AN EVALUATION OF BEEF CATTLE AND BOBWHITE QUAIL HABITAT MODELS ON THE SERGEANT MAJOR WATERSHED AT CHEYENNE, OKLAHOMA

By

JOHN ARTHUR ECKROAT

Bachelor of Science
Oklahoma State University
Stillwater, Oklahoma
1965

Master of Science
Oklahoma State University
Stillwater, Oklahoma
1997

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AT CHEYENNE, OKLAHOMA

Thesis Approved:

D L Nofziger
Thesis Adviser

DM Engle

T J Bidwell

Samuel D Fuhlendorf

[illegible]

Alfred Carlozzi
Dean of the Graduate College

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This is dedicated to Mr. Jim Wilkinson, born February 18, 1906, Oklahoma Territory, died August 4, 2000, Oklahoma City, Oklahoma.

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CHAPTER I

INTRODUCTION

In 1948, the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) initiated construction of 10,450 upstream flood control dams in 47 states under the PL-534, PL-566, Pilot, and RC&D water resource programs. These watershed projects represent a $14 billion infrastructure investment and have provided flood control, municipal water supply, recreation, and wildlife habitat enhancement on 130 million acres throughout the United States. At the same time, the resource programs had negative impacts on stream hydrology, native fishes, and riparian zones. The evaluation of the positive and negative impacts of these programs over a 50-year time span has given new insight into watershed management.

These projects have reached, or are nearing, the end of their 50-year expected lifespan. Many of these dams have significant rehabilitation needs, with more than 2000 dams requiring rehabilitation at an estimated cost of $540 million. Today, many of these watershed project areas exist in completely different settings than they did at their inception. Current governmental policies have placed much more emphasis on environmental, recreational, and wildlife issues. Urban sprawl has greatly affected these watersheds by placing more demands upon the watershed to supply a larger quantity of water, better quality water, recreational areas, aesthetics, and environmental quality. There is currently no federal statutory authority for implementing the rehabilitation of these projects. In order to implement statutory authority, a pilot project was initiated to determine what was needed to rehabilitate and maintain watersheds.

In July 1998, the USDA/NRCS announced that funding would be provided for a national pilot rehabilitation project in Oklahoma. The 19,650-acre Sergeant Major Watershed located in Roger Mills County Oklahoma was selected for the project. The city of Cheyenne, Oklahoma lies in the northeast corner of the watershed. The watershed provides municipal water, recreation, flood control, domestic livestock grazing, wildlife habitat, and other valuable resources to the community.

In 1998, a 15-member local planning/coordinating group composed of landowners within the watershed, representatives from the city of Cheyenne, and other interested citizens, identified local community resource needs. The needs were determined to be rehabilitation of high priority flood control dams, protection of the city drinking water supply, improvement of rangeland conditions and wildlife habitat, updating of aging conservation practices, education of oil and gas company representatives in erosion control methods around well sites, and solving storm runoff problems within the city.

In the summer of 1999, I performed an inventory of the Sergeant Major watershed using two models proposed by the NRCS. The inventory was conducted to delineate areas within the watershed that were suitable habitat for beef cattle (*Bos spp.*), bobwhite quail (*Colinus virginianus*), and a combination of the two. This information was necessary for the NRCS to begin designing and implementing policies and management plans for improving and maintaining beef cattle and bobwhite quail habitat within the watershed. These goals were to be achieved by educating landowners about range and wildlife management through workshops and on-site assistance, developing conservation plans for all land in the watershed, and developing grazing plans on at least one-half of the rangeland.

Because the models provided by the NRCS were untested, I chose to obtain independent assessments from subject matter experts. Experts were asked to classify habitat suitability potentials for all Sergeant Major Watershed ecological sites. Utilization of all ecological sites was assumed to conform to UDSA soil survey recommendations for beef cattle (USDA 1982). The USDA recommends moderate utilization by beef cattle. Expert classification of Sergeant Major habitat was compared to model output. The expert classifications did not reflect model classifications. For example, experts classified Red Shale ecological sites poor habitat for both cattle and bobwhite quail. The models, with actual watershed observations, produced good and excellent habitat classifications for both beef cattle and bobwhite quail on Red Shale ecological sites. Because of this discrepancy and several others between expert classifications and model output, I examined possible sources for these discrepancies.

First, NRCS model output from Sergeant Major was examined for sensitivity to bias. The actual watershed output was examined for the effect that human bias in the measurement of component suitability levels might have on model output. That is, the possibility of human observers inducing enough bias (consistent error) into component measurement to force the NRCS model to overestimate the classifications in the Sergeant Major Watershed. This examination showed that the good and excellent classifications were resistant to change when negative (underestimation of component suitability level) or positive (overestimation of component suitability level) bias was introduced. This resistance to change was thought to be the result of the model's inherent inability to produce poor and fair classifications. Next, the actual Sergeant Major Watershed beef cattle and bobwhite quail output was examined by stepwise linear regression. Sample site average scores were the dependent variables of the regression, and all model component scores were the independent variables. This examination was performed so that the impact of individual model components on model output might be better understood.

The last step in the evaluation of model output on the Sergeant Major watershed was to examine the models themselves. Computer programs were written to produce all possible combinations of scores from the two NRCS models. These combinations and resulting classifications were examined in light of habitat requirements for beef cattle and bobwhite quail. Numerous unreasonable classifications were found indicating problems with the models themselves. The models themselves were then examined for bias. Bias was then induced into the components of all combinations to simulate estimator bias in component measurement. All output was examined to quantify how many of the possible combinations changed class when bias was introduced into the model. This examination determined each classification's sensitivity to human error in habitat suitability level measurement.

CHAPTER II

EVALUATION OF BEEF CATTLE AND BOBWHITE QUAIL HABITAT ON THE SERGEANT MAJOR WATERSHED AT CHEYENNE, OKLAHOMA

Introduction

This chapter evaluates beef cattle and bobwhite quail habitat on the Sergeant Major Watershed located near Cheyenne, Oklahoma. Two untested NRCS models were used to classify habitats. The NRCS beef cattle model measured desirable forage, forage utilization, brush canopy, and water. The NRCS bobwhite quail model measured nesting cover, bunchgrass use, escape cover, screening cover, openness, food, bare ground, and edge.

Because the NRCS models had only been used as teaching devices, and were untested in actual field habitat suitability classification, expert classification of the Sergeant Major Watershed habitat was compared to model output. There were discrepancies between expert classifications of habitat and model classifications of habitat, so additional tests were initiated. The objectives of this study were to: 1) examine the distribution of the number of sites in each classification, 2) compare the NRCS models output to expert classification of habitat suitability within the watershed, 3) examine the sensitivity of the NRCS model output to bias, and 4) examine the contribution of each input component to the model output by performing stepwise regression on model output from Sergeant Major.

Study site

The Sergeant Major Watershed encompasses approximately 19,650 acres, and is about 8.5 miles North/South by 4.5 miles East/West. The watershed is located in Roger Mills County, Oklahoma (35° 37' N, -99° 39' W). Rainfall is approximately 26 inches annually with 16 inches occurring from March through August (USDA 1982). Most of the watershed is located south/southwest of the city of Cheyenne, Oklahoma. The city itself is located within the watershed in the extreme northeast corner. There are approximately 27 soil types (Figure 1) and 10 ecological sites (Figure 2) in the Sergeant Major watershed. Ecological sites within the watershed are of four general groups, sandy, loamy, red shale, and bottomlands. A 1988 Map Information Assembly and Display System (MIADS) digital soil map was used to determine the spatial location of soil types. Soil types with similar soil and vegetation characteristics were combined to delineate ecological sites. Ecological sites, soil types, vegetation species composition, and forage end of season standing crop (ESSC) potential are described herein to give insight into ecological site potential for beef cattle habitat, bobwhite quail habitat, or both.

Ecological sites

Sandy sites include the Deep Sand, Deep Sand Savannah, Sandy Prairie, and Eroded Sandy Land ecological sites. These sites are found on approximately 26% of the watershed. The Deep Sand ecological site consists of deep loamy fine sands on undulating to hilly uplands. Approximately 18% of the south part of the watershed is Deep Sand Savannah ecological sites. These sites consist of deep, sandy soils on uplands. Nobscot and Brownfield fine sands, 0 to 4% slopes, Nobscot and Brownfield fine sands, 4 to 8%

slopes, and Nobscot fine sand, 0 to 4% slopes are the soils in the Deep Sand Savannah. Tall and midgrasses make up the climax grass vegetation. Dominant grasses include little bluestem (*Schizachyrium scoparium* Nash), indiangrass (*Sorghastrum nutans* Nash), switchgrass (*Panicum virgatum* L.), sand bluestem (*Andropogon gerardii* Hack.), sand lovegrass (*Eragrostis trichodes* Nutt.), and sideoats grama (*Bouteloua curtipendula* Michx.). Desirable beef cattle and bobwhite quail habitat forbs and legumes present are leadplant (*Amphora canescens* (Nutt.) Pursh), roundhead lespedeza (*Lespedeza capitata*), Stuves lespedeza (*Lespedeza stuevei* Nutt.), fringeleaf ruellia (*Ruellia hunilis* Nutt.), western ragweed (*Ambrosia psilostachya* DC.), erect dayflower (*Commelina erecta* L.) and sundrop (*Calylophus berlandieri* Spach). The dominant shrubs are shinnery oak (*Quercus HavardiiII* Rydb.), a deciduous, clonal species, with lesser amounts of sand sagebrush (*Artemisia filifolia* Torr.), Oklahoma plum (*Prunus gracilis* Engelm.), and skunkbrush (*Rhus aromatica* Ait.). Undesireable grasses on this site are mat sandbur (*Cenchrus spinifex* Cav.), common witchgrass (*P. capillare*), and gummy lovegrass (*E. curtipedicellata*). In excellent condition and with adequate rainfall, this site can produce 3500 lbs. ESSC. In years of inadequate rainfall, this site can produce 1700 lbs. ESSC (USDA 1982).

The Sandy Prairie ecological sites in the watershed are composed of Dill-Quinlan Fine Sandy Loam, Miles Fine Sandy Loam, Miles-Nobscot Complex, Miles-Springer Complex, Pratt Loamy Fine Sand, and Reinach Fine Sandy Loam soils. These sites are moderately deep and deep, permeable soils on gently rolling uplands. The climax vegetation is tall and midgrasses. Sand bluestem, little bluestem, and blue grama are the predominant grasses. Common woody plants are sand sagebrush, shinnery oak, skunkbrush, and Oklahoma plum. If this site is in excellent condition and there is adequate rainfall, it can have 3300 lbs. ESSC. It is estimated that the site will have approximately 1500 lbs. ESSC in inadequate rainfall periods.

The Eroded Sandy Land ecological site is made up of Eroded Sandy Land, and Nobscot and Brownfield soils, eroded. These soils were formerly cultivated, and have experienced erosion from wind and water. Productivity is low. If this ecological site was allowed to revegetate, without artificial seeding, silver bluestem (*A. saccharoides*), sand dropseed (*Sporobolus cryptandrus*), and other undesirable beef cattle habitat grasses and unpalatable forbs would become the dominant species. If this site were in excellent condition, with adequate rainfall, it would have approximately 2000 lbs. ESSC. In inadequate rainfall periods, the site has the potential to have 1200 lbs. ESSC.

The second general classification, the loamy range group, is Loamy Prairie and Shallow Prairie, and Eroded Prairie ecological sites. Loamy Prairie ecological sites occur on gently sloping to steep uplands. There are hilly areas and ravines in this ecological site. The soils in this site are Carey Silt Loam, Mansker Loam, Quinlan Woodward Loam, St. Paul Silt Loam, Woodward Fine Sandy Loam, and Woodward Quinlan Loam. The vegetation consists of tall, mid, and shortgrasses. The predominant tallgrass is sand bluestem. The dominant midgrasses are little bluestem and side-oats grama. Blue grama (*Bouteloua gracilis*) is the principal shortgrass. In areas that are heavily grazed, blue grama and buffalograss (*Buchloe dactyloides*) increase and become dominant. If this site is in excellent condition and rainfall is adequate, forage ESSC potential is about 3000 lbs. In times of reduced rainfall, forage ESSC will average 1700 lbs.

The Shallow Prairie ecological site is mostly loamy, steep soils with some deep ravines. The soils of this ecological site are predominantly Quinlan Woodward Loams. The climax vegetation is tall and midgrasses. The dominant grasses are little bluestem, side-oats grama, and blue grama. Buffalograss is also present on this ecological site. If rainfall is adequate and the site is in excellent condition, forage ESSC can be 2000 lbs. If rainfall is reduced, ESSC decreases to approximately 1000 lbs.

Eroded Prairie ecological sites are steep, loamy soils that were formerly cultivated. These sites are severely eroded and ESSC has been greatly reduced. The soils within this site are Mansker complex, severely eroded, and Quinlan soils, severely eroded. The ESSC on this site, in excellent condition, would be 1800 lbs. in years of adequate rainfall, and 1000 lbs. in years of inadequate rainfall.

Red Shale ecological sites are the third group of the watershed. Soils of this site are Rough Broken Land and Vernon-Quinlan complex. Shale red beds and red shale hills underlie these soils and canyons are common throughout the watershed. Climax vegetation is mid and shortgrasses. Side-oats grama, blue grama, and buffalograss are dominant. Moisture holding capacity is low and runoff is high. Fragrant mimosa (*Mimosa borealis*) is common on these sites. Hairy tridens (*Triodia albenscens*) is dominant in overgrazed areas. If this site were in excellent condition, the estimated ESSC would be 1400 lbs. in years of adequate rainfall and 700 lbs. in years of inadequate rainfall.

The fourth group, the bottomland areas, is the Loamy Bottom Land, Sandy Bottom Land, and Sub-irrigated ecological sites. Loamy Bottom Land ecological sites are deep, loamy soils that are on bottomlands but are not frequently flooded. These are the most productive sites in the watershed. Soils of this ecological site are Norwood Silt

Loam, Spur and Port Silt Loam, Yahola Fine Sandy Loam, and Zavala Fine Sandy Loam. The dominant grasses are sand bluestem, switchgrass, indiangrass, and western wheatgrass (*Elymus smithii*). Woody plants include American elm (*Ulmus americana*), hackberry (*Celtis occidentalis*), and cottonwood (*Populus spp.*). As the climax grasses decrease, woody plants will increase over time and dominate the site. If this site were in excellent condition, the estimated ESSC would be 4000 lbs. in years of adequate rainfall and 2500 lbs. in years of inadequate rainfall.

Sandy Bottom Land ecological sites are comprised of Lincoln soils. These soils are deep, nearly level, and subject to frequent flooding. The primary climax plants are switchgrass, sand bluestem, little bluestem, and indiangrass. Woody species present are tamarisk (*Tamarix spp.*) sand sagebrush, skunkbrush, cottonwood, and willow (*Salix spp.*). If this site were in excellent condition, the estimated ESSC would be 4000 lbs. in years of adequate rainfall and 3000 lbs. in years of inadequate rainfall.

Sub-irrigated ecological sites are only Sweetwater soils. This ecological site comprises a very small area in the Cimarron river bottom on the north end of the watershed. These are sandy and loamy soils along creeks and waterways. They are generally moist at the surface and seldom dry below a depth of about three feet. Forage end of season standing crop is high. Tallgrasses are the climax vegetation. The principal grasses are switchgrass, sand bluestem, prairie cordgrass (*Spartina pectinata*), and eastern gamagrass (*Tripsacum dactyloides*). This site is usually fenced in with other sites, and is commonly overgrazed and in fair to poor condition. If this site were in excellent condition, the estimated ESSC would be 6000 lbs. in years of adequate rainfall and 4000 lbs. in years of inadequate rainfall.

Methods

Sample Sites

One hundred ninety-five random sample sites were selected using Arc/View (ESRI Version 3.2). Parameters were set within the Arc/View program to ensure that sample points would be at least 1,320 feet apart and 660 feet from any outside boundary of the watershed. Cultivated areas, oil well sites, cemeteries, municipal areas, Conservation Reserve Program (CRP) lands, introduced pastures, and all other non-rangeland areas were deleted as non-rangeland polygons from the Arc/View program before sample points were determined. Only rangeland was considered in this study. Sample points were assigned unique ID numbers, and spatially identified with latitude and longitude readings to six decimal places, affording sub-meter accuracy in location.

A Rockwell Corporation, Precision Lightweight Global Positioning System (PLGR) was used to locate the ESRI Arc/View pre-determined sample sites. The PLGR was coupled to a Personal Data Assistant (PDA) computer. The PLGR GPS unit is not affected by selective availability (i.e. satellite signal scrambling), and receives accurate positions in real time. The latitude and longitude of all sample sites were pre-programmed into the PLGR GPS unit. The PLGR was then programmed to navigate to the latitude/longitude of the sample sites.

Sampling

We navigated in close proximity to the pre-determined latitude/longitude of a sample site. At the sample site, the PLGR was allowed ample time to gather satellite data and triangulate location. At least four satellites were locked on for every location reading. Sample site location by the PLGR was estimated to be within three to six feet of the ESRI Arc/View pre-determined site. The size of the site to be sampled was not specified in the models. Sample sites were determined to be a circle with a radius of 300 feet and containing approximately 6.5 acres. All observations were made relative to what was present on site. Amounts of biomass present, end of season standing crop, and spatial distribution are not considered by the NRCS model. Juxtaposition to other sites was not considered.

To increase consistency of component suitability level estimations in this study, the habitat suitability levels were estimated and recorded by two rangeland specialists working together at the same sample site, at the same time. This was done to reduce subjective human error inherent to individual biases. Component scores were estimated by examining the entire sample area. The number of samples taken within each ecological site is reported in Table 1.

Expert classification of habitat

Expert rankings were based upon suitability of use for beef cattle and northern bobwhites of vegetation as described in the same NRCS ecological site guidelines used to classify the sample sites (USDA 1982). These classifications were made assuming moderate forage utilization by beef cattle as recommended in the USDA soil survey manual. The experts were familiar with the Sergeant Major Watershed area. They predicted the potential beef cattle and bobwhite quail habitat classifications for each ecological site using the same suitability classes used in the models (i.e. poor, fair, good, and excellent). The expert classifications are listed in Table 2.

Sensitivity to bias

All classifications of sample sites were tested for sensitivity to input bias for both beef cattle and bobwhite quail habitat by changing a single component suitability level score up or down one level. This procedure simulated what would happen to the classifications if we made enough error in our estimation of a component score in the field to raise that component total score one suitability level (i.e. the value 20 for less than 30% nesting cover was given as a score in the quail model when in reality the score should have been 100 for more than 30% nesting cover). The results were analyzed for sensitivity to one-level overestimation or underestimation bias in all components.

Stepwise regression and component correlations

The four NRCS beef cattle model components (Table 3) and eight NRCS bobwhite quail model components (Table 4) were examined using stepwise linear regression. Average scores of the models were the dependent variables, and all components of the particular model were the independent variables. The numerical values used in the model for each component suitability level were used in the regression.

Results and Discussion

The NRCS habitat suitability models included four beef cattle and eight bobwhite quail habitat suitability components. The NRCS beef cattle components and their scoring are outlined in Table 3. The NRCS bobwhite quail model components and their scoring are outlined in Table 4. Each component suitability level for both models was recorded at each sample site. The number of sites with each habitat suitability level of each component is reported in Tables 5 and 6.

Suitability of sites for beef cattle

NRCS beef cattle site classifications were compared to expert classifications and to ecological sites. The NRCS beef cattle model output from Sergeant Major produced no poor, no fair, 47 good, and 148 excellent sites. Experts classified the same sites as 25 poor, 25 fair, 49 good, and 96 excellent beef cattle habitat. Expert classifications of habitat on the Sergeant Major Watershed did not reflect NRCS model output classifications. The NRCS model scores, based on recorded observations were compared to expert classification of habitat (Table 7). This was done to see the range of scores, the means, and the medians that the models produced for the different expert classifications. If the model reflects expert opinion of class, scores should increase as habitat improves. No systematic changes in mean or median values were observed as class changed (i.e. means and medians did not increase with improved class rank). Minimum and maximum scores of all classes were essentially the same, indicating scores cannot distinguish class. Clearly, the model output has little, if any, relation to the classifications of the experts.

NRCS model classifications were examined by ecological site to see if the model classifications differed among ecological sites (Table 8). Individual ecological sites should reflect a distinguishable range of scores because they possess like qualities. If the sites did produce similar scores, then expert classifications for both beef cattle habitat and bobwhite quail habitat should correspond and follow some pattern of output by ecological site. This is the basic premise experts used in their classifications, so it seemed logical that the ecological sites would reflect expert opinion of class. I examined the model output to see if this was the case.

Experts expected Breaks and Shallow Prairie to have similar habitat quality for beef cattle, but quite different habitat quality from Red Shale (Table 2). The NRCS beef cattle model was not able to distinguish between these ecological sites. This indicated that the models could not discern critical changes in component suitability levels, or they were measuring the wrong components to distinguish ecological site. Loamy Bottom, Loamy Prairie, and Sandy Prairie were also considered by experts to be much different from Red Shale (Table 2), but the model fails to distinguish between them (Table 8). Deep Sand Savannah, ranked fair for beef cattle habitat by the experts, had a model mean and median higher than Breaks (good habitat), and Loamy Bottom (excellent habitat). The NRCS model classification output did not distinguish ecological sites.

Suitability of sites for quail

NRCS bobwhite quail model site classifications were compared to expert classifications, and to ecological sites. The NRCS bobwhite quail model output produced no poor, 11 fair, 86 good, and 98 excellent bobwhite quail habitat sites. Experts classified the same 195 sample sites as 25 poor quail sites, 124 fair quail sites, 1 good quail site, and 45 excellent quail sites. These classifications did not reflect the NRCS model classification output.

Shallow Prairie represents 6475 acres or approximately 1/3 of the watershed (USDA 1982). Experts classified these ecological sites only fair quail habitat (Table 2). The NRCS bobwhite quail model rated quail habitat in this area as no poor, 8 fair, 48 good, and 43 excellent. In this study, 25 sites were in Red Shale ecological sites. Experts predicted only poor bobwhite quail habitat on Red Shale sites. The model produced no poor, and only 1 fair bobwhite quail habitat site on Red Shale ecological sites. When compared to expert classification, these findings revealed a likely flaw in the model.

The habitat classification output from the NRCS bobwhite quail model, based on observed watershed scores, were compared to expert classification of habitat by mean and median (Table 9). The areas classified by experts as poor, fair, and excellent have nearly the same mean and median values. There is no consistent change in mean or median as the classification changes. Model output for bobwhite quail habitat was examined by ecological site (Table10). There is no apparent relationship between model mean or median and ecological sites changes. Deep Sand Savannah, Sandy Prairie, and Shallow prairie each contain almost a full range of model output scores. The Shallow Prairie area, which comprised approximately 1/3 of the watershed and was sampled at 99 locations, had the widest range of scores (48 - 99). This examination showed that almost any score is possible in any ecological site.

NRCS beef cattle model sensitivity to bias

I wanted to determine the cause for the discrepancies between expert classifications and model output, so I first examined the model's sensitivity to human error in component suitability level measurement. This study showed model sensitivity to measurement error, and the effect of that error on model output. The sensitivity to bias study performed on the NRCS beef cattle results from Sergeant Major is summarized in Table 11. In this table, one can see the overall model class changes that occur in the model output when a one-suitability level error is made in component measurement. The net change in each class, and the absolute change caused by each component are reported in Table 12. The bias producing the greatest change in the beef habitat classification output is an underestimation of brush canopy. That bias produces an increase in the number of good classifications by 72, while decreasing the excellent class count by 72. The bias producing the least change in model classification output was the overestimation of water, but water was impossible to overestimate because it was within one-half mile of all but one site and was scored 100 at all sites but one.

The NRCS model classified all sample points good or excellent for beef cattle habitat. A negative bias (underestimation) of one level in forage utilization would result in two sites being classified fair. With the exception of these two cases, all sites would be classified as good or excellent even if these biases were present. So, although overestimating or underestimating a single model component by one-suitability level would change the classification of a substantial number of sites (Table 12), nearly all of the sites would remain in the good and excellent categories (Table 11). A bias of one level in any model component cannot change the overall classification by more than one level. In general, overestimating a suitability level results in a higher classification of a site while underestimating usually lowers the classification. This model has an exception in that particular single biases in forage utilization can result in higher and lower overall classifications simultaneously. This is illustrated in Figures 3 and 4.

NRCS bobwhite quail model sensitivity to bias

I wanted to see how the NRCS bobwhite quail model reacted to human error so, I performed the same model output sensitivity to error analysis on the NRCS bobwhite quail model that I did on the beef cattle model. The results of the sensitivity study performed on the bobwhite quail model are contained in Table 13. In this table, one can see the number of sites in each class when a one level error is made in component measurement. The poor classification was not affected by any single level bias in any component. The fair class had 11 sites with no bias and a maximum of 20 sites with bias. Good had 86 sites without bias and a maximum 117 with bias. Excellent had 98 sites without bias and a maximum of 132 with bias. The change in number of sites is shown in Table 14. Overestimating or underestimating nesting cover produced the largest number of changes. Underestimating bare ground and openness were second in importance by producing absolute value changes of 66 and 64 respectively. Overestimating bunchgrass use or food abundance produced the smallest change. Some classifications changed as bias was introduced into the model, and some did not. Poor was least affected by bias, excellent was most affected.

The NRCS bobwhite quail model classified 11 sites fair, and 184 sites good and excellent. A negative bias (underestimation) of one level in all components would result in the number of sites classified as fair increasing from 3 to 9. All other sites would be classified as good or excellent even if these biases were present. Overestimating or underestimating a single suitability level by one level would change the classification of a substantial number of bobwhite quail sites, but nearly all of the sites would still remain in the good and excellent categories. A bias of one suitability level in any category cannot change the overall classification by more than one class. Overestimating any suitability level tends to result in a higher classification for a site. Underestimating a suitability level tends to result in a lower estimate.

How habitat components contribute to classification

I wanted to measure the individual contribution of each component to the total model output, so I examined both models using stepwise linear regression. Brush canopy contributed the most to the beef model (R^2 of 0.691). Utilization added 0.164 to the R^2 of the model, while desirable forage added 0.143. These three components combined produced an R^2 of 0.998, and explained almost all of the variability in the model. Water contributed only 0.002 to the R^2 (Table 15). Water, however, was not a variable in the Sergeant Major watershed because it was within one-half mile of all but one site and received the highest score (100) for all but one sample point.

Edge contributed 0.656 to the R^2 of the quail model. Nesting cover and bare ground combined added 0.246 to the R^2 of the model. These three components contributed 0.902 to the R^2 of the model, and explained 90% of the variability in the model while the 5 remaining components combined added only added 0.098 R^2 to the model and explained only 10% of the variability (Table 16).

Discussion

The NRCS models classify all the sites in Sergeant Major as good or excellent for beef cattle and all but 11 of them good or excellent for bobwhite quail. This may be due to the fact that: 1) the watershed actually contains 100% good and excellent beef cattle habitat, and 94% good and excellent bobwhite quail habitat, 2) the observers introduced enough bias into the observations to raise scores to these levels, or 3) the NRCS beef cattle and bobwhite quail models overestimate habitat suitability.

According to expert classifications, the Sergeant Major Watershed contains ecological sites that are neither good nor excellent habitat for beef cattle or bobwhite quail. Experts rank the Red Shale ecological site poor for both. There were no poor sites for either beef cattle or bobwhite quail in Red Shale sites. There were no fair sites for beef cattle in Red shale sites. These facts cast serious doubt on the possibility that the watershed contains 100% good or excellent cattle habitat and 94% good or excellent bobwhite quail habitat.

Single component bias in any suitability level of any component of the NRCS models does not change the overall general classifications of either model sufficiently to better match expert opinion. This indicates that it is unlikely that human observers introduced enough bias into the observations to overestimate the scores.

The two NRCS model scores and their means and medians could not distinguish habitat classifications or ecological sites. This means that there are weaknesses within the models, and that the models are not structured properly to adequately discern significant changes in component suitability levels.

Neither model measures biomass presence. Without a biomass measurement, a site cannot be qualified for beef cattle or bobwhite quail habitat. For example, one beef cattle animal unit requires 26 pounds of forage per day (USDA 1982). The NRCS beef cattle model does not quantify how much forage is on site; therefore one has no idea as to the ability of a site to sustain an animal unit for any given time. Beef cattle habitat suitability cannot be determined under this scenario. The NRCS quail model has the same problem. One cannot determine, by model components, how much capacity a site has for sustaining quail.

Some observations in both models were relative estimates of the amount of individual components present on site compared to other components on site (e. g. desirable forage as a percentage of all forage present). These types of measurements do not quantify how much of the component is present on-site at a particular time, and therefore no conclusion can be made as to the capacity of the site over time. The mixing of relative measurements with quantity estimates seems to beget problems within the models. It does not seem logical to measure component suitability levels in ways that do not quantify presence or absence of those component suitability levels on site. For example, utilization is measured by key species leaf length. This measure may be irrelevant if there is not enough key species present on site to affect habitat classification (i. e. if a single plant of one key species is on site and measured, the site gets a score for utilization even though one single plant has no impact on the habitat suitability of the site).

Conclusions

After examining the NRCS beef cattle and bobwhite quail model output on the Sergeant Major Watershed, and comparing these outputs to expert opinion, I came to these conclusions.

- The output of both NRCS models did not reflect expert classifications of habitat suitability on the Sergeant Major Watershed. The models, when compared to expert classifications, generally over ranked both beef cattle and bobwhite quail habitat. Experts classified one ecological site, Red Shale, as poor habitat for both beef cattle and bobwhite quail. Both models produced no poor, and several excellent sites in the Red Shale sites. It is possible that the experts under-ranked all ecological sites, however, it is highly unlikely that they under-ranked Red Shale sites by two classes, and caused the discrepancy between their opinion of Red Shale sites and model output.
- The sensitivity to bias analysis examined the impact of observer bias in model input upon model output. This analysis suggested that thuman observers did not introduce enough bias to account for the differences between expert opinion and model output. Although there were many changes in the number of sites when bias was introduced into model inputs, the overall output of the model remained relatively constant in that most of the classifications remained good and excellent. This analysis could not explain why the models did not agree with expert opinion.
- No examination of the Sergeant Major output performed in this study could explain why the models overrated habitat, and did not agree with expert opinion. It was concluded that the NRCS models were seriously flawed.

Table 1.

The ecological site name, the number of samples taken from each ecological site, and the approximate acreage of each ecological site within the Sergeant Major Watershed.

Ecological site	Number of Samples	Acres
Breaks	4	2610
Deep Sand	0	210
Deep Sand Savannah	21	3300
Limey Upland	0	20
Loamy Bottom Land	7	2200
Loamy Prairie	12	1260
Red Shale	25	1230
Sandy Land	3	1140
Sandy Bottom Land	0	30
Sandy Prairie	24	1270
Shallow Prairie	99	6470
Totals	**195**	**19,740**

Table 2.

Expert classification of beef cattle and bobwhite quail classes on the Sergeant Major Watershed using ecological site guides provided by NRCS.

Ecological Site	Expert Classification For Beef Cattle	Expert Classification For Bobwhite Quail
Breaks	Good	Fair
Deep Sand	Fair	Excellent
Deep Sand Savannah	Fair	Excellent
Eroded Sandy Prairie	Fair	Good
Eroded Shallow Prairie	Fair	Fair
Loamy Bottom Land	Good	Fair
Loamy Prairie	Excellent	Fair
Red Shale	Poor	Poor
Sandy Prairie	Fair	Fair
Shallow Prairie	Fair	Fair

Table 3.

Score sheet for NRCS model of habitat suitability for beef cattle.

MODEL COMPONENT	HABITAT SUITABILITY LEVEL	SCORE
Desirable Forage	76 - 100% Desirable	100
	51 - 75% Desirable	75
	26 - 50% Desirable	50
	0 - 25% Desirable	25
Utilization	Light to None	75
	Moderate	100
	Heavy	30
	Severe	0
Brush Canopy	> 30%	30
	< 30%	100
Water	< 1/2 Mile	100
	1/2 - 1 Mile	75
	> Mile	20
AVERAGE[1]		

[1] AVERAGE = Sum of model component scores / 4

Habitat classification from average: 0 - 25 = Poor 26 - 50 = Fair 51 - 75 = Good 76 - 100 = Excellent

Table 4.

Score sheet for NRCS model of habitat suitability for northern bobwhite quail.

MODEL COMPONENT	HABITAT SUITABILITY LEVEL	SCORE
Nesting Cover:	> 30% Bunch Grasses	100
(% grass plant community by area)	< 30% Bunch Grasses	20
Bunchgrass Use:	Light - None	80
(% weight of years growth removed)	Moderate	100
	Heavy	40
	Severe	0
Screening Cover:	> 51%	100
(% area cover at 6 inches)	26 - 50%	70
	0 - 25%	20
Openness:	Open	100
(openness by area below 6 inch height)	Moderate	70
	Rank	0
Escape Cover:	> 10%	100
(woody plants/brush areas greater than	1 – 10%	50
10 ft. in diameter by % of area)		
	None	0
Food Plant Abundance:	> 50%	100
(% of area food producing plants)	26 - 50%	70
	1 - 25%	30
	None	0
Bare Ground:	> 50%	100
(% of surface area clear)	26 - 50%	90
	0 - 25%	10
Edge Index:	Changes > 8 Times	100
(distinct change in vegetative elements)		
	Changes 5 - 8 Times	90
	Changes 2 - 5 Times	50
	No Edges	0
AVERAGE[1]		

[1] Average = Sum of model component scores / 8

Habitatclassification from average: 0 - 25 = Poor 26 - 50 = Fair 51 - 75 = Good 76 - 100 = Excellent

Table 5.

The component description of the NRCS beef cattle model, the habitat suitability levels of each component, and the number of sample sites in each suitability level within the Sergeant Major Watershed.

COMPONENT	HABITAT SUITABILITY LEVEL	NUMBER OF SITES IN HABITAT SUITABILITY LEVEL
Desirable Forage	76 - 100% Desirable	13
	51 - 75% Desirable	134
	26 - 50% Desirable	43
	0 - 25% Desirable	5
Utilization	Light to None	91
	Moderate	97
	Heavy	7
	Severe	0
Brush Canopy	Greater than 30%	76
	Less than 30%	119
Water	Less than 1/2 Mile	194
	1/2 - 1 Mile	1
	More than Mile	0

Table 6.

The component description of the NRCS bobwhite quail model, the habitat suitability levels of each component; and the number of sample sites in each suitability level within the Sergeant Major Watershed.

MODEL COMPONENT	HABITAT SUITABILITY LEVEL	NUMBER OF SITES IN HABITAT SUITABILITY LEVEL
Nesting Cover:	More than 30% Bunch Grasses	105
(% grass plant community by area)	Less than 30% Bunch Grasses	90
Bunchgrass Use:	Light - None	101
(% weight of years growth removed)	Moderate	87
	Heavy	7
	Severe	0
Screening Cover:	Greater than 51%	131
(% area cover at 6 inches)	26 - 50%	58
	0 - 25%	6
Openness:	Open	46
(openness by area below 6 inch height)	Moderate	146
	Rank	3
Escape Cover:	More than 10%	87
(woody plants/brush > 10 ft. diameter by % of area)	1 – 10%	73
	None	35
Food Plant Abundance:	Greater than 50%	154
(% of area food producing plants)	26 - 50%	38
	1 - 25%	3
	None	0
Bare Ground:	Greater than 50%	44
(% of surface area clear)	26 - 50%	88
	0 - 25%	63
Edge Index:	Changes more than 8 Times	61
(distinct change in vegetative elements)	Changes 5 - 8 Times	33
	Changes 2 - 5 Times	67
	No Edges	34

Table 7.

Summary statistics for NRCS beef cattle model output for sites within areas classified as poor, fair, good, and excellent by experts.

	Expert Classification By Ecological Site			
Beef Model	Poor[1]	Fair	Good	Excellent
Mean	82.95	77.15	82.67	83.47
Median	87.50	76.25	87.50	84.37
Minimum	70.00	57.50	57.50	58.75
Maximum	93.75	100.00	100.00	100.00
Range	23.75	42.50	42.50	41.25
Standard deviation	7.73	10.64	9.54	11.61
Number of sites	25	25	127	18

[1] NRCS model scores for poor are 0-25, fair 26-50, good 51-75, and excellent 76-100.

Table 8.

Summary statistics for NRCS beef cattle model output for ecological sites in Sergeant Major Watershed.

	Ecological Sites						
	Breaks	Deep Sand Savannah	Loamy Bottom	Loamy Prairie	Red Shale	Sandy Prairie	Shallow Prairie
Expert Classification[1]	Good	Fair	Excellent	Excellent	Poor	Excellent	Good
Mean	75.62	76.55	74.29	87.71	82.95	78.47	84.13
Median	75.62	76.25	70.00	87.50	87.50	81.25	87.50
Minimum	70.00	57.50	58.75	76.25	70.00	57.50	70.00
Maximum	81.25	100.00	93.75	100.00	93.75	93.75	100.00
Range	11.25	42.50	35.00	23.75	23.75	36.25	30.00
Std. Deviation	6.50	10.87	12.03	8.53	7.73	9.80	9.11
Number of Samples	4	21	7	12	25	27	99

[1] NRCS model scores for poor are 0-25, fair 26-50, good 51-75, and excellent 76-100.

Table 9.

Summary statistics for NRCS bobwhite quail model output for sites within areas classified as poor, fair, good, and excellent by experts.

	Expert Classification By Ecological Site			
Quail model	Poor[1]	Fair	Good	Excellent
Mean	76.55	74.97	91.25	74.52
Median	75.00	76.25	91.25	71.25
Minimum	50.00	47.50	91.25	46.25
Maximum	92.50	98.750	91.25	96.25
Range	42.50	51.25	N/A	50.00
Standard Deviation	11.31	13.11	N/A	15.63
Number of Samples	25	148	1	21

[1] NRCS model scores for poor are 0-25, fair 26-50, good 51-75, and excellent 76-100.

Table 10.

Summary statistics for NRCS bobwhite quail model output for ecological sites in Sergeant Major Watershed.

	Ecological Sites						
	Breaks	Deep Sand Savannah	Loamy Bottom	Loamy Prairie	Red Shale	Sandy Prairie	Shallow Prairie
Expert Classification[1]	Fair	Excellent	Fair	Fair	Poor	Excellent	Fair
Mean	60.63	74.52	78.21	74.27	76.55	74.12	75.81
Median	58.75	71.25	85.00	75.63	75.00	76.25	77.50
Minimum	50.00	46.00	61.00	56.00	50.00	48.00	48.00
Maximum	75.00	96.000	93.00	91.00	93.00	93.00	99.00
Range	25	50.00	31.00	35.00	43	45.00	51.00
Standard Deviation	10.43	15.63	14.25	12.48	11.31	13.11	13.09
Number of Samples	4	21	7	12	25	27	99

[1] NRCS model scores for poor are 0-25, fair 26-50, good 51-75, and excellent 76-100.

Table 11.

Sensitivity to bias[1] showing the number of sites in each habitat classification category as single level negative and positive bias is introduced into the NRCS beef cattle habitat suitability model.

Bias	Component	Poor	Fair	Good	Excellent
Negative Bias	Forage	0	0	94	101
	Utilization	0	2	68	125
	Brush Canopy	0	0	119	76
	Water	0	0	95	100
No Bias		0	0	47	148
Positive Bias	Forage	0	0	8	187
	Utilization	0	0	74	121
	Brush Canopy	0	0	4	191
	Water	0	0	47	148

[1] Bias is consistent error in component level measurement.
Positive (overestimation) and negative (underestimation) biases were introduced into the model component levels to simulate observer bias in field measurement. The change in model output by class was observed as a change in number in the respective classes.

Table 12.

Changes in number of sites in each habitat classification due to a single-level component bias in the NRCS beef cattle habitat suitability model. Absolute change is the sum of the absolute values of changes for a particular suitability parameter.

Bias	Component	Poor Change	Fair Change	Good Change	Excellent Change	Absolute Change
Negative Bias	Forage	0	0	47	-47	94
	Utilization	0	2	21	-23	46
	Brush Canopy	0	0	72	-72	144
	Water	0	0	48	-48	96
Positive Bias	Forage	0	0	-39	39	78
	Utilization	0	0	27	-27	54
	Brush Canopy	0	0	-43	43	86
	Water	0	0	0	0	0

Table 13.

Sensitivity to bias[1] showing the number of sites in each habitat classification category as single level negative and positive biases introduced into the NRCS bobwhite quail habitat suitability model.

Bias	Component	Poor	Fair	Good	Excellent
Negative Bias	Nesting	0	14	117	64
	Bunchgrass	0	14	90	91
	Screening	0	20	95	80
	Openness	0	20	109	66
	Escape	0	14	110	71
	Food	0	20	93	82
	Bare Ground	0	14	116	65
	Edge	0	15	103	77
No Bias		0	11	86	98
Positive Bias	Nesting	0	0	63	132
	Bunchgrass	0	11	87	97
	Screening	0	11	79	105
	Openness	0	1	81	113
	Escape	0	0	68	127
	Food	0	11	84	100
	Bare Ground	0	0	68	127
	Edge	0	0	76	119

[1] Bias is consistent error in component level measurement.
Positive (overestimation) and negative (underestimation) biases were introduced into the model component levels to simulate observer bias in field measurement. The change in model output by class was observed as a change in number in the respective classes.

Table 14.

Changes in number of sites in each habitat classification due to a single-level component bias in the NRCS bobwhite quail habitat suitability model. Absolute change is the sum of the absolute values of changes for a particular suitability parameter.

Bias	**Component**	**Poor Change**	**Fair Change**	**Good Change**	**Excellent Change**	**Absolute Change**
Negative Bias	Nesting	0	3	31	-34	68
	Bunchgrass	0	3	4	-7	14
	Screening	0	9	9	-18	36
	Openness	0	9	23	-32	64
	Escape Cover	0	3	24	-27	54
	Food	0	9	7	-16	32
	Bare Ground	0	3	30	-33	66
	Edge	0	4	17	-21	42
Positive Bias	Nesting	0	-11	-23	34	68
	Bunchgrass	0	0	1	-1	2
	Screening	0	0	-7	7	14
	Openness	0	-10	-5	15	30
	Escape Cover	0	-11	-18	29	58
	Food	0	0	-2	2	4
	Bare Ground	0	-11	-18	29	58
	Edge	0	-11	-10	21	42

Table 15.

Stepwise regression of NRCS beef cattle model showing R^2 and R^2 change as components are added to the model.

Model	R^2	R^2 Change
Brush Canopy	0.691	0.691
Brush Canopy, Utilization	0.855	0.164
Brush Canopy, Utilization, Desirable Forage	0.998	0.143
Brush Canopy, Utilization, Desirable Forage, Water	1.000	0.002

Table 16.

Stepwise regression of NRCS bobwhite quail model showing R^2 and R^2 change as components are added to the model.

Model Variables	R^2	R^2 Change
Edge	0.656	0.656
Edge, Nesting Cover	0.798	0.142
Edge, Nesting Cover, Bare Ground	0.902	0.104
Edge, Nesting Cover, Bare Ground, Escape Cover	0.934	0.033
Edge, Nesting Cover, Bare Ground, Escape Cover, Screening Cover	0.956	0.021
Edge, Nesting Cover, Bare Ground, Escape Cover, Screening Cover, Bunchgrass	0.969	0.013
Edge, Nesting Cover, Bare Ground, Escape Cover, Screening Cover, Bunchgrass, Openness	0.984	0.015
Edge, Nesting Cover, Bare Ground, Escape Cover, Screening Cover, Bunchgrass, Openness, Food	1.000	0.016

Figure 1.

Sergeant Major Watershed soil types.

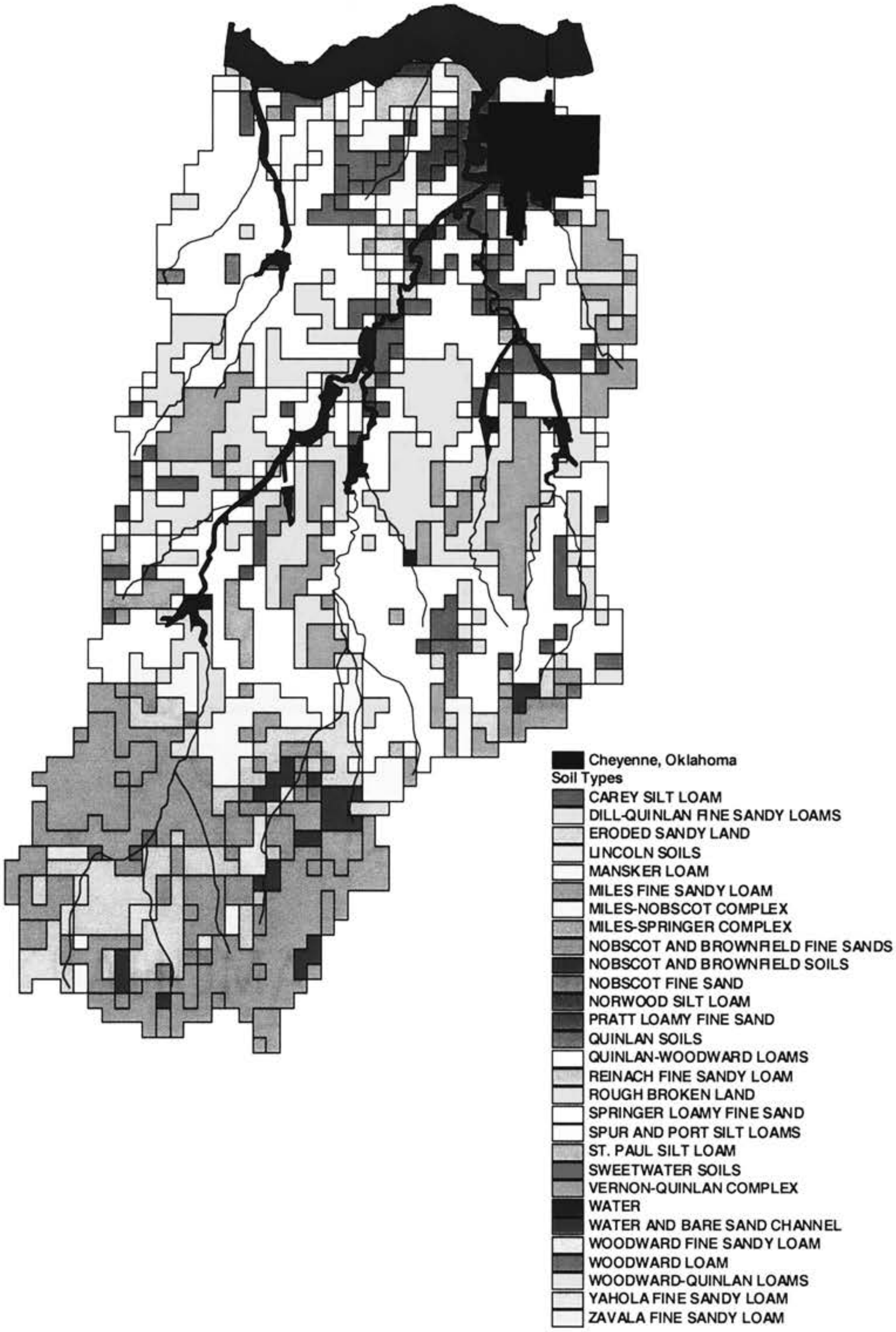


Figure 2.

Sergeant Major Watershed ecological sites.

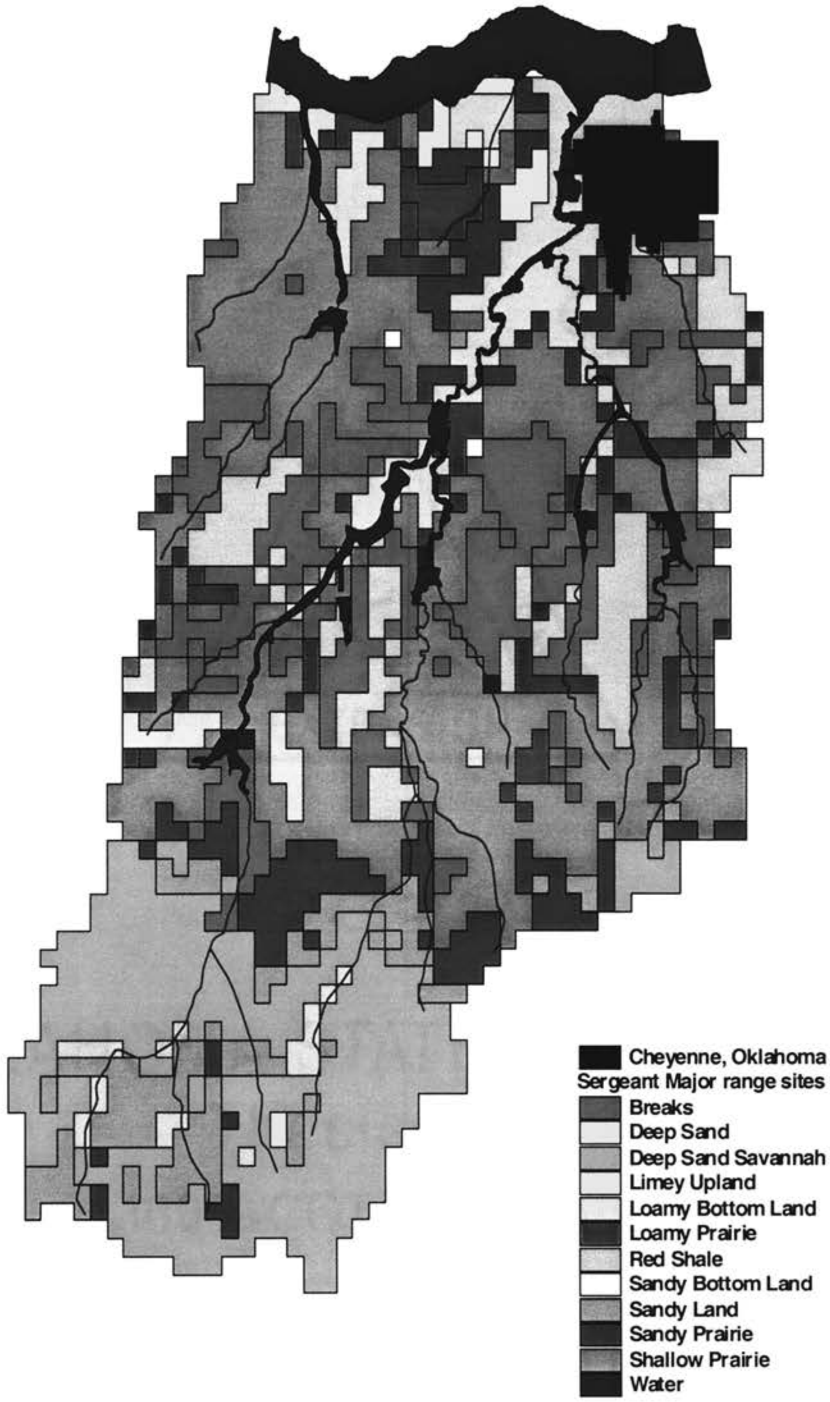


Figure 3.

Class change when negative bias (underestimation) introduced into utilization component.

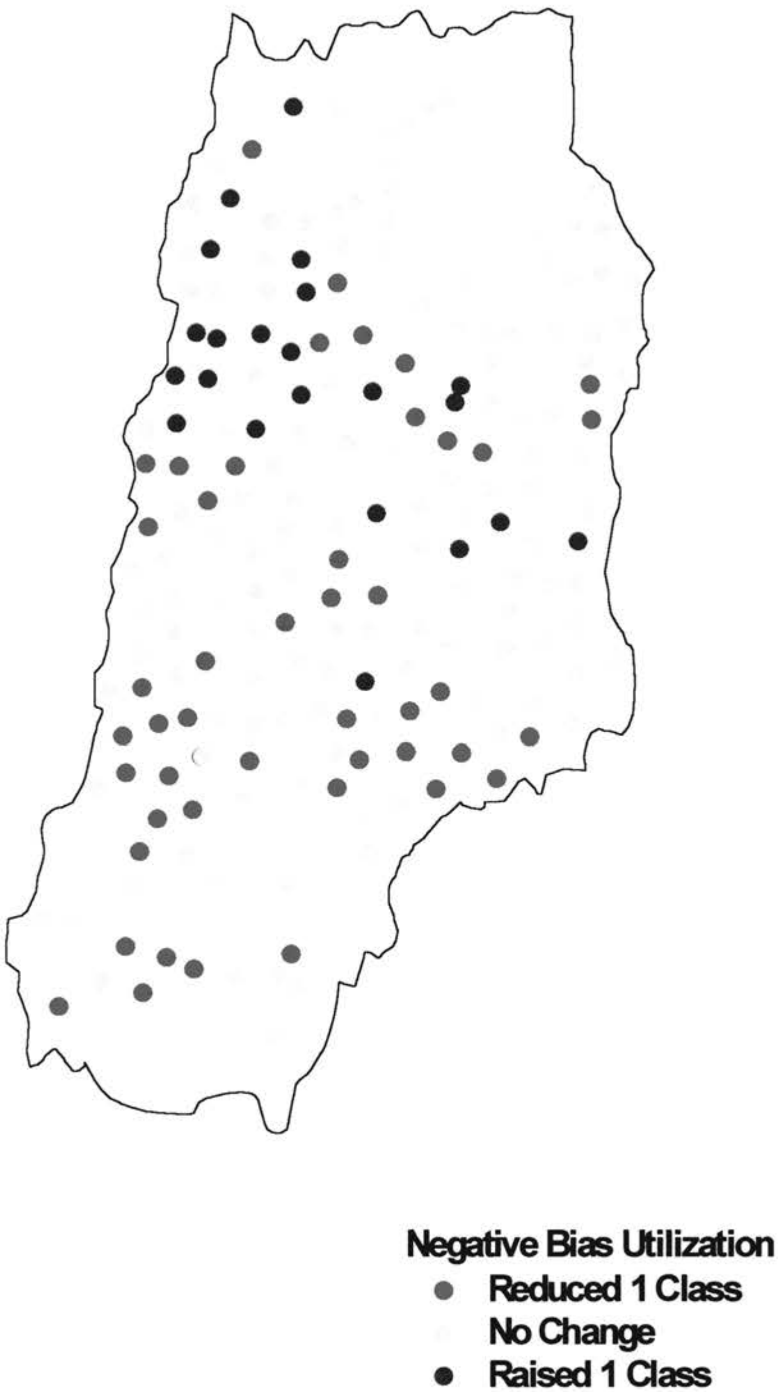
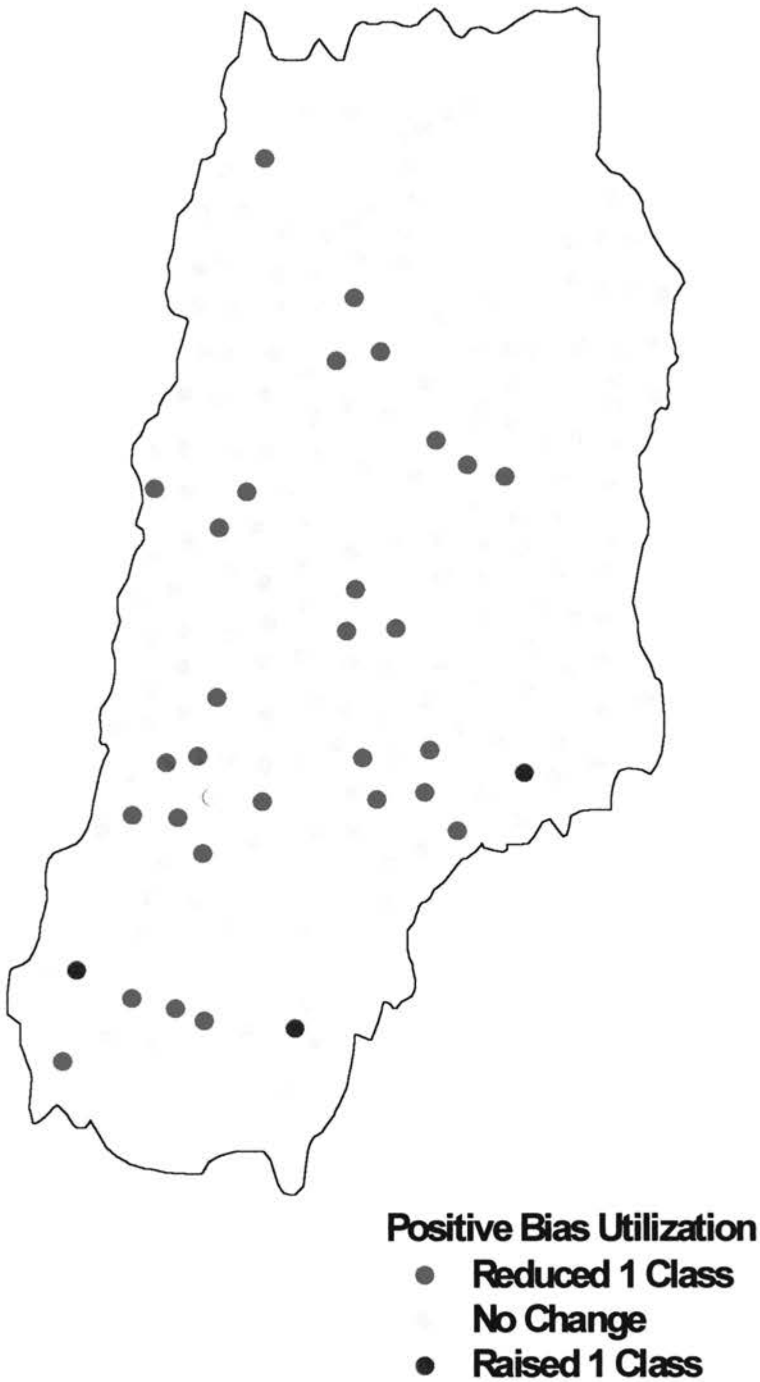


Figure 4.

Class change when positive bias (overestimation) introduced into utilization component.



CHAPTER III

EVALUATION OF THE NRCS BEEF CATTLE MODEL

Introduction

The examination of beef cattle habitat in the Sergeant Major Watershed produced anomalies in the results (Chapter II). These anomalies suggested a need to further examine the NRCS beef cattle model. It is important to note that the model had only been used as a teaching device and had never been used to evaluate watershed beef cattle habitat. There is no literature reporting past performances of the model.

This chapter evaluates the conceptual logic, scoring, sensitivity to bias, and overall reasonableness of the NRCS beef cattle habitat model. The model was evaluated by examining all possible combinations of scores, output sensitivity to input bias, and reasonableness of inherent model statements. Introducing bias to component input of all possibilities of the model examined how human error in field observations might affect output of the model. The smaller the absolute change for the poor, fair, good, and excellent classes for a particular component when bias was introduced, the less influence measurement error in that component has on total model output.

Model components

The beef cattle model was created by the USDA/NRCS, and was designed to educate high school students in range management. The model was, and still is, used at annual range management youth camps held in Stillwater, Oklahoma. The model designers had the following five objectives: 1) the model should be easily used by high school aged students, 2) the model can be used after six hours of instruction, 3) the model can be used to demonstrate geographic information system and global positioning system technology at the introductory level, 4) the model should not be too scientifically complex for novice users, and 5) a 200 acre field survey could be completed in two hours (personal communication Mark Moseley, 2000).

Comparison of models

Various personnel within the NRCS developed the beef cattle model. They primarily relied on three references, and their experience and expertise in range management to construct the beef model (Moseley 2000). The three publications were: "Grazing Management An Ecological Perspective" (Heitschmidt and Stuth 1996), "Grazing Lands Applications" (1996), and the NRCS "National Range and Pasture Handbook" (USDA NRCS 1997).

The NRCS model was patterned after the model, "Judging Rangeland for Livestock and Wildlife Values" (JRLWV) (Bidwell and Moseley 1996). The JRLWV model has been used at the National Range Judging Contest since 1995. Although patterned after the JRLWV model, major changes were made in the NRCS model for various reasons. The reason for changing the model was to simplify it for novice users (personal communication Mark Moseley, 2000). To gain a better understanding of the NRCS model and its development, a comparison between it and the parent model, the JRWLV, was made. The JRLWV was developed approximately 3 or 4 years before the NRCS model. In the NRCS model, some JRLWV components were dropped, the suitability level scoring was revised, and calculation and interpretation of final score was changed.

The JRLWV model contains seven components: Forage Condition, Forage Diversity, Forage Utilization, Forage Accessibility, Grazing Restraint, Water, and Site Integrity (Table 17). The NRCS beef model reduced the JRLWV model from seven to four components, and changed the names to Forage (Forage Condition), Utilization (Forage Utilization), Brush Canopy (Grazing Restraint), and Water (Moseley personal communication).

Desirable Forage: Desirable forage refers to food producing plants that are preferred by cattle through grazing experience and/or nutritional status (Huston and Pinchak 1991). A beef cattle diet consists of grasses, forbs, legumes, woody-browse, and mast (Bidwell and Moseley 1995). Estimating the percent desirable food plants present and available to cattle in a defined area determines desirable forage. It should be noted that desirable forage is a relative percentage measurement of desirable forage to all other forage available on-site and it is not a quantitative or measurement. This measurement in no way indicates how much desirable forage is available by weight on site. Desirable forage has four scoring levels (Table 17).

Utilization: Utilization is the amount of leaf area removed by grazing or other means. Utilization is determined by examining the length of the leaves of key utilization plants (Cook and Stubendieck 1986). These key plants are listed in USDA (1982) ecological site guides. Utilization has four levels for scoring.

Brush Canopy: Brush canopy is the percent, by area, of brush or low woody canopy cover on the site. This component was determined by an estimate of brush canopy cover area within a radius of 300 feet from the center point of the site. This component is scored at two levels.

Water is the availability of water to a grazing site. Water is scored with decreasing values as distance from the water source to the grazing site increases. This component has three levels of scoring.

The NRCS beef cattle model was designed after the JRLWV model. In the JRLWV model, the scoring is based on a 40 point scoring system whereas the NRCS model is based on a 100 point scoring system. The 100-point scoring system was introduced into the NRCS model because the NRCS model builder thought it easier for students and other novice users to relate to a 100-point system than to a 40-point system (personal communication Mark Moseley, 2000). Table 17 shows a comparison of the two models. To facilitate the comparison, JRLWV model scores have been converted to a basis of 100 points in the table. Most of the scoring of the NRCS model levels differs from the JRLWV model.

The JRLWV and NRCS models are similar in Forage scoring, with both forage scoring systems using discrete quartile scoring, and no zero score for either model. Forage Utilization is scored differently in the two models. The NRCS rates heavy utilization 20 points lower comparatively, and has a zero value for severe utilization instead of 25. The JRLWV model does not have a zero value for utilization. Heavy utilization reduces beef habitat classification in the NRCS model more than in the JRLWV model. A score of 100 implied proper moderate use. A score of 75 implied no use, slight depression in vigor, and a stagnant stable trend. A score of 30 implied 50 – 80% utilization of desirable forage, root growth decline, and a downward range trend. A score of zero indicated severe plant damage, root growth stoppage, and a rapid downward range trend (personal communication Mark Moseley, 2000). Brush canopy in the NRCS model is scored 100 and 30. This suggests that once brush canopy reaches 30% on a site, accessibility to forage by beef cattle is the same for 31% brush canopy as it is for 100% brush canopy. The JRLWV model recognizes more percentage breaks in brush canopy. There is not a zero score in either model indicating that accessibility to forage will always be present to some extent on all ecological sites. Water is scored 100, 87.5, 75, 50, 37.5, 25, and 0 in the JRLWV model. The JRLWV model sets two miles as the maximum distance to water. Distances to water greater than two miles are scored zero. Water in the NRCS model is scored 100, 75, and 20. The score of 20 is given to all distances over one mile with no distance limit. There is no water value of zero in the NRCS model.

Model calculations

In the NRCS beef cattle model, the scores of the four components are added together and divided by four for the average (Table 17). This average score is then converted to a qualitative description of poor, fair, good, and excellent. The JRLWV model is scored by adding the lowest suitability level scores of three major components together and dividing by three (Table 18). This gives the average of the lowest scores or limiting factors. Because the JRLWV model uses the lowest suitability scores of a component, its calculations analyze the limiting factors of a site. In contrast to the JRLWV, the NRCS model simply adds all scores of components together and divides by the number of components in the model. Another major difference between the two models is that the NRCS model dropped three of the components contained in the

JRLWV model. Limiting factors are not specified in the NRCS model. Both models fail to consider the critical limiting factors of a site. If at least one suitability level score is different from the rest, the JRLWV and the NRCS model's average score will always be better than the lowest limiting factor score. In other words, the model classification score will almost always be better than the lowest component suitability level score. This raw score can be great enough to raise the classification of a site, when in reality, the site can be no better than the lowest suitability level score. Both models have major weaknesses in calculation and interpretation of final scores, even though calculation and interpretation of the final score are major differences in the two models.

Methods

All possible combinations of scores

In order to examine all the output from the NRCS beef cattle model, a computer program was written to produce all possible combinations of scores from the model. The program generated 96 possible combinations of scores (Tables 19 and 20). The components of these scores were then subjected to positive and negative bias to see what changes in model output occurred. Inherent model statements using the 96 combinations of scores were examined. The discrete numbering system used to arrive at these 96 combinations was also evaluated.

Introduction of bias to input

A computer program was written to determine the magnitude of change in model output as negative and positive input bias was introduced. For example, all 96 forage scores, except those already at the highest or lowest levels (i.e.100 or 0) were raised or lowered one level to simulate an overestimation or underestimation bias of desirable forage by one level in data measurement. This simulated what would happen to the model output if the estimator were biased in estimating the forage component enough to raise or lower that component level one step (e.g. the level 51-75% desirable forage was an overestimation of the site when in reality the level should have been 25-50% desirable forage). The greater the sum of net count change in the four classes for a given component bias, the more effect error in that's component's measurement has on the model. Magnitude of change in the model was analyzed for all possible combinations of negative and positive biases (Table 21), but only single level biases were evaluated (Table 22).

Results and Discussion

Model characteristics

There are 96 possible combinations of suitability levels in the NRCS beef cattle model (Tables 19 and 20). Of these combinations only 2 produced poor classifications, 25 produced fair classifications, 49 produced good classifications, and 20 produced excellent classifications. These combinations of suitability levels from the model produced questionable statements. The following model statements illustrate this.

- If Desirable Forage is greater than or equal to 51%, beef habitat is always at least fair.
- If Utilization is heavy, habitat is always at least fair.
- If Brush Canopy is less than 30%, habitat is always at least fair.
- If Water is less than or equal to1 mile, habitat is always at least fair.
- If Desirable Forage is only 0 – 25%, habitat can still be excellent
- If Utilization is severe, habitat can still be good
- If Brush Canopy is more than 30%, habitat can still be excellent
- If water is more than 1 mile from the area, the habitat can still be excellent

The model fails to recognize the stifling affect that low scores in certain components can have on the habitat. These statements raise serious questions concerning the conceptual logic and the way points are assigned to different categories in the model. They also indicate that the model does not deal adequately with critical factors essential for beef cattle production. If there is no water on the grazing site, the model does not necessarily classify the site as poor. The classification produced by the model can be better than the lowest score of critical factors. For example, it is understood that water must be present within some undetermined maximum distance for beef cattle to survive, but this fact is not scored as such within the model. Also, desirable forage from 0 - 25% is scored 25. A site with no desirable forage present severely limits beef cattle habitat because of palatability problems (Holechek, Pieper, and Herbel. 1998). The model does not consider 0% desirable forage critical to the classification process.

An additional problem in the model is the use of discrete scoring. Discrete scoring systems, where a single value is given for a range of observations, are problematic to many models (Steel and Torre 1960). Discrete scoring systems are used to group scores into categories for ease of recording observations. The beef model uses a 25-point range discrete classification scoring system where a score of 0 is the same as 25, (i. e. the class is poor for both scores and both scores receive a score of 25. This system may not reflect the actual condition of a site. Discrete numbers are used in both the scoring and in the conversion of scores to classifications. One component, brush canopy, has 70 points between levels. In the classification scheme, there is a full class difference between average scores of 50, which is fair, and 51, which is good. In reality, there is a difference between Desirable Forage scores of 51% and 75%, but perhaps, not a significant difference between a class score of 50, which is fair, and 51, which is good.

Impact of bias

Results from introducing single bias in component scoring for all possible combination of scores are contained in Table 22. The results in the table reflect the number of ways the model can produce each class. Table 22 summarizes these results for a single bias. For example: the row with no bias (row 7) has 2 poor, 25 fair, 49 good, and 20 excellent sites. These are the basic classes generated by the model. If water is underestimated by one level, the count possibilities change to 4 poor, 38 fair, 45 good, and 9 excellent (row 2).

The total change in the model output, or the absolute change in model output, caused by a positive or negative bias in component measurement is reported in Table 22. For example, the total model output change in classification caused by a single level underestimation of water is computed by adding the absolute changes of the poor, fair, good, and excellent classifications in the negative bias water row (row 7 subtracted from row 2). The actual calculations are: (4 – 2) + (38 – 25) + (45 – 49) + (20 – 9) or 30 absolute change in model output. Absolute change is important because it identifies what individual component bias produces the most change in classification scores.

Although overestimating or underestimating a single factor by one level would change the classification of a substantial number of sites, good and poor classes remain relatively unchanged when compared to fair and excellent. When a component is underestimated, the majority of the output is classified fair and good. When a component is overestimated, most of the output is good and excellent. The majority of classes, regardless of bias, are always fair or better combinations. A bias of one level in any category cannot change the overall classification by more than one level. In general, overestimating a factor results in a higher classification for the site. Underestimating a factor results in a lower estimate. This is generally what happens in this model's output. The exception to this is the fact that poor remains relatively constant, and only gains 2 when negative bias is introduced to the output (Table 22).

Conclusions

- The NRCS beef cattle model has only two suitability level combinations that can result in a poor classification. Many more possibilities exist for good and excellent classifications.
- The model fails to recognize critical limiting factors.
- The weighting and calculations used in the model results in false or misleading statements.
- Single-level bias input does not substantially increase the possibility of classifying areas as poor.
- Although the potential production of an ecological site is known from ecological site guides (USDA 1982), the temporal status of a particular sample site is unknown. The actual status of a sample site must be determined to accurately classify habitat at that site. The NRCS beef cattle model does not consider end of season standing crop (i. e. it does not measure biomass present on-site). Because of this, sites cannot be qualified as to their ability to sustain a species over time. If the sustainability of a site over time cannot be determined, the classification of that site cannot be determined. This is a major flaw in the model.

This model should not be used for this type of habitat suitability assessment. It will overestimate habitat quality in poor or fair sites. This could lead to erroneous management decisions.

Table 17.

Comparison of Judging Rangeland for Livestock and Wildlife Values Model and NRCS beef cattle model with adjusted scores to 100 points for JRLWV model.

	Judging Model	Adjusted Judging Model %	NRCS Beef Model
Forage			
76 – 100 % Desirable	40	100	100
51 – 75% Desirable	30	75	75
26 – 50% Desirable	20	50	50
0 – 25% Desirable	10	25	25
Forage Diversity			
4 Major Plant Types	40	100	Dropped From Model
3 Major Plant Types	30	75	Dropped From Model
2 Major Plant Types	20	50	Dropped From Model
1 Major Plant Type	10	25	Dropped From Model
Utilization			
Light to None	30	75	75
Moderate	40	100	100
Heavy	20	50	30
Severe	10	25	0

Table 17 continued.

	Judging Model	Adjusted Judging Model %	NRCS Beef Model
Grazing Accessibility			
Slope less than 5%	40	100	Dropped From Model
Slope 5 – 10% Smooth	35	87.5	Dropped From Model
Slope 5 – 10% Rough	25	62.5	Dropped From Model
Slope 11 – 15% Smooth	30	75	Dropped From Model
Slope 11 – 15% Rough	20	50	Dropped From Model
Slope greater than 15% Smooth	15	37.5	Dropped From Model
Slope greater than 15% Rough	10	25	Dropped From Model
Brush Canopy			
Less than 30%	40	100	100
31 – 50%	30	75	30
51 – 80%	20	50	30
Greater than 80%	10	25	30
Water			
Less than ½ Mile	40	100	100
½ - 1 Mile	35	87.5	75
1 – 1 ¼ Mile	30	75	20
1 ¼ - 1 ½ Mile	20	50	20
1 ½ -1 ¾ Mile	15	37.5	20
1 ¾ - 2 Miles	10	25	20
More than 2 Miles	0	0	20
Site Integrity			
Invading Plants Present	0	0	Dropped From Model
Invading Plants Not Present	40	100	Dropped From Model

Table 18.

Calculation of Judging Rangeland Livestock and Wildlife Values Model for beef habitat:

Component	Sub Component	Sub Component Score	Lowest Sub Component Score (Limiting Factor)
Forage Factors			
	Forage End of season standing crop		
	Forage Diversity		
	Forage Utilization		
Distribution factors			
	Grazing Accessibility (slope)		
	Brush Canopy		
	Water		
Site Integrity			
	Invading Plants Present		
	Invading Plants Present		
	TOTAL[1]		
	AVERAGE[2]		

[1] Sum of lowest sub components.

[2] Average =Lowest Forage Factor + Lowest Distribution Factor + Lowest Site Integrity score/ 3

Habitat ratings from average: Excellent 31 – 40 Good 21 – 30 Fair 11 – 20 Poor < 11

Table 19.

All possible scores and classes of NRCS beef cattle model.

Forage	Utilization	Canopy	Water	Score	Class[1]
25	0	30	20	18.75	0
50	0	30	20	25	0
50	30	30	75	46.25	1
100	0	30	20	37.5	1
75	0	30	20	31.25	1
50	0	30	75	38.75	1
50	0	30	100	45	1
50	0	100	20	42.5	1
25	75	30	20	37.5	1
50	30	30	20	32.5	1
50	30	100	20	50	1
50	100	30	20	50	1
75	30	30	20	38.75	1
50	75	30	20	43.75	1
75	0	100	20	48.75	1
75	0	30	75	45	1
75	75	30	20	50	1
25	30	30	100	46.25	1
25	0	30	75	32.5	1
25	0	30	100	38.75	1
25	0	100	20	36.25	1
25	0	100	75	50	1
25	30	30	20	26.25	1
25	30	30	75	40	1
100	30	30	20	45	1
25	30	100	20	43.75	1

Forage	Utilization	Canopy	Water	Score	Class[1]
25	100	30	20	43.75	1
50	30	100	100	70	2
50	75	100	20	61.25	2
50	75	30	100	63.75	2
25	100	100	75	75	2
50	75	30	75	57.5	2
25	75	30	75	51.25	2
25	75	30	100	57.5	2
50	100	100	20	67.5	2
25	75	100	20	55	2
50	100	30	100	70	2
50	30	30	100	52.5	2
25	0	100	100	56.25	2
50	30	100	75	63.75	2
25	75	100	75	68.75	2
25	75	100	100	75	2
25	100	100	20	61.25	2
25	100	30	100	63.75	2
50	0	100	100	62.5	2
50	0	100	75	56.25	2
25	100	30	75	57.5	2
25	30	100	75	57.5	2
25	30	100	100	63.75	2
50	100	30	75	63.75	2
100	30	30	75	58.75	2
75	75	30	100	70	2
75	75	100	20	67.5	2
50	75	100	75	75	2

Forage	Utilization	Canopy	Water	Score	Class[1]
100	0	30	100	57.5	2
100	0	100	20	55	2
75	75	30	75	63.75	2
100	0	100	100	75	2
100	0	30	75	51.25	2
100	30	30	100	65	2
100	30	100	20	62.5	2
100	100	30	20	62.5	2
100	75	30	20	56.25	2
100	75	30	75	70	2
100	75	100	20	73.75	2
100	0	100	75	68.75	2
75	0	100	75	62.5	2
75	30	30	75	52.5	2
75	30	30	100	58.75	2
75	30	100	75	70	2
75	0	100	100	68.75	2
75	0	30	100	51.25	2
75	100	30	20	56.25	2
75	100	30	75	70	2
75	100	100	20	73.75	2
75	30	100	20	56.25	2
100	75	30	100	76.25	3
100	75	100	100	93.75	3
100	100	30	75	76.25	3
100	100	100	100	100	3
100	75	100	75	87.5	3
100	100	100	75	93.75	3
100	100	100	20	80	3

Forage	Utilization	Canopy	Water	Score	Class[1]
100	100	30	100	82.5	3
50	100	100	100	87.5	3
100	30	100	100	82.5	3
75	75	100	100	87.5	3
50	100	100	75	81.25	3
75	100	100	75	87.5	3
25	100	100	100	81.25	3
50	75	100	100	81.25	3
75	30	100	100	76.25	3
75	75	100	75	81.25	3
75	100	30	100	76.25	3
75	100	100	100	93.75	3
100	30	100	75	76.25	3

[1] Classes: 0 = Poor, 1 = Fair, 2 = Good, 3 = Excellent

Table 20.

Word table of all possible combinations for NRCS beef cattle habitat model.

Forage	Utilization	Canopy	Water	Class
0-25% Desirable	Severe	>30%	>1 mile	Poor
26-50% Desirable	Severe	>30%	>1 mile	Poor
0-25% Desirable	Heavy	>30%	>1 mile	Fair
51-76% Desirable	Severe	>30%	>1 mile	Fair
0-25% Desirable	Severe	>30%	1/2 - 1 mile	Fair
26-50% Desirable	Heavy	>30%	>1 mile	Fair
0-25% Desirable	Severe	<30%	>1 mile	Fair
0-25% Desirable	Light to None	>30%	>1 mile	Fair
76-100% Desirable	Severe	>30%	>1 mile	Fair
51-76% Desirable	Heavy	>30%	>1 mile	Fair
26-50% Desirable	Severe	>30%	1/2 - 1 mile	Fair
0-25% Desirable	Severe	>30%	<1/2 mile	Fair
0-25% Desirable	Heavy	>30%	1/2 - 1 mile	Fair
26-50% Desirable	Severe	<30%	>1 mile	Fair
0-25% Desirable	Moderate	>30%	>1 mile	Fair
26-50% Desirable	Light to None	>30%	>1 mile	Fair
0-25% Desirable	Heavy	<30%	>1 mile	Fair
51-76% Desirable	Severe	>30%	1/2 - 1 mile	Fair
26-50% Desirable	Severe	>30%	<1/2 mile	Fair
76-100% Desirable	Heavy	>30%	>1 mile	Fair
26-50% Desirable	Heavy	>30%	1/2 - 1 mile	Fair
0-25% Desirable	Heavy	>30%	<1/2 mile	Fair
51-76% Desirable	Severe	<30%	>1 mile	Fair
26-50% Desirable	Heavy	<30%	>1 mile	Fair
26-50% Desirable	Moderate	>30%	>1 mile	Fair
0-25% Desirable	Severe	<30%	1/2 - 1 mile	Fair
51-76% Desirable	Light to None	>30%	>1 mile	Fair
0-25% Desirable	Light to None	>30%	1/2 - 1 mile	Good
51-76% Desirable	Severe	>30%	<1/2 mile	Good
76-100% Desirable	Severe	>30%	1/2 - 1 mile	Good
51-76% Desirable	Heavy	>30%	1/2 - 1 mile	Good
26-50% Desirable	Heavy	>30%	<1/2 mile	Good

Forage	Utilization	Canopy	Water	Class
0-25% Desirable	Light to None	<30%	>1 mile	Good
76-100% Desirable	Severe	<30%	>1 mile	Good
51-76% Desirable	Heavy	<30%	>1 mile	Good
26-50% Desirable	Severe	<30%	1/2 - 1 mile	Good
51-76% Desirable	Moderate	>30%	>1 mile	Good
0-25% Desirable	Severe	<30%	<1/2 mile	Good
76-100% Desirable	Light to None	>30%	>1 mile	Good
76-100% Desirable	Severe	>30%	<1/2 mile	Good
0-25% Desirable	Moderate	>30%	1/2 - 1 mile	Good
26-50% Desirable	Light to None	>30%	1/2 - 1 mile	Good
0-25% Desirable	Light to None	>30%	<1/2 mile	Good
0-25% Desirable	Heavy	<30%	1/2 - 1 mile	Good
76-100% Desirable	Heavy	>30%	1/2 - 1 mile	Good
51-76% Desirable	Heavy	>30%	<1/2 mile	Good
0-25% Desirable	Moderate	<30%	>1 mile	Good
26-50% Desirable	Light to None	<30%	>1 mile	Good
26-50% Desirable	Severe	<30%	<1/2 mile	Good
76-100% Desirable	Heavy	<30%	>1 mile	Good
51-76% Desirable	Severe	<30%	1/2 - 1 mile	Good
76-100% Desirable	Moderate	>30%	>1 mile	Good
51-76% Desirable	Light to None	>30%	1/2 - 1 mile	Good
26-50% Desirable	Light to None	>30%	<1/2 mile	Good
0-25% Desirable	Heavy	<30%	<1/2 mile	Good
0-25% Desirable	Moderate	>30%	<1/2 mile	Good
26-50% Desirable	Moderate	>30%	1/2 - 1 mile	Good
26-50% Desirable	Heavy	<30%	1/2 - 1 mile	Good
76-100% Desirable	Heavy	>30%	<1/2 mile	Good
26-50% Desirable	Moderate	<30%	>1 mile	Good
51-76% Desirable	Light to None	<30%	>1 mile	Good
76-100% Desirable	Severe	<30%	1/2 - 1 mile	Good
51-76% Desirable	Severe	<30%	<1/2 mile	Good
0-25% Desirable	Light to None	<30%	1/2 - 1 mile	Good
76-100% Desirable	Light to None	>30%	1/2 - 1 mile	Good
26-50% Desirable	Heavy	<30%	<1/2 mile	Good

Forage	Utilization	Canopy	Water	Class
26-50% Desirable	Moderate	>30%	<1/2 mile	Good
51-76% Desirable	Heavy	<30%	1/2 - 1 mile	Good
51-76% Desirable	Moderate	>30%	1/2 - 1 mile	Good
51-76% Desirable	Light to None	>30%	<1/2 mile	Good
76-100% Desirable	Light to None	<30%	>1 mile	Good
51-76% Desirable	Moderate	<30%	>1 mile	Good
0-25% Desirable	Moderate	<30%	1/2 - 1 mile	Good
0-25% Desirable	Light to None	<30%	<1/2 mile	Good
26-50% Desirable	Light to None	<30%	1/2 - 1 mile	Good
76-100% Desirable	Severe	<30%	<1/2 mile	Good
76-100% Desirable	Moderate	>30%	1/2 - 1 mile	Excellent
51-76% Desirable	Heavy	<30%	<1/2 mile	Excellent
76-100% Desirable	Heavy	<30%	1/2 - 1 mile	Excellent
76-100% Desirable	Light to None	>30%	<1/2 mile	Excellent
51-76% Desirable	Moderate	>30%	<1/2 mile	Excellent
76-100% Desirable	Moderate	<30%	>1 mile	Excellent
51-76% Desirable	Light to None	<30%	1/2 - 1 mile	Excellent
0-25% Desirable	Moderate	<30%	<1/2 mile	Excellent
26-50% Desirable	Light to None	<30%	<1/2 mile	Excellent
26-50% Desirable	Moderate	<30%	1/2 - 1 mile	Excellent
76-100% Desirable	Moderate	>30%	<1/2 mile	Excellent
76-100% Desirable	Heavy	<30%	<1/2 mile	Excellent
51-76% Desirable	Moderate	<30%	1/2 - 1 mile	Excellent
51-76% Desirable	Light to None	<30%	<1/2 mile	Excellent
26-50% Desirable	Moderate	<30%	<1/2 mile	Excellent
76-100% Desirable	Light to None	<30%	1/2 - 1 mile	Excellent
51-76% Desirable	Moderate	<30%	<1/2 mile	Excellent
76-100% Desirable	Light to None	<30%	<1/2 mile	Excellent
76-100% Desirable	Moderate	<30%	1/2 - 1 mile	Excellent
76-100% Desirable	Moderate	<30%	<1/2 mile	Excellent

Table 21.

Summary of all possible combinations of biases and class counts for NRCS beef cattle model. A negative bias implies underestimation. A positive bias indicates overestimation. Numbers under classes are the number of combinations that can result in a particular class with bias inputs.

Water bias	Brush bias	Utilization bias	Forage bias	Number Poor	Number Fair	Number Good	Number Excellent
-1	-1	-1	-1	24	58	14	0
-1	-1	0	-1	12	62	22	0
-1	-1	1	-1	0	66	30	0
0	-1	1	-1	0	40	54	2
0	-1	0	-1	6	48	40	2
-1	-1	1	0	0	52	42	2
-1	-1	0	0	8	54	32	2
-1	0	-1	-1	12	55	27	2
0	-1	-1	-1	12	56	26	2
-1	-1	-1	0	16	56	22	2
-1	0	0	-1	6	47	40	3
1	-1	1	-1	0	14	78	4
1	-1	0	-1	0	34	58	4
-1	-1	1	1	0	38	54	4
-1	0	1	-1	0	39	53	4
-1	-1	0	1	4	46	42	4
-1	1	-1	-1	0	52	40	4
1	-1	-1	-1	0	54	38	4
-1	-1	-1	1	8	54	30	4
-1	1	0	-1	0	32	58	6
0	-1	-1	0	8	46	36	6
-1	0	-1	0	8	46	35	7
-1	1	1	-1	0	12	76	8
0	-1	0	0	4	38	46	8
0	0	-1	-1	6	43	39	8
-1	0	0	0	4	38	45	9
0	-1	1	0	0	30	56	10

Water bias	Brush bias	Utilization bias	Forage bias	Number Poor	Number Fair	Number Good	Number Excellent
1	-1	-1	0	0	36	50	10
0	-1	-1	1	4	36	46	10
-1	0	1	0	0	30	55	11
0	0	0	-1	3	33	49	11
-1	1	-1	0	0	36	48	12
-1	0	-1	1	4	37	43	12
1	-1	0	0	0	22	60	14
0	0	1	-1	0	23	59	14
0	-1	0	1	2	28	52	14
0	1	-1	-1	0	30	52	14
1	0	-1	-1	0	31	51	14
0	0	-1	0	4	33	45	14
-1	0	0	1	2	29	50	15
1	-1	-1	1	0	18	62	16
-1	1	0	0	0	22	58	16
1	-1	1	0	0	8	70	18
0	-1	1	1	0	20	58	18
-1	0	1	1	0	21	57	18
1	0	0	-1	0	19	58	19
-1	1	1	0	0	8	68	20
0	1	0	-1	0	18	58	20
-1	1	-1	1	0	20	56	20
0	0	-1	1	2	23	51	20
0	0	0	0	2	25	49	20
1	0	-1	0	0	20	55	21
0	1	-1	0	0	20	54	22
1	0	1	-1	0	7	65	24
1	1	-1	-1	0	8	64	24
1	-1	0	1	0	10	62	24
0	1	1	-1	0	6	64	26
-1	1	0	1	0	12	58	26
0	0	1	0	0	17	53	26
1	0	-1	1	0	9	59	28

Water bias	Brush bias	Utilization bias	Forage bias	Number Poor	Number Fair	Number Good	Number Excellent
0	0	0	1	1	17	49	29
0	1	-1	1	0	10	56	30
1	0	0	0	0	12	53	31
1	-1	1	1	0	2	62	32
1	1	-1	0	0	4	60	32
-1	1	1	1	0	4	60	32
0	1	0	0	0	12	52	32
1	1	0	-1	0	4	58	34
0	0	1	1	0	11	47	38
1	1	-1	1	0	0	56	40
1	0	1	0	0	4	51	41
0	1	1	0	0	4	50	42
1	0	0	1	0	5	48	43
1	1	1	-1	0	0	52	44
0	1	0	1	0	6	46	44
1	1	0	0	0	2	46	48
1	0	1	1	0	1	37	58
0	1	1	1	0	2	36	58
1	1	0	1	0	0	34	62
1	1	1	0	0	0	32	64
1	1	1	1	0	0	12	84

Table 22.

The number of component suitability combinations producing each habitat classification category as single level negative and positive bias is introduced into the NRCS beef cattle habitat suitability model.

Bias	Component	Poor	Fair	Good	Excellent	Absolute Change
Negative Bias	Water	4	38	45	9	30
	Brush Canopy	4	38	46	8	30
	Utilization	4	33	45	14	20
	Forage	3	33	49	11	18
No Bias		2	25	49	20	0
Positive Bias	Forage	1	17	49	29	18
	Utilization	0	17	53	26	20
	Brush Canopy	0	12	52	32	30
	Water	0	12	53	31	30

CHAPTER IV

EVALUATION OF THE NRCS BOBWHITE QUAIL HABITAT MODEL

Introduction

The classification of bobwhite quail habitat on the Sergeant Major watershed using the NRCS model resulted in higher classifications than those of range scientists. These results do not appear to be due to biased inputs to the model. As a result, the model itself must be examined more thoroughly. Conclusions regarding the quality of bobwhite quail habitat within the watershed could not be determined as long as these questions existed. This chapter examines the NRCS bobwhite quail habitat model's conceptual logic, scoring, overall reasonableness of inherent statements, and sensitivity to bias.

Model components

There has been considerable research performed on bobwhite quail (*Colinus virginianus*) habitat since the 1920s (Guthery 1997). Several different models and methods exist to evaluate bobwhite quail habitat (Schroeder 1985, Bidwell et al. 1991, Rice et al. 1993, Guthery 2000). There are similar components in most of these models. Like the NRCS beef cattle model, the NRCS quail model was also patterned after the model, "Judging Rangeland for Livestock and Wildlife Values" (JRLWV), (Bidwell and Moseley 1995) (Table 23). The NRCS quail model consists of eight components with various levels and scores. The components are: Nesting Cover, Screening Cover, Openness, Escape Cover (Thickets) within 300 feet of the central point, Food Plant Abundance, Bare Ground, and Edge Index.

Nesting Cover: Nesting Cover is the percent warm-season (tallgrass or midgrass) bunchgrasses, from the previous year, that are available during nesting season (April 1 to July 31). Nesting cover has 2 levels.

Bunchgrass Use: Bunchgrass use is an estimate of the utilization of the bunchgrasses that are present on a site. Bunchgrass use contains 3 levels of scoring. If the herbaceous height that would remain during nesting season is more than 8 inches, the site use is rated light to none, and receives a score of 80. If the herbaceous height that remains during nesting season measures between 6 – 8 inches, use was considered moderate, and the site received a score of 100. If the herbaceous height that remains during nesting season measures 4 – 6 inches, use is considered heavy, and the site receives a score of 40. If the herbaceous height that remains during nesting season measures less than 4 inches, use is considered severe, and the site receives a score of 40.

Screening Cover: Screening cover is defined as that cover above the height of a quail, approximately 6 inches. There are 3 levels for screening cover.

Openness: Openness is the amount of clear space below 6 inches of herbaceous height. There are three scoring levels for openness. If the site is open below 6 inches, with no obstructions, it is given the score of 100. If the site is moderately open below 6 inches, it is given the score 70. If the site is closed or rank below 6 inches with no openness, it is scored 0.

Escape Cover (Thickets within 300 feet): Escape cover is defined as an area, usually brush or shrub cover, where quail can loaf and escape predators. These areas can be as small as 10 feet in diameter. Escape cover with diameters of 30 feet or greater is desired (Roseberry and Klimstra 1984). There are three levels for escape cover.

Food Plant Abundance: Food plant abundance is defined as the presence of known quail food plants within the site that will supply the food necessary to carry a covey year-round with special emphasis put on the ability of the site to supply food from the fall of one year until March of the following year (Rosene 1969). Although this study did not encounter all food plants for quail, there are over one hundred quail food plants in the state of Oklahoma (Bird 1931, Lee 1948, Baumgartner 1952, Wiseman 1977, Rollins 1981, Peoples 1992).

Bare Ground: Bare ground is the amount of unobstructed travel corridor that permits movement to escape cover and accessibility to food. Bare ground is positively related to openness. There are three levels within this component.

Edge Index: Edge index is defined as changes between habitat components within the home range. There are four levels in this component. This component is measured on a north/south line from the central point of the site.

Comparison of models

Reviewing the NRCS model and comparing it to its parent model (JRLWV) gives an insight into the thought processes that formed the components and scoring scheme of the NRCS model. Although patterned after the parent JRLWV model (Table 23), there were major changes made in the NRCS quail model. Like the beef model in Chapter III, the main reason for changing the model was to simplify it for novice users (Moseley 2000).

The JRLWV model contains six major components with sub components. The total number of items scored in the JRLWV model is fourteen (Table 24). The JRLWV model contains Nesting Cover, Nesting Cover Height, Brood Habitat Quantity, Screening Cover, Escape Cover, Protective Cover Composition, Protective Cover Canopy, Food Abundance, Food Diversity, Bare Ground, Edge Index, and Site Integrity. The NRCS model dropped Brood Habitat Quantity, Protective Cover Composition, Protective Cover Canopy, Food Diversity, and Site Integrity. A major difference in the models is the fact that the JRLWV model uses the lowest or limiting factor scores to determine habitat while the NRCS model does not. Both models are weak in that model output averages will usually be better than the lowest limiting score. In other words, both models do not recognize critical limiting factors that, by themselves, determine habitat suitability potential for a particular site.

Table 23 provides a convenient comparison of the models. To facilitate the comparison, the JRLWV scores have been converted to a 100-point system in the table. The NRCS model tends to eliminate or reduce the number of suitability levels, change the scoring scheme of suitability levels, and eliminate some model components entirely.

Model calculations

In the NRCS model, the scores of the eight components are added together and divided by eight for the average. This average score is then converted to qualitative descriptions of poor, fair, good, and excellent (Table 3). The JRLWV model is scored differently. The JRLWV model calculates the average of limiting factors of the 6 major components Nesting Cover, Brood Habitat, Protective Cover, Food, Edge, and Site

Integrity (Table 24). Interpretation of average value is then converted to qualitative classes poor, fair, good, and excellent.

Sensitivity to bias

The NRCS quail model was examined for the effect of input bias on model output. All possible combinations of bias will not be presented in this chapter due to the large amount of data required to do so. This chapter will only examine one single overestimation or underestimation bias affect on model output.

Methods

All possible combinations

All eight NRCS bobwhite quail model component suitability level scores were entered into a computer program designed to give all possible combinations of suitability levels and resulting scores. The program produced 10,368 possible combinations of the suitability levels for the model.

The bobwhite quail model was examined for bias in input effect upon the model by changing a single component suitability level score up or down one level, and observing the resultant changes of output in the model. For example, of the 10,368 possible combinations containing nesting cover scores, those scored 20 (i.e. less than 30% bunchgrasses), were raised by 80 points to simulate an overestimation error of nesting cover by one suitability level in input measurement. This procedure simulated what would happen to the model if the human estimators made enough error in their estimation of the nesting cover component to raise that component suitability level score one level (i.e. the value 20 for less than 30% bunchgrasses was given as a score when in reality the score should have been 100 more than 30% nesting cover). The magnitude of change in the model was observed for one suitability level overestimation and underestimation of all eight components individually (Tables 25 and 26).

Results and Discussion

Model Characteristics

The NRCS bobwhite quail model generated 10,368 possible combinations. It produced 112 combinations yielding poor classifications, 3037 yielding fair classifications, 6202 yielding good classifications, and 1017 yielding excellent classifications (Table 25). Clearly, only a small fraction of the combinations can yield a poor classification. This could contribute to the model's tendency to overestimate bobwhite quail habitat.

Some component level combinations produce questionable classifications. The following statements illustrate this.

- If Nesting Cover is less than 30%, the habitat can still be excellent.
- If Bunchgrass Use is severe, the habitat can still be excellent.
- If Screening Cover is 0% - 25%, the habitat can still be excellent.
- If Openness is rank, the habitat can still be excellent.
- If Escape Cover is 1 - 10%, the habitat can still be excellent.
- If Food Plant Abundance is none the habitat can still be excellent.
- If Bare Ground is 0 - 25% the habitat can still be excellent.

- If there are no edges the habitat can still be excellent.
- If 3 scores are 0, habitat can still be good.
- If 4 scores are 0, habitat can still be fair.

These statements emphasize the fact that the model fails to recognize the serious consequences that low scores in certain components can have on bobwhite quail habitat. These statements raise serious questions concerning the conceptual logic and scoring scheme of the model. The model fails to recognize critical limiting factors of quail habitat (e.g. nesting cover, bunchgrass use, screening cover, openness, and food). Bobwhite quail habitat should contain areas for brood rearing, loafing cover, nesting, feeding, dusting, night roosting, and escape from predators (Schroeder 1985, Bidwell et al. 1991). If the any one of these components is absent from the site, it cannot sustain bobwhite quail populations over time. Because of the additive nature of the calculation of final scores in the model, it does not consider any component to be essential and capable of overwhelming scores of other components.

Another problem of this model is its use of discrete numbers in its scoring system. Discrete numbers usually do not exactly quantify the value observed, but instead, gives the observation in question some number that reflects a range of numbers that the observation will be in. Therefore, the model uses a scoring system that may not adequately reflect the true condition of a site. It uses discrete numbers in both the scoring and in the conversion to classifications. This leads to possible problems in accurately quantifying both the level scores and the classifications (i.e. a level score of 26% for food plant abundance is the same as a score of 50%, while there is a full class difference between the averages of 50 and 51). In reality, there is a difference between 26% and 50% plant food abundance. There is not a significant difference between final model average scores of 50 and 51. This model uses discrete numbers (level scores) to determine another set of discrete numbers (classifications).

Impact of bias

The results from introducing bias into component scoring are contained in Table 25. The table gives the number of ways the model can produce each class as different biases are introduced. The greatest change-in-class-count in the model output for a single bias occurs with an underestimation or overestimation of nesting cover with a total absolute change of 2614 (Table 26). When bias is introduced into the model, the maximum change of the classes poor, fair, good, and excellent from no bias is 94, 1231, 634, and 673 respectively, so, poor is least affected by bias because it has the smallest change from no bias. Good remains relatively stable under bias.

Conclusions

- The NRCS bobwhite quail model has only 112 ways out of 10,368 suitability level combinations that can result in a poor classification.
- The model fails to recognize critical limiting factors.
- The weighting and calculations used in the model results in false or misleading statements.
- Single level bias input does not substantially increase the possibility of classifying areas as poor. The largest class is always good, fair second, excellent third, and poor last regardless of single level induced bias introduced.
- The model does not measure end of season standing crop, therefore the amount of biomass present on-site is unknown. Sample sites cannot be accurately qualified for bobwhite quail habitat classification because, without a biomass measurement, the capacity of the site to sustain the species for a given length of time is unknown. This is a major flaw in the model.

Table 23.

Comparison of Judging Rangeland for Livestock and Wildlife Values Model and NRCS bobwhite quail model.

	Judging Rangeland Model	Adjusted Judging Model Scoring	NRCS Quail Model
Nesting Cover:			
Nesting Cover Quantity			
> 30% Home Range Preferred Grasses	40	100	100
20 – 30% Preferred Grasses	30	75	20
10 – 20% Preferred Grasses	20	50	20
1 – 10% Preferred Grasses	10	25	20
No Preferred Grasses	0	0	20
Nesting Cover Height			
Degree of Utilization (Light or None)	30	75	80
Degree of Utilization (Moderate)	40	100	100
Degree of Utilization (Close)	10	25	40
Degree of Utilization (Severe)	0	0	0
Brood Habitat:			
Brood Habitat Quantity			
40% or > Warm Season Grasses, Forbs, Crops	40	100	Dropped From Model
30 – 40% Warm Season Grasses, Forbs, Crops	30	75	Dropped From Model
20 – 30% Warm Season Grasses, Forbs, Crops	20	50	Dropped From Model
10 – 20% Warm Season Grasses, Forbs, Crops	10	25	Dropped From Model
1 – 10% Warm Season Grasses, Forbs, Crops	5	12.5	Dropped From Model
No Warm Season Grasses, Forbs, Crops	0	0	Dropped From Model
Screening Cover			
Herbaceous Canopy Cover > 50% Above 6"	40	100	100
Herbaceous Canopy Cover 30 – 50% Above 6"	30	75	Dropped From Model
Herbaceous Canopy Cover 26 – 50% Above 6"			70
Herbaceous Canopy Cover 10 –30% Above 6"	20	50	Dropped From Model
Herbaceous Canopy Cover 1- 10% Above 6"	5	12.5	Dropped From Model
Herbaceous Canopy Cover 0 – 25% Above 6"			20
No Herbaceous Canopy Cover Above 6"	0	0	Dropped From Model

	Judging Rangeland Model	Adjusted Judging Model Scoring	NRCS Quail Model
Openness			
Open Below 6"	40	100	100
Moderate Below 6"	20	50	70
Rank Below 6"	5	12.5	0
Protective Cover:			
Escape Cover Within 300 Feet			
10% or > Coverts	40	100	100
5 – 10% Coverts	30	75	50
1 – 5% Coverts	10	25	50
< 1% Coverts	5	12.5	0
No Coverts	0	0	0
Protective Cover Composition			
Living Shrubs/Low Trees	40	100	Dropped From Model
Artificial Cover (Brush Piles/Shelters)	20	50	Dropped From Model
Large Trees with Extensive Low Stems	5	12.5	Dropped From Model
No woody Plants	0	0	Dropped From Model
Protective Cover Canopy			
80% or > Canopy @ 2 – 3 Feet Height	40	100	Dropped From Model
60 – 80% Canopy @ 2 – 3 Feet Height	30	75	Dropped From Model
40 – 60% Canopy @ 2 – 3 Feet Height	20	50	Dropped From Model
20 – 40% Canopy @ 2 – 3 Feet Height	10	25	Dropped From Model
< 20% Canopy @ 2 – 3 Feet Height	5	12.5	Dropped From Model
Food:			
Food Quantity			
> 50% Home Range Food Producing Plants			100
40% or > Home Range Food Producing Plants	40	100	Dropped From Model
30 – 40% Home Range Food Producing Plants	30	75	Dropped From Model
26 – 50% Home Range Food Producing Plants			70
20 – 30% Home Range Food Producing Plants	20	50	Dropped From Model
10 – 20% Home Range Food Producing Plants	10	25	Dropped From Model

	Judging Rangeland Model	Adjusted Judging Model Scoring	NRCS Quail Model
1 – 25% Home Range Food Producing Plants			30
1 – 10% Home Range Food Producing Plants	5	12.5	Dropped From Model
No Home Range Food Producing Plants	0	0	0
Food Diversity			
Food Plants Of All 4 Major Food Groups	40	100	Dropped From Model
Food Plants Of 3 Major Food Groups	30	75	Dropped From Model
Food Plants Of 2 Major Food Groups	10	25	Dropped From Model
Food Plants Of 1 Major Food Group	5	12.5	Dropped From Model
Food Accessibility (Bare Ground)			
Plant Litter Covers < 50% Of Soil Surface	40	100	100
Plant Litter Covers 26 – 50% Of Soil Surface			90
Plant Litter Covers 50 – 70% Of Soil Surface	30	75	Dropped From Model
Plant Litter Covers 70 – 90% Of Soil Surface	10	25	Dropped From Model
Plant Litter Covers 75 – 100% Of Soil Surface			10
Plant Litter Cover > 90% Of Soil Surface	5	12.5	Dropped From Model
Edge:			
Edge Index			
Edge Changes > 8 Times Within Home Range	40	100	100
Edge Changes 6 - 8 Times Within Home Range	30	75	Dropped From Model
Edge Changes 5 - 8 Times Within Home Range			90
Edge Changes 4 – 5 Times Within Home Range	20	50	Dropped From Model
Edge Changes 2 – 5 Times Within Home Range			50
Edge Changes 2 - 3 Times Within Home Range	10	25	Dropped From Model
Edge Changes 1 Time Within Home Range	5	12.5	Dropped From Model
Edge Does Not Change Within Home Range	0	0	0
Site Integrity:			
Invading Plants Present	0	0	Dropped From Model
Invading Plants Not Present	40	100	Dropped From Model

Table 24.

Calculation of score for Judging Rangeland Livestock and Wildlife Values model.

Component	Sub Component	Sub Component Score	Lowest Sub Component Score (Limiting Factor)
Nesting Cover Factors			
	Nesting Cover Quantity		
	Nesting Cover Height		
Brood Habitat Factors			
	Brood Habitat Quantity		
	Screening Cover		
	Openness		
Protective Cover			
	Escape Cover		
	Composition		
	Canopy		
Food			
	Food Quantity		
	Food Abundance		
	Food Diversity		
	Bare Ground		
Edge Index			
	Number of Changes in Habitat Components		
Site Integrity			
	Invading Plants Present		
	Invading Plants Present		
	TOTAL[1]		
	AVERAGE[2]		

[1] Sum of 6 lowest sub component scores.

[2] Average = Sum of limiting factor scores / 6

Habitat Ratings: Excellent 31 – 40 Good 21 – 30 Fair 11 – 20 Poor < 11

Table 25.

The number of component suitability combinations producing each habitat classification category as a single level negative and positive bias is introduced into the NRCS bobwhite quail habitat suitability model.

Bias	Component	Poor	Fair	Good	Excellent
Negative Bias	Nesting Cover	206	4250	5568	344
	Bunchgrass Use	179	3667	5781	741
	Screening Cover	184	3836	5765	583
	Openness	197	4076	5596	499
	Escape Cover	190	4038	5689	451
	Food Plants	175	3775	5832	586
	Bare Ground	203	3988	5587	590
	Edge	186	3810	5727	645
No Bias		112	3037	6202	1017
Positive Bias	Edge	38	2264	6677	1389
	Bare Ground	21	2086	6817	1444
	Food Plants	49	2299	6572	1448
	Escape Cover	34	2036	6715	1583
	Openness	27	1998	6808	1535
	Screening Cover	40	2238	6639	1451
	Bunchgrass Use	45	2407	6623	1293
	Nesting Cover	18	1824	6836	1690

Table 26.

Sensitivity to bias showing the total number of changes in sites for each habitat classification category as bias is introduced in the NRCS bobwhite quail habitat suitability model. Numbers are the net change in class. Absolute change is the sum of all class changes for a particular bias.

Bias	Poor Change	Fair Change	Good Change	Excellent Change	Absolute Change
Nesting -	94	1213	-634	-673	2614
Bunchgrass -	67	630	-421	-276	1394
Screening -	72	799	-437	-434	1742
Openness -	85	1039	-606	-518	2248
Escape -	78	1001	-513	-566	2158
Food -	63	738	-370	-431	1602
Bare ground -	91	951	-615	-427	2084
Edge -	74	773	-475	-372	1694
No Errors	0	0	0	0	0
Edge +	-74	-773	475	372	1694
Bare ground +	-91	-951	615	427	2084
Food +	-63	-738	370	431	1602
Escape +	-78	-1001	513	566	2158
Openness +	-85	-1039	606	518	2248
Screening +	-72	-799	437	434	1742
Bunchgrass +	-67	-630	421	276	1394
Nesting +	-94	-1213	634	673	2614

CHAPTER V

SUMMARY CONCLUSIONS

NRCS model classifications of habitat on the Sergeant Major watershed did not reflect expert opinion. The models over ranked both beef cattle and bobwhite quail habitat. Sensitivity to bias examinations showed that induced single-level bias did change the classification of a substantial number of sites, but the total number of sites in the combined good and excellent classes remained relatively unchanged, indicating a resistance of the models to produce poor and fair classes, while favoring good and excellent classes. Possible observer bias examinations did not explain the differences between expert classifications of habitat and model output. NRCS model output of habitat classification did not appear to be related to class, ecological site, or expert opinion, and could not explain the differences between the experts and the models. The models did not measure on-site biomass, so habitat suitability for sustaining the species in question over time could not be determined, therefore, habitat suitability could not be determined. Several component measurements were made relative to other components present on site. The lack of biomass measurement and the mixing of relative measurements with quantitative measurements are serious weaknesses of both models. Because of the findings of this study, neither NRCS model should be used for habitat assessment.

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VITA

John Arthur Eckroat

Candidate for the Degree of

Doctor of Philosophy

Thesis: AN EVALUATION OF BEEF CATTLE AND BOBWHITE QUAIL HABITAT MODELS ON THE SERGEANT MAJOR WATERSHED AT CHEYENNE, OKLAHOMA.

Major Field: Crop Science

Biographical:

Personal Data: Born in Oklahoma City, Oklahoma, on April, 2 1943, the son of William M. Eckroat Jr. and Kathryn E. Eckroat. Enjoy playing mandolin in a bluegrass band. Like to fish. Gave up hunting.

Education: Graduated St. Gregory's High School, Shawnee, Oklahoma in May 1961; received Bachelor of Science degree in Agronomy, Field Crops Option, from Oklahoma State University, Stillwater, Oklahoma in May 1965; received Master of Science degree in Range Science from Oklahoma State University in May, 1997. Completed the requirements for Doctor of Philosophy degree with a major in Crop Science at Oklahoma State University in May 2001.

Experience: Employed by Standard Oil of Ohio as a fertilizer plant manager. Owned and operated Eckroat Incorporated, Hennessey, Oklahoma. Owned and operated Eckroat Seed Company, Vernon, Texas and Oklahoma City, Oklahoma

Professional Memberships: Society for Range Management.