FINAL REPORT
SOUTH DAKOTA DEPARTMENT OF GAME, FISH AND PARKS
WILDLIFE DIVERSITY SMALL GRANTS PROGRAM

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Project Title: Use of Shelterbelt Woodlands by Neotropical Migrant Birds in the Northern Great Plains.

The stated objectives of this project as provided in the contract were to:

1. Document density and diversity of Neotropical migrants using shelterbelt woodlands in southeastern South Dakota during both spring and fall migration periods.
2. Determine energetic condition of migrants and document: (a) whether energetic condition changes during stopover, and (b) whether length of stopover is related to energetic condition.
3. Perform vegetative analysis of shelterbelt habitats to determine if potential differences in vegetative structure of shelterbelt and riparian woodlands are related to potential differences in density, diversity, or energetic conditions of migrants using these woodlands.

I. POINT COUNTS

We censused birds with a fixed-radius circular plot method (Hutto et al. 1986) at seven points in six different farmstead woodlots. These woodlots ranged from about 0.5-2.5 hectares in area. Each woodlot had a single census point, except for the largest woodlot, which had two points separated by more than 200 m. Point counts were conducted three times weekly in spring (16 April - 2 June) and fall (18 August - 6 October) migration periods in 1996 and 1997. All counts were conducted between 0600-0935 CST and directions of the census route were reversed on successive count days to avoid temporal bias. Point counts were not conducted on days with rain or high winds. Counts were initiated upon arrival at the census point and lasted 10 min. All birds observed by sight or sound were identified and their distance from the census point measured with a Ranging Model 620 rangefinder. Birds were counted as either inside or outside 25 m from the point for calculations of density and abundance, respectively.

A total of 232 point counts were conducted in spring, with 1,091 Neotropical migrants of 40 species observed for an average of 4.70 birds/point (Table 1). In fall, a total of 284 point counts were conducted, and 1,096 Neotropical migrants of 40 species were observed for an average of 3.86 birds/point (Table 1). For both seasons a total of 47 species of Neotropical migrants were tallied. Densities (birds km^{-2}) were calculated from all observations within 25 m from the point and abundances (birds/point) were calculated from all observations, irrespective of their distance from the observer. Both calculations were used to ensure that species that are easily detected, even at large distances from the observer were not underrepresented in our density estimates. These calculations were the same as those we used for density and abundance of migrants in riparian areas in

southeastern South Dakota (K.L. Dean and D.L. Swanson, unpubl. data).

Overall densities and abundances of Neotropical migrant species are presented in Table 1. During both spring and fall migrations, density and abundance calculations provided very similar pictures of variation in the number migrants using woodlots throughout the migratory periods (Figure 1). In spring, numbers of migrants increased steadily from the week of 15 April to the week of 13 May and then dropped off slightly after that. Fall migration showed bimodal peaks in migrant numbers with the first peak occurring in late August-early September and a second peak occurring in late September-early October. The early fall peak results from a wide variety of Neotropical migrants, while the late fall peak results mainly from three species, Orange-crowned Warblers (*Vermivora celata*), Yellow-rumped Warblers (*Dendroica coronata*), and Ruby-crowned Kinglets (*Regulus calendula*). Abundances for individual migrant species throughout spring and fall migratory periods are provided in Table 2. Densities and abundances of Neotropical migrants during peak migration in spring were higher than those in fall. Overall densities and abundances of Neotropical migrants in farmstead woodlots were higher than those for riparian areas, perhaps because birds were more likely to be detected in the smaller areas of the woodlots than the larger wooded riparian areas. Nevertheless, these data indicate that a large number of a wide variety of Neotropical migrants use farmstead woodlots as stopover habitat during migration.

II. MIST NET DATA

Mist netting was conducted at the largest of the farmstead woodlots (about 2.5 hectares in area). We opened 7-10 mist nets (2.6 X 9 m, 30 mesh) daily during spring and fall migration periods. Nets were generally open from sunrise to 1100 CST and often were opened again in the evening for 2-3 h prior to sunset. Net placement was consistent throughout migratory periods and between years. Mist nets were not opened on days with rain or high winds. For birds captured by mist net, we measured mass, visible fat score (Helms and Drury 1960), tarsus, tail, and sex/age when possible. Birds were banded with a U.S. Fish and Wildlife Service standard aluminum band and then released. We generated a total of 4,342 net hours (1 net open for 1 hour) in spring and 5,107 net hours in fall, for a grand total of 9,449 net hours over the two-year study period. We captured 679 Neotropical migrants in spring of 31 species (excluding Neotropical migrant groups [Mimidae, Cuculidae, Icterinae, *Pheucticus*] that were difficult to distinguish between breeding and migrating birds) and 1,299 Neotropical migrants of 30 species in fall (Table 3). The overall capture rates for Neotropical migrants were 156.4 birds/1000 net hours in spring and 254.3 birds/1000 net hours in fall.

Capture rates and point counts provided similar pictures of temporal variation in numbers of Neotropical migrants using farmstead woodlots. Capture rates increased in spring to peak during the week of 13 May, while fall capture rates showed a high initial peak during late August and early September with a secondary peak occurring in late September and early October (Figure 2). Peak and overall capture rates were higher in fall than in spring, in contrast to point count data where abundances were higher in spring than in fall. Several factors probably contribute to this discrepancy between methods, including easier detection of birds on point counts in spring because of less vegetation and more vocal birds, and habitat shifts toward scrub habitat, instead of woodlands in fall (most fall captures occurred in scrub habitats, but fall point counts were still centered in wooded areas, see below). Capture rates in farmstead woodlots were similar to those in riparian areas in the Big Sioux River corridor, but were lower than those for the Missouri River corridor (K.L. Dean and D.L. Swanson, unpubl. data). However, these comparisons are confounded by substantially lower total net hours (about 1000 net hours per corridor per season) in riparian habitats which may influence overall capture rates. Together, capture and point count data indicate that high, and roughly

similar, numbers of Neotropical woodland migrants utilize both riparian woodlands and farmstead woodlots in southeastern South Dakota as stopover habitat during migration.

III. COMBINED MIST NET AND POINT COUNT DATA

Capture and point count data were pooled to determine species richness (number of species) and diversity (Shannon Index). Species richness of Neotropical migrants increased gradually throughout the spring migration period, with peak richness occurring in late May/early June at 30 species (Fig. 3). This pattern contrasts with that of abundance, which peaked during the week of 13 May and declined thereafter. The increased richness in late spring primarily resulted from small numbers of rare migrants detected at this time (e.g., Yellow-bellied Flycatcher, Veery, Philadelphia Vireo, Blackburnian Warbler, Worm-eating Warbler), although late migrants that are more regular (e.g. Red-eyed Vireo, Mourning Warbler) also contribute. In fall, species richness peaked in late August/early September at 30 species and declined thereafter (Fig. 3). This peak richness was coincident with the first abundance peak in fall. The late fall abundance peak showed low species richness because it was composed largely of Ruby-crowned Kinglets and Orange-crowned and Yellow-rumped Warblers.

Comparisons of species numbers between different sites and different studies are confounded by differences in sampling effort and numbers of observations because more species would be expected to be detected with an increased number of observations. The technique of rarefaction has been developed to compare richness at sites with different sample sizes and works by calculating an expected number of species ($E[S_n]$) for a given sample size from each site (James and Rathbun 1981). We calculated rarefaction curves in spring and fall from our woodlot capture data and compared these curves with similar curves from pooled capture data from Missouri and Big Sioux River riparian areas (Dean and Swanson, unpubl. data). Expected species richness was slightly, but not significantly (Kolmogorov-Smirnov test, $P = 0.4\text{-}0.5$), higher in riparian woodlands than in farmstead woodlots in both spring and fall (Fig. 4). These data indicate similar species richness of Neotropical woodland migrants in riparian areas and farmstead woodlots during migration, suggesting that both can serve as important stopover habitat for a wide variety of Neotropical migrants.

Diversity of Neotropical migrants was computed from pooled capture and point count data as the Shannon Diversity Index (H'), which incorporates measures of both species richness and evenness into the calculation. Overall H' values were 2.57 in spring and 2.68 in fall indicating similar diversity of Neotropical migrants in farmstead woodlots at both seasons. Overall diversity in farmstead woodlots was also similar to that in riparian woodlands in southeastern South Dakota (H' values from 2.1-2.8, Dean and Swanson, unpubl. data). Neotropical migrant diversity increased gradually throughout the spring migration period in farmstead woodlots with peak diversity in late May and early June (Fig. 5). Fall Neotropical migrant diversity peaked in late August and early September and declined over the remainder of the fall migration period (Fig. 5). Temporal patterns of diversity in farmstead woodlots were very similar to patterns of species richness (Fig. 3) in both spring and fall migration periods. Temporal variation in Neotropical migrant diversity during fall migration was very similar in farmstead woodlots and riparian woodlands (Dean and Swanson, unpubl. data) in southeastern South Dakota, but spring migration patterns were somewhat divergent. In riparian woodlands, spring diversity increased gradually until mid-May and declined thereafter, mirroring the temporal variation in overall abundance of Neotropical migrants (Dean and Swanson, unpubl. data). Diversity and species richness in farmstead woodlots continued to increase throughout the spring migration period, even though overall abundance peaked in mid-May and declined thereafter, as in riparian corridors. These differences in temporal patterns in spring can probably be explained by the small numbers of relatively rare migrant species that were detected late in the spring

migration season in farmstead woodlots.

Combining capture and point count data also allows assessment of seasonal trends in the abundance of individual Neotropical migrant species using farmstead woodlots as stopover habitat. Several species showed clear seasonal trends in abundance (Tables 1 and 3). Species that were more abundant in spring than in fall included Hermit, Gray-cheeked, and Swainson's Thrushes, and Tennesee, Blackpoll, and Palm Warblers. Those species more abundant in fall than in spring included Nashville, Orange-crowned, Bay-breasted, Mourning, Wilson's, and Canada Warblers. These data are consistent with seasonal trends for individual Neotropical migrant species in riparian woodlands in southeastern South Dakota (Dean and Swanson, unpubl. data) and suggest that seasonal shifts in migratory routes occur in these species.

IV. ENERGETIC CONDITION AND STOPOVER BIOLOGY

Upon capture of a Neotropical migrant we measured mass to the nearest 0.1 g, wing chord, wing span, tarsus, and tail length to the nearest 0.1 mm, and visible fat class in furcular and abdominal regions on a scale of 0 (no fat) to 5 (maximum fat) according to Helms and Drury (1960). Studies addressing the effects of energetic condition on stopover behavior routinely compare mass, visible fat scores, or energetic condition index (mass/wing chord) at first capture between birds captured only once (single captures) and recaptured birds. When single captures and recaptures show significant differences in mass or fat, generally single captures are fatter than recaptured individuals, suggesting that lean birds are more prone to stopover (Moore and Kerlinger 1987, Loria and Moore 1990, Kuenzi et al. 1991, Yong and Moore 1997). It is assumed that birds captured only once continue migration after the day of capture and that the initial capture represents the actual arrival date of the bird at the stopover site. These assumptions do not hold for all birds, but probably provide conservative results with regard to comparisons between single captures and recaptures. If single captures do stopover, then assuming migrants gain mass during stopover (see below for a justification at our study site) they would be leaner than those birds continuing migration and this would artificially decrease mean mass or fat score of single capture individuals. If initial capture is not the actual arrival date, then mass or fat may be different than at actual arrival, but the probability of capturing a migrant at first arrival should be the same for single captures and recaptured birds, so this should affect both groups similarly. Thus, comparisons of mass, fat, or energetic condition at first capture between single captures and recaptured birds should provide a test of whether lean birds are more likely to stopover.

The duration of stopover for Neotropical migrants in this study was conservatively determined by subtracting the date at first capture from the date at last capture. Because mass varies with time of day in foraging birds, we corrected mass to 1200 h for all comparisons by determining the rate of mass gain per hour for individual species and adjusting the measured mass for the time of day when capture occurred. We recaptured 9.7% of Neotropical migrants in the spring of 1996, 14.5% in the spring of 1997, 13.9% in the fall of 1996, and 8.1% in the fall of 1997. The longest stopover durations were 12 days in spring, by a Swainson's Thrush, and 13 days in fall, by a Wilson's Warbler and a Nashville Warbler. Mean ($\pm$ SD) stopover duration for all Neotropical migrant species (excluding potentially breeding species) was 2.69 $\pm$ 2.36 days in spring ($n = 77$) and 3.80 $\pm$ 2.82 days in fall ($n = 114$). These durations did not differ significantly ($t_{189} = 1.078$, $P > 0.2$). Mean stopover durations for individual Neotropical migrant species are provided in Table 4.

We compared mean visible fat scores (Mann-Whitney *U*-test) and energetic condition (mass/wing chord) (t-test) at initial capture of birds captured only once (single captures) with birds that were recaptured to determine if energetic condition was related to the propensity for stopover. For only two species were fat scores significantly different between single captures and recaptured

birds. These species were Orange-crowned ($P = 0.02$) and Blackpoll ($P < 0.01$) Warblers, and in both species recaptured birds were significantly leaner than single capture birds (Fig. 6). When we compared mean energetic condition, only Blackpoll Warblers showed significantly lower ($P < 0.05$) energetic condition in recaptured birds than in single capture birds. Other species did not show significant differences in fat score or energetic condition between single captures and recaptures. These data suggest that for Orange-crowned and Blackpoll Warblers that lean birds are more likely to stopover than fat birds. This is consistent with several other studies demonstrating that if significant differences in mass, fat, or energetic condition occur between single capture and recaptured birds that recaptured birds are leaner, which suggests that energetic condition does affect stopover decisions in some species (Moore and Kerlinger 1987, Loria and Moore 1990, Kuenzi et al. 1991, Yong and Moore 1997).

Recaptured Neotropical migrants gained mass at our study site in three of four seasons, suggesting that farmstead woodlots do provide suitable stopover habitat. However, comparisons of mass gains for birds recaptured after one day with birds recaptured two or more days after initial capture revealed an interesting pattern. In both fall seasons Neotropical migrants lost mass on the first day following capture, but showed mass gains following the initial mass loss when recaptured two or more days after initial capture (Fig. 7). These data are similar to those for other studies which show an initial period of mass loss during stopover followed by a period of mass gain (Rappole and Warner 1976, Moore and Kerlinger 1987, Yong and Moore 1997). This pattern has been variously attributed to gaining familiarity with the stopover habitat, to rebuilding the digestive tract following a migratory flight, or to competition among conspecifics (Rappole and Warner 1976, Moore and Yong 1991, Yong and Moore 1997). An anomalous pattern of mass change with stopover occurred during the spring of 1996. During this season, even individuals captured two or more days after their initial capture generally showed mass losses, and mass loss per day in these birds was slightly greater than for individuals captured only one day after their initial capture (Fig. 7). The spring of 1996 was unusually rainy and cold, which presumably decreased the availability of arthropod prey for Neotropical migrants since most of these birds are primarily, if not exclusively, insectivorous in spring (Ehrlich et al. 1988, Parrish 1997). The spring of 1997 was more moderate with less inclement weather, and migrants were able to gain mass during this season. Thus, inclement weather can apparently negatively impact mass gain during stopover. The potential impacts of this reduction in mass gain during stopover on successful completion of migration and on territory establishment and breeding success on the nesting grounds is unknown, but of potentially great importance.

V. VEGETATION AND HABITAT SELECTION

We performed a modified point-centered quarter analysis (Bonham 1989) of vegetation in farmstead woodlots in which we censused birds. Points for vegetation analysis were centered on the same points that were used for point counts. We identified the nearest tree or shrub of greater than 1 cm diameter-at-breast-height (dbh) in each of the four cardinal directions at the census point and at 10, 20, 30, and 40 m in each of the four cardinal directions from the census point, where possible (sometimes woodlots were too narrow to include all of these points). A total of 656 trees or shrubs of 15 species were counted by this method. The most common tree species were elms, which comprised 54% of all trees counted on farmstead woodlots. Other prominent tree species included Mulberry (19.7%), Box Elder (8.7%), Hackberry (7.9%), and Green Ash (4.1%) (Fig. 8). All of the other tree species counted comprised less than 2% of the total. Farmstead woodlots had fewer tree species and generally lower vegetative diversity than riparian woodlands in southeastern South Dakota (Dean and Swanson, unpubl. data). Nevertheless, use of farmstead woodlots by Neotropical migrants

for stopover habitat, as exemplified by capture and point count data, was similar to that of riparian woodlands. Thus, the lower vegetative diversity of farmstead woodlots did not appear to negatively impact use of these habitats, relative to riparian woodlands, by Neotropical migrants for stopover.

During spring and fall seasons we recorded capture effort (in net hours) for each habitat type in which mist nets were erected within the farmstead woodlot study site. Habitat types during the spring migration period included woods, marsh edge, ditch, and shrub (Fig. 9). The woods habitat consisted of nets placed within the woodlot canopy. Marsh edge habitat occurred at the boundary of a cattail marsh, with standing water, and a wooded area. The ditch habitat was a narrow wooded corridor surrounding a ditch draining the marsh that carried water in spring. Finally, the shrub habitat consisted of an area of about an acre of regenerating elms from about 4-8 ft. in height. During fall migration nets were placed in these same habitats, as well as in a patch of Giant Ragweed of approximately 40 m^2 adjacent to the wooded ditch and a pasture (Fig. 10). We recorded the habitat in which Neotropical migrants were captured in both fall seasons and in the spring of 1997 (Figs. 9 and 10). In spring, distributions of capture effort and captures were not significantly different (Chi-squared Goodness-of-Fit test), suggesting an even distributions of migrants among habitat types (Fig. 9). During fall migration, however, distributions of capture effort and captures were significantly different ($P < 0.001$, Fig. 10). Captures in fall were shifted away from wooded areas toward shrubby habitats, especially ragweed, which accounted for 78.6% of all captures in fall, but only 30% of capture effort. This apparent shift in habitat use may also help explain why abundances of Neotropical migrants in fall were lower than those in spring (Fig. 1, Table 1) even though capture rates were higher in fall. Part of this discrepancy might result because point counts were centered within the wooded canopy of farmstead woodlots at both seasons, so birds in shrub habitats away from the wooded areas would go undetected, and this probably underrepresented birds during fall point counts.

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Spring	<25	Density	All	RA
AMRE	18	39.51	24	0.103448
BAOR	29	63.655	46	0.198276
BAWW	7	15.365	7	0.030172
BBCU	2	4.39	3	0.012931
BGGN	1	2.195	1	0.00431
BLBW	3	6.585	3	0.012931
BLPW	19	41.705	28	0.12069
BRTH	14	30.73	45	0.193966
CAWA	1	2.195	1	0.00431
COYE	34	74.63	69	0.297414
CSWA	6	13.17	7	0.030172
EAPH	1	2.195	2	0.008621
GCFL	1	2.195	2	0.008621
GCTH	1	2.195	4	0.017241
HETH	2	4.39	8	0.034483
INBU	5	10.975	9	0.038793
LEFL	77	169.015	119	0.512931
MAWA	9	19.755	9	0.038793
MOWA	6	13.17	8	0.034483
MYWA	171	375.345	261	1.125
NAWA	3	6.585	5	0.021552
NOWA	4	8.78	7	0.030172
OCWA	38	83.41	52	0.224138
OROR	7	15.365	11	0.047414
OVEN	3	6.585	4	0.017241
PHVI	3	6.585	4	0.017241
RCKI	37	81.215	54	0.232759
REVI	4	8.78	6	0.025862
SCTA	1	2.195	1	0.00431
SOVI	2	4.39	2	0.008621
SWTH	18	39.51	37	0.159483
TEWA	53	116.335	85	0.366379
TRFL	7	15.365	7	0.030172
VEER	0	0	2	0.008621
WAVI	17	37.315	36	0.155172
WEWA	0	0	1	0.00431
WIWA	0	0	3	0.012931
WPWA	5	10.975	7	0.030172
YBFL	0	0	1	0.00431
YWAR	73	160.235	110	0.474138
Grand Tot	682	1496.99	1091	4.702586

Fall	<25	Density	All	RA
AMRE	7	12.53	11	0.038732
BAOR	32	57.28	62	0.21831
BAWW	19	34.01	31	0.109155
BBCU	3	5.37	6	0.021127
BBWA	6	10.74	12	0.042254
BGGN	1	1.79	1	0.003521
BHGR	1	1.79	1	0.003521
BLBW	2	3.58	5	0.017606
BRTH	14	25.06	25	0.088028
BTNW	0	0	2	0.007042
CAWA	4	7.16	9	0.03169
COYE	28	50.12	40	0.140845
CSWA	2	3.58	3	0.010563
EAKI	2	3.58	2	0.007042
EAPH	4	7.16	5	0.017606
EAWP	1	1.79	5	0.017606
GCFL	2	3.58	3	0.010563
INBU	9	16.11	24	0.084507
LEFL	48	85.92	68	0.239437
MAWA	1	1.79	6	0.021127
MOWA	8	14.32	12	0.042254
MYWA	48	85.92	116	0.408451
NAWA	60	107.4	95	0.334507
NOPA	1	1.79	1	0.003521
NOWA	1	1.79	1	0.003521
OCWA	77	137.83	137	0.482394
OROR	3	5.37	4	0.014085
OVEN	2	3.58	9	0.03169
PHVI	0	0	3	0.010563
PIWA	0	0	1	0.003521
PRWA	1	1.79	1	0.003521
RCKI	77	137.83	132	0.464789
REVI	16	28.64	30	0.105634
SOVI	7	12.53	17	0.059859
SWTH	4	7.16	5	0.017606
TEWA	6	10.74	9	0.03169
TRFL	16	28.64	22	0.077465
WAVI	24	42.96	42	0.147887
WIWA	30	53.7	53	0.18662
YBFL	1	1.79	1	0.003521
YWAR	62	110.98	84	0.295775
(blank)	0	0		0
Grand Tot	630	1127.7	1096	3.859155

Table 1: Overall densities (birds km^{-2}) and relative abundances (RA, birds/point) for individual Neotropical migrant species in farmstead woodlots during spring (left) and fall (right) migration periods. Species codes are the four-letter codes from the U.S. Bird Banding Laboratory.

Table 2: Relative abundances (RA, birds/point) for individual Neotropical migrant species in farmstead woodlots as a function of week-long migratory periods (1 = 15 April and 15 August, 2 = 22 April and 22 August, etc.) during spring and fall migration periods. Species codes are the four-letter codes from the U.S. Bird Banding Laboratory.

Count of	Period	RA	season	RA		RA		RA		RA		RA		RA		RA		RA		RA		RA		RA		RA		RA		RA		RA
	1	1			2	2			3	3			4	4			5	5			6	6			7	7			8	8	
Species	fall	fall	spring	spring	fall	fall	spring	spring	fall	fall	spring	spring	fall	fall	spring	spring	fall	fall	spring	spring	fall	fall	spring	spring	fall	fall	spring	spring	fall	fall	
AMRE	1	0.071		0	2	0.041		0	1	0.024		0	7	0.167		0		0	5	0.179		0	4	0.103		0	15	0.429		0		0
BAOR	5	0.357		0	17	0.347		0	32	0.762		0	8	0.19	5	0.128		0	9	0.321		0	16	0.41		0	16	0.457		0		0
BAWW		0		0	3	0.061		0	9	0.214		0	11	0.262	3	0.077	4	0.095	3	0.107	4	0.103		0		0	1	0.029		0		0
BBCU		0		0		0		0	3	0.071		0	3	0.071		0		0		0		0		0		0	3	0.086		0		0
BBWA		0		0		0		0	1	0.024		0	5	0.119		0	5	0.119		0	1	0.026		0		0		0		0		0
BGGN		0		0		0		0	1	0.024		0		0	1	0.026		0		0		0		0		0		0		0		0
BHGR		0		0		0		0	1	0.024		0		0		0		0		0		0		0		0		0		0		0
BLBW		0		0	3	0.061		0	1	0.024		0	1	0.024		0		0		0		0		0		0	3	0.086		0		0
BRTH		0		0	5	0.102	4	0.103	10	0.238	8	0.25	6	0.143	17	0.436	3	0.071	12	0.429	1	0.026	2	0.051		0	2	0.057		0		0
BTNW		0		0	1	0.02		0		0		0	1	0.024		0		0		0		0		0		0		0		0		0
CAWA		0		0	3	0.061		0	4	0.095		0	2	0.048		0		0		0		0		0		0	1	0.029		0		0
COYE	6	0.429		0	6	0.122		0	2	0.048		0	10	0.238	3	0.077	8	0.19	11	0.393	6	0.154	25	0.641	1	0.029	30	0.857	1	0.048		0
CSWA		0		0		0		0	1	0.024		0	2	0.048		0		0		0		0	2	0.051		0	5	0.143		0		0
EAKI		0		0		0		0	2	0.048		0		0		0		0		0		0		0		0		0		0		0
EAPH		0		0	1	0.02		0		0	2	0.063	1	0.024		0		0		0	3	0.077		0		0		0		0		0
EAWP		0		0	2	0.041		0	1	0.024		0		0		0	1	0.024		0	1	0.026		0		0		0		0		0
GCFL		0		0		0		0	3	0.071		0		0		0		0	1	0.036		0		0		0	1	0.029		0		0
INBU	5	0.357		0	9	0.184		0	5	0.119		0	3	0.071		0	1	0.024		0		0	3	0.077	1	0.029	6	0.171		0		0
LEFL	1	0.071		0	22	0.449		0	17	0.405		0	25	0.595	2	0.051	3	0.071	40	1.429		0	41	1.051		0	36	1.029		0		0
MAWA		0		0		0		0	2	0.048		0	4	0.095		0		0	1	0.036		0		0		0	8	0.229		0		0
MOWA		0		0	6	0.122		0	4	0.095		0	2	0.048		0		0		0		0	2	0.051		0	6	0.171		0		0
MYWA		0		0		0	22	0.564		0	51	1.594		0	135	3.462	1	0.024	52	1.857	6	0.154	1	0.026	54	1.543		0	55	2.619		0
NAWA		0		0	2	0.041		0	3	0.071		0	29	0.69		0	35	0.833	1	0.036	23	0.59	1	0.026	2	0.057	3	0.086	1	0.048		0
NOPA		0		0		0		0		0		0		0		0	1	0.024		0		0		0		0		0		0		0
NOWA	1	0.071		0		0		0		0	2	0.063		0	2	0.051		0	2	0.071		0	1	0.026		0		0		0		0
OCWA		0		0		0	3	0.077		0	9	0.281		0	27	0.692	6	0.143	12	0.429	39	1	1	0.026	73	2.086		0	19	0.905		0
OROR	2	0.143		0		0		0	2	0.048		0		0		0		0	1	0.036		0	7	0.179		0	3	0.086		0		0
OVEN		0		0		0		0	2	0.048		0	6	0.143	1	0.026	1	0.024	3	0.107		0		0		0		0		0		0
PHVI		0		0		0		0		0		0	3	0.071		0		0		0		0	1	0.026		0	3	0.086		0		0
PIWA		0		0	1	0.02		0		0		0		0		0		0		0		0		0		0		0		0		0
PRWA		0		0		0		0		0		0		0		0		0		0	1	0.026		0		0		0		0		0
RCKI		0	2	0.1		0	22	0.564		0	21	0.656	2	0.048	6	0.154	6	0.143	3	0.107	60	1.538		0	40	1.143		0	24	1.143		0
RLVI		0		0	4	0.082		0	13	0.31		0	13	0.31		0		0		0		0		0		0	6	0.171		0		0
SOVI		0		0	1	0.02		0	2	0.048		0	5	0.119	1	0.026	1	0.024	1	0.036	8	0.205		0		0		0		0		0
SWTH		0		0		0		0		0	1	0.031	3	0.071	6	0.154		0	11	0.393	1	0.026	5	0.128	1	0.029	14	0.4		0		0
TEWA		0		0		0		0	3	0.071		0	5	0.119	1	0.026	1	0.024	10	0.357		0	31	0.795		0	43	1.229		0		0
TRFL	1	0.071		0	8	0.163		0	10	0.238		0	3	0.071		0		0		0		0	2	0.051		0	5	0.143		0		0
WAVI		0		0	3	0.061		0	13	0.31		0	20	0.476		0	5	0.119	6	0.214	1	0.026	17	0.436		0	13	0.371		0		0
WIWA		0		0	12	0.245		0	27	0.643		0	12	0.286		0	2	0.048	1	0.036		0	1	0.026		0	1	0.029		0		0
YBFL		0		0		0		0		0		0	1	0.024		0		0		0		0		0		0	1	0.029		0		0
YWAR	13	0.929		0	25	0.51		0	21	0.5		0	21	0.5	12	0.308	2	0.048	33	1.179	2	0.051	39	1		0	26	0.743		0		0
HETH		0	1	0.05		0	5	0.128		0	2	0.063		0		0		0		0		0		0		0		0		0		0
WPWA		0		0		0	2	0.051		0	1	0.031		0	3	0.077		0	1	0.036		0		0		0		0		0		0
BLPW		0		0		0		0		0		0		0	2	0.051		0	9	0.321		0	7	0.179		0	10	0.286		0		0
VEER		0		0		0		0		0		0		0		0		0		0		0		0		0	2	0.057		0		0
GCTH		0		0		0		0		0		0		0		0		0	4	0.143		0		0		0		0		0		0
WEWA		0		0		0		0		0		0		0		0		0		0		0		0		0	1	0.029		0		0
SCTA		0		0		0		0		0		0		0		0		0		0		0		0		0	1	0.029		0		0
Grand T	35	2.5	3	0.15	136	2.776	58	1.487	196	4.667	97	3.031	214	6.095	227	5.821	86	2.048	232	8.286	157	4.026	209	5.359	172	4.914	265	7.571	100	4.762		

Table 3. Total captures and overall capture rates (birds/1000 net hours) for spring and fall migratory periods for Neotropical woodland migrants in farmstead woodlots. Species codes are the four-letter BBL banding codes.

Species	Fall Captures	Fall Capture Rate	Spring Captures	Spring Capture Rate
AMRE	8	1.566348567	6	1.381905786
BAWW	11	2.15372928	5	1.151588155
BBWA	3	0.587380713	1	0.230317631
BLBW	2	0.391587142		0
BLPW		0	30	6.909528931
BTNW	1	0.195793571		0
CAWA	11	2.15372928	4	0.921270524
COYE	102	19.97094423	68	15.66159891
CSWA	4	0.783174284		0
EAPH	4	0.783174284		0
EAWP		0	1	0.230317631
GCFL	1	0.195793571		0
GCTH		0	14	3.224446835
GWWA	2	0.391587142		0
HETH		0	7	1.612223417
INBU	15	2.936903564	7	1.612223417
LEFL	56	10.96443997	65	14.97064602
MAWA	4	0.783174284	4	0.921270524
MOWA	62	12.1392014	3	0.690952893
MYWA	65	12.72658211	117	26.94716283
NAWA	200	39.15871418	2	0.460635262
NOWA	14	2.741109993	15	3.454764466
OCWA	200	39.15871418	24	5.527623145
OVEN	16	3.132697135	8	1.842541048
RCKI	88	17.22983424	11	2.533493941
REVI	13	2.545316422	6	1.381905786
SOVI	2	0.391587142		0
SWTH	4	0.783174284	102	23.49239837
TEWA	26	5.090632844	20	4.606352621
TRFL	34	6.656981411	14	3.224446835
VEER		0	1	0.230317631
WAVI	25	4.894839273	8	1.842541048
WEWA		0	2	0.460635262
WIWA	144	28.19427421	4	0.921270524
WOTH		0	1	0.230317631
WPWA		0	8	1.842541048
YBFL	4	0.783174284	3	0.690952893
YWAR	178	34.85125562	118	27.17748046
Grand Total	1299	254.3358486	679	156.3856715

Table 4. Mean (± SD) stopover durations (days) in spring and fall for Neotropical migrants that were recpatured at least one day following their initial capture at a farmstead woodlot in southeastern South Dakota. Species codes are the four-letter codes from the U.S. Bird Banding Laboratory.

Species	n	Spring Duration	n	Fall Duration
AMRE	1	2.0	0	—
BAWW	0	—	2	1.5
BLPW	4	2.5 ± 1.7	0	—
CAWA	4	1.8 ± 1.0	2	6.0
GCTH	3	1.3 ± 0.6	0	—
HETH	2	1.0	0	—
LEFL	6	3.3 ± 2.9	3	4.0 ± 1.7
MAWA	2	6.0	1	5.0
MOWA	1	2.0	12	3.6 ± 3.2
MYWA	9	3.4 ± 2.1	0	—
NAWA	0	—	22	4.4 ± 3.2
OCWA	1	1.0	21	3.4 ± 2.2
OVEN	2	2.5	3	1.3 ± 0.6
REVI	0	—	1	1.0
SWTH	26	3.1 ± 2.8	1	1.0
TEWA	0	—	2	10.0
TRFL	0	—	3	2.3 ± 0.6
WEWA	2	1.0	0	—
WIWA	0	—	22	4.2 ± 3.3
YBFL	1	1.0	1	2.0
YWAR	13	2.0 ± 1.9	18	3.4 ± 2.1

Figure 1. Density (birds km^{-2}) and relative abundance (birds/point) of Neotropical woodland migrants in farmstead woodlots as a function of seven-day periods (beginning on the indicated date) during spring and fall migration.

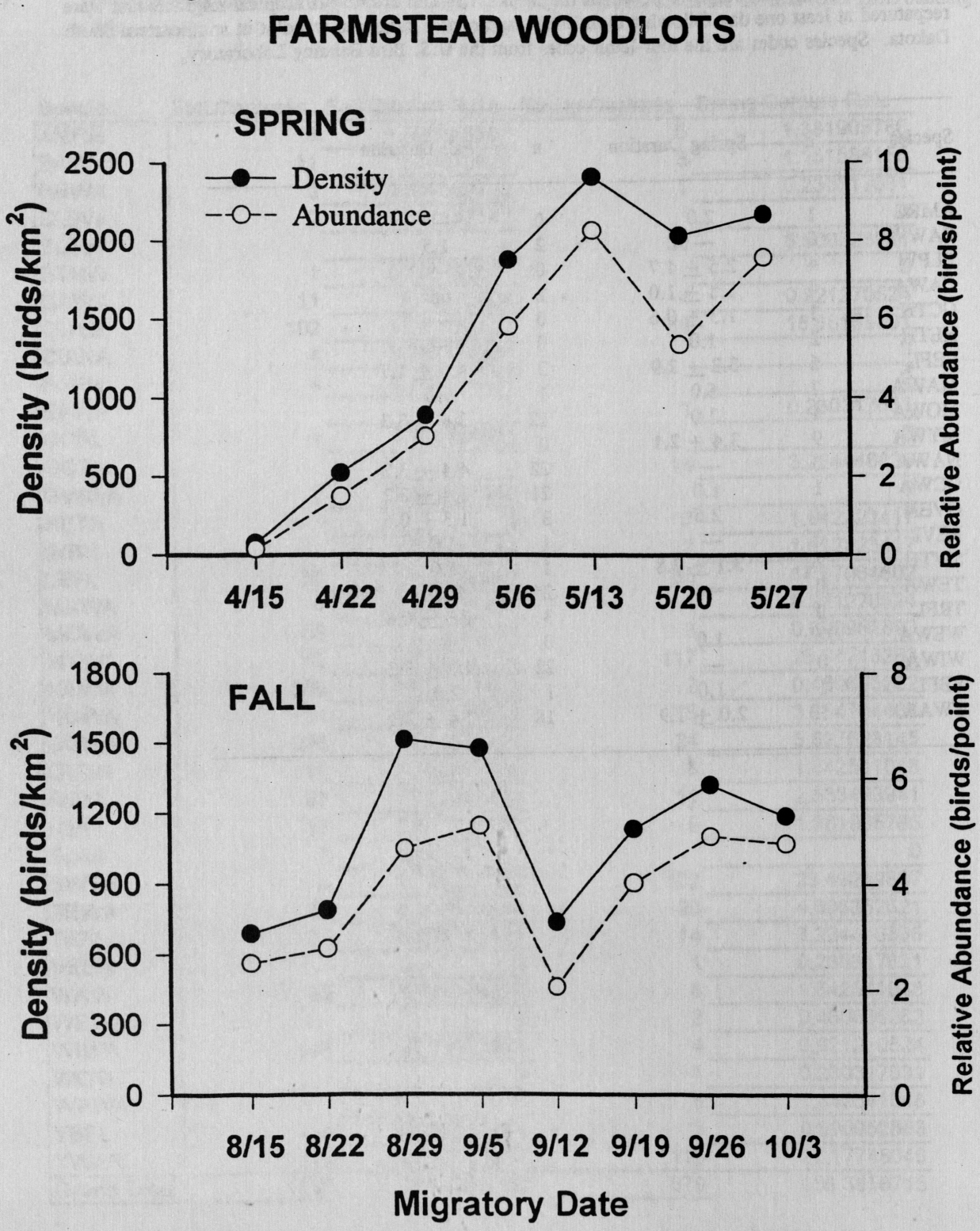


Figure 2. Capture rates (birds/1000 net hours) for Neotropical woodland migrants in farmstead woodlots in southeastern South Dakota as a function of successive 7-day periods throughout spring and fall migration. Migratory periods for spring and fall are the same as the dates listed in Figure 1.

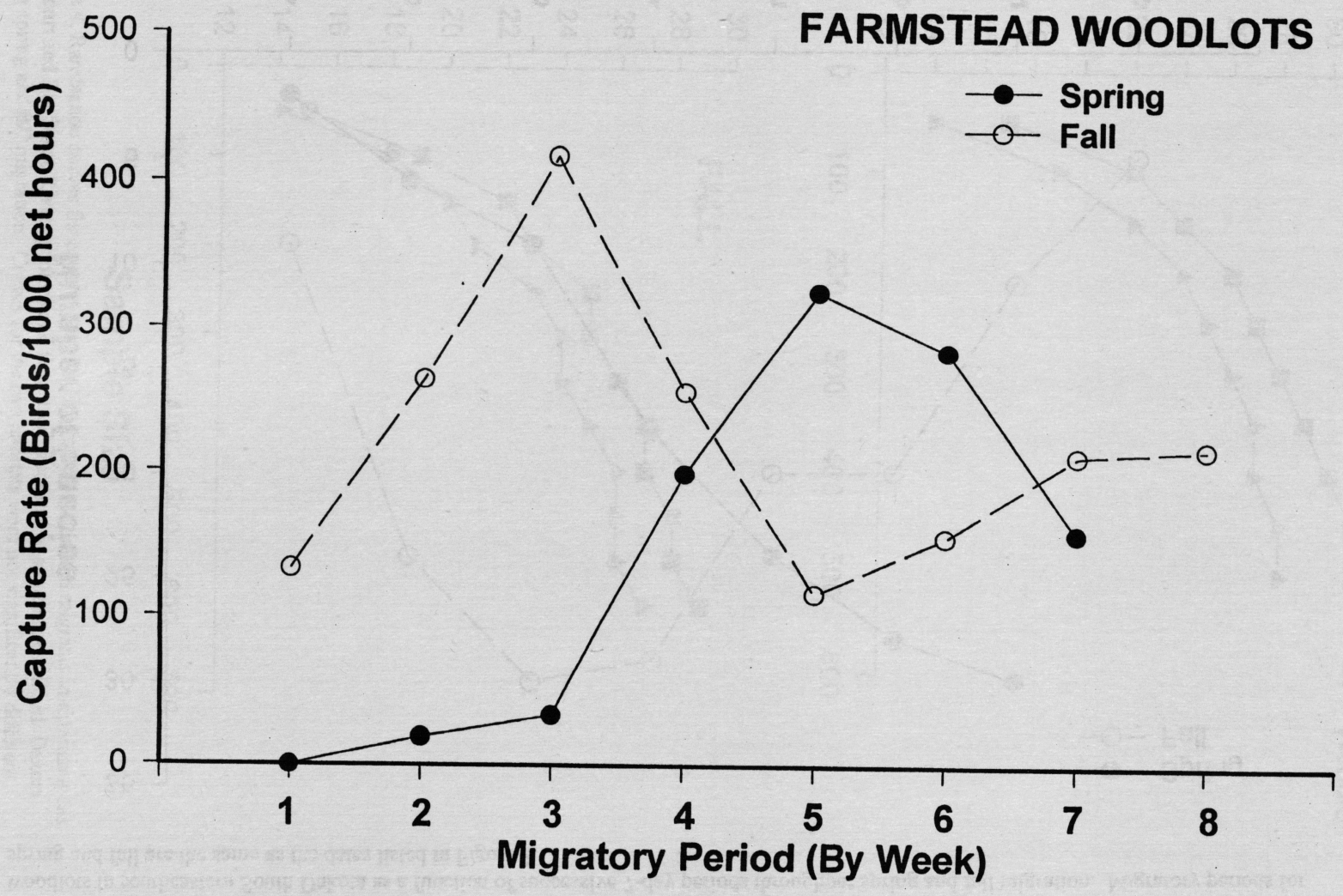
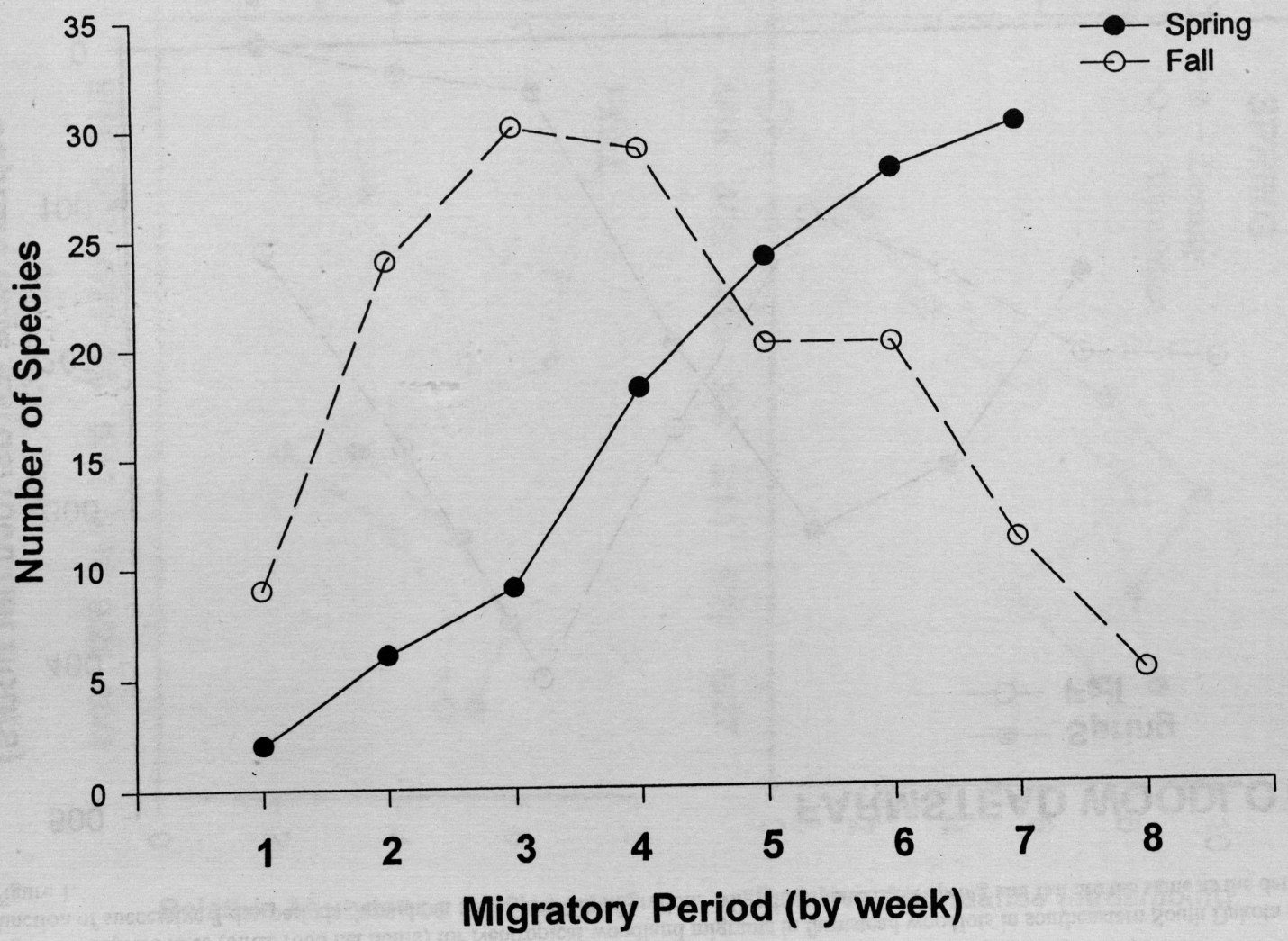


Figure 3. Species richness (number of species) of Neotropical woodland migrants from pooled capture and point count data for farmstead woodlots in southeastern South Dakota as a function of successive 7-day periods throughout spring and fall migration. Migratory periods for spring and fall are the same as the dates listed in Figure 1.



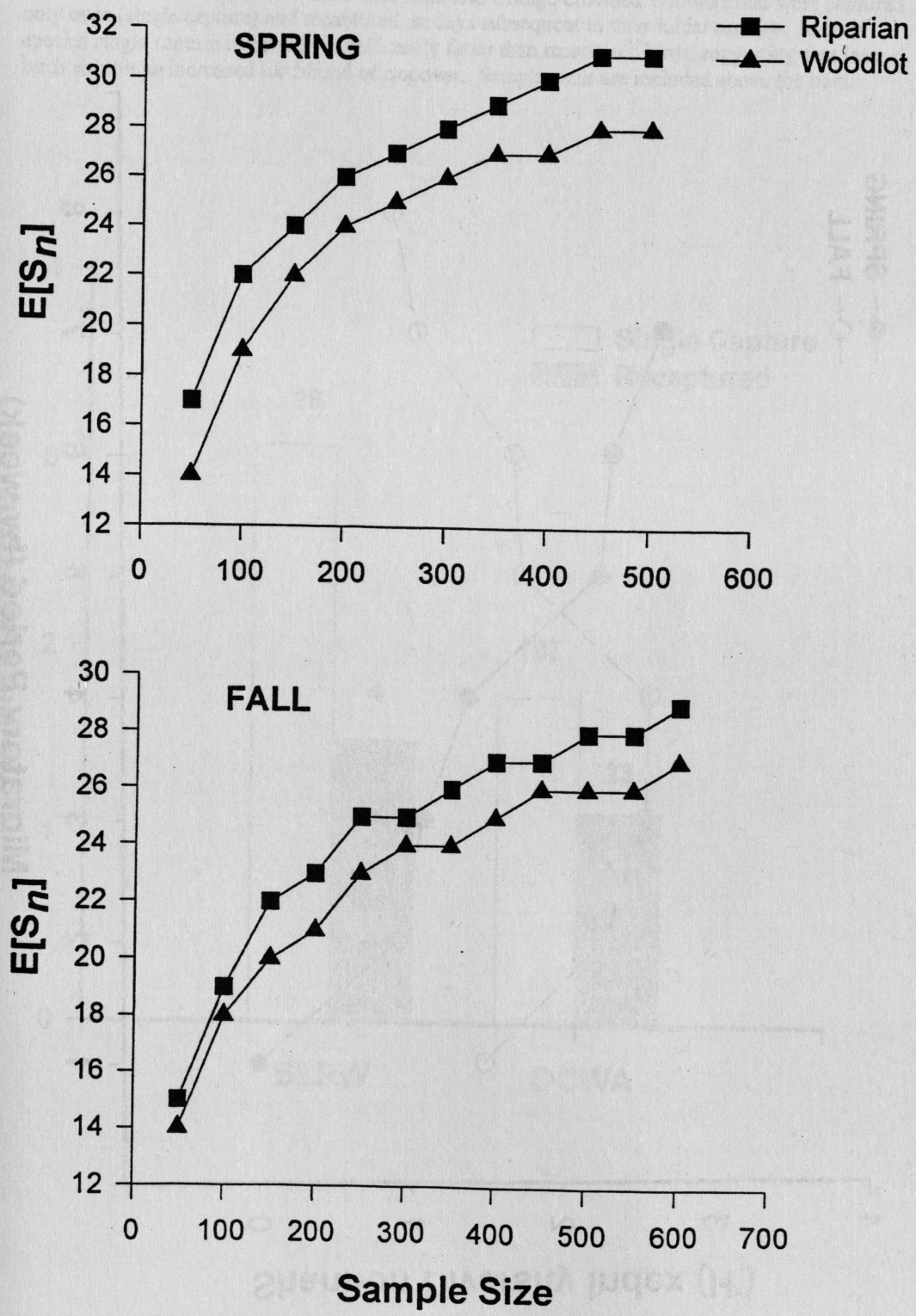


Figure 4. Rarefaction curves for capture data for Neotropical woodland migrants in riparian areas (Missouri and Big Sioux Rivers pooled) and farmstead woodlots in southeastern South Dakota during spring and fall migration. Curves for the two habitats were not significantly different.

Figure 5. Shannon Diversity Index (H') for Neotropical migrants in farmstead woodlots in southeastern South Dakota as a function of successive 7-day periods throughout spring and fall migration. Migratory periods for spring and fall are the same as the dates listed in Figure 1.

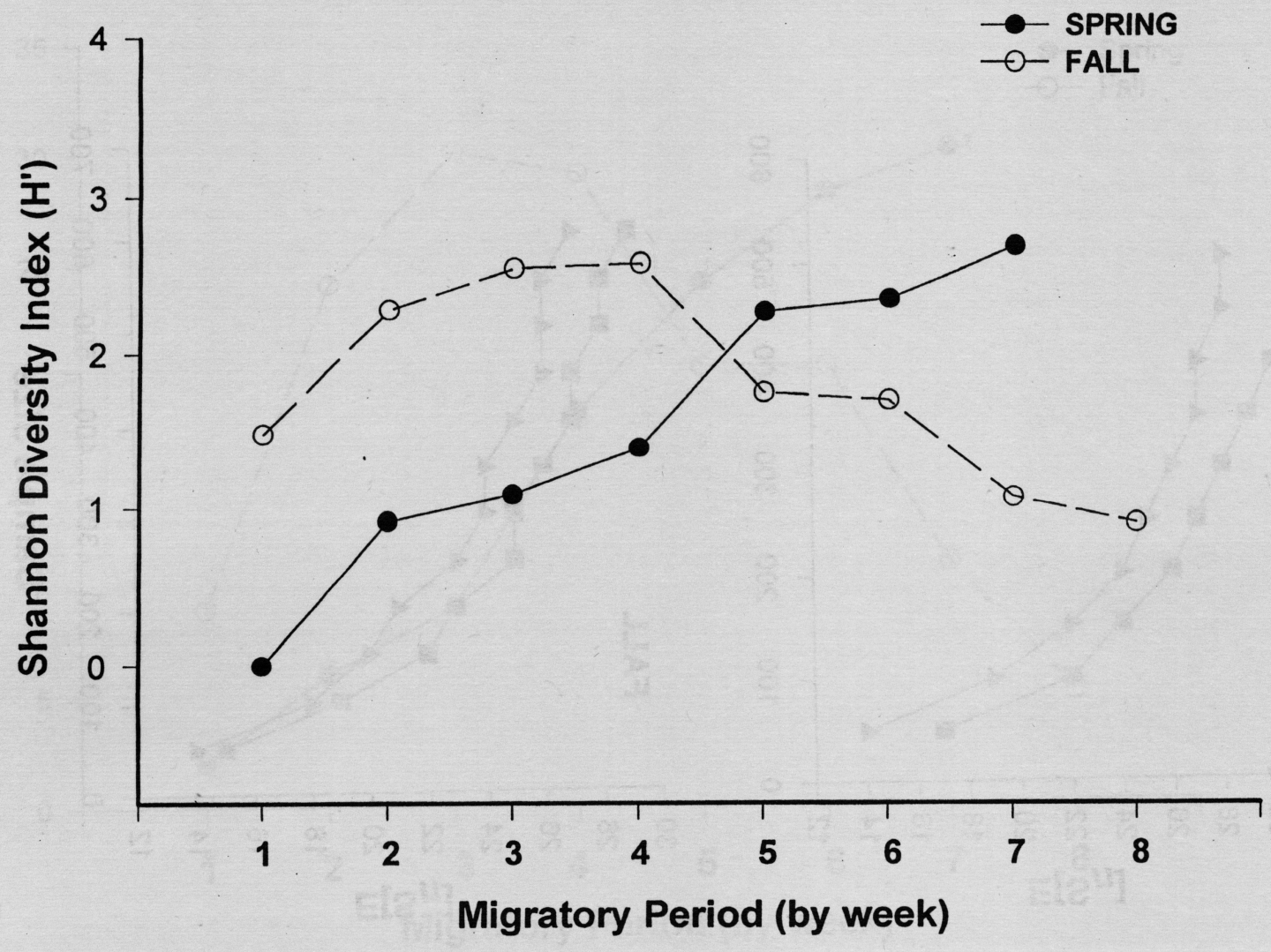


Figure 6. Mean visible fat scores for Blackpoll and Orange-crowned Warblers that were captured only once (single capture) and recaptured on days subsequent to their initial capture. In both species single capture birds were significantly fatter than recaptured birds, suggesting that lean birds exhibit an increased likelihood of stopover. Sample sizes are included above the bars.

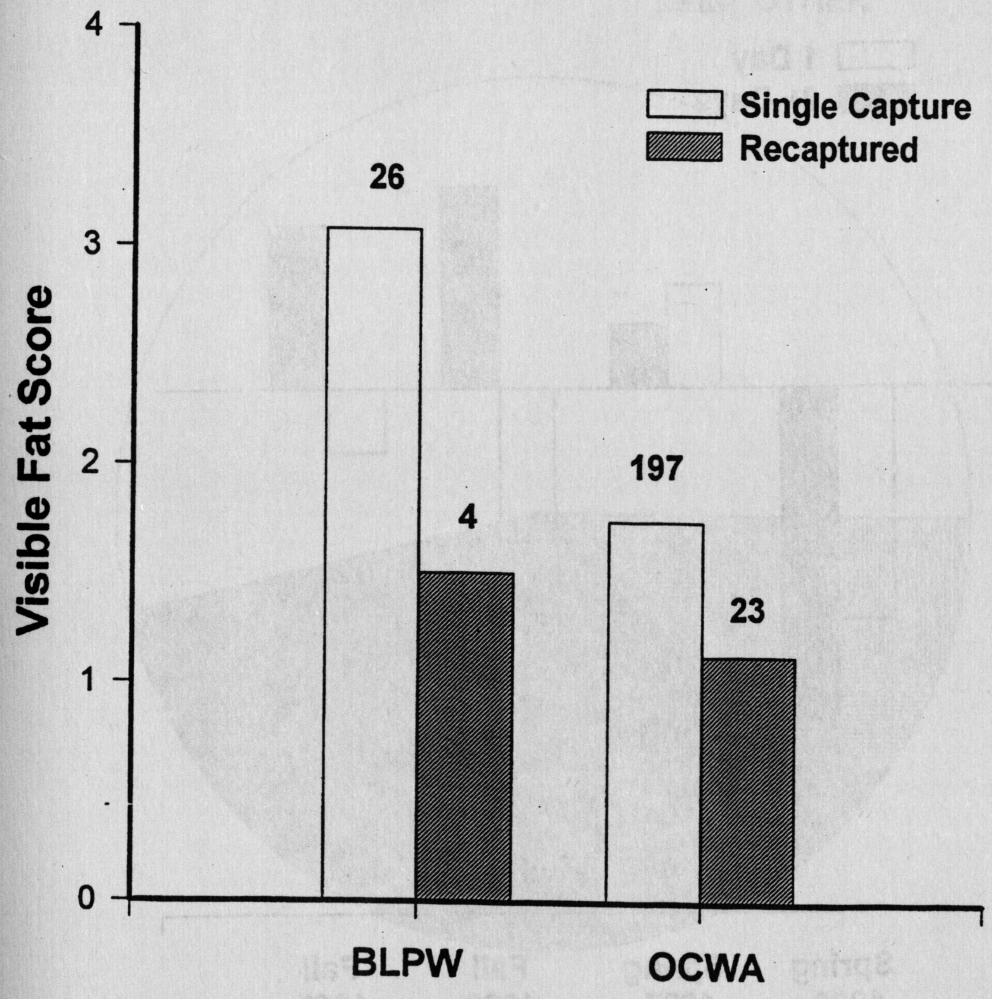
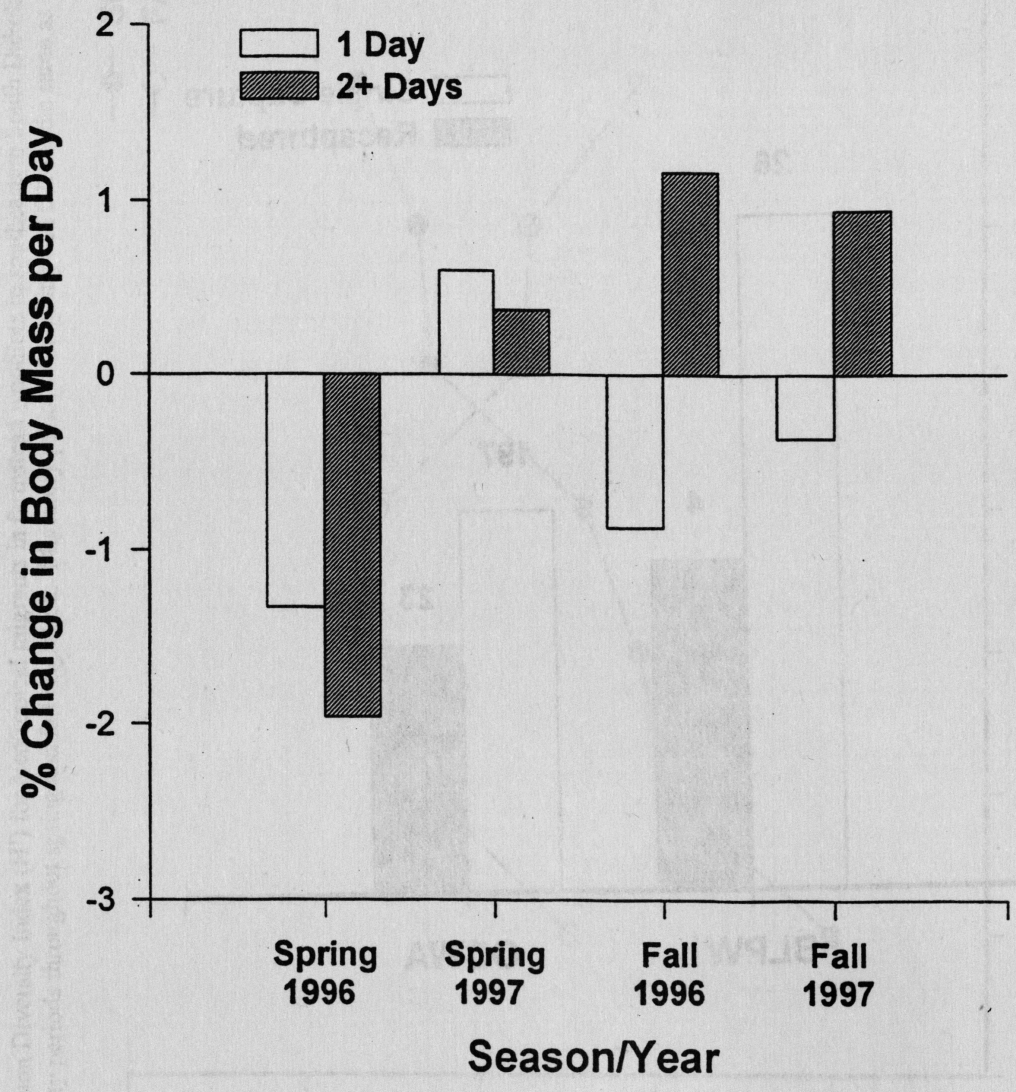


Figure 7. Percent change in body mass per day for recaptured Neotropical migrants in farmstead woodlots in southeastern South Dakota during the four seasons in this study. Values are for birds recaptured on the day following initial capture (1 Day) and 2 or more days after initial capture (2+ Days). All mass values were corrected to 1200 h for this analysis.



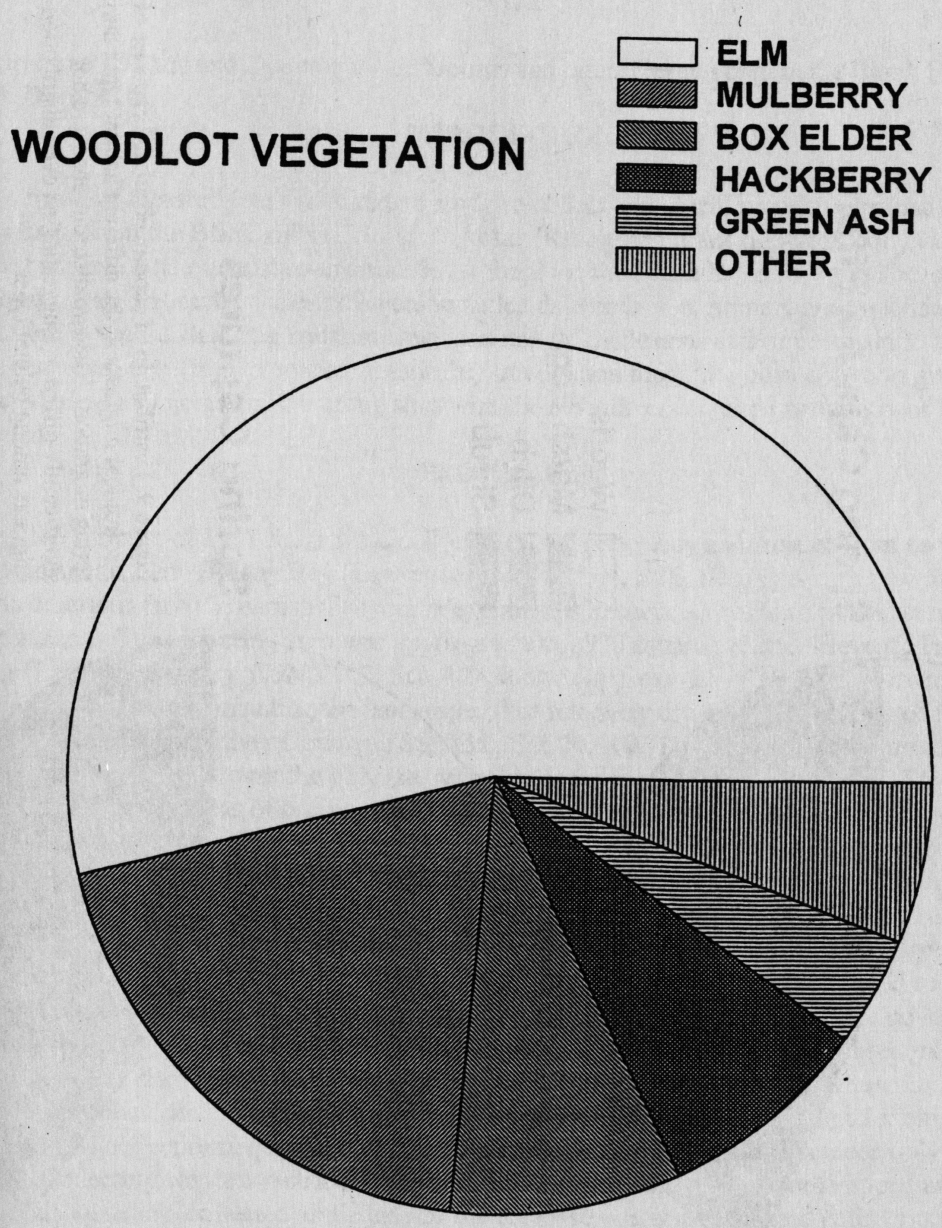


Figure 8. Vegetation present in farmstead woodlots, as sampled by a modified point-centered quarter analysis (Bonham 1989). The "other" category contains 10 species of trees and shrubs, each of which comprised less than 2% of the total trees or shrubs counted.

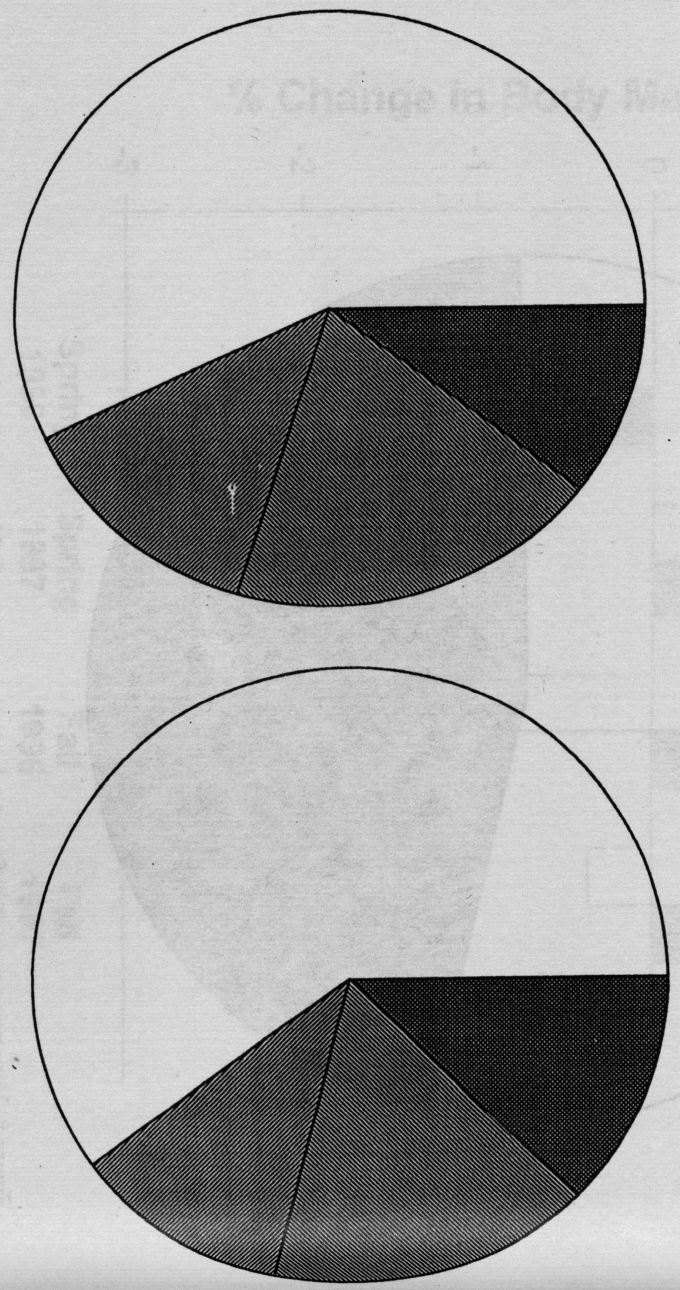


Figure 9. Distribution of capture effort and captures of Neotropical migrants in the different habitat types during spring migration. The two distributions were not significantly different, suggesting an even distribution of migrants among habitat types.