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LAND USE AND BOBWHITE POPULATIONS IN AN AGRICULTURAL SYSTEM IN WEST TENNESSEE

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Abstract: The efficacy of a computer assisted habitat evaluation system (IMGRID: Information Management on a GRID cell system) was tested on Ames Plantation in west Tennessee. Habitat characteristics and bobwhite (*Colinus virginiana*) population size were compared to delineate the effect of land use changes on bobwhites. Significant changes in land use occurred. Pastures decreased from 120.4 ha in 1966 to 35.0 ha in 1980, while soybeans increased from 102.4 to 193.1 ha. Idle land decreased from 212.9 ha to 178.6 between 1966 and 1980. Bobwhite population size was negatively correlated with the area maintained in soybeans (r = -0.63) and positively correlated with pastures (r = 0.76) and idle land (r = 0.76). Multiple component analyses indicated highest use by bobwhites of (1) areas where idle land, forests, and agriculture came within close proximity, (2) areas near food plots, and (3) idle land alone. Single component analyses identified high use by bobwhites of idle land, wild herbaceous vegetation, and food plots. Within forests or idle land, bobwhites preferred areas containing honeysuckle.

The quality of habitat is one of the most important factors influencing the fate of many wildlife populations today. The importance of habitat necessitates developing a suitable, comprehensive system of habitat evaluation. Such a system should be capable of identifying critical components of habitat and forecasting the effects of manipulating these components. It would be useful for determining a site's potential for wildlife as well as being a predictive tool for wildlife managers.

Originally, analyses of habitat features were facilitated through observation of aerial photographs or cover maps (Dalke 1937, Graham 1945, Arnold 1946). Recent research has broadened the scope of these early works with some success (Hanson and Miller 1961, Burger and Linduska 1967, Baxter and Wolfe 1972, Schuerholz 1974). Computer technology has enhanced the sophistication with which habitat and population data can be stored and analyzed.

Many computerized geographical systems are currently available that could accommodate diverse types of wildlife data (Wilcott and Gates 1977, Brooks and Pease 1978). One such system, IMGRID, has been tested by the Tennessee Valley Authority (TVA) and the Tennessee Wildlife Resources Agency (TWRA) on the Catoosa Wildlife Management Area (CWMA) (Davis 1980). Although extensive work has been done on the CWMA, with a promising outlook for IMGRID, the majority of the habitat analyses have been for relatively large, wide ranging species such as white-tailed deer (*Odocoileus virginianus*), European wild hogs (*Sus scrofa*), and eastern wild turkeys (*Meleagris gallopavo silvestris*).

IMGRID appeared appropriate for use on the Ames Plantation in west Tennessee. During 15 years of quail research, bobwhite densities and concurrent habitat conditions have been recorded. This project investigated the merits of using IMGRID for delineating relationships between various characteristics and bobwhite populations.

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STUDY AREA

Ames Plantation is the site of the National Field Trial for pointing bird dogs. An 832.5 ha tract within the plantation, designated as the Morning Field Trial Course (MFTC), was used for the study. Loess soils, consisting of the Loring, Grenada, and Calloway series, averaging 1-3 m in depth and overlying Coastal Plain marine sediment, predominate on the area (Flowers 1964). Topography is moderately dissected to gently rolling; average altitude is 135 m (Flowers 1964). The growing season averages 210 days. Average annual precipitation is about 135 cm. The yearly average temperature calculated by Eubanks (1972) from U.S. Weather Bureau (1966, 1967, 1968, 1969) data is 16.4 C.

The MFTC is highly agricultural, with extensive areas planted to soybeans. It is intensively managed for bobwhites. Since 1966, bobwhite populations have fluctuated greatly, from 3.8 birds/ha in December 1972 to 1.4 birds/ha in March 1980 (Table 1).

Table 1. Census data from December and March censuses, 1966-1980, on Ames Plantation in west Tennessee.

Month	Year	Number of Coveys	$\bar{x}$ Birds/ Covey	Total Number Birds Found
March (Pre-breeding)				
	1967	76	12.2	925
	1968	81	13.2	1,023
	1969	82	12.6	1,033
	1970	66	12.6	832
	1971	77	12.5	964
	1972	95	13.0	1,269
	1973	85	11.8	983
	1974	62	11.0	681
	1975	61	10.3	637
	1979[a]	61	10.9	701
	1980	50	11.4	573
Mean		72.4	12.0	879
December (Post-breeding)				
	1966	90	13.1	1,184
	1967	101	14.6	1,478
	1968	108	13.9	1,505
	1969	73	13.8	1,077
	1970	89	13.2	1,179
	1971	111	12.0	1,334
	1972	111	14.3	1,587
	1973	93	12.3	1,145
	1974	66	13.8	847
	1976[a]	72	12.3	897
	1977	83	13.3	1,101
	1978	65	12.0	782
	1979	62	11.9	736
Mean		86.5	13.0	1,142
February[b]				
	1980	59	10.2	663

[a]Populations not censused during March 1976-1978 or December 1975.
[b]Additional census made in 1980.

METHODS

Aerial photographs were standardized to produce scaled maps of the study area for 1966, 1971, 1975, and 1980. An acetate grid, with grids representing 1.0 ha, was overlaid on these maps. Various components of habitat specifically identified with the aid of field maps were numerically coded in their respective grid cells for use by IMGRID. Bobwhite census data were also encoded for correlation with habitat types.

General land uses were consolidated into categories: agriculture, pasture, wild herbaceous vegetation, idle land, and forests. The three most abundant cover types in each grid cell were encoded, each into a separate data element (mutually exclusive sets of information that describe a resource or land use unit, e.g. soil mapping units, forest types, etc.) (Beeman 1977). Numerical values were arbitrarily assigned to these components in such a way that IMGRID could later detect the various combinations of habitats in each grid cell.

During 1980, information on honeysuckle, forest types, herbaceous vegetation, and land use was collected in the field at a higher resolution (grid cells represented 0.25 ha) for a more detailed evaluation of specific use patterns. Samples of honeysuckle were collected, dried, and weighed to identify representative stands of honeysuckle. Plots were subsequently categorized in terms of density as Absent, Low (0.1-250 g/m^2), Moderate (251-500.0 g/m^2), or Abundant (more than 500 g/m^2).

The data collected at the 0.25 ha grid cell size were generally encoded as ranked values representing specific data entities. For example, the data encoded for the forest type data element were the following:

Data code	Forest type
00	None present
01	Seedling pine
02	Seedling bottomland hardwood
03	Seedling upland hardwood
04	Cedar
05	Pole sized pine
06	Pole sized bottomland hardwoods
07	Pole sized upland hardwoods
08	Sawtimber pine
09	Sawtimber bottomland hardwood
10	Sawtimber upland hardwood

A planimeter was used for 1980 data to calculate the area maintained in each habitat type. IMGRID was also used to assess the composition of habitats. T-tests were then used to compare IMGRID's estimates to those calculated by the planimeter.

Mean population estimates were derived for the years 1966, 1971, 1975, and 1980 (Table 2). Patterns of land use were then regressed with the mean populations to correlate land use patterns with population size.

Table 2. Classes of average populations of census data from Ames Plantation, surrounding the years from which IMGRID habitat data were available.

Category	Census	Population Size	Average Population
	December 1966	1,184	
	March 1967	925	
	December 1967	1,478	
	March 1968	1,078	
	December 1968	1,505	
	March 1969	1,033	
1966			1,200.5
	December 1969	1,077	
	March 1970	832	
	December 1970	1,179	
	March 1971	964	
	December 1971	1,334	
	March 1972	1,269	
	December 1973	1,587	
	March 1973	983	
1971			1,152.8
	December 1973	1,145	
	March 1974	881	
	December 1974	847	
	March 1975	637	
	December 1976[a]	897	
	March 1977[b]	681.7	
1975			814.8
	December 1977	1,101	
	March 1978[b]	836.7	
	December 1978	782	
	March 1979	701	
	December 1979	736	
	March 1980	573	
1980			788.3

[a]December 1975 and March 1976 censuses were not performed.
[b]Average survival ($\bar{x} = 0.76$) from December to March was calculated for all other censuses to obtain the estimated March population.

IMGRID keywords were used to overlay habitat features with census data for 1966, 1971, 1975, and 1980 to detect trends in habitat use. These trends were analyzed using two techniques, multiple component analysis and single component analysis.

The multiple component analysis permitted the identification and delineation of the interactive effects of important combinations of habitats. Habitats were categorized as pasture, idle land, forests, food plots, and agriculture. The three major habitat components of each grid cell were recognized; 25 possible combinations of habitats existed. The percentage of grid cells with coveys was calculated for each of these combinations.

The single component analysis isolated individual habitat types, without regard to other habitats. For example, all grid cells with soybeans were located and those cells also containing coveys were delineated. This analysis permitted the isolation of all habitat types present during each year.

Chi-square tests were used to detect differences in habitat use in every census for both analyses. Chi-square tests detected differences in use but not the location of these differences. For this reason the percentage of grid cells that contained coveys was calculated for each habitat type (Huntsberger and Billingsley 1977). Important habitats were identified as those exhibiting high percentages of use.

In some instances certain habitats or combinations of habitats from the IMGRID analyses exhibited an expected chi-square value of less than 1. These combinations were clumped into logical categories for analysis.

T-tests were used on December and March single and multiple component analyses for all years to test for a difference in habitat use trends between censuses. Since three censuses were performed in 1980, analysis of variance was used to test for different patterns of use during that year.

RESULTS

IMGRID accurately depicted the composition of habitat when compared with the area defined by a planimeter. Subsequent IMGRID analyses detected major changes in land use between 1966 and 1980 (Table 3). Pasture decreased from 120.4 ha (14.4 percent) in 1966 to 35.0 ha (4.2 percent) in 1980. Soybean production increased from 102.4 ha (12.3 percent) in 1966 to 193.1 ha (23.2 percent) in 1980. The total area maintained in idle land decreased from 212.9 ha (25.5 percent) in 1966 to 178.6 ha (21.4 percent) in 1980.

No differences in habitat use between December and March censuses were found for most years of the study ($P \leq 0.05$). For this reason censuses for each year were combined for analysis. In instances where there were significant differences between years, the censuses were analyzed separately.

Multiple component analyses indicated consistent use of certain habitat types throughout the study. These included grid cells with idle land only; grid cells with idle land, forest, and agriculture; and grid cells containing food plots. Pastureland was highly used during 1966 and 1971.

Single component analyses clearly illustrated that food plots were highly used. Idle land, areas classified as wild herbaceous vegetation, and fallow fields were also highly used.

The intensive multiple component analysis performed during 1980 indicated that edges of idle land and wild herbaceous vegetation were highly preferred. The intensive single component

Table 3. Composition of land use for 1966, 1971, 1975, and 1980 on Ames Plantation.

Land Use Type	No. of ha in 1966	No. of ha in 1971	No. of ha in 1975	No. of ha in 1980
Pine	55.4	53.8	68.8	64.2
Hardwoods	249.3	243.0	237.8	243.9
Fallow Fields	78.7	----	20.9	10.8
Food Plots	16.3	14.9	19.8	9.2
Lespedeza	----	23.3	2.2	38.3
Corn	29.6	25.0	11.6	70.1
Soybeans	102.4	181.7	168.0	193.1
Ponds	4.8	3.8	3.3	4.3
Idle Land	129.4	189.2	169.5	163.5
Cotton	48.1	29.3	30.8	----
Pasture	120.4	56.5	52.3	35.0
Milo	----	3.8	6.1	----
Wheat	----	16.5	17.6	----
Alfalfa	----	5.3	2.2	----
Hay	----	4.3	----	----
Field Peas	15.8	----	----	----

analysis for 1980 also defined idle land and wild herbaceous vegetation as the most highly used habitat types.

Additional IMGRID analyses for 1980 data found grid cells with honeysuckle to be preferred over those without. A moderate (251 g/m2 - 500 g/m^2) density was favored. Bottomland hardwoods were the preferred forest type, and idle land or forest types with honeysuckle were preferred covey locations.

The area maintained in row crops was not highly correlated with bobwhite populations. However, as soybean acreage increased, bobwhite numbers declined ($r = -0.63$). The amount of idle land ($r = 0.76$) and the amount of pastureland ($r = 0.76$) were positively correlated with the number of bobwhites on the study area.

DISCUSSION

Soybeans are a preferred food source on Ames Plantation, and they provide excellent habitat for bobwhites throughout much of the year (Eubanks and Dimmick 1974). However, harvested soybean fields provide no protection for bobwhites during critical winter periods. Use of soybean habitat was highest during the two years in which acreage was lowest. During the two years in which soybean acreage was greatest, the most highly used habitats were those supplying cover, such as fallow fields, wild herbaceous vegetation, and idle land. By 1980, 23.2 percent of the MFTC was planted in soybeans, much of this in large fields. These large expanses of soybeans replaced large idle fields and permanent pastures, perhaps creating shortages of necessary winter cover.

Idle land was consistently one of the most highly used habitat types. Idle land characteristically contained herbaceous vegetation often accompanied by dispersed hardwoods. These conditions provide ideal situations for quail (Klimstra and Roseberry 1975, Roseberry et al. 1979). Idle land and forests were major sources of winter cover. The decline in idle land has resulted in fewer favorable covey headquarters as defined by Yoho and Dimmick (1972). As a result, bobwhites have shifted to forests for winter cover. Forests were not highly used by bobwhites for food on Ames Plantation (Eubanks and Dimmick 1974), and the widespread use of forests is nontraditional (Stoddard 1931:404, Murphy and Baskett 1952, Kabat and Thompson 1963:55, Casey 1965). High use of hardwoods indicates a shift in importance from traditional early successional herbaceous vegetation to closed overstory forests. Use of these marginal habitats is unfavorable for bobwhites.

High positive correlation of bobwhite populations with pasture is not normally expected. However, the pastures maintained on the MFTC in 1966 and 1971 were lightly grazed and, therefore, resemble old field habitat. High use in those years reflected adequate densities of herbaceous vegetation interspersed in some cases with food plots. Perhaps also important, but not derived from this study, these pastures provided excellent nesting habitat.

Food plots, although comprising a relatively few hectares, were important to bobwhites throughout the study. These plots were established in pastures that originally provided a lush growth of broomsedge (Andropogon virginicus) but were otherwise relatively poor sources of winter foods. These food plots were planted with soybeans but also contained vegetation that could have been classified as idle. As pastures were converted to soybeans, the importance of unharvested food plots persisted, but their usefulness was likely related to their provision of cover as well as for food. For these reasons, habitats containing food plots were represented as one of the most highly used habitats in every multiple component analysis.

The intensive multiple component analysis in 1980 showed idle land to be a part of the three most highly used habitat types. The intensive single component analysis showed wild herbaceous vegetation to be the most highly used habitat type; idle land was second. The importance of idle land has been discussed; its reduced acreage has increased its relative value. Wild herbaceous vegetation was identified only for the intensive 1980 analysis. It was used to describe areas of wild vegetation free from woody invasion. In other analyses, this category of vegetation was classified as idle or fallow. Because of the shift of importance to soybeans, wild herbaceous vegetation may become increasingly important.

The nature of the walk flush census may introduce bias into the interpretation of habitat use trends. The censuses may push birds into heavy cover and overestimate the importance of honeysuckle or dense cover. However, it is believed that increasing scarcity of these areas is limiting the quail population on the MFTC.

Use trends may not accurately portray the significance of some habitat types. Soybeans are obviously important to bobwhites on the MFTC, yet little time is spent feeding in soybean fields due to the ease in obtaining seeds. Therefore, walk flush censuses may underestimate the importance of soybeans. The various IMGRID techniques used for analysis minimize these kinds of biases.

MANAGEMENT IMPLICATIONS

Extrapolation of data on the relative composition of land use and trends in habitat use yielded obvious management implications. The most obvious change in land use was an overall shift to increased acreage planted to soybeans. In early years of the study, when populations were high, lightly grazed pastureland afforded excellent herbaceous cover, and a diversity of row crops was maintained. Subsequent changes in land use patterns were accompanied by marked declines in bobwhite numbers. Transition lanes between soybeans and hardwoods have been shown to buffer shortages of adequate cover and to be beneficial for bobwhites (Rosene 1969). Increasing borders of herbaceous vegetation on the periphery of strategic soybean fields should greatly improve overall conditions for bobwhites. Optimum vegetation density and composition of these borders would be maintained through periodic burning or plowing.

Diversity, the key to bobwhite management (Pimlott 1969), may be encouraged through establishing smaller irregularly shaped fields. These fields would create an edge effect and allow interspersion of desirable habitats such as idle land with herbaceous vegetation and hardwoods with honeysuckle.

The presence of well distributed nesting areas is a necessary ingredient of good quail habitat (Reid et al. 1979). Broomsedge, the primary grass associated with nest construction in west Tennessee, can be encouraged through timely plowing or burning. However, indiscriminant burning can cause destruction of potential nest sites and optimum densities of honeysuckle. Site specific management using IMGRID as coordinator could approach optimum densities, quantities, and the proper juxtaposition of soybeans and idle land with herbaceous vegetation and honeysuckle.

The maintenance of food plots in critical areas can supply necessary components of food or cover (Robel et al. 1974). Areas deplete of winter food supplies may be supplemented by productive food plots, while areas lacking winter cover will benefit from the protection of idle land in those food plots.

CONCLUSIONS

The IMGRID approach to habitat analysis successfully identified critical changes in habitat composition with respect to their impact on bobwhite population numbers. Obvious management implications emerged, though no revolutionary concepts for bobwhite management were developed.

Perhaps the most instructive (and surprising) lesson derived from our analysis was the negative impact of expanding soybean acreage on the study area, inasmuch as soybeans constitute the principal food of bobwhites on this area during winter (Eubanks and Dimmick 1974). This negative correlation, coupled with the positive relationships among populations, pastureland, and permanent idle lands, suggested to us that increasing the potential food supply failed to compensate for the corresponding dramatic reduction in security cover and possibly nesting cover. During the latter years of our study, soybeans were harvested completely, except in the fenced food plots, often as early as late October and early November, leaving large fields essentially barren of cover to the edge. The critical need for late winter food and permanent idle land for cover was highlighted in March 1981, when the population was at its lowest ebb in 15 years. Roughly 25 percent of the population was located in and adjacent to 10 food plots that occupied about 1 percent of the total area.

The usefulness of IMGRID for evaluating habitat quality on our area was limited by the large amount of manpower necessary to encode appropriate data. Technology now exists to moderate this problem, but significant habitat characteristics such as the presence and density of honeysuckle can not be encoded from aerial photos, requiring laborious field checking. Additionally, the nature of grid cell encoding limits the degree of specificity that can be used. This can reduce the accuracy of habitat evaluation for species with diverse habitat requirements, such as bobwhites. Small grid cells, while partially alleviating this problem, place additional demands on field time. Thus, for species with biological characteristics similar to bobwhites, the IMGRID system's usefulness is largely limited to intensive research projects.

We did find the IMGRID system very useful for identifying key elements and combinations of elements in bobwhite habitat, and for displaying these graphically. The system can enable the land use planner to pinpoint areas of poor habitat as well, and to delineate those habitat characteristics that are lacking.

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