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# Red-Tailed Hawk Nesting in Kansas: Influence of Landscape Characteristics

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**RED-TAILED HAWK NESTING IN KANSAS: INFLUENCE OF LANDSCAPE CHARACTERISTICS—**Factors that affect nest site selection in red-tailed hawks (*Buteo jamaicensis*) include the physical features surrounding the nest and landscape characteristics. Features surrounding nests include: tree height, tree diameter (dbh), percent canopy cover, slope, nest openness, and density of woody plants or shrubs (Titus and Mosher 1981, Bechard et al. 1990, Tietje et al. 1997, Actkinson et al. 2007). Landscape characteristics that influence nest site selection by red-tailed hawks vary across regions. In Georgia, red-tailed hawks selected nest site in areas with greater area of agriculture and open pasture (Moorman and Chapman 1996), whereas in Oklahoma prairies, the hawks selected nest sites in landscapes with greater wooded area (McConnell et al. 2008). In Wisconsin, a greater high-density urban habitat and road area along with small patch sizes correlated with greater nest productivity (Stout et al. 2006). In the sagebrush grasslands of Oregon, dispersion and density of perches resulted in increased nest productivity (Jaynes 1984).

According to central foraging theory, a nest site should be located close to preferred hunting area (Orians and Pearson 1979). Landscape characteristics such as patch size, distance between perch and prey, and perch availability can influence capture success of a perching predator (Andersson et al. 2009). I recorded red-tailed hawk nesting in south-central Kansas over 22 years. I determined which landscape characteristics were associated with red-tailed hawk nests by drawing a circular plot with a 550-m radius around a nest and comparing landscape characteristics among preferred nesting sites, randomly selected sites, and potentially suitable sites where no nest was recorded during a 22-yr period.

My study area included 104 km$^2$ in south-central Kansas (Fig. 1). The study area was bisected west to east by a highway. Along the highway, there was one range-township section to the north and one to the south, producing a rectangular shape. The area represented the western edge of tallgrass prairie of the Flint Hills region (United States Department of Agriculture 2012). The tallgrass prairie in my study area has been converted into a patchwork of farms, pastures and residences including three small towns (each with less than 3,000 residents). Grasses that dominated the pastures are: big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*) and Indian grass (*Sorghastrum nutans*). Osage-orange (*Maclura pomifera*) trees dominated the hedgerows while cottonwoods (*Populus deltoids*) and hackberry (*Celtis occidentalis*) dominated the wooded areas with coral berry (*Symphoricarpos orbiculatus*) as an understory.

From 15 March to 30 April of 1988 to 2009, I located red-tailed hawk nests from an automobile and on foot (Craighead and Craighead 1956). I drove the perimeter road (77% were gravel) around each section at least four times each year. The area is mostly an open landscape with tree stands restricted to hedgerows or strips along a creek or river. I used a Celestron Ultima 100 spotting scope (Celestron LLC, Torrance, California, USA) to verify if a bird was incubating on the nest or if nestlings were present. Any distinctive platform of sticks that had no bird on it, perched nearby or circling above was approached to the base of the tree to verify that it was unoccupied. Nests that were used in different years and were

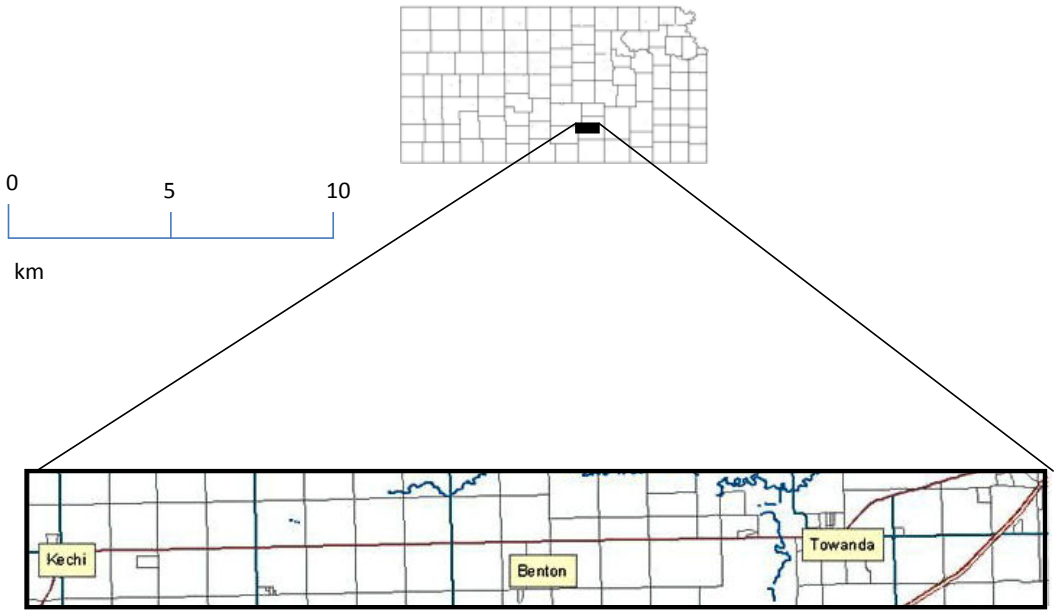


Figure 1. Red-tailed hawk study area located in western Sedgwick and eastern Butler counties of south-central Kansas, USA. Highway K-254 bisects the area with one range-township section to the north and one section to the south of the highway that extends from Kechi, Kansas to the intersection of highway K-196.

within 200 m of one another but in a different tree were considered one nesting site with the geometric center representing the nesting site (Gilmer et al. 1983).

To identify preferred nesting sites, a subset was selected from a pool of 102 sites that had been used by a red-tailed hawk and/or great horned owl (Langley 2013). Preferred nesting sites (NEST; $n$ = 17) were ones used by red-tailed hawks for 6–11 yrs. with a mean of 6.7 yrs. Sites considered as NO-NEST ($n$ = 16) were potentially suitable sites with no nest recorded in 22 years. To identify a potentially suitable nesting site within that area where no nesting had occurred, a tree was selected that appeared similar to trees used by red-tailed hawks elsewhere in the study area. Specifically, the selected tree had to be at least 15 m in height and had branches that were similar in size to those of trees where red-tailed hawks had nested. To identify randomly selected sites (RANDOM), I divided each of the 40 map sections in the study area into quarter sections ($n$ = 160) and assigned each quarter section a number; 40 numbers were randomly generated to select a quadrant. I classified a tree with the characteristics described above and positioned closest to the center of that quadrant as a randomly selected nesting site.

When examining habitat associations with avian nesting, different scales are suggested (Block and Brennan 1993, La Sorte et al. 2004, McConnell et al. 2008). I used the minimum size (550 m radius) of a "midscale" plot suggested for red-tailed hawk nests; the corresponding radius size plot eliminated overlap among selected nest sites throughout my study area. I plotted nesting sites on 2008 aerial photograph imagery available through the Butler County's office of Natural Resources Conservation Service. Within the circular plot around the nest site, I used Arc Map 9.27 (ESRI Inc., Redlands, CA, USA) to delineate polygons describing patches comprised of agriculture (currently or recently plowed), pastures (native prairie with occasional trees), wooded areas (riparian areas, tree lines or hedge rows >3 m across), residential areas, ponds and roads. I used Geodata tool 9.2011.01.13 (ESRI Inc.) to quantify the area and perimeter of each patch. I examined the following landscape features within the circular plots: total area of particular land use within the circular plot, total perimeter length (sum of the perimeters of all the polygons around each nesting site for a particular land use), number of patches, patch size, patch perimeter (length of perimeter of an individual patch), patch shape index and patch fractal dimension. I calculated patch shape index and fractal dimension using FRAGSTATS Version 4 (McGarigal et al. 2012). The shape index measured the extent to which the polygon shape deviates from a perfect square. The fractal dimension measured the irregularity along the edge of the border. Two measurements of anthropogenic influence on selection of red-tailed hawk nests included: distance from a house to the nest and distance from a road to the nest or plot center of NO-NEST and RANDOM.

I used a two-way analysis of variance (ANOVA) to evaluate landscape characteristics of plots and patches within land uses among nest groups (NEST, NO-NEST, RANDOM). I used a post-factor $G$-test to separate effects of landscape characteristics among land uses and nest groups (Sokal and Rohlf 1981) and one-way ANOVA to compare distances to nearest house and road.

No interaction occurred in total area within the circle between land use types and groups ($F_{10, 421}$ = 1.7, $P$ = 0.72). Pasture and agriculture areas accounted for twice as much as residential, wooded, road, and pond areas combined (Table 1). The total perimeter length (m) of NEST (5,619, SE = 856), NO-NEST (3,157, SE = 337) and RANDOM (4,584, SE = 271) differed from one another ($F_{2, 421}$ = 6.5, $P$ = 0.002; Table 1) and a significant interaction occurred between groups and land-uses ($F_{10, 421}$ = 2.5, $P$ = 0.006). The NEST group had longer total perimeters in the pasture, residential, wooded, and road areas than the ones in the NO-NEST group. The NEST group had longer total perimeter lengths in the pasture than those in the RANDOM group. The NO-NEST group had shorter total perimeters in the residential and road areas than those in the RANDOM group. The NEST (4.3, SE = 0.3) and RANDOM (4.3, SE = 0.2) groups had more ($F_{2, 421}$ = 11.9, $P$ < 0.001) patches than the NO-NEST (2.7, SE = 0.3) group, but no significant interaction ($F_{10, 421}$ = 1.3, $P$ = 0.23) was evident among groups and land use types.

Mean patch size (ha) was of NO-NEST (5.9, SE = 0.8) group was more than 50% larger ($F_{2, 1737}$ = 9.1, $P$ < 0.001) than mean patch size in the other two groups (NEST, 3.7, SE = 0.3; RANDOM, 3.6, SE = 0.2), which did not differ from one another (Table 1). No significant ($F_{10, 1737}$ = 1.8, $P$ = 0.07) interaction occurred between land use types and groups for patch size.

The greatest shape index values among the land use types occurred in road land use (Table 1). This difference is more a function of the linear nature of a road than a function of variation in patch shape. The shape index value differed ($F_{2, 1737}$ = 7.2, $P$ < 0.001) among groups as follows: NEST (1.99, SE = 0.05) > RANDOM (1.88, SE = 0.03) > NO-NEST (1.76, SE = 0.07). A significant interaction ($F_{10, 1737}$ = 6.9, $P$ < 0.001) occurred among land use types and groups. The shape index values of agriculture, pasture and resident areas in NEST group were larger, but in wooded and road areas were smaller than those of the NO-NEST group. The NEST group had larger shape indices in agriculture, residential and road areas and in the wooded area smaller than those in the RANDOM group. The shape indices of the residential, wooded and road areas in the NO-NEST group were larger and in pasture and pond areas smaller than those of the RANDOM group.

Patches in the road area had the largest fractal dimension value among land use types (Table 1). Mean fractal values differed ($F_{2, 1737}$ = 8.8, $P$ < 0.001) among groups as follows: NEST (1.12, SE = 0.1) > RANDOM (1.11, SE = 0.01) > NO-NEST (1.09, SE = 0.01). A significant interaction ($F_{10, 1737}$ = 6.8, $P$ < 0.001) occurred among land use types and groups.

Table 1. Characteristics of landscape features within a 550-m circular plot surrounding red-tailed hawk nest sites (NEST), potential nest sites but no nest recorded in 22 years (NO-NEST), and RANDOM sites from 1988 to 2009 in south-central Kansas, USA.

| Group[a] | AG | PAST | RES | WOOD | POND | ROAD |
|---|---|---|---|---|---|---|
| | | | Land-use area[b] | | | |
| NEST | 21.0 (5.3)[c] | 43.2 (5.9) | 10.0 (2.0) | 13.4 (2.9) | 1.6 (0.5) | 4.0 (0.9) |
| NO-NEST | 31.9 (6.7) | 48.3 (7.9) | 4.9 (2.5) | 7.2 (1.9) | 0.8 (0.3) | 0.7 (0.2) |
| RANDOM | 29.5 (3.5) | 36.1 (4.4) | 12.8 (2.0) | 9.6 (1.6) | 1.3 (0.3) | 4.0 (0.5) |
| | | | Perimeter length (m) | | | |
| NEST | 3,097 (590)[e] | 13,353 (4,409)[d,e] | 4,242 (571)[d] | 6,211 (797)[d] | 847( 221) | 5,619 (1,110)[d] |
| NO-NEST | 4,062 (831) | 6,775 (788) | 1,498 (463)[e] | 4,835 (768) | 484 (176) | 1,288 (389)[e] |
| RANDOM | 5,090 (546) | 7,359 (920) | 3,834 (581) | 5,192 (579) | 687 (130) | 5,340 (491) |
| | | | Number of patches | | | |
| NEST | 3.1 (0.5) | 6.5 (0.6) | 5.3 (0.7) | 5.7 (0.8) | 2.4 (0.5) | 3.0 (0.5) |
| NO-NEST | 3.1 (0.8) | 0.6 (0.6) | 2.3 (0.6) | 4.2 (0.7) | 1.6 (0.5) | 0.6 (0.1) |
| RANDOM | 4.5 (0.5) | 5.5 (0.7) | 5.5 (0.7) | 4.9 (0.5) | 2.1 (0.3) | 3.5 (0.3) |
| | | | Patch size (ha) | | | |
| NEST | 6.3 (1.0) | 6.8 (0.9) | 1.9 (0.3) | 2.4 (0.5) | 0.7( 0.2) | 1.5 (0.1) |
| NO-NEST | 10.2 (1.8) | 12.1 (2.2) | 2.1 (0.9) | 1.7 (0.4) | 0.5 (0.1) | 1.0 (0.2) |
| RANDOM | 6.4 (0.6) | 6.5 (0.8) | 2.3 (0.3) | 2.0 (0.3) | 0.6 (0.1) | 1.1 (0.1) |
| | | | Shape Index | | | |
| NEST | 1.53 (0.07)[d,e] | 1.75 (0.10)[d] | 1.76 (0.14)[d,e] | 2.02 (0.10)[d,e] | 1.25 (0.04) | 4.30 (0.15)[d,e] |
| NO-NEST | 1.23 (0.03) | 1.46 (0.05)e | 1.36 (0.08)[e] | 2.40 (0.14)[e] | 1.16 (0.05)[e] | 5.06 (0.06)[e] |
| RANDOM | 1.30 (0.02) | 1.74 (0.07) | 1.21 (0.02) | 2.28 (0.07) | 1.26 (0.03) | 3.74 (0.09) |
| | | | Fractal Dimension | | | |
| NEST | 1.08 (0.01)[d,e] | 1.10 (0.01)[d,e] | 1.09 (0.01)[d,e] | 1.13 (0.01)[d,e] | 1.05 (0.01)[d] | 1.30 (0.01)[d,e] |
| NO-NEST | 1.04 (0.01)[e] | 1.07 (0.01)[e] | 1.06 (0.01)[e] | 1.17 (0.01) | 1.03 (0.01)[e] | 1.34 (0.01)[e] |
| RANDOM | 1.05 (0.01) | 1.04 (0.01) | 1.04 (0.01) | 1.17 (0.01) | 1.05 (0.01) | 1.28 (0.01) |
| | | | Patch perimeter length (m) | | | |
| NEST | 1,187 (104) | 1,385 (100) | 800 (74) | 1,111 (125) | 387 (54) | 1,988 (81) |
| NO-NEST | 1,300 (123) | 1,656 (229) | 647 (119) | 1,155 (148) | 298 (39) | 2,061 (424) |
| RANDOM | 1,112 (52) | 1,350 (84) | 616 (32) | 1,093 (87) | 34 (35) | 1,661 (78) |

[a]AG = agricultural, PAST = pasture, RES = residential, WOOD = wooded, POND = pond and ROAD = road land-use;
[b]Land-use measures the total kind of land-use in the circle in hectares. Perimeter length measures the total perimeter of all the patches in that kind of land-use in meters. Number of patches is the mean. Patch size measures the mean area of individual patches in hectares. Shape index represents the value of the ratio of perimeter to area. Fractal Dimension measures the ratio of logs of perimeter and area. Patch length measures the perimeter length of individual patches in meters; [c]Mean with SE estimate in parentheses; [d]NEST differed from NO-NEST in a post-factor G test at ($P < 0.05$); [e]NEST or NO-NEST differed from RANDOM in a post-factor G test at ($P < 0.05$).

NEST group had larger fractal values in the agriculture, pasture, residential and pond areas and smaller in wooded and road areas than those in NO-NEST group. NEST group had larger fractal values in agriculture, pasture, residential and road areas and in the wooded area smaller than those of the RANDOM group. The NO-NEST group had larger fractal values in the pasture, residential and road areas and in agriculture and in pond areas smaller than those in the RANDOM group. Patch perimeter lengths (m) in the NEST (1,152, SE = 46) and NO-NEST (1,184, SE = 73) groups were greater ($F_{2, 1737} = 3.4$, $P < 0.001$) than those of the RANDOM (1,047, SE = 30) group, but no significant ($F_{10, 1737} = 1.5$, $P = 0.15$) interaction was evident.

All three groups showed similar responses to human activity. The mean distance (m) to nearest house for the NEST (530, SE = 62), NO-NEST (458, SE = 62) and RANDOM (321, SE = 10) groups were similar ($F_{2, 71} = 0.4$, $P = 0.70$). Distance (m) to nearest road was similar ($F_{2, 71} = 0.6$, $P = 0.55$) among NEST (291, SE = 20), NO-NEST (400, SE = 78) and RANDOM (92, SE = 7).

If a landscape characteristic strongly influences nest selection, the following rank order of differences NEST > RANDOM > NO-NEST is predicted. The value of the landscape characteristic differs from that of randomly selected sites and differs in opposite directions for preferred nests and where no nest has occurred. Landscape characteristics that strongly influenced nest site selection in red-tailed hawks included the total length of perimeters, shape index, and fractal dimension values. In this rural-suburban setting, perimeter length can reflect the availability of perches. Most fence posts, power poles and lines, hedgerows and trees occur along the perimeter of a patch. Perch availability is one factor that affects success in hunting for a perching predator (Andersson et al. 2009). A larger shape index value means that at some point the perimeter is closer to middle of a patch than it could be in a perfectly shaped square. Distance from a perch to a prey affects hunting success in perching predators (Andersson et al. 2009). Distribution of perches reduced the distance between a hawk and a prey, improved capability to search a patch and resulted in increased nest productivity (Jaynes 1984). Thus, red-tailed hawks could be selecting for nest sites where there was relatively short distances from the edges to center of patches for foraging.

Mean fractal values also showed a similar ranked pattern as shape index and a higher value indicative of more irregular shaped border. In Wisconsin, a lower fractal value was associated with a greater nest productivity in red-tailed hawks and it was less likely that the veiw for a perched predator was obstructed (Stout et al. 2006). Just the opposite pattern occurred in Kansas, where the greatest fractal value occurred with preferred nesting sites rather than lowest. The size and number of trees may have been larger along the border of a patch in Wisconsin than in south-central Kansas; thus making irregularity of the border obscure the view to greater extent in Wisconsin than in Kansas.

Potentially suitable sites that were not used had a distinctive set of characteristics. These sites had shorter total perimeter and patch perimeter lengths than randomly selected sites; hence there were fewer perches such as fence posts, hedgerows, trees and power poles. NO-NEST sites also had fewer number of patches, larger patch sizes, less irregularly shape patches and smaller fractal dimension values than randomly selected sites. Presumably, red-tailed hawks avoid some areas based on certain landscape features. Influence from human activity as measured by distances to the nearest house or road, however, did not influence nesting site selection in this study which is consistent with studies in Oregon and California (Jaynes 1984, Speiser and Bosakowski 1988).

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## LITERATURE CITED

Actkinson, M. A., W. P. Kuvlesky Jr., C. W. Boal, L. A. Brennan, and F. Hernandez. 2007. Nesting habitat relationships of sympatric crested caracaras, red-tailed hawks and white-tailed hawks in south Texas. Wilson Journal of Ornithology 119:570–578.

Andersson, M., J. Wallander, and D. Isaksson. 2009. Predator perches: a visual perspective. Functional Ecology 23:373–379.

Bechard, M. J., R. L. Knight, D. G. Smith, and R. E. Fitzner. 1990. Nest sites and habitats of sympatric hawks (*Buteo* spp.) in Washington. Journal of Field Ornithology 61:159–170.

Block, W. M., and L. A. Brennan. 1993. The habitat concept in ornithology: theory and applications. Pages 35–91 *in* D. M. Power, editor. Current ornithology. Volume 11. Plenum Press, New York, New York, USA.

Craighead, J. J., and F. C. Craighead. 1956. Hawks, owls and wildlife. First edition. Stockpole Company, Harrisburg, Pennsylvania, USA.

Gilmer, D. S., P. M. Konrad, and R. E. Stewart. 1983. Nesting ecology of red-tailed hawks and great horned owls in central North Dakota and their interactions with other large raptors. The Prairie Naturalist 15:133–143.

Jaynes, S. W. 1984. Influences of territory composition and interspecific competition on red-tailed hawk reproductive success. Ecology 65:862–870.

Langley, W. M. 2013. Nesting patterns of red-tailed hawk and great-horned owl in south-central Kansas. The Prairie Naturalist 45:57–59.

La Sorte, F. A., R. W. Mannan, R. T. Reynolds, and T. G. Brubb. 2004. Habitat associations of sympatric red-tailed hawks and northern goshawks on the Kaibab Plateau. Journal of Wildlife Management 68:307–317.

McConnell, S., T. J. O'Connell, and D. M. Leslie, Jr. 2008. Land cover associations of nesting territories of three sympatric buteos in shortgrass prairie. Wilson Journal of Ornithology 120:708–716.

McGarigal, K., S. A. Cushman, and E. Ene. 2012. FRAGSTATS: Spatial Pattern Analysis Program for Categorical Maps. Version 4. University of Massachusetts, Amherst, USA. <http://www.umass.edu/landeco/research/fragstats/fragstats.html>. 12 January 2013.

Moorman, C. E., and B. R. Chapman. 1996. Nest-site selection of red-shouldered and red-tailed hawks in a managed forest. Wilson Bulletin 108:357–368.

Orians, G. H., and N. E. Pearson. 1979. On the theory of central place foraging. Pages 155–177 *in* D. H. Horn, R. Mitchell, and G. R. Stairs, editors. Analysis of ecological systems. Ohio State University Press, Columbus, USA.

Sokal, R. R., and F. J. Rohlf. 1981. Biometry. Second edition. W. H. Freeman Company, San Francisco, California, USA.

Speiser, R., and T. Bosakowski. 1988. Nest site preferences of red-tailed hawks in the highlands of southeastern New York and northern New Jersey. Journal of Field Ornithology 59:361–368.

Stout, W. E., S. A. Temple, and J. H. Papp. 2006. Landscape correlates of reproductive success for an urban-suburban red-tailed hawk population. Journal of Wildlife Management 70:989–997.

Tietje, W. D., P. H. Bloom, and J. K. Vreeland. 1997. Characteristics of red-tailed hawk nest sites in oak woodlands of central California. U.S. Department of Agriculture Forest Service General Technical Report PSW-GTR-160. Washington, D.C., USA.

Titus, K., and J. A. Mosher. 1981. Nest site habitat selected by woodland hawks in the central Appalachians. Auk 98:270–281.

United States Department of Agriculture. 2012. Natural Resources Conservation Service, Kansas physiographic provinces. <http://ks.nrcs.usda.gov/about/profiles/physic.pdf>. Accessed 18 June 2013.

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