Modeling Wild Turkey Habitat Suitability in Kansas

Michael Houts[1], Brandon Houck[2], Mike Mitchener[3],
[1] Kansas Department of Wildlife and Parks, Kansas Applied Remote Sensing Program,
[2] National Wild Turkey Federation, [3] Kansas Department of Wildlife and Parks

Abstract
The wild turkey (*Meleagris gallopavo*) is an important game bird in Kansas, and its widespread distribution has led to Kansas being ranked among the ten best states to hunt wild turkeys. In 2001 the Kansas Department of Wildlife and Parks (KDWP) and the National Wild Turkey Federation began work on the *Kansas Wild Turkey Management Plan*. KDWP personnel and biologists were surveyed in 2001 to collect data on known turkey locations throughout the state. The resulting information was processed and entered into a GIS that displayed the Township, Range, and Section of known wild turkey locations. The GAP wild turkey habitat map was compared to the known locations and the level of agreement assessed. Results showed good level of agreement, but it was inconsistent across the state. To address the issue of habitat variation, unique logistic regression habitat models were generated for each ecoregion to capture the changes in land cover and habitat preferences of wild turkeys across the state. The proportion of land cover types within known wild turkey locations was assessed using a generalized GAP land cover map and used to create habitat suitability models. Results showed a relatively consistent level of accuracy between ecoregions with an overall accuracy of 72% for the state.

Introduction
Wild turkeys (*Meleagris gallopavo*) occurred historically throughout eastern Kansas and along many river drainages to the west (Mitchener 2001). Unregulated hunting and habitat modification or destruction had eliminated wild turkeys from most of their original range in the U.S. by the end of the 19^{th} Century (Kennamer et al. 1992). In the late 1950's wild turkeys began to appear along the Arkansas River near Arkansas City in Sumner County. Some trapping and transplanting began there, and throughout the 1960's KDWP began a series of releases of wild turkeys obtained from other states into areas where surveys indicated potential habitat. In the 1970's the in-state trapping, relocation, and releases of birds increased (Mitchener 2001). Recently, in-state transfers of wild turkeys have decreased because of increased demand from other states and the general notion that most of the suitable habitat within the state already contained birds.

There are two subspecies of wild turkeys located in Kansas, the eastern (*Meleagris gallopavo silvestris*) and the Rio Grande (*Meleagris gallopavo intermedia*). The portion of Kansas east of the flint hills is occupied by the eastern wild turkey and the region south of the Arkansas River is occupied by the Rio Grande turkey; the central and northwestern portions of Kansas are occupied by both of the sub species (Figure 1). These two sub-species of turkeys are similar in most regards, with the primary difference being that eastern turkeys prefer a mix of open mature hardwood forests and fields, while the rio grande turkeys utilize brushy riparian areas and open grasslands. Wild turkeys forage throughout the day on a diet consisting primarily of plant foods such as acorns, berries, and seeds, but small invertebrates (insects, snails, and worms) are also eaten. Insects make up a large portion of a young wild turkeys diet, and poult (young turkey) survival is lower in areas with low insect populations. Nests are built on the ground in scratched-out shallow depressions that are hidden in the under-story vegetation of forests or dense patches of grass in more sparsely forested areas. When not nesting, wild turkeys roost in large trees (trunks > than 14 inches in diameter) within one-half mile of a food source. The home range for a flock of wild turkeys can range between 350 acres and over 60,000 acres, with a mix of forests, grasslands, and croplands providing the optimal mosaic of landscape patches (Backs and Eisfelder 1990, Gustafson et al. 1994.).

Generally, species range maps are depicted as very general guides to the area occupied by a species and seldom provide detail at the intrastate or county level. The GAP vertebrate species maps attempted to provide more precise information about potential distributions by using actual habitat characteristics to delineate potential habitat within the species general range. For a more detailed account of the GAP species models, the reader is encouraged to obtain A GAP Analysis of Kansas (Cully, J. et al 2002). The result of this process yielded a map of the potential wild turkey habitat based on known habitat associations within the species known range.

The wild turkey is an important game bird in Kansas; with over 45,000 permits and game tags sold annually to spring hunters and over 11,000 permits and game tags sold to fall hunters (Applegate and Roberson 2001). Kansas has recently ranked among the ten best states to turkey hunt in several popular articles. In 2001 the Kansas Department of Wildlife and Parks (KDWP) and the National Wild Turkey Federation (NWTF) began work on the *Kansas Wild Turkey Management Plan*. As part of the plan, a mapping effort began to document locations of wild turkey populations and habitat so Kansas could better mange a sustainable wild turkey population.

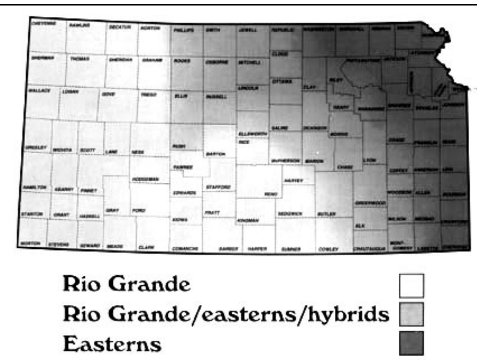


Figure 1. Map showing the general distribution of the two sub-species of wild turkeys in Kansas. Reproduced from Hlavachik and Blair, 1997.

The objectives of this study were to (1) create a map of the known wild turkey locations; (2) create and assess a new wild turkey habitat map based on known turkey locations and ecoregion specific models; and (3) compare the known wild turkey locations to the GAP wild turkey map.

Methods

Mapping Wild turkey Distribution

Public land managers, conservation officers, and biologists within the Kansas Department of Wildlife and Parks (KDWP), were surveyed in late 2001 to collect data on known locations of wild turkeys. Each participant received a cover letter and county maps for their area of responsibility. Participants were instructed to mark all sections where wild turkeys were known to occur at some time during the year, as well as critical winter roosts, potential trap sites, depredation sites, potential release sites, and areas believed to hold a pure subspecies (i.e., Rio Grande or eastern). Two hundred fifty-nine maps representing all 105 counties were returned to the (NWTF) where 8,874 locations were entered into a single spreadsheet. Entries consisted of the legal description (Township, Range, Section) and in some cases additional information (e.g., potential release site).

The Kansas Applied Remote Sensing (KARS) Program used LEO 3.6 software to define the sections boundaries indicated in the spreadsheet as geographic coordinates. The output list of coordinates was assessed and duplicate entries were removed as well as some other entries where the entire county was indicated as having wild turkeys. This reduced the number of turkey sites to 8,737. The coordinates and their unique ID numbers were then entered into an AML that generated an ARCINFO coverage of the section locations. The turkey coverage contained a total of 8,818 polygons, with 81 of these being interior polygons created by the surrounding 8,737 turkey polygons. To separate these interior polygons, an attribute field "turkey" was added and turkey polygons were assigned a value of 1, while interior polygons received a value of 0.

Assembling the datasets

To be compatible with the known turkey location data, the habitat suitability models would also used the PLSS grid as a minimum mapping unit. The raw PLSS grid for the state was not a uniform grid, and had missing cells around military bases and the Kansas River. To resolve this, arcs were manually inserted to continue the grid pattern across the voids to create a uniform grid coverage for the state. For increased interpretation and analysis of the spatial distribution of the data, an ARCINFO coverage of the Omernik level two ecoregions of Kansas was formatted to match the PLSS data set. Ecoregion boundaries were adjusted to follow the PLSS section lines so that when a union was performed between the two coverages, individual polygons would not be split into two ecoregions. The result of the processing was an added attribute to each PLSS polygon identifying the ecoregion it resided in. When known turkey location attribute data was added to the statewide PLSS grid, one known turkey location fell outside the statewide PLSS coverage, thereby reducing the number of known locations to 8,736. The statewide PLSS coverage was then subset into seven individual ecoregion coverages.

Like many habitat models that associate habitat suitability with land cover (Donovan et al. 1987, Gustafson et al 1994, Lyon 1983, Houts 1999), this one compares a generalized version of the Kansas GAP Vegetation Map with known wild turkey locations. The original GAP map contained 43 classes with a two hectare (4.9 acres) minimum mapping unit. This was generalized down to nine classes (forest, shrubland, tallgrass, mixed grass, shortgrass, wetlands, agriculture, urban, and water), then smoothed using a 3x3 moving median filter, then filtered to remove patches smaller than 3 pixels in size (6 hectares, 14 acres). The raster based generalized GAP map was then converted to a polygon file and intersected with ecoregion PLSS coverages. The area of each land cover class with each grid cell was calculated, and converted to a percentage of the grid cell area. The result of this process was a 1x1 mile grid covering each ecoregion, with each grid cell having attributes describing the known presence or absence of turkeys and the percent of the grid cell area covered by each of the nine land cover classes.

Creating Ecoregion Specific Habitat Models

Wild turkey habitat preferences were assessed using a generalized Kansas GAP land cover map intersected with the PLSS grid. Statistics were calculated in SPSS to compare the proportion of each land cover class within the 8,736 known turkey locations and a random sample of 22,100 locations where turkeys were not known to exist (30% of non-turkey locations). Results from the statistical analysis were used as a starting point for generating numerous logistic regression models in an effort to find the best unique combination of land cover variables to model each ecoregion.

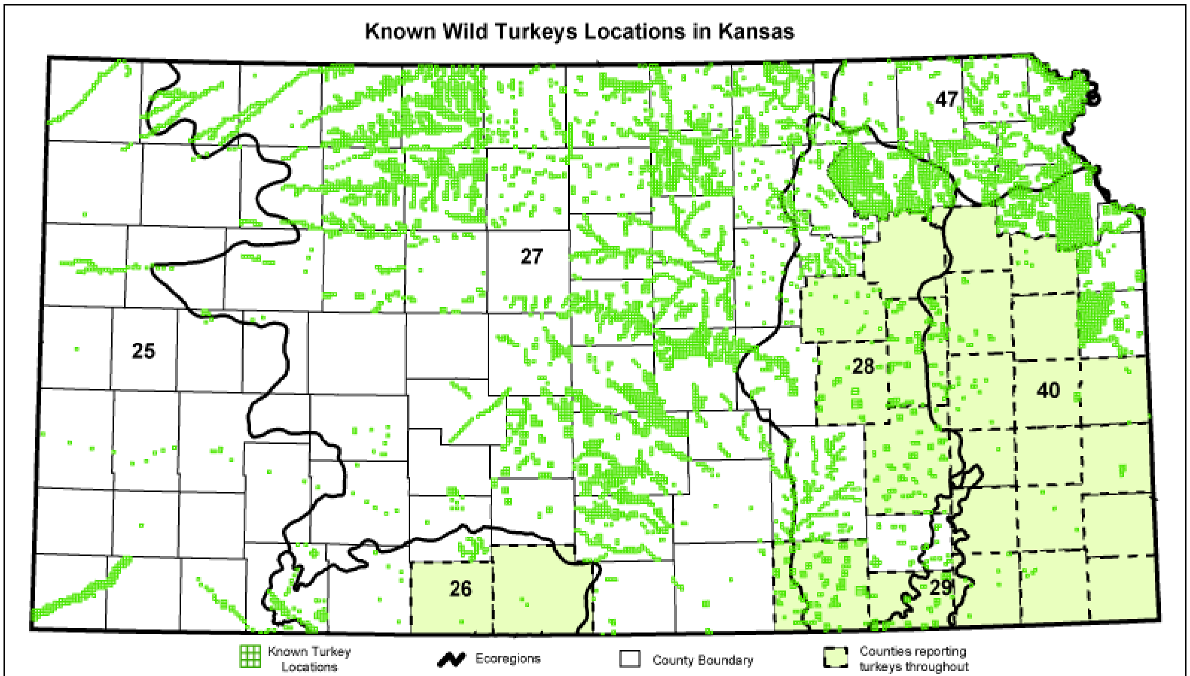
To begin the modeling process, all of the known and randomly selected non-turkey sites within each ecoregion were entered into logistic regression analysis using a forward stepwise approach with all land cover percentages identified as potential variables. This process was repeated several additional times with certain variables hypothesized to be good predictors specified to enter the logistic regression model. The ability of the models to predict known turkey locations while minimizing errors of omission and commission was analyzed using an error matrix until three candidate models were selected.

A random subset of 75% of each ecoregions know turkey grid cells, and an equal number of randomly selected non-turkey cells, were used to build the ecoregion models. For example, in ecoregion 28, there were a total of 9,586 grid cells with 1,334 known turkey cells and the remaining 8,252 designated as non-turkey cells. Thus, 75% (1,000) of the known turkey cells and an equal number (1,000) of non-turkey cells were used to create a dataset for generating models. The three candidate logistic regression models for each ecoregion were then applied to the dataset. This process of random cell selection and modeling was performed five times for each ecoregion, with the final ecoregion models using the average of the coefficients (3 variables and a constant) from the five iterations.

The final ecoregion models generated from the 75% subsets were then applied to the entire dataset for each ecoregion. The accuracy of the three models for each ecoregion was assessed by comparing predicted habitat (probability >= 50%) against known locations with errors of omission, commission, and an overall accuracy calculated for each ecoregion. The accuracy of the GAP vertebrate species map was assessed by intersecting it with known turkey location data. As a result of the GAP habitat data not being based on the PLSS grid cells, a rule was created to required the GAP habitat data occupy at least 15 percent of a known turkey grid cell for it to be counted as correctly identified. This was done to account for GAP habitat data only nicking the corner of a known turkey grid cell, and thereby artificially inflating the accuracy.

Results

Processing of the turkey location data resulted in the creation of a GIS coverage depicting the location of 8,736 known turkey locations throughout the state, and the identification of 25 counties where turkeys were reported to be present throughout the county (Figure 2). A visual assessment of the known locations showed the anticipated pattern of riparian corridors, indicating that the data was processed and mapped correctly.



ecoregion	25	26	27	28	29	40	47
Known turkeys	456	108	5014	1335	66	903	849

Figure 2. Map of known wild turkey location as reported by a survey of regional experts shown with Omernik level two ecoregions outlined and numbered in bold black. Inset table shows the number of known turkey locations within each ecoregion.

Ecoregion Specific Habitat Models

An independent sample T-test comparing known and unknown turkey locations against the generalized GAP land cover map showed that there was a significant difference for all land cover classes except urban areas (sig. < 0.01). When each ecoregion was analyzed individually, a slightly more restrictive representation of wild turkey habitat was identified (Table 1).

Table 1. Variables identified as significant by a T-test for each ecoregion.

Ecoregion	Variables* with sig. < 0.01
25	1, 2, 3, 5, 7
26	2, 4, 5, 7
27	1, 2, 3, 5, 6, 7, 8, 9
28	1, 2, 3, 7, 9
29	3
40	1, 2, 3, 4, 7, 9
47	1, 7, 9

* 1. forest, 2. tall grass, 3. mixed grass, 4. short grass 5. shrub land, 6. wetland, 7. agriculture, 8. urban, 9. water

The first logistic regression model for each ecoregion, created using a forward step-wise method of entry on all variables, generated reasonable results, however, by adjusting the variables used, better classification accuracies were achieved. After multiple iterations using different variables, the best variable combination was identified for each ecoregion. Though the variables and coefficients for each ecoregion varied, there were consistent themes between ecoregions, indicating that the models were identifying consistent habitat preferences (Table 2). When the final ecoregion models were applied to the dataset (the mean coefficients of five iterations on unique 75% subsets of the data), a map showing the predicted probability of wild turkey habitat was generated (Figure 3).

Table 2. Variable used and the associated regression coefficients for each ecoregion

eco	variable	coeff	eco	variable	coeff
25	Const.	0.10	29	Const.	0.447
	1	6.705		3	-1.79
	5	1.205		4	2.178
	7	-0.92		8	161.7
26	Const.	0.504	40	Const.	-0.038
	1	-0.91		3	-6.105
	3	13.42		4	4.546
	7	-2.97		8	-0.198
27	Const.	-1.15	47	Const.	-0.914
	1	13.24		1	6.534
	3	1.387		7	-0.454
	4	0.524		8	-0.206
28	Const.	-0.96			
	1	6.305			
	2	-42.3			
	7	0.86			

1. forest, 2. tall grass, 3. mixed grass, 4. short grass 5. shrub land, 6. wetland, 7. agriculture, 8. urban, 9. water

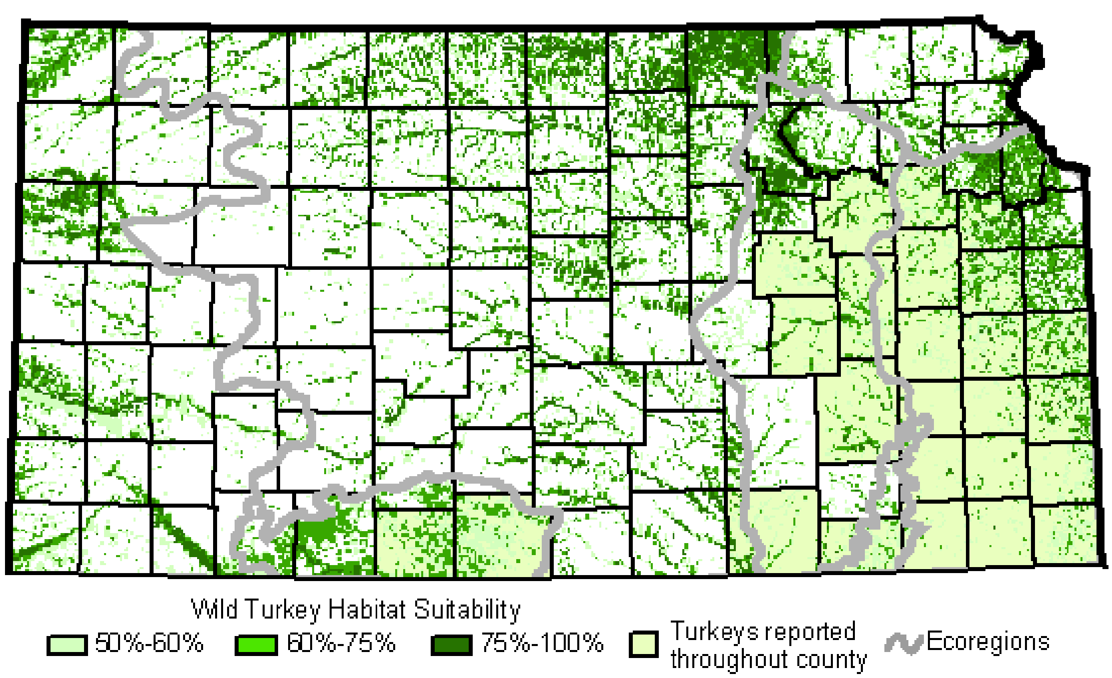


Figure 3. Probability of suitable wild turkey habitat as predicted by ecoregion-specific habitat models. Values greater than 50% considered suitable habitat.

Comparison between known turkeys and GAP species map

A visual assessment of the GAP turkey habitat map showed many similarities between the areas of predicted and known wild turkey habitat (Figure 5). In both cases, the locations tended to occur in woody areas and follow riparian corridors. There were many area of predicted habitat where wild turkeys were not known to exist, and conversely there were known areas that were not predicted as turkey habitat. When interpreting these results, it should be remembered that this only assesses the GAP predicted habitat in terms of errors or omission, not errors of commission. Therefore, it examines known turkey locations that either were or were not predicted, while predicted areas that were not known habitat do not affect the accuracy.

Of the 8,736 known turkey locations, 2,428 of them (27.8%) did not intersect at all with the GAP predicted data, which conversely meant that 72.2% of the known turkey locations had some overlap with the GAP predicted habitat. After adjustments made to account for intersections of less than 15%, the statewide overlap was reduced to 63.6% indicating that 8.6% of the initial accuracy was based on "slivers" of agreement. When the percent agreement between known locations and the GAP habitat map was plotted, it showed the dramatic gradient in accuracy from east to west, with a high percentage of overlap in the eastern ecoregions, and a low percentage of overlap in the western ecoregions (Figure 6). By way of comparison, when the ecoregion specific suitability was mapped for the known locations, there were fewer instances of known locations being mapped as unsuitable habitat, especially in western Kansas (Figure 7).

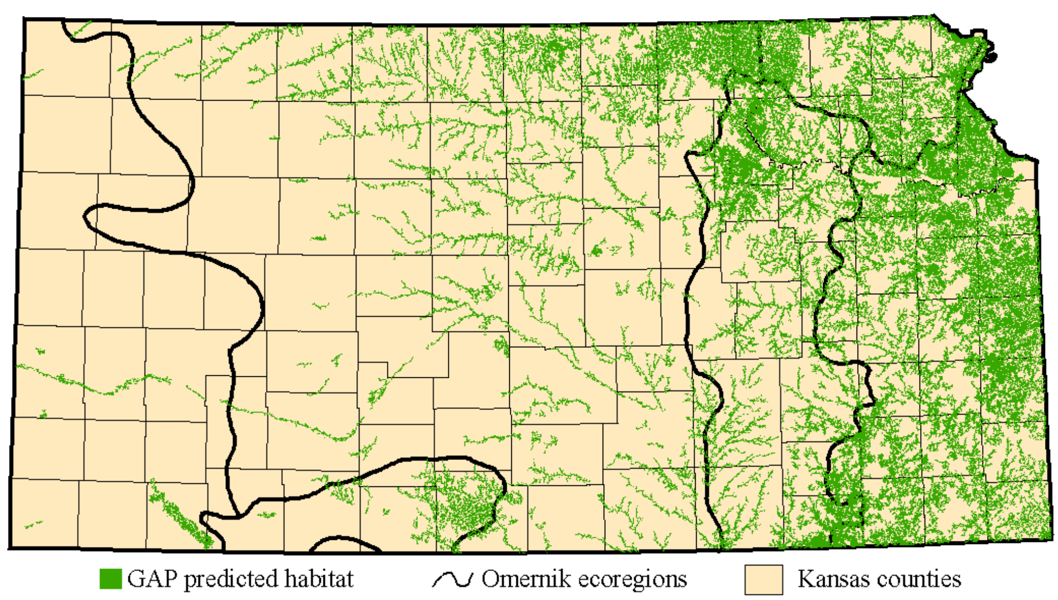


Figure 5. Areas predicted as wild turkey habitat by the GAP vertebrate species map for wild turkeys.

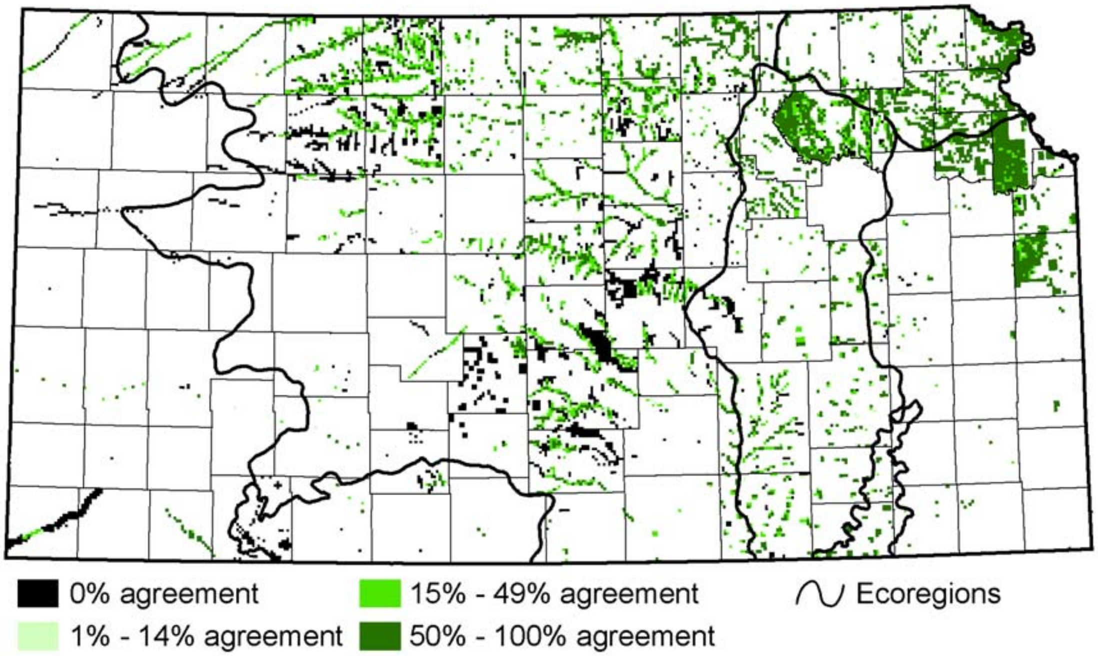


Figure 6. Map showing the percent overlap between known wild turkey locations and the areas predicted by the GAP species habitat map.

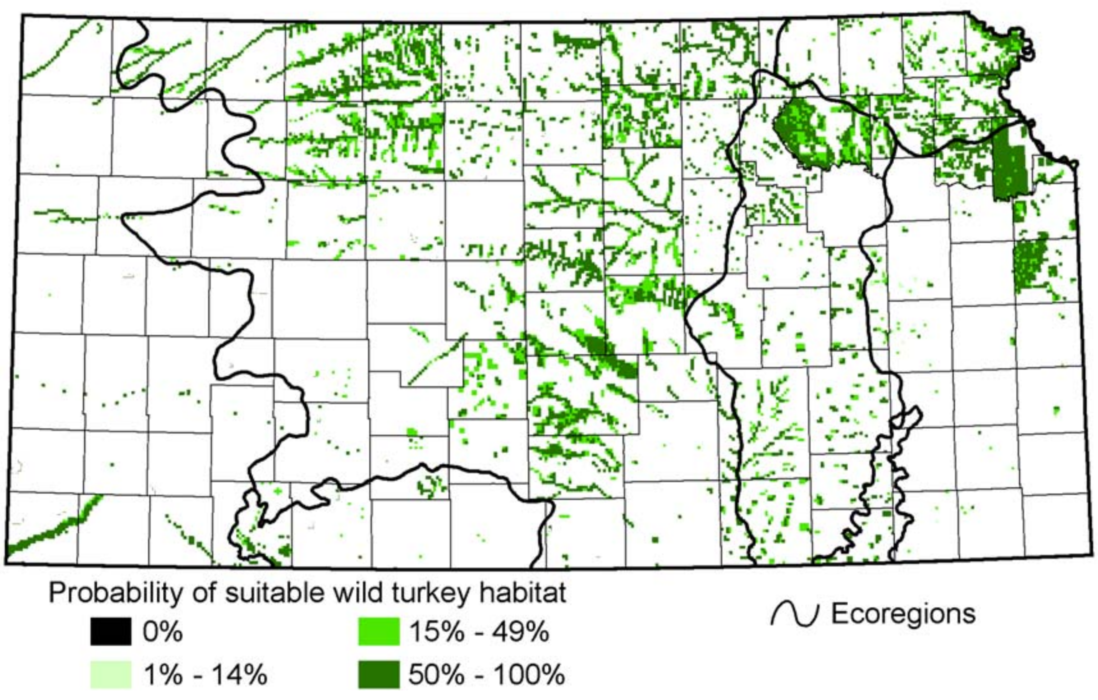


Figure 7. Map of known wild turkey locations showing the probability of suitable habitat as predicted with ecoregion specific logistic regression models. Probabilities greater than 50% were considered suitable habitat.

When the accuracies of the different models were assessed, it became apparent that the ecosystem specific models produced a more consistent, though not necessarily greater, level of accuracy across the state (Figure 8). The ecoregion specific models produced accuracies between 61 and 78 percent, with an average of 68 percent. In contrast, the GAP model had average accuracy 64 percent, but produced accuracies ranging from 14 percent in the west to greater than 98 percent in the east. A more thorough assessment of the ecoregion models accuracy can be found in the confusion matrices in appendix 1.

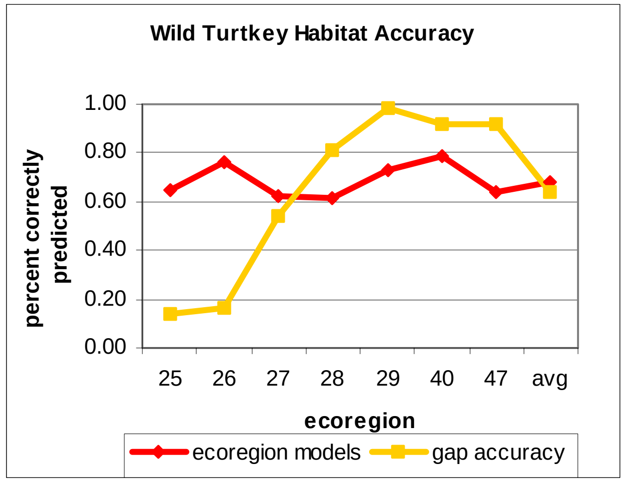


Figure 8. Accuracy of the ecoregion specific models and the GAP turkey habitat map.

Discussion

Any evaluation of this project should start with an analysis of the known turkey location data, as any errors in this source data would be propagated throughout the modeling and assessment process. Several factors were considered that might have influenced the outcome of the models and their accuracy. First, the lack of specific known turkey locations in southeast Kansas resulted in fewer training sites for the eco-40 model, and may have been the cause of the eco-40 model under-predicting suitable habitat in the southwestern portion of ecoregion 40. While the accuracy for ecoregion 40 was the highest of the eco-specific models, it is hard to have confidence in the numbers when examining the distribution of the model results compared to the known locations and the abundance of "present throughout county" occurrences. It appears that the model performed very well on the northern portion of the ecoregion, but lost power in the southern portion as a result of the uneven distribution of training sites. Secondly, since the surveys were done on a per county basis, there are several examples of dense groupings of known locations suddenly ending at county lines. While this probably did not have a major impact on model creation or accuracy, it is an issue that should be recognized when considering the known location data.

While the ecoregion specific models were able to adjust to changes in turkey habitat use between western and eastern Kansas to provide a more uniform level of accuracy across the state, there were also some problems with the models. In ecoregions where the known location data was not evenly distributed throughout the ecoregion or across habitat types, the models tended to limit the predicted habitat. Conversely, if the known locations occurred primarily within a land cover combination that was common, the amount of suitable habitat could have been over predicted and resulted in errors of commission, as could be the case in ecoregion 25. Another factor that is evident is the difference in predicted habitat between ecoregions. While the models predicted evenly across county lines (unlike some of the known location data) they sometimes created unnatural breaks at ecoregion boundaries.

While there was a high degree of spatial correlation between the GAP turkey habitat map and known turkey locations, the agreement is not complete or evenly distributed across the state. As a result of the larger number of known turkey locations and the large area of GAP predicted turkey habitat in the eastern third of the state, the eastern ecoregions had a high level of agreement between predicted and known locations, and those that did agree shared a large amount of overlap. Conversely, the central and western ecoregions had a lower level of agreement between predicted and known turkey locations, and many of those only overlapped slightly. This spatial gradient in accuracy was successfully addressed by creating ecoregion specific habitat models indicating that regional-scale modeling efforts may benefit from using a mosaic of smaller habitat models that can adjust to subtle changes in habitat preference.

eco25	0	1	
0	11852	4170	0.74
1	161	295	0.65
	0.987	0.066	0.74

eco29	0	1	
0	387	334	0.54
1	18	48	0.73
	0.956	0.126	0.55

eco26	0	1	
0	1573	1941	0.45
1	26	82	0.76
	0.984	0.041	0.46

eco40	0	1	
0	7155	3614	0.66
1	195	709	0.78
	0.973	0.164	0.67

eco27	0	1	
0	24460	7174	0.77
1	1876	3139	0.63
	0.929	0.304	0.75

eco47	0	1	
0	1980	771	0.72
1	311	542	0.64
	0.864	0.413	0.70

eco28	0	1	
0	6086	2166	0.74
1	518	816	0.61
	0.922	0.274	0.72

overall	0	1	
0	53493	20170	0.73
1	3105	5631	0.64
	0.945	0.218	0.72

Appendix 1. Error matrices showing the accuracies produced by each of the ecoregion habitat models.

Literature Cited

Applegate, R.D., and M. Robertson. 2001. Wild turkey status report for Kansas 2001. Kansas Department of Wildlife and Parks, Emporia, Kansas.

Backs and Eisfelder 1990.

Cully, J., S. Egbert, J. Harrington, T. Hornemann, G. Kaufman, C. Lauver, E. Martinko, and K. Price. 2002. A GAP Analysis of Kansas. Kansas Cooperative Fish and Wildlife Research Unit, Manhattan, Kansas.

Donovan, Michael L., Dale L. Rabe, Charles E. Olson Jr. 1987. Use of Geographica Information Systems to develop habitat suitability models. Wildlife Society bulletin. 15:574-579.

Gustafson, Eric J., George G. Parker, Steven E Backs. 1994. Evaluating Spatial Pattern of wildlife habitat: A case study of the wild turkey. American Midland Naturalist. 131: 24-33.

Hlavachik, B., and M. Blair. 1997. The Wild Turkey Story. Kansas Wildlife and Parks. 54:2-11.

Houts, M.E. 2000. Modeling Gray Wolf Habitat in the Northern Rocky Mountains. University of Kansas, Masters Thesis.

Kennamer, J.E., M. Kennamer, and R. Brenneman. 1992. History. Pages 6-17 *in* J.G. Dickson, editor. The wild turkey: biology and management. Stackpole Books, Mechanicsburg, Pennsylvania.

Lyon, John Grimson. 1983. Landsat derived land-cover classification for locating potential kestrel nesting habitat. Photogrammetric Engineering and Remote Sensing. Vol. 42, no.2: 245-250.

Mitchener, M.W. 2001. Kansas Wild Turkey Management Plan. Kansas Department of Wildlife and Parks. Pratt, Kansas.