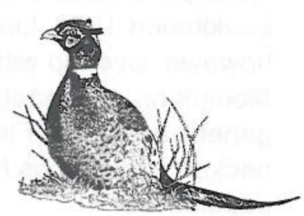
Effects of Experimental Sichuan Pheasant Releases on Pheasant Abundance



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Introduction

The Wildlife Division initiated the Sichuan pheasant (*Phasianus colchicus strauchi*) introduction in 1985 as one response to a long-term pheasant decline (Squibb 1985, Prince et. al. 1988). Michigan's sister state relationship with Sichuan Province, People's Republic of China created an opportunity to obtain Sichuan pheasants directly from their native range. The primary factor motivating this introduction was the prediction that Sichuan pheasants would occupy a niche in Michigan different from that occupied by ring-necked pheasants (*Phasianus colchicus torquatus*). Biologists hypothesized that Sichuan pheasants would thrive in brushy southern Michigan habitats that had become more plentiful on idle farmlands since the 1960's.

Another potential advantage of the Sichuan program was the introduction of new genetic variation into a declining pheasant population. The combination of a history of artificial selection of captive ring-necked pheasants and a population bottleneck during initial introductions may have limited genetic variability. Low genetic variability may decrease overall fitness, increase the frequency of deleterious alleles, and increase inbreeding depression (Flegel 1996). Low genetic variability may also limit the adaptation of ring-necked pheasants to habitat change (Trautman 1982).

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Research on captive, released, and established pheasants have demonstrated some morphological and behavioral traits of Sichuan pheasants that would support the hypothesis of incomplete niche overlap with ring-necked pheasants (Campa et al. 1987, Rabe et al. 1988, Luukkonen 1990, Luukkonen 1994, Prince et al. 1994, Niewoonder 1995). Sichuan pheasants, however, overlap with ring-necked pheasants in many behaviors (Luukkonen 1990, 1994). Monitoring of phenotypic characteristics (Belyea and Reis 1993, Luukkonen 1994) and detailed genetic analyses (Flegel 1996) of harvested pheasants within Sichuan post-release and ring-necked populations have documented the successful infusion of Sichuan traits into local populations.

While behavioral and genetic research confirmed some predictions of the Sichuan program, a complete evaluation should include measuring short and long-term impacts of releases on local pheasant abundance. Studies of pheasant abundance in the 93 km^2 (36 mi^2) Livingston County Study Area showed that pheasants increased during Sichuan release and immediately post-release to a peak winter population of 1580 birds, but then declined over 2 years to a near pre-release population of 880 birds (Luukkonen 1994). However, the Livingston County study was not designed as an experimental test of the hypotheses that releases impact pheasant abundance and so lacked replication and control. This study was initiated to overcome the limitations of early studies with the objective of measuring the short-term impacts of Sichuan releases on local pheasant abundance.

Acknowledgments

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Study Area and Methods

Study Area

The study area included 8, 93 km^2 (36 mi^2) plots located in Barry and Eaton County (Fig. 1). This area was chosen because it was among the few top priority release sites in the Sichuan introduction program that had not already received birds. The study area encompasses two distinctive landscapes, classified by Albert (1995) as the Ionia and Kalamazoo Interlobate Subsections of the Southern Lower Michigan Section. Generally, the Ionia Subsection (Eaton Co. and Northeast Barry Co.) contains more gently sloping terrain and soils of higher fertility than the Kalamazoo Interlobate Subsection. Agricultural land uses are more prevalent in the Ionia Subsection while forest cover is more extensive in the Kalamazoo Interlobate Subsection.

Experimental Design

Initially, several experimental designs were considered, all of which required buffer areas between release and control plots. Buffers were necessary to minimize the impact of Sichuan dispersal onto control areas. The need for buffers limited the pool of potential sites and the presence of two distinctive landscape types further complicated site selection. A paired arrangement (release-control) of sites was chosen such that study areas with similar habitat conditions were paired while maintaining 4.8 km (3 mi) buffers between release and control areas (Fig. 1). The phrase "control areas" is used throughout this paper for convenience. Readers should understand that many factors that impact pheasant abundance, such as weather and habitat conditions, were not under our control. We assume that changes in pheasant numbers attributable to these factors were similar within pairs.

Sichuan pheasants were released during March 1993 (1160 birds), December 1993 (1328 birds), March and April 1994 (1256 birds), December 1994 (1000 birds), and March 1995 (1763 birds) for a total of 6507 birds. Releases followed guidelines established for previous Sichuan releases conducted across southern Michigan. Each release area contained 10 release sites spaced ≥ 1.6 km (1 mi) apart. December releases occurred after the close of the pheasant hunting season, which was open in all years of the study.

Population Monitoring

Winter (January-March) pheasant populations were monitored using flush counts in potentially suitable habitat. Randomly selected quarter sections were chosen as the first sampling unit. Within each randomly selected quarter section, three parcels of land ≥ 25 ha (10 ac) were selected randomly from plat maps. Field workers were instructed to visit each parcel in a specified order until a parcel with at least 6 ha (2.5 ac) of suitable habitat was found. The landowner was then contacted for permission to conduct surveys. Training sessions were held describing suitable habitats and count methods.

Field workers recorded the date, starting and ending times, numbers of hens, roosters, and unknown sex pheasants seen, pheasant sign (tracks and roosts), and an estimate of the acreage searched. Maps were drawn in the field detailing site locations, cover types searched, and locations of pheasant observations. Approximately 20 sites per study area were searched from 1 to 3 times each winter, depending on snow cover. Snow cover was considered essential to aid in locating pheasants and tracks. The same sites were retained in successive years if suitable cover remained. Replacement sites where chosen near the original site when cover was removed. Sex and subspecies (males only) of pheasants encountered while driving to search sites was plotted on study area maps.

Spring populations were monitored using crowing count indices (Kimball 1949, Gates 1966). A 9-stop route was established for each study area. Each survey route was run 4 times during May 1993-96. All routes were surveyed simultaneously within years and each observer was assigned a pair of routes. Observers began surveys 40-minutes before sunrise and listened for 3-minutes at each stop.

Pheasant hunter success was monitored via hunter interviews on peak days of the pheasant season, 1993-95. One observer was assigned to each study area with instructions to contact as many hunters as possible. The number of hunters in each party, length of hunt, numbers of hens and roosters seen, and number of roosters taken were recorded. The width and completeness of neck rings were measured to identify subspecies of harvested roosters.

Data Analysis

Field maps of winter flush count sites were used to delineate the boundaries of these sites on base maps of each study area developed from color infrared aerial photographs. Site boundaries were then digitized to estimate the area searched each winter. Digitized base maps were used to estimate the area of potentially suitable winter habitat present on the study area. Estimates of potentially suitable habitat facilitated calculating minimum pheasant "population estimates" as: (birds observed/ha)x(suitable area). This method will produce estimates biased downward because: 1. not all pheasants present are observed, 2. base maps do not include small habitat patches that could be occupied, and 3. pheasants using areas with sparse cover would be missed based on our definition of suitable habitat. Thus, population estimates are best interpreted as an index adjusted for the area of potentially suitable habitat.

Winter and spring population indices were analyzed using mixed (random and fixed factors) linear models (Searle 1971). These analyses were implemented with the PROC MIXED procedure in SAS (Littell et al. 1996). The focus of these analyses was to evaluate population changes on treatment and control areas by testing for treatment by time interactions.

Two model types were fit to the winter flush count data. For both model types, the number of birds observed per hectare of searched habitat (birds/ha) and the number of birds observed adjusted for area of potentially suitable habitat (population estimate) were tested as response variables. The first model type (standard), considered treatment (release, no release) and months since initiation of the experiment (1, 10, 11, 22, 23, 34, and 35) as fixed categorical factors. Pair (1-4) was included in these models as a random factor. The second model type (repeated) used a repeated measures approach. Model type 2 nested site within treatment as the subject factor and the covariance structure was modeled using the spatial power law (Littell et al. 1996:126-130). This covariance structure allows for unequal timing between surveys and accounts for the tendency of observations taken close in time to be more highly correlated than measurements taken farther apart.

A series of models was fit to crowing count data to account for lower crowing rates of Sichuan pheasants compared to ring-necked pheasants (Luukkonen et al. In Press). Two scenarios were considered. The first scenario included 3 models, each model assumed all release area pheasant populations for years 1994-96 were composed of either 0, 30, or 50% pure-strain Sichuan roosters. The second scenario increased the Sichuan percentage over time (1993=0%, 1994=30%, 1995=40%, and 1996=50%). Model structure was analogous to model type 1 above, except year replaced month. Pair was again included as a random factor. Crowing counts were log transformed to stabilize variances. Taking the logarithm of zero was avoided by adding 1 to all counts.

Results and Discussion

Winter roadside observations suggested that pheasant populations in release areas were composed of approximately 45% combined Sichuan and hybrid male pheasants (Table 1). Hunter harvested pheasants were approximately 27% Sichuan or hybrid (Table 1). The difference in estimates between roadside observations and hunter harvested birds may reflect the timing of the surveys relative to releases. Winter counts began in January, shortly after December releases, while October and December hunter surveys began approximately 6 months after April releases. Fall released Sichuan roosters have shown higher survival rates than spring released roosters (Rabe 1991). Thus, more released Sichuan roosters would be expected in winter populations. Hunter bag checks demonstrated that there was a small amount of Sichuan pheasant immigration onto control areas (Table 1).

The number of pheasants observed/ha during winter counts was correlated with crowing indices (Table 2). Similarly, the number of pheasants observed/ha during winter was correlated with winter counts adjusted for potentially suitable winter habitat ($r=0.89$; $n=56$; $P < 0.001$). The relatively high correlations among winter and spring indices is one indication that our methods provided consistent indicators of pheasant population abundance. Hunter effort and harvest data were sparse for some townships, precluding meaningful comparisons with other indices on an area by area basis. Taken in aggregate, hunter pheasant observations declined from 1993-95 (Table 3).

Standard mixed models indicated that pheasant populations were larger on release sites than controls and that populations varied over time (Fig. 2; Table 4: models 1-2; Table 5: models 5-8). Treatment effects in the repeated measures models were not significant, but time effects were (Table 4: models 3-4). Comparisons of pre-release least-squares means indicated that pheasant populations were over 2 times higher on treatment areas compared to controls prior to releases (models 1 and 2; $T \geq 1.72$; df=39; $P < 0.10$). For this reason, the presence of significant treatment effects should not be interpreted as a population response to releases. Release effects are more accurately portrayed by the treatment by time interaction; this factor tests the hypothesis that population change over time was consistent between treatment and control areas. Treatment by time interactions were not significant for any of the models. Adjusting crowing counts to account for subspecific crowing rates had little effect on the treatment by year interaction (Table 5). Analysis of winter hen populations with models analogous to models 1-4 did not change the inference made regarding treatment by time interactions (Fig 2; $F \leq 1.59$; $P \geq 0.175$).

Graphical evaluation of pheasant population trends on paired areas demonstrated some individual variation that could be masked by analysis of aggregated sites (Figs. 3 and 4). Winter trends in pair 3 and fall trends in pairs 1 and 3 suggest a short-lived population increase in response to releases (Figs 3 and 4). However, models fit to crowing data for pairs 1 and 3 individually did not detect a treatment by time interaction ($F \leq 1.5$; df=1,31; $P \geq 0.24$). The trends in release sites 1 and 3 were similar to the population trend in the Livingston County release from 1987-93, except the peak numbers in Livingston County were sustained for a longer duration.

Winter pheasant populations showed regular reductions in abundance between January and February counts within years (Fig. 3), which is most likely a result of winter mortality. Pheasant remains (feathers, bones, and legs) were commonly observed at some sites. These results are consistent with observations of high winter predator losses among radio-tagged pheasants in Livingston County (Luukkonen 1994).

Conclusions and Management Implications

Releases of Sichuan pheasants would be expected to contribute to pheasant abundance only if several conditions are satisfied. Southern Michigan habitats must provide resources that act as surrogates to resources found within the Sichuan pheasant's natural range in the People's Republic of China. Successful breeding of Sichuan and Sichuan x ring-necked hybrids is well documented in this and other Michigan study areas (Niewoonder 1995). Furthermore, previous studies of pheasant plumage characteristics have documented the flow of Sichuan genes into release area populations. Studies of pheasant genetics over a broad area of southern Michigan have confirmed this finding and suggest that plumage coloration provides a conservative measure of gene flow (Flegel 1996).

The addition of new genetic material might allow pheasants to increase over the short-term if the new phenotypes can utilize limiting resources that are unexploited by ring-necked pheasants. This assumes that advantageous traits can persist long enough to allow population growth. Data from released pheasants have shown a breeding season survival advantage for first generation (F1) ring-necked x Sichuan hybrid hens compared to the parent subspecies (Niewoonder 1995). However, research on wild-trapped pheasants has shown inconsistent winter survival differences between hybrid and ring-necked hens (Luukkonen 1994). If survival advantages are present only in F1 hybrids, then continued crossing could result in a relatively rapid loss of heterotic effects. This is consistent with the short-term population increase and decline in the proportion of birds with identifiable Sichuan traits in the Livingston County release (Luukkonen 1994).

The results of this study failed to demonstrate increases in pheasant abundance attributable to Sichuan pheasant releases. The most plausible explanation for these results is that release area populations are constrained by the same limiting resources as ring-necked populations. Research in Livingston County suggested that winter cover affording protection from predators with juxtaposed food resources was limiting, although inadequate brood rearing cover could not be ruled out. Future research should test the hypothesis that winter resources are limiting so that strategies to overcome habitat deficiencies can be developed and tested.

The long-term effects of introducing Sichuan pheasants are unknown. Clearly, southern Michigan landscapes will continue to change. Future pheasant population trends in Michigan compared to trends in similar regions where Sichuan pheasants were not introduced may be our only indication of the degree to which Sichuan releases have facilitated adaptation to those changes.

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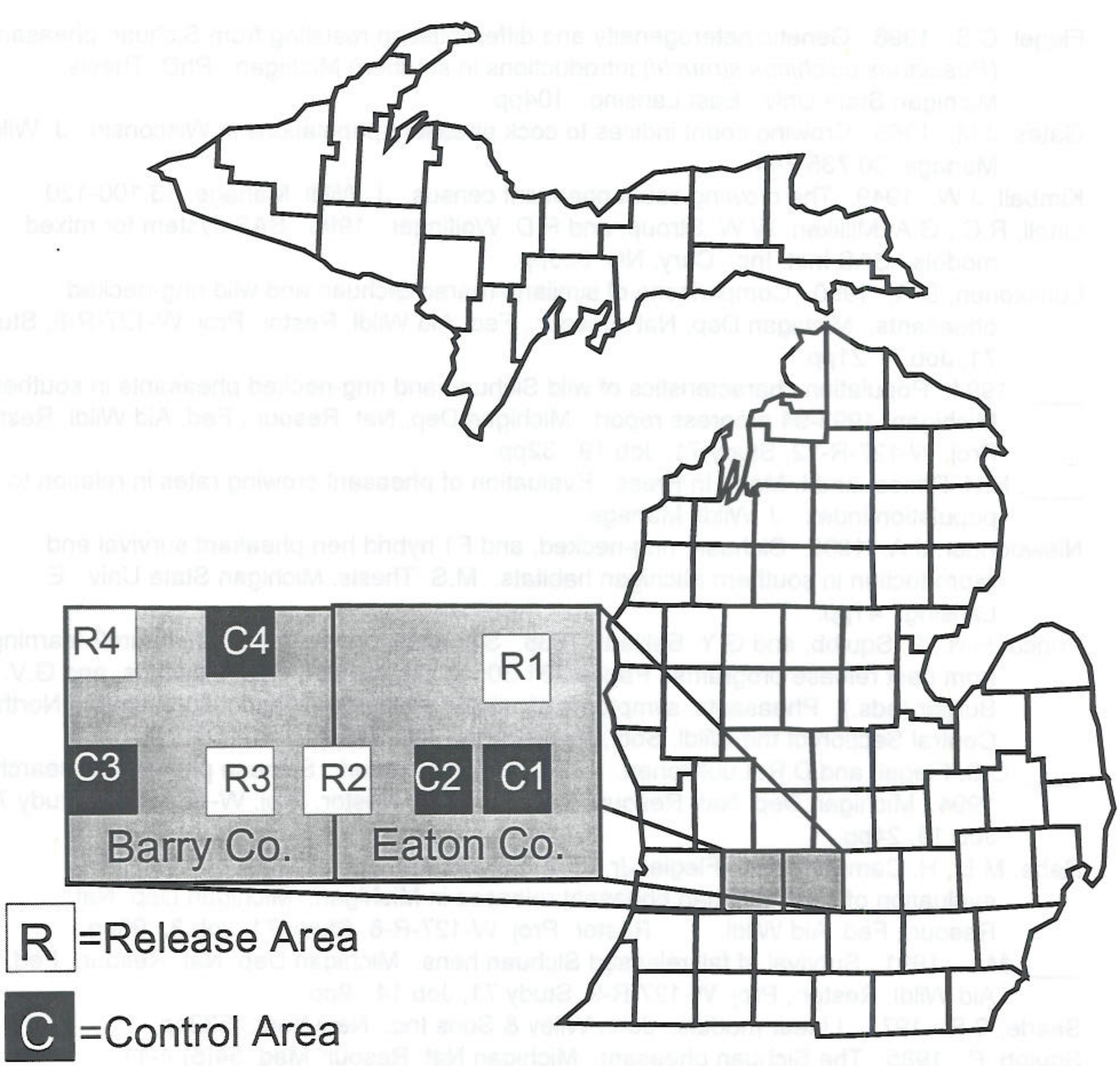

Figure 1. Locations of paired control (C1-C4) and release (R1-R4) areas in Barry and Eaton Counties, Michigan.

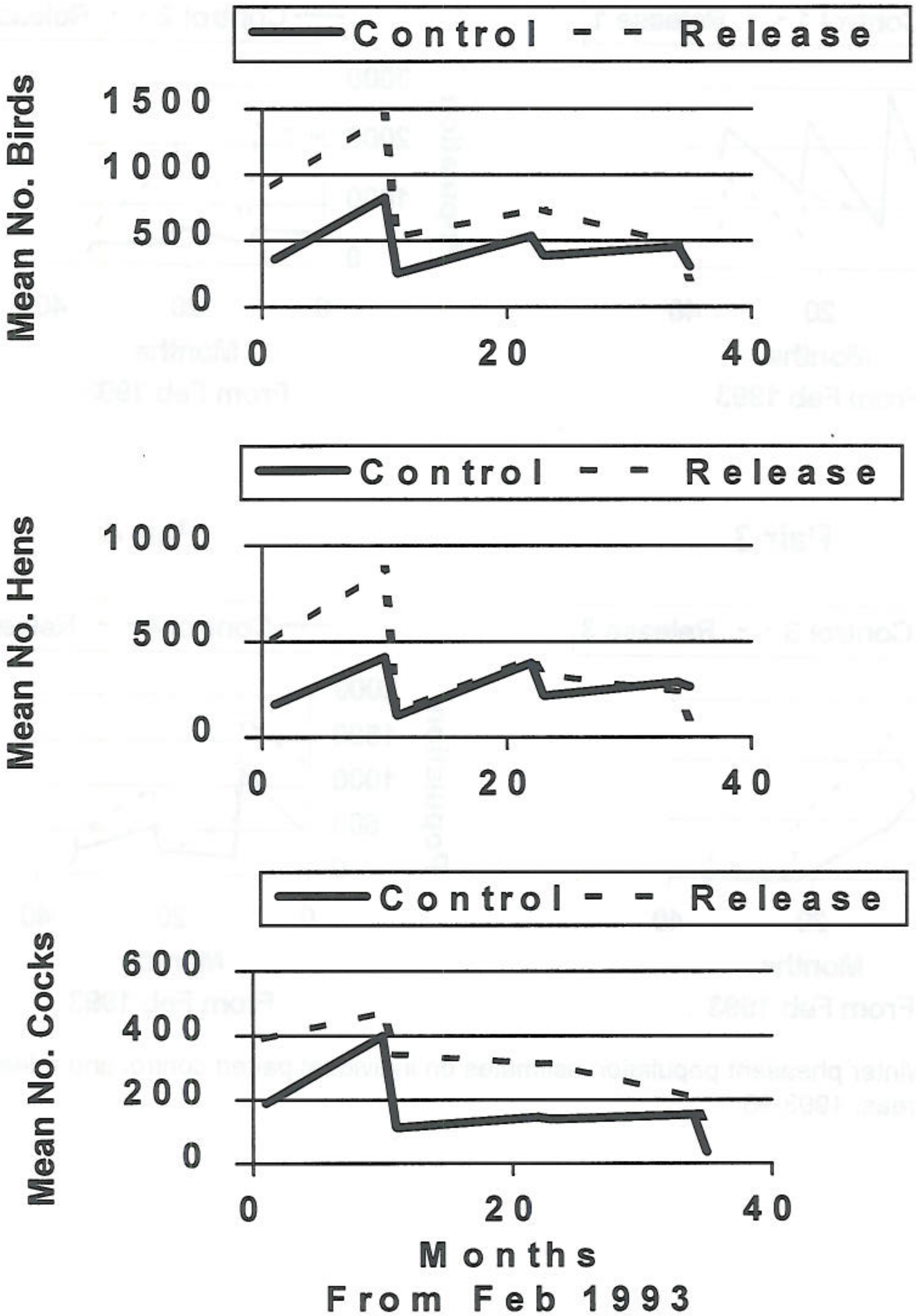

Figure 2. Mean winter pheasant population estimates on paired control and release areas, 1993-96. Upper graph depicts trends for combined sexes, middle graph depicts hen trends and lower graph depicts cock trends.

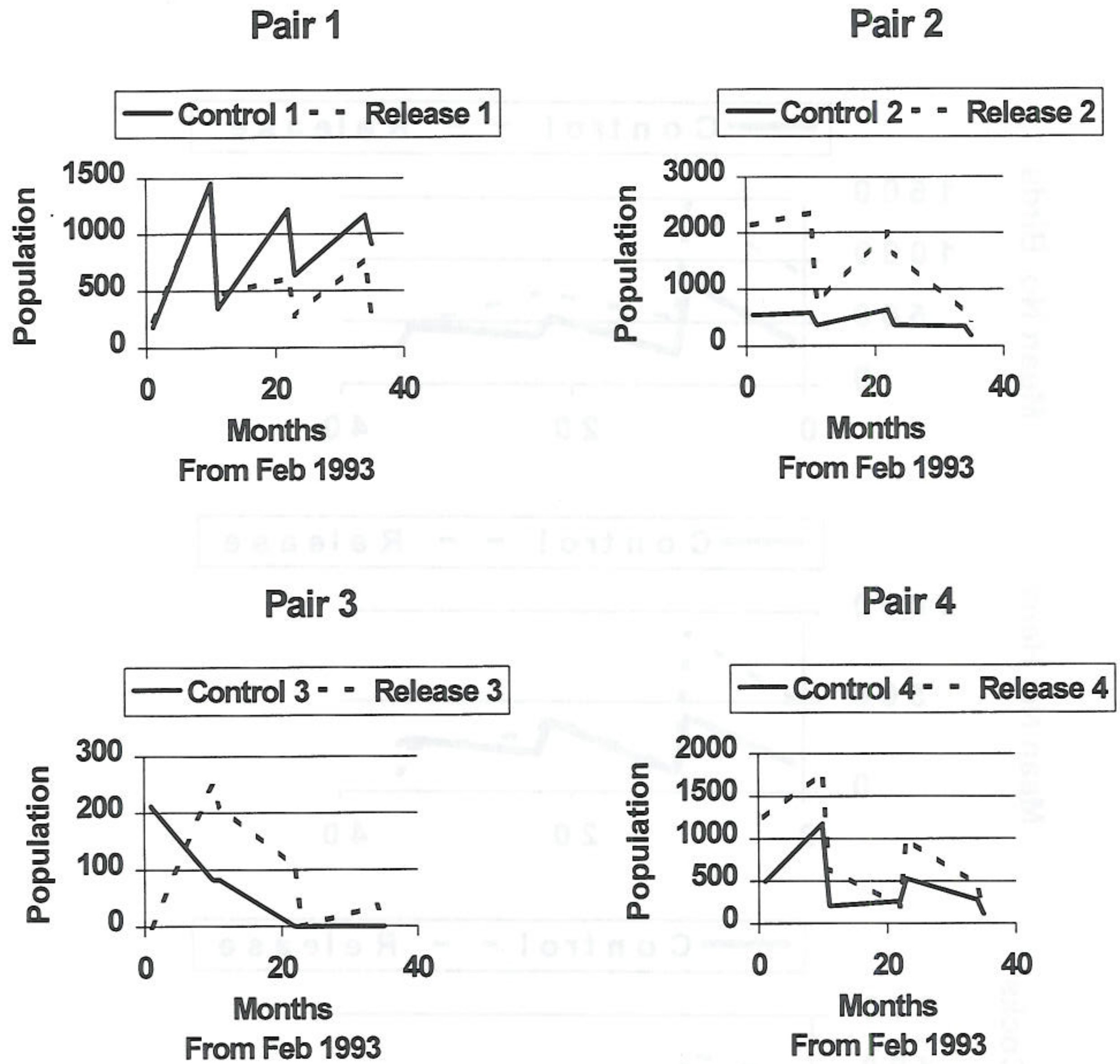

Figure 3. Winter pheasant population estimates on individual paired control and release areas, 1993-96.

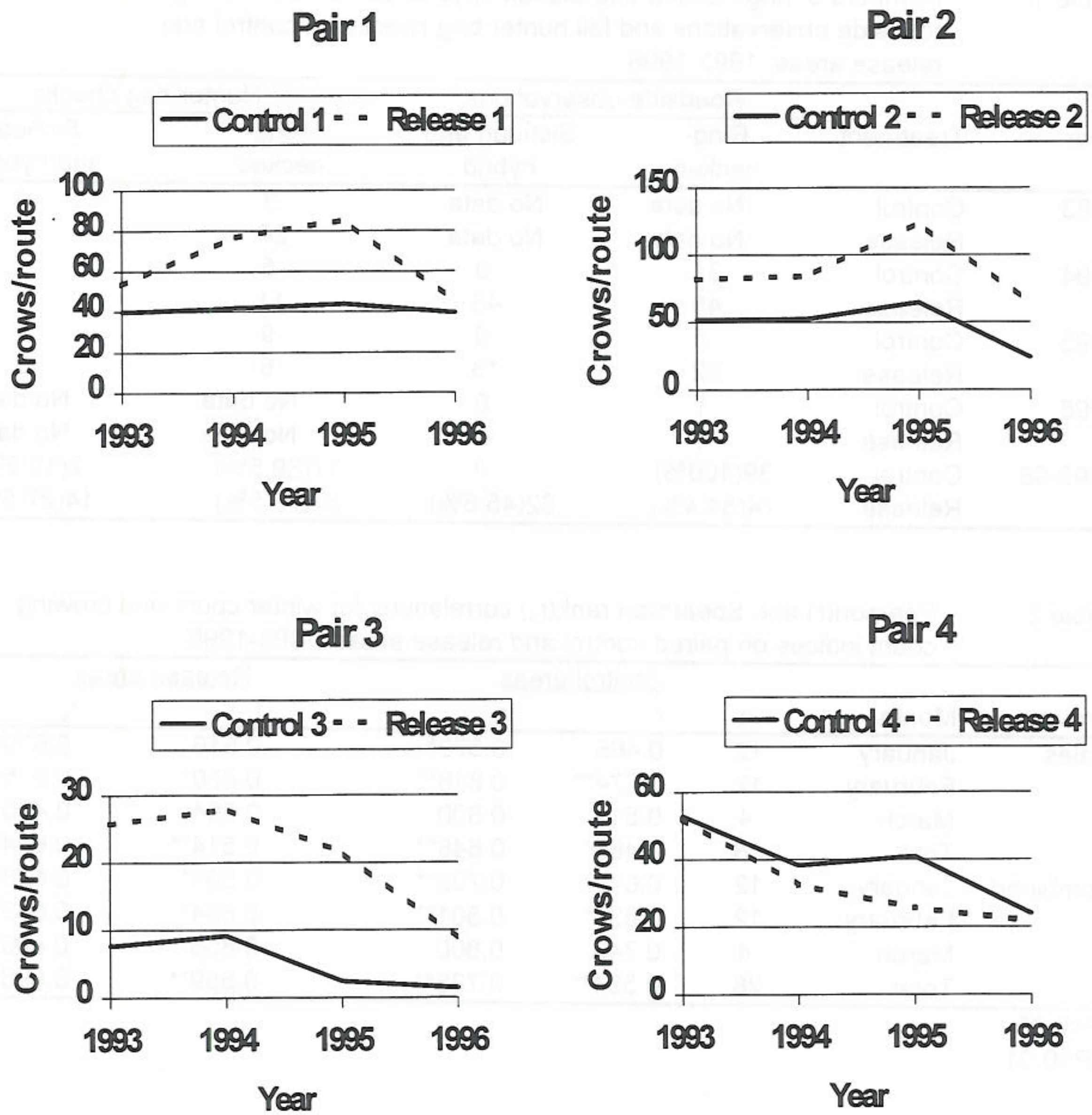

Figure 4. Spring male pheasant population trends, based on means for 4 replicate crowing count routes per site per year, on individual paired control and release areas, 1993-96.

Table 1. Numbers of ring-necked and Sichuan/hybrid cocks seen during winter roadside observations and fall hunter bag checks on control and release areas, 1993-1996.

Year	Treatment	Roadside observations		Hunter bag checks	
		Ring-necked	Sichuan and hybrid	Ring-necked	Sichuan and hybrid
1993	Control	No data	No data	3	0
	Release	No data	No data	20	4
1994	Control	31	0	5	1
	Release	48	46	11	7
1995	Control	7	0	9	1
	Release	22	13	6	3
1996	Control	1	0	No data	No data
	Release	4	3	No data	No data
1993-96	Control	39(100%)	0	17(89.5%)	2(10.5%)
	Release	74(54.4%)	62(45.6%)	37(72.5%)	14(27.5%)

Table 2. Pearson(r) and Spearman rank(r_s) correlations for winter count and crowing count indices on paired control and release areas, 1993-1996.

Group	Month	n	Control areas		Release areas	
			r	r_s	r	r_s
Males	January	12	0.465	0.579*	0.516	0.629*
	February	12	0.774**	0.818**	0.630*	0.635*
	March	4	0.512	0.800	0.594	0.400
	Total	28	0.466*	0.646**	0.514**	0.644**
Combined	January	12	0.640*	0.723**	0.599*	0.678*
	February	12	0.634*	0.801**	0.634*	0.683*
	March	4	0.742	0.800	0.856	0.800
	Total	28	0.554**	0.738**	0.559**	0.696**

*P<0.05
**P<0.01

Table 3. Hunting effort, pheasant observation rates, and harvest rates on paired control and release areas, 1993-95.

Year	Treatment	Parties	Hunters per party	Party hours hunted	Birds observed per party hour	Birds harvested per party hour
1993	Control	15	2.33	41.5	2.0	0.34
	Release	18	2.39	55.7	2.6	0.43
1994	Control	16	2.56	58.0	1.1	0.10
	Release	18	2.94	47.0	0.4	0.36
1995	Control	7	2.86	14.0	0.3	0.79
	Release	16	2.69	33.5	0.4	0.36

Table 4. Linear mixed models fit to winter pheasant counts in Barry and Eaton counties, Michigan, 1993-1996.

Model Number	Model Type	Response Variable	Factor	d.f.	F	P
1	Standard	Birds/ha	Treatment	1,39[a]	7.39	0.010
			Months	6,39	4.42	0.002
			Treatment X Months	6,39	1.00	0.442
2	Standard	Population Estimate[b]	Treatment	1,39	5.25	0.027
			Months	6,39	3.14	0.013
			Treatment X Months	6,39	0.68	0.670
3	Repeated	Birds/ha	Treatment	1,6	2.42	0.170
			Months	6,36	4.17	0.003
			Treatment X Months	6,36	0.60	0.730
4	Repeated	Population Estimate[b]	Treatment	1,6	1.64	0.247
			Months	6,36	5.11	0.001
			Treatment X Months	6,36	0.50	0.804

[a](Numerator degrees of freedom, denominator degrees of freedom).
[b]Population estimate (birds observed per hectare searched) X area of potentially suitable winter habitat.

Table 5. Linear mixed models fit to pheasant crowing counts with varying percentage of Sichuan roosters, 1993-96.

Model	% of Roosters Sichuan							
Number	1993	1994	1995	1996	Factor	d.f.	F	P
5	0	0	0	0	Treatment	1,116[a]	26.74	0.000
					Year	3,116	7.62	0.000
					Treatment X Year	3,116	0.23	0.873
6	30	30	30	30	Treatment	1,116	36.21	0.000
					Year	3,116	7.64	0.000
					Treatment X Year	3,116	0.24	0.872
7	50	50	50	50	Treatment	1,116	44.02	0.000
					Year	3,116	7.65	0.000
					Treatment X Year	3,116	0.24	0.871
8	0	30	40	50	Treatment	1,116	36.29	0.000
					Year	3,116	6.49	0.000
					Treatment X Year	3,116	0.36	0.782

[a](Numerator degrees of freedom, denominator degrees of freedom).