Red Squirrel

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ILLINOIS NATURAL HISTORY SURVEY

Section of Wildlife Research

The Status of the Red Squirrel

(*Tamiasciurus hudsonicus*) in Illinois

W-92-R-2

Final Report

1 October 1983 through 30 September 1985

Performance Report

Final Report

State: Illinois Project Number: W-92-R-2

Project Title: The Status of the Red Squirrel (<u>Tamiasciurus hudsonicus</u>) in Illinois

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Need:

The red squirrel was apparently absent from Illinois for approximately 60 years before its apparent reappearance in the Kankakee and Iroquois River area in the early 1970's. Its status since that time has not been assessed. Several ideas exist concerning the origin of this population. Some local residents and wildlife managers believe the squirrels were introduced from Minnesota, others believe they immigrated from populations in Indiana, whereas still others believe the Kankakee population is a remnant of the original population that has persisted in Illinois, but in low numbers. Information concerning the origin of this population is important in determining the status, ecological background, and taxonomy of the red squirrel in Illinois.

The red squirrel is typically found in coniferous, mixed coniferous, or northern hardwood habitats (Layne 1954, Smith 1970, Gurnell 1984). Reappearance of red squirrels in deciduous hardwood forests in Illinois suggests a need for habitat and squirrel management recommendations that are different than are normally suggested for this species in typical range.

Nothing has been published on the red squirrel in Illinois other than that it is known to occur (Mahan and Heidorn 1984). Little recent information is available on red squirrels in habitats similar to those found in Illinois. Therefore, a determination of the habitat requirements, basic ecology, and abundance of red squirrels in Illinois is necessary to the development of meaningful management policies.

Objectives:

1. To determine the subspecific taxonomic status, and therefore the probable origin of red squirrel populations in Illinois.
2. To determine seasonal densities of red squirrels in local habitats of varying quality.
3. To determine abundance and spatial organization of all species of diurnal tree squirrels in different habitats.
4. To investigate movements and home ranges of red squirrels in different habitats.
5. To determine red squirrel habitat requirements and preferences.
6. To develop management recommendations and guidelines for the red squirrel and its habitats in Illinois.

Prior Research:

The red squirrel has been studied extensively with regard to its density, movement, home range, and relative abundance in coniferous forest habitats (Hatt 1929, Smith 1968, Kemp and Keith 1970, Rusch and Reeder 1978, Gurnell 1984) and in mixed deciduous-hardwood forests (Layne 1954). The taxonomy of Tamiasciurus has also been extensively explored (Lindsay

1981, Lindsay 1982). None of these studies is totally relevant to populations of red squirrels in Illinois that occur in deciduous forests.

Population densities of red squirrels vary widely depending on the habitat type in which they are found (Rusch and Reeder 1978). Little data are available from deciduous habitats but densities appear to be lower there than they are in coniferous habitats.

Both fox and gray squirrels have been reported from areas where red squirrels are common (Layne 1954, Reichard 1976, Madson 1978) but reports of interactions were rare (but see Ackerman and Weigl 1970). Competitive interactions between fox and gray squirrels are generally thought to be unimportant (Brown and Yeager 1945, Smith and Follmer 1972); although Brown and Batzli (1985) suggested that some distributional patterns were consistent with a competitive hypothesis. The importance of any interactions between red squirrels and other sympatric species of tree squirrel in purely deciduous habitats is unknown.

Long range movements of red squirrels are primarily related to the dispersal of juveniles after weaning and breeding (Kemp and Keith 1970, Rusch and Reeder 1978). Seasonal movements were reported by Rusch and Reeder (1978) in spring and fall. Most spring movements were related to breeding activities and fall movements to dispersal of young, but some movements appeared to be related to food supplies. Permanent movements, in the way of range extensions have also been noted (Mumford and Whitaker 1982).

Red squirrels are highly territorial and actively defend a home range (or territory, as they are essentially synonymous in red squirrels) in northern coniferous habitats (Smith 1968, Rusch and Reeder 1978, Gurnell 1984). Defence of a territory consists of loud calling and chases. This energetically expensive activity is justified by the large store of pine cones, called a midden, near the center of each territory. Territories are maintained year-round but are most stable during late fall and winter when food supplies are low. Layne (1954) suggested that in mixed forests, red squirrels were less territorial--only defending a very small area around a den or food supply. But his conclusions are suspect because his studies were conducted on a college campus, not in a natural habitat and his sample sizes were low. No studies of red squirrel territoriality have been conducted in more natural, deciduous habitats.

Red squirrels are known from pine, spruce, aspen, popular, hemlock, and mixed deciduous-coniferous (oak-hickory and beech-maple mixed with white pine) forests (Layne 1954, Smith 1968, Kemp and Keith 1970, Rusch and Reeder 1978, Gurnell 1984). Their requirements appear to be a sufficient food supply and they seem to adapt to a wide variety of habitats (Layne 1954). Red squirrels prefer coniferous habitats over deciduous ones where food supplies are not a factor (Rusch and Reeder 1978). Again little is known of their requirements or preferences within deciduous hardwood forests.

Three theories exist concerning the origin of the red squirrel populations in Illinois. First, it is commonly reported that red squirrels from Minnesota were introduced into Kankakee County, Illinois near Aroma Park during the late 1960's by a private individual. Second, it is felt by some individuals that current Illinois red squirrels are a remnant of the populations that occurred in the state at the turn of the century and have remained undetected since that time owing to low numbers. Third, red squirrels are common in nearby Indiana and they experienced a range expansion toward Illinois, down the Kankakee River into Newton County, Indiana in the 1970's (Mumford and Whitaker 1982). This range expansion could have continued into Illinois. As the Indiana and Minnesota populations are different subspecies of red squirrel, a determination of which subspecies occurs in Illinois should help differentiate between these hypotheses.

Study Areas:

Field portions of the study were conducted in two vastly different woodlots in Kankakee County, Illinois. Campbell's Woods is an 45 ha woodlot that is on the Natural Areas List of the State of Illinois and is located 4 km south of Aroma Park on the Iroquois River. It is a high quality upland forest dominated by red oak, elm and maple (see Table 1 for a more complete description). Only 12.5 ha of this woodlot were used for trapping in this study. Elk's Woods is a highly disturbed woodlot on the Kankakee River, 2 km northeast of Aroma Park. Its disturbed condition is characterized by a thick understory of brambles, dogwood, viburnum and black cherry. Black oak dominates the canopy (see Table 2 for a complete tree listing). Seventeen and 1/2 ha of the woods were used for trapping. This woodlot also contains a refuse pile and a large irrigation canal. Adjacent to the deciduous woods are several ha of red and white pines. Much of the woods is also susceptible to occasional flooding. Other areas, including the Iroquois County Conservation Area, various woodlots along the Kankakee and Iroquois Rivers, and other wooded areas in Kankakee, Will and Iroquois Counties were used for feeding and behavioral observations and taxonomic determinations.

Materials and Methods:

Seasonal densities, relative abundances, and squirrel movements were determined by live-trapping during fall, winter, and spring of 1984-85. Fall trapping was conducted in November and December, winter trapping in

January, February and early March, and spring trapping in April and May. Wooden box traps modified from Baumgartner (1938) and Havahart #0745 wire traps were placed at 50-m intervals in each woodlot. Traps were prebaited for approximately one week prior to one week of trapping. Data on location of capture, sex, breeding condition, and weight were taken prior to ear tagging and release of the animal at the capture site. Initially traps were left open continuously and checked twice daily, but excessive trap deaths overnight forced closing of traps at night and traps were checked each afternoon.

In an effort to obtain more detailed data on home ranges than could be obtained by live-trapping alone, Richard Wright, a graduate student at Governors State University, agreed to cooperate in conducting a radio-tracking study of red squirrel home ranges. A 9-ha grid was set out in Elk's Woods with flagging at 25-m intervals and was trapped intensively in an effort to trap all red squirrels on the grid. Traps placed in sites of red squirrel activity proved more successful that traps in the regular trapping grid. Layne (1954) had similar success. Areas of red squirrel activity were often identified by locating black walnuts eaten by red squirrels. The distinctive manner in which red squirrels open black walnuts make differentiation easy (Mumford and Whitaker 1982). Equipment for this portion of the study was supplied by Governors State University and the data collected formed a major portion of Mr. Wright's thesis (Wright 1985), but are included in this report to help increase our understanding of red squirrels in Illinois.

Each adult animal trapped on the grid was fitted with a MPM-1220-LD transmitter and tracked with a 12 channel LA-12 receiver and a three element Yagi antenna. Triangulation proved to be too inaccurate for obtaining radio fixes, so animals were tracked into the woods until their locations were determined. Animals could be located before the presence of the tracker disturbed the squirrel's activity. Radio fixes were taken during all periods of the day and continued from November 1, 1984 through December 30, 1984. Two of the seven animals collared died within two days of handling, suggesting that the collars had some negative affect on them. Causes of death were not apparent. Two other radio-collared animals died during the study following several weeks of data collection.

Graphical analysis of the radio-tracking data was achieved using a fast Fourier transform that produced a utilization distribution for each animal (Anderson 1982). Three dimensional representations of each home range were produced using programs adapted from Korites (1983). A comparison of this technique with other home range techniques can be found in Wright (1985) and Anderson (1982).

Habitat preferences and requirements were investigated using the trapping data and quadrat sampling of the vegetation in 100 square meters around each trap site. DBH and tree species were recorded for all stem greater than 5 cm DBH, sapling counts were also taken. These data were used to compute importance values (IV = plot density x plot basal area) for each tree species in each quadrat. These importance values, and total plot densities, basal areas and sapling densities were used in a series of stepwise discriminant analyses (Nie et al. 1975) to determine the characteristics of red squirrel habitats. Further, factor analysis (Nie et al. 1975) was used to determine if correlations between variables were biasing the results of the discriminant analyses.

In an effort to determine the subspecies of red squirrel that occurs in Illinois, discriminant analysis (Nie et al. 1975) was used to produce a function that would discriminate between between *Tamiasciurus hudsonicus loquax*, which is native to Indiana and Ohio and *T. h. minnesota*, which occurs in Minnesota, Wisconsin and northern Michigan. Measurements of eight cranial characteristics for each of 12 skulls from each subspecies were used in the discriminant analysis and measurements for the 14 skulls collected in Illinois were then used to classify the squirrels from Illinois. A Pearson product-moment correlation between the discriminant function and each variable was also used to determine the strength of the classification technique.

Results and Discussion:

Live-trapping in fall and winter produced reasonable estimates of densities of tree squirrel populations in Campbell's and Elk's Woods (Table 3). Spring trapping success was poor and produced unreliable results. Estimates of fox squirrel populations are probably reliable, because the majority of fox and gray squirrel populations are captured when similar trapping techniques are used (Brown and Batzli, 1985). Red squirrel densities, however, are probably underestimated. Observations of free ranging red squirrels following trapping periods suggested that trapping was not as successful as it was with fox squirrels. Flying squirrel densities for fall represent a reasonable sample but traps were closed at night during later trapping sessions, thus decreasing the possibility of capturing this nocturnal species.

Seasonal trends in red squirrel densities were difficult to interpret owing to the poor trapping success in spring and the short term of this study. Based on these limited data, it would appear that population densities are fairly stable from fall to winter and that population densities may be higher in less disturbed woodlots. It is also possible that differences in population densities of red squirrels are due to differences in tree composition between the two woodlots.

Fox squirrels were generally more abundant than red squirrels in the study areas, particularly in Elk's Woods. Fox squirrel densities were similar or slightly less than densities reported from central Illinois forests where fox squirrel are sympatric with gray squirrels (Nixon et al. 1984, Brown and Batzli 1985). The ratio of fox to red squirrels was higher in Elk's Woods, the disturbed woodlot, than it was in Campbell's Woods, the high quality woodlot (Figures 1 and 2, respectively).

No seasonal movements of red squirrels were detected by the live trapping. Squirrels captured in both fall and winter were found in the same or adjacent trap locations. However, it should be remembered that seasonal movements may not be detected in only one year worth of trapping. Long range movements were rare, with only two squirrels moving more than 100 m between captures. A single 200 m movement was recorded for an adult male but this was within the normal movements suggest by the radio-tracking portion of the study (see below).

Seven red squirrels were fitted with radio collars but sufficient data was gathered on only 4 animals. A total of 575 radio-fixes were obtained on the two males and two females reported in this study. MAP (.50) and MAP (.95) estimates of home range are given in Table 4. A MAP (.95) estimates gives the smallest area which accounts for 95% of an animal's space utilization (Anderson 1982). These home range estimates compare favorably in size to those reported by Smith (1968). MAP (.50) estimates were small, indicating that these animals spent most of their time in a few locations. Radio locations taken at night indicated the use of multiple dens. Home ranges or territories reported from coniferous habitats are distinct and nonoverlapping. Graphical representations of the utilization distributions for the animals in this study suggest multi-modal and non-symmetrical home ranges and an extensive amount of overlap between home ranges (Figure 3).

The home ranges of the four animals in this study overlapped to a great degree (Figure 4). Not only did home ranges overlap in space but also in time. In 58% of the 154 observation bouts where more than one squirrel was radio-tracked, two or more squirrels were located in the same grid cell, a 12.5 m x 12.5 m area. Squirrels 6 and 12 were found in the same cell 24.2% of the time. This is in contrast to findings in coniferous habitats (Smith 1968, Gurnell 1984). For a more detailed description of red squirrel home ranges in Illinois forests see Wright (1985).

Overlap also occurred between red and fox squirrels. Within the 9-ha radio-tracking grid, home ranges of 10 fox squirrels overlapped with the home ranges of the four red squirrels that were radio-collared. This would suggest that interactions between red and fox squirrels are not an important factor in determining squirrel distributions.

Live-trapping proved inadequate for determining home ranges of red squirrels. Low recapture rates reduced the number of animals with sufficient numbers of captures to make home range determinations. No animal was captured in more than three locations; most were captured at the same location numerous times. Red squirrel home ranges are irregular in shape and movement of traps during the radio-tracking indicated that red squirrels do not move out of their home range to enter traps as fox squirrels do.

These data indicate that red squirrels in deciduous habitats in Illinois behave differently than their counterparts in coniferous habitats, as suggested by Layne (1954). The radio-tracking data demonstrate that Illinois red squirrels do not maintain mutually exclusive territories. This idea is supported by observational data on free living red squirrels that indicates intraspecific interactions are rare, that animals often use the same areas, and that territorial behavior is rare. The absence of territoriality in deciduous habitats may be related to the foods available and eaten there. Observations of feeding habits of red squirrels suggests that they use a wide variety of foods found in deciduous forests including: black walnuts, red, black and white oak acorns, hickories, maple samaras, fungi, sugar maple sap, and buds from sugar maple and black walnut trees. These deciduous forest foods are probably difficult to defend against fox and flying squirrels, opossums, raccoons, woodpeckers and mice. Therefore, it may be energetically undesirable to defend a food supply (Smith 1968). This idea is supported by the fact that food storage piles, middens, were not found in deciduous forests in Illinois, as they are in northern coniferous habitats. Although Illinois red squirrels do not store food in middens, they do store nuts and fungi in trees; again, a difficult food supply to defend.

In pine plantations, which are common in Kankakee County, red squirrel foods also include cones of red, white, jack and Virginia pines. Food stores are not found in these habitats either, but some suggestion of storage in burrows made by woodchucks and red squirrels was noted. Red squirrels in Illinois use tree dens, leaf nests, ground burrows, and brush piles for nesting. During the radio-tracking several animals were commonly found in an old car in the junk pile. The highest densities of red squirrels in Elk's Woods were in the area of the junk pile. This information would suggest that areas of human disturbance may attract red squirrels.

Stepwise discriminant analysis was successful in providing information on the habitat preferences and requirements of red squirrels in Illinois even though live-trapping only extended for one year. Results of the analyses for Elk's Woods, Campbell's Woods, and a combined analysis are presented in Tables 5, 6 and 7, respectively. A factor analysis of the 24 importance value and three plot variables indicated little correlation between variables. Of the 13 orthoginal factors produced, only one was significantly correlated with more than one IV, mulberry and black cherry. All other factors represented one tree species. These results indicated that the variables used in the discriminant analyses were not correlated and provided an unbiased data base for examining red squirrel preferences.

Black walnut was significantly associated with the discriminant function in all three discriminant analyses. Other than plot density, it was the only variable included in all three analysis. Plot density was negatively associated with red squirrel activity in all three analyses. Although plot density was only significantly associated with the discriminant function in Elk's Woods, it would appear that red squirrels do not prefer denser areas of the woods as originally thought. Most other trees that were included in the analyses are food sources for red squirrels (Smith 1968, Reichard 1976, this study). Sapling density did not appear in any of the analyses.

These analyses would suggest that food is the most important factor in determining red squirrel habitat requirements. Based on feeding observations, black walnuts were the most important food items during winter. Black walnuts have also been shown to be a high quality food for squirrels (Smith and Follmer 1972, Havera and Smith 1979).

Five of the eight skull variables were included in the discriminant function used for subspecific determination, which classified 90 percent of the 21 skulls correctly (Table 8). Although the classification rate was good, the results of the Pearson product-moment correlation reveal that the discriminating power of the function is not great; only three of the variables were significantly correlated with the function and the correlation coefficients were low (Table 8). Nevertheless, the classification of Illinois samples suggested that both subspecies were present. Six animals were classified as the Minnesota subspecies, seven as the loquax subspecies and one was unclassified owing to missing data. The three skulls from the Iroquois County Conservation Area, near Indiana, were put in the loquax group, while the eight samples from Kankakee county were split evenly between the two subspecies. The two from isolated pine plantations in Will County were classified with the Minnesota group.

There are two possible ways to interpret these findings. The first interpretation is that both subspecies do occur in Illinois. This would suggest that the introduction of red squirrels from Minnesota was successful and that the more likely explanation of red squirrels extending their range from Indiana is also true. The distributions of subspecies observed in this study are consistent with this idea. In any case, it is unlikely that the red squirrel inhabited Illinois for 60 years and went unnoticed.

Secondly, the data available to this study for discriminating between the two subspecies may have been insufficient for an accurate classification of Illinois samples. This idea is supported by the low correlations. A larger data base is currently be sought to answer this question.

Management Recommendations:

Based on the data collected in this study, several recommendations concerning the management of red squirrels and red squirrel habitat are indicated:

First, red squirrels do not affect fox squirrels to any detectable degree and interactions between the two species are negligible. This information should be emphasized to Illinois hunters in order to reduce the illegal shooting of red squirrels. Hunters have long felt that the red squirrel is detrimental to fox squirrel populations, and often shoot them in hopes of improving huntable squirrel populations.

Second, food supply is the most important requirement for red squirrels in Illinois deciduous forests and black walnuts are an important food source for red squirrels during winter, when food supplies are lowest and energy demands are greatest. Furthermore, red squirrels prefer habitats that contain greater availabilities of black walnuts.

Third, neither habitat quality or understory density has a strong influence on red squirrel distributions. Although the higher quality Campbell's Woods had slightly higher densities of trappable red squirrels than did the poor quality, highly disturbed Elk's Woods, densities around the junk pile in Elk's Woods were twice that in Campbell's Woods (1.8 vs. 0.8 squirrel per ha). Prior to this study, an association between red squirrels and habitat (tree and/or sapling) density was thought to occur. The lack of any correlation between sapling density and red squirrel activity in any of the discriminant analyses and the negative correlation of plot density with red squirrels would indicate that any manipulation of understory cover or tree density with respect to red squirrel abundance would be ineffective. Based on the results of this study, habitat quality should not an overriding factor in projecting or manipulating red squirrel numbers.

Fourth, the protected status of the red squirrel in Illinois should be maintained. This would allow this species to find its own population levels and will help prevent the useless killing of red squirrels. It should also be noted that red squirrels present a pest problem in some rural and suburban areas in the state. Red squirrels are commonly trapped from attics and barns where their gnawing causes considerable damage. This destruction of red squirrels probably does not adversely affect red squirrel populations in the state.

Finally, a program should be initiated to accurately determine the current extent of red squirrel range in Illinois and to monitor the range expansion of the red squirrel in the state in the future.

References Cited:

Ackerman, R. and P. D. Weigl. 1970. Dominance relations of red and gray squirrels. Ecology, 51:332-334.

Anderson, D. J. 1982. The home range: a new nonparametric estimation technique. Ecology, 63:103-112.

Baumgartner, L. L. 1938. Population studies of the fox squirrel in Ohio. Trans. N.A. Wildl. Conf., 3:685-689.

Brown, B. W. and G. O. Batzli. 1985. Field manipulations of fox and gray squirrel populations: how important is interspecific competition? Can. J. Zool., In Press.

Brown, L. G. and L. E. Yeager. 1945. Fox squirrels and gray squirrels in Illinois. Bull. Ill. Nat. Hist. Surv., 23:447-536.

Gurnell, J. 1984. Home range, territoriality, caching behaviour and food supply of the red squirrel (Tamiasciurus hudsonicus fremonti) in a subalpine lodgepole pine forest. Anim. Behav., 32:1119-1131.

Hatt, R. T. 1929. The red squirrel: its life history and habitats, with special reference to the Adirondacks of New York and the Harvard forest. Roosevelt Wildl. Ann., 2:11-146.

Havera, S. P. and K. E. Smith. 1979. A nutritional comparison of selected fox squirrel foods. J. Wildl. Manage., 43:691-704.

Kemp, G. A. and L. B. Keith. 1970. Dynamics and regulation of red squirrel (Tamiasciurus hudsonicus) populations. Ecol., 51:763-779

Korites, B. J. 1983. Graphics for the Apple. Kern Publications, Duxbury, Mass., 259pp.

Layne, J. N. 1954. The biology of the red squirrel Tamiasciurus hudsonicus loquax (Bangs), in central New York. Ecol. Monogr., 24:227-267.

Lindsay, S. L. 1981. Taxonomic and biogeographic relationships of Baja California chickaroos (Tamiasciurus). J. Mammal., 62:673-682.

Lindsay, S. L. 1982. Systematic relationship of parapatric tree squirrel species (Tamiasciurus) in the Pacific Northwest. Can. J. Zool., 60:2149-2156.

Madson, C. 1978. Squirrels on the Howard Potter research area. Wisc. Acad. Sci. Art. Ltrs., 66:294-318.

Mahan, C. J. and R. R. Heidorn. 1984. The mammals of Iroquois County Conservation Area. Trans. Ill. St. Acad. Sci., 77:23-28.

Mumford, R. E. and J. O. Whitaker. 1982. Red Squirrels. In Mammals of Indiana, Indiana University Press, Bloomington. p 277-285.

Nie, N. H., C. H. Hill, J. G. Jenkins, K. Steinbrenner, and D. H. Bent. 1975. SPSS. Statistical package for the social sciences. 2nd Ed. McGraw-Hill Book Co., New York.

Nixon, C. M., S. P. Havera and L. P. Hansen. 1984. Effects of nest boxes on fox squirrel demography, condition and shelter use. Amer. Midl. Nat., 112:157-171.

Reichard, T. A. 1976. Spring food habits and feeding behavior of fox squirrels and red squirrels. Amer. Midl. Natr., 96:443-450.

Rusch, D. A. and W. G. Reeder. 1978. Population ecology of Alberta Canada red squirrels. Ecol., 59:400-420.

Smith, C. C. 1968. The adaptive nature of social organization in the genus of three squirrels Tamiasciurus. Ecol. Monogr., 38:31-63.

Smith, C. C. 1970. The coevolution of pine squirrels (Tamiasciurus) and conifers. Ecol. Monogr., 40:349-371.

Smith, C. C. and D. Follmer. 1972. Food preferences of squirrels. Ecology, 53:82-91.

Wright, R. C. 1985. Home range utilization of red squirrels (*Tamiasciurus hudsonicus*) in a deciduous woodland in Illinois. Unpubl. MS Thesis, Governors State Univ., University Park, IL, 61pp.

Table 1. Vegetational summary for Campbell's Woods. Values for basal areas are given in square meters per ha and densities are stems per ha.

TREE SPECIES	BASAL AREA	DENSITY
American elm (*Ulmus americana*)	3.08	238.0
Slippery elm (*Ulmus rubra*)	3.90	170.0
Basswood (*Tilia americana*)	3.69	136.0
Red oak (*Quercus rubra*)	11.42	42.0
Sugar Maple (*Acer saccharum*)	3.11	134.0
Ash (*Fraxinus* spp.)	1.64	56.0
Ohio Buckeye (*Aesculus glabra*)	1.07	74.0
Honeylocust (*Gleditsia triacanthos*)	2.27	24.0
Bur oak (*Quercus macrocarpa*)	1.66	8.0
Black walnut (*Juglans nigra*)	1.27	18.0
Hackberry (*Celtis occidentalis*)	.36	36.0
Swamp white oak (*Quercus bicolor*)	1.47	8.0
Bitternut hickory (*Carya cordiformis*)	.22	20.0
Paw Paw (*Asimina triloba*)	.11	26.0
Black cherry (*Prunus serotina*)	.22	12.0
Ironwood (*Ostrya virginiana*)	.14	12.0
White oak (*Quercus alba*)	.13	2.0

Woodlot Basal Area	35.76
Woodlot Density	1016
Sapling Density	5040

Table 2. Vegetational summary for Elk's Woods. Values for basal areas are given in square meters per ha and densities are stems per ha.

TREE SPECIES	BASAL AREA	DENSITY
Black oak (*Quercus velutina*)	15.47	164.5
Black cherry (*Prunus serotina*)	1.60	291.9
Silver maple (*Acer saccharinum*)	3.68	100.0
River Birch (*Betula nigra*)	4.67	51.6
White oak (*Quercus alba*)	2.62	32.2
American elm (*Ulmus americana*)	.86	87.1
Ash (*Fraxinus* spp.)	1.03	37.1
Black walnut (*Juglans nigra*)	1.07	27.4
Cottonwood (*Populus deltoides*)	1.65	12.9
Bur oak (*Quercus macrocarpa*)	1.47	9.7
Mulberry (*Morus* spp.)	.59	22.6
Bitternut hickory (*Carya cordiformis*)	.14	14.5
Red pine (*Pinus resinosa*)	.08	6.5
Shagbark hickory (*Carya ovata*)	.06	6.4
Hawthorn (*Crataegus* spp.)	.05	8.1
Box elder (*Acer negundo*)	.07	4.8
Black maple (*Acer nigrum*)	.03	9.7
Hackberry (*Celtis occidentalis*)	.07	4.8
Basswood (*Tilia americana*)	.08	8.1
Butternut (*Juglans cinerea*)	.02	3.2
Smooth Sumac (*Rhus glabra*)	.01	3.2
Slippery elm (*Ulmus rubra*)	.003	1.6

Woodlot Basal Area	35.33
Woodlot Density	908
Sapling Density	9277

Table 3. Densities of tree squirrels live-trapped on study areas during fall 1984, and winter and spring 1985 (numbers are squirrels per ha (N))

	CAMPBELL'S WOODS			ELK'S WOODS		
	RED	FOX	FLYING	RED	FOX	FLYING
FALL	0.72 (9)	0.32 (4)	0.08 (1)	0.57 (10)	1.03 (18)	0.29 (5)
WINTER	0.96 (12)	1.04 (13)	0.08 (1)	0.57 (10)	1.71 (30)	0.00 (0)
SPRING	0.16 (2)	0.24 (3)	0.00 (0)	0.00 (0)	0.69 (12)	0.00 (0)

Table 4. Summary of radio-tracking data from Elk's Woods. MAP home range estimates are given in ha.

Animal No.	Sex	Age	Weight(g)	N Total Observations	MAP (.95)	MAP (.50)
1	Female	Adult	190	135	0.52	0.12
6	Male	Adult	200	150	0.37	0.09
8	Female	Adult	215	167	0.64	0.06
12	Male	Adult	210	123	0.52	0.06

Table 5. Group means for presence and absence and coefficients of vegetational variables (tree importance values, plot density and basal area, and sapling density) included in a stepwise discriminant analysis of red squirrel live-trap locations in Elk's Woods.

STEP	VARIABLE	PRESENCE	ABSENCE	DISCRIMINANT FUNCTION COEFFICIENTS
1	Slippery elm	1.25	0.00	0.52
2	Hackberry	12.63	0.00	0.51
3	Cottonwood	722.25	0.62	0.55
4	Black walnut	520.25	129.04	0.50 *
5	Black oak	8003.63	4258.60	0.59 *
6	Plot density	787.50	957.78	-0.37 *
7	Bur oak	477.13	118.02	0.35

* $P < 0.05$

Table 6. Group means for presence and absence and correlations of vegetational variables (tree importance values, plot density and basal area, and sapling density) included in a stepwise discriminant analysis of red squirrel live-trap locations in Campbell's Woods.

STEP	VARIABLE	PRESENCE	ABSENCE	DISCRIMINANT FUNCTION COEFFICIENTS
1	Black walnut	365.00	70.69	0.82 *
2	Buckeye	737.00	82.29	0.60
3	Pawpaw	11.07	44.11	-0.62
4	Red oak	3300.27	1654.51	1.14
5	Plot basal area	34.42	36.33	-0.88
6	Basswood	1948.53	1731.83	0.51
7	Plot density	906.67	1062.86	-0.30

* $p < 0.05$

Table 7. Group means for presence and absence and correlations of vegetational variables (tree importance values, plot density and basal area, and sapling density) included in a stepwise discriminant analysis of red squirrel live-trap locations in both Elk's and Campbell's Woods.

STEP	VARIABLE	PRESENCE	ABSENCE	DISCRIMINANT FUNCTION COEFFICIENTS
1	Black walnut	445.13	103.51	0.58 *
2	Buckeye	356.61	36.00	0.48
3	Cottonwood	372.77	0.35	0.45
4	Black Oak	4130.90	2395.46	0.61
5	Plot density	845.16	1003.75	-0.27
6	Red oak	1596.90	723.85	0.61
7	Pawpaw	5.35	19.30	-0.32
8	Bur oak	314.77	143.45	0.30
9	Plot basal area	34.40	35.42	-0.44
10	Basswood	949.32	764.23	0.28
11	Hackberry	48.68	25.06	0.23

* $p < 0.05$

Table 8. Group means for skull measurements (in mm), which were included in the discriminant function, of the two possible subspecies and the Illinois sample of red squirrels. Pearson product-moment correlations are also given.

VARIABLE	LOQUAX	MINN.	ILLINOIS	CORRELATION WITH DSCRMNT. FUNCTION	
Braincase Breadth	19.67	20.07	19.85	0.35	*
Post Dental Breadth	3.76	3.80	3.68	0.44	**
Rostrum Breadth	12.08	11.68	11.70	-0.44	**
Greatest Skull Length	46.01	46.12	46.62	-0.22	
Mid-line Nasal Length	12.06	12.16	12.48	0.04	

* P < 0.025
** P < 0.005

FIGURE LEGENDS

Figure 1. The overall relative abundances of all tree squirrels trapped in Elk's Woods.

Figure 2. The overall relative abundances of all tree squirrels trapped in Campbell's Woods.

Figure 3. Three dimensional representations of the utilization distributions of red squirrels radio-tracked in Elk's Woods. Information on graphs indicates sex, and MAP (.50) and MAP (.95) estimates of home range in ha.

Figure 4. Percentage overlap between the utilization distributions of red squirrels radio-tracked in Elk's Woods.

Figure 1

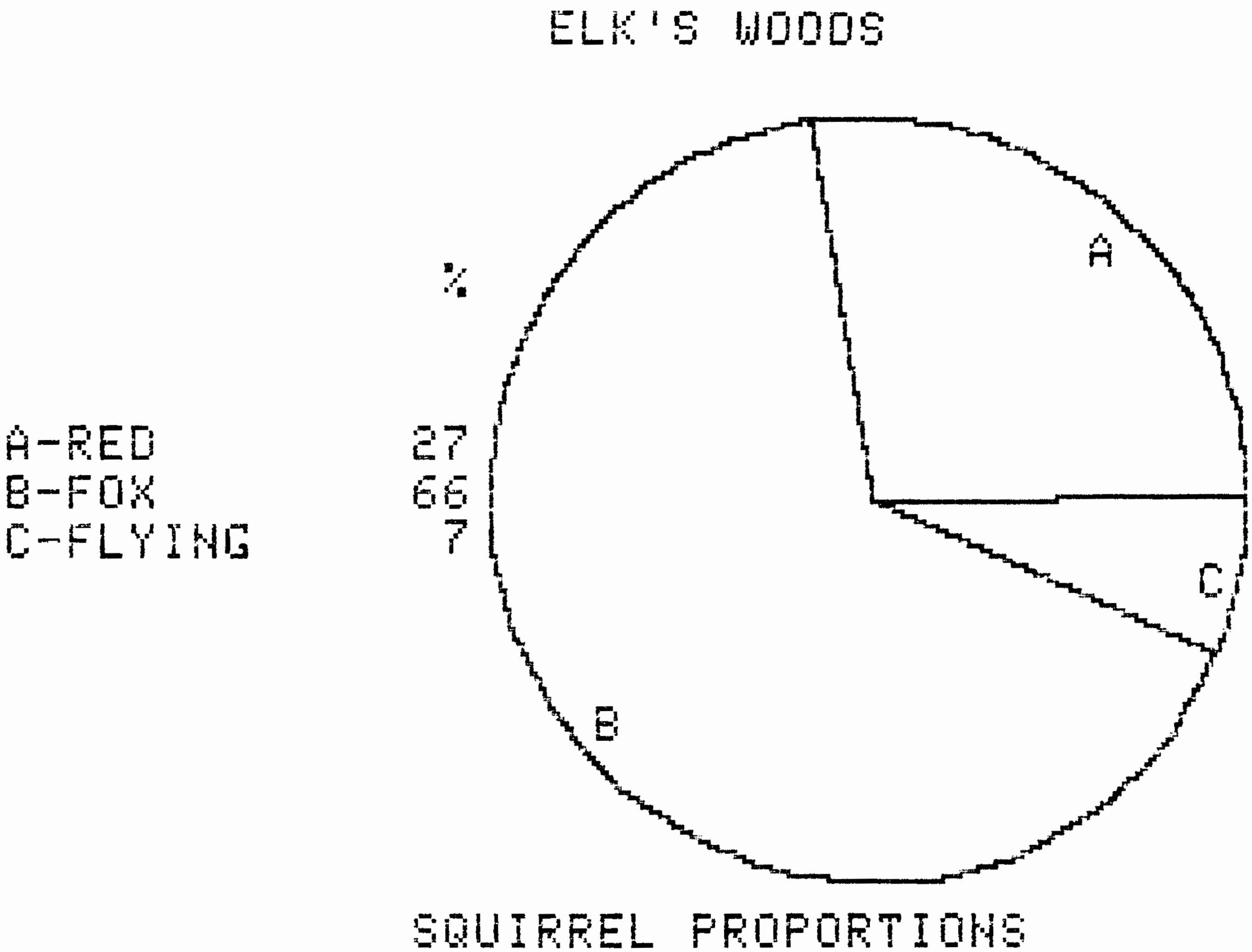

ELK'S WOODS
%
A-RED 27
B-FOX 66
C-FLYING 7
A
B
C
SQUIRREL PROPORTIONS

Figure 2

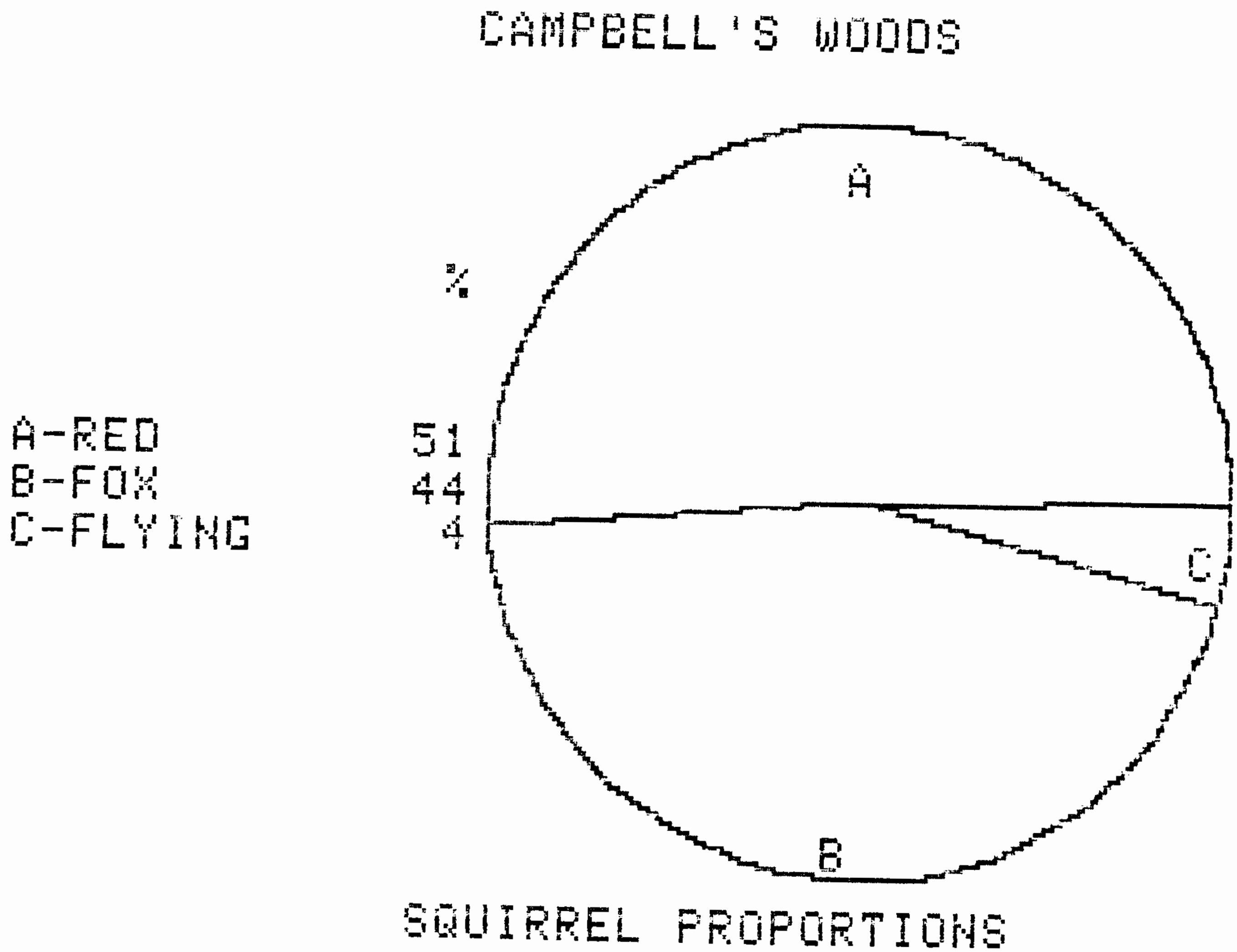

CAMPBELL'S WOODS
%
A-RED 51
B-FOX 44
C-FLYING 4
A
B
C
SQUIRREL PROPORTIONS

Figure 3

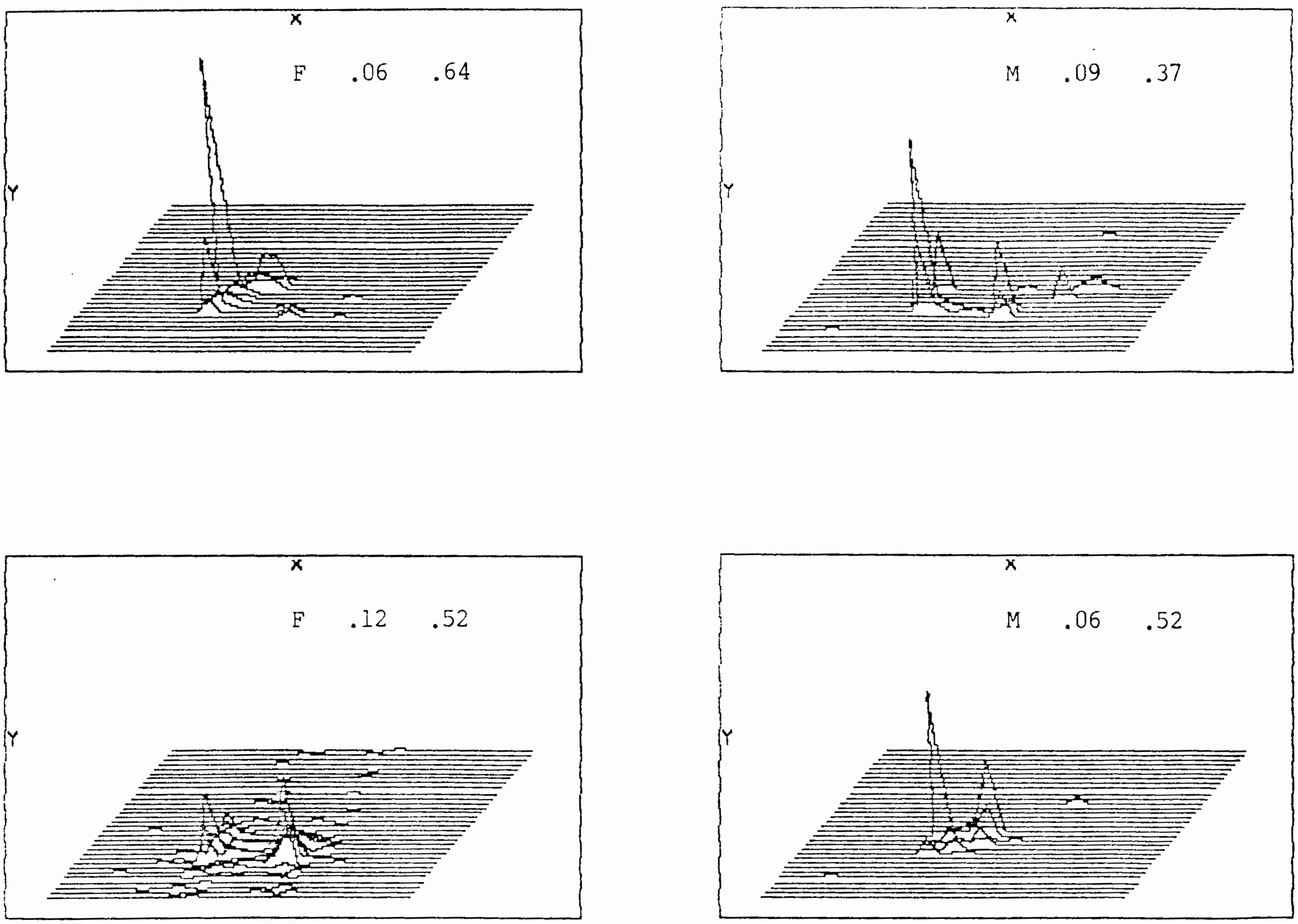
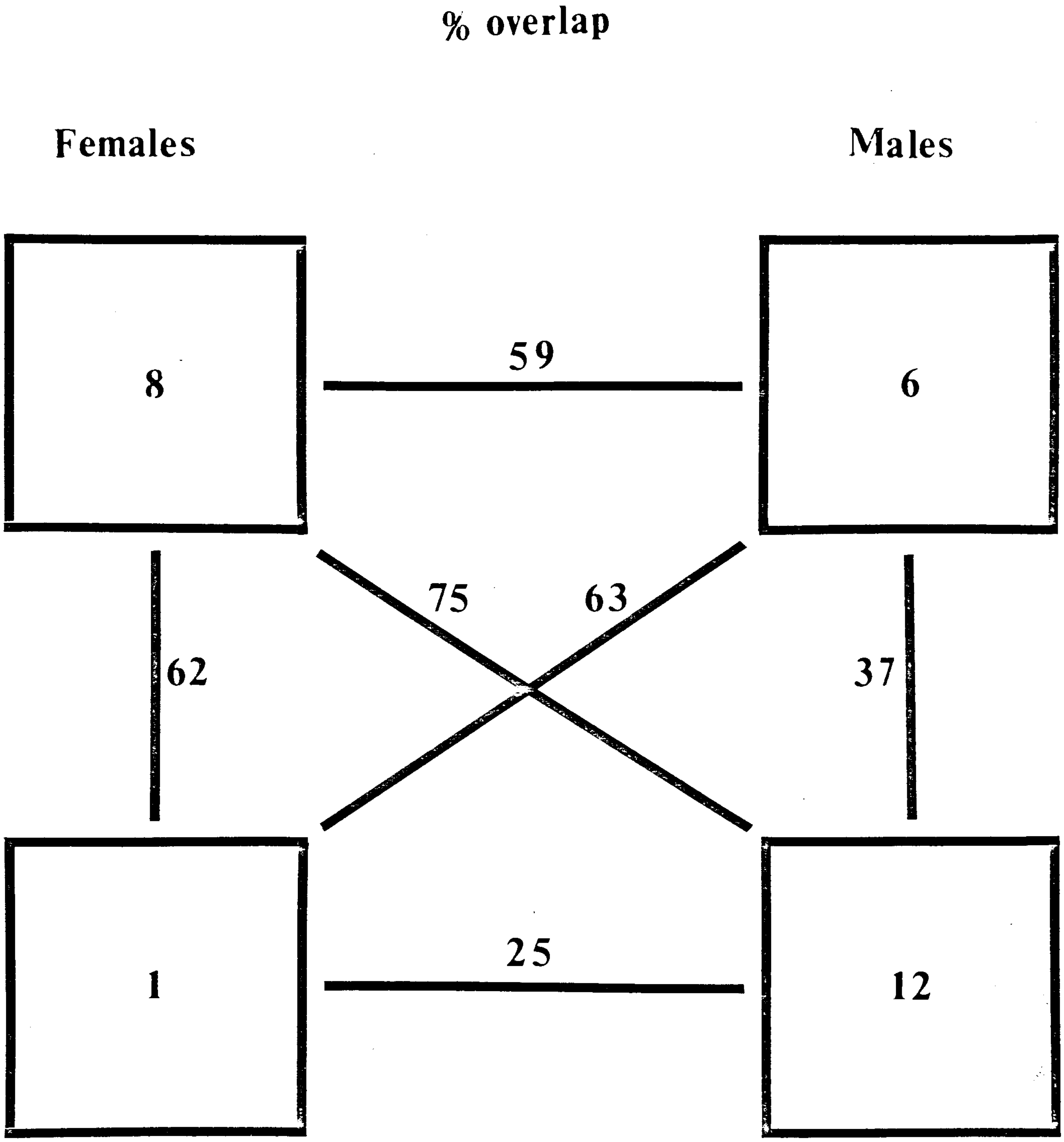


Figure 4



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