 March 8, and on a large number of additional burrows March 17. Subsequently a majority of these burrows were promptly opened from within. Some were refumigated with the same mixture with little success. On April 2, 4, and 5 many burrows were fumigated with the 3-to-1 mixture, with results only slightly more satisfactory.

We should judge that with diluted carbon bisulfid, as with the pure article, 1 ounce to the burrow is sufficient. However, one ounce of the pure carbon bisulfid seems to be more effective than an ounce of the carbon bisulfid mixed with an ounce of gasoline.

LESS SUCCESSFUL METHODS.

Our efforts have convinced us that trapping prairie dogs cannot be made a successful way of fighting them. We have succeeded in catching a few with concealed steel traps, but the process is slow and the small catch is wholly out of proportion to the large number of traps set. Traps are usually avoided unless carefully concealed. No. 0 steel traps carefully set with the trap, chain, and stake covered with loose soil will occasionally catch a prairie dog. We did not try other kinds of traps, but experimenters who have done so report them to be a failure. Shooting these animals is not a success both because of the difficulty of approaching them close enough and the fact that at the first shot the dogs scurry for their burrows, and will not venture forth again for some time, making the process exceedingly slow. Drowning out the animals, while possible if sufficient water supply is available, is also too slow to have any practical use, except of course on irrigated lands where they are held in check by the flooding. Nor has the use of disease cultures proved a practical way of exterminating these animals.

BIBLIOGRAPHY.

1. PETERS, A. T. Extermination of Prairie Dogs. Press Bul. 13, Nebraska Agr. Exp. Sta., pp. 1-4 (1900).
2. MERRIAM, C. H. Directions for the Destruction of Prairie Dogs. Circular 32, Division of Biological Survey, U. S. Dept. Agriculture, pp. 1-2 (1901).
3. LANTZ, D. E. Inquiries Concerning Prairie Dogs and Gophers. Press Bul. 97, Kansas Agr. Exp. Sta., pp. 1-2 (1901).
4. LANTZ, D. E. Destroying Prairie Dogs—A Preliminary Report. Press Bul. 108, Kansas Agr. Exp. Sta., pp. 1-2 (1902).
5. MERRIAM, C. H. The Prairie Dog of the Great Plains. Yearbook for 1901, U. S. Dept. Agriculture, pp. 257-270 (1902).
6. LANTZ, D. E. Destroying Prairie Dogs and Pocket Gophers. Bul. 116, Kansas Agr. Exp. Sta., pp. 147-163 (1903).
7. LANTZ, D. E. Poison for Prairie Dogs and Pocket Gophers. Press Bul. 119, Kansas Agr. Exp. Sta., pp. 1-2 (1903).
8. PAYNE, J. E. The Prairie Dog as a Range Pest. Press Bul. 16, Colorado Agr. Exp. Sta., pp. 1-2 (1903).
9. LANTZ, D. E. Poison for Prairie Dogs and Other Rodents. Press Bul. 130, Kansas Agr. Exp. Sta., pp. 1-2 (1904).
10. PETERS, A. T. and AVERY, S. Destroying Prairie Dogs. Bul. 86, Nebraska Agr. Exp. Sta., pp. 3-15 (1904).
11. HANEY, J. G. and ELLING, O. H. Prairie Dogs in Bul. 128, Kansas Agr. Exp. Sta., p. 262 (1904).
12. LANTZ, D. E. Kansas Mammals in their Relation to Agriculture. Bul. 129, Kansas Agr. Exp. Sta., pp. 350-352 (1905).
13. POPENOE, E. A. Press Bul. 153, Kansas Agr. Exp. Sta., pp. 1-2 (1906).
14. MERRIAM, C. H. Directions for the Destruction of Prairie Dogs. Circular 32, revised, Bureau of Biological Survey, U. S. Dept. Agriculture, pp. 1-3 (1908).
15. LANTZ, D. E. Use of Poisons for Destroying Noxious Mammals. Yearbook for 1908, U. S. Dept. Agriculture, pp. 427-429 (1909).
16. SCHEFFER, T. H. Prairie Dog Situation. Circular 4, Kansas Agr. Exp. Sta., pp. 1-7 (1909).
17. CLARK, R. E. The Prairie Dog Must Go. American Forestry, xviii, No. 1, pp. 28-33 (1912).
18. SPAULDING, M. H. The Control of Prairie Dogs and Ground Squirrels. Circular 20, Montana Agr. Exp. Sta., pp. 9-26 (1912).

19. JOHNSON, S. A. Prairie Dogs and Methods of Control. Circular 2, Colorado State Entomologist, pp. 7-13 (1912).
20. BURNETT, W. L. Prairie Dogs and Ground Squirrels. Circular 4, Colorado State Entomologist, pp. 2-3 (1912).
21. BURNETT, W. L. Report on Rodent Investigations for 1912. Circular 6, Colorado State Entomologist, pp. 5-9 (1912).
22. BURNETT, W. L. Fourth Annual Report of the State Entomologist of Colorado. Circular 7, Colorado State Entomologist, pp. 67-71 (1913).
23. BURNETT, W. L. Report on Prairie Dog Investigations in Colorado. Circular 8, Colorado State Entomologist, pp. 3-13 (1913).