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Ring-necked pheasant (*Phasianus colchicus*) abundance was measured on 15 study areas using roadside counts during the summers of 1990-1994 to examine possible relationships to permanent grasslands and 9 other cover types. The majority of permanent grasslands was enrolled in the Conservation Reserve Program (CRP) and likely would have been actively used for agriculture if not for the CRP. Roads were divided into 300 m segments and the proportion of each cover type was determined within 200 m and 800 m of each segment. A non-parametric procedure was used to determine the most significant predictors of number of pheasants observed on each road segment during roadside surveys. Year, study area, and proportion of cover type were used as predictor variables. Proportion of permanent grassland cover was the most significant predictor in every model examined. Numbers of pheasants, predominantly broods, were approximately 10 times higher in samples that had >30% grassland compared to samples with ≤10%. There was no statistically significant increase in number of pheasants as grassland increased from 30 to 100%. Year-to-year variation and differences among study areas were the second most significant factors in predicting the number of pheasants observed. Small grains and pasture were also positively correlated to pheasant numbers. If CRP grassland had not been available, pheasant abundance would have been significantly lower in the study areas.

Introduction

Populations of ring-necked pheasants (*Phasianus colchicus*) in the Midwest and many other grassland birds have declined in recent decades in response to loss of prime habitat (Warner et al. 1984, Warner and Etter 1986, Sauer et al. 2003). Many investigators have shown that pheasants preferentially nest and raise their broods in non-row crop herbaceous vegetation, especially grasslands, small grains, and hay (Hanson and Labisky 1964, Kuck et al. 1970, Hanson and Progulske 1973, Warner 1979, Ewing 1992). As the amount of row crops increased, both area available for nesting and chick survival rate declined (Warner et al. 1984).

Government farm policies can greatly affect the quantity and quality of habitat available for pheasants. For example, most annual set-aside programs have neutral or negative effects on pheasant populations because fields are frequently left fallow or disturbed during nesting or brood rearing periods (Berner 1984, Kimmel and Berner 1998). However, multi-year cropland retirement programs, with the provision for planting perennial cover, have the potential to reverse pheasant population declines by providing more grassland (Edwards 1984, Berner 1988, Kimmel and Berner 1998). Multi-year cropland retirement programs require participating farmers to remove land enrolled in the program from agricultural production for a set period of time (e.g. 10-15 years for CRP) in exchange for payments. Most

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multi-year cropland retirement programs require the landowner to plant some kind of cover vegetation while the land is in the program. Cropland retirement programs may be established for different purposes including protecting environmentally sensitive land and water, improving wildlife habitat, and reducing commodity production (Napier 1990).

In 1985, the Federal Food Security Act established the Conservation Reserve Program (CRP), which provided for the removal of land from agricultural production and planting of perennial cover for >10 years. Under the CRP, >14 million ha of erosion-prone cropland have been retired in the United States (United States Department of Agriculture 1993). In Minnesota, 96% of CRP land has been planted to cool season (CP1) or warm season (CP2) perennial grassland (Osborn et al. 1992). Common cool season perennial grasses used in the upper Midwestern United States include smooth brome (*Bromus inermis*) and Kentucky bluegrass (*Poa pratensis*) and common warm season perennial grasses include switchgrass (*Panicum virgatum*), Indiangrass (*Sorghastrum nutans*), and big bluestem (*Andropogon gerardii*). Nationally, the majority of these grasslands have not experienced anthropogenic disturbance since being planted, except to control weeds and insect pests (Napier 1990), and for emergency haying or grazing (Hays and Farmer 1990).

It is well established that different vegetation types have different effects on pheasant productivity (Kuck et al. 1970, Gates and Hale 1974, Dumke and Pils 1979, Warner 1979). The relationships of pheasant abundance to differing proportions of vegetation types at varying scales on the landscape has been less well documented, though more recent research has explored different aspects of this issue. Haroldson et al. (2006) demonstrated that for each 10% increase of grass in the landscape, provided primarily by CRP, pheasant surveys averaged 12.4 birds/route higher in spring and 32.9 birds/route higher in summer. Clark et al. (1999) found that pheasants were more likely to nest in areas with more grass and larger blocks of grass. Leif (2005) showed that male pheasants selected areas with grassland and woody

cover. The purpose of this study was to explore these relationships at 2 scales: the summer home range of adult pheasants and the home range of 4-8 week old broods. We limited our study areas to those with grasslands primarily originating from the CRP to determine the effect of this program on pheasant populations. We also explore the upper limit where adding more grass to the landscape does not further increase pheasant densities.

Study Area and Methods

In 1990, the Minnesota Department of Natural Resources (MNDNR) began a study to determine the effects of the amount of land in CRP and in a similar state program, Re-Invest in Minnesota (RIM), on pheasant abundance. Fifteen study areas in south-central Minnesota were selected to be as similar as possible except for the amount of CRP/RIM land Kimmel et al. (1992). Topography was flat to rolling and the dominant land use on all study areas was agricultural, with 52-93% in row crops (corn and soybeans). The amount of grassland (primarily CRP) varied from 0 to 30% (Table 1). Study areas were approximately square and between 22-27 km^2. Aerial photographs (1:11000 scale) of the study areas were taken in late July - early August of each year from 1990-1994. Photographs were taken as close to August 1 as conditions would allow. Ground surveys were then performed to identify the land use in each field and note the approximate location of field boundary changes. Using the aerial photos and ground surveys, land use on study areas was digitized using EPPL7, a geographic information system (GIS) Land Management Information Center (1991). Land use in each field was assigned to 1 of 10 cover types: row crops, small grains, hay, pasture (grassland that has been grazed), grassland (undisturbed grassland), wooded areas, buildings, open water, gravel pit, or bare ground. Road systems and watercourses were also digitized. Resolution of the GIS data was 30 m in 1990 and 10 m in 1991-1994. Many features smaller than 30 m across (e.g., roadsides and small bare spots) were not mapped.

Bird abundance was determined using roadside

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Table 1: Average percentage of cover types on 15 study areas, south-central Minnesota, 1990-1994. Totals may add to more than 100% due to rounding.

Land Use	Study Area														
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Row crops	91	69	66	82	80	76	75	87	65	74	52	65	65	54	93
Hay	1	2	1	1	3	3	1	1	3	1	1	1	2	5	0
Small grains	1	2	2	2	3	3	2	1	3	3	1	2	2	2	2
Pasture	0	4	1	1	0	4	1	1	1	3	3	1	3	1	0
Grassland	2	15	21	8	6	9	17	6	17	13	30	28	20	29	0
Gravel pit	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Woodland	2	3	5	0	1	0	2	1	5	3	6	0	3	3	0
Buildings	2	2	2	2	3	3	2	3	3	3	2	2	2	4	2
Open water	0	1	0	1	2	0	0	0	0	0	2	0	0	0	0
Bare ground	1	2	1	2	1	3	1	0	3	1	3	1	2	0	3

counts Bennett and Hendrickson (1938), Klonglan (1955). Roadside counts have been used to investigate relationships between pheasant populations and habitat Riley (1995). Counts on each study area were repeated 10 times annually between July 20-August 20. Survey routes through each study area were divided into 300 m segments and the number of pheasants within the bounds of each road segment was recorded. We used the number of birds seen on each road segment/10 repetitions as an index of pheasant abundance.

Using the GIS, we calculated the percent of each cover group within 800 m and 200 m in all directions from each road segment. This created roughly elliptical samples with areas of 250 ha (1900 m long by 1600 m wide) and 20 ha (700 m long by 400 m wide), respectively. These sizes were chosen to approximate the summer home range of adult pheasants (250 ha) and the home range of 4-8 week old broods (25 ha) Gates and Hale (1974), Warner (1979), Gatti et al. (1989).

For each road segment sample, total number of pheasants seen was paired with habitat data and analyzed using Formal Inference-Based Recursive Modeling (FIRM), a non-parametric procedure Hawkins (1992). FIRM divides the data into subsets based on the predictor variable that gives the most significant explanation of the variability of the response variable. The output is a dendrogram showing the most significant predictors and how the data were divided according to each of these. Predictors used by FIRM must be <16 classes. For this study we grouped the percentage of each cover type into 11 classes: 0%, >0-10%, >10-20%, etc. Each of the 5 years and 15 study areas was placed in its own class. Thus, each sample was composed of a number of pheasants seen (response variable) and class values for the percentage of each of the 10 cover types, the year it was taken, and the study area on which it occurred (12 predictor variables) Drake (1998).

FIRM calculates the mean and standard error of the response variable for each predictor class. Using a t-test, FIRM compares the means of the most similar classes within each predictor. If they are not significantly different, the samples in both classes are merged into a single composite class and the mean and standard error are calculated for the new composite class. This process is continued for all classes

within each predictor until no further merging is possible. The result is a grouping of the samples by predictor values. For each predictor, a significance level is computed for the merged groups, based on one-way analysis of variance. Two methods are used to calculate significance of the merged groups. These 2 methods, called the Bonferroni approach and multiple comparison approach, both take into account number of classes in each predictor. This reduces the probability of a predictor being classified as significant simply because it had more classes than another.

The final step in the FIRM analysis is to choose the predictor that has the greatest significance level (smallest *P*-value) and separate the samples into subsets based on that predictor. For example, if Predictor B has 5 classes and was found to be the most significant predictor, it might turn out that classes 1 and 2 were statistically similar to each other and 3, 4, and 5 were similar to each other but different from 1 and 2. The samples in 1 and 2 would be put into a new composite group and those in 3, 4, and 5 would be put into a second group. The analysis is then repeated on each resulting group, using all the predictors again, until no additional significant predictors are found or user specified criteria are satisfied.

Following construction of models using the entire dataset, we performed a model validation step. We randomly assigned each sample to one of three subsets and performed the same FIRM analysis on each subset. The models created for each subset were used to attempt to explain variation in pheasant abundance in the other two subsets. Thus, for each of the four situations (250 ha - all variables, 250 ha - land-cover variables only, 25 ha - all variables, 25 ha - land-cover variables only), three models were constructed and each verified using the other two subsets. This gave 12 models and 24 validations.

Results

We evaluated pheasant abundance on 4275 road segments and their associated 250 and 25 ha samples during the 5-year study. All birds seen were included in the analyses; however, 86.3% were chicks or hens with broods. The average estimated age of chicks seen in this study was 8.5 weeks. The mean number of pheasants seen on each road segment per 10 days of observation was 1.14 (range 0-59). The proportion of grassland in each study area was relatively stable during the 5 years of study and CRP/RIM lands made up 70% of the total amount of grassland.

250 ha Samples

The most significant predictor of pheasant abundance when using 250 ha samples was proportion of grassland (Figure 1). The statistically different groups for 250 ha samples were samples with ≤10%, >10-20%, >20-30%, and >30% grassland. Mean number of pheasants seen approximately doubled with each 10% increase in grassland, resulting in 9.7 times more pheasants seen in samples with >30% grassland (group 5) than in those with ≤10% grassland (group 2).

Year and study area further influenced pheasant abundance. Year was the most significant predictor for samples with ≤30% grassland. Significantly fewer pheasants were seen on samples in groups 2 and 3 in 1992 and 1993, in group 4 in 1993, and in group 3 in 1990. Year was a significant predictor for group 5, also, with a decline in mean number of pheasants seen in 1993. However, study area was more significant in explaining variation within this group. Within group 5, samples in study area B (group 18) and study areas L, M, and N (group 17) averaged 5.8 and 2.4 times as many pheasants, respectively, as seen as in study areas C, F, G, H, I, J, and K (group 16).

When just the 10 cover types were included in the analysis, grassland remained the most significant predictor for the whole dataset (Figure 2). The most important predictor for the lowest grassland group (group 2) was the proportion of small grains. Within group 2, the few samples with >10% small grains averaged 0.98 pheasants per road segment (group 7) while those with ≤10% small grains averaged 0.30 (group 6). Within group 6, that is, samples with ≤10% small grains, those samples that had >10%

Grassland
P=7.99 x 10^-70
Group 1
4275
1.14
3.96
0.06

0-10%
Group 2
2191
0.32
1.63
0.04

Year
P = 5.94 x 10^-5

'90-91 Group 6	'92-93 Group 7	'94 Group 8
840	832	469
0.41	0.12	0.52
1.70	0.83	2.41
0.06	0.03	0.11

>10-20%
Group 3
673
0.86
2.93
0.11

Year
P = 1.61 x 10^-4

'90 Group 9	'91 Group 10	'92-93 Group 11	'94 Group 12
134	144	267	128
0.36	1.27	0.54	1.56
1.43	3.73	2.05	4.20
0.12	0.31	0.13	0.37

>20-30%
Group 4
493
1.56
4.46
0.2

Year
P = 1.43 x 10^-3

'90-92 Group 13	'93 Group 14	'94 Group 15
296	99	98
2.18	0.17	1.08
5.43	0.85	2.60
0.32	0.09	0.27

>30%
Group 5
918
3.07
6.65
0.22

Study Area
P = 1.86 x 10^-15

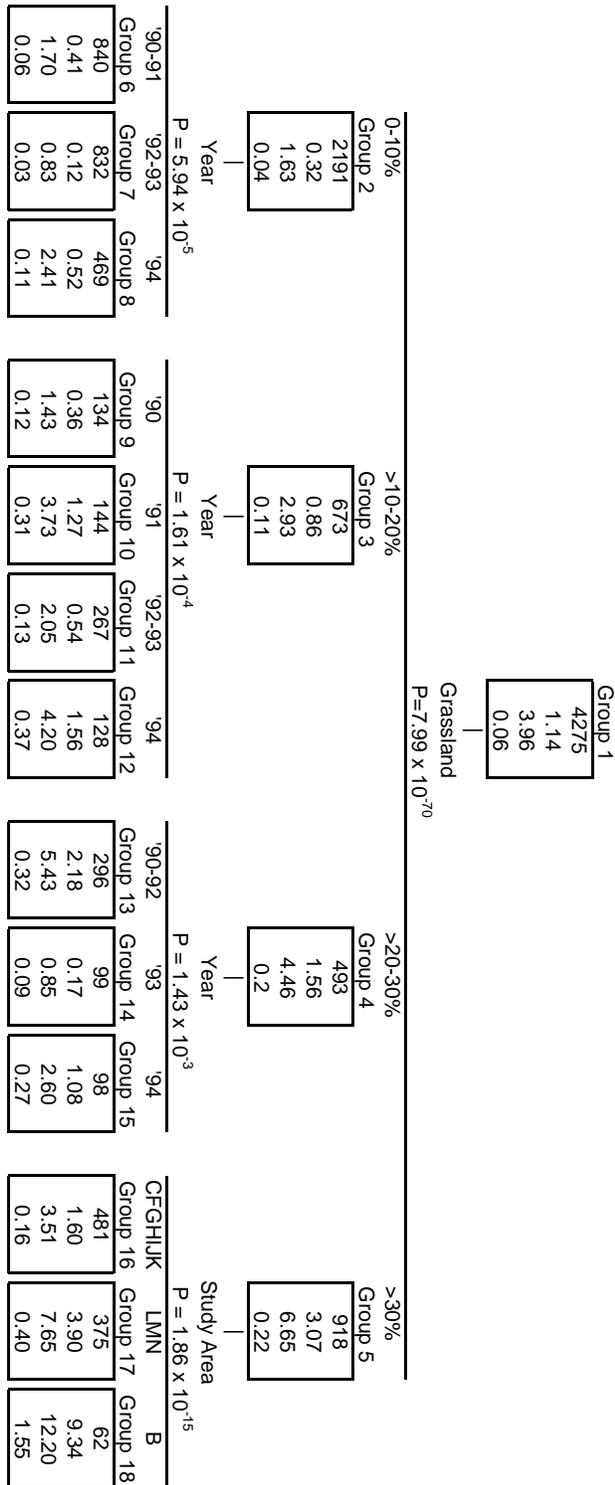| CFGHIJK Group 16	LMN Group 17	B Group 18
481	375	62
1.60	3.90	9.34
3.51	7.65	12.20
0.16	0.40	1.55

Figure 1: Significant factors affecting ring-necked pheasant abundance on a 250 ha scale, all variables. Most significant predictor of pheasant abundance and P-value are between levels of the dendrogram. Boxes enclose statistics for each significant group. Within boxes, 1st row = number of samples within the group, 2nd row = mean number of pheasants/sample/10 observations, 3rd row = standard deviation, 4th row = standard error.

pasture had 1.1 pheasants/road segment (group 11) while those with ≤10% pasture had 0.29 pheasants (group 10). Groups with >10-20% and >20-30% grassland had no significant predictors for variation in pheasant numbers. Group 5 (>30% grassland) had the most pheasants in samples with no standing water and >10-20% small grains (group 13).

25 ha Samples

The results using 25 ha samples were similar to those for 250 ha samples. The most important predictor of the number of pheasants seen in the 25 ha samples was the proportion of grassland. The significantly different groups were 0%, >0-10%, >10-30%, and >30% grassland (Figure 3). Mean number of birds seen per road segment approximately doubled from group to group. Mean number of pheasants seen in samples with >30% grassland was 9.9 times higher than the mean for samples with 0% grassland. When all predictors were used in the analysis, study area and year were the most significant predictors in all 4 grassland groups (groups 2-5). Study area was a significant predictor of differences in each of these groups. It was the most significant predictor for all samples that had >0% grassland (groups 3-5) and was significant but not the most significant predictor in group 2. Year was most significant in group 2. The effect of study area differences on samples in groups 3-5 was large. Samples within group 3 on study areas with higher pheasant counts (group 11) averaged 5.9 times more pheasants compared to samples on study areas with lower pheasant counts (group 10). Within group 4 the difference was 3.8 times (group 12 vs. 13), and within group 5, the 2 higher study area groups (16 and 17) averaged 4.4 and 9.6 times as many pheasants as the lowest group (14). Year was significant only in the 0% and >30% grassland groups. It was the most significant predictor in the 0% grassland group with significant declines in pheasant abundance in 1992 and 1993. The mean number of pheasants/road segment fell from 0.43 in 1990-1991 to 0.15 in 1992 to 0.02 in 1993 on 25 ha samples with 0% grassland, a decrease of 95%. By contrast, the number of pheasants in the >30%

grassland group fell from 3.95 in 1990-1991 to 0.99 in 1993, a 75% decrease. The >0-10% and 10-20% grassland groups experienced non-significant declines in these years. These two groups were smaller than the others and may not have had enough samples to reveal significant year-to-year variation.

When just cover types were included in the analysis, only the >0-10% (group 3) and >30% (group 5) grassland groups were split further (Figure 4). Both were split based on amount of small grains. Group 3 was split into samples that had 0-30% small grains (group 6, 0.6 pheasants/segment) and >30-60% small grains (group 7, 3.8 pheasants/segment). Group 5 was split into two groups: samples with 0% small grains (group 8, 2.6 pheasants/segment) and >0-50% small grains (group 9, 3.9 pheasants/segment).

Model Validation

Each of the models constructed using one-third of the data gave similar results as when the entire dataset was used. The results of model validation for both the 250 ha and 25 ha samples were similar and will be treated together here. In every model based on subsets, grassland was the most significant predictor of pheasant abundance. The points chosen for splitting were different from the model based on all the data, but the trends were similar. The fewest pheasants were seen on the samples with little or no grassland and the number increased with percentage of grassland to 30-40% grassland. Secondary predictors and the groupings based on them varied from model to model, but study area and year were the most common significant predictors after grassland. Hay fields and small grains were the most common secondary predictors when just habitat variables were considered. When the 12 smaller models were validated, the initial splits based on grassland were also significant predictors of the validation data. Secondary predictors were much less consistent in their ability to explain the variation in pheasant abundance.
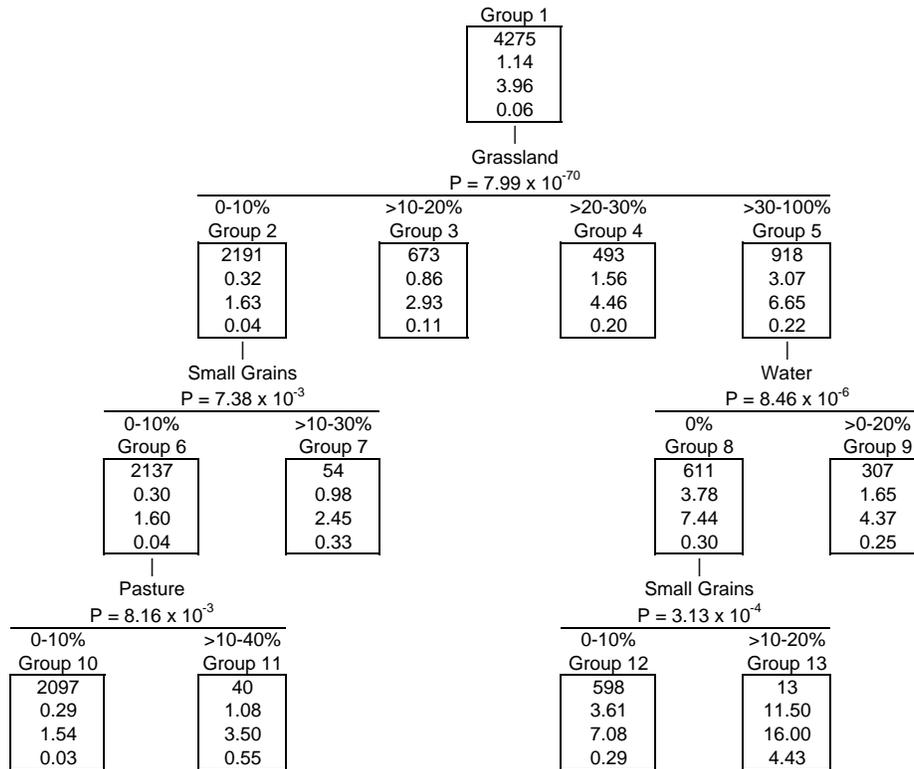
Figure 2: Significant factors affecting ring-necked pheasant abundance on a 250 ha scale, land-cover variables only. Most significant predictor of pheasant abundance and P-value are between levels of the dendrogram. Boxes enclose statistics for each significant group. Within boxes, 1st row = number of samples within the group, 2nd row = mean number of pheasants/sample/10 observations, 3rd row = standard deviation, 4th row = standard error.

Discussion

The proportion of grassland was the most important predictor of the number of pheasants seen. The effect of the proportion of grassland was statistically significant with extremely small P-values. Statistically significant differences may not always be practically significant since, especially with large data sets like we had, small responses within the data can be detected. Our results were also practically significant, though, with a 10-fold increase in pheasant abundance from samples with little or no grassland to those with >30% grassland. No further increase in pheasant abundance was detected in samples with >30% grassland.

The lack of a positive response by pheasants to >30% grassland has two likely explanations. Hanson and Progulske (1973) and Warner (1979) noted that pheasants were found increasingly in row crops after late July. As pheasant chicks shift their diet from exclusively insects to largely vegetable matter after 4 weeks of age, row crop fields and other non-grassland habitats can provide food as the vegetation matures (Loughrey and Stinson 1955). Within the home range of a brood, a moderate amount of grassland cover may provide adequate safe brooding and nesting habitat and beyond that minimum, other cover types may be of equal or greater benefit as greater amounts of grassland. The second possible reason for not detecting any trends in samples with >30% grassland could be that few samples had large amounts of grassland and there was substantial variability ('noise') in the numbers of pheasants

Group 1
4275
1.14
3.96
0.06

Grassland
$P = 1.00 \times 10^{-64}$

0%
Group 2
2001
0.29
1.74
0.04

Year
$P = 4.34 \times 10^{-4}$

'90-91
Group 6
752
0.43
1.80
0.07

'92
Group 7
418
0.15
0.97
0.05

'93
Group 8
411
0.02
0.31
0.02

'94
Group 9
420
0.45
2.72
0.13

>0-10%
Group 3
602
0.68
2.74
0.11

Study Area
$P = 8.90 \times 10^{-5}$

ACDFG
HIKLM
Group 10
446
0.28
1.61
0.08

BLNO
Group 11
155
1.68
4.19
0.34

>10-30%
Group 4
655
1.44
4.24
0.17

Study Area
$P = 5.56 \times 10^{-6}$

ACDEFG
HIJKLMO
Group 12
545
0.99
3.27
0.14

BN
Group 13
110
3.70
6.95
0.67

>30-100%
Group 5
1017
2.87
6.26
0.20

Study Area
$P = 1.42 \times 10^{-18}$

DGH
JKO
Group 14
272
1.03
2.84
0.17

CEFIN
Group 15
464
2.31
4.80
0.22

LM
Group 16
228
4.56
8.26
0.55

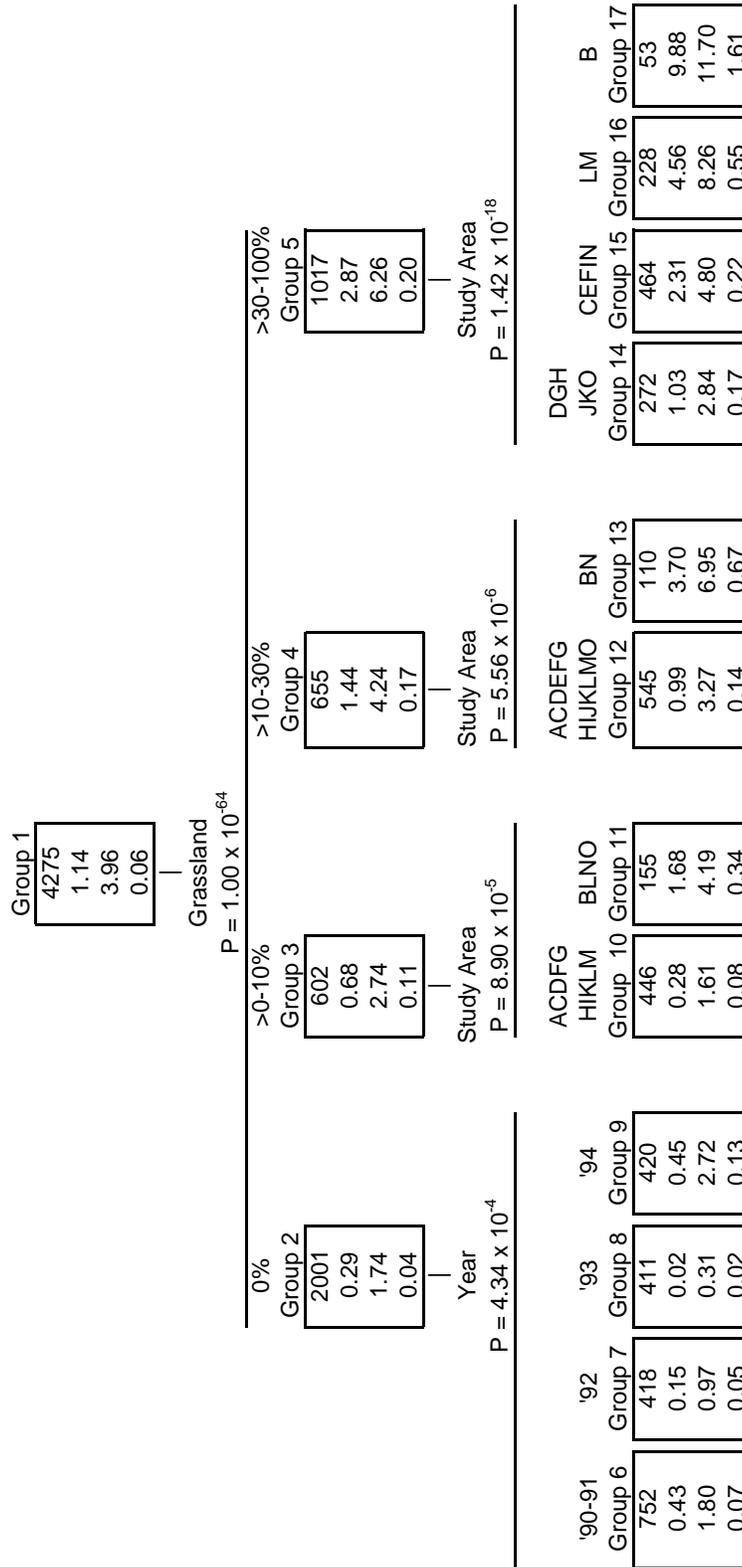B
Group 17
53
9.88
11.70
1.61

Figure 3: Significant factors affecting ring-necked pheasant abundance on a 25 ha scale, all variables. Most significant predictor of pheasant abundance and *P*-value are between levels of the dendrogram. Boxes enclose statistics for each significant group. Within boxes, 1st row = number of samples within the group, 2nd row = mean number of pheasants/sample/10 observations, 3rd row = standard deviation, 4th row = standard error.

Group 1

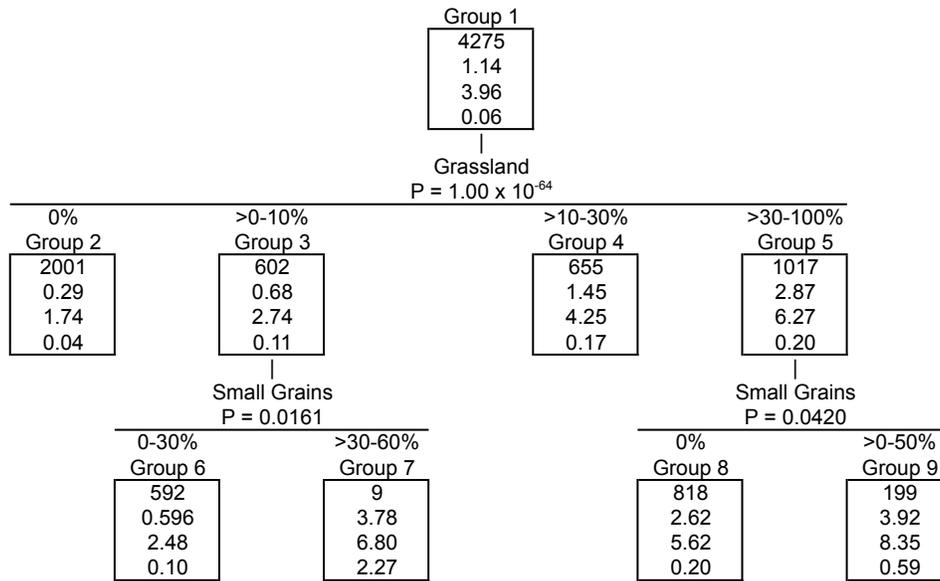| |
|---|
| 4275 |
| 1.14 |
| 3.96 |
| 0.06 |

Grassland
$P = 1.00 \times 10^{-64}$

0%	>0-10%	>10-30%	>30-100%
Group 2	**Group 3**	**Group 4**	**Group 5**
2001	602	655	1017
0.29	0.68	1.45	2.87
1.74	2.74	4.25	6.27
0.04	0.11	0.17	0.20

Small Grains
$P = 0.0161$

Small Grains
$P = 0.0420$

0-30%	>30-60%	0%	>0-50%
Group 6	**Group 7**	**Group 8**	**Group 9**
592	9	818	199
0.596	3.78	2.62	3.92
2.48	6.80	5.62	8.35
0.10	2.27	0.20	0.59

Figure 4: Significant factors affecting ring-necked pheasant abundance on a 25 ha scale, land-cover variables only. Most significant predictor of pheasant abundance and P-value are between levels of the dendrogram. Boxes enclose statistics for each significant group. Within boxes, 1st row = number of samples within the group, 2nd row = mean number of pheasants/sample/10 observations, 3rd row = standard deviation, 4th row = standard error.

seen. For instance, of the 1017 (24% of the total) 250 ha samples that had >30% grassland, only 166 (4% of the total) samples had >60% grassland. Thus, the statistical tests may not have been able to detect differences because the sample size was not sufficient to compensate for the variation.

Habitats besides grassland were also shown to have impacts on the abundance of pheasants. Amount of small grains and pasture were both positively correlated with the number of pheasants seen. These two cover types were not nearly as significant as amount of grassland, but they were important secondary habitats. However, the overall effects of these cover types on pheasant abundance are not clear. These cover types, as well as hayfields, may provide feeding habitat, especially in mid- to late-summer. Warner (1984, pg. 84) stated that hay and small grain fields were "prime pheasant brood habitat". But pheasants attempting to nest in these cover types may be killed by mowing or harvesting, (Warner and Etter 1985). A more complete evaluation of the value of small grains, hayfields, and pasture to pheasant reproduction in southern Minnesota would require study areas with greater acreage of these types. Very few samples had >30% of any of these cover types and the combined total of small grains, hayfields, and pasture was <10% of any study area. These facts limited our ability to detect impacts of different amounts of small grains, hayfields, and pasture.

Other studies have shown the importance of grassland, hayfields, and small grains to pheasant reproduction. Kozicky (1951), Hanson and Progulske (1973), and Warner (1979) showed that small grains and hay were favored vegetation in the summer. Ewing (1992) found that 76% of radio-tracked chicks were located in grass/hay fields although that cover type occupied only 9.5% and 26.5% of his two study areas. Baskett (1947) and Warnock and Joselyn (1964) determined that hayfields, strip cover, pasture, and small grains produced more pheasants than other habitats. All of

these studies showed that grassland and grassland-like cover types were more productive and used more for pheasant reproduction than non-grassland-like cover types (e.g. row crops and woody habitat). Of the above studies, only Ewing (1992) included two study areas with differing amounts of grassland, but he did not measure the differences in productivity between them.

Our results imply that pheasant abundance is more susceptible to environmental variation in marginal habitats. The samples with the lowest proportion of grassland were the most affected by yearly variation. In 1990-1991, samples with no grassland had 11% as many pheasants as samples with >30% grassland. In 1993, the figure dropped to 2%. 1993 was an abnormally wet year with an average rainfall on the study areas 46% higher than the other years from May 15 through August 15 (R. Kimmel, MNDNR, unpublished data). Thus, in certain years pheasants can have some success even where there is little grassland. When the environmental conditions are not favorable, the impact may be proportionately greater in landscapes with less grassland. Riley et al. (1998) and Perkins et al. (1997) found similar results in northern Iowa in studies they conducted between 1990-1994. Both studies were done on the same two large (93.2 and 124.3 km^2) study areas. Riley et al. (1998) studied chick survival and found that, although survival rates between the two study areas did not differ in most years, in 1993 the rate was significantly lower in the study area with less perennial grassland. Perkins et al. (1997) examined winter survival of pheasant hens. Although mean survival rates did not differ significantly, variation on the study area with less grassland (9.3%) was greater than on the study area with more grassland (25.0%).

Study area was the most significant predictor in samples that had >30% grassland for 250 ha samples and for all levels of grassland for 25 ha samples. It was significant, but not the most significant, in other groups, also. Certain study areas consistently had more pheasants on samples that had the same proportion of grassland as other study areas. Samples on study areas B, L, M, and N consistently had more pheasants than other study areas. We expected these study areas would have higher numbers of pheasants seen because they had 15-29% grassland and 3 were in the top 5 for the amount of grassland (Table 1). That samples on these areas should differ from samples containing the same amount of grassland and on study areas that overall had equal or greater proportions of grassland is a reflection of factors beyond differences in the proportions of local habitat.

The study area variable is a composite variable. It reflects factors that differ between study areas and occur principally on a larger scale than the samples used in this investigation. These factors include the amount of favorable habitat on a scale larger than the individual samples, mortality/survivorship, and the spatial arrangement of the habitat components in relation to each other. The most important of these factors may be the amount of favorable summer and winter habitat beyond the scale of the individual 250 or 25 ha sample. Favorable summer habitat is necessary for successful nesting and rearing of broods and for survival of adults.

As shown in this study and others (Hanson and Progulske 1973, Warner 1979), grassland is a necessary component in good summer habitat. Large areas with at least moderate amounts of grassland will have more pheasants and any samples in these areas will, on average, also have more pheasants. Samples near productive summer habitats are likely to have more pheasants due to dispersal.

Evidence that the study area variable was not simply a proxy for the amount of grassland on a larger scale was the number of pheasants seen on study area B. This study area had 15.4% grassland, 8th out of 15 in the amount of grassland and only half as much as the highest. Whenever study area was a significant predictor, both 25 ha and 250 ha samples on study area B were in the group with the most pheasants. One possible factor contributing to this difference was the effect of winter habitat. Pheasants prefer different types of cover in summer than in winter and they will move farther between summer and winter habitats than they will within

either seasonal habitat (Gatti et al. 1989). Good winter habitat may have been more plentiful near study area B. We were unable to measure the quality and quantity of winter habitat in and around the study areas for this analysis.

A second possible factor is the difference in quality between the types of grass cover or even between individual fields with the same grass cover. We did not separate cool-season grasses (CP1) from warm-season grasses (CP2) in this study. Pheasants have been observed to use CP2 fields more in winter (Delisle and Savidge 1997, R. Kimmel, MNDNR, personal communication), presumably because the CP2 grasses are more resistant to compression by snow.

Another possible contributing factor is the spatial pattern of the cover types. Two study areas with the same percentages of cover types may have different pheasant production because one has an arrangement of habitat types that is more favorable than the other. Although this was not addressed in this study, Gustafson et al. (1994) found that spatial pattern was important for classifying wild turkey (*Meleagris gallopavo*) habitat.

Management Implications

This study demonstrates that 1) proportion of permanent grassland has a great impact on the abundance of pheasants, but this ceases to be statistically detectable at >30% grassland; 2) effects of factors other than summer habitat (i.e. yearly variation and study area effects in this investigation) are also important to pheasant abundance, and 3) cover types other than grassland can be beneficial to pheasants. While managers may not have control over the weather, predation, or other factors that vary from site to site, establishing and maintaining at least moderate amounts of permanent grassland cover is of primary importance in increasing pheasant populations. There will still be substantial year-to-year variation in pheasant numbers but the presence of permanent grassland cover may ameliorate the effects of environmental variation.

Finally, nearly all the grassland examined in this study was the result of CRP/RIM. In the absence of these programs, most samples in this study would have had 0-10% grassland, probably with similar impacts on pheasant abundances (Figs. 1 and 3). Thus, multi-year farm programs, such as CRP, can be an important means of providing permanent grassland cover for pheasants and other wildlife, especially in intensively farmed landscapes.

Acknowledgments

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