An Assessment of Game Warden Personnel Needs in Texas

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Abstract: The goal of this study was to assess the law enforcement needs of the Texas Parks and Wildlife Department. Data were obtained from several state agencies and a mail-out survey to Texas game wardens. Game wardens (N = 397) and their captains (N = 33) returned 685 of 690 mailed questionnaires (99% response rate). All 254 counties were represented. A regression model explained 78% of the total variation in the distribution of game wardens and estimated a statewide excess of 16 game wardens. In contrast, the game wardens indicated that 160 more game wardens were needed. Differences between the model estimates and wardens' perceptions were attributed to a lack of data (e.g., number of anglers, boaters, or campers), incomplete data (e.g., number of hunters for dove, pheasant, and waterfowl), and unreliable data (e.g., number of deer, quail and turkey hunters, and game harvests) for each county. Game wardens gave the highest importance values to these factors as determinants of game warden need in each county. Future personnel assessments will require county-level information on the number of hunters, anglers, boaters, campers, and the miles of flowing streams and rivers.

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The Law Enforcement Division (LED) of the Texas Parks and Wildlife Department (TPWD) has the mission of enforcing the state's laws and regulations regarding hunting, fishing, and other uses of wildlife resources for recreational and commercial purposes. However, 20 years have passed since the TPWD assessed its law enforcement needs (Boydston 1972).

From 1950 to 1990, the state population annually increased an average of 21.6%. In 1995, its estimated size of population was 18.7 million, which was a 10.2% increase since 1990 (Murdock et al. 1997). By the year 2000, its population is projected to have increased to 19.3 million, and by 2030 it will have grown to 33.8

million people. Much of this growth has occurred and is projected to continue to increase among new residents, racial minority groups, and in the state's metropolitan areas. It is reasonable to expect, therefore, parallel growth in the numbers of outdoor recreationists, tourists, and other consumers and the demands they will make of the state's wildlife and other natural resources (Murdock et al. 1990, 1996).

There is a changing public climate toward more accountability and fiscal austerity in all levels of state government. As the state's population has grown, so has the size and cost of state government. The TPWD is well aware of the public's desire for more efficient and effective uses of tax dollars and is committed to performing periodic assessments of how it does business, defines its clientele and their needs, and informs and educates the public about its mission and accomplishments. Being on the front line in daily contacts with and service to the public, the LED is responsible for protecting the public's safety, as well as ensuring that the state's natural resources are not abused or destroyed by user groups. How well it performs this mission depends upon numerous factors, including the number of professionally trained game wardens it has in each county, the resources and equipment available, and the cooperative assistance it provides to and receives from other law enforcement agencies.

The goal of this study was to assess the current and future law enforcement needs of the Texas Parks and Wildlife Department (TPWD). Study objectives were to: (1) determine the operational, demographic, and ecological factors that are important indicators of law enforcement manpower needs by county; (2) assess the current and projected number and county locations of game wardens needed statewide, and (3) give game wardens the opportunity to identify the operational, demographic, and ecological factors that affect law enforcement manpower needs in their assigned counties.

Manpower Studies

Few studies of game warden manpower needs have been conducted (Glover 1987, Cribbs and Young 1988, Beffa and Witter 1993, Christensen et al. 1995). In the only study of TPWD law enforcement personnel, Boydston (1972) examined 33 variables (16 of which were directly measured and 17 were transformed using logs and other procedures). He found only 8 significant variables for estimating the number of manpower hours needed. These variables were: (1) the total number of water safety, game and fish arrests, (2) the log of the number of deer harvested, (3) the log of the county population, (4) the log of the number of submerged acres, (5) the total number of county acres, (6) the miles of rural roads, (7) the ratio of the number of deer harvested to the total number of county acres, and (8) the sum of the number of submerged acres and number of public water acres. These variables explained 74% of the total variation in the number of annual manhours required to annually work one county. The most important variable was the number of water safety, game, and fish arrests, which accounted for 55.3% of the variance in the dependent variable. Many of the variables identified by Boydston were used in the current study. Both the Boydston and the current study based manpower need on a 40-hour week, 50-week year.

Methods

Sources of Data

The data analyzed in this study were obtained from several sources. The TPWD provided data on the number of each type of license sold during 1995, the numbers and types of violation citations given from 1991 to 1996, the numbers of hunters and harvested game species (e.g., deer, quail, turkey), and the miles or acres of ecological features (e.g., estimated miles of shoreline and streams and acres of lake area). It also provided data on the number of warden hours assigned monthly to each county. The State Data Center at Texas A&M University provided the 1995 estimates of county population size and projections of future sizes of county's populations. Finally, the Texas Department of Transportation provided data about the miles of different types of roads in the state.

Mail Survey

Unlike the earlier manpower assessment studies cited above, this study asked all game wardens and their captains to provide information about their assigned counties. A mail survey of game wardens was conducted in May 1997. Each game warden and his/her captain was sent 1 or more questionnaires that were keyed to assigned county(ies). The questionnaire addressed, in part, perceived number of game wardens needed in a county and factors that justified manpower needs. The survey questionnaire was a mark-sense instrument (Natl. Computer Systems, Owatonna, Minnesota). Questionnaires completed and returned by game wardens were machine scanned by Measurement and Research Services at Texas A&M University for the construction of a data set.

Analytical Procedures

Analysis of the secondary data proceeded in 5 stages: exploratory analysis, variable transformation, computation of bivariate correlations, maximum R-square variable selection, and manpower estimation. Each of these stages is discussed below.

Exploratory Analysis.—Data analysis should include initially an exploratory examination of the distributional features of each variable to determine the selection of appropriate statistical procedures. Such an examination is important because these procedures require the data to have particular characteristics (e.g., normality and interval-level measurement). A univariate analysis was conducted on each variable in the data set using the Statistical Analysis System (SAS Inst. 1990). The results of that analysis indicated that none of the study variables were normally distributed. Normally distributed data have skewness (i.e., the number of cases above and below the mode in a frequency distribution curve) and kurtosis (i.e., the degree of flatness or peakedness of the frequency distribution curve) values equal to zero, an indication of distributional symmetry. Extreme data values, such as those observed among several Texas counties' study variables, affected the shape of the variables' frequency distributions. Consequently, data transformation procedures were applied to improve the symmetry of these variables by reducing their skewness and kurtosis values as close to zero as possible.

Transformation Procedures.—Study variables were transformed using procedures discussed by Trabachnick and Fidell (1989). These procedures included conversions of the data by calculations of their square root values or power reduction (i.e., 0.1 or 0.3) values. Although completely normal distributions were not obtained, the variables' symmetries were greatly improved.

Bivariate Correlation Analysis.—Bivariate correlation coefficients (r_i) were computed using all of the transformed study variables to determine the strength of their associations with each other. Statistical tests of significant difference were conducted for the hypothesis: rho = 0. This null hypothesis states that 2 variables are not associated. Bivariate correlation coefficients were also computed to detect very strong ($r > 0.995$) inter-variable relationships, an initial sign of potential multicollinearity where 2 variables measure the same phenomenon (e.g., number of hunters and hunter days per county). Maximum R-square and multiple regression analyses require that independent variables have no multicollinear relationships.

Maximum R-Square Analysis (MAXR).—The MAXR attempts to find the "best" 1-variable model with the highest R-square. Then another variable is added that produces the largest increase in the R-square. After the best 2-variable model is identified, each of the variables in the model is compared to each variable not in the model in a series of different combinations of variables that result in the best 3-variable model being obtained. Comparisons begin again in a similar manner to determine the best 4-variable model. This comparing-switching process continues until MAXR finds no other combination of variables that increase the R-square coefficient.

The difference between the stepwise selection procedure and the MAXR is that all variable switches are evaluated before any switch is made in MAXR. With a stepwise procedure, the worst variable can be removed, without considering what the addition of the best remaining variable(s) might accomplish (SAS Inst. 1990).

The transformed data for the 17 independent variables in the study were evaluated relative to their ability to predict the number of game warden duty hours annually spent in Texas counties. Consequently, 16 models of the best combinations of the study variables were produced. They varied from the best 1-variable model to the best (and only) 17-variable model.

Three criteria were used next to select the most parsimonious model. Parsimony was defined to be the model with the fewest number of variables and the highest R-square. The 3 criteria were: (1) the model had to have a statistically significant F-value, (2) all variables in the model had to be statistically significant at alpha equal to 0.05, and (3) the increase in the R-square from one model to the model with next added variable had to be greater than 0.5%. Symbolic expressions of the models that varied from the best single-variable model to the model with all independent variables included were:

$$\hat{y} = b_o + b_1x_1 + e \text{ (best 1-variable model)}$$

$$\hat{y} = b_o + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + e \text{ (best 5-variable model)}$$

$$\hat{y} = b_o + b_1x_1 + b_2x_2 + b_3x_3 + \ldots + b_{17}x_{17} + e \text{ (the 17-variable model)}$$

where: y = estimated annual number of game warden hours
x_1 = a selected independent variable
x_2 = the second selected independent variable
x_3 = the third selected independent variable
b_0 = a constant computed from the data
$b_{(1,2,\ldots a)}$ = regression coefficients
e = residual of unexplained variation in the dependent variable

Because MAXR computed standardized betas for only the 17-variable model, multiple regression analysis was conducted using the parsimonious model to produce standardized betas. Standardization is necessary to collectively compare the selected variables on the same measurement scale. The magnitude of each standardized beta indicates its weight or importance relative to the other variables in the model: the higher the beta value, the more important a variable is for predicting changes in the number of game warden manpower hours worked.

Manpower Estimation.—After determination of the standardized regression model, each county's data was inserted into the model to estimate the number of manpower hours needed for each county. This estimate, it should be noted, is relative to the model identified by the MAXR analysis and the importance of the standardized betas whose magnitudes were collectively influenced by the data on all Texas counties. The model may not completely account for the conditions or factors that are unique to a specific county. Consequently, 3 measures of each county's game warden manpower needs were made: the predicted measure, the observed measure (i.e., the number actually assigned to a county), and the number perceived to be needed by the game warden(s) who are assigned to that county and responded to the mail survey. Differences in these measures were assessed.

Results and Discussion

Game Warden Survey

Game wardens ($N = 397$) and their captains ($N = 33$) returned 685 of 690 questionnaires which produced a survey response rate of >99%. All 254 counties were represented 1 or more times (e.g., game warden or captain, or >1 game warden in a particular county).

Wardens were asked about how many game wardens were needed overall in their assigned county(ies) to accomplish their mission and to positively impact public compliance rates. They reported that 160 additional game wardens were needed statewide. They justified their estimates of need based on a list of 25 factors. According to the wardens, the 8 most important factors that determined game warden need by county were number of hunters, game harvests, hunter days, miles of county roads, size of county, number of boaters, number of anglers, and miles of flowing streams and rivers. Of the 8 most important factors selected by the wardens, accurate or reliable county-by-county data sets existed for only 2 factors (e.g., miles of county roads and size of county).

Multivariate Analysis—Using our selection criteria, an 8-variable model was chosen as the most parsimonious model produced by the MAXR procedure and included 4 of the top 10 factors selected by game wardens or their captains. As shown below, this model was then rerun to calculate the standardized regression coefficients (Table 1).

$$\hat{y} = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_ix_i + e$$

where: y = estimated annual number of game warden hours (HOUR)
x_1 = average number of hunting violations from 1991–1996 (HUTV)
x_2 = average number of water safety violations from 1991–1996 (WSTV)
x_3 = estimated size of county population in 1995 (POP95)
x_4 = number of commercial fishing licenses sold in 1996 (LIC10)
x_5 = average number of deer, quail, and turkey taken from 1991–1996 (THAR)
x_6 = miles of coastal shoreline (SHORELT)
x_7 = average number of deer, quail, and turkey hunters from 1991–1996 (THUN)

Table 1. Multiple regression statistical model to estimate annual number of game warden hours needed in a Texas county.

Source	*df*	Sum of Squares	Mean Square	F Value	Prob > F	R-Square	Adjusted R-Square
Model	8	1237.72	154.71	112.24	.0001	.785	.778
Error	245	337.71	1.37				
C Total	253	1575.44					

Variable	Parameter Estimate	Standard Error	Prob > [t]	Standardized Estimate
Intercept	−3.126	1.789	.0818	.000
HNTV[a]	.522	.136	.0002	.167
WSTV	.215	.025	.0001	.369
LIC10	.579	.183	.0018	.143
POP95	.906	.258	.0005	.155
THAR	−.075	.019	.0001	−.148
THUN	.177	.028	.0001	.264
CNTYLAND	1.895	.485	.0001	.130
SHORELT	1.643	.217	.0001	.259

a. HNTV = average number of hunting violations, 1991–1996; WSTV = average number of water safety violations, 1991–1996; LIC10 = average number commercial fishing licenses sold, 1991–1996; POP95 = estimated size of population in 1995; THAR = average number of deer, quail and turkey harvested, 1991–1996; THUN = average number of deer, quail and turkey hunters, 1991–1996; CNTYLAND = size of county in acres; SHORELT = miles of coastal shoreline.

x_8 = size of county in acres (CNTYLAND)
b_0 = a constant computed from the data
$b_{(1,2,...n)}$ = regression coefficients
e = residual of unexplained variation in the dependent variable

This model explained 78% of the variation in the dependent variable; 22% of the variation could not be attributed to any of the research variables and was associated with "unknown" causes; e.g., number of anglers and boaters for which no county-level data existed.

The 8-variable regression model estimated a statewide excess of 16 game wardens (Table 2). Differences between the county estimates and actual numbers of assigned game wardens varied by administrative regions. No differences occurred for regions 2 and 7. The estimated number of game wardens was greater than the number assigned in regions 6, 8, and 9, and slightly less than the number assigned in regions 1, 3, 5, and 10. The largest difference occurred in region 4 where 14 more wardens were assigned than estimated to be needed. Counties having the largest O − E differences were Galveston (5.9), Harris (2.5), Matagorda (2.5), and Jefferson (2.2).

In contrast to the estimated excess of 16 wardens, the game wardens indicated in their responses to the mail survey that 160 more game wardens (397 assigned minus 557 perceived) were needed (Table 2). None of the regions had numbers of assigned wardens equal to or greater than their perceived numbers needed. Region 10 produced the closest match (−2 wardens), compared to the most extreme differences by regions 3 (−20 wardens), 6 (−35 wardens), and 8 (−39 wardens). These 3 regions accounted for 59% of the difference between observed and perceived needs. A negative number indicated that the perceived number was larger than the assigned number (O − P). Other regions reported differences that varied between −7 and −17 game

Table 2. Comparison of the observed, estimated, and perceived numbers of game wardens needed by administrative region in Texas in 1997.

Region	Observed[a]	Estimated[b]	Perceived[c]	Differences[d]		
				O–E	O–P	E–P
1	24	23	34	1	−10	−11
2	35	35	48	0	−13	−13
3	42	39	62	3	−20	−23
4	60	46	68	14	−8	−22
5	39	34	56	5	−17	−22
6	38	42	73	−4	−35	−31
7	32	32	41	0	−9	−9
8	40	45	79	−5	−39	−34
9	37	38	44	−1	−7	−6
10	50	47	52	3	−2	−5
Total wardens	397	381	557	16	−160	−176

a. Reported by the Law Enforcement Division of the Texas Parks and Wildlife Department.

b. Results are based on the multiple regression model and transformed data. Hours were adjusted back to their original scale of measure and rounded to the nearest whole hour for reporting purposes. One game warden year equals 2,000 hours.

c. Based on the perceived manpower needs as reported by field wardens and their captains in a mail survey conducted in May 1997.

d. Differences between observed, estimated, and perceived manpower needs are reported in portion of a manpower year.

wardens. The largest disparities (>3.0 wardens) occurred in region 8 (Delta, –4.8; Dallas –3.5; Collin, –3.2; and Hunt, –3.0 counties) and in region 3 (Anderson, –3.0; and Freestone, –2.97 counties).

None of the regions had estimated numbers of wardens equal to or greater than their perceived numbers needed (Table 2). Regions 9 (–6 wardens) and 10 (–5 wardens) had the smallest differences, followed by regions 7 (–9 wardens), 1 (–11 wardens), and 2 (–13 wardens). A negative number indicates that the perceived number was larger than the estimated number (E–P). The largest differences appeared in regions 8 (–35 wardens), 6 (–34 wardens), 3 (–23 wardens), and 4 and 5 (each with –22 wardens). Counties with the most variation (>3.0 wardens) were Dallas (–5.1), Hunt (–3.5), and Collin (–3.0) in region 8; Sabine (–3.4), Anderson (–3.2), and Cherokee (–3.1) in region 3; and Galveston (–8.6) and Harris (–4.5) in region 4.

Discussion

How could such disparities occur in the findings? First, 2 radically different approaches toward answering the same question produced radically different answers. The county estimates produced by the regression model required accurate observed values of the number of game wardens per county. Unlike the Boydston (1972) study, there were no vacant counties in this study. All counties were assigned at least 1/3 of a warden. Does a 1/3 game warden assignment constitute a county that is covered at the required level to positively impact compliance rates? Also, the accuracy of the number of game wardens per county might have been compromised by wardens who said in the mail survey that they were not assigned to a given county.

Secondly, the regression model was applied at the state level. The variables initially selected for inclusion in the regression model were based on a practical understanding of the levels of public involvement in angling, hunting, camping, and other forms of outdoor recreation in a county. An assessment of game warden need by county should be based on what people do (e.g., hunting, boating, angling, camping), how many engage in these activities in a county, and for how long. In this study, the attempt to determine levels of public outdoor recreational uses within each county was compromised by a lack of data (e.g., number of anglers, boaters, or campers), incomplete data (e.g., number of hunters for dove, pheasant, and waterfowl), and unreliable data (e.g., number of deer, quail, and turkey hunters and game harvests). Game wardens and their captains gave the highest importance values to these factors as determinants of game warden need in each county. There were no county-level data sets that quantified warden need based on the commercial uses (e.g., saltwater fisheries, shrimping, and animal collection for the food or pet trade) of wildlife. Since these factors were unavailable to use as independent variables in the regression model, surrogate measures of the level of public use (e.g., hunting, angling, and water safety violations and commercial fishing license sales) were applied. Other researchers (Beffa and Witter 1993) also had to rely on citation rather than actual public use data. However, county-level citation data is influenced by many factors, including the different levels of game warden contact with user groups, the level of activity in a county, high autocorrelations between some citations (e.g., fishing and water safety), and whether the county location of a recorded violation was the actual site of the violation (e.g., Rockwall County in Region 8 had higher issuance levels of fishing and water safety violations than might be expected given its small size and having only 5 acres of lake land).

Thirdly, a regional break-out of the statewide model estimates demonstrated some important considerations in assessing game warden manpower needs. The regression model estimated that the highest number of wardens (4 each) were needed in regions 6 and 8. These were also the regions of the highest differences between observed and perceived need. These corroborations of need in regions 6 and 8 needed to be examined more closely. The differences between estimated and perceived additional manpower in these regions suggested that some counties within these regions may have higher levels of public participation in hunting, boating, or angling than can be effectively monitored by the existing number of wardens.

Finally, although warden perceptions of need were subjective measures, they represented the best assessment of local recreational conditions and levels and trends of public use according to game wardens' experiences. Three of the 8 independent variables in Table 1 were selected by the wardens in the mail survey. Even though the regression model explained >77% of the variance in present game warden deployment by county and predicted a statewide manpower excess of 16 wardens, the model lacks several of the independent variables identified as highly important by the wardens. In short, game wardens' perceptions may reflect future manpower needs (i.e., how many public contacts by a single warden are possible to positively impact compliance rates), while estimates by the regression model reflect current need based on measured past performances and conditions.

In most organizational studies, the tendency exists among respondents to assess a greater need than may actually exist. To what degree that occurred in this study is unknown. However, game wardens and their captains have the best vantage point in assessing on a day-by-day basis what is occurring in their counties and the adequacy of local manpower and other resources to accomplish their mission. Future manpower needs may lie somewhere between the predications made by the multiple regression model and the perceptions of game wardens.

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