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Population Distribution and Mobility of Deer in Eastern South Dakota

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POPULATION DISTRIBUTION AND MOBILITY OF DEER IN EASTERN SOUTH DAKOTA

BY

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POPULATION DISTRIBUTION AND MOBILITY OF DEER

IN EASTERN SOUTH DAKOTA

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable as meeting the thesis requirements for this degree, but without implying that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Adviser // Date

Wildlife Management Department

POPULATION DISTRIBUTION AND MOBILITY OF DEER IN EASTERN SOUTH DAKOTA

Abstract

ROLLIN DE MERS SPARROWE

Under the supervision of Associate Professor Paul F. Springer

Population distribution and mobility of deer were studied intensively along a 15-mile stretch of the Big Sioux River, and less intensively on an expanse of 1400 square miles in central eastern South Dakota. Objectives were to determine relative population numbers and distribution of deer, the extent of their daily and seasonal movements, and the principal factors influencing these populations and movements, and to test winter herd counts as a population index. Deer were captured in Clover traps or with a Cap-Chur gun and were marked individually with ear tags, ear streamers, and collars. Some deer were tracked by radio telemetry.

Deer were most widely distributed during the summer. Ranges of many animals during this season were restricted to a few favored bedding and feeding sites, but some young animals wandered up to 20 miles. During the summer-fall transition, deer remained widely distributed but gathered in sloughs and thickets after cover in fields of corn and other crops was reduced by harvest. Fall ranges were restricted until the rut and hunting seasons scattered deer during November and December. Some herds started to form in early December but were broken up

by hunters. Deer remained scattered until the end of the hunting seasons on December 31.

In early January discrete herds of up to 80 animals began to form, but true yarding did not occur. Some herds wintered in fairly well-defined areas, but as much as 30 percent of the deer population remained widely scattered through the winter. Winter herds maintained fairly stable numbers, but some deer moved up to 12 miles between herds. Sloughs and wooded areas in draws or along stream bottoms with unused or washed out section-line roads creating 2- or 3-section blocks were favored as wintering areas. Some herds remained within these blocks, whereas other herds roamed over as much as 6 sections of land. Some wintering areas were used in more than one year.

Herds generally remained distinct until the spring thaw. Some herds broke up immediately, but others broke up gradually. Animals moved out in several directions and at varying rates, but a definite predominance of northward movements along the Big Sioux River and its tributaries was noted.

Cattle reduced the potential value of some areas as deer habitat. When cover conditions were optimum, as in summer, deer movements tended to be restricted. When cover was sparse, deer often traversed wide expanses of open fields between patches of heavy cover. During the fall, hunting influenced deer movements and distribution more than any other factor.

The deer population in this study was partially migratory

in that it used all of the study area for summer range but withdrew to a small part of it for the winter. The home range pattern of deer included one or more sub-areas which provided the total deer habitat requirements. When these requirements were disturbed, depleted, or changed, deer moved to a new sub-area. Because of the nature of the habitat, movements between sub-areas were sometimes extensive and produced a multiple home range.

Data from this study indicated that deer management units, if they could be administered effectively, might better be based on natural drainages than on counties as is now the case. Instability of winter herds ruled out the use of winter herd counts as an accurate population index. Since agricultural interests control the level at which deer populations may be maintained, a greater annual reduction in population size may soon be necessary to maintain deer at a level acceptable to farmers. Preserving natural vegetation and establishing artificial plantings that benefit other wildlife species will also benefit deer.

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INTRODUCTION

Studies of the movements of a species may yield basic information which can be used in wildlife management programs (Sanderson 1966:215). Such information is not available for white-tailed deer (Odocoileus virginianus) in eastern South Dakota. This study was conducted to supply information which could be used to start a more comprehensive program of deer management in eastern South Dakota. The objectives were to (1) determine relative population numbers and distribution of deer on key areas within various habitat types of eastern South Dakota, (2) determine the extent of daily and seasonal movements of deer on these key areas, (3) identify the principal factors influencing these deer populations and their movements, and (4) determine the feasibility of using a census of winter deer herds as a population index. Data on the basic life history of deer in the study area were also collected.

The history of white-tailed deer populations in eastern South Dakota parallels that of deer in much of the Great Plains region (Cook 1945) and also in parts of the eastern United States (Cook and Hamilton 1942:287, Pietsch 1954:3-10). Before 1900, destruction of habitat and unregulated hunting by settlers reduced deer numbers to near extinction over much of their former range. About 1925, aided by protection from hunting, remnant populations of deer grew and began to repopulate parts of their old range. Cook (1945) emphasized the importance of Upper and Lower Souris, Sand Lake, and Waubay National Wildlife Refuges in the Dakotas in acting

as reservoirs for deer repopulation. Hunt and Mangus (1954:494) found a similar situation with deer from Mud Lake National Wildlife Refuge in northwestern Minnesota spreading into the surrounding agricultural land. Management of these areas for waterfowl also provided suitable deer habitat and thus contributed directly to the increase in deer populations.

Deer populations in eastern South Dakota increased rapidly, especially in the 1940's, until crop depredation complaints could no longer be ignored. In 1947, four counties east of the Missouri River were opened to the first deer hunting season in 26 years (Popowski 1962:2). Nine hunting seasons were held from 1947-1959, and in 1959 all 44 counties were open. The early hunts were held mainly to reduce deer numbers, but hunter interest increased, and in 1959 a regular annual season was begun with a limited number of licenses being issued for each county. Both the number of permits and public interest increased with each season, and in 1965 the number of applications was three times the number of available permits.

Eastern South Dakota deer are currently managed on a county basis. Landowners are entitled to half of the rifle permits, and non-landowners are entitled to half. Bow hunting permits are unlimited. Wardens and game managers of the Department of Game, Fish and Parks determine the number of permits to be allotted. Permit allocations are based on the rate of hunter success, the number of road kills, and gross estimates of the deer population. A consistently high rate of hunter success

(almost 90 percent of reporting hunters are successful), an increasing number of road kills, and a generally growing deer population have resulted in a steady increase in the number of permits allotted each year. The growing population of both deer and hunters has created a need for more intensive management of the local herd, and the purpose of this report is to provide some of the basic information necessary for management.

The South Dakota Cooperative Wildlife Research Unit (South Dakota Department of Game, Fish and Parks, Bureau of Sport Fisheries and Wildlife, South Dakota State University, and Wildlife Management Institute, cooperating) provided financial assistance and field expenses during the study. The assistance of Dr. Paul F. Springer, Unit Leader, and Dr. Donald R. Progulske, Wildlife Management Department Head, in planning and implementing the study and reviewing the manuscript is gratefully acknowledged. Thanks are due the employees of the South Dakota Department of Game, Fish and Parks for their advice and aid in reporting deer sightings. Appreciation is also expressed to farmers, sportsmen, and other citizens who reported deer sightings or allowed access to their land, and to fellow students who helped with field work.

STUDY AREA

The study centered along a 15-mile stretch of the Big Sioux River and adjacent agricultural land, from 3 miles west of Brookings to 3 miles below the Brookings-Moody County line (Figs. 1,2).

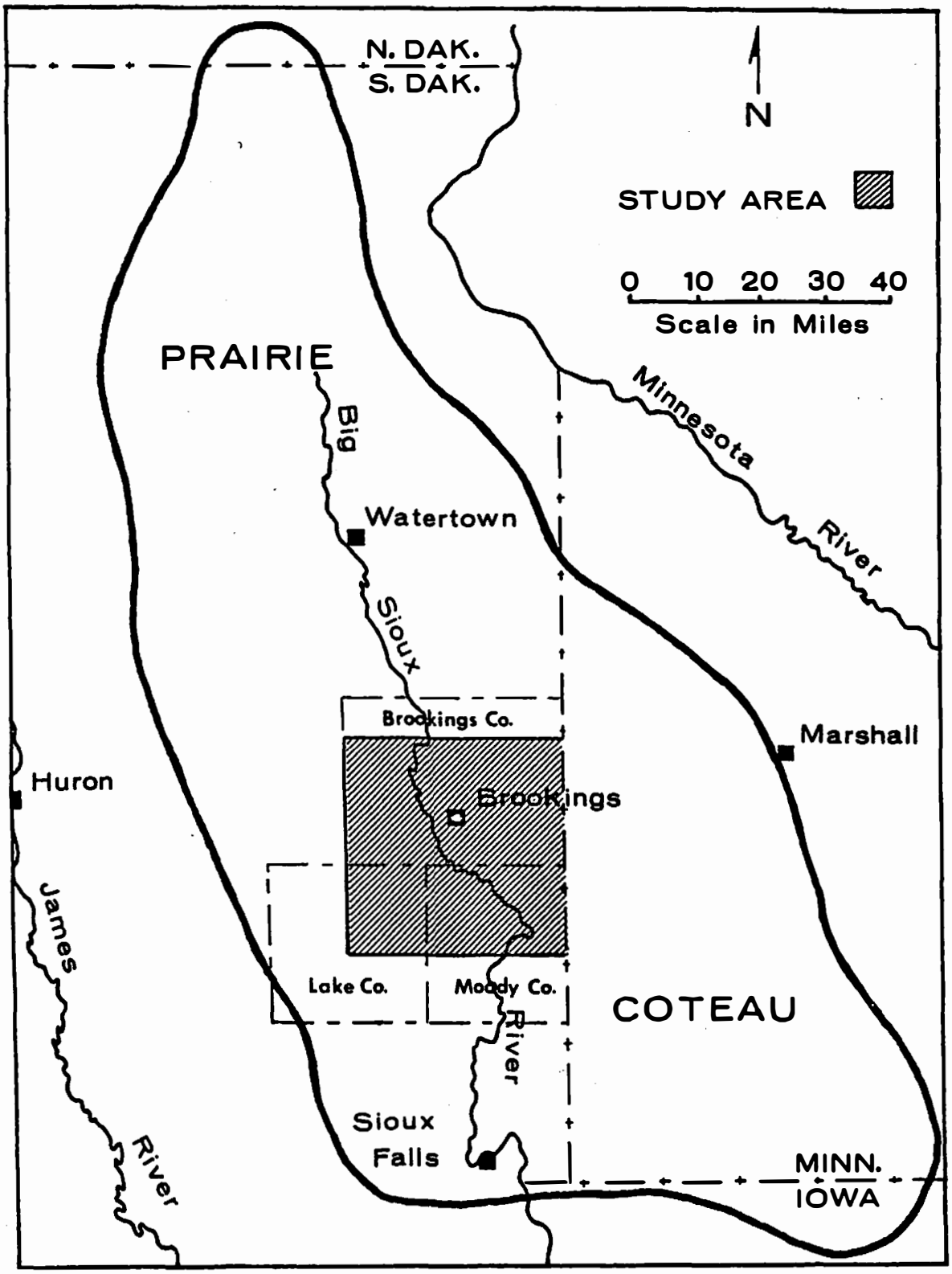

Fig. 1. Location of study area.

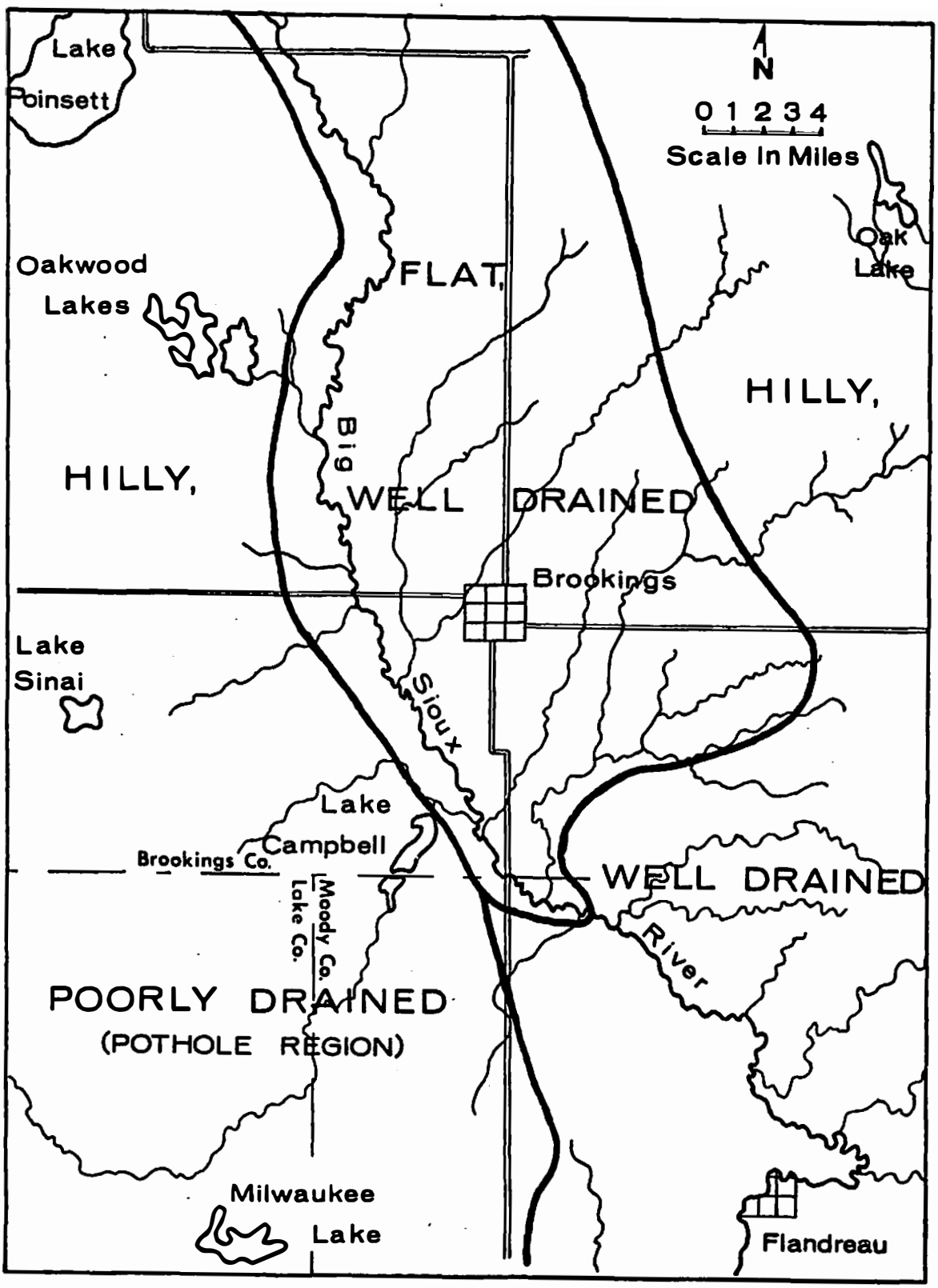

Fig. 2. Land types on study area.

Extensive movements by marked deer required that a larger area be covered less intensively, including the southern two-thirds of Brookings County, the northern half of Moody County, and the northeastern one-quarter of Lake County, an expanse of about 1400 square miles (Fig. 1). This area is located on the Prairie Coteau, a hilly, lake-dotted highland occupying a large part of eastern South Dakota and southwestern Minnesota (Rothrock 1943:12). The western part of the study area is located on the edge of a poorly drained region characterized by the presence of many glacial potholes and sloughs. A flat region having few potholes lies near the center, whereas a hilly region lies to the east (Fig. 2). The latter two regions are drained by the Big Sioux River and its tributaries.

The climate of the area is continental with wide extremes in daily and seasonal temperatures. Summer temperatures reach 100 F, whereas the winters are cold and dry, with temperatures reaching -30 F. Average weekly mean temperatures range from 12.3 F in late January to 72.6 F in late July, with an annual weekly average of 44.1 F. Annual precipitation, which averages 21.62 inches, occurs as gentle rain or snow or violent thunderstorms (Westin 1958:4-6). Snow accumulations are rarely heavy, but strong prevailing winds commonly cause considerable drifting.

Native vegetation of the region was true prairie and was dominated by mid grasses of both the sod and bunch grass life form (Weaver and Clements 1938:518,519). Porcupine grass (Stipa

spartea), and dropseed (Sporobolus asper and S. heterolepis) were the most characteristic dominants, often with big bluestem (Andropogon Gerardi) and indian grass (Sorghastrum nutans) from the post climax and needle-and-thread (Stipa comata) from the mixed prairie. Short grass species such as blue grama (Bouteloua gracilis) and buffalo grass (Buchloe dactyloides) occurred on some pastures. Upland and lowland forbs were present, and poorly drained sites supported marsh vegetation.

Highly fertile Chernozem soils of predominantly dark, silt loams and silty clay loams developed under native mid and tall grasses (Westin et al. 1959). Since most of the area is now intensively farmed or grazed, the native vegetation is scarce and has been replaced largely by small grains, corn, soybeans, and introduced hays. Beef cattle, dairy cattle, swine, and sheep are raised through a combination of supplemental feeding and pasturing. Vegetation of the Big Sioux River bottom, creek bottoms, farm woodlots, and shelterbelts is grazed heavily, sometimes during the entire year. Erosion resulting from this general overgrazing is a serious problem throughout the study area.

Potholes and sloughs provide dense cover, whereas woody cover is found along the Big Sioux River and its tributaries, around some lakes, and in farm woodlots and shelterbelts. Characteristic trees along river and stream bottoms and around lakes include American elm (Ulmus americana), slippery elm (U. rubra),

cottonwood (Populus deltoides), peach-leaved and black willows (Salix amygdaloides and S. nigra), boxelder (Acer Negundo), green ash (Fraxinus pennsylvanica), and hackberry (Celtis occidentalis). Shrubs include Missouri gooseberry (Ribes missouriense), wild black currant (R. americanum), hawthorns (Crataegus spp.), sandbar willow (Salix interior), buckbrush (Symphoricarpos occidentalis), chokecherry (Prunus virginiana), and wild plum (Prunus americana). Shelterbelt plantings usually include evergreens, such as eastern redcedar (Juniperus virginiana) or ponderosa pine (Pinus ponderosa), or deciduous species, such as American elm or green ash. Scientific names were taken from Fernald (1950).

The vegetation pattern is one of dense, wide-spread cover throughout the summer, with gradually diminishing cover in the fall, and restricted cover during the winter and early spring. Ready access to the area is provided by the division of the entire area into sections (one square mile), with roads on all sides of each section. This habitat is contrastingly different from the usual white-tailed deer range in the southwestern and eastern United States where deciduous or coniferous forests or brushy cover is the rule.

METHODS

Deer were captured for marking with Clover single-gate deer traps (Clover 1956) and by a Cap-Chur gun (Palmer Chemical and

Equipment Company, Douglasville, Georgia) shooting syringe darts loaded with 450-600 mg nicotine salicylate.

Clover deer traps have been used with varying success by several workers (McKenzie 1962:12-15, Gruell and Papez 1963:415, and Patrick 1963:2-12). McKenzie reported that the rat-trap tripping mechanism often did not work properly because of icing and wind action, and the gate failed to drop. Early in the present study icing and wind-blown debris caused several malfunctions of the traps. The rat-trap apparatus was replaced by a simple trip-wire stretched sideways across the trap about 1 foot high, and connected directly to the gate hook by another wire (Fig. 3). After the simple trip-wires were attached, no trap failures were attributed to the tripping mechanism.

Deer caught in the Clover traps may struggle violently when approached by the trapper, and rapid handling was recommended by Clover (1956:199) to avoid injury. Entering the trap to subdue the deer, or releasing them into a catch-net were suggested as handling methods, but these operations endanger both the trapper and the deer and risk escape by the trapped animal. In this study handling deer in the traps was simplified by the use of 6-inch mesh netting (stretch measure), made of no. 84 nylon twine, which allowed easy access to the animal through the netting. The netting on the top of the trap was cut square, rather than the usual diamond shape, thus permitting the trap to be easily folded. After a deer was trapped the anchor wires were detached

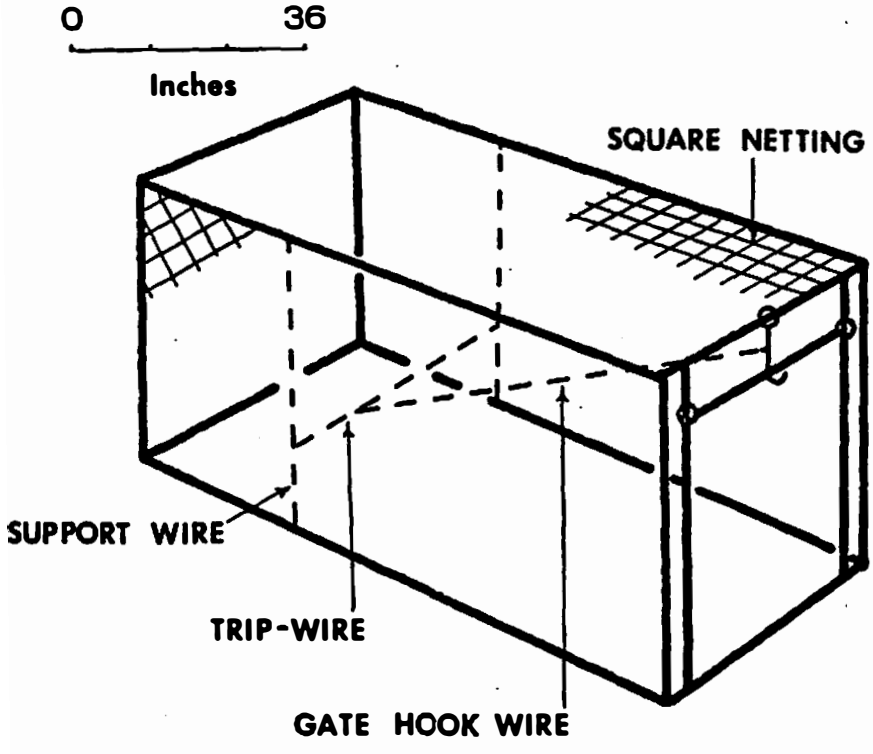

Fig. 3. Trip-wire used on Clover traps. Note square netting on top of trap.

and the trap was folded longitudinally to subdue the deer. The animal and the trap were then easily laid flat on the ground for the tagging operation (Fig. 4). One person, using this method, could handle and mark a captured deer without help. Twelve deer, including seven fawns, three adult does, and two adult bucks, were thus handled without assistance.

The Cap-Chur gun was of limited use in this study because of difficulties in approaching deer and the time required for the drug to take effect. These problems were magnified by the open nature of the habitat in winter and early spring and the very dense cover afforded by corn and other vegetation in the summer. When cover was sparse a deer struck by a syringe could run out of the section before the drug took effect, and when cover was heavy a short jump could take the animal into a dense thicket or slough.

Captured deer were marked individually with streamers of Saflag plastic impregnated nylon cloth (Safety Flag Company of America, P. O. Box 1005, Pawtucket, Rhode Island) and with colored collars. Streamers were tied in a jesse knot and attached to a numbered cattle ear tag which was placed in each ear. Collars of 3-inch-wide Saflag material sewn together with nylon thread (Fig. 5) were slipped over the heads of some does, whereas several other does and all bucks were fitted with Boltaron plastic expanding collars (Fashingbauer 1962) bearing various designs or symbols of red and silver Scotchlite reflective tape (Minnesota Mining

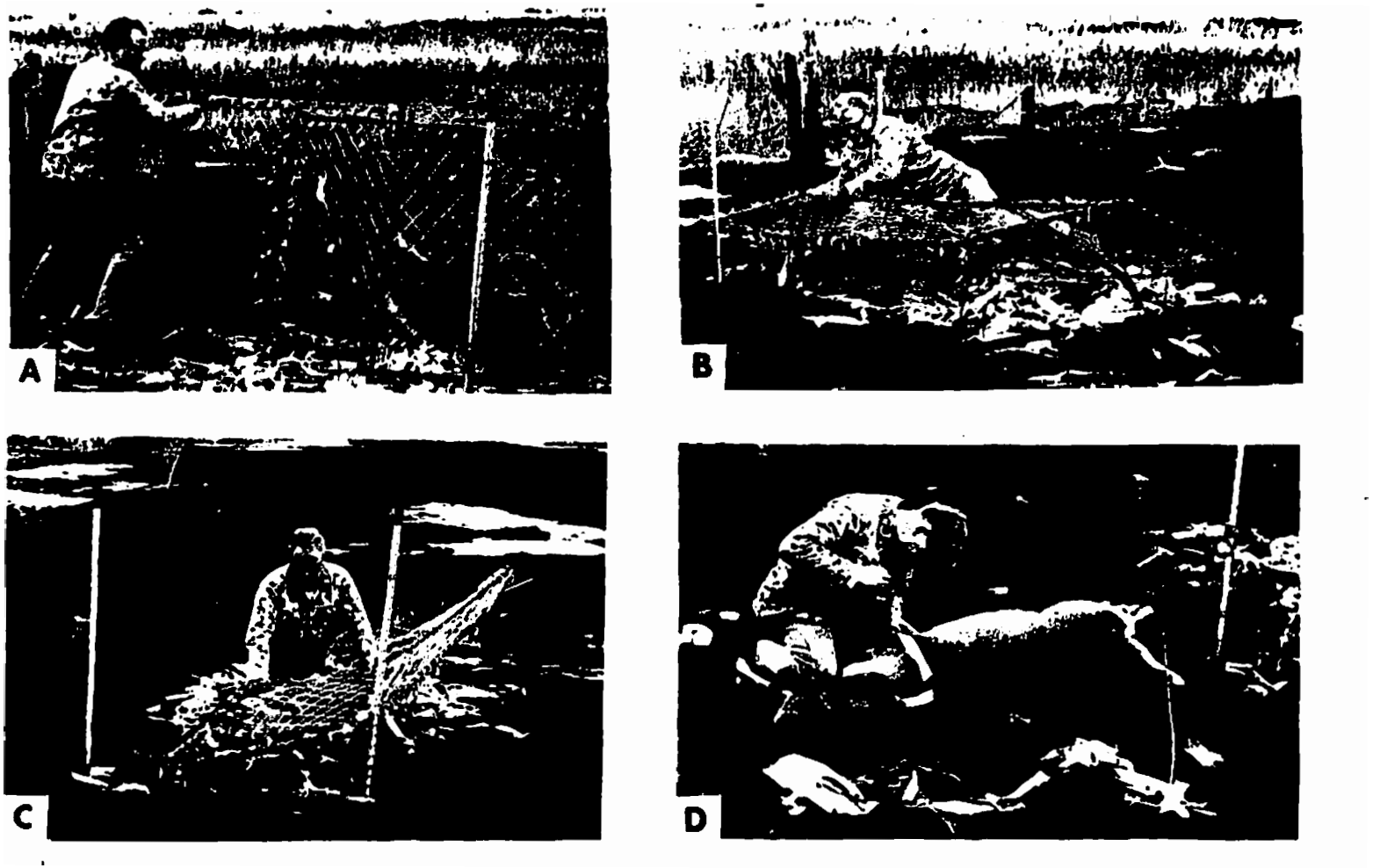

Fig. 4. Sequence of handling a trapped deer. A. Anchor wires detached and trap being folded. B. Trap being laid flat with deer inside. C. Deer subdued, aided by the weight of the handler. D. Deer tied, stretched between two posts, and blindfolded to allow attachment of a radio-harness.

and Manufacturing Company, St. Paul, Minnesota) (Fig. 6). In some cases Saflag streamers were attached to the collars.

A radio-tracking system operating in the 27 megacycle Citizens' Band was used to follow some deer. The transistorized transmitter was about the size of a cigarette pack with a 26-inch whip antenna and was powered by four Eveready no. 302642 batteries in a parallel series arrangement (Hoxsie and Robbins 1963:5). It and the batteries were fitted in leather pouches attached to the sides of a wide, saddle-like leather band which extended around the chest of the animal behind the forelegs. Woven cotton straps connected the ends of the saddle together, and straps between the legs and extending forward on the neck connected the saddle to the neck loop. Tubular rivets were used to fasten the harness together. Saflag material covered the neck loop and part of the saddle to make the animal easier to locate by sight (Fig. 7). The entire apparatus weighed about 3 1/2 pounds.

Receivers of the system were HA-60 Lafayette "Walkie-talkies" modified by Mr. Frank Hoxsie of Overton, Nebraska (Fig. 8). A directional loop antenna, a beat frequency oscillator, and a manual sensitivity control were added to produce a portable unit which received at distances up to 8 miles. Under most conditions signal reception was best in the 1/2- to 2-mile range.

Receiving conditions in the field varied greatly because of interference from powerlines, vehicle motors, and farm equipment.

Fig. 5. Trapped doe with Saflag collar and ear streamers.

Fig. 6. Deer leaving trap site wearing Saflag ear streamers and Boltaron expanding plastic collar with Scotchlite symbols.

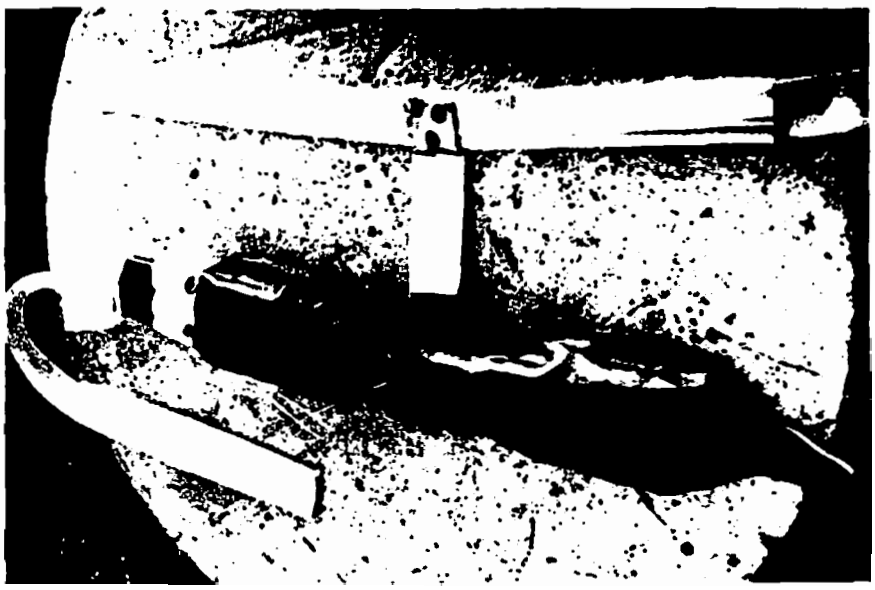

Fig. 7. Radio-harness with battery pack and transmitter.

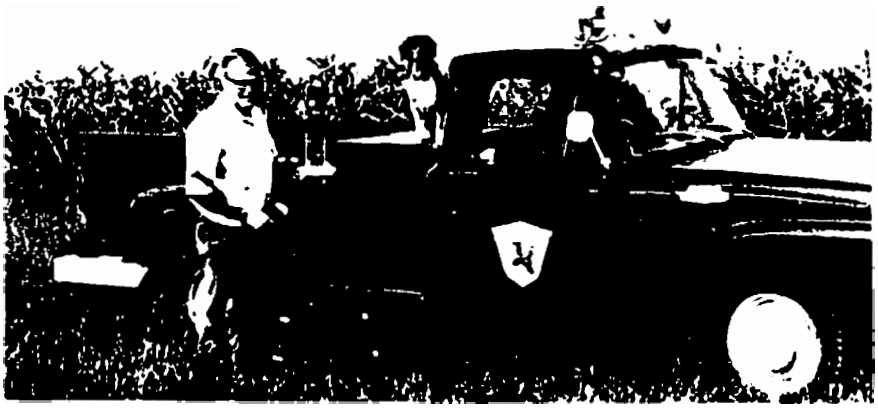

Fig. 8. Equipment used to trace deer movements. Note portable radio receiver on tripod; also, spotlights on truck for night work.

Precise compass triangulation for locating animals was therefore not always possible. Fencelines, sectionline roads, and other landmarks known to the investigator were helpful in mapping locations of harnessed animals. Radio fixes were considered accurate because the animal being tracked was seldom more than 1/2 mile from the receiver, and because harnessed animals were frequently seen after being located by radio.

Personal contacts with farmers and sportsmen, posters advertising the study, letters to local residents, appearances at sportsmen's meetings, and radio and newspaper appeals were employed to stimulate public cooperation in tracing marked deer movements.

A powerful spotlighting system was installed in a pick-up truck for night work in locating marked deer and for use of the Cap-Chur gun (Fig. 8). A 110-volt accessory generator and dash board control box (distributed by Kurland Motors Inc., Denver, Colorado) were mounted on a Ford pick-up truck. Two "Unity" roof mount 12-volt spot-lights were installed on the roof of the cab. The conventional wiring and 12-volt beams were replaced by 110-volt "GE" searchlight bulbs connected to the control box by a wire extending out through a hole in the back of the spot-light case and through the weather stripping of the wing windows into the truck cab. Plugs on the ends of the wires were then inserted in the control box for operation of the unit. This unit produced enough light to illuminate large areas of fields or

bottomlands. The performance of the system was described by Duerre (1959:26-30).

During the winters of 1964-65 and 1965-66 aerial surveys were conducted to census deer concentrations, locate marked animals, and assess the effects of hunting and other factors upon deer distribution and movements. A two-place tandem Piper Super Cub was flown at about 200-300 feet elevation with a pilot and one additional observer. Known deer concentrations and blocks of habitat were surveyed by intensive searches over each area with no attempts being made to standardize the flight pattern. Areas apparently not used by deer herds were checked to eliminate the possibility that an important part of the population might be overlooked.

RESULTS

Seasonal Distribution

Deer were most widely distributed during the summer and used sloughs, soil bank fields, creek and river bottoms, and croplands such as corn, oats, wheat, and alfalfa for bedding, loafing, and feeding areas. Willow thickets, stream bottoms, and other areas offering abundant browse were favored in early summer, whereas cornfields were favored in mid and late summer. By late summer, cornfields offered both food and dense cover and received heavy use. Parts of cornfields adjacent to sloughs or other dense vegetation were used as travel lanes into surrounding corn and

alfalfa fields, and the ground had the appearance of a stockyard, being chopped up by the hooves of many passing deer. During most of the summers of both 1964 and 1965, deer or their tracks were found in every section of land examined in this study.

During the summer-fall transition in September and early October, deer remained widely distributed and used willow thickets, sloughs, and cornfields heavily. As the crop harvest began, groups of several does of various ages with their fawns were frequently seen in harvested small-grain fields and hayfields, but still used cornfields. When standing corn was reduced by harvest, deer bedded in sloughs and thickets but moved into harvested cornfields to feed.

In October and November bucks joined does, and these groups of deer used areas of heavy cover for bedding and fed in harvested cornfields. By about December 1 of each year three powerful factors were influencing deer distribution: the rut, the hunting seasons, and the start of severe winter weather. Each factor is discussed in detail in subsequent sections.

Deer were least widely distributed during the months of January, February, and March. Individuals and herds used harvested cornfields and alfalfa fields for feeding and bedding but more often bedded in heavy cover. Large areas of summer range were devoid of deer, whereas herds of up to 80 animals wintered in large sloughs, wooded areas, or along stream bottoms. Many deer remained with discrete herds throughout the winter, but an

important number wintered alone or in small groups scattered over parts of the summer range. As an example, on a February 20, 1966, aerial survey 30 percent of slightly over 100 deer located were in groups of 5 or less or were alone. Changes in deer distribution during mid-winter are discussed later.

Many deer remained concentrated on wintering areas until the spring thaw which occurred in mid-March 1964 and early April 1965, when they dispersed in several directions from the wintering areas and at varying rates, with most individuals reaching their summer ranges by late May.

Summer Movements

Observations of several marked does and radio-tracking data on a yearling buck during June and July 1965 indicated that ranges of many animals were restricted to a few favored bedding and feeding sites. The yearling buck was tracked from June 16, 1965, until July 14, 1965, during which period he used a narrow strip of habitat about 2 miles long. His daily bedding and feeding activities centered around a small area of timbered river bottom, a wheatfield next to the river, a thicket, and the edge of a large slough (Fig. 9). Two marked adult does and a yearling doe, with fawns, and an adult doe with yearling fawns were observed many times throughout the summer within separate 1- to 3-section areas. These deer also favored a few specific localities within their home ranges.

Does were secretive during the fawning season which extended

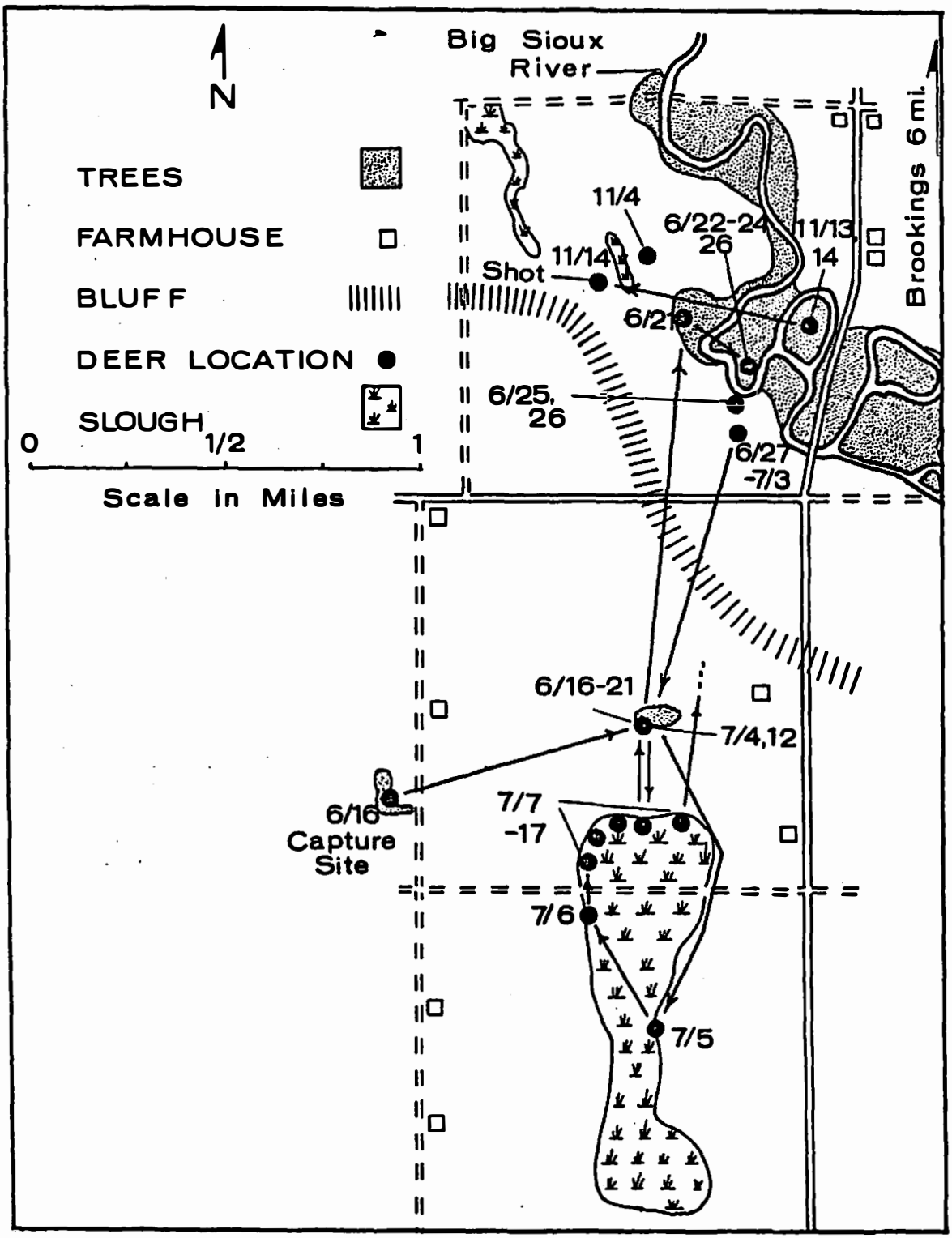

Fig. 9. Movements of yearling buck, June 16-November 14, 1965 (radio-tracked June 16-July 14).

into July, but by mid-summer they began to be seen more frequently with their fawns. Groups of does of various ages with their fawns were encountered at night in pastures, grainfields, or hayfields. Some authors have suggested that these may represent family groups composed of several generations of progeny (Dasmann and Taber 1956:148, Severinghaus and Cheatum 1956:117,135).

Groups of from three to eight bucks, often composed of yearlings only, were encountered several times in early summer. These deer were seldom seen again in the same location and apparently were wandering across country. Dasmann and Taber (1956:149) reported similar buck groups among black-tailed deer (O. hemionus columbianus) in spring and summer. Adult bucks seemed to be more sedentary than some young bucks, but not enough observations were made to allow a general conclusion.

The longest detected movement during the summer was by a yearling doe which had moved 20 miles north from her winter trap site on the Big Sioux River bottom to a group of wooded lakes (Oakwood Lakes, Fig. 2) by late June 1965 and returned to the trap site by September 30, 1965. An adult doe moved about 8 miles upriver from her summer range during late summer and returned by early fall. Some movements of considerable length may have occurred during this period since several marked deer were reported in the fall at points distant from their capture sites on the river bottom the previous winter. A lack of sightings between spring and fall made it impossible to determine when

these movements occurred.

Fall Movements

Rutting Season. - During the summer-fall transition and continuing through October 1965 several marked does were observed on their summer ranges, indicating that movements of does were limited to small areas prior to the breeding season.

The length of the breeding season is not well documented for eastern South Dakota. During both 1964 and 1965 the start of the rut coincided with the opening of the bow hunting season in late October. Bucks were first observed with does during the third week in October 1965, and one buck was seen actively pursuing a doe during the first week in November. The peak of the rut probably occurred in mid-November in both 1964 and 1965, when bucks and does were seen more frequently during all times of the day. Bucks with swollen necks were seen with does in mid-December, and rutting activities probably continued until the end of December.

During the breeding season several bucks, usually including an old, dominant male, often accompanied individual groups of does and fawns. Each of these groups used a separate, distinct area which often included a slough or a stretch of river bottom. Bucks were observed moving between areas occupied by does, possibly seeking does in breeding condition. Considerable movements by bucks may have occurred.

Early Bow Hunting Season. - Archer activities drove deer out of some areas of heavy cover and probably broke up some breeding season groups of bucks and does. During the early bow seasons (October 31-November 26, 1964, and October 30-November 25, 1965) archers concentrated their efforts along slough edges, in woodlots and shelterbelts, and along the Big Sioux River and its tributaries. Most deer moved out of these areas into soil bank fields and cornfields during the day. Some animals moved back to the river bottom at night but returned to the fields at dawn.

Efforts of bow hunters during the 1965 season were aided by unusually warm weather which allowed hunters to use tree stands effectively and discouraged large drives which were more common in 1964 and which often moved deer considerable distances. A high rate of successful kills was noted early in the 1965 season. Some deer movements occurred, apparently in direct response to the activities of bow hunters. One marked doe with a fawn was shot at twice on opening weekend of the 1965 season in a section of the Big Sioux River bottom. Repeated harassment by archers in the same area apparently caused her to move out for she was reported with her fawn 14 miles north along the Big Sioux River 3 weeks later. A marked yearling buck and an adult doe with fawns apparently were not driven away by archers since they were killed in November near their summer ranges.

Between October 14 and November 17, 1964, a marked yearling buck travelled 7 miles southwest but had moved back 8 miles

northeast by November 3, 1964. He moved first away from the river bottom, then back to the river, travelling overland all the way and following no particular drainage or land types. Two weeks later he was found 6 1/2 miles northwest. During the next 2 weeks he was frequently seen alone or with seven other deer moving over an area about 4 miles long by 1 1/2 miles wide (Fig. 10). These animals were repeatedly harassed by archers, and this, combined with rutting activities of a large buck running with the group, caused rapid movements of up to 2 miles during mid-day and at night. The yearling buck was very conspicuous because he was wearing a non-functioning radio transmitter in a harness, a collar, and ear streamers. He was shot on December 3, 1964, about 6 miles northwest of his capture site by a hunter who had seen the markings and returned looking for this particular deer.

Three yearling animals moved considerable distances. In the fall of 1964 a yearling buck was reported 20 miles southeast of his summer capture site. In October 1965 a yearling buck was sighted 20 miles northwest of his winter trap site. On November 14, 1965, a doe, marked as a fawn in January 1965, 14 miles south of Brookings, was killed by a hunter 10 miles south of Sleepy Eye, Minnesota. This animal had moved more than 100 airline miles east since it was last seen near its trap site on March 21, 1965. These movements could have occurred as spring dispersal, summer wandering, or in response to the rut or hunting seasons. A lack

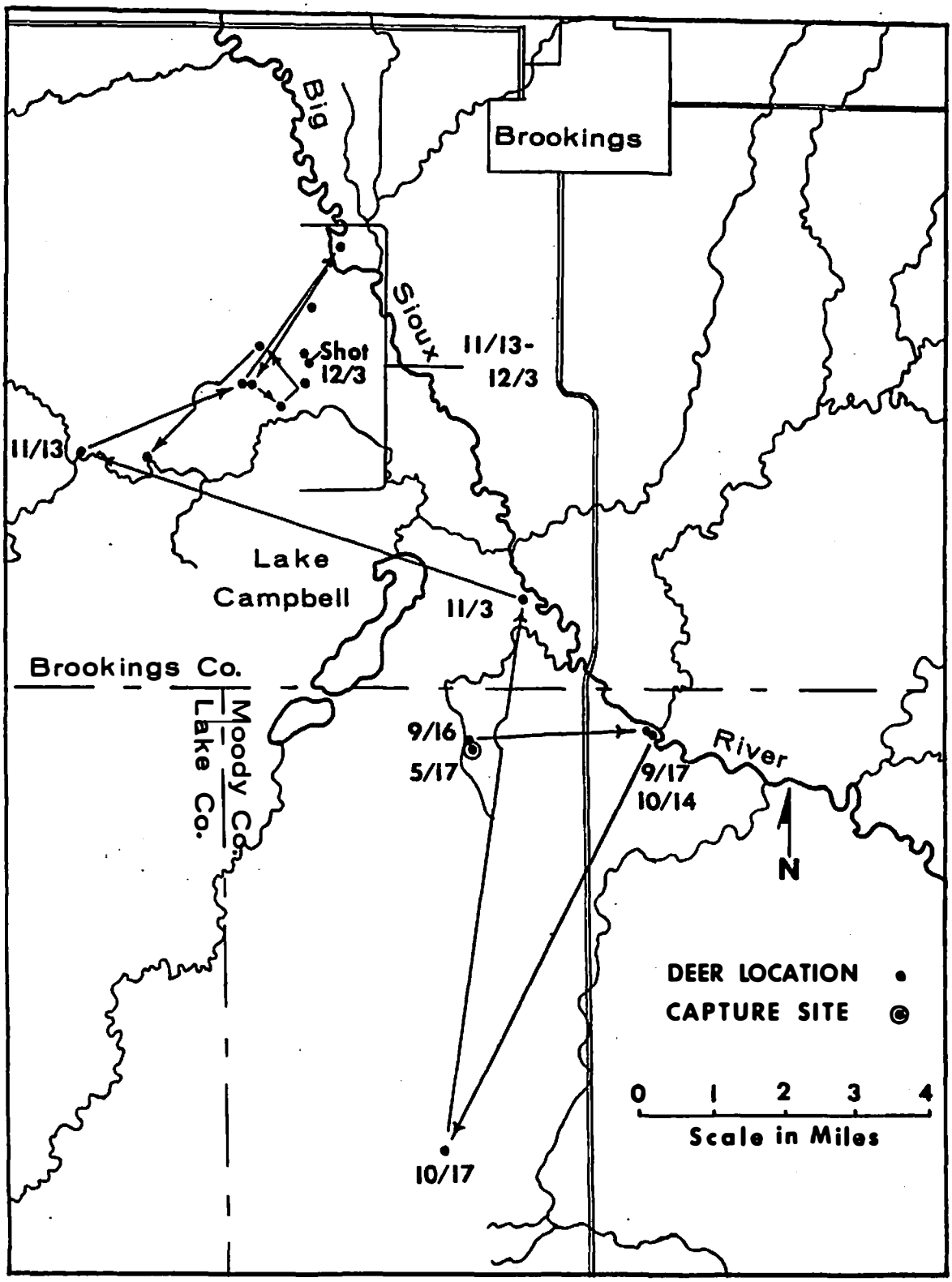

Fig. 10. Movements of yearling buck, May 17-December 3, 1964.

of records between sightings makes it impossible to determine when they took place.

Rifle Hunting Season. - The rifle hunting seasons (November 28-December 6, 1964, and November 27-December 5, 1965) had immediate and strong effects on deer distribution and movements. Both hunting seasons were preceded by the first heavy snowstorms of the season, which occurred 8 days before the 1964 season and 1 day before the 1965 season. A rapid warm-up followed the 1964 storm, and groups of deer which may have formed during the storm dispersed again. In 1965 the storm was followed by two cold and windy days, and efforts of hunters were greatly inhibited by blowing and drifting snow. During both years hunters repeatedly worked the heavy cover of sloughs and the Big Sioux River bottom, often chasing deer across open land for several miles. When pursued in this manner, deer often stayed in fields where they could observe attempts to approach them. An aerial survey on the third day of the 1965 season revealed that heavy hunter activity along the Big Sioux River and in many other areas of good cover had driven out most deer. Most of the few animals that were located were in soil bank fields or in harvested cornfields. Many areas occupied by numerous deer before the rifle season were devoid of deer after the first weekend.

An aerial survey on the sixth day of the 1965 rifle season showed that deer were still widely scattered, were avoiding the river bottom, and were using soil bank fields, cornfields, and

small patches of grass or slough vegetation. No large groups of deer were seen, but many individuals or small groups of three to four animals were found in open areas. Several small groups of deer which had been noted from the air 3 days earlier had dispersed, and two marked does had moved 4 and 8 miles, respectively, presumably in response to hunter activity.

A yearling doe harnessed on December 4, 1964, was approached by hunters while bedded in a slough the next day but did not move out even though the hunters came within 50 yards. The following day she was chased from the slough, pursued 2 miles west, and, after outdistancing her pursuers, she continued on 1 1/2 miles farther to a small slough. Three days later when jumped from her bed she moved about 2 1/4 miles east. After spending 3 days in a large slough she moved 3 miles north to the river bottom where she joined an older doe and two fawns. During the next 2 weeks she was observed several times with the doe and fawns and ranged over an area about 2 by 3 miles in size. Most movements were between patches of dense cover or into harvested cornfields. Some movements were over a mile, both during the day and at night (Fig. 11).

On the morning of December 26, 1964, the radio-harnessed doe was bedded in a thicket about 30 yards wide by 50 yards long on a section corner. In the afternoon she was still in the thicket, though tracks in the fresh snow indicated that hunters had driven around the thicket and that at least one hunter had

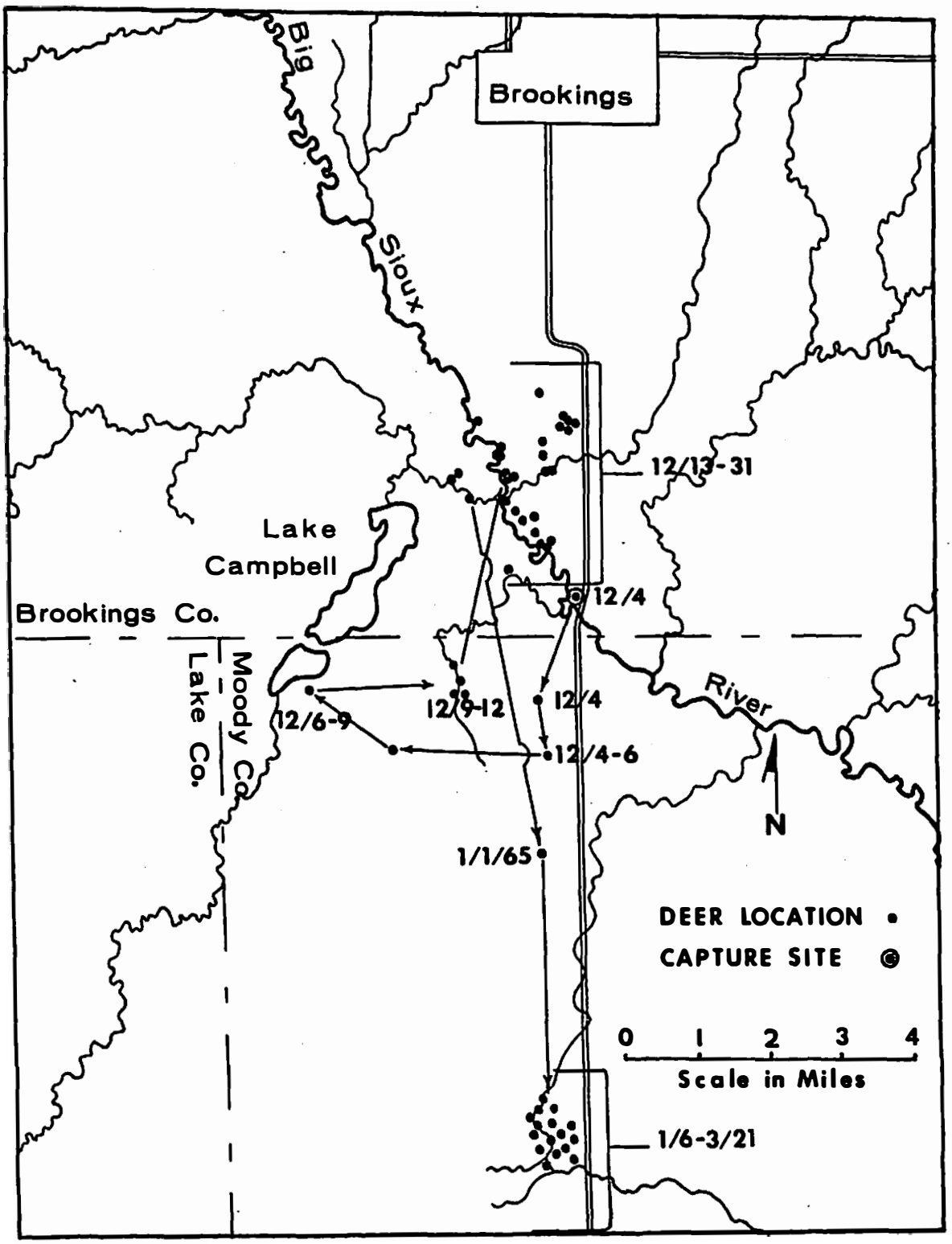

Fig. 11. Movements of yearling doe, December 1964-March 1965 (radio-tracked December 3, 1964-February 2, 1965). Some points represent more than one fix or sight record.

walked through it close to the deer. When encountered in the open this doe would run up to a mile or more, passing some good escape cover, until she reached the safety of the river bottom.

During the rifle season in 1965 a radio-harnessed doe with her marked fawn stayed in a clump of tall grass and a weedy field adjoining a large willow thicket near the Big Sioux River. These deer had spent the summer and fall in the same area. Five other deer, including a buck pursuing an unmarked doe, were frequently seen at night in the same weed field. The activities of the buck while chasing the unmarked doe near the road on the third morning of the hunting season attracted hunters who chased the deer from the area. The harnessed doe was located 1 3/4 miles downriver but moved back to the same field that night accompanied by her marked fawn. Two days later she was again chased 1 3/4 miles downriver, and again she returned with her fawn (Fig. 12).

Late Bow Hunting Season. - The second part of the 1964 and 1965 bow hunting seasons began on December 12 and 11, respectively, 6 days after the close of the rifle seasons and extended through December 31. Colder weather and skittish deer prompted archers to resort to drives rather than stands, often chasing deer for several miles. A December 18, 1965, aerial survey indicated that deer had withdrawn from large parts of their summer range and had begun to gather in groups of from 5 to 24 animals (Fig. 13). Several scattered individuals or pairs were also noted (Fig. 14). A large wooded draw, which was closed to hunting, was used by

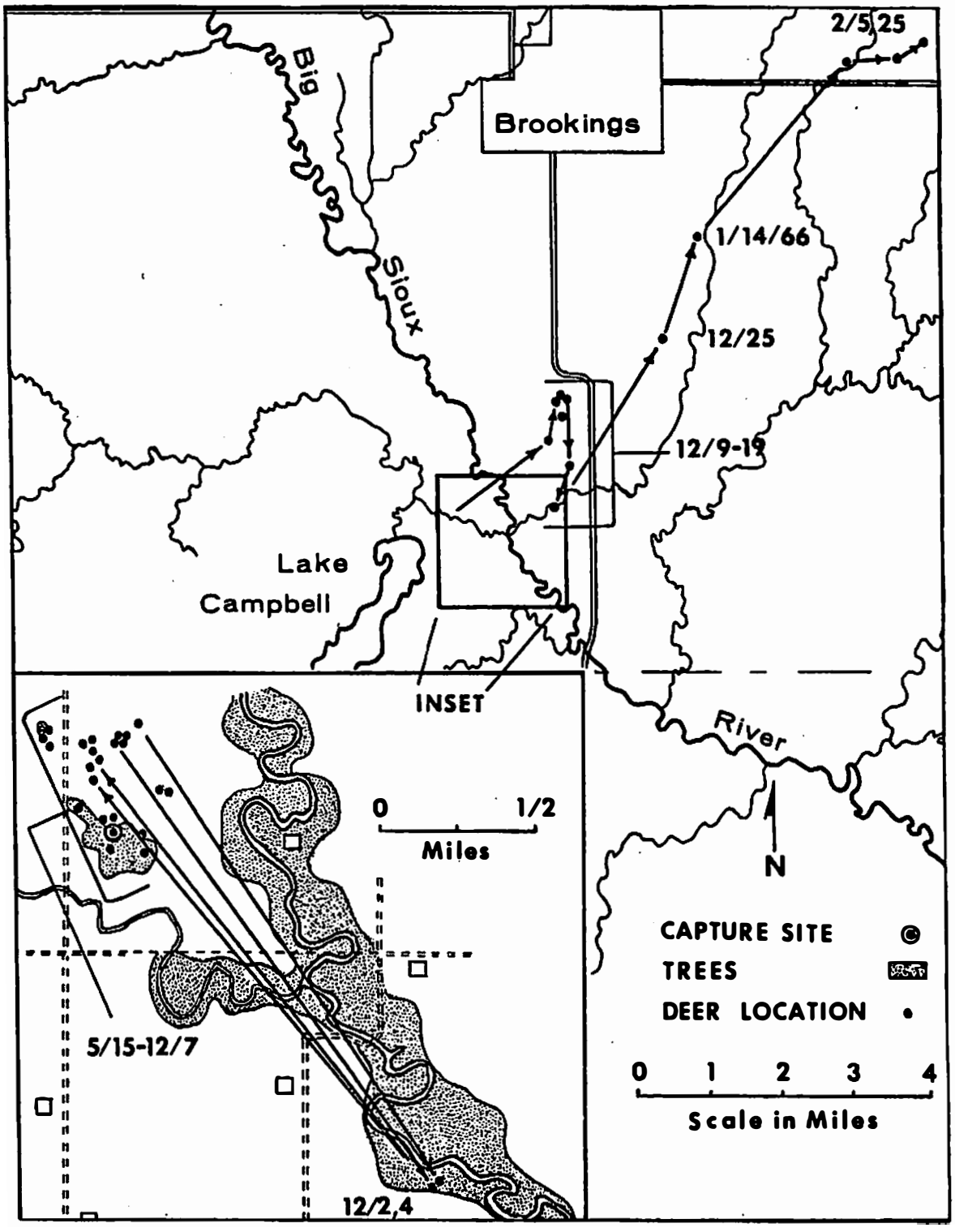

Fig. 12. Movements of yearling doe, May 15, 1965-February 25, 1966 (radio-tracked November 26-December 18, 1965). Some points represent more than one fix or sight record.

Fig. 13. Aerial photo of part of a herd of 40 deer crossing a corn stubble field.

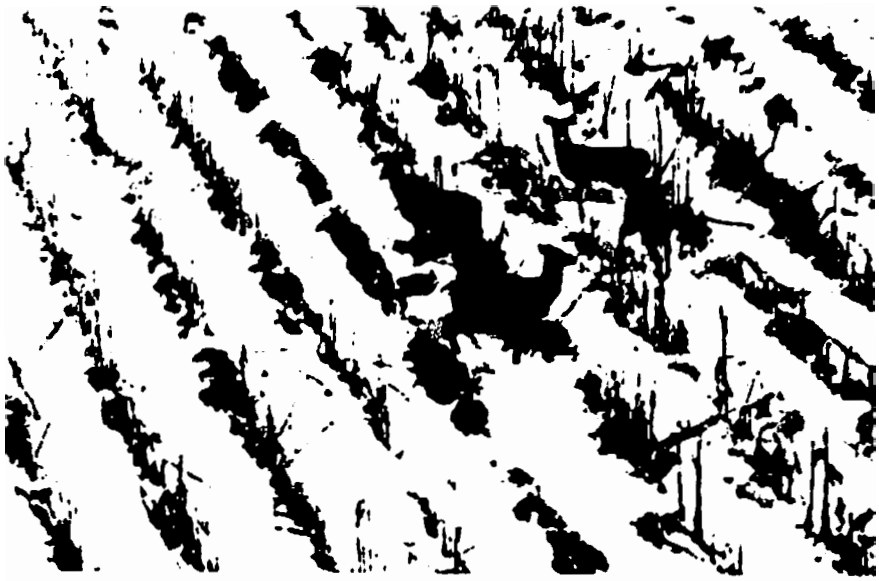

Fig. 14. Deer rising from their beds in a harvested cornfield.

deer during this time, as were soil bank fields and cornfields. Most other areas of woody growth were subject to hunter disturbance and were avoided by deer. Harvested cornfields were frequently used as daytime bedding sites in late December (Fig. 14). Deer bedded in open fields were not easily approached by hunters.

On December 19, 1965, a herd of 24 deer, including 6 identifiable animals, was harassed by four parties of archers in a 2-section block. Most of the group stayed together during the day, moving into the center of one section and bedding at the junction of a harvested cornfield and a large pasture or standing in other open areas where they could observe any attempts to approach them. Just before dark four parties of hunters approached the deer, and the animals split into smaller groups and left the 2-section area. During the next week four groups of deer, including three of the six identifiable animals, were located in four different directions from the 2-section area, all about 1 1/2 miles away. In January and February five marked animals from this herd were all located at distances up to 10 miles from the 2-section area (Fig. 15).

The activities of archers during late December 1965 were more sustained than in 1964. Whereas hunting pressure was light in late December 1964, drives along the river and in other areas continued until the season ended in 1965. An adult doe, radio-harnessed on December 22, 1965, spent 2 days and nights bedded in the middle of a harvested cornfield near the Big Sioux River.

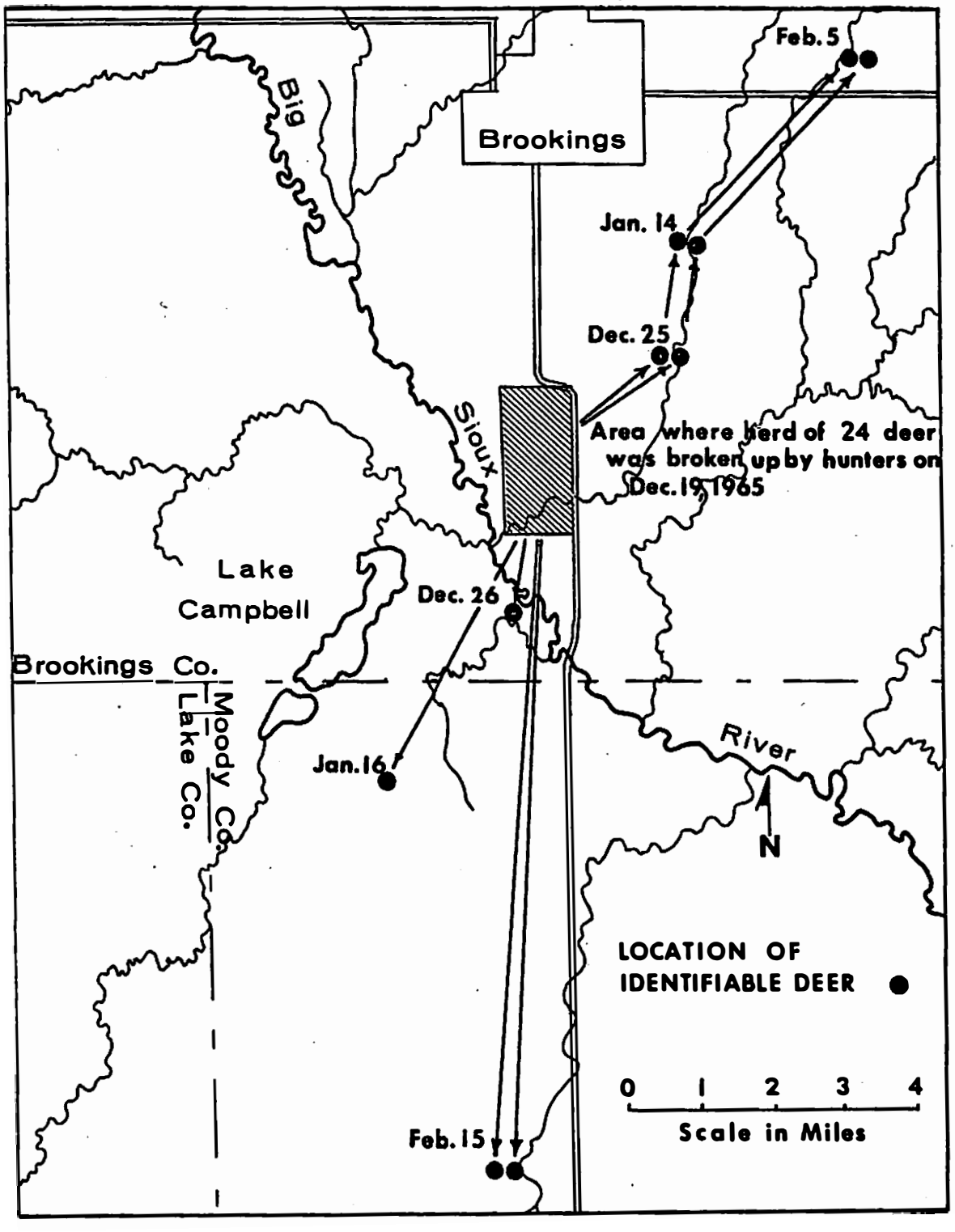

Fig. 15. Movements of marked deer from a herd of 24 broken up by hunters. Each point represents one animal.

The doe moved into the river bottom for 2 days; then the radio signal was lost. Hunter drives through the area failed to drive her out, nor was she seen by the hunters. An aerial and radio search for this deer along more than 15 miles of river bottom and a check of all known nearby wintering areas failed to locate this animal, indicating that she probably had moved rapidly over a considerable distance. This supposition was confirmed when she was reported almost 10 miles south in late February.

A general movement of some deer toward the northeast during December 1965 contrasted with the tendency of deer to remain near the river or to move southward in late December of 1964. This was attributed to a larger number of hunters and greater hunter pressure along the river in 1965.

Winter Deer Herds

Herd Formation. - Although snow cover was light and food and cover were readily available over much of the area, some deer gathered in herds by the first week in December. A herd of 19 deer was broken up by hunters during the December 1964 rifle season, and herds of 7 and 12 deer which gathered before the 1965 rifle season were broken up by hunters during the first weekend of the season. It is doubtful that any herd could remain discrete during the rifle season since activities of hunters were intensive and thorough. Hunters often drove through heavy cover several times in a single day and chased all or part of

the herd for several miles. After December 31 deer were free from hunting pressure and subject to normal winter influences of weather and daily feeding and bedding requirements. Discrete herds of up to 80 deer were formed.

Herd Location and Activities. - Areas with unused or washed out section-line roads creating 2- or 3-section blocks were favored by deer herds during the winter. Large sloughs and wooded areas in draws or along stream bottoms were often used. All of the wintering areas had the common characteristics of being relatively free from activities of humans or livestock and offering a good food supply as well as protection from the cold winds which commonly blow during winter. One area included wide expanses of stubble-covered hills, a broad, flat open area, and some tree cover along the river, but had none of the heavy cover afforded by sloughs and dense river bottom. Avoiding the human disturbance factor apparently was more important than other considerations such as heavy cover.

In February and March of 1964 a herd of 48-80 animals used a 50-acre slough 2 miles southwest of the Big Sioux River. The section surrounding the slough included stubble fields of hay, corn, and alfalfa, whereas the slough contained quaking aspen (Populus tremuloides) and willow in addition to semi-aquatic marsh vegetation. The herd was not easily approached and when startled would run toward the river, heading directly north out of the section by following a trail across harvested cornfields

to a small bluff, and then proceeding either straight to the river or to a large willow thicket 2 miles north. Groups of deer from the herd would sometimes travel the same route between the slough and the river or to the southeast into other adjoining sloughs (Fig. 16).

Heavy hunting pressure in the wintering area probably caused these deer to avoid contacts with humans and undoubtedly contributed to their shy behavior.

The herd fed most often in adjacent cornfields and browsed on willow and aspen in the slough. When a foot or more of snow accumulated in the fields, the herd fed more frequently during mid-day and for longer evening and morning periods.

The owner of the slough reported that wintering deer had gradually increased from 30 to 60 animals over an 8-year period. When first observed on February 11, 1964, 48 deer were counted. More than 60 were observed on February 18, and more than 80 on March 9. The additional deer probably moved in from the Big Sioux River or nearby sloughs. On March 10, while two Clover traps were being set in the slough, the herd moved out to the north and never returned. The deer remained scattered along 2 miles of the Big Sioux River and in one large willow thicket near the river until the thaw in mid-March. By late March many of the deer had left the wintering area.

In 1965 a herd of from 24 to more than 30 animals was observed from January 6 until the first week in April. The herd used a

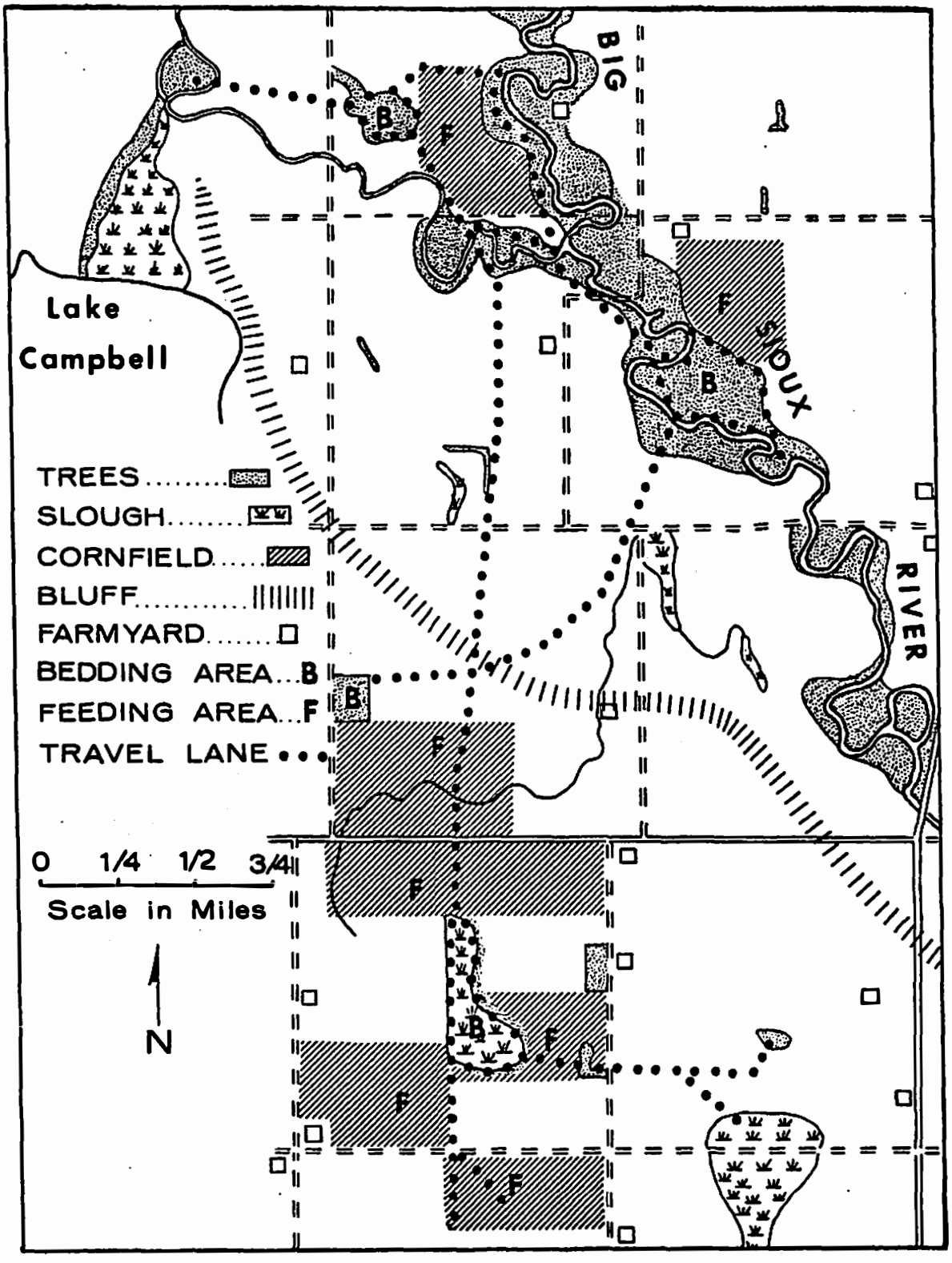

Fig. 16. Activities of herd of 48-80 deer, February-March 1964.

slough in north-central Moody County on the west side of a well travelled highway. The slough was 3/4 mile long, varied in width from 50 to 400 yards, and was composed mainly of tall, dense river bulrush (Scirpus fluviatilis) with some broad-leaved cattail (Typha latifolia). The surrounding fields in the section were corn stubble, alfalfa, or heavily grazed pastures. The road across the south end of the section was closed by snow drifts, forming a 2-section block in which the deer were relatively free from human disturbance. The section to the south was hilly with corn stubble and many heavily grazed pastures. Two large thickets of willow and other deciduous trees were located in the southeast corner near a farmyard, but deer were never found in them. A drainage ditch ran north into the large bulrush slough and was used by the herd as a travel lane to cornfields in the south section (Fig. 17). A chain of sloughs ran south-eastward through 2 sections on the east side of the highway.

Usually the herd numbered about 24, but on several occasions 6 or more additional deer were seen with the herd for short periods. These deer probably moved in from a herd of more than 50 animals which wintered in a large slough complex 3 miles to the southwest.

The usual daily pattern of herd activity included feeding in cornfields or alfalfa in the morning, bedding in the slough during mid-day, and then gradually moving out into the fields in late afternoon and evening. Deer usually began to leave the

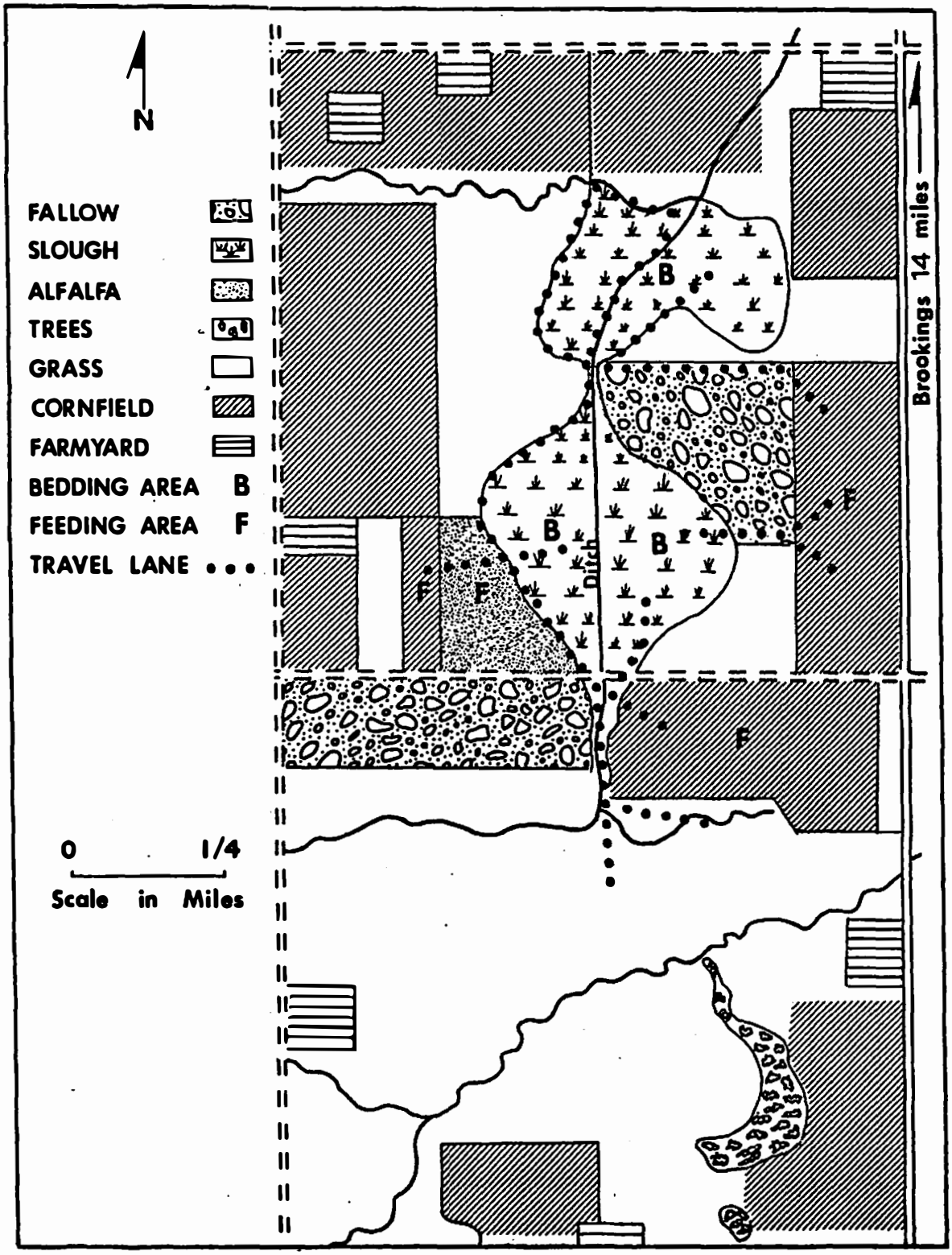

Fig. 17. Activities of herd of 24 deer, January-March 1965.

slough about 2 hours before dark, browsing on marsh vegetation as they came and then leaving the slough in a steady streem after a few individuals had made the first move into the open.

These deer were often seen next to the highway by motorists at night, and one animal was killed by an automobile while crossing the highway to the east. Often, parts of the herd were observed feeding or moving about during mid-day, but evening feeding movements usually included the entire herd. Increased daytime activity was noted when snow covered the fields to a depth of more than a foot.

Local residents indicated that although a good number of deer had been present during the rifle hunting season, few, if any, hunters had entered the slough. This lack of disturbance by hunters undoubtedly contributed to the relative serenity of the herd and to their stable behavior in a small area.

Some wintering areas were used by herds in more than one winter, whereas other areas were not. Fig. 18 shows the location of known winter herds in 1964, 1965 and 1966. Only partial information is available for 1964. A slough used by a herd of 80 deer in 1964 (near Lake Campbell) was not used again in 1965 or 1966. A 2-mile stretch of river bottom used in 1964 and 1965 was unused in 1966. No essential differences in the vegetation, the food supply in surrounding fields, or the amount of human activity were noted between years. Several specific areas were not used in succeeding years, but a herd did gather in the same

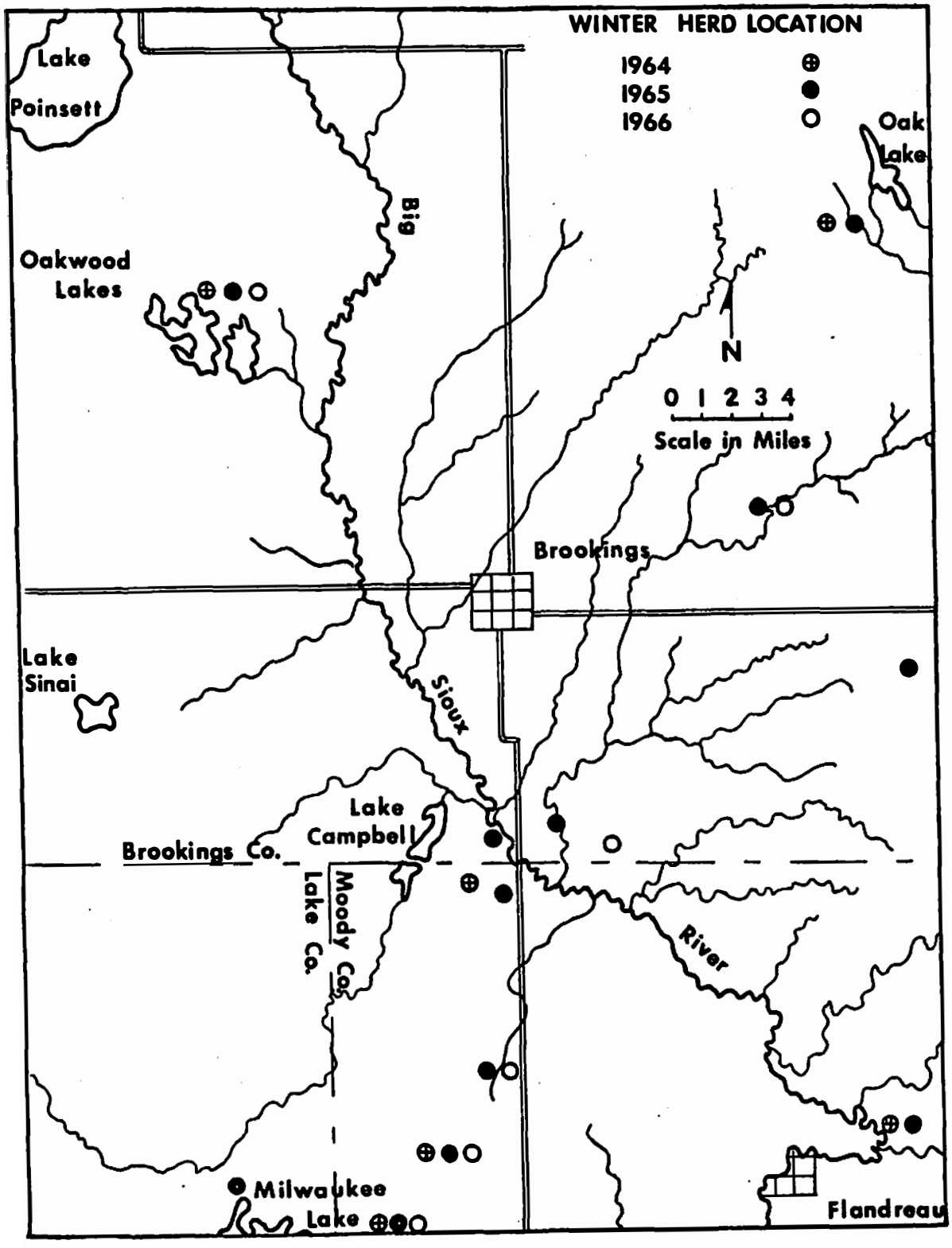

Fig. 18. Location of winter deer herds 1964, 1965, 1966. Incomplete data for 1964.

general area. The differences in use of specific areas in 1965 and 1966 probably resulted from the tendency of deer to remain more widely dispersed through the winter in 1966 than in 1965.

Behavior of Deer in Herds. - Deer herds usually acted as a unit with one or more individuals acting as leaders. Even if the whole herd was not alarmed, the first movement by an individual often instigated action by the entire group. Feeding activities of herds bedded in sloughs or other heavy cover were often begun by one individual, usually a fawn or yearling of undetermined sex, which moved into the open. Other deer usually followed soon after, and the group would wander leisurely into the cornfields and begin feeding. While the herd was feeding a few individuals were alert at any given time, and certain ones seemed more watchful than others. When one individual was alarmed and bolted, the entire herd would often follow, bounding off without seeing the danger, and running as much as 2 miles before stopping. Among herds which commonly bedded in sloughs, an alarm reaction by one or a few deer would usually provoke a general flight through the slough into the open on the opposite side. Some deer were alarmed by the flight of others to the point that they left their beds and bounded off with the rest of the herd. In some instances, deer a half mile away would be attracted by the movement of fleeing deer and would join the main group. When alarmed, winter herds seemed to prefer to run into an open area where they could see all around them rather than to seek heavy

cover.

Family groups of an adult doe with fawns, often accompanied by one or more yearling deer, were frequently observed in herds. One radio-harnessed yearling doe and an older doe with fawns bedded and fed together, often slightly apart from the herd of 20 deer with which they were wintering. Dasmann and Taber (1956: 148) considered such family groups to be the most stable social unit within black-tailed deer herds.

One marked adult doe apparently led a group of 8-12 does and fawns on daytime wanderings. She was aggressive in encounters with other deer. Twice during mid-day the group was seen wandering around the section, making no attempt to feed. The fawns were running and jumping about as if playing. Severinghaus and Cheatum (1956:163,164) believed that play patterns were less developed in white-tailed deer than in mule deer (O. hemionus), but in the present study fawns and yearlings in winter herds were often observed chasing each other around vigorously.

Some deer exhibited antagonistic behavior toward other deer when feeding in cornfields. Several times when a feeding family group was approached by other deer, an adult doe in the group laid her ears back and threatened the approaching deer, sometimes by striking out with her forelegs. Defense or return antagonism was never noted. On one occasion a fawn approaching a doe with two fawns was driven off by the doe. Large bucks were given a visibly wide berth by other deer on feeding areas. Lowering of

the head in a threatening manner by large, antlered bucks caused smaller deer to leap aside. Severinghaus and Cheatum (1956:118) described "an obvious tendency toward group dominance by larger deer" among white-tailed deer in the Adirondacks. Dasmann and Taber (1956:159) found that dominance hierarchies were well developed among black-tailed deer. In areas with heavy snow, a scarcity of food, and large numbers of competing deer, such as in the deer yards of the Lake States, younger animals may experience serious food shortages when forced to compete with older deer (Kabat et al. 1953:15,16). In eastern South Dakota such behavior is probably of little survival significance because food is readily available to all ages and sizes of deer.

Herd Stability. - Some winter herds maintained stable numbers, but there was considerable movement between herds by individuals or small groups of deer. On January 1, 1965, a radio-harnessed yearling doe with an older doe and two fawns and eight other deer moved from the Big Sioux River overland almost 10 miles to the south to join a herd wintering in a slough. Two marked fawns moved 6 and 12 miles south between winter herds during February 1965. Several other deer were trapped, marked, and released near areas used by winter herds but were never seen with any of the known winter herds on the study area. These were probably transients, not part of the local herds.

On February 5, 1965, when the air temperature rose from a nighttime low of -24 F to a high of 28 F (a rise of 52 F), a

herd of about 20 deer broke up into groups and dispersed up to 2 miles from the bedding location. A week of daily temperatures averaging almost -9 F had preceded this date, and two days averaging almost 30 F followed. A week later, when the temperature had dropped again, these deer apparently joined others to form a herd of 35 about 3 miles to the northwest. A similar increase in activity of wintering deer on days when the temperature rose rapidly was noted at other times during the study and may be an important factor influencing both movements and herd stability.

Spring Dispersal and Movements

Herds generally remained distinct until the spring thaw which occurred in mid-March 1964, early April 1965, and early March 1966. When the thaw began, some herds broke up immediately, whereas other herds gradually broke up into smaller groups and began to disperse. Animals moved out in several directions and at varying rates, but a definite predominance of northward movements along the Big Sioux River and its tributaries was noted.

The most complete information is available for the spring dispersal in 1965 (Fig. 19). During the first week in April the thaw caused extensive flooding of the Big Sioux River, its tributaries, and nearby sloughs. The flooding accelerated the dispersal of winter deer herds from sloughs and from the Big Sioux River. By the second week in April most herds had moved

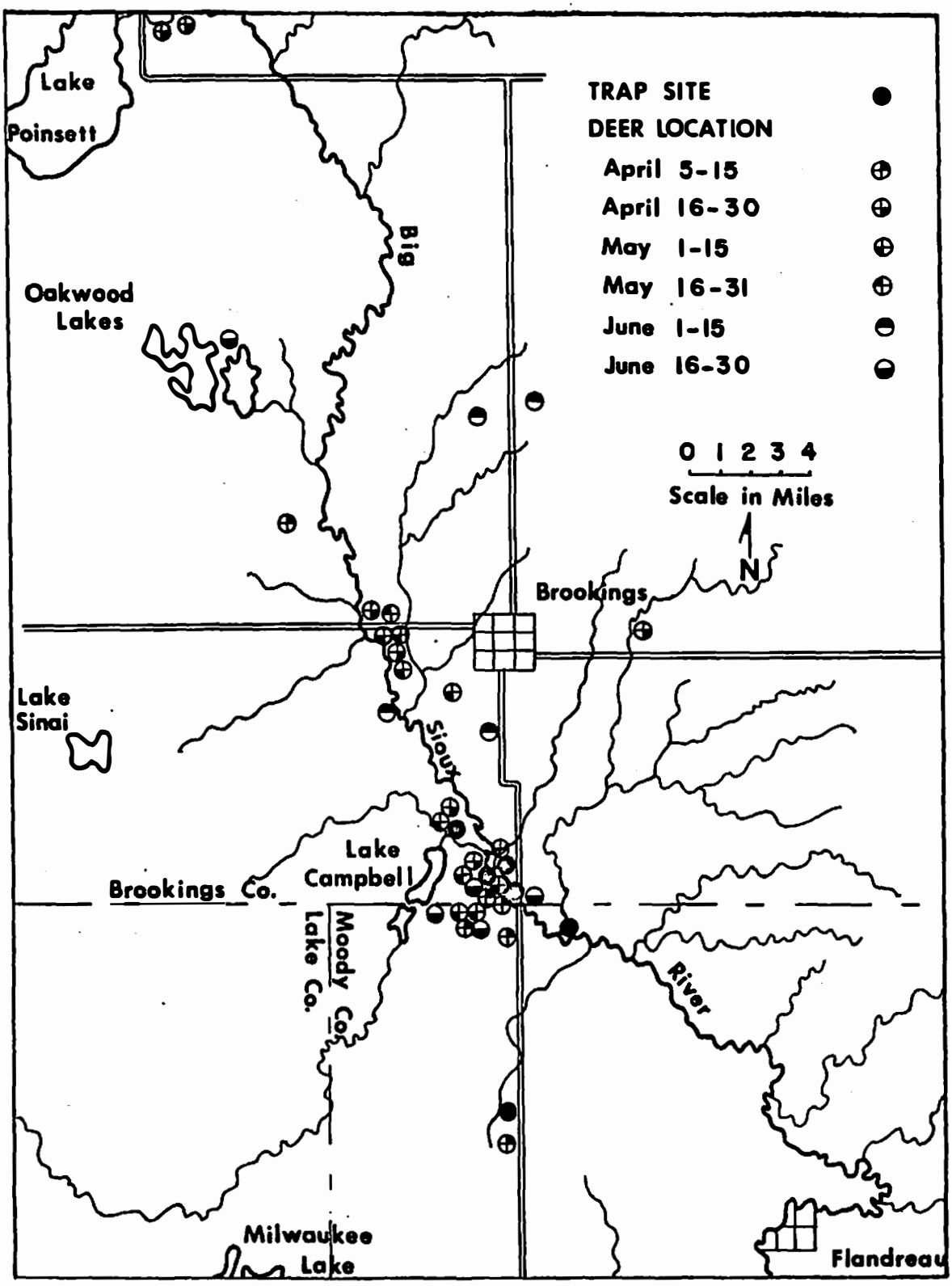

Fig. 19. Dispersal of marked deer in spring and early summer, 1965.

out of their wintering areas and were broken up into small groups. At this time some marked individuals were sighted by local residents near the wintering areas, but other deer moved farther and more rapidly, and on April 6 reports were received of marked deer 15 miles northwest of the nearest trap site. On April 24 a marked deer was sighted more than 30 miles northwest of the nearest trap site and was reported 4 miles farther north later the same night. None of these reports allowed positive identification of the deer, but the descriptions indicated that all three sightings may have been of the same animal. The descriptions also indicated that the deer probably was one which had been with a herd until the first week in April.

Dispersal records are available for 5 of 6 marked deer from a herd of 24 which wintered in 1964-65 in a north-central Moody County slough (Fig. 20). During the first week in May a radio-harnessed adult doe and a marked yearling doe were observed 18 miles north of the slough. Soon afterward a marked yearling buck which had been tagged in the slough, but which had been transported 9 miles north during the winter because he had become a pest in the traps, was observed in the same section as the other two marked deer. All three deer were reported together during May. On June 8 the yearling buck was killed by a car as the three deer were crossing a highway next to the Big Sioux River. The fact that these deer originally were marked at the same slough, plus their behavior when observed together, suggested

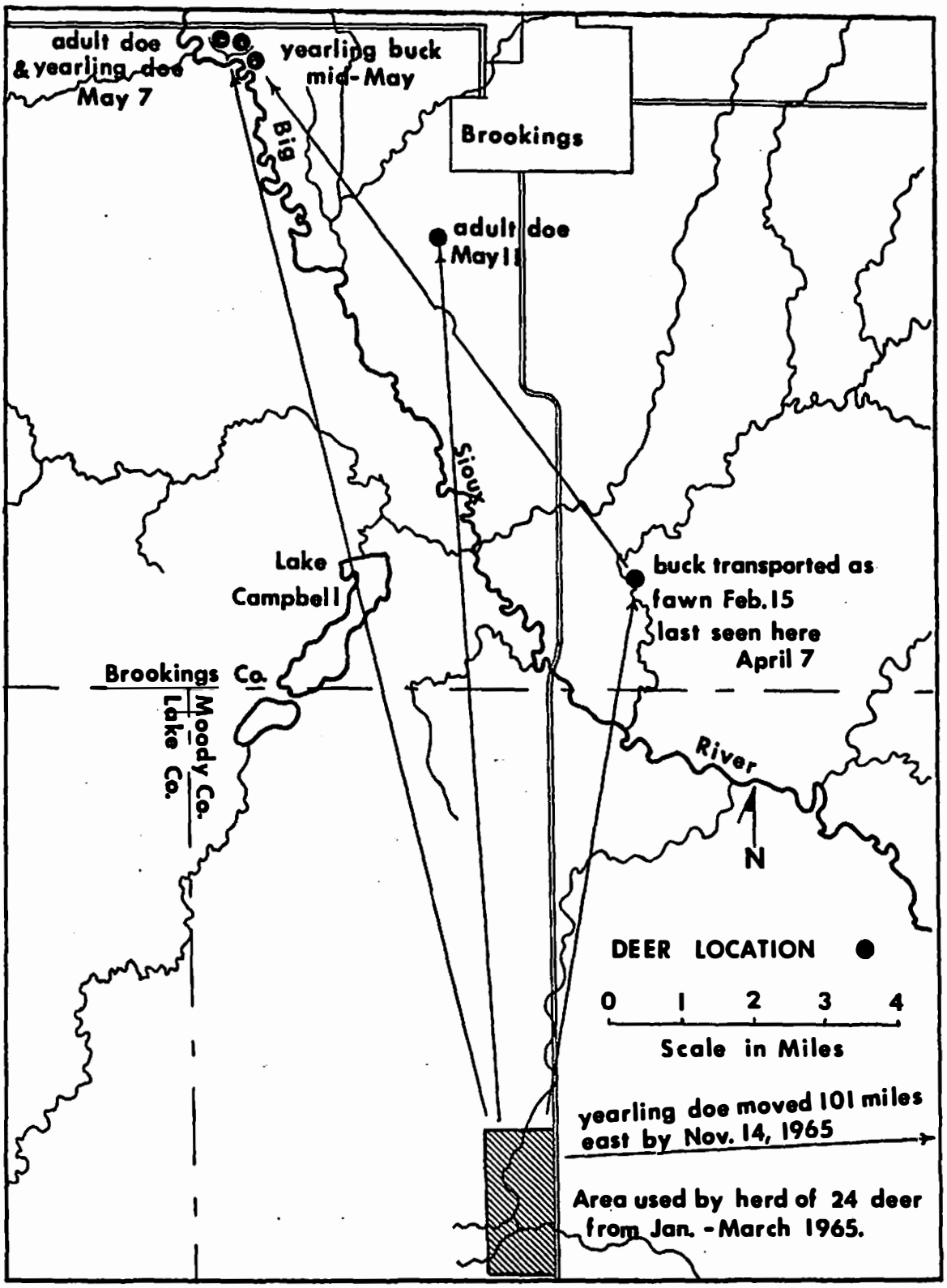

Fig. 20. Dispersal of marked deer from a herd of 24 in 1965.

that they may have been a family group. Another adult doe moved 13 miles north of the slough by early June. In contrast to these animals which moved north up the Big Sioux River, a yearling doe travelled more than 100 airline miles east into Minnesota between March 21 and November 14, 1965, crossing two rivers and leaving the Prairie Coteau.

Radio-tracking data on an adult doe in late April and early May of 1965 showed that some deer did not move out as rapidly or as far as other deer. A brief aerial search for the same doe revealed that three marked fawns, plus some other unmarked animals, were still in the same heavily timbered section of the Big Sioux River bottom in which they had been trapped and marked during the winter. Six days later a herd of dairy cattle was released on the same section, and the deer apparently moved out since one of the marked fawns was observed 1 1/2 miles to the northwest. By the first week in May some marked deer, particularly does, had apparently reached their summer ranges since they were reported at the same areas in which they were later located throughout the summer.

DISCUSSION AND CONCLUSIONS

Methods

Retention of Markings. - Almost 90 percent of the markings used were accounted for from a week to 16 months after being placed on deer. Nearly half of those accounted for were lost

by deer during the same interval. Four Boltaron collar losses were attributed to breakage at temperatures near or below zero, one collar was lost during warm weather, and three were lost at unknown times. Fashingbauer (1962:213) found that Boltaron may shatter upon severe impact at near zero temperatures. Results of the present study agree with those of Fashingbauer who recommended that a plastic more suited to stress at cold temperatures be found. Five Saflag collars were lost to unknown causes. Thirteen deer lost one or more ear tags over periods from a few days to almost a year. Some tags probably pulled free when deer were moving through heavy vegetation. One buck lost a tag while fighting during the rut. Other bucks might have lost tags while rubbing velvet off their antlers. Craighead and Stockstad (1960:436) found that movement of streamers attached to cattle ear tags caused ear irritation in penned deer and elk, and that some tags were lost within a year. In the present study no evidence of ear irritation was noted in marked deer retrapped or returned dead. The large gap between sides of the clamped tag could have allowed the tag to catch on vegetation and pull free. Smaller, more tightly fitting tags might be retained longer.

Deer Sightings. - Few marked deer were sighted during the summer because of the dense cover afforded by cornfields and other heavy vegetation. Most of the summer sightings were of a few marked deer which were observed in the same areas several times. The more open nature of the cover in the fall, winter,

and early spring, greater mobility among deer at these seasons, and a large number of hunters active in the fall and winter resulted in more sightings during these periods. Archers were particularly valuable as observers because their careful hunting methods often allowed a close look at an animal.

Newspaper articles, posters, letters to residents, talks at sportsmen's and service clubs, and many personal contacts yielded limited assistance by the public. Reports of sightings were often received indirectly, incompletely, and long after their occurrence. Even persons who knew about the study and the importance of reporting marked deer failed to do so because they thought the investigator "always knew what was going on". Some bias is believed to exist in the predominance of deer movement records along the Big Sioux River in the center of the study area because the people best acquainted with the study, including the investigator, were in this area most often. There was probably a greater chance that a marked animal would be reported more than once in the same area than in a new area, because as word of the first report was circulated, people began to look more carefully in the report area.

Telemetry Problems. - A lack of competent electronics assistance greatly hampered radio work during the study. Many technical problems were encountered in the form of greatly variable performance by the transmitters and receivers in the field. Each transmitter performed differently than the others,

and the performance of individual units changed daily and even hourly. The range of some transmitters varied from 50 yards to a mile within a few hours time, while the animal had apparently not moved. Tests with sample transmitters revealed that location of the transmitter, location of the receiver in relation to the transmitter, time of day, and temperature caused the greatest variation in performance. Powerlines, farm machinery in operation, hilly topography, and possibly geological formations inhibited the reception of a signal. Interference from machinery and other radio transmission was heavy at all hours on weekends and during the daytime on weekdays, but usually decreased at night during the week. Prolonged subzero weather reduced the efficiency of both transmitters and receivers.

Batteries lasted as long as 8 weeks, but most transmitters failed for other reasons long before the batteries ran out. Breakage of the whip antenna cut transmitting range drastically on two occasions, whereas three transmitters failed when the harness slipped. Harness failure was attributed to slippage of the main saddle loop over the shoulders and eventually over the head of the deer. This apparently resulted from making the dorsal connecting strap on the harness too short, causing the harness to shift forward with movement of the shoulders.

Influence of Study Methods on Deer. - Collars, ear streamers, and radio-harnesses normally caused no evident physical difficulties to the animal or changes in behavior between marked deer

and their unmarked companions. After their release most deer apparently adjusted to the presence of their new "equipment". One small fawn chewed the ends of its ear streamers, and another fawn chewed the ends of streamers which were attached to the collar. A few deer were bothered by long ear streamers flapping near their eyes on windy days and responded by shaking their heads.

Handling of captured deer for tagging or attaching radio equipment produced reactions which varied from violent struggling and loud distress calls by deer of all ages and both sexes to almost complete submission by a 6-month old doe. The most aggressive animal was another 6-month old doe that was trapped three times. During each handling procedure this fawn bawled continuously and struck out at the handler with her forelegs. Radio-harnessed deer ran up to 2 miles after their release. Two radio-equipped does remained hidden in heavy cover for several days after their release before they apparently resumed normal behavior. These examples indicate that handling and marking may cause some individuals to behave abnormally for an unknown period, whereas others may be affected less.

Harnesses slipped over the heads of three radio-equipped deer, and one other harness broke after 6 months of wear. Running and jumping movements of the animals were impeded by the large saddle loop hanging from their necks, and deer thus encumbered were observed to lie down more frequently than others. The

broken harness fell off while the deer was still on the summer range, whereas two of the other deer moved 6 and 8 miles, respectively, during the winter while dragging their harnesses and were apparently able to keep up with groups of deer with which they travelled. The fourth animal had to be destroyed when she was apparently injured from becoming tangled in a wire fence after the harness wrapped around her forelegs.

The markings used made it easier for a hunter to see a deer and probably increased hunter harassment of marked animals. Four marked deer were killed because they wore conspicuous markings. Two radio-harnessed bucks and one collared doe were killed by hunters who saw the markings and selected the marked deer to shoot. One collared buck was killed by an automobile because the attention of the driver was averted by the presence of two additional marked animals at the roadside. These findings agree with those of Gruell and Papez (1963:417) who found that belled mule deer were more susceptible to hunting than unbelled deer.

The presence of the investigator caused deer to move fairly long distances on several occasions. These movements were not considered unusual because deer on the study area were normally exposed to similar human interference during the course of their daily lives and presumably reacted in the same manner.

Value of Aerial Surveys. - The use of a light airplane proved of great value to this study. Movements of marked and unmarked

deer and winter herds were readily traced from the air. Deer tracks were easily followed after a fresh snowfall. Snow was not necessary to count deer, but animals were easier to locate when fresh snow covered the ground.

Hosley (1956:229) in his review of the literature on airplane counts of deer concluded that aerial counts were most reliable where tree cover was scarce. In this study marked deer were observed and identified readily in sloughs or open fields but with difficulty when in tree cover along the river. Numerous low passes over sloughs and tree cover were necessary to make deer stand up so they could be counted or identified.

Intensive aerial counts of deer on known concentration areas corresponded closely to ground counts, and in some cases deer were seen from the air where they were not seen from the ground. Numerous passes (up to 10) over an area were often necessary to locate deer, even on known concentration areas. Deer were hard to find from the air in areas which were new to the observer.

Factors Influencing Deer Movements

Rutting Season. - Because rutting activities coincided with the deer hunting seasons, crop harvest, and seasonal changes in habitat and weather, the effect of the rut on deer movements was not clear. Movements of a yearling buck (Fig. 10) and movements of several unmarked bucks between areas occupied by does suggested that bucks may move considerable distances because of breeding activities. Three times during the study bucks were

observed vigorously chasing does, engaging in short dashes back and forth or in circles, and occasionally running off in straight chases of several hundred yards until they were lost from sight. Dasmann and Taber (1956:146-147) reported that blacktail bucks travelled widely from one doe group to another. There are some indications that whitetail bucks may travel farther during the rut than at other times of the year (Severinghaus and Cheatum 1956:152).

Cattle and Farm Operations. - The presence of cattle apparently reduced the potential value of some areas as deer habitat. In the spring when cattle were first turned out along the river, deer moved out. As the vegetation became more dense and browse and cover became available, deer moved back to the river but avoided those areas used by stock for bedding. A similar pattern was noted in thickets and shelterbelts. When cattle were allowed to heavily overgraze the vegetation, deer use decreased and, in some cases, ceased. Certain thickets and shelterbelts which were grazed year-round were used little by deer, if at all. Some areas which offered potentially good wintering habitat were unused, presumably because cattle were present on all or part of the area. Several pastures or hayfields were heavily used by deer in late summer and early fall but received little or no use after cattle were turned out to pasture. A similar reduction of deer use was noted in the fall and winter when cattle were allowed to feed in harvested cornfields.

Deer movements were apparently not greatly influenced by the intrusion of farm machinery engaged in planting or harvest. These operations seldom disturbed deer which were feeding or bedded close by. Farmers related that does with fawns were often closely approached by a moving tractor but ran off if the operator dismounted.

Shelterbelts and soil bank fields close to farmyards were often used by deer for long periods.

Habitat. - Deer, being creatures of the "edges" (Severinghaus and Cheatum 1956:137), have adapted well to intensive agriculture in eastern South Dakota. The interspersion of pastures, grain and hay fields, cornfields, sloughs, shelterbelts, and stream bottoms furnishes excellent deer habitat for about 6 months of the year. In late spring, early summer, and early fall, food and cover are abundant everywhere, and deer of all ages may be found throughout the study area. This abundance of habitat needs means that deer do not have to travel far to find their daily food and cover requirements.

In the late fall, winter, and early spring, food is still readily available throughout the study area, but heavy cover is limited. Sloughs, shelterbelts, stream bottoms, and soil bank fields supply the heavy cover at this time, but the expanses of cornfields and other croplands are bare (Figs. 21,22,23,and 24). This limited amount of suitable winter cover, both for protection from hunters and from weather, may be the factor limiting deer

Fig. 21. Aerial photo of Big Sioux River.

Fig. 22. Wooded oxbow that provided escape and bedding cover for deer. Big Sioux River in background.

Fig. 23. Aspen and willow slough used as winter bedding area. Surrounding cornfields provided feeding sites.

Fig. 24. Weedy soil bank field near Big Sioux River. Note collared fawn.

populations on the study area. The problem on most winter ranges in northern latitudes is one of food as well as cover (Kabat et al. 1953:15,16, Dahlberg and Guettinger 1956:146). Mustard and Wright (1965) found that corn was the food item most heavily utilized by Iowa whitetails. Deer in the present study utilized corn throughout much of the year, particularly in the winter, and waste corn was available in almost every section on the study area.

The constantly changing nature of the habitat from widespread cover to restricted cover through the seasons greatly influenced deer movements. When cover conditions were optimum, as in the summer, deer movements tended to be restricted. When cover was scarce, deer movements were partly controlled by the available heavy cover. Wide expanses of open fields often were transversed between patches of heavy cover.

Hunting Seasons. - Hunting influenced deer movements and distribution more than any other factor. The early bow hunting season in November drove deer from heavy cover at the time when the harvest was reducing available cover in the fields. Archers were persistent, and marked deer moved up to 14 miles because of hunting pressure. Although success was low for bowhunters, there have been more archers in the field in each succeeding year of the study.

The combination of rutting activities, the archery season disturbance during November, and a great reduction in available

cover makes deer especially vulnerable to rifle hunters in early December. Many local rifle hunters show little hunting "finesse" but are very efficient in covering the areas used most by deer. Reported success consistently approaches 90 percent. Thickets and brushy cover are worked by men on foot, whereas soil bank fields are covered by car or pick-up. The scarcity of heavy cover results in repeated hunter movements through the same patches of cover, often several times in a single day. Bad weather, the rut, and hunting disturbances seem to first cause deer to group together. They then become more conspicuous and are harassed by hunters. This same pattern continues through the late bow season in December, when cold temperatures and the approaching end of the hunting season force archers to act more like rifle hunters and resort to drives. Archers seeking deer in open areas are rarely successful but disturb deer and cause considerable movement.

An increase in the number of rifle permits (from 100 in 1964 to 150 in 1965) in Brookings County and a greater number of archers produced noticeably stronger hunter pressure on the Big Sioux River and a few other areas of heavy cover in the county. The number of rifle permits in Moody and Lake Counties remained the same in both years. In 1965 a general movement of deer out of the river bottom and other heavy cover was noted, and the area of greatest deer density shifted to the northeast in open, hilly country. The same pattern continued through the late

bow hunting season in 1965. Following the 1965 hunting seasons more deer wintered in the northeast than after the 1964 seasons, and only one herd gathered on the Big Sioux River bottom.

Because of the restricted escape cover during the hunting season, the deer population could be seriously reduced if too many permits were issued. Deer in the study area have compensated for this lack of cover somewhat in that they often take to open fields for protection from hunters (Fig. 14). Although this behavior is an important factor for survival, it alone would not prevent excessive harvest.

Home Range and Movements

The home range concept, or some modification of it, has been employed by many writers in attempts to categorize and partially explain the daily and seasonal movements of animals. Burt (1940:25) defined home range as "... that area about its established home which is transversed by the animal in its normal activities of food-gathering, mating, and caring for young." He also noted that home ranges may change from one area to another; migratory animals may have different home ranges in summer and winter; home ranges may vary with sex or age of the animal, season of the year, population density, or other factors; and that home ranges rarely occur in convenient designs, but are usually amoeboid in shape, and to connect the outlying points gives a false impression of the actual area covered. Sanderson (1966)

reviewed study techniques and methods of evaluating data on mammal movements and concluded that movement studies should emphasize a mammal's specific needs under all circumstances all year rather than the distance it moves, the shape of its home range, or the area covered. He pointed out (p. 219) that "If all the requirements of a species could be provided in a small area, its home range would probably be smaller - down to some unknown minimum size - than the average now found for the species." Deer movements in the present study exhibited many of the variables expressed in the above discussion.

Dahlberg and Guettinger (1956:59) found that the idea of prescribed summer and winter ranges was not entirely compatible with the situation in Wisconsin. They suggested that some deer probably develop an affinity for a small area with which they are familiar and remain in it as long as their habitat requirements are met. They felt that this affinity is not as strong when habitat conditions deteriorate or when other disturbances affect their survival. Similarly, deer in this study did not have fixed summer and winter home ranges, but had multiple summer and winter home ranges which consisted of a variable number of small sub-areas. Each of these sub-areas, alone or in combinations, supplied basic requirements (food, cover, etc.) at the time a deer used the area. Deer did not leave until one or more requirements were disturbed, depleted, or otherwise changed.

The definition of home range given by Burt (1940:25) is

used in subsequent discussion with the reservation that "the established home" of the animal is considered a shifting area rather than a fixed one.

The movements of a radio-harnessed yearling buck (Fig. 9) illustrate a shifting home range. He spent the entire period from June 16-21, 1965, in a cattail-willow-cottonwood thicket about 50 yards long and 25 yards wide. On June 21 he was jumped from a bed, and he ran 1 mile north to the river. The buck had bedded in four places on the edge of the thicket, all within 10 yards of each other, and had browsed on willow and annual forbs in the immediate vicinity of the bedding site. Apparently everything required by this buck during the 5 days was available within a few yards of his bedding site. He did not move until his safety was threatened by the intrusion of man.

The buck used a similarly restricted area of river bottom brush and timber for 3 days, then crossed the river and spent the next 9 days within a 100-yard strip of hayfield and adjoining wheatfield. He used three bedding sites and once moved back across the river for part of one night during a violent thunderstorm. Apparently this hayfield-wheatfield location was suitable for feeding and bedding but lacked protection during the thunderstorm. The buck subsequently moved 1 mile south back to the small thicket for 1 day, then moved 1/4 mile south into a slough and spent July 5-17, 1965, along 400 yards of the north edge of the slough. The only exceptions were one nighttime trip

southward around the slough, and a 1/4-mile northward movement (during a thunderstorm) into the small thicket he had used before. On July 17, 1965, he was jumped from his bed on the slough edge, and he ran 1 1/2 miles north to the river. Again, the slough edge had supplied all his needs except cover during a severe thunderstorm and protection from the intrusion of man.

The buck apparently spent the rest of the summer and the fall near the river bottom within a single section. He was reported in the same section a few times in the summer and twice in the fall. In November he was shot while in the river bottom brush where he had moved, presumably because adequate cover had been eliminated by hay harvest (Fig. 9).

Home range area calculations based on points of location for this deer give a false impression of the area used because expanses of small grains, hayfields, and pastures between the river bottom location, the thicket, and the slough were used only for travel. Similarly, including the entire thicket would give a distorted home range area since he used only a small part of it.

A yearling doe tagged on May 15, 1965, also used a restricted area during the summer. From May 15-July 29 she was observed six times, either on the north edge of the 40-acre willow thicket in which she was tagged or in a smaller thicket about 300 yards to the northwest across the road. Her fawn was marked on November 24. The yearling doe was retrapped near the original capture site 2

days later and fitted with a radio-harness. Radio-tracking data from November 26-December 7 (including the 10-day rifle hunting season) revealed that, except when disturbed by rifle hunters, the doe used a 20-acre area including a corner of an alfalfa field, a clump of tall grass and cattails, and part of a weedy field. Her marked fawn was seen with her several times and accompanied her when she was twice chased 1 1/2 miles southeast along the river bottom. Both times they returned at night to the weed field. Movements of this doe (Fig. 12) further indicate that specific areas of limited size may suffice as a home range sub-area until a change occurs, which in this case was disturbance by hunters.

Movements of a yearling doe (Fig. 11) and of a yearling buck (Fig. 10) during the fall and winter of 1964-65 illustrate that a home range area calculated from peripheral points of observation would not accurately show their home ranges. Omission of a single sight location, for example the October 17 report on the buck, would greatly reduce the total area included in the calculated home range regardless of the method used.

Many marked deer spent the winter period as part of a herd in a localized area. Movements of a radio-harnessed yearling doe in January and February illustrate the winter activities of one individual (Fig. 11). The deer was under the influence of the herd at this time and her movements usually corresponded with those of the herd. Marked animals within winter herds had

an activity pattern similar to this radio-harnessed doe.

Year-round ranges of deer in other regions have been found to be less than those reported here. Where seasonal weather extremes are not pronounced, deer occupy the same range on a year-round basis. White-tailed deer in Texas (Hahn 1945, Hahn and Taylor 1950, Thomas et al. 1964, Michael 1965) and Missouri (Progulske and Baskett 1958) rarely moved more than 2 miles from their capture sites. Black-tailed deer in California (Taber and Dasmann 1958:41) and Washington (Zwickel et al. 1953) often lived out their lives on an area about 1 mile in diameter.

Migratory deer have separate winter and summer ranges, between which they travel over well-defined trails (Dasmann 1964:118). Seasonal extremes in weather may provoke migrations between these ranges (Severinghaus and Cheatum 1956:154). Schmautz (1949) found that some Montana whitetails migrate at least 20-25 miles from summer to winter ranges. Olson (1938) and Carlsen and Farmes (1957) mentioned migration of Minnesota whitetails. Dahlberg and Guettinger (1956:55) said that although white-tailed deer are not generally considered migratory, some use summer ranges that are distinct from their winter ranges. Seasonal migrations are common among mule deer in mountainous areas and were described by Leopold et al. (1951:76-82), Longhurst et al. (1952:33-51), and Ashcraft (1961) in California. Migrations of up to 90 miles by Nevada mule deer were reported by Gruell and Papez (1963). Some Oregon blacktails made 6- to 8-mile migrations

between summer and winter ranges (McCullough 1964).

The deer population in this study was partially migratory in that it used all of the study area for summer range but withdrew to a small part of it for the winter. Migration generally followed drainages rather than established trails. Only one marked adult doe returned to the same wintering area in two consecutive years. Leopold (1951:91) and Gruell and Papez (1963:420) found that mule deer tended to re-use specific winter and summer ranges. Both studies showed that mule deer tended to follow established migration routes and that home ranges on both summer and winter ranges were restricted locally. Zalunardo (1965:347-351) found that mule deer in Oregon re-used the same wintering areas each year but dispersed throughout the entire summer range. Movements were restricted on both summer and winter ranges. Progulske and Baskett (1956:186,187) described seasonal shifting of home ranges during fall and said that it may not be the rule for deer to return year after year to the same seasonal ranges. Dahlberg and Guettinger (1956:59,60) felt that if the summer travels of a Wisconsin whitetail took it beyond its normal summer range, it would accept any area meeting the requirements for yarding cover. Deer in the present study probably behaved in the latter manner. Effects of the hunting seasons scattered deer widely, and these deer probably wintered wherever they were when the hunting seasons ended.

Lengthy spring and summer movements by some young bucks and

does may be partially explained in terms of spring dispersal or as a characteristic age-group movement. Taber and Dasmann (1958:43) found that young black-tailed deer may wander before settling down to a well-defined home range. Leopold et al. (1951:62) described summer wanderings by young California mule deer. Andersen (1953:62) found similar spring dispersal movements among young Danish roe deer (Capreolens capreolens). Carlsen and Farmes (1957:400) noted that the longest movements by Minnesota whitetails were by deer younger than 2 1/2 years.

In addition to the 100-mile eastward movement by a yearling doe during this study, deer tagged by the Department of Game, Fish and Parks at sites 60 miles northwest and 100 miles north of Brookings travelled 110 miles west and 125 miles northwest, respectively (unpublished data, South Dakota Department of Game, Fish and Parks). The 125-mile movement was by a yearling buck between winter and the following fall. These movements may represent simple wandering. Abundant food and cover in the spring and summer and lack of physical barriers to travel provided a continuum of good deer habitat conducive to wide travels. Taber and Dasmann (1958:43) said that young black-tailed deer may sometimes be driven away by their mother during the fawning season. Such behavior might precipitate dispersal or wandering by young animals, but no observations of this type were recorded during this study.

In summary, the home range pattern of deer in this study

included one or more specific sub-areas which provided the total deer habitat requirements. When these requirements were disturbed, depleted, or changed, deer moved to a new sub-area. The nature of the habitat sometimes resulted in lengthy movements between sub-areas and produced a multiple home range.

Factors Influencing Winter Herds

Deer concentrated in winter herds during this study, but true yarding, as in forested regions (Kabat et al. 1953, Dahlberg and Guettinger 1956, Gill 1957, Banasiak 1961), did not occur. Hamerstrom and Blake (1939:208) and Dahlberg and Guettinger (1956:61) found that intensity of yarding varied with the severity of the winter. Banasiak (1961:37) observed that in agricultural areas in Maine, deer tended to group in small numbers and roam over relatively large areas throughout most of the winter, and that it was difficult to delineate a yard with definite boundaries. He also recognized a behavior pattern, intermediate between the extremes of yarding and not concentrating at all, in which deer congregated loosely within a general area for part of the winter and yarded in a definite site only during severe weather or during winters with greater than usual snow cover. The latter behavior is similar to that observed during the present study.

Deer concentrations during this study varied each year (Fig. 18). During the winters of 1964 and 1965, deer were generally found in large groups in fairly well-defined wintering areas, but

these herds were quite mobile, and a definite yard could not be delineated. Snowfall was not heavy in either year except for one blizzard in late March of 1965 which did not cause yarding. In 1966 as much as 30 percent of the deer population did not gather in herds but remained widely scattered well into the winter. Toward late February a few more joined herds, but, in general, winter concentrations were looser than in the two previous years. Snowfall in 1966 was about the same as in 1965. A severe blizzard during the first week in March of 1966 was followed by a rapid thaw and did not cause yarding.

Deer did not gather in herds because of any single weather factor or seasonal requirement. Severe winter weather and a reduction in available heavy cover tended to bring groups of deer together in a few general areas. Two months of constant harassment by hunters (November-December) also terminated at the same time, after which deer largely avoided any contact with humans. The combination of these factors, plus a natural tendancy to group together, probably caused deer herds to form.

Hamerstrom and Blake (1939:211) found that a drop in air temperature to a weekly average of about 20 F seemed to start winter concentrations in Wisconsin, and that a return to the same average apparently started the spring dispersal. The first heavy snowstorms of the winter season and the start of 20 F (or lower) average weekly temperatures occurred on November 19, 1964, and on November 26, 1965. In both years deer first concentrated

in herds during or following the snowstorms. Hunting activities broke up deer herds soon after they were formed, and the herds did not re-form until late December. The snowstorms and subsequent cold weather, rather than temperatures alone, probably caused the initial herd formation.

An average temperature of 35.2 F for March 10-16, 1964, 35.0 F for April 1-7, 1965, and 38 F for March 9-15, 1966 (U. S. Department of Commerce Weather Bureau Climatological Data, South Dakota), started the spring dispersal. It should be noted that the rise in average temperatures was accompanied by a general thaw and subsequent flooding of stream bottoms and sloughs, and that these factors probably accelerated the dispersal.

McCullough (1964:255) found that black-tailed deer migrations in Oregon were closely related to relative humidity and suggested that "thresholds" which trigger movements may exist so that cumulative effects of environmental changes over a 5-7 day period were necessary to trigger extensive movements. Deer dispersal in the present study was influenced by a cumulative 7-day temperature of about 35 F, which would seem to support the "threshold" idea, but again subsequent thaw and flooding of the winter areas were involved in the dispersal. In contrast, Darling (1937:107) found that a sudden drop in temperature caused red deer (Cervus elaphus) to move downhill as much as 1000 feet in elevation. Sudden drops in temperature were not observed to cause movement by deer in the present study, but deer already were in areas

offering the best protection from weather. Only one rapid rise in temperature occurred (a rise of 52 F on February 5, 1965, followed by 2 days of temperatures over 40 F). This caused one deer herd to disperse temporarily.

Population Distribution

Stratification of deer range by population distribution within ecological types would be useful in interpreting population dynamics and thus in managing deer. Deer distribution within the three land types (Fig. 2) was not consistent enough to allow stratification. The center of deer activities and points of greatest deer density at all seasons were along the Big Sioux River and its tributaries and in a few large pothole complexes. This pattern held in all three land types, and indicated that these habitats within the land types should probably be the basis for studying deer populations, rather than the broader, more diversified land types (Fig. 2).

In a large segment of pothole habitat on the western edge of the study area, deer were common during the summer but were not as abundant as along the Big Sioux River and adjacent farmlands. Waste corn was readily available in fields adjoining these potholes. A few pothole complexes were used by winter herds in each year of this study, but no herds were found among much of the true pothole area during the winter even though several of the large potholes appeared to be excellent winter habitat.

One possible reason for this decrease in use is that the area is heavily hunted for ducks and pheasants during the fall, and the disturbance may drive deer out. Herds do form in some of the larger marshy lakes farther west (off the study area), and this may partially explain the movement of deer out of some of the western pothole region. Deer apparently spend the winter period outside much of the pothole region and do not return until spring. The limited use in winter is surprising when one realizes that restricted winter cover is a possible limiting factor elsewhere on the study area, whereas good winter cover is abundant in many of the larger potholes.

In the flat, flood plain region in the north-central part of the study area, deer were most common along the Big Sioux River and tributary creeks (Fig. 2). Much of this region eastward from the river and north of Brookings to the more hilly region is intensively farmed and deer numbers were low at all seasons. The area southeast of Brookings supported almost as many deer as the river bottom because of the many thickets along the creek bottoms.

In the hilly region on the eastern part of the study area (Fig. 2) deer were found in "pockets" of high density along the creek bottoms. Much of this area is pasture or hay land with some corn, and heavy cover is available mainly on creek bottoms.

Because deer were most evenly distributed during the summer, population estimates were based on summer observations. Within

the more intensively studied stretch of the Big Sioux River from 3 miles west of Brookings to 3 miles south of the Brookings-Moody County line (including adjacent farmlands for 2-3 miles on each side) (Fig. 2) the summer deer population was about 150-200 animals. A conservative total estimate including the larger, less intensively studied 1400 square-mile area (Figs. 1,2) was about 600 animals. These figures are not based on census data and would not necessarily indicate the fall or winter population on these two areas.

Management Implications

From a biological standpoint, data from this study do not support the use of counties as deer management units in eastern South Dakota. Winter movements, spring dispersal patterns, and travels of deer at various seasons showed that county management units do not represent natural units of deer range. Movements of many deer in this study centered along the Big Sioux River and its tributaries and radiated outward into other habitat types. Whereas the river and stream bottoms were heavily utilized, specific regions within the other habitat types were used more heavily than others. If they could be administered effectively, deer management units might better be based upon natural drainage systems which could be further broken down into sub-units. Sub-units based upon tributary drainages, blocks of other suitable habitat, or combinations of the two would allow more intensive

management on a sound biological basis.

Instability of winter herds in time and location of formation, intensity of concentration, and deer numbers ruled out the use of winter herd counts as an accurate population index. Index counts would be reliable only if they were made at about the same time each year and under similar conditions. The deer population would have to be localized in well-defined and easily recognizable areas. The great variability observed in the winter activities of herds and individual deer in this study indicates that winter counts are not reliable population indices.

Since county deer management is a current tool, it should be stressed that great seasonal variability in deer densities on large areas within a county, as noted in this study, can give a false impression of the year-round deer population. It would be inaccurate, for example, to base an estimate of the deer population in any county on winter counts alone (even if they could be made accurately) because many deer wintering in a county might disperse out of it in the spring. Conversely, a county with a low wintering population might benefit from an influx of deer in the spring. The more even distribution of deer in the summer and early fall suggests that a census during either period would give a more reliable indication of the number of deer which would be present locally at the beginning of the first hunting season in the fall.

Many basic facts about the life history of deer east of the Missouri River (East River deer) are not known. Additional studies

in this direction should consider productivity, herd composition, mortality factors, and environmental requirements. A life equation (Severinghaus and Cheatum 1956:176-186) should be constructed in order to closely follow the status of the population. Additional attention should be given to development of suitable census methods, delineation of biologically and administratively sound management units, evaluation of limiting factors (such as escape cover during the hunting seasons), and a close appraisal of the status of deer within the agricultural community.

The wide mobility of the East River deer population, their excellent year-round physical condition and apparent high productivity, the consistently high rate of hunter success, and the apparent continuing increase in total deer numbers indicate that the population has not yet reached carrying capacity for the region. Whereas the concept of carrying capacity usually connotes habitat limitations on an animal population (Dasmann 1964:59), possibly the most important limitation on the carrying capacity of the East River deer range is that imposed by farmers and their economic values. Bever (1957:25) in speaking of East River deer said:

> From the standpoint of economic value the high degree of cultivation almost relegates deer to the position of a weed species. However, since the esthetic value of deer probably equals its hunting value, a low density of deer per square mile can be maintained for the benefit of hunters and the lovers of wildlife. When deer numbers exceed the limitations defined as reasonable by the farmer a short season is usually effective in reducing the population for a few years.

Increasing public interest has raised deer considerably above the position of a "weed species," but agricultural interests still control the level at which deer numbers are maintained. It is therefore important that deer be regularly harvested to the fullest degree to avoid conflicts with agricultural interests. Currently, farmers are tolerating the deer population at its relatively low level. Deer numbers are growing steadily however, and it is possible that greater annual reduction in population size may soon be necessary to maintain deer at a level acceptable to farmers.

In the current trend toward agricultural efficiency and "clean farming," habitat destruction has dealt a serious blow to both ducks and pheasants in eastern South Dakota. Many areas of value to ducks and pheasants are important to deer. Deer habitat, such as escape cover during the hunting seasons, is being swiftly destroyed by the same demands for more crop production without regard for other values. Preserving the natural wetland areas, brushy cover, thickets, and natural vegetation along rivers and streams, and establishing artificial plantings, such as shelterbelts, which benefit other wildlife, will also benefit deer.

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